Field tests with Madex Plus against CpGV-resistant codling moth populations in organic orchards in 2006

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Abstract

When resistance to the Mexican isolate of Cydia pomonella *Granulovirus (CpGV-M) arose in several organic orchards in Germany in 2004 and 2005, the future of codling moth control became a serious concern of organic fruit growing. In 2006, a new virus isolate from Andermatt Biocontrol AG (Madex Plus) was first tested in two field trials in organic orchards on codling moth populations resistant against the Mexican isolate of CpGV. Madex Plus showed a better efficacy on these populations than Madex 3. However, larval mortality larvae seemed to be somewhat delayed. A very good effect was shown in population control. The number of larvae in corrugated card board belts was significantly reduced after treatment with Madex Plus. In addition to these trials, on-farm trials in all orchards concerned of the CpGV-M resistance were carried out. The results of on-farm trials showed the same tendency: high efficacy in population control against a background of slightly delayed larval death. In 2007, Madex Plus was applied successfully in all organic orchards with CpGV-M-resistant codling moth populations in Germany.*

Keywords: Codling moth, granulovirus, resistance, Madex Plus

Introduction

In the year 2004, in Germany for the first time populations of the codling moth (CM) *Cydia pomonella* L. with resistance to the Mexican isolate of *Cydia pomonella* Granulovirus (CpGV-M) were found (Fritsch et al., 2005). Since then, this kind of resistance has been demonstrated in about 20 orchards. The fruit growers concerned had to accept high damage since there were no effective alternative strategies and the populations already reached very high levels and were quite impossible to manage. In response to this situation, Andermatt Biocontrol developed Madex Plus containing a new isolate of CpGV which could overcome resistance in laboratory tests. The German growers with resistant populations organized on-farm trials to gain as many results with Madex Plus as quickly as possible. Furthermore, in two orchards field trials were carried out in 2006. Due to the results obtained in these trials, in 2007 an approval by the Federal Office of Consumer Protection and Food Safety (Plant Protection Act, article 11.2: Risk of delay) for the use of Madex Plus in organic orchards with resistant populations were given. The results and the experiences from the season in 2007 are part of the discussion.

Material and Methods

Each of the two field trials was submitted to three treatments: Madex Plus, Madex 3 and untreated control. In the orchard BW-FN (internal code to keep anonymous) the applications were carried out with the farmer's spraying equipment. Thus, due to drifting problems the plots had to be large and repeats were not possible. In the orchard BW-HI (internal code to keep plot anonymous) applications were made with a motorized knapsack-sprayer until runoff. Since even here for drifting problems 4 repeats were not possible and a randomly distributed block design with two repeats has been set up.

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In the orchard BW-FN the applications were done on 9.6., 16.6., 23.6., 30.6., 12.7., 19.7., 26.7., 1.8., 10.8., 16.8. and on 25.8.06, each with 50 ml/ha and m tree height of the CpGV-products. Orchard BW-HI was treated over the whole season at weekly intervals with 50 ml/ha and m tree height of the CpGV-products. For on-farm trials, growers were instructed to apply 50 ml Madex Plus/ha/m tree height at intervals of 7 “sunny days”, whereby each day with clouds or rain was calculated as a half-“sunny day”. The whole orchard was treated, except for a section of 20 trees in in each of 6 adjacent rows at one end of the orchard which served as the untreated control.

Assessments were based on 10 or more marked trees per plot. At BW-FN, 1,000 randomly selected fruits per row were assessed at each time-point for the presence of codling moth larvae, whereby a new row was used each time so that all larval instars could be monitored. Infestations were scored as “stopped damage” (gallery without larva or with dead larva) and “active damage” (living larva or signs that larva had emerged from the fruit and completed its development). Corrugated cardboard belts (30 cm wide) were wrapped around the trunks of representative trees to monitor survival of larvae for overwintering. The belts were applied before the descending of first larvae in June and removed after harvest at the end of September.

Results

In the field trial on population BW-HI, only Madex Plus gave a significant reduction of the active CM infestation whereas on the population BW-FN, also Madex 3 showed a certain efficacy on fruit infestation (fig. 1). It was striking that in the Madex Plus plots, hardly no larvae shortly before emergence from fruit were found. The assessment of the corrugated cardboard belts showed a significant reduction of population density in both orchards by Madex Plus whilst Madex 3 gave no significant effect (figure 2).

In the on-farm trials only fruit infestation could be assessed as active or stopped damage at different dates (figure 3). In each orchard efficacy of Madex Plus on the CpGV-M-resistant CM populations could be stated. In these trials, too, very few larvae shortly before emergence of the fruit were found in the Madex Plus plots.

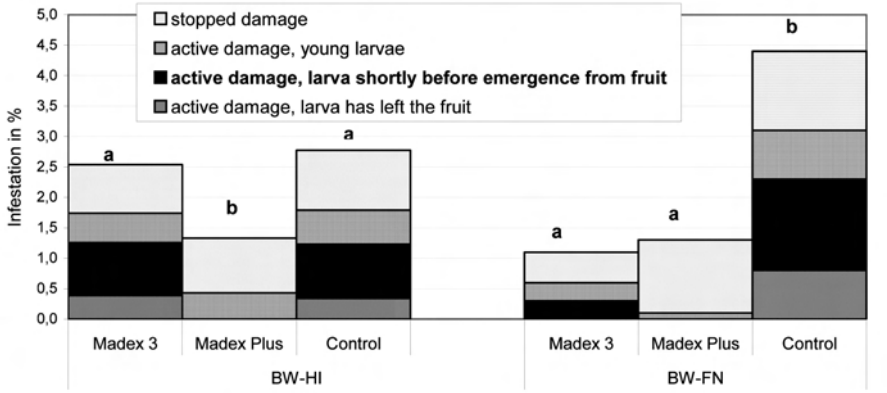

Figure 1: Fruit infestation at the beginning of August in two orchards with CpGV-M-resistant codling moth populations treated with Madex Plus. Different numbers indicate statistically significant differences in active damage (Fishers exact test; $\alpha = 0.05$)

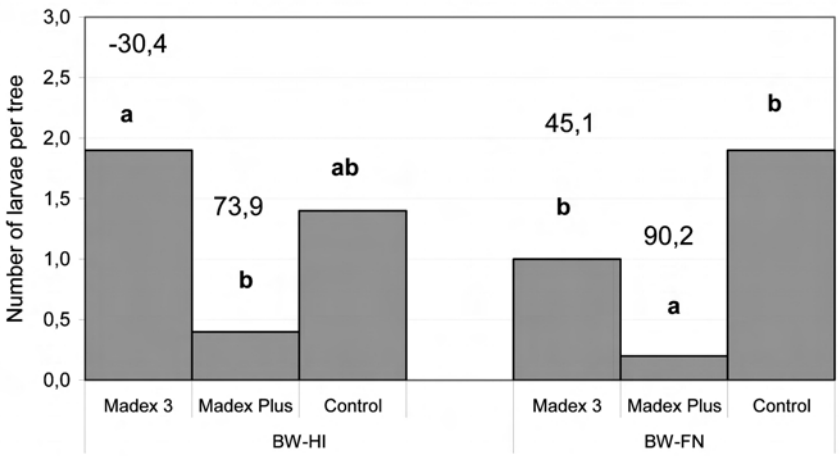

Figure 2: Number of diapausing larvae found in autumn in corrugated cardboard belts in two orchards with CpGV-M-resistant codling moth populations treated with Madex Plus. Different letters indicate statistically significant differences in active damage (Fishers exact test; α = 0.05). The degree of efficacy in % (ABBOTT) is given above the letters.

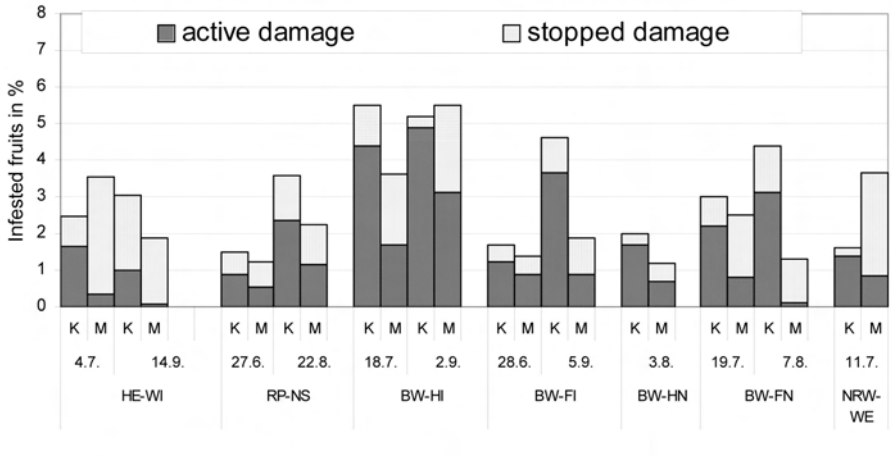

Figure 3: Active and stopped infestation of the fruits in the on-farmtrials on different CpGV-M-resistant CM populations with Madex Plus at different assessment dates

In most orchards, the efficacy of Madex Plus was high, and from observations of the second generation as well as experiences in the year 2007 we can assume that the efficacy on population control was much higher than the reduction of fruit damage.

Discussion

These first results showed that Madex Plus breaks resistance in CpGV-M-resistant CM populations even in the field. Nevertheless, the data indicate that there is a tendency to a slower efficacy of Madex Plus against the CpGV-M-resistant CM populations in comparison to the well known efficacy of CpGV-M on non resistant CM populations.

Jehle (pers. communication) reports similar findings in laboratory biotests with another resistance overcoming isolate, CpGV-I12 (Jehle et al., 2006). CpGV-I12 showed a 1-2 day delay in killing time in a CpGV resistant CM strain compared to a susceptible strain.

The efficacy of Madex Plus and CpGV-I12 on populations without CpGV-M resistance in the field is reported equal to or even higher than that of Madex 3 (Zingg et al., oral communication); the lower speed of mortality was observed only in CpGV-M-resistant populations. In population control, however, the efficacy of Madex Plus on CpGV-resistant populations seemed rather high. This was also confirmed by subsequent experiences in 2007 when Madex Plus was applied in all organic orchards with CpGV-M-resistant codling moth populations in Germany. The relatively high degree of fruit damage was ascribed to the delayed killing effect of Madex Plus, permitting infected larvae to infest fruits before dying.

In Germany, there are about 20 *C. pomonella* populations with proven resistance against CpGV-M. This virus has become an indispensable tool for codling moth control and is widely used with excellent results. However, there are also populations with first signs of resistance development, such as a low degree of stopped damage or a slight increase in the population despite intensive Madex 3 treatments.

In view of the first publication on the mode of inheritance of CpGV-M resistance (Asser-Kaiser *et al*., 2007), we have to reconsider the organic management strategy for these orchards. If a population is “on the way to resistance”, higher amounts of CpGV-M will only promote the selection of resistant individuals (Asser-Kaiser *et al*., 2007). Thus, orchards showing first signs of resistance development should switch as fast as possible to the use of the new CpGV-isolates Madex Plus or I 12. If they do not switch now and a CpGV-M resistant population is selected, the new isolate can still break that resistance, albeit at the cost of slower mortality of larvae and, therefore, higher fruit damage.

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