ISOMATE® C LR

A new approach to the control of Codling moth (Cydia pomonella)

and leafroller

Morphological and biological features of *Cydia pomonella*

Adult Grey forewings crisscrossed with fine alternating grey and white undulate bands. The tip of each forewing has a distinctive coppery-tinged, dark brown spot. The dusky reddish backwings also have a copper to gold sheen.

Egg Disk-shaped and opaque white when first laid, the eggs later develop a reddish embryonic ring. The black head-thorax of the larva becomes visible just before hatching.

Larva Newly hatched larvae are white with black heads. As they progress through five instars, their colour changes, turning to pale yellow and eventually becoming tinged with pink during the mature stage.

Pupa Yellow at pupation, the colour gradually changes to brown.

The codling moth or *Cydia pomonella* originated in Europe, spreading to Asia in ancient times. By 1700 they had been brought to America by colonists.

Distribution of codling moths depends on the accumulation of at least 600 degree-days during the vegetative period of the host plant.

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Low winter temperatures do not prevent diapausing larvae from overwintering, while the southern distribution limit is determined by the moths' need to spend part of the diapause period at very low temperatures.
The Codling moth is a typically carpophagous species which feeds almost exclusively on pome fruits and occasionally on walnuts (*Juglans regia*).

- Codling moth has from one to three generations each year depending on nutritional, genetic and climatic factors.

The overwintering larvae - distinguishable by their white colour - can be found mainly in cracks and crevices and under flaking tree bark.
The first pupae usually appear in Italy by the end of March. The moths usually emerge during the daytime and start to appear earlier in southern areas of Europe than in the north. Indeed, moths may be captured as early as the beginning of April in Emilia-Romagna (Italy). There's no proper synchronism between moth emergence and plant phenology, as the first moths of the season may appear even before blossoming.

- Female moths release pheromones which attract the males of the species

Virgin female moths fly to the tops of apple trees to call for their mates at dusk. They release plumes of pheromone, a semio-chemical element which stimulates intra-specific interactions. Male moths locate females by flying upwind, criss-crossing over the trails of pheromone produced by the female moths.
Most females mate within an hour of the onset of calling (emission of pheromone into the air). Then they begin to lay eggs.
Eggs are usually laid singly on or close to fruit, mainly on smooth areas like the upper surface of leaves. Eggs laid in early spring may take 20 days or more to hatch depending on the mean temperature of the period, while those laid in summer take only 7 or 8 days.
The newly hatched larvae tend to disperse randomly as they immediately begin crawling to seek fruit upon which to feed. They generally wander (for several

metres) for a period of 1-2 days. Larvae usually penetrate fruit skins in protected areas (calyx end, stem end or points of contact between fruits).

After entering the fruit, the larvae start to feed beneath the surface.
Following a spiral pattern, they pass through the first moult and then tunnel to the centre of the fruit, where they feed on the seeds.
The feeding behaviour and habits of newly hatched larvae are largely determined by temperature. In very high temperatures, the larvae enter the fruit through the calyx end and bore rapidly to the core. As larval development nears completion, the larvae eat their way out of the fruit. Mature larvae leave the fruit and construct silken cocoons in protected areas where they pupate and become adults.

Leafrollers morphological and biological features

Tortricidae family comprehend a certain numbers of polifagous species belongings to *Pandemis*, *Argyrotaenia*, *Archips*, *Adoxophyes* genus. Larvae of these insects can generate external damages on fruits consisting on tipical superficial erosion.

Genere *Pandemis* Hb

Adult Fore wings brown or red-brown (wingspan 17-20 mm). Triangular pretornal area, wide median band, and oval sub-apical spot are somewhat darker. Narrow external marginal spot goes from sub-apical spot toward back corner. Hind wings dark brown or gray-brown.
Egg Eggs are lentiform, slightly lengthened, light green. Female usually lays eggs in light green shields on the upper side of leaves.
Larva green color, depending on age.

Pandemis heparana

Genere *Argyrotaenia* Steph.

Adult Forewings variable in color, from gray to red-brown with dirty-yellow or reddish median and tornal bands (wingspan 13-14 to 16-18 mm). Hindwings brownish-gray or gray, with broad grayish fringe.
Larva Caterpillar green, shining, translucent, 12 mm in length. Head and thoracic legs yellow.
Egg Females lay 45-200 eggs by groups on the upper side of apple leaves. Each batch contains 4 to 150, with an average 30-50 eggs.

Argyrotaenia pulchellana

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Genere *Archips* Hb

Adult Forewings red-brown or lilac-brown, with strongly bent anterior and external margins; therefore, the apical angle sharp and somewhat projecting (wingspan 20-26 mm). Females larger than males.
Larva 1st instar yellow-green. Caterpillars of 5th instar with olive or dark green dorsal side and with slightly lighter ventral side.
Egg oval, light green layd by groups (batches), 50-100 eggs in a batch, on the upper surface of leaves.

Archips podanus

Genere *Adoxophyes* Meyr

Adult Wings ocher-yellow or light-brown, with a pattern of transverse and longitudinal lines; male wing with costal outfold (wingspan 15-22 mm).Female wing, less distinct; male wing has 3 highly visible main spots: a pretornal spot, median band, and subapical spot.
Larva Younger caterpillars yellow-green. Head and prothoracic scutellum black. Adult caterpillars olive green or dark green. Head, prothoracic scutellum and thoracic legs light or yellow brown.

Adoxophyes orana

Egg flat, discoid, light yellow or yellow-green. Shield-like egg-batches (80-100 eggs on average) look like yellow-green, varnished, indistinct drops 2-6 mm in diameter

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CARATTERISTICHE DEL PRODOTTO

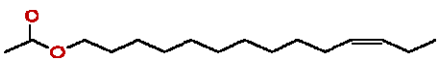
Isomate® C LR

Isomate® C plus twist-tie dispensers are supplied in vacuum packs of 400 units. Each brown-red polymer dispenser consists of two parallel tubes. The wire-filled tube is designed to ensure rigidity, while the other sealed tube is filled with pheromone. The dispensers are designed to be twisted around the branches of the trees.
In case of left-over stocks, unopened packages can easily be stored in cold storage facilities at temperatures below 10 °C (50 °F).
After cold storage, dispensers must be kept at room temperature for at least one month prior to field application.

Application rate

1000 dispensers per hectare (standard rate)*
* estimated rate which may vary according to orchard conditions

Chemical structure

 (E,E)-8,10-Dodecadien-1-ol (Codlemone)	 Dodecan-1-ol
 Tetradecan-1-ol	 (Z)-9-Tetradecenyl acetate
 (Z)-11-Tetradecenyl acetate	

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Nominal field life

Average dispenser release life is 130/150 days (**ALWAYS** depending on local daily mean temperatures and average daily wind velocity).
Early rather than late application is recommended.
Research data show that bringing the date of application of the dispenser forward by one month, only reduces the field life of the dispenser by a few days.

PLANNING AN ISOMATE® C LR IPM PROGRAMME

Aims

The aims of an IPM programme using mating disruption techniques are following:

- To prevent significant damage by Codling moth and leafrollers,
- To reduce the population of Codling moth and leafrollers or maintain very low levels,
- To build beneficial insect and mite population.

In case of **low pest population density** and if **no** migration of mated female moths from adjacent orchards occurs, the first of these aims can be easily fulfilled during the first year of implementation. The other aims can be fulfilled over a number of years (at least two) of uninterrupted application.
Once sufficient beneficial insect populations have been established, the number of applications used against secondary pests such as mites or psylla may also be reduced.

Special attention should be paid to irregular orchards in which there are numerous gaps, orchards located in windy areas and orchards surrounded by herbaceous crops which provide no protection from the wind.

Codling moth infestation assessment

Codling moth pressure in the orchard may be assessed by analysing:

1. Codling moth infestation at previous harvest

Codling moth infestation at previous harvest	Codling moth pressure
< 0.01	Very low
From 0.01 to 0.09	Low
From 0.1 to 0.4	Low to moderate
From 0.5 to 0.9	Moderate
From 1 to 4	High
From 5 to 10	Very high
> 10	Disastrous

2. Last season's monitoring trap catches (in conventionally managed orchards)

Pheromone trap counts in conventionally managed orchards (moths/trap/season)	Codling moth pressure
< 20	Very low
20-50	Low
50-100	Moderate
100-200	High
> 200	Very high

Planning an appropriate pest management programme

Codling moth pressure	ISOMATE® C LR based IPM programme	When to use this strategy
Very low to low	ISOMATE® C LR (1000/ha) One application in early spring (before the first flight of overwintering moths)	This is the standard treatment for well managed orchards with low CM pressure. All pests should be constantly monitored in the orchard.
Moderate to high	ISOMATE® C LR (1000/ha) together with a light programme using conventional insecticides	This is the programme to use when CM populations in the first year or two are too high to be able to rely exclusively on ISOMATE® C LR.
Very high	ISOMATE® C LR (1000/ha) together with a full programme using conventional insecticides	This programme has been successfully used to drastically reduce Codling moths in orchards where populations and damage levels were high despite a heavy use of insecticides.

ISOMATE® C LR – Technical notes

Choosing the proper insecticide

The use of active ingredients with low impact on "beneficial insects" is recommended.

An example of the proper use and timing of application for some of these active ingredients is reported in the following table:

Cydia pomonella		
Following AI should be applied after the threshold of 1-2 adults/trap/week has been exceeded		
Ovicides		
IGR	**Characteristics**	**Notes**
Diflubenzuron	IGRs are chitin synthesis inhibitor that prevent the N-glucisamine production essential for the chitin development in the insects cuticle.	These ovicides inhibit the development of the embryo inside the egg both in the case of direct spraying on eggs and in the case of oviposition on treated foliar surfaces. Persistence: 15-20 days.
Flufenoxuron		
Larvicides		
VIRUS	**Characteristics**	**Notes**
Codling moth Granulosis Virus (CpGV)	This biological insecticide must be ingested in order to be effective, after which the viral occlusion bodies dissolve in the larval midgut and release infectious virions. These enter the cells lining the digestive tract, where they replicate; eventually, the other tissues are infected and the larva stops feeding and eventually (within 3–7 days) dies. After death, the larva disintegrates, releasing billions of new occlusion bodies, which may infect other codling moth larvae upon ingestion.	Granulosis-based products must be applied close to egg-hatching in such a way that the virus is swallowed by newly hatched larvae
MAC	**Characteristics**	**Notes**
Tebufenozide	Insecticidal ecdysteroid agonist that cause insect larvae to moult prematurely and die (Moulting Accelerating Compound).	This insect growth regulator has no ovicide efficacy. Therefore it must be applied at the end of embryonic development or on newly hatched larvae. Persistence: 21 days.
Methoxyfenozide		
SPYINOSIN	**Characteristics**	**Notes**
Spinosad	Spinosad acts on the post-synaptic nicotinic acetylcholine (Ach) and γ-aminobutyric acid (GABA) receptors, resulting in tremors, paralysis, and death of the target insects.	The product acts principally on larvae both by contact and ingestion. It is used at the end of embryonic development or on newly hatches larvae.
AVERMECTIN	**Characteristics**	**Notes**
Emamectina benzoato	The mode of action is similar to abamectin (GABA - and glutamate-gated chloride channel agonist), Emamectin benzoate acts by stimulating the release of r-aminobutyric acid, an inhibitory neurotransmitter, thus finally activating chloride channels. The target insect stop feeding within hours of ingestion, and die 2-4 day.	It possesses larvicidal activity by contact and ingestion. The optimal application timing ranges from pre-hatching egg to larvae late stage (L_4-L_5).

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NEONICOTINOIDS	Characteristics	Notes
Thiacloprid	It disrupts the nervous system by acting as an inhibitor at nicotinic acetylcholine receptors.	Efficacy on eggs and on larvae (L1 age).
RYANODIN	**Characteristics**	**Notes**
Rynaxypyr (chlorantraniliprole)	Rynaxypyr's mode of action is activation of insect "ryanodine receptors" (RyRs), which stimulates the release of calcium from internal stores of smooth and striated muscle, causing impaired muscle regulation, paralysis, and finally death.	Rynaxypyr possesses ovi-larvicidal activity. Ovicidal activity consist in either killing the embryo or the completely developed larvae inside the egg, such that the egg membrane remains intact and the individual does not hatch. Larval mortality is caused by exposure of the neonates to the residues deposited on the outer egg surface, from ingestion of the treated egg membrane or corion, during egg hatch.
NEMATODS	**Characteristics**	**Notes**
Entomophatogenic Nemtodes (*Steinernema feltiae, S. carpocapsae*)	Entomopathogenic nematodes naturally occur in the environment as parasites of many insect larvae. These small organisms (0,4-1 mm) actively seek out their insect hosts. When a host has been located, the nematodes penetrate into the insect through body openings and release symbiotic bacteria that multiply and rapidly kills the insect in 24-72 hours.	The nematodes must be mixed with water and applied with a sprayer to the tree trunk, main branches and the soil beneath the tree preferably in correspondence of rainy weather or abundant irrigations.
NON-ESTHER PYRETHROID	**Characteristics**	**Notes**
Etofenprox	Etofenprox acts on the nervous system of insects disturbing the function of neurons by interaction with the sodium channel.	It has insecticide activity by contact and ingestion, has a broad spectrum of action on a wide variety of pests, with fast knockdown
ORGANOFOSFORICI	**Characteristics**	**Notes**
Chlorpyrifos etile	Organophosphates interfere with acetylcholine-mediated synaptic transmission in the nervous systems inhibiting the enzyme acetylcholinesterase (AChE) resulting in acute cholinergic over-stimulation at nicotinic and muscarinic synapses of the peripheral, autonomic and central nervous systems.	Organophosphates must be applied at the end of embryonic development or on newly hatched larvae. Some of these products are able to destroy larvae even in the first subepidermal strata of the fruit
Chlorpyrifos metile		
Phosmet		

N.B.: In the application of various products, carefully follow the instructions and warnings on the label provided by the manufacturers.
Some a.i. may not be authorized in some IPM programs, therefore refer to local IPM Gudelines

In the case of Leafrollers, bear in mind that a lot of species overwinters as larvae so it is important to accurately evaluate previous year population in order to plan a insecticide spray on spring time if needed.
On larvae mating disruption has NO efficacy.

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Side-effects of some pesticides on natural enemies

IOBCwprs Working Group "Pesticides and Beneficial Organisms & IOBCwprs Commission "IP Guidelines and Endorsement" (05.12.2005 Comm.)	**Tipo**	**Classificazione degli effetti collaterali sugli organismi utili** **N** = innocuo o leggermente tossico (Riduzione campo, semi-campo 0-50%, lab 0-30%) **M** = moderatamente tossico (Riduzione campo, semi-campo 50-75%, lab 30-79%) **T** = tossico (Riduzione campo, semi-campo > 75%, lab >80%) Dati in corsivo = dati di laboratorio (IOBC) **Dati in grassetto** = dati di semi-campo (IOBC) Dati con asterisco ***** = Test di campo (IOBC)															
Principi attivi	I = Insetticida A = Acaricida	Acari predatori (*Typhlodromus pyri*)	Acari predatori (*Phytoseiulus persimilis*)	Ragni (*Pardosa spp.*)	Ragni (*Cheiracanthium mildei*)	Antocoridi (*Anthocoris nemoralis*)	Antocoridi (*Orius laevigatus*)	Crisope (*Chrysoperla carnea*)	Coccinellidi (*Coccinella 7-punctata*)	Stafilinidi (*Aleochara bilineata*)	Carabidi (*Poecilus cupreus*)	Parassitoidi (*Aphidius rhopalosiphi*)	Parassitoidi (*Trichogramma cacoeciae*)	Sirfidi (*Syrphus corollae*)	Tossicità per le api	Tossicità per i lombrichi (*Eisenia foetida*)	Tossicità per i pesci
Azadiractina	I	N	T			T	N	M	N		**N**	**M**	T	M	-		
BT var. kurstaki	I	N*	**N**			M		**N**	**N**	**N**	N		N		-		-
Buprofezin	I	N	**N**		N	N		N	**N**	N			N		-		+
Chlorpyrifos-ethyl	I	T	**T**	T	T	M		**T**	**M**	**T**			T	T	+	+	+
Chlorpyrifos-methyl	I	M-T				M		**T**	**N**				T		+		+
Diflubenzuron (IGR)	I	N*	**N**		T	N	M	**T**	**N-M**	N			N		-	-	-
Fenoxycarb (IGR)	I	N*	**N**		N	N*	M	**M**	**N**	**N**		**M**	N		+		+
Flufenoxuron (IGR)	I	N*	N			M		M*		T	N						
Granulosis-Virus	I	Metodo di controllo selettivo senza effetti nocivi sugli organismi utili															
Imidacloprid	I	N*	T			T	**T**	**M**	T		N	T	T		+	(-)	(-)
Indoxacarb	I	N				M		N	M	N			M	N	-	-	+
Lufenuron	I	N*	**N**			N	**M**	**T**	**T**			M	M		-		-
Methoxyfenozide (IGR)	I	N				N		**N**					N		-		-
Phosmet	I	T*	**T**					N*	**M**	**N**			T				
Pirimicarb	I	N				N		N	N				M	M	-	-	-
Rotenone	I	M				M		M					M		-		+
Spinosad	I	N*	N				N	N	N				M		+		-
Tebufenozide (IGR)	I	N*	N			N	**N**	**N**	**N**		N	N	N		-		
Teflubenzuron (IGR)	I	N				N		N	T				N	N	-		-
Thiacloprid	I	N		M					T	N	M	T			-		+
Triflumuron	I							T*							-		
Abamectina	A	N-T	**T**				**T**	**N**	**N**			T	T		+		+
Clofentezine	A	N*	**N**		N	N*		N	**N**	**N**			N	N	-		-
Etoxazolo	A	M						M					N		-		+
Exitiazox	A	N*	**N**		N	N*		N	**N**	**N**			N		-		-
Fenazaquin	A	M				M									-		+
Fenpiroximate	A	N-M	T			N-M	**N**	N	T	N	N	T	M		-		+
Spricodiclofen	A	N-M				M		**N**	**M**				N	N	+		-
Tebufenpyrad	A	M*	T			T	**N**	N	**N**		N	T	T	M	-		+

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TIMING AND METHOD OF APPLICATION OF ISOMATE® C LR IN ORCHARDS

Timing of application

Isomate® C LR dispensers **must** be applied in spring before the first Codling moth flight (biofix or first catch in monitoring traps). Early application is to be preferred as the amount of pheromone released by dispensers is sufficient to remain effective for the entire season and it is very important to control the first moths emerging in the orchard.
Depending on the dispenser specifications, a delay in application does not necessarily defer termination of the release of the active ingredient.
Research data show that bringing the date of implementation of the dispenser forward by one month, only reduces the field life of the dispenser by a few days.

Location of dispensers

Dispensers should be placed within half a metre of tree tops.

Application rate

1000 dispenser/ha (tipico)*
* indicativo e variabile in funzione della situazione del frutteto

Control of application programme

In order to establish the application scheme it is important:

1) To know the overall surface of the orchard in such a way as to be able to assess the total number of dispensers required. Once the number has been calculated, a further 5% should be added (according to the size of the orchard) for additional applications in border rows.

2) To know the total number of plants per hectare (calculated on the basis of plant spacing).

3) To apply dispensers uniformly throughout the entire orchard according to the recommended application rate.

4) To apply one dispenser per each of the first three trees of the orchard and each of the trees in the first two border rows (in areas with prevailing winds from a

particular direction, supplementary dispensers need only be placed on leeward borders).

5) To place dispensers according to the application diagram without reducing application rate. Any left-over dispensers should be used in hot spots of the orchard and windy areas (edges, high spots) in which pheromone concentration may be reduced. Download our dosage calculation software from www.cbceurope.it/biocontrol

Method of application

Isomate® C LR dispensers must be applied on lateral branches without twisting them too tightly.

Avoid applying dispensers as shown in following pictures

IN-SEASON MONITORING OF ORCHARDS

If fruit damage at harvest in the previous season stood at 1% or more, the orchard in question should be carefully monitored during the early season.
Indeed, only by careful monitoring of the orchard during the season in progress is it possible to assess whether the mating disruption technique is functioning properly.
Border rows and potential hot spots - i.e. areas in which high codling moth infestation levels were recorded during previous years - should be scouted regularly.

At least 1,000 fruits per hectare should be checked for damage. Sample fruit should be chosen from the central area of the orchard and from the leeward borders. If fruit damage exceeds the established thresholds, supplemental treatments may be needed. Scouting should take place frequently, especially during the period of larval development of each codling moth generation.

Timing of intervention	Damaged fruits/1000
June	3
July	5
August	8

Carefully verify orchards Leafroller infestations and apply additional insecticide spray when these exceed IPM threshold in order to lower the population:

Pandemis e *Archips*
- Overwintering generation
Over 10 % of organs with larvae
- Following generations
Over 5 % of organs with larvae

Eulia
Over 5 % of organs with larvae.

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