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

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Abstract
In 2000 and 2001, in a field trial, the persistence of the biological effect of coding 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 bloom 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 reduc-

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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 slings* 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 CGV plot it was 1.1 % of the fruits (2.7 injured apples per tree). Stopped damage* could not be determined.

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

<table>
<thead>
<tr>
<th>Sampling date</th>
<th>Hatching period of the larvae (D AT)</th>
<th>Reduction of population in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.7</td>
<td>31.7</td>
<td>38-46</td>
</tr>
<tr>
<td>3.8</td>
<td>16.8</td>
<td>49-60</td>
</tr>
<tr>
<td>23.8</td>
<td>29.8</td>
<td>61-83</td>
</tr>
<tr>
<td>23.9</td>
<td>27.9</td>
<td>84-97</td>
</tr>
</tbody>
</table>

At each sampling date of the corrugated cardboard belts, in 2000, a distinct reduction of the number of larvae in the CGV treated plot could be observed (Table 1). The reduction was highly significant ($\alpha = 0.01$) at all dates with the exception of 29.8, where the difference was only significant ($\alpha = 0.05$). 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 CGV in May suggests, that over a considerable period of time after the treatment a biological effect of CGV 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 vigour of the trees. The variety "Rubine" used in 2001 had numerous fruit clusters which had no contact with the leaves and were exposed much more to sunshine than was the case for "Elstar" in 2000.

Since the fruit damage in 2000 in both plots was similar, it can be concluded that the reduced population in late summer is simply due to the effect of CpGV on the first generation of or the 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 exposure on the fruits. However, it is presumable that the fruit damage which included the seed cavity was higher in the untreated plots 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 a 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 & Udejije (1996) indicate that the UV-irradiation 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 CpGV 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 may be 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 populations subject to such strategies must be observed.

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Literature Cited

