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The plant volatile attractant (E,Z) – 2,4-ethyl-decadienoate (DA2313) for Codling Moth monitoring (*)

Abstract - Trials have been carried out to assess the potential of (E,Z)–2,4-ethyl decadienoate (DA2313) for monitoring *Cydia pomonella* (CM). DA2313 baited traps were attractive for males and females even though the total number of catches is lower compared to the synthetic pheromone (E,E)-8,10-dodecadienol. DA2313 baited traps catch a significantly higher number of insects when placed at the top of the trees (3.5-4.0 m) rather than at the height of 2 m, the opposite of what can be observed for pheromone traps. Traps with a wider sticky base catch much more females than standard size traps.

Riassunto - *Sperimentazione di (E,Z)–2,4-decadienoato di etile (DA2313) per il monitoraggio di* Cydia pomonella.

Sono state effettuate sperimentazioni per verificare la possibilità di utilizzare (E,Z)–2,4-decadienoato di etile (DA2313) per il monitoraggio di *Cydia pomonella*. Trappole innescate con DA2313 catturano sia i maschi del lepidottero, anche se in misura inferiore rispetto al feromone sintetico (E,E)-8,10-dodecadienolo, che le femmine, in proporzione variabile. Le trappole innescate con DA2313, collocate a 3,5-4,0 m di altezza, catturano un numero di adulti significativamente maggiore rispetto a quelle posizionate a 2 m, al contrario di quelle innescate con feromone sintetico. Trappole con una base invischiata più ampia hanno catturato un numero di femmine consistentemente superiore rispetto alle trappole di dimensioni standard.

Key words: *Cydia pomonella*, plant volatiles, DA2313, (E,Z)–2,4-ethyl decadienoate, pheromone, monitoring, pome fruits.

INTRODUCTION

Codling moth (CM), *Cydia pomonella* (L.), is a major pest of apple, pear and walnut in most fruit growing areas of the world. Since its sex pheromone, (E,E)-8,10-

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dodecadienol (E8E10-12:OH), has been identified (Roelofs *et al.*, 1971), it has been used for baiting traps to monitor adult flight. The widespread application of traps resulted in a considerable improvement of control techniques (Riedl *et al.*, 1979) and they still remain a basic tool in integrated pest control.

Pheromone traps are attractive only for males, so this fact represents the most critical point in order to interpret the female behaviour (Wall, 1989), that is more closely connected to the fruit damages.

The identification of (E,Z)–2,4-ethyl-decadienoate (DA2313) as attractant able to catch both males and females of *C. pomonella* (Light *et al.*, 2001) allows to figure a new important scenario regarding control tactics against this pest.

During 2000 and 2001 preliminary trials were carried out in Italy to evaluate the potential of DA2313 in monitoring *C. pomonella.*

Attractancy tests were performed within a research project coordinated by Trécé, using different E8E10-12:OH and kairomone doses and blends, supplied by the Company (Table 1), on pome fruits of different northern Italy geographic areas (Table 2). The orchards were representative of the growing area and managed by different control strategies: traditional (chemical) and by mating disruption technique. The trap used in each trial was the Pherocon IIB model, at least 15 meters apart from each other. In each trial, 4 to 8 replicates were planned.

Considering the total catches, in some situations kairomone was as attractive as E8E10-12:OH: during 2000, 40 mg DA2313 was always the best attractive dose, while in 2001, 20 mg showed a comparable performance. Lower and higher doses were always less effective.

Sometimes DA2313 baited trap catches decreased during the second CM flight compared to the pheromone ones.

Table 1 - Lures tested in preliminary trials (2000-2001).

Lure (mg)	**2000**	**2001**
pheromone 1	x	x
pheromone 3	x	x
pheromone 10	x	x
DA 3	x	x
DA 10	x	
DA 20		x
DA 40	x	x
DA 80	x	
pheromone 1 + DA 0.1		x

Table 2 - Orchards in which preliminary trials (2000-2001) on the attractivity of DA have been carried out.

Site	Crop	Control strategy	2000	2001
Trento 1	apple	Pheromone	X	X
Trento 2	apple	Chemical	X	X
Trento 3	apple	Pheromone		X
Bologna 1	apple	Chemical	X	
Bologna 2	apple	Chemical	X	
Bologna 3	apple	Abandoned	X	
Bologna 4	pear	Chemical	X	X
Bologna 5	pear	Chemical		X
Bologna 6	pear	Chemical		X
Bologna 7	pear	Chemical		X
Cuneo 1	apple	Pheromone	X	X
Cuneo 2	apple	Organic	X	X
Cuneo 3	apple	Pheromone		X
Cuneo 4	apple	Organic		X

Unlike the first reported experiences in the USA (Light *et al.*, 2001), we observed very few females in the traps.

During 2001, a E8E10-12:OH/DA2313 (1.0:0.1 mg) blend showed higher performance compared to both single attractants; this could be due to a synergistic effect of the addition of the plant volatile, as reported by Light *et al.* (1993); when this effect should occur, it could be possible to improve the efficacy of Attract & Kill systems.

Following these preliminary works, a research program (Bioinnova) was planned for better defining the possibility of application of DA2313: first results are here reported on field trials with 2 E8E10-12:OH doses, 2 DA2313 doses and 4 blends of E8E10-12:OH and DA2313. Some parameters potentially involved in catching efficacy and sex ratio (trap height, trap size, selectivity) have been evaluated.

MATERIALS AND METHODS

ATTRACTIVENESS. The trials have been carried out in 14 orchards (11 apple and 3 pear). Two different varieties of each species have been chosen, according to harvest time: Gala (early) and Golden Delicious (late) for apple, William (early) and Abate Fétel (late) for pear (Table 3).

Table 3 - 2002: experimental orchards.

	Site		cv	reps	Control strategy	Notes
TN 1	S. Michele	apple	Golden	3	chemical	
TN 2	Gardolo	apple	Golden	2	chemical	
TN 3	Gardolo	apple	Gala	2	chemical	
TN 4	Mattarello	apple	Gala	3	chemical	
TN 5	Romagnano	apple	Golden	2	chemical	
TN 6	Borgo	apple	Golden	2	chemical	
TN 7	Gardolo	apple	Breaburn	2	chemical	
TN 8	Aldeno	apple	Golden	3	chemical	
TN 9	Mezzolombardo	apple	Golden	3	pheromone	
RA 1	Massa Lombarda	pear	Abate fétel	3	chemical	
RA 2	Voltana	pear	William	3	chemical	
RA 3	Voltana	pear	William	3	chemical	
CN 1	Cuneo	apple	Golden	4	chemical	
CN 2	Cuneo	apple	Gala	4	chemical	Anti-hail net

Two E8E10-12:OH and DA2313 doses and 4 blends were evaluated in different combination with 2-4 replicates (Table 4) in order to compare:

- total catches (males+females) with E8-E10-12:OH (1.0 and 3.0 mg), DA2313 (0.1 and 20 mg), and 2 blends of E8E10-12:OH/DA2313 (1.0:0.1 and 3.0:20 mg);
- total catches (males+females) with the 4 blends;
- total catches (males+females) with E8E10-12:OH (3.0 mg), DA2313 (20 mg) and 1 E8E10-12:OH/DA2313 (3.0:20 mg) blend, to evaluate synergistic effect of DA2313 on pheromone;
- percentage of females on total catches of the different lures.

Pherocon IIB (Trécé) traps were adopted, 15-20 meters apart from each other.

Baits were replaced every 2 weeks (lower DA2313 doses), or every 5 weeks (higher DA2313 doses).

Traps were checked weekly; traps with insect catches were replaced with new ones and observed in the laboratory: CM males, virgin and mated females were recorded. If other species were caught in a significant number, specific trials were set up to assess the attractiveness of DA2313 in apple orchards or in other specific situations, according to the species concerned.

Attractiveness data were analyzed by ANOVA and means were separated by LSD test to assess significant differences ($p \leq 0.05$).

Table 4 - Field trials for the evaluation of attractiveness of different doses (mg) of DA, synthetic pheromone (ph) and 4 blends of the two attractants.

Site	1mg ph	3mg ph	0,1mg DA	20mg DA	1mg ph + 0.1mg DA	0.3mg ph + 3mg DA	3mg ph + 3 DA	3mg ph + 20 DA
TN 1	X	X	X	X	X			X
TN 2	X	X	X	X	X			X
TN 3	X	X	X	X	X			X
TN 4	X	X	X	X	X			X
TN 5		X		X				X
TN 6		X		X				X
TN 7		X		X				X
TN 8					X	X	X	X
TN 9					X	X	X	X
RA 1	X	X	X	X	X			X
RA 2	X	X	X	X	X			X
RA 3					X	X	X	X
CN 1	X	X	X	X	X	X	X	X
CN 2	X	X	X	X	X	X	X	X

INFLUENCE OF TRAP HEIGHT. During 2001 a trial was carried out to investigate the influence of trap height on attractiveness. The experimental field was an abandoned orchard, with 4 m high trees; traps were baited with 2 DA2313 doses (20 and 40 mg), 1 pheromone dose (3 mg), and 1 E8E10-12:OH/DA2313 (1.0:0.1 mg) blend. Two series of traps were set up, one at the height of 2 m and the other near the top of trees, exchanging the place of each series every week for 9 weeks, from July 10th to September 10th.

EFFECT OF TRAP SIZE. A trial was set up to assess if a wider sticky surface could give an increase of the number of insects catches, with a special regard to females. Plexiglas panels (30x30 cm) were put underneath the traps and immediately out of the two trap openings. The panels were glued with STP oil, that was periodically applied; 9 traps as above described, 3 of which baited with DA2313 (20 mg), 3 with E8E10-12:OH and 3 unbaited, were placed randomly near the top of the trees; 9 standard Pherocon IIB with the same baits were used as control. Traps were checked daily, from July 8th till August 7th.

RESULTS

ATTRACTIVENESS. As to total catches, both in the first and the second CM generation, DA2313 caught a significant lower number of insects than lures containing E8E10-12:OH, but the blend E8E10-12:OH/DA2313, 0.1:1.0 mg, showed the best attractant power during the second flight (Table 5). Even if significant differences among the four blends were not noticed, the blend E8E10-12:OH/DA2313, 0.1:1.0 mg, was always one of the more effective (Table 6).

No synergistic effect of DA2313 on E8E10-12:OH was noticed in the specific trials (Table 7).

Females were caught in a significant number only in DA2313 baited traps (Tables 8, 10) and in traps baited with the blend E8E10-12:OH/DA2313, 0.3-3.0 mg (Table 9).

Table 5 - Total catches (males+ females) per trap per week of C. pomonella *with different lures ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
DA 0.1mg	24	0,354	C	DA 0.1mg	21	0,270	C
DA 20mg	24	0,415	C	DA 20mg	21	0,271	C
ph 3mg+ DA 20mg	24	2,032	B	ph 3mg+ DA 20mg	21	1,467	B
ph 3mg	24	2,688	AB	ph 3mg	21	1,950	AB
ph 1mg+ DA 0.1mg	24	2,947	AB	ph 1mg	21	2,222	AB
ph 1mg	24	3,160	A	ph 1mg+ DA 0.1mg	21	2,506	A

Table 6 - Total catches (males+ females) per trap per week of C. pomonella *with different blends of pheromone and DA ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
ph 3mg+ DA 20mg	17	1,028	A	ph 3mg+ DA 20mg	17	0,796	A
ph 0.3mg+ DA 3mg	17	1,205	A	ph 3mg+ DA 3mg	17	0,855	A
ph 3mg+ DA 3mg	17	1,317	A	ph 1mg+ DA 0.1mg	17	1,308	A
ph 1mg+ DA 0.1mg	17	1,348	A	ph 0.3mg+ DA 3mg	17	1,352	A

Table 7 - Total catches (males+ females) per trap per week of C. pomonella *in the trials for evaluating synergistic effect of DA on pheromone ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
DA 20mg	28	0,503	B	DA 20mg	25	0,259	B
ph 3mg+ DA 20mg	28	2,806	A	ph 3mg+ DA 20mg	25	2,152	A
ph 3mg	28	3,586	A	ph 3mg	25	2,747	A

Table 8 - Percentage of females on total catches (males+ females) per trap per week of C. pomonella *with different lures ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
ph 3mg	24	0,208	B	ph 3mg	21	1,143	B
ph 1mg	24	0,917	B	ph 3mg+ DA 20mg	21	2,190	B
ph 1mg+ DA 0.1mg	24	2,125	B	ph 1mg	21	3,048	B
ph 3mg+ DA 20mg	24	5,500	B	ph 1mg+ DA 0.1mg	21	5,429	B
DA 0.1mg	24	43,583	A	DA 20mg	21	18,952	A
DA 20mg	24	45,417	A	DA 0.1mg	21	22,238	A

Table 9 - Percentage of females on total catches (males+ females) per trap per week of C. pomonella *with different blends of pheromone and DA ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
ph 1mg+ DA 0.1mg	17	2,882	B	ph 3mg+ DA 20mg	17	3,235	A
ph 3mg+ DA 3mg	17	7,647	AB	ph 3mg+ DA 3mg	17	3,882	A
ph 3mg+ DA 20mg	17	8,000	AB	ph 1mg+ DA 0.1mg	17	9,294	A
ph 0.3mg+ DA 3mg	17	14,706	A	ph 0.3mg+ DA 3mg	17	14,529	A

Table 10 – Percentage of females on total catches (males+ females) per trap per week of C. pomonella *in the trials for evaluating synergistic effect of DA on pheromone ($p \leq 0.05$).*

I flight				*II flight*			
lure	**Count**	**Mean**		**lure**	**Count**	**Mean**	
ph 3mg	28	0,250	B	ph 3mg	25	0,960	B
ph 3mg+ DA 20mg	28	5,000	B	ph 3mg+ DA 20mg	25	2,720	B
DA 20mg	28	44,464	A	DA 20mg	25	25,240	A

Significant numbers of *Hedya nubiferana* Haworth and *Cydia molesta* (Busck) and some specimens of *Cydia fagiglandana* (Zeller) were caught in apple orchards. When traps were installed in chestnut groves caught *C. fagiglandana* as well as *Cydia splendana* (Hübner).

While very few females of *C. molesta* were recorded, both sexes of the other species were equally caught.

INFLUENCE OF TRAP HEIGHT. 768 males and 12 females catches have been recorded during the trial. Traps located at the top of the trees caught by far more insects than lower ones, except when baited with E8E10-12:OH (Fig. 1). The blend E8E10-12:OH/DA2313 , 0.1-1.0 mg, was the most attractive lure regardless of position. The best performing dose of DA2313 (40 mg), caught in higher trap location even more than E8E10-12:OH at the same position.

EFFECT OF TRAP SIZE. Traps with a wider sticky surface caught a higher number of insects, with marked differences between sexes and attractants: 151.7 and 62.7 males/trap were caught in wider and standard pheromone traps, respectively. E8E10-12:OH lured

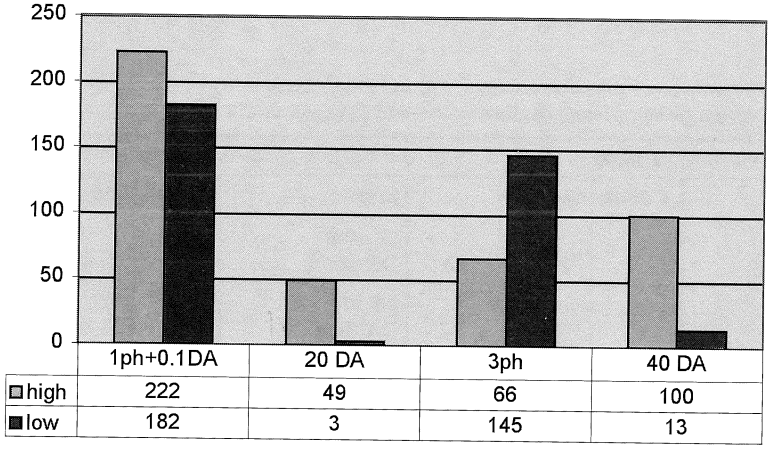

Fig. 1 - Effect of trap heigh on the attractiveness of different lures: total catches per trap.

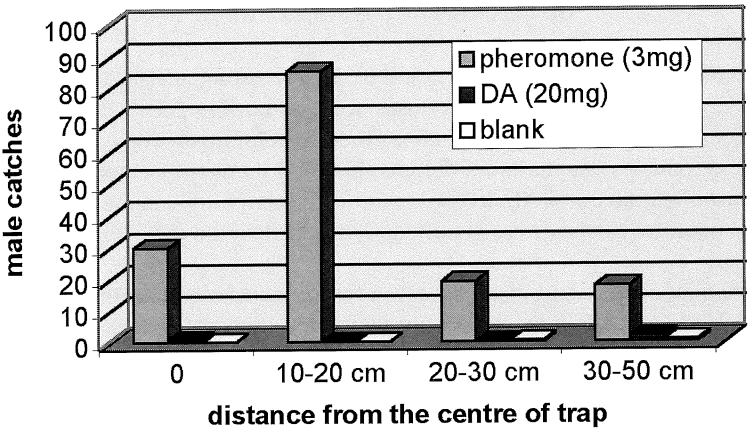

Fig. 2 - Effect of trap size on male catches.

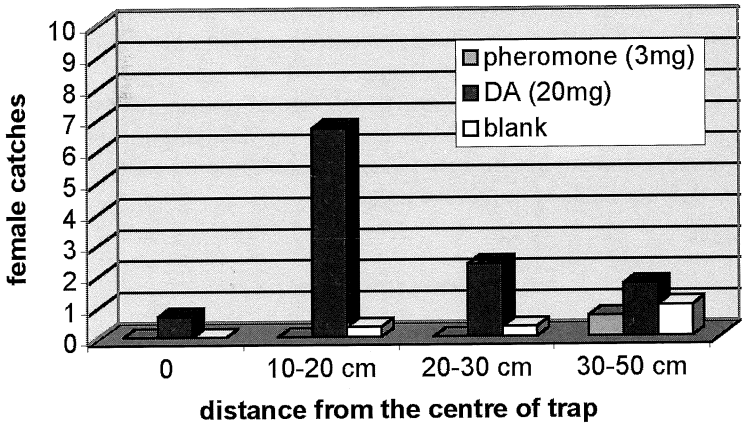

Fig. 3 - Effect of trap size on female catches.

males, mostly inside the trap and in the sticky area beneath the trap (10-20 cm from the lure) (Fig. 2) 3.3 males and 2.3 females/trap were caught in the standard DA2313 baited traps while 2 males and 11.3 females/trap in the wider one. Females were caught almost exclusively outside the trap (Fig. 3). In both type of lures the addition of the sticky panel reduce the number of moths caught inside the traps.

DISCUSSION AND CONCLUSIONS

Our results confirm that DA2313 could be an interesting attractant for monitoring *C. pomonella* even though the tested doses seem to be less active than expected. A dose of 20 mg of DA2313 had been chosen after preliminary trials, due to a higher percentage of females caught and a comparable total number of catches to 40 mg, at least in some situations. In 2002 trials, lower doses proved to be equally attractive for both sexes, but total catches were significantly lower than the ones obtained with pheromone traps.

No synergistic effect have been observed for the tested blend during 2002 (E8E10-12:OH/DA2313 – 3.0:20 mg); this is not consistent with the results of the trials on trap height and of the preliminary tests, in which E8E10-12:OH/DA2313, 1.0:0.1 mg attracts sometimes more insects than 1 mg pheromone (Fig. 1 and Table 6). It cannot be excluded that an improved attractiveness of E8E10-12:OH could be obtained with some blends, either in terms of male or total catches.

DA2313 traps proved to be very sensitive to the height of placement. Higher traps are always more attractive.

The results of trap size trials suggest that females approach DA2313 in a different way compared to male approach to pheromone; in fact only 6% of females compared to 20% of males land within the trap.

In order to set up a reliable monitoring tool, further investigations will be focused on defining the best dose of DA2313 to be used for detecting the presence of both males and females and studies on new types of traps could be carried out in order to find out a satisfying balance in the sex ratio.

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