Persistence of the biological effect of codling moth granulovirus in the orchard - preliminary field trials

Dauer der biologischen Wirksamkeit des Apfelwicklergranulovirus in Feldversuchen

Jutta Kienzle[1]; Christof Schulz[1]; Claus P.W. Zebitz[1]; Juerg Huber[2]

Abstract

In 2000 and 2001, in a field trial, the persistence of the biological effect of codling moth granulovirus (CpGV) was investigated. With a single treatment at full concentration of CpGV (MADEX 3, 100 ml/ha) a considerable reduction of CM population was achieved over the whole vegetation period. This may indicate, that over a considerable period of time after a treatment a biological effect of CpGV sufficient for an increased mortality of the larvae was present in the orchard. However, the onset of mortality was not fast enough to protect the fruit from damage. Further research has to be done to gain more experience in handling this effect. It could be very important for the reduction of the number of treatments in organic apple growing.

Keywords

Codling moth, Codling moth granulovirus, persistence

Introduction

Codling moth granulovirus (CpGV) is widely used in organic fruit growing in Germany with good results. The common strategy was to add CpGV to each fungicide treatment. Thus, the frequent treatments usually considered as inevitable in strategies with CpGV were ensured. In the last years, however, new products as potassium soap (for sooty blotch control) or lime sulphur are commonly used during the hatching period of the codling moth (CM) larvae. These products should not be applied in tank mix with CpGV since the high pH is considered to destroy the biological activity of the virus. Thus, to avoid additional applications, the common strategy for the use of CpGV in organic fruit growing should change to a reduced number of treatments for CM control.

It is well known, that for a high efficacy in the protection of the fruit from damage downgrading its market quality a high number of treatments with CpGV is necessary. A lower efficacy in fruit protection and, therefore, a lower number of treatments, can be tolerated only if the CM population and, thus, the infestation potential of CM is very low. For these reasons, the main interest of this study was directed towards the efficacy of the virus in CM population control – which means on a long term also damage control.

In this context, the question of the persistence of the biological effect of CpGV in the orchard was raised. In the past, the effect of CpGV was assessed as reduction of damage, i.e. mortality of larvae before they could damage the fruit to a degree that its market quality was downgraded.

1) *University of Hohenheim, Institute for Phytomedicine, D-70593 Stuttgart*
2) *Institute for Biological Control, BBA, Heinrichstr. 243, D-64287 Darmstadt*

For our purpose, the interest was directed towards control of CM population, i.e. the total mortality of the larva also at later larval instars.
Since observations in the field suggested a rather persistent effect of CpGV applications in population control, in 2000 and 2001 field trials were realized.

Material and Methods

The experimental orchards of 0,3-0,4 ha were located at the research station for horticulture of the University of Hohenheim. In 2000, the experiment took place in an orchard with the variety "Elstar" on M9 planted in 1986 with vigorous trees and low yield. In 2001, another orchard with the variety "Rubinette" on M9 planted in 1994 was used. These trees were smaller and less vigorous but with a very high yield.
In both experiments, the orchard was divided into two equal parts with an untreated buffer zone of 20 m. One part was treated with CpGV in full concentration (MADEX 3, Andermatt Biocontrol, 100 ml/ha) at May 23, 2000 and at May, 30, 2001, resp. The second part served as untreated control. After this, the whole orchard remained without any insecticide treatment until the end of the season. At June, 27, 2001 there was a strong damage by hail in the orchard.
Fruit damage by CM was assessed several times during both years (approx. 1000 fruits per sampling date and plot). Since the trees were also provided with trap bands for the assessment of the survival of the larvae, the fruits remained on the trees and were not opened. Thus, only deep entries and superficial stings could be discriminated. At harvest, several trees were completely harvested (including fallen fruits) and more than 2000 fruits per plot were checked. Harvest assessment was done at September 9, in 2000 and September 15, in 2001. The fruits were split open to identify „stopped damage" also if the entry was deeper. „Stopped damage" means, that the entry did not reach the seed cavity, i.e. the larva did not complete its development in the fruit. In 2001, due to the hail damage, superficial stings and "stopped damage" could not be distinguished with certainity. Thus, for 2001, the data for "stopped damage" are not given.
Corrugated cardboard belts were fixed around the trunks of the trees and assessed in regular intervals (100-50 trees per plot). Thus, the effect of the single treatment on the diapausing larvae could be observed from interval to interval. The belts were fixed in 2000 at the end of June and checked at July 26, August 3, August 23 and September 9, 2000. In 2001, the first fixation of the belts took place also at the end of June. They were checked at July 31, August 16, August 29 and September 27, 2001.
The probable hatching period of the larvae found in each interval in the belts was calculated using sum of degree-days >8,1 °C (Welte, personal communication). For completion of larval and pupal development 100 degree-days each were assumed.
Statistical analysis of the data (trap belts) was done by χ^2 2x2 contingency tables.

Results

In 2000, at Hohenheim, the CM flight started during the first decade of May. Nevertheless, first injured fruits could not be found until the last days of June, i.e. four weeks after the treatment. At the assessment of the 5th of July, there was a slight difference in injured fruits between the treated and the untreated part. In the treated part there were also some „stings" on the fruits.

At harvest, fruit damage was almost equal in the treated part (29.5 %) as in the untreated control (28.4 %). The number of fruits with „stopped damage“, however, was (not significantly) higher in the treated part (17.4 %) than in the untreated part (12.8 %). In 2001, the CM flight started at the end of May. The assessments in summer due to the strong hail damage did not give reliable results. The first important hatching period, however, could be observed in the second decade of July. At harvest, the fruit damage with entries that reached the seed cavity or contained living larvae was 1.9 % of the fruits (3.9 injured apples per tree) in the control, in the CpGV plot it was 1.1 % of the fruits (2.7 injured apples per tree). „Stopped damage“ could not be detected.

Table 1: Effect of CpGV on the diapausing larvae and probable hatching period (in days after treatment) of the corresponding larvae from the egg

Sampling date		Hatching period of the larvae (DAT)		Reduction of population in %	
2000	2001	2000	2001	2000	2001
26.7.	31.7.	38-48	42-54	64.2	75.1
3.8.	16.8.	49-60	55-68	74.2	84.2
23.8.	29.8.	61-83	69-81	67.8	64.9
23.9.	27.9.	84-97	82-91	46.4	20.3

At each sampling date of the corrugated cardboard belts, in 2000, a distinct reduction of the number of larvae in the CpGV treated plot could be observed (Table 1). The reduction was highly significant (α = 0.01) at all dates with the exception of 23.9. where the difference was only significant (α = 0.05). In 2001, at the first date the reduction of population in % is rather high. However, due to the late start of the infestation in 2001, the number of larvae was too low to allow a significant statistical difference. At the next two sampling dates, in 2001, the reduction of the number of larvae in the treated plot was highly significant. At 27.9., data of both plots were similar.

Discussion

The reduction of CM population over a period of more than two month by a single treatment with CpGV in May suggests, that over a considerable period of time after the treatment a biological effect of CpGV sufficient for an increased mortality of the larvae was present in the orchard. In both years, at the last sampling date, the effect faded off. The higher decline in 2001 may be due to the different fruit load and vigorousity of the trees. The variety “Rubinette” used in 2001 had numerous fruit clusters which had no contact with the leafs and were exposed much more to sunshine than it was the case for “Elstar” in 2000.

Since the fruit damage in 2000 in both plots was similar, it can be excluded that the reduced population in late summer is simply due to the effect of CpGV on the first generation or to a difference in fruit attack. With regard to the small size of the plots, this was also not to be expected. In 2001, the “stopped damage” could not be assessed due to the hail lesions on the fruits. However, it is presumable that the fruit damage which included the seed cavity was higher in the untreated plot because a higher part of the damage in the treated plot was “stopped” as observed in 2000. Therefore it is evident that the larvae did not die fast enough to

prevent fruit damage. Nevertheless, there was an significant reduction of the population for the following generation by the single CpGV treatment.
It is well known that most of the CpGV applied with a treatment is inactivated rather quickly by UV-irradiation with a half life of about two days (Huber, 1980). Thus, frequent treatments are believed to be inevitable for CpGV. However, Huber (1980) and Glen & Payne (1984) observed also, that a small part of the CpGV persists for much longer time in the orchard. Laboratory findings of Huber & Luedcke (1996) indicate that the UV-inactivation of CpGV curve is bi-shaped. This means, that most of the CpGV is inactivated very fast (about 99 %), a small part, however, is subjected to a much lower inactivation.
For a common product, 1 % of the normal dose would be totally ineffective. For CpGV, however, the low slope of the dose-effect-curve must be considered. Since with 1/10 of the normal concentration also rather good effects in damage control can be achieved, it seems realistic, that 1/100 of this concentration (1 % of the CpGV applied) could be enough to cause a considerable but slow larval mortality – as observed in this experiment.
These findings can be important for a strategy with a reduced number of treatments in the organic orchards: In situations where the treatments are focussed mainly on control of the population of the first generation (i.e. in May and June), it should be possible to reduce the number of treatments considerably, accepting intervals between the treatments that are much longer than the “seven sunny days” usually recommended. Reduced number of treatments can also be used if GpGV is applied in combination with mating disruption with the aim to keep the CM population at a level where the latter method can give good fruit damage control.
First experiences in practice with the use of a high dose at the first important hatching period of CM larvae and long intervals between the following treatments in early summer indicate that such strategies maybe successful. Nevertheless, more experience must be gained before safe recommendations can be given to the growers. In this context not only the short success of the strategy in one year but the long term development of CM population subjected to such strategies must be observed.

Acknowledgements

We wish to thank the Volkswagen-Stiftung, Hannover, for funding of the project (II/74 037).

Literature Cited

Glen, D.M. & Payne, C.C. 1984: Production and field evaluation of codling moth granulosis virus for control of *Cydia pomonella* in the United Kingdom. Ann. Appl. Biol. **104**: 87-98.

Huber, J. 1980: Field persistence of the codling moth granulosis virus. IOBC/WPRS Bull.**3**: 58-59.

Huber, J. & Luedcke, C. 1996: UV-Inactivation of baculoviruses: the bisegmented survival curve. IOBC/WPRS Bull. **19**: 253-256.