Field observations about the behaviour of codling-moth in Trentino (North-Eastern Italy)

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Abstract

Codling-moth and applescab are the most important pathogens in both conventional and organic apple productions. In order to control any phytopathological problem, it is important to improve the knowledge of the behaviour of each specific pest. Since several years (starting from 1986) we are improving in Trentino (North-Eastern Italy) the observations of the population dynamics of codling-moth in order to find the best way to control and treat this pest insect.

Constant monitoring and the knowledge of the characteristics of the different compounds and possible methods to control the codling-moth (mating disruption, granulose virus and specific nematodes) represent the most important basis to organize an effective control-strategy.

Keywords: codling moth, behavioural observations

Introduction

A very accurate study, conducted in the apple production area of Adige Valley (Trentino) between 1986 – 2007, allowed us to develop from the codling-moth behaviour a simple program that, correlating the key phases of the development of the insect to the thermal sum starting from the beginning of January (daily mean of the temperatures above 10 degrees, measured hour by hour), permits to organize the monitoring and the management of this insect (Fig. 1).

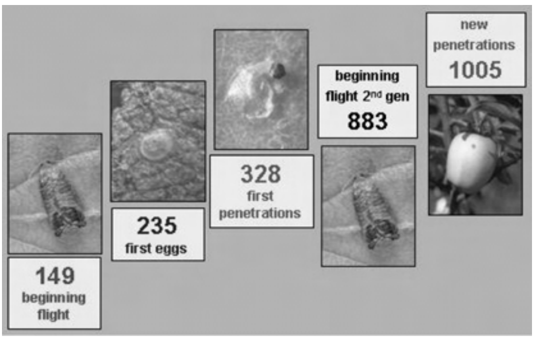

Figure1: Development of codling-moth on the basis of the day degrees (mean of the years 1986 – 2007)

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As an example, the development of populations of the ’90, of the beginning of 2000 and of the year 2006 are reported. These dynamics point out that the calender date can change from one year to the other, but the day degrees remain similar (Table 1).

Table 1: Development of codling-moth according to the date and to the day degrees in different years

	Beginning of the flight	First eggs	First penetrations	New penetrations (2nd generation)
	Observation date of the different developmental stages of the codling-moth			
Year 1991	17/5	4/6	14/6	7/8
Year 2001	30/4	14/5	24/5	30/7
Year 2006	2/5	17/5	27/5	24/7
	Day degrees of the different developmental stages of the codling-moth			
Mean 1986 - 2006	**149**	**235**	**327**	**1000**
Year 1991	151	273	358	1016
Year 2001	143	245	322	1091
Year 2006	142	238	329	1052

To augment the information, we report some observations on the codling-moth development in our environments. We are convinced that getting familiar with the development stages of the insect can help to improve its management.
Knowledge, indeed, can help technicians, researchers and growers in the control and management of any pest, not only in practical, but also from a psychological point of view.

Material and Methods

Since 1986 we starded to observe the development of codling moth by monitoring in the same orchard flight (with pheromone-traps), oviposition-dynamic (number of eggs/hour) and penetrations (on 1000 apple and/or 10 trees). For every codling moth stage we improve the observations in order to find the best way to describe biology and practical informations.

Monitoring of the codling-moth flight

The monitoring of the flight might be one of the easiest methods to apply in practice. Unfortunately, in the evaluation of the population it is generally not very useful compared to the visual observation. There are indeed no strict and reliable relationships between catches in traps, population density and damage on the fruit. According to our experiences, it is important to know the beginning of the activity (first point of the development program). The rest is often not very precise. During all these years, we found differences between the captures in the terminal parts of the tree (usually the higher parts) and captures in the lower partss, even though the dynamics look similar when the flight is abundant (Table 2).

Table 2: total monthly captures in 1986 referring to the same plot with traps located in the highest and the lowest parts of the plants.

MONTH	MONTHLY CAPTURES IN THE HIGHER PARTS	MONTHLY CAPTURES IN THE LOWER PARTS
APRIL 1986	5	3
MAY 1986	89	57
JUNE 1986	92	76
JULY 1986	137	102
AUGUST 1986	87	61
SEPTEMBER 1986	6	4

Confirming the poor reliability of traps, figure 2 shows the flight course in the same zone in a hotspot and in a "normal" situation. It is clear that there is no relation between the level of the flight and the infestation pressure of the pest: in the hotspot, the damage at the end of the season was 20%, while in the "normal" situation, at harvest, there was no damage.

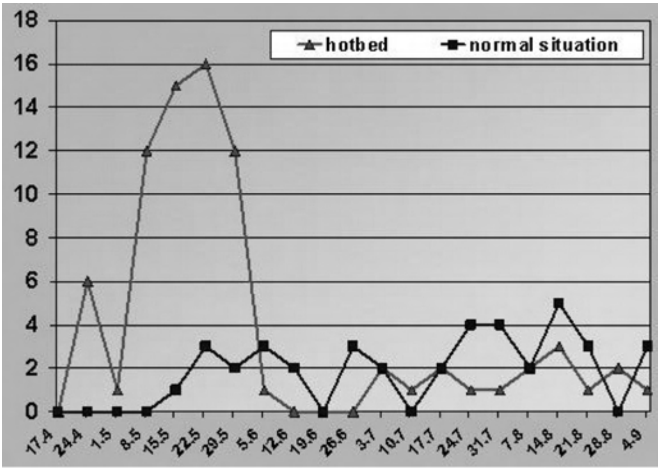

Figure 2: Flight in 2003 in a hotspot and in a normal situation (weekly captures)

Oviposition

The oviposition dynamics, monitored in an untreated plot, can give fundamental indications for codling-moth management in any other zone. Figure 3 illustrates an example of the year 2006, where the flight is correlated to the oviposition.

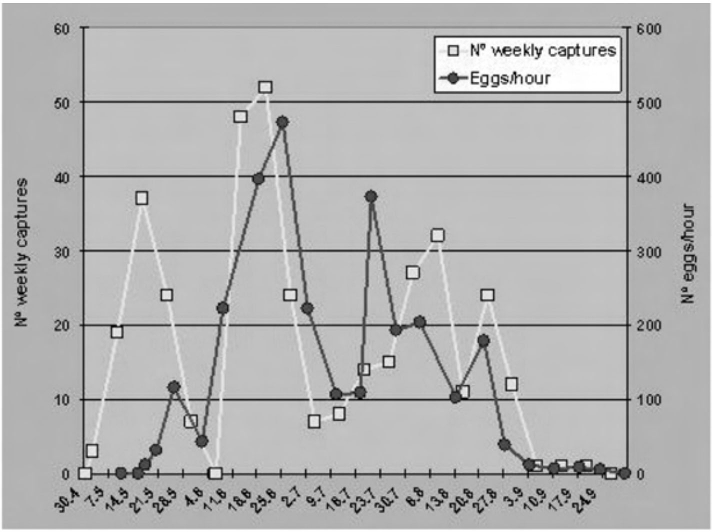

Figure 3: Captures and oviposition of codling-moth in Adige valley in 2006

Further observations on oviposition, conducted during several years are presented in the figure below. For the monitoring of the egg development (Graph 4), the different stages have been distinguished as fresh egg, red band and black head (the latter stage being very short and therefore hardly recognizable in the field).

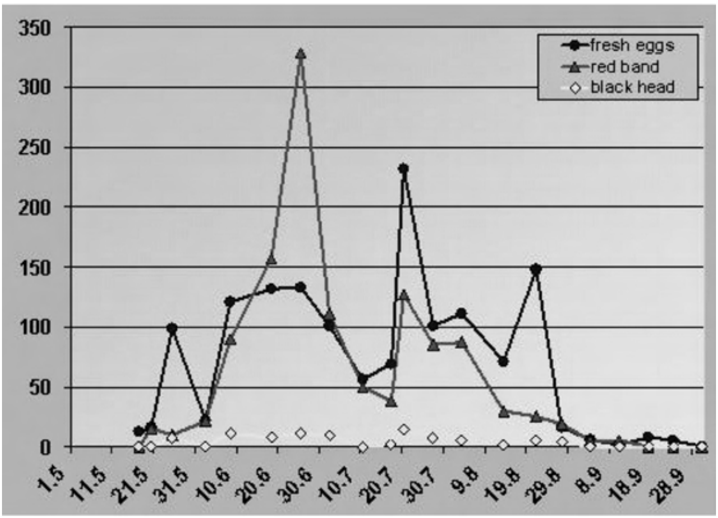

Figure 4: Development of the codling-moth eggs in Adige valley in 2006 (control eggs/hour)

During the whole season the eggs are laid on both leaves and fruits (figure 5); the oviposition on leaves takes places on both the upper and the lower side (figure 6).

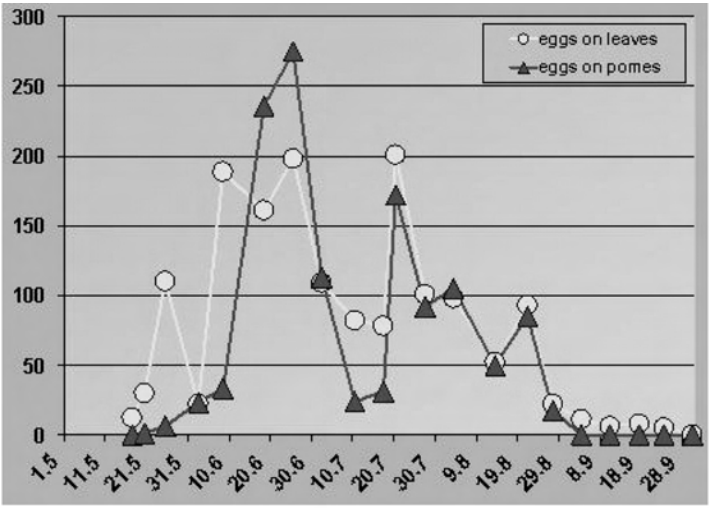

Figure 5: Codling-moth oviposition on leave and fruits in Adige valley in 2006 (control eggs/hour)

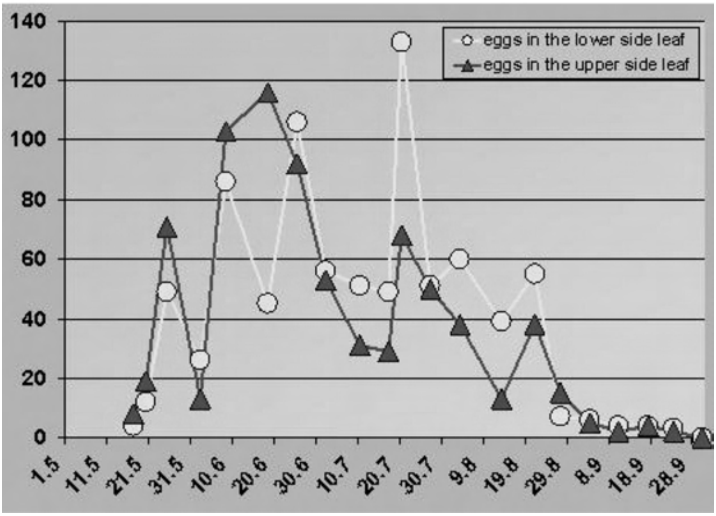

Figure 6: Codling-moth oviposition on the lower and upper sides of the leaves in Adige valley in 2006 (control eggs/hour)

The main part of the eggs is located not more than 10 cm away from the fruit (Table 3).

Table 3: Distance of codling-moth eggs from the fruit on Golden Delicious (September 15th 2005 – Adige valley – 99 apples)

	0 – 10 cm from the pome	**10 – 20 cm from the pome**	**> 20 cm from the pome**
Rosette	**14**		
Leaves of the shoot	**60**	**28**	**8**
Pome	**7**		
Pedicel	**1**		
Branch	**0**	**7**	**0**

In July 2005, during an intensive egg laying activity in the second generation, the observation of the egg distribution were related to the different height levels in the plants (3 Sansa/M9 trees planted in 2002). A similar amount of eggs was found on all levels: ground level – 1,2 m - 58 eggs, intermediate levels (1,2 – 1,8 m - 83 eggs) and highest levels (>1,8 m - 82 eggs).

Larval penetrations

On different varieties, in both the first and the second generations, observations were conducted in order to verify the position of the fruit penetrations. In the first generation 75.5% of the larvae penetrates the apple from the side, 20.2% from the calyx end and 4.3% from the stem cavity. The percentages for the second generation are quite similar: 81.4% from the sides, 14.5% calyx end and 4.1% stem cavity.

The same trees, on which the egg distribution was controlled, were then used to estimate the damage distribution. The results, reported in Table 4, point out that the per cent damage is lower in the intermediate level (1,2 – 1,8 m), even though the amount of the controlled fruits was double.

Table 4: Distribution of the codling-moth damage related to the location of the fruit in the tree (3 Sansa trees grafted on M9 – August 9th 2005)

	N° controlled apples	**N° damaged apples**	**% damaged apples**
height < 1,2 m	140	60	42,8
1,2 m < height < 1,8 m	270	68	25,2
height > 1,8 m	110	46	41,8

Some general remarks must be made about the characteristic hotspot distribution of codling-moth presence and damage. The damage is very often found every year in the same areas of the plot and often on the same trees, at least until the plantation is eradicated. Eradication usually eliminates hotspots, at least for a certain period, indicating that overwintering takes place more on the trees than on the ground.

The need of untreated control plots obliges to change area every year, otherwise a hotspot develops that can create, as time goes by, a potential local damage. This demonstrates that the insect, if not forced, does not move around.

Damage evaluation

When evaluating the damage, it is important to consider, together with the possibility of a localised distribution of the codling-moth, also the fruit load. In the same season, the smaller is the amount of apples on the tree, the higher is the risk of a high per cent damage. The evaluation of the population refers indeed not to a standard number of fruit checked, but rather to the actual control of the production. In 2005, by checking each fruit on 10 light fruit-loaded and 10 heavy fruit-loaded trees in the same plot, the per cent damage was 57.6 and 30.2%, respectively; however, the actual population amounted to 405 apples with codling-moth out of 703 total fruits on the light fruit-loaded and 851 out of 2819 on the heavy fruit-loaded trees. Therefore, contrary to the mathematic interpretation of the percentages of infestation, the real population was more than the double on the heavy fruit-loaded.

Remarks for the practice

This study may suggest some advice important for the practice:

- This simple model that describes the dynamics based on the day degrees (figure 1) is a useful tool for the field indications and a very precise reference in both conditions of normal populations and hotspots.
- It is possible to organize the protection strategies according to this simple model, especially during the first generation, on the basis of the population development (expressed as day degrees), of the inspections in the field and of the characteristics of the chemical compounds and the available methods. Anyway, these indications have to be used as a suggestion to apply and to adapt to the specific situations, and not as rules of absolute value.
- The inspection of the distribution of the eggs on plants, which showed a homogeneous presence from the bottom to the top of the tree and a high concentration even on the lower side of the leafs, corroborates the need to garanty the most effective coverage of the crop.
- The damage is always found in hotspots: starting from the same tree to plants in the same plot with a different fruit load (it is more concentrated where the production is more reduced). This distribution within the same plot depends, besides the fruit load, also on the history of the codling-moth presence: it shows indeed the tendency to be localised always in the same area and, often, on the same trees. Observations repeated during several seasons show that codling-moth does not move around very much.
- These findings are important for the field inspections, which can be done, initially, only in the hotspots and then extended also to the rest of the plot.
- Pay attention to the evaluation of the threshold in any period: 1% at harvest means something different in a season with unloaded trees or in a productive season. In the latter case the population is definitely different and this should be considered when organizing an adequate management strategy for the following season.

Protection strategy organization

First of all, it must be underlined that the experiences reported here refer to valley bottom environments in Trentino and, therefore, before being used in different areas, they have to be tested under these conditions.

Codling-moth protection tries to synthesize knowledge, field inspection of the development dynamic and damage situation and the characteristics of the available control means.

The organization of the protection measures should first take in consideration the result of the inspection done at the previous year harvest. In the reference situations it is possible to suggest and apply these conditions:

- the lower the levels of infestation (0 – 0,2%) the better the protection strategy adopted worked and should work also in the following season,
- if the damage is around 0,3 – 0,5%, then the result is good, but attention should be paid in the following season, because under favourable conditions, the population might require additional treatments,
- a final damage around 1% is an acceptable result, but it is likely that additional treatments are required in the following season,
- a damage at harvest over 1% cannot be changed in the present season, but any case the first generation needs to be completely managed in the next year.

Codling-moth control

The following scheme allows to adapt the management of the first generation, if necessary, to the characteristics of the available means of control. When the mating disruption strategy is used, it is advisable to apply the dispensers around 100 day degrees, because they must be exposed before the beginning of the flight; at 120 – 130 day degrees. Traps should be placed in both the areas under mating disruption and the traditional ones. Around 330 day degrees, coinciding with the beginning of penetrations, treatments with granulosis viruses should be started, especially in the hotspots. In low CM pressure conditions, before starting the interventions, the actual presence of the very first penetrations should be verified by inspections.

The following interventions, feasible with a 5-10 days delay depending on the doses, are organised on the basis of constant inspections, of indications about the population development and of the climatic course.

The result of the population management is evaluated at the end of the first generation (around half-July in the considered areas): if there is no damage, inspections will go on, treatments will be suspended until the next observation and it will be evaluated if the mating disruption by itself can manage the situation. With damages or in historical hotspots the treatments with viruses will go on and will be managed according to the parameters mentioned above (result of the inspections, development of the population, climatic trend).

In fall, in expectation of rain or with the over-canopy irrigation, with high populations, the use of nematodes specific for codling-moth larvae (*Steiernema carpocapsae*) might give good results. Preliminary tests conducted in Italy point to a decreases of 50-90% in the overwintering population. At the moment, our experiences are not sufficient to make a secure statement

Conclusions

This note represents the synthesis of a work lasting for many years. It tries to underline the importance to value each experience, from the simplest field observation to the most elaborated laboratory experiment. The aim of this approach is the management of a problem that is one of the most worrying in the field of plant protection. In many situations a big limit was clinched in this management, which shows the chance to apply only the virus as control mean, even if it can use also the mating disruption.

The repeated use of the same approach led to the segregation of resistant populations (regarding the virus, resistance has been reported in Germany and Switzerland) and, concerning this, also organic farming is a weak and risky system that would need other control strategies.

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