New Approaches to Test the Field Efficacy of Plant Protection Products on Tortrix Moth Control in Apple Orchards

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Abstract

The field efficacy of granuloviruses depends not only on the resistance characteristics of the tortrix moth population but also on ultraviolet light exposure which has a strong negative influence on product stability. Plant production products (PPPs) containing the granulovirus require protection against ultraviolet irradiation. Efficacy testing of such products in an open orchard needs a high and even pest infestation. In the Lake Constance apple growing region artificial conditions to test PPPs in the open field are used to help ensure sufficient pest pressure within the experimental plots. Since 2009, the Kompetenzzentrum Obstbau-Bodensee (KOB) has conducted efficacy testing of PPPs using field cages. Different types of cages have provided satisfactory results. But factors such as the workload and the cage cost also need to be considered when choosing the most appropriate cage type for use in field studies. A small, low cost cage can be used for provisional tests but a larger more expensive cage provided the best results.

Keywords: Granulovirus, Tortricidae, cage methodology, field studies

Introduction

Field studies to test the efficiency of granuloviruses usually provide limited results in comparison to PPPs with a more pronounced residual effect. Experimental study protocols often use set spray intervals, and thus, application dates may not relate well to larval hatching. If there are longer treatment intervals it is possible to have insufficient efficiency during periods of intense larval hatching. Furthermore, the efficiency of PPPs containing the granulovirus depends not only on the applied product rate per hectare and the spray concentration used but also strongly depends on the exposure to ultraviolet irradiation after application. The possibility to conduct a successful field study can only be estimated by the pest abundance at the time of harvest in the previous year. If the weather conditions in the current test period are constantly or even temporarily unfavourable for the development of the pest, validity of the results can be limited by a low infestation (< 5 %) in the untreated control (UTC). At the KOB in Bavendorf located near Lake Constance in South-west Germany, field trials with cages have been performed since 2009 especially to test the effectiveness of new PPPs against tortricid species. Using cages it is possible to ensure sufficient pest infestation in the UTC by the release of adult moths to achieve infestation in a wanted / necessary level.

Material and Methods

Large cages

The basic structure consisted of wooden slats and an aluminium grid with a small access hatch to enter the cage. A cage was large enough to enclose two whole apple trees (2m x 1.6m x 2.5m i.e. 8m³). In the sample area Q.18 of KOB there are four blocks, each with 25 ‘c.v. Jonagold’ trees per row, with one cage per block. Trees with a similar crop load were chosen and manually thinned to 160-200 fruits per cage before setting up the cages

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around the trees. In each cage, ten pairs of moths were released. After mating and sufficient egg laying (40-50 % egg laying on the fruits) moths were killed with pyrethrum. Two spray application timings were used, either at egg laying (T1) or at larval hatching (T2). The PPPs for testing were applied once with a motorised knapsack sprayer.

Small cages

Mosquito netting (70 cm x 50 cm) wrapped around a shoot with 3-5 apples and closed with strings at the ends was used to obtain the small cages. Two pairs of moths were released per small cage. After moth release, the treatments were as described for the large cages. As it was not possible to observe eggs through the mosquito netting, the pyrethrum application was based on pest development in the large cages. This automatically resulted in a higher egg infestation in the small cages compared to the larger ones. After the pyrethrum application the small cages were removed and the test PPPs sprayed on the apple shoots/fruit in a similar way to the large cages.

Treatments

The PPPs tested in all cages and all years were based on the granulovirus formulation providing protection against ultraviolet irradiation. In 2011, only one type of sun protector was used and applications were conducted at either T1 or T2. As a reference treatment, a synthetic insecticide was used at T1 and the standard granulovirus treatment at T2. In 2012, trials were performed in the large cages but regrettably the results were not able to be evaluated. In 2011 and 2012 the target pest was *Cydia pomonella*. In 2013, weather conditions were not optimal for field trials with *C. pomonella*, so *Adoxophyes orana* was used.

Harvest and evaluation

When the codling moth larvae reached the fifth instar in UTC, all apples in the cages of the chosen trees were harvested. In the laboratory the apple surfaces were inspected for deposited eggs and entry sites of the larvae. Every apple, irrespectively with eggs or not, was cut open to assess larval infestation. The number, developmental instar and status (dead or alive) of larvae per apple and treatment were assessed.

Trials with *A. orana* were evaluated in another way. When larvae reached the 3^{rd} – 4^{th} instar in UTC, evaluation began and the number of long shoots, shoot infestation, apple clusters, damaged apples, and number of killed and live larvae was assessed.

Results

Large cages

The formulated granulovirus with UV-protectant showed the lowest efficacy compared with the reference treatment and the unformulated product (Table 1). Among the synthetical insecticides to control *A. orana*, the test products A and B revealed the highest efficacy compared with the standard treatment (Table 2).

Table 1: Results of *C. pomonella* control with the test product GranuCaps WPK-48 (WPK is a company abbreviation of the sun protector) in comparison to Madex Max and a synthetic insecticide in 2011. GranuCaps was applied after egg laying (T1) and in another variant at larval hatching (T2) (UTC = untreated control).

Treatment	Amount of fruits	Without infestation	Stopped infestation	Living larvae	Incidence of infestation in %	Statistics (Tukey HSD / α=0,05)	Percent Efficacy (Abbott)
UTC	602	192	228	182	68,11	a	0
Reference T1	516	317	141	58	38,57	b	57,52
Madex Max T2	668	119	221	37	68,44	ab	37,79
GranuCaps WPK-48 T1	538	240	178	120	55,39	ab	28,1
GranuCaps WPK-48 T2	610	266	221	123	56,39	ab	24,14

Table 2: Results of tests with synthetic insecticides against *A. orana* in 2013 showing the feasability of artificial infestation in a limited trial area (cage). (UTC = untreated control).

Treatment	Amount of long shoots	Without infestation	Infested long shoots	Stopped infestation	Incidence of infestation in %	Statistics (Tukey HSD / α=0,05)	Percent Efficacy (Abbott)
UTC	297	235	62	0	20,74	a	0
Reference T1	305	291	14	0	4,53	b	78,15
Product B T1	272	269	3	3	1,13	c	94,9
Product C T1	283	283	0	0	0	c	100

Small cages

In the 2011 trials with small cages Madex Max was tested on *C. pomonella* and a synthetic insecticide used as a reference. As already mentioned above the small cages resulted in high pest infestations in some replicates with over 300 %. There were also experiments in the small cages with *A. orana* but the moths did not have enough free space for mating and egg laying.

In 2012, GranuCaps with two different sun protectants were compared, as well as the two different application timings of T1 or T2. Each product was applied once. The efficacy of NeemAzal T/S was also tested. Overall, the different granulovirus products show almost no difference in their efficacy. But it must be mentioned that the product GranuCaps, which has a similar efficiency factor to the standard Madex Max, was also applied at T1.

Table 3: First trials with small cages to control *C. pomonella* with Madex Max applied during larval hatch (T2) compared with a synthetic insecticide as reference applied at egg laying (T1) in field studies in 2011 (UTC = untreated control).

Treatment	Amount of fruits	Without infestation	Stopped infestation	Living larvae	Incidence of infestation in %	Statistics (Tukey HSD / α=0,05)	Percent Efficacy (Abbott)
UTC	30	3	3	24	90	a	0
Reference T1	30	27	2	1	10	c	75,66
Madex Max T2	30	7	20	3	76,67	b	19,48

Table 4: Results of trials to control *C. pomonella* with different types of CpGV products, NeemAzal T/S, and a reference insecticide in field studies in 2012 (UTC = untreated control).

Treatment	Amount of fruits	Without infestation	Stopped infestation	Living larvae	Incidence of infestation in %	Statistics (Tukey HSD / α=0,05)	Percent Efficacy (Abbott)
UTC	91	28	56	32	96,7	a	0
Reference T1	102	89	27	9	35,29	d	84,42
Madex Max T2	124	65	117	1	95,16	ab	28,94
GranuCaps WPK-48 T1	108	62	82	13	87,96	ab	31,79
GranuCaps WPK-48 T2	108	68	76	7	76,85	ab	37,14
GranuCaps WPK-51 T1	103	60	54	9	61,17	bc	34,09
GranuCaps WPK-51 T2	95	49	98	5	108,42	ab	33,1
GranuCaps WPK-48+Madex Max T2	87	47	116	9	143,68	a	33,59
NeemAzal T/S	92	45	61	14	81,52	ab	29,35

Discussion

Costs

The two cage types used in these experiments have advantages and disadvantages. Compared to the large cage, the small cage is extremely cheap and the cages can be prepared in only ten minutes. We established that six small cages were comparable with one large cage. 60 minutes were needed only to prepare small cages for one treatment variant. The material expenses for six small cages were 1.16 € with labour costs of 22.62 € (at 21.46 € per h).

In contrast, the large cages required higher material and labour costs. Material costs were 170.35 € per large cage, and construction took 6.5 hours or 309.84 € (at 21.46 € per h), that is around 80 times higher than a small cage.

Once the cages are prepared they need to be set up in the field, which takes 30 minutes per large cage, whereas in the same time it is possible to fix 18 small cages in the trees. In this regard small cages are also favourable compared with large ones.

Plant protection products

In these trials different CpGV products were tested in comparison to a chemical insecticide with an ovicidal and larvicidal effect on the moths. In our trials this reference product is much more effective than the new CpGVs with sun protectants. However, the standard recommendation against codling moth in apple orchard is to applicate CpGV not only once like we did. A splitted application of the authorized amounts of granuloviruses has a higher effect especially in combination with mating disruption. CpGVs with sun protectants that are sprayed splitted at the same time as the chemical insecticide should be able to have an equal protection against codling moths.

Environmental effects

Under certain weather conditions the small cages get wet and the leaves need more time to dry. Leaves dry much faster in the large cage, similar to conditions to the open field. It has not been observed but it is possible that apple scab can more easily infect the leaves or fruits in the small cages if the drying period is longer.

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References

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