Efficacy of new CpGV (*Cydia pomonella* Granulovirus) isolates against resistant and suceptible Codling moth populations in Italy

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Abstract

From 2007 to 2009, various field trials have been carried out on pome fruit in order to evaluate the efficacy of different new Cydia pomonella *Granulovirus (CpGV) isolates against both susceptible and resistant codling moth populations. The results of some of these trials, conducted against the first codling moth generation, are reported. All tested isolates showed high efficacy in controlling* C. pomonella *populations susceptible to the Mexican isolate as well as populations with reduced susceptibility to the Mexican isolate. The new CpGV isolates can therefore be considered valuable tools for the control of both susceptible and resistant codling moth populations.*

Keywords: *Cydia pomonella*, Granulovirus, pome fruit, codling moth

Introduction

First suspicions of field resistance to the Mexican isolate of CpGV (CpGV-M), which used to be the active substance of all CpGV-based products on the European market, were raised in Germany (Fritsch *et al.*, 2005). The resistance to CpGV-M was then confirmed also for several other CM populations collected in France, Italy, Switzerland and Holland (Schmitt *et al.*, 2008). Thanks to the support of the European Commission (Craft Project Sustain CpGV: www.sustaincpgv.eu) and the joined effort of extension services, scientists, growers, and CpGV producers, new CpGV isolates have been developed, which are able to overcome CpGV-M resistance (Eberle *et al*., 2008; Zingg, 2008; Berling *et al*., 2009).

From 2007 to 2009 numerous field trials have been conducted in Emilia Romagna, Italy, by the local extension service against both 1st and 2nd generation larvae of CM on pome fruit. These trials aimed at verifying the efficacy of new CpGV isolates against both susceptible and resistant CM populations in the field. The results of four trials, all carried out on pear against 1st generation larvae of CM, are reported.

Material and Methods

All trials were conducted in commercial pear orchards. Trial 1-2007 was carried out in 2007 in Solara (Modena) in a pear cv Abate Fetel orchard (plant height: 4.0 m; row x plant spacing: 4.0x2.0 m) on a CM population, which did not show any reduced susceptibility to CpGV-M, while trial 2-2007 was conducted in Villafranca di Forlì (Forlì-Cesena) in a 14-year old organic pear cv William orchard (plant height: 3.5 m; row x plant spacing: 4.0x3.0 m) with confirmed resistance to CpGV-M. Since previous laboratory and field studies had shown that this CM population was highly resistant to CpGV-M (Ladurner, 2006; Schmitt *et*

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al., 2008), CpGV-M was not tested in this trial. The trials carried out in 2008 and 2009, instead, were conducted in Bagno di Piano (Bologna) in a 24-year old pear cv Abate Fetel orchard (plant height: 2.5 m; row x plant spacing: 4.0x2.0 m) against a CM population with suspected reduced susceptibility to CpGV-M.

Treatments were applied from beginning of May (first egg hatch) to end May-beginning of June (hatch completed) (crop stage: BBCH 71 - 72). To compare the different treatments, in all trials, a randomized complete block design was used with 4 replicates per treatment and with 3-5 trees per plot. The CpGV isolates tested in each trial, the application rates and the timing of the applications are summarized in Table 1.

Table 1: Treatments, application rates, number of applications per treatment, and applications dates in the different trials (applied spray volume: 1458 l/ha in Trial 1-2007, 1500 l/ha in Trial 2-2007, 1200 l/ha in Trial 3-2008, and 1172 l/ha in Trial 4-2009).

Treatment no.	Active substance	Applied rate (ml f.p./ha)*	Applied rate (no. OBs/ha)*	No. applic.s	Application dates (dd/mm)
Trial 1-2007: population susceptible to CpGV-M					
1	CpGV-M	1000 ml/ha	$1.0x10^{13}$	3	8/05, 17/05, 25/05
2	CpGV-I12	1000 ml/ha	$1.0x10^{13}$	3	8/05, 17/05, 25/05
3	CoGV-V01	100 ml/ha	$3.0x10^{12}$	3	8/05, 17/05, 25/05
4	Untreated control	-	-	-	-
Trial 2-2007: population resistant to CpGV-M					
1	CpGV-V01	100 ml/ha	$3.0x10^{12}$	4	2/05, 9/05, 17/05, 26/05
2	CpGV-I12	100 ml/ha	$3.0x10^{12}$	4	2/05, 9/05, 17/05, 26/05
3	Untreated control	-	-	-	-
Trial 3-2008: population with reduced susceptibility to CpGV-M **					
1	CpGV-M	408 ml/ha	$8.2x10^{12}$	3	22/05, 31/05, 05/06
2	CpGV-I12	84 ml/ha	$2.5x10^{12}$	3	22/05, 31/05, 05/06
3	CpGV-R5	804 ml/ha	$8.0x10^{12}$	3	22/05, 31/05, 05/06
4	Untreated control	-	-	-	-
Trial 4-2009: population with reduced susceptibility to CpGV-M					
1	CpGV-M	1172 ml/ha	$1.1x10^{13}$	3	14/05, 21/05, 28/05
2	CpGV-U4	586 ml/ha	$1.2x10^{13}$	3	14/05, 21/05, 28/05
3	CpGV-R5	1172 ml/ha	$1.1x10^{13}$	3	14/05, 21/05, 28/05
4	Untreated control	-	-	-	-

* ml f.p./ha = ml formulated product/ha; no. Obs/ha = number of Occlusion Bodies/ha.

** Due to unavailability of the new CpGV isolates at egg hatch, CpGV-M at 804 ml f.p. /ha ($8.0x10^{12}$ Obs/ha) was applied to all plots on 15 May 2008.

At the end of the first CM generation (13 June in Trial 1-2007, 11 June in Trial 2-2007, 27 June in Trial 3-2008, and 16 June in Trial 4-2009), the number of fruits damaged by CM larvae was counted on 100-240 fruits, selected randomly from the central part of each plot. Damaged fruits were scored as follows: 1. superficial damage: stopped damage just below the surface of the fruit; no living larvae; 2. active damage: fruits with living larvae not yet entered into the core and with full damage (= penetration to the core, with or without larvae). Superficial damage is considered acceptable on pear, because stung fruits can still be marketed (Lacey *et al.*, 2008; Casagrandi, 2009). We therefore decided to omit data on superficial damage.

For each plot, the percentage of fruits with active CM damage was calculated. Active damage values were compared across treatments using one-way-ANOVAs, followed by Student-Newman-Keul's test for posthoc comparison of means. To improve homoschedasticity, in all trials data were arcsen (radq(x/100))-transformed. Hartlett's, Cochran's and Bartlett's test were used to test for homogeneity of variances.

Furthermore, percent efficacy according to Abbott of the different treatments in reducing active fruit damage was determined.

Results

In all trials, significant differences among treatments in the percentage of active fruit damage emerged: damage was always significantly lower in CpGV-treated than in untreated control plots (Table 2). Irrespective of the susceptibility of the target population to CpGV-M, the new isolates always showed high and comparable efficacy in reducing active fruit damage, with mean efficacy values ranging from 83 to 99%. Mean efficacy values were comparable to that of CpGV-M against the susceptible population (Trial 1-2007), and considerably higher than that of CpGV-M against populations with reduced susceptibility to GpGV-M (Table 2; Ladurner, 2006).

Table 2: Percentage of active fruit damage (m±s.e.) in the different treatments and trials, and efficacy (Abbott) of the treatments in reducing active fruit damage. Different letters within the same trial indicate statistically significant differences (Student-Newman-Keul's test: P<0.05).

Treatment no.	Active substance	Active fruit damage (%)	Efficacy (%)
Trial 1-2007: population susceptible to CpGV-M			
1	CpGV-M	0.8 ± 0.5 a	87.5 ± 8.0
2	CpGV-I12	1.0 ± 0.7 a	83.3 ± 11.8
3	CoGV-V01	1.0 ± 0.7 a	83.3 ± 11.8
4	Untreated control	6.0 ± 1.2 b	-
	ANOVA	$F_{(3, 12)}$=5.7929, P=0.0110	
Trial 2-2007: population resistant to CpGV-M			
1	CpGV-V01	0.7 ± 0.3 a	94.6 ± 2.2
2	CpGV-I12	1.3 ± 0.3 a	89.3 ± 2.4
3	Untreated control	12.1 ± 2.1 a	
	ANOVA	$F_{(2, 9)}$=44.6346, P<0.0001	
Trial 3-2008: population with reduced susceptibility to CpGV-M			
1	CpGV-M	10.3 ± 1.6 b	58.3 ± 6.4
2	CpGV-I12	2.1 ± 0.7 a	91.7 ± 2.8
3	CpGV-R5	0.6 ± 0.4 a	97.5 ± 1.5
4	Untreated control	24.8 ± 4.9 c	-
	ANOVA	$F_{(3, 12)}$=23.4153, P<0.0001	
Trial 4-2009: population with reduced susceptibility to CpGV-M			
1	CpGV-M	5.8 ± 2.7 b	68.8 ± 14.4
2	CpGV-U4	0.3 ± 0.3 a	98.7 ± 1.3
3	CpGV-R5	1.4 ± 0.2 ab	92.7 ± 1.3
4	Untreated control	18.6 ± 3.1 c	-
	ANOVA	$F_{(3, 12)}$=15.3247, P=0.0002	

Discussion

The new CpGV isolates tested in our trials showed high efficacy in controlling both CM populations susceptible to CpGV-M and populations with reduced susceptibility to CpGV-M. However, also to these new isolates the potential for development of resistance exists, and management strategies that will maintain the efficacy of CpGV are therefore needed. In addition to the isolation and development of new effective isolates and further research on the resistance mechanism (Wandeler *et al.*, 2009), an integrated approach that alternates other CM control methods with CpGV products should be considered not only in IPM, but also in organic farming. Possible alternatives, which may be used also in organic farming, are soft insecticides (horticultural mineral oil against eggs, spinosad, etc.), mating disruption techniques, entomopathogenic nematodes, other biocontrol agents, and good orchard sanitation (e.g. removal of infested fruit) (Lacey *et al.*, 2008; Vergnani *et al.*, 2008).

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