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Efficacy of low doses of (E, Z)-2,4-ethyl decadienoate and synthetic pheromone blends to monitor *Cydia pomonella* (Lepidoptera Tortricidae) adults (*)

Abstract - Trials were carried out to assess the possible attractive effect of the pear ester (E, Z)-2,4-ethyl decadienoate (DA2313) and the synthetic pheromone (E,E)-8,10-dodecadienol on the behaviour of *Cydia pomonella* adults. Field trials were conducted in five different sites, four in Italy and one in France. Traps baited with the pear ester alone, with the synthetic pheromone alone, and with different blends of the two compounds were placed in the field. Trap catches were recorded weekly. The synthetic pheromone caught more males than the pear ester, while the latter alone was the most attractive to females. Blends of pear ester and pheromone at different doses were not as effective as the pear ester alone to capture females.

Riassunto - *Efficacia di miscele a basse dosi di (E, Z)-2,4-decadienoato di etile e feromone sintetico nel monitoraggio degli adulti di* Cydia pomonella *(Lepidoptera Tortricidae).*

Sono state condotte prove per valutare la capacità attrattiva di (E, Z)-2,4-decadienoato di etile e del feromone sintetico (E, E)-8,10-dodecadienolo nei confronti degli adulti di *Cydia pomonella*. Le sperimentazioni hanno interessato cinque località, quattro in Italia e una in Francia. Sono state poste a confronto trappole innescate con il solo decadienoato di etile, con il solo feromone sintetico e con differenti miscele dei due composti. Le trappole contenenti il feromone hanno catturato il maggior numero di maschi. Il decadienoato di etile ha permesso la cattura anche di femmine; le miscele hanno sempre catturato meno femmine rispetto al decadienoato di etile da solo.

Key words: plant volatiles, sex pheromone, codling moth, monitoring, field test.

INTRODUCTION

The codling moth, *Cydia pomonella* (L.), is the most important pest in apple, pear and walnut orchards of many countries. Traditional control techniques are based on re-

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peated insecticide applications. Their impact on the environment is extremely negative, and insecticide induced resistance increased (Varela *et al.*, 1993; Knight *et al.*, 1994; Sauphanor *et al.*, 1998; Ioriatti *et al.*, 2000).

The identification of the codling moth sexual pheromone, (E, E)-8,10-dodecadienol (codlemone), by Roelofs *et al.* (1971) started the development of more environmentally friendly control techniques. The pheromone is successfully used in baited traps to monitor the flight of adult males. With the identification of the pear ester (E, Z)-2,4-ethyldecadienoate (DA2313) as a moth attractant, a new research was prompted in order to identify its potential applications in insect monitoring. The pear ester was shown to be attractive for both male and female (virgin and mated) *C. pomonella* adults in walnut and apple orchards (Light *et al.*, 2001; Coracini *et al.*, 2004). Research regarding female attractants would be very useful for measuring the efficiency of pheromone-based suppression strategies, such as mating disruption.

In Italy, a preliminary work for evaluating the attractiveness of the pear ester to codling moth adults has been carried out since 2000. The research was conducted within a research project (Bioinnova) coordinated by Trécé, using different doses and blends of pheromone and pear ester in apple and pear orchards of different production areas in northern Italy. Ioriatti *et al.* (2003) confirmed that the pear ester could be a promising attractant for *C. pomonella* monitoring.

Host plant volatiles can have a synergistic effect on the response of male moths to the sex pheromone (Landolt & Philips, 1997). A blend of green leaf volatiles, when added to the codlemone, significantly increased catches of codling moth males (Light *et al.*, 1993).

We therefore decided to investigate the potential synergism between the pear ester and the codlemone. In Italy, research showed that a blend of codlemone:pear ester (1.0:0.1 mg) attracted more insects than 1.0 mg of codlemone alone. However, in several other trials of the same project the monitoring efficacy of the pheromone, in combination with higher doses of the pear ester, seemed to be lower (Ioriatti *et al.*, 2003). It was therefore suggested that low dose blends increase the attractive power, resulting in increased male and total catches.

The present study was carried out to establish the efficacy of low doses of the pear ester and the pheromone, both alone and blended, for monitoring male and female codling moth adults.

MATERIAL AND METHODS

Trials were carried out in 2003 in 5 different geographic areas (4 in Italy: Trento, Cuneo, Massa, and Campobasso; 1 in France: Chem) on apple and pear (Massa) (table 1). Organic farming strategies were used in the apple orchard in Campobasso, while in the other orchards chemical control strategies were applied (Table 1).

To investigate the efficacy of low doses of the pheromone alone and in combination with the pear ester in capturing codling moth adults, we counted the number of male

Table 1 - Description of the study sites.

Study site, country	Crop	Varieties	Control strategy
Trento, Italy	apple	Golden Delicious	Chemical
Cuneo, Italy	apple	Golden Delicious	Chemical
Chem (Montpellier), France	apple	Different varieties	Chemical
Campobasso, Italy	apple	Different varieties	Organic
Massa, Italy	pear	Abate Fétel	Chemical

and female catches in traps baited with the pear ester alone, with the pheromone alone, and with different blends of pheromone and pear ester (see below for details). Rubber septa dispensers placed in the centre of the trap floor (Pherocon II B Trécé) were used. In each orchard, the following baits (treatments) were compared:

– 0.1 mg pear ester,
– 1 mg pheromone,
– 0.1 mg pheromone,
– 0.1 mg pheromone + 0.1 mg pear ester,
– 1 mg pheromone + 0.1 mg pear ester.

The traps with the different baits were placed at 20 m distance from each other in the outer part of the canopy at the top of the trees. A randomized block design with 4 replicates per treatment was used. Baits were replaced every 2 weeks. The traps were checked for catches weekly. Traps with insects were replaced with new traps, and were brought to the laboratory in order to determine the number of *C. pomonella* males and females captured in each trap.

The number of male and female catches and the total catches recorded in the four Italian orchards were compared across treatments by means of one-way ANOVAs, and the Tukey HSD test was used for posthoc comparison of means. The number of male catches, female catches, and the total number of catches recorded in the French orchard were compared across treatments using the nonparametric Kruskal-Wallis ANOVA, followed by Dunn's multiple comparison procedure based on Kruskal-Wallis rank sums (Hollander & Wolfe, 1973).

Overall catches of all sites were transformed using natural logarithm. A factorial analysis of variance was applied to test the effects of site and treatment on the natural logarithm transformation of the number of catches.

Significant main effects and interaction were further analysed using the Tukey HSD test at P= 0.05. Procedure GLM of SPSS (version 11.5, 2002) was applied.

RESULTS

For male catches significant differences among treatments were recorded in all sites (Table 2). In the Italian sites, the number of males caught was always higher in the traps baited with 1 mg pheromone alone, intermediate in those baited with 0.1 mg pheromone

Table 2 - Results of the analyses of variances in the different study sites.

Site	Male catches			Female catches			Total catches (males + females)		
	d.f.	F	P	d.f.	F	P	d.f.	F	P
Trento	4, 18	4.3232	0.0159	4, 18	5.4783	0.0064	4, 18	3.7031	0.0274
Cuneo	4, 18	3.7642	0.0259	4, 18	1.4472	0.2671	4, 18	3.5372	0.0318
Chem	4, 18	9.6286	0.0472	4, 18	14.0534	0.0071	4, 18	9.0143	0.06808
Campobasso	4, 18	68.1078	<0.0001	4, 18	26.4911	<0.0001	4, 18	43.1962	<0.0001
Massa	4, 18	11.2621	0.0002	4, 18	1.2243	0.3458	4, 18	10.7956	0.0003

alone and with the two blends of pheromone and pear ester, and lower in the traps baited with the pear ester alone (Figs 1, 2, 4, and 5). In the French site, male catches for the traps baited with the two pear ester and pheromone blends were higher than for those baited with the pheromone alone, but differences were not significant (Fig. 3). Also in the French site the lowest number of male catches was obtained with the traps baited with the pear ester alone (Fig. 3).

Differences among treatments for female catches were statistically significant in Trento, Chem and Campobasso, but not in Massa and Cuneo (Table 2). Nevertheless, in all sites female catches were higher in the traps baited with the pear ester alone, intermediate in those baited with both the pear ester and the pheromone, and lower in the traps containing the pheromone alone (Figs 1-5).

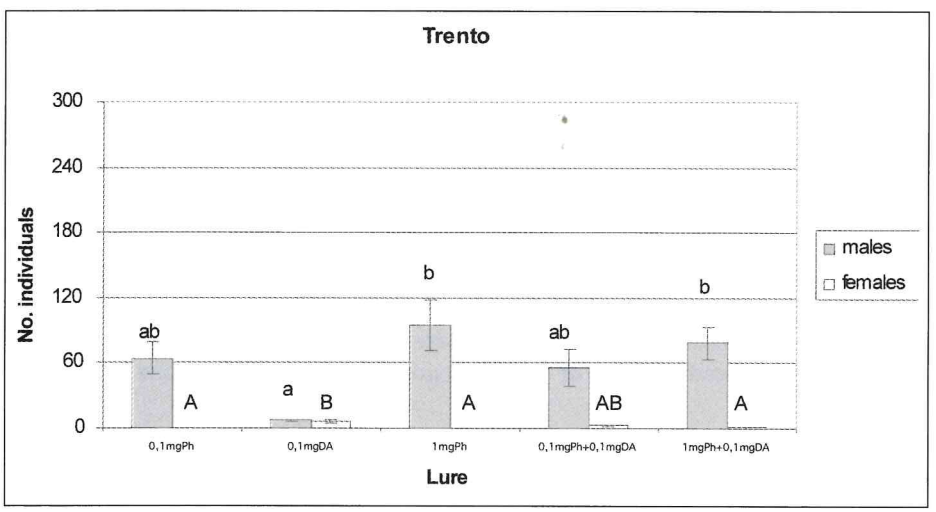

Fig. 1 - Number of *C. pomonella* males and females (m±s.e.) captured in the traps with the different baits in Trento, Italy (DA=pear ester; Ph=pheromone). Different letters within columns of the same type indicate statistically significant differences (Tukey HSD Test: P<0.05).

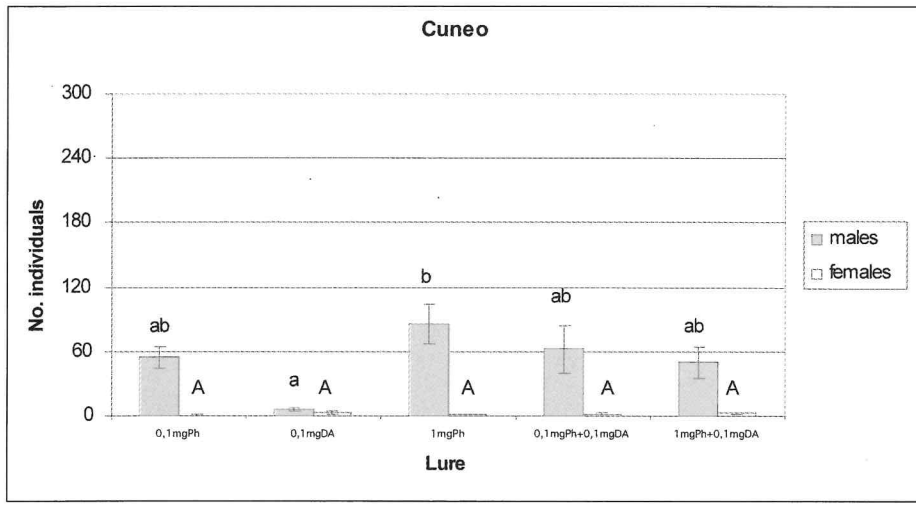

Fig. 2 - Number of *C. pomonella* males and females (m±s.e.) captured in the traps with the different baits in Cuneo, Italy (DA=pear ester; Ph=pheromone). Different letters within columns of the same type indicate statistically significant differences (Tukey HSD Test: P<0.05).

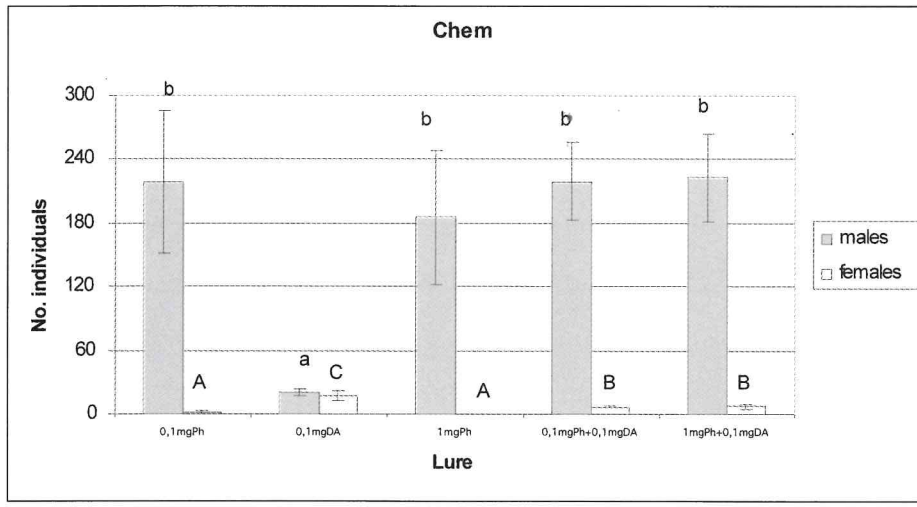

Fig. 3 - Number of *C. pomonella* males and females (m±s.e.) captured in the traps with the different baits in Chem, France (DA=pear ester; Ph=pheromone). Different letters within columns of the same type indicate statistically significant differences (P<0.05).

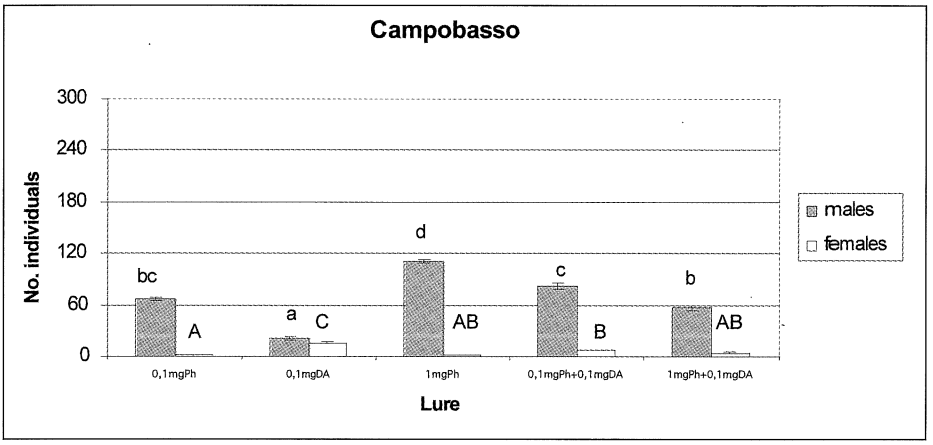

Fig. 4 - Number of *C. pomonella* males and females (m±s.e.) captured in the traps with the different baits in Campobasso, Italy (DA=pear ester; Ph=pheromone). Different letters within columns of the same type indicate statistically significant differences (Tukey HSD Test: P<0.05).

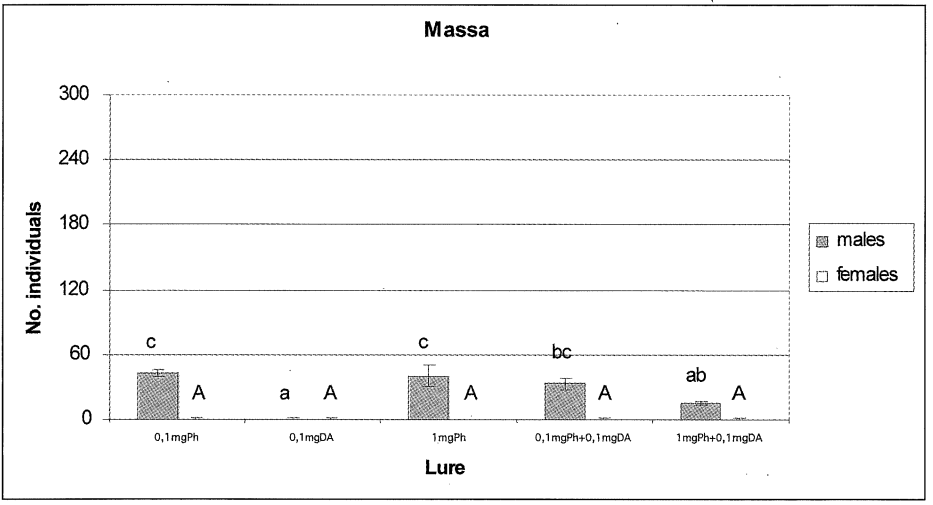

Fig. 5 - Number of *C. pomonella* males and females (m±s.e.) captured in the traps with the different baits in Massa, Italy (DA=pear ester; Ph=pheromone). Different letters within columns of the same type indicate statistically significant differences (Tukey HSD Test: P<0.05).

In the Italian sites, results regarding the total catches were always comparable to those obtained for the number of male catches, while in the French site, differences among treatments for the total catches were not significant (Table 2).

DISCUSSION AND CONCLUSIONS

In most cases the traps baited with both the pear ester and the pheromone are as efficient in capturing males as those with pheromone alone and in capturing females as those with DA alone. In the Italian sites results for the total catches were always comparable with those of males only, while in the French site differences among treatments for total catches were not significant due to the high number of females caught.

Our results for the traps baited with blends of pheromone and pear ester are consistent with those of Il'ichev (2004). This author did not detect any significant increase in moth catches with low dose blends of codlemone:pear ester (0.5 mg:0.5 mg) compared to a commercial codlemone lure in apple orchards. In our trials, irrespective of the doses used in the traps, no significant synergistic effects of blends of pheromone and pear ester were recorded on either males or females. This low efficiency of the blends could be due to the fact that, in *C. pomonella*, the behavioural response to the two compounds is partly mediated by a common sensory channel. De Cristofaro *et al.* (2004) demonstrated the presence of antennal olfactory cells responding to both the compounds. The authors suggested that this lack of specificity may be related to a similar olfactory affinity of the receptor to both the pear ester and the sex pheromone. The two compounds could thus compete for the same receptors, whith a reduced efficacy of the blends compared to the single compounds.

Knight *et al.* (2005) found synergistic effects with high dose lures of pear ester and codlemone (3.0/3.0 mg): catches of male moths were significantly increased compared to 3.0 mg codlemone alone in apple orchards, with or without mating disruption. The presence of receptor cells responding to the pheromone alone and the pear ester alone, and of cells responding to both the compounds could be the reason of the increased response level recorded with high doses of both blend components.

In conclusion, traps baited with the pheromone alone confirmed to be highly effective for monitoring *C. pomonella* males. Traps baited with the pear ester alone could be a useful tool to monitor *C. pomonella* females, while further studies (both laboratory and field trials) are needed to successfully use blends of pheromone and pear ester.

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