

# Mating disruption of the small fruit tortrix (*Grapholita lobarzewskii*) in organic apple orchards of northeastern Italy

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## Abstract

The small fruit tortrix, *Grapholita lobarzewskii* (Nowicki) (Lepidoptera Tortricidae), is a serious problem in the organic apple orchards of the Friuli Venezia Giulia region (northeastern Italy), particularly in hilly areas. Three trials on mating disruption of *G. lobarzewskii* were carried out in two organic apple orchards characterized respectively by very high and low population pressure of this carpophagous pest. Red Isomate-OFM (C-plus)<sup>®</sup> dispensers, used for the control of the Oriental fruit moth, *Grapholita molesta* (Busck), were applied once a year at a rate of 600 dispensers/ha. The pheromone blend released from the dispensers has remarkable analogies with that of *G. lobarzewskii*. In plots where the dispensers were applied, the male catches in the pheromone traps were very low or null, indirectly confirming the mating reduction. A reduction of eggs laid on apple fruit was also observed. Mating disruption reduced significantly the percentage of apple fruit attacked by the small fruit tortrix both in the apple orchard with very high population pressure and in the orchard with low population pressure. A not negligible proportion of infested fruit rotted and fell much earlier with respect to harvest time and it suggests partial weight compensation by undamaged apple fruit. In the orchard with a high population pressure, mating disruption was not able to reduce the percentage of attacked apple fruit to acceptable levels. However, since alternative control methods against the small fruit tortrix are not currently available to organic agriculture, the mating disruption approach must be advised in all the apple-growing areas where this pest causes severe damage.

**Key words:** *Cydia pomonella*, *Grapholita molesta*, sex pheromones, damage, control, organic agriculture.

## Introduction

The small fruit tortrix, *Grapholita lobarzewskii* (Nowicki) (Lepidoptera Tortricidae), is a carpophagous pest that can cause occasional and locally severe damage on apples and plums, mainly in central Europe (Charmillot and Pasquier, 2001). In Italy, outbreaks of this pest have been observed in organic apple orchards located in hilly areas of Piedmont (Pinna and Navone, 1995), Lombardy (Trematerra *et al.*, 1996) and Friuli Venezia Giulia (Gambon and Barro, 2000). Additionally, uncultivated shrubs of *Prunus* spp. and *Crataegus* spp. are recorded as host plants to the tortricid moth (Trematerra, 2003).

This species has one generation per year and overwinters as full-grown larvae within a silken cocoon beneath bark or other shelters (Charmillot *et al.*, 1989). Pupation occurs in the spring. A slight proterandry was suggested by Graf *et al.* (1999). In Friuli Venezia Giulia the male flight lasts about two months, from mid May to mid-late July, and shows a peak in late May-early June (Gambon and Barro, 2000). The eggs are laid on fruit (Trematerra *et al.*, 1996). After hatching, the larvae first feed below the fruit skin and then bore deeper into the fruit. As fruit size increases, a flattened depression corresponding to the attack point is visible (Gambon and Barro, 2000). Late in the season the larvae can make several superficial tunnels below the skin, leaving a characteristic star-shaped pattern. The damaged fruit can rot and fall in advance. From mid August the full-grown larvae leave the fruit to search for overwintering shelters.

In conventional farms the small fruit tortrix is indirectly controlled by insecticide treatments applied against the codling moth *Cydia pomonella* L. and the Oriental fruit moth *Grapholita molesta* (Busck). For specific treatments, growth regulators and neurotoxic

products can be used (Charmillot *et al.*, 1989; 2007; Pinna and Navone, 1995; Trematerra *et al.*, 1996).

In organic farms, where synthesis products are not authorized, the control of *G. lobarzewskii* can be based on mating disruption, already successfully demonstrated in Switzerland (Charmillot and Pasquier, 2001; Zingg, 2001) and Germany (Trautmann and Lange, 2000).

Pheromone-mediated mating disruption has proven to be highly effective in the control of many moth pests (Cardé and Minks, 1995). The efficacy is higher when the orchard surface is wider and moth population pressure is lower (Cardé and Minks, 1995; Cravedi, 2001; Melandri and Pasqualini, 2007). Unfortunately, in organic agriculture these conditions often do not occur and no effective insecticide treatments are available to preliminarily reduce the population density of these moths. However, *G. lobarzewskii* is a univoltine species that does not progressively increase in population density during the season as it often occurs for codling moth and Oriental fruit moth (Molinari and Cravedi, 1990; 1995; Cardé and Minks, 1995).

The aim of this contribution is to test the efficacy of mating disruption of the small fruit tortrix in organic apple orchards characterized by different pressure of the moth. In this research also other carpophagous tortricids attacking apple fruit in northeastern Italy were considered.

## Materials and methods

The trials were carried out during 2000-2002 in two organic apple orchards of the province of Udine (Friuli Venezia Giulia region, northeastern Italy), characterized by different *G. lobarzewskii* population pressures.

### Trial 1 and trial 2

These trials were carried out in 2000 and 2001 in a farm located at S. Margherita del Gruagno (municipality of Moruzzo), in a hilly area (160 m above sea level) characterized by a high woody-plant biodiversity due to the presence of many hedgerows and groves. Spontaneous shrubs of *Prunus* spp. and *Crataegus* spp. were observed. The surface area of the apple orchard was about 1.1 ha. All the plants were of cv. 'Florina' (year of plantation 1995, spindle-type training system, planting density of 1000 trees/ha). Preliminary samplings showed that the year before the beginning of the trials, at harvest, 46% of apple fruit was attacked by *G. lobarzewskii*, 1.4% by *C. pomonella* and 1.6% by tortricid leafrollers (the criteria to distinguish the attacks of different tortricids are reported in "Sampling and statistical analysis").

The mating disruption (0.8 ha) and untreated (0.3 ha) plots were separated by a one hectare vineyard. In the mating disruption plot a single application of Red Iso-mate-OFM (C-plus)<sup>®</sup> dispensers (Biocontrol) for the control of *G. molesta* was made. The specific pheromone dispensers for *G. lobarzewskii* are not currently available commercially, but the pheromone blend of the two tortricids shows remarkable analogies consisting mostly of E8-12Ac and Z8-12Ac, even if in different proportions (Cardé *et al.*, 1979; Witzgall *et al.*, 1989). The dispensers were hand-applied at the beginning of May, before the emergence of adults, at a rate of 600 dispensers/ha. To reduce the incidence of border areas with low concentrations of the pheromone and the risk of mated females immigration by hedgerows, the dispensers were applied also in the hedgerows around the apple orchards and they were doubled on the plants placed along the orchard border sides. The dispensers were hung on branches in the upper third of the apple tree canopy. Both the plots were free of pesticide sprays. *C. pomonella* was controlled only in the trial 2 by mating disruption.

### Trial 3

Trial 3 was carried out in 2002 in a farm located at Beivars (municipality of Udine) in a flat area (120 m a.s.l.) characterized by a scarce woody-plant biodiversity and high occurrence of arable crops. The surface area of the apple orchard was about 2.4 ha. The plants were of cv. 'Florina', 'Golden Lasa', 'Prima', 'Priscilla' and 'Granny Smith' (years of plantation 1998-2000, spindle-type training system, planting density of 1700 trees/ha). The year before the beginning of the trial, at harvest, 2.0% of apple fruit was attacked by *G. lobarzewskii* and 7.4% by other carpophagous moths, in particular by *G. molesta*.

The mating disruption (1.9 ha) and untreated (0.5 ha) plots were contiguous. The pheromone dispensers to control *G. lobarzewskii* were applied with the same criteria as trials 1 and 2. In both plots the codling moth was controlled by mating disruption and by four applications of codling moth granulosis virus (Carpovirusine). No other pesticides were sprayed.

### Samplings and statistical analysis

The monitoring of the male flights of *G. lobarzewskii* was carried out by pheromone wing traps (Traptest<sup>®</sup>, Isagro, Novara, Italy) baited with the specific pheromone blend. Two traps were placed in early May (before the beginning of male flight), both in the untreated and treated plots, and checked weekly. The traps were hung on apple branches at about 1.5 m over the ground level.

Periodic samplings of the apple fruit were conducted on cv. 'Florina' plants both in the treated and untreated plots. In trial 1, ten samplings were carried out weekly, from mid May to late July. In trial 2, seven samplings were carried out weekly from mid June to late July; moreover two samplings were carried out at the end of August and the end of September, respectively. In trial 3, three samplings were made respectively in late July, late August and late September. In trials 2 and 3 samplings were carried out up to harvest time (September) in order to estimate the infestation level of other tortricid species.

At each sampling, 500 apple fruit was observed both in treated and untreated plots (20 fruit per plant on 25 different plants). In order to avoid biased sampling of fruit, the rows and the plants were a priori fixed. For the treated plot of trial 3, the five rows nearest to the untreated plot were not considered for samplings. For each apple fruit, the number of attacks of the different carpophagous tortricids was recorded. During the season *G. lobarzewskii* larval penetrations were distinguished by those of *C. pomonella* and *G. molesta* for the spiral-shaped entrance holes (Charmillot *et al.*, 1989). In the last sampling also *C. pomonella* and *G. molesta* attacks were distinguished on the basis of larval morphology or gallery characteristics (Zandigiaco *et al.*, 2006). In trial 1, until mid June, the fresh eggs of *G. lobarzewskii* on the apple fruit were also counted, and in trial 2 the attacked fruit was discriminated between rotten and non-rotten ones.

The data, expressed as proportion of attacked apple fruit, were compared using a  $\chi^2$  test.

## Results

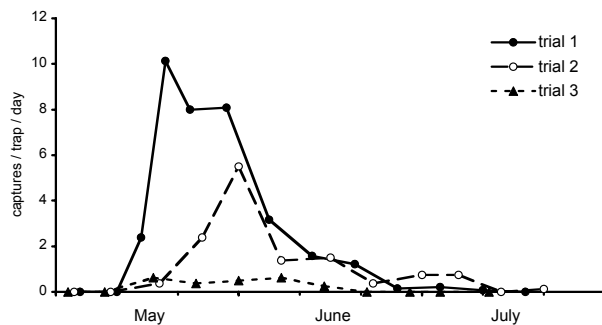
### Trial 1

In the untreated plot, the male flight of *G. lobarzewskii* started at mid May and ended at the beginning of July with a peak in the second half of May (figure 1). The peak of egg laying, in agreement with the male flight, was observed in late May (figure 2).

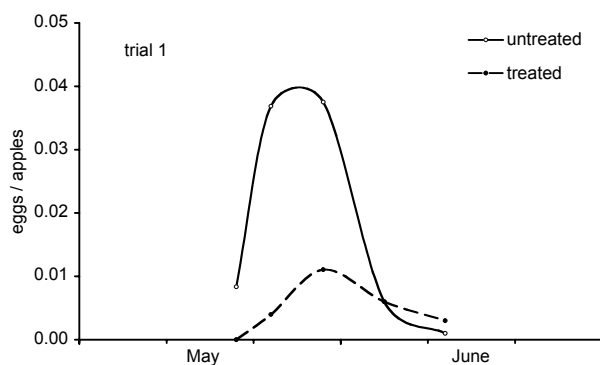
The first attacked apples were observed in late May in the untreated plot and one week later in the treated one (figure 3). The infestation increased during June and reached a peak in July. In the untreated plot a slight decrease in the percentage of attacked apples was observed in late July, due to the fall of a proportion of the damaged apples.

The total of males caught by the pheromone traps, placed in the treated and untreated plots, were 2 and 344, respectively. This occurrence was associated with lower

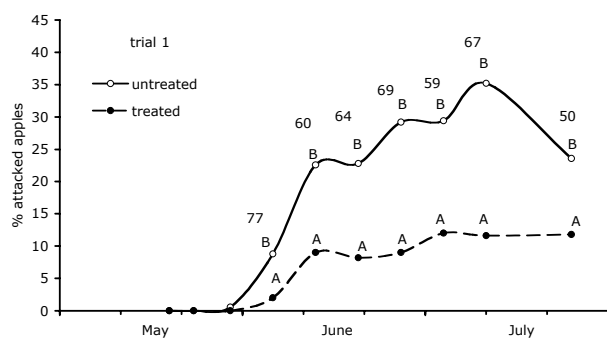
numbers of fresh eggs in the treated plot than in the untreated plot (figure 2). The percentage of fruit infested by larvae of the small fruit tortrix in the treated plot was significantly lower than in the untreated with the treated plot having one third the level of infestation during the peak period (end of July) (figure 3).



**Figure 1.** Male flights of *G. lobarzewskii* recorded in the untreated plots of the trials.



**Figure 2.** Fresh eggs of *G. lobarzewskii* on apple fruit in the untreated and treated plots of trial 1.



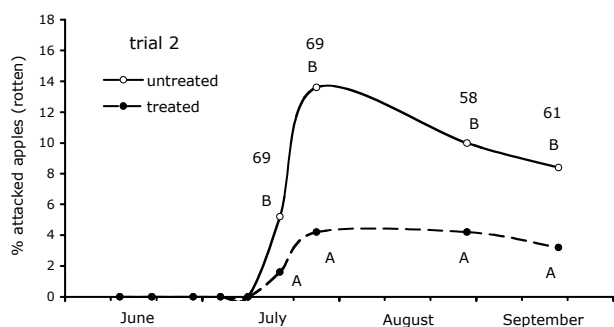
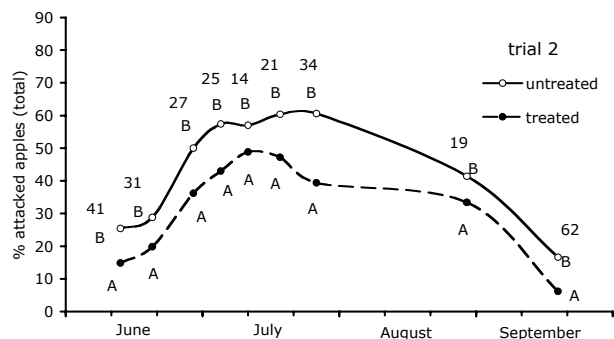
**Figure 3.** Apple fruit infested by *G. lobarzewskii* in the untreated and treated plots of trial 1. Different capital letters in the same sampling data indicate statistically significant differences by  $\chi^2$  test ( $P = 0.01$ ). Above the untreated line the efficacy (%) of mating disruption is indicated.

### Trial 2

The flight of *G. lobarzewskii* males, monitored in the untreated plot, began at mid May and ended at the beginning of July (figure 1). The peak of captures was observed between the end of May and the beginning of June. In the treated plot no adults of the small fruit tortrix were found in the pheromone traps.

In both the plots, the peak of fruit infestation by *G. lobarzewskii* was observed at mid July (figure 4). Later, the percentage of attacked fruit progressively decreased, as a result of the fall of many damaged fruit, and reached relatively low levels at harvest. The percentage of infested fruit decreased in concomitance with the first appearance of rot on the apples, which is probably a factor affecting the fruit fall.

The percentage of total fruit infested by *G. lobarzewskii* in the treated plot was significantly lower than that found in the untreated plot in all the samplings (figure 4). The differences were particularly consistent with regards to the number of attacked and rotten fruit (figure 4). The reduction of the attack at the peak of the infestation was of about a third; at harvest the efficacy was apparently higher due to the contribution of fruit fall both in the treated and the untreated plots. However, at harvest the absolute difference in the percentage of attacked fruit between the treated and the untreated plots was similar to the levels recorded in July.



**Figure 4.** Apple fruit attacked (total or rotten) by *G. lobarzewskii* in the untreated and treated plots of trial 2. Different capital letters in the same sampling data indicate statistically significant differences by  $\chi^2$  test ( $P = 0.01$ ). Above the untreated lines the efficacy (%) of mating disruption is indicated.

*C. pomonella* and *G. molesta* caused more serious damage during the summer generations and at harvest no significant differences between treated and untreated plots were observed for both species (figure 5). The fruit infested in early season was securely attacked by *C. pomonella* because *G. molesta* larvae can penetrate the apples only in late summer. At harvest, these two carpophagous moths infested around 20% of fruit (figure 5), and therefore were present at a higher level than *G. lobarzewskii* (figure 4).

Attacks to apple fruit by leafroller tortricids was observed throughout the vegetative season, but their contribution to total damage was less important than the other carpophagous species. In late August a significant higher infestation of leafrollers was observed in the untreated plot.

### Trial 3

In the untreated plot, captures of *G. lobarzewskii* started at mid May and were kept high up to the beginning of June to conclude at mid June (figure 1). In the treated plot no males were recorded in the pheromone traps.

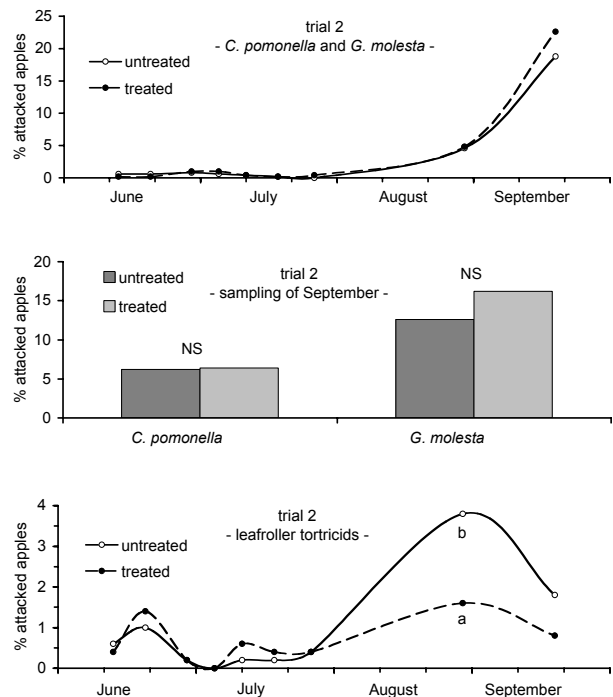
Mating disruption reduced drastically the infestation of *G. lobarzewskii* reaching 90% efficacy (figure 6). At harvest the efficacy was apparently lower because the greater part of attacked fruit fell, mostly in the untreated plot.

At harvest, the percentage of apples attacked by leafroller tortricids was not significantly different between the two treatments and was higher than the attacks by the small fruit tortrix (figure 6). At harvest, both in treated and untreated plots no apples were infested by *C. pomonella* and only the 0.2% by *G. molesta*.

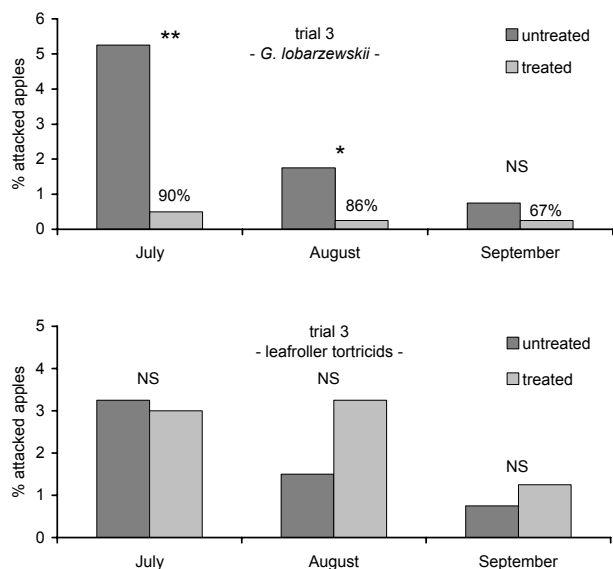
### Discussion

Mating disruption of *G. lobarzewskii* in apple orchards is effective not only when the population pressure is low (trial 3), but also when it is very high (trial 1 and trial 2). However, the percentage efficacy was very high only in the first case (trial 3). On the other hand, the presence in the apple orchards of untreated plots, that are a potential source of mated females, could have partially reduced the efficacy of the treatment. A higher population pressure was observed in the apple orchard of trials 1 and 2 located in the area where spontaneous host plants of the small fruit tortrix were present.

On organic farms mating disruption is economically convenient also when the effectiveness is partial and the damage is still very high. In fact, a reduction in the percentage of attacked apples by 2-3% (sum of *G. lobarzewskii* and *G. molesta* damage) is sufficient to justify the cost of mating disruption. The data relative to trial 2 indicate that the greater proportion of the fruit attacked by *G. lobarzewskii* larvae fall before harvest. Therefore, partial weight compensation due to a higher growth of undamaged fruit could further reduce the yield losses by this moth. On the contrary, for the other carpophagous species the weight compensation is less important, because apples are mostly attacked close to harvest and then fruit fall occurs when the fruit has already com-



**Figure 5.** Apple fruit infested by *C. pomonella*, *G. molesta* and leafroller tortricids in the untreated and treated plots of trial 2. Different letters in the same sampling data indicate statistically significant differences by  $\chi^2$  test ( $P = 0.05$ ). NS = not statistically significant differences.



**Figure 6.** Percentage of the apple fruit infested by *G. lobarzewskii* and other carpophagous moths in the untreated and treated plots of trial 3. Above the treated columns the efficacy (%) of mating disruption is indicated. \*\* = statistically significant differences at the 0.01 level ( $\chi^2$  test); \* = statistically significant differences at the 0.05 level; NS = not statistically significant differences.

pleted its development. Besides, apples damaged by the small fruit tortrix, that are not rotten at harvest, could still be used for transformed products (i.e. juices), thus further reducing economic damage.

Although the dispensers used in these trials release a pheromone specific for *G. molesta*, no control of this moth was observed in trial 2. This effect could be dependent on a different number of generations a year between *G. lobarzewskii* and *G. molesta*. Actually, the occurrence of a higher number of generations in *G. molesta* could favour an increase of its population during the season, and this might also be associated with inadequate longevity of the dispenser (Cardé and Minks, 1995; Kovanci *et al.*, 2004).

A positive side effect of mating disruption against *G. lobarzewskii* on leafrollers control was suggested by trial 2, but not confirmed by trial 3.

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