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The control of *Cydia molesta* in stone- and pome-fruit orchards by false-trail following

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Abstract: The defence of stone- and pome-fruit orchards from *Cydia molesta* by the method of false-trail following, or "disorientation", has been evaluated. Such a method consists in the setting up of several prevailing pheromone trails, released by an appropriate number of dispensers loaded with low pheromone dosage, able to compete with those of the female insect and thus disorientate males in their search for partners. The soundness of the disorientation method has been demonstrated through experimental and large-scale demonstrative trials, covering more than 200 hectares of peach orchards and 32 hectares of pome-fruit orchards located in several Italian regions in 1998-99.Specific, biodegradable, pheromone dispensers, named Ecodian, numbering 2000/ha for a total amount of 20 g active ingredient per hectare, were used for each application, which had an average duration of 45-50 days. In peach orchards, in 1998 damages lower than 5% were registered on 159 of the 186 demonstration tests (81%), against 186 of the 209 tests (89%) in 1999. Damages less than 1% were registered in 74 tests in 1998 and 119 tests in 1999. In pome-fruit orchards, the dispensers for *Cydia molesta* were applied in mid-July on fields where, for the most part, the mating disruption was practiced with Ecopom Isagro dispensers for the defence against *Cydia pomonella*. Of the 22 demonstration trials in 1998, only 1 suffered damage of 2%, while in the other 21 the control was total. An excellent control of *Cydia molesta* was also achieved in 1999, only 1 out of the 31 tests suffered damage higher than 5% (mainly due to the border effect) while in 24 tests the attack was kept within 1%.

Key words: pheromone, false-trail following, disorientation, *Cydia molesta*, stone fruit, pome fruit

Introduction

Over the last few years, the agro-industrial system has undergone substantial changes consequent to both the growing power of the large-scale retail companies, which can determine the demand of "controlled" (certified) products to promote the sales of their own brand names, and the development of European, National and Regional environment-friendly politics encouraging the use of techniques of integrated production.

These changes have resulted in the implementation of new plant protection guidelines granting a further premium on the adoption of innovative methodologies that are respectful of the environment and of consumers' health.

Within this frame, the method of false-trail following or "disorientation" for the control of *Cydia molesta* and A*narsia lineatella* represents a valid tool, since not only it can be applied in biological control programs, but is particularly suitable for the protocols of integrated pest management (Molinari *et al*., 2000a, b).

Such a method consists in the setting up of several prevailing pheromone trails, released by an appropriate number of dispensers loaded with low pheromone dosage, able to compete with those of the female insect and thus disorientate males in their search for partners.

The effectiveness of the method is likely to depend on its keeping males busy visiting the artificial pheromone sources most of the time rather than the females actually present in the treated area. For this purpose we optimised, by means of the laboratory and field tests here described, a new biodegradable pheromone dispenser.

Dispenser design

Isagro's Ecodian dispensers are made of Mater-Bi, a proprietary product of the company Novamont , that is a mixture of biodegradable materials, such as cornstarch and thermoplastic polymers (Bastioli *et al.*, 1992).

Various industrial grades Mater-Bi have been tested for their suitability in pheromone absorption and release, ranging from practically impermeable materials to very fast releasing ones. Mixtures of them, different thickness of dispensers, and different pheromone loadings have also been tested.

Table 1 reports the half-lives of dispensers obtained with selected materials in open field conditions.

Table 1. Half-lives of Ecodian dispensers made of different Mater-Bi

Entry	Material	Pheromone loading (% w/w)	Half-life (days)
1	ZF03U + AF05H (1:1)	1	80
2	ZF03U	1	22
3	ZF03U/A	1	25
4	ZF03U/A	0.5	23
5	ZI01U	1	18

Granules of Mater-Bi, industrial grade ZF03U/A, have been treated in an horizontal mixer with the pheromone blend for *Cydia molesta*, then moulded into a suitable

shape to obtain Ecodian CM dispensers, (Figure 1). Pheromone loading was 1% w/w, i.e. 10 mg/dispenser. Ecodian AL dispensers were manufactured in the same way, using the pheromone blend of *Anarsia lineatella* (Rama *et al.*, 1999).

Figure 1. Ecodian dispenser

Determination of release rates were carried out by exposing the dispensers under controlled conditions (35 °C, air speed 1 m/s), as well as in the open field. Each dispenser was weighed, dissolved in 20 ml of tetrahydrofurane containing n-hexadecanol as internal standard, and analysed by gas chromatography.

Figures 2 and 3 show the release rate of Ecodian CM and AL standard- and high thickness-dispensers (3.5 mm o. d.), periodically picked up from both environments.

Figure 2. Release rates for *Cydia molesta* formulations

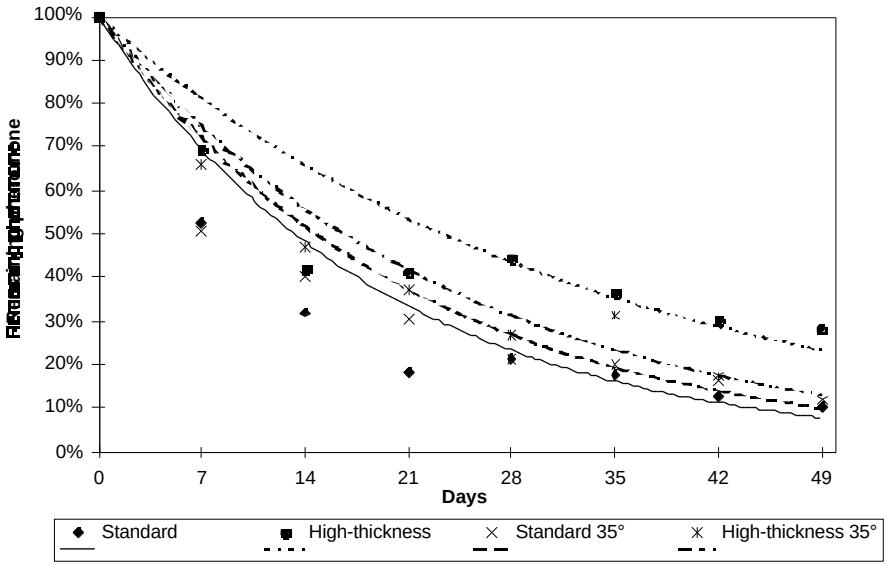
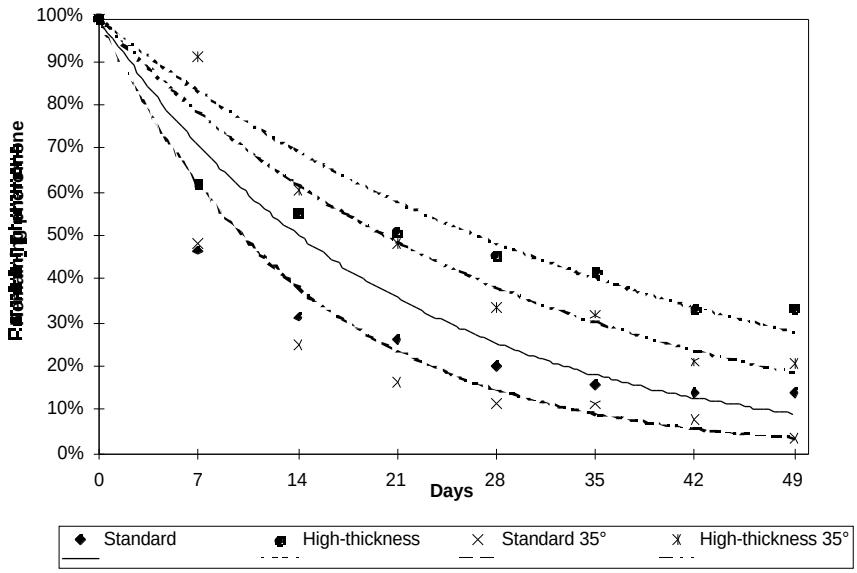


Figure 3. Release rates for *Anarsia lineatella* formulations



Field tests

The experimental trials have been conducted during a four-year period, 1996–99, while demonstrative tests were carried out on a large scale during a two-year period, 1998-99, in an area of over 200 ha in various Italian Regions. Specific biodegradable dispensers, numbering 2000/ha for a total amount of 20 g. a.i./ha, were used for each application, which had an average duration of 45-50 days. In stone-fruit orchards, two different applicable protocols were used: the first (A) consisted in the application of dispensers at the start of the flight of the first generation of *Cydia molesta*, while in the second one (B) the dispensers were applied at the start of the flight of the second generation of the pest followed by an insecticide treatment with the purpose to reduce the population.

In the case of apple and pear orchards, the experimental tests were carried out over two years, 1998-1999, and involved an area of 32 ha in the Regions of Emilia Romagna and Trentino Alto-Adige. The dispensers for *Cydia molesta* were applied in mid-July on fields where, for the most part, the mating disruption was practiced with Isagro's Ecopom dispensers for the defence against *Cydia pomonella*.

Assessment of the method efficacy included: (1) weekly controls of pheromone traps catches; (2) visual checks on 500 shoots and 300 fruits in at least five different locations in the plot for stone fruit, on at least 100 fruits in five different locations in apple orchards; (3) evaluation of total damage at harvest, splitting it into four categories, from 0 to 1%, 1 to 5%, 5 to 10%, and >10% of attacked fruits on the total of production.

Discussion

Stone fruit

In more than 95% of stone-fruit orchards involved in the trials, the contemporary presence of *C. molesta* and *A. lineatella* was observed, thus it was necessary to control both pests at the same time by applying a joint strategy through the distribution of both Ecodian CM and Ecodian AL dispensers. The results obtained, outlined in Figures 4 and 5, are hence referred to the total damage caused by both pests.

Figure 4. Stone fruit: classes of damage 1998

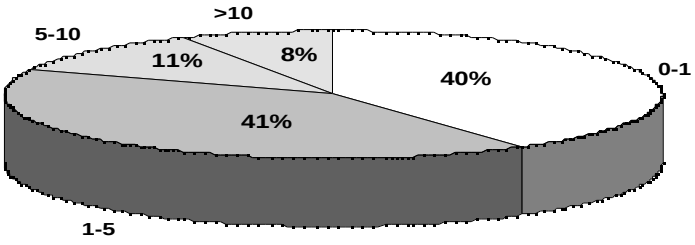
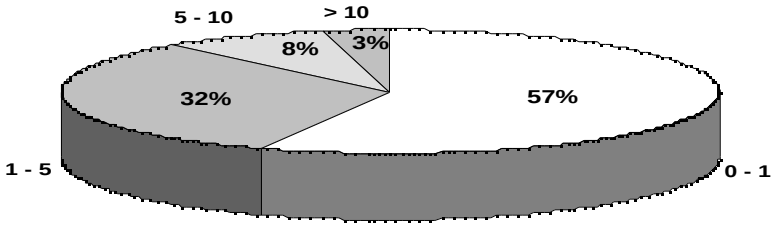


Figure 5. Stone fruit: classes of damage 1999



It is worth noting that in the second year better results were achieved, mainly because the application protocols were more precise. In 1999 mistakes such as those in the timing of application of either dispensers or insecticide planned by protocol B, were sharply reduced. Moreover, much more attention was paid in the choice of orchards, avoiding those too small or of irregular shapes and particular consideration was used in the interpretation of pheromone trap catches (see Table 2).

In both years, no further chemical treatments except those planned by protocol

B were needed on almost 75% of total trials. In few situations it was necessary to stop the tests in order to avoid greater damage.

Table 2. Stone fruit: incidence of chemical treatments 1998-99

	Pesticides on support (%)		Closed trials (%)	
Motivation	1998	1999	1998	1999
Orchards not suitable	4.30	0.48	1.08	---
Wrong application	2.15	0.96	1.61	0.96
High pest population	3.23	4.78	3.76	0.48
Dispensers depletion[a]	8.06	8.13	---	---
Other pests	9.00	11.00	---	---

[a]Dispenser depletion indicates the partial efficiency loss shortly before the harvest (7-10 days before); therefore in some cases a short-efficacy insecticide was used rather than carrying out the second installation of dispensers

Pome fruit

All orchards submitted to experimentation showed the simultaneous presence of *Cydia pomonella* and *C. molesta*. Also in the case of pome fruit it was hence necessary to adopt a combined approach for pest control. Various strategies were implemented after the application of Ecodian dispensers and their distribution is summarized in Table 3.

Table 3. Control strategies against *C. pomonella*

Type of treatment	Apple (No. of trials)		Pear (No. of trials)	
	1998	1999	1998	1999
Bacillus thuringiensis	6	5	3	--
Mating disruption	6	10	3	13
Chemical control	--	3	1	--
No treatment	--	--	3	--
Total	12	18	10	13

Combination of Ecodian and *B. t.*

Some trials have been carried out combining chemical treatments against *C. pomonella* prior of the application of Ecodian CM dispensers for *C. molesta* and

continuing with *Bacillus thuringiensis* treatments, specifically aimed at controlling codling moth without interfering with the biology of *C. molesta*, since the two pests show different development stages at different times. Such a strategy proved to be very effective both on apple and pear keeping the overall damage within 1%.

Combination of Ecodian and mating disruption (Ecopom)

A good orchard protection was achieved also with the combination of the two Isagro pheromone-based products (Ecopom and Ecodian). This method was applied in about half the trials in 1998, increasing to over 60% on apple and reaching the totality on pear in 1999. Tables 4 and 5 report the damage distribution for apple and pear, respectively.

On apple, the good efficacy of Ecodian in the control of *C. molesta* was confirmed; only one of the 16 trials carried out in the two years, showed a damage of about 8%. It has to be noted, however, that this cultivar (Fuji) was harvested in October, about 80 days after the installation of the method, i.e. when the dispensers had already lost their activity.

Table 4. Apple - Damage distribution

	Cydia molesta		Cydia pomonella	
Damage	1998	1999	1998	1999
0 to 1%	6	8	2	2
1 to 5%	0	1	0	7
5 to 10%	0	1	3	1
> 10%	0	0	1	0

In the case of pear, the efficacy of the combination mating disruption-disorientation was also satisfying, but in 1999 greater damage by *C. molesta* was recorded on the borders of a single plot and on cv. Passacrassana, harvested in October. Even the results achieved on codling moth by mating disruption were good in both years.

Table 5. Pear - Damage distribution

	Cydia molesta		Cydia pomonella	
Damage	1998	1999	1998	1999
0 to 1%	3	9	2	9
1 to 5%	0	3	1	3
5 to 10%	0	1	0	1
> 10%	0	0	0	0

Combination Ecodian-insecticides

Very good results, with overall damages less than 1%, were obtained also in the trials on apple carried out in Trentino, where the classical chemical control was combined with Ecodian disorientation. The kind of treatments and their timing are reported in Table 6.

Table 6. Chemical control of *C. pomonella* and *C. molesta* in Trentino

Epoch	Chemical control	Disorientation
Beginning May	IGR	IGR
Mid May	IGR (Leafrollers)	IGR (Leafrollers)
Mid June	IGR	IGR
End July	Organophosphate	Organophosphate
End July-beginning August		Ecodian application
Mid August	Organophosphate	

Ecodian alone

In those pear trials, where no insecticides were applied after mid July, the damage by *C. pomonella* increased accordingly to the period of ripening of fruits, from less than 1% on cv. Conference (mid August) up to 6% on cv. Abate (mid September). It was hence necessary to perform a chemical spray on cv. Passacrassana (mid October). The control of *C. molesta* was instead almost complete, having registered a damage lower than 1% in three different trials while only one showed 2.3% attack.

Conclusions

The method of disorientation, or false trail following, tested on more than 200 Ha of stone-fruit orchards afforded an effective control of the populations of *Cydia molesta* and *Anarsia lineatella*, comparable to traditional insecticide treatments.

Stone-fruit orchard protection was achieved by applying the method both at the beginning of first generation of pests and later on, at the start of the second generation.

In pome-fruit orchards, the disorientation of *C. molesta* can be successfully utilized to integrate the various strategies for the control of *C. pomonella*. Of particular interest is the possibility to combine two different pheromone-based techniques, applied on diverse pests and at different times according to the real needs. In any case, since the higher risk of damage by *C. molesta* on pome-fruit is normally

recorded close to the harvest, the opportunity to control this pest without the use of insecticides makes it possible to obtain residue-free fruits.

In both cases, stone- and pome-fruit, the high versatility of the disorientation method allows its implementation in biological control programs and particularly in the protocols of integrated pest management.

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