Bait sprays against the European cherry fruit fly *Rhagoletis cerasi*: Status Quo & Perspectives

K. Köppler[1], T. Kaffer[1], H. Vogt[1]

Abstract

Bait spray experiments against Rhagoletis cerasi were carried out in 2005 to 2007. The main principle of this method is to use food (e.g. sugar and proteins) as baits for the flies with small amounts of insecticides, which is applied on parts of the cherry tree. Main focus was aimed at laboratory and field cage experiments using the commercial GF-120 Naturalyte Fruit Fly Bait™ with the insecticide spinosad, which is registered against North American cherry fruit fly species in the US and Canada. Furthermore, additional bait spray formulations as alternatives to GF-120 were used to define the right food bait quality for a high attractiveness and low reproduction ability. Beyond, the negative effect on reproduction of flies for azadirachtin (neem) was shown. During this project, promising results, e.g. efficacies up to 99 % with infestation rates below the infestation threshold were obtained. From 2008 on, other insecticides, like azadirachtin (neem) and pyrethrine in an appropriate food bait mixture will be used. Questions like efficacy, adequate concentrations, persistence, rainfastness and practicability in commercial cherry orchards will be answered.

Keywords: *Rhagoletis cerasi*, bait sprays, GF-120, neem, spinosad

Introduction

The European cherry fruit fly is the most serious pest in cherry orchards, causing fruit damage and yield losses (Vogt, 2002, Daniel & Wyss, 2003). In organic and integrated cherry production no effective control was possible until now. Since 2006 'Spruzit Neu' (i.e.: pyrethrines and rape seed oil; W. Neudorff GmbH KG, Emmerthal, Germany) has been registered against sucking and biting insects in cherries with two applications per year. Side effects of this insecticide are used against cherry fruit fly. As its persistence is rather short, this may limit the efficacy from case to case. Even in conventional farming, the use of broad spectrum insecticides is restricted. Dimethoate as active substance could only be used from the remaining stock until 2007 and according to § 11 PflschG ("Gefahr im Verzug") until 2006. The application of acetamiprid as active substance was also restricted for 2007 with the annual exemptional permission (§ 11 PflschG). Hence, there is an urgent need to develop alternative strategies for all, conventional, integrated and organic cherry growers, which can also be used for origins of infestation, like back yard cherry trees.

One possibility to control cherry fruit fly might be bait sprays. In contrast to cover sprays the per ha rate of insecticides is strongly reduced and combined with a food bait formulation. It should act as phagostimulant and the higher the intake of the food bait, the better the effect of the insecticides. Main bait components up to now are proteins and sugar. Both components are necessary for adult feeding (e.g. Boller, 1971, 1984, Haisch, 1968). This method, previously using broad spectrum insecticides, is applied since years against different species of fruit flies (Roessler, 1989).

[1] Kirsten Köppler, k.koeppler@bba.de, Thomas Kaffer, t.kaffer@bba.de, Heidrun Vogt, h.vogt@bba.de, Julius Kühn-Institut, Bundesforschungsinstitut für Kulturpflanzen, Institut für Pflanzenschutz in Obstbau, Schwabenheimer Str. 101, D-69221 Dossenheim, Germany

In using new reduced-risk insecticides against *Rhagoletis* species in the US (e.g. Pelz *et al*., 2004, 2006, Yee & Chapman, 2005), good experience has been made with the spinosad containing GF-120™ Naturalyte Fruit Fly Bait (Dow Agrosciences, Indianapolis, Indiana, USA, i.e. Burns *et al*., 2001, Prokopy *et al*., 2003). Spinosad is an insecticide, naturally derived from the actinomycete *Saccaropolyspora spinosa* (Sparks *et al*., 1998, Thompson *et al*., 2000) and is registered against the north American cherry fruit fly species *R. indifferens* and *R. cingulata* in the US and Canada. First experiences with bait sprays against *R. cerasi* have been published by Haniotakis *et al.*, 1987 and Köppler *et al*., 2006. The azadirachtin containing neem product NeemAzal-T/S® (Trifolio-M GmbH, Lahnau, Germany) might be another naturally derived insecticidal component for bait sprays, based on extracts from the neem tree *Azadirachta indica*. Neem is known to reduce the fertility of fruit fly females (De Ilio *et al.*, 1999, Köppler & Vogt, 2003). Following, fruit infestation can possibly be decreased. Beside the commercially produced GF-120 Fruit Fly Bait, other food baits are conceivable. The protein and sugar mixture, proposed by Boller, 1984 could be used as food attractant. Futhermore, corn steepwater, a corn by-product, was already tested as bait for *Rhagoletis* species (Yee, 2006). The main objective of our work was to find and evaluate bait sprays based on different food baits and insecticides against the cherry fruit fly in field cages. Furthermore, the effect of different food bait qualities and of neem on reproduction of cherry fruit flies was investigated in laboratory trials.

Material and Methods

Bait spray trials in field cages

2005 to 2007, bait spray experiments were carried out in field cages on cherry cultivars ‘Hedelfinger’ and ‘Kordia’ on dwarfing rootstock (planted 1977 and 2002, respectively). Single trees were caged with a 3 x 3 x 3 m in size sewed gaze ‘Tuell 01’ (Brettschneider Fernreisebedarf GmbH, Munich, Germany), held by a metal water pipe frame and fixed at the ground with sand. An entrance was realized by a zipper. Each experimental trial had 4 replicates (2 in each on ‘Hedelfinger’ and ‘Kordia’), i.e. 4 cages. 30 ml of bait sprays were applied on 2 to 3 branches of each tree using a handsprayer with 1 application/week for 4 weeks. GF-120 (5%, 20%, 5% + 5% NH_4carbonat), brewers yeast-sucrose solution (1:4:7) with 5% NeemAzal®-T/S (with and without prefeeding of flies with neem) and corn steepwater (Cargill Deutschland GmbH, Krefeld, Germany) with 0.02% Spinosad (Dow AgroSciences, see above) in a 20% solution were used as bait sprays and the respective food bait without insecticides as a control. Within these 4 weeks 3 times a defined no. of flies were released into the cages (3 x 5 to 10 ♂ and 3 x 8 to 15 ♀). After 4 weeks all cherries per tree were harvested and infestation was determined manually.

Quality of food baits

The field cage trial showed a significant difference between food bait qualities. For bait sprays, a high attractiveness for consumption, but a low food quality for ovary development is necessary. To find the optimal food bait, a laboratory trial was prepared. For this, 8 variations of food bait were used with 5 replicates in each, yeast-sucrose (1:4, 0.1:4, 0.01:4), sucrose, GF-120 blank-sucrose (1:1), corn steepwater-sucrose (1:1, 0.5:1, 20% 1:1). Initial no. of flies in each cage (BugDorm1, BioQuip Products, Rancho Dominguez, CA, USA) was 10♂:10♀. Mortality and egg laying ability in dependence of food were recorded for 9 weeks.

Effect of neem on mortality and fecundity on *R. cerasi* in dependence on age of female flies

In this lab experiment, flies of different ages (2 to 5 and 6 to 9 days old) were fed with the yeast-sugar-mixture (1:4) containing neem (1 and 5%) with and without an additional insecticide free food source for 6 days. For each treatment, 5 cages with 2♂:4♀ in each were prepared. Mortality and egg laying behaviour was recorded.

Statistical analyses

Statistical analyses were conducted with SPSS 10.0 for Windows (SPSS Incorporation, USA). Because of distribution of data, non parametrical analyses were applied, H-test for analyses of variance, U-test for pairwise comparisons and following correction after Bonferrroni (P * n with n = no. of pairwiese comparisons). Beside this, χ^2-test was used for relevant data.

Results

Bait spray trials in field cages

In fig. 1 the infestation rates after different bait spray treatments are shown. Infestation could be reduced significantly in dependence on different insecticide concentrations, added compounds or pre-treatment of flies. Infestation decreased significantly ($P<0.05$) with GF-120 from 59.8% to 4.4% (5%, efficacy 92.6), to 0.4% (5% + NH_4carbonat, efficacy 99.4%) and to 1.8% (20%, efficacy 97.0%). The neem containing bait spray formulation reduced fruit infestation ($P<0.01$) from 61.8 to 0.1% (efficacy 99.9%) with pre feeding and to 15.8% (efficacy 74.5%) without pre feeding of flies. With the bait mixture containing corn steepwater and the same insecticide as GF-120 (Spinosad), the infestation rate could be decreased from 68.9% to 1.2% (efficacy 98.2, $P<0.05$).

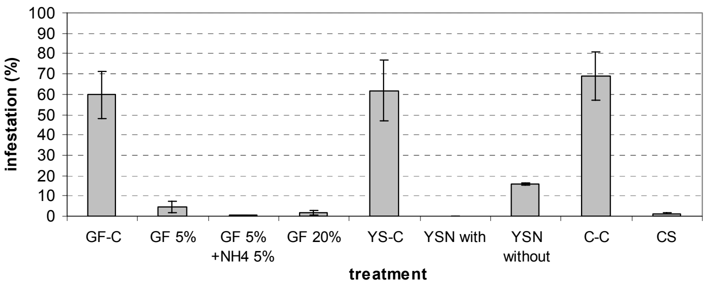

Fig. 1: Percent infestation rates after application of different bait spray formulations in field cage trials; GF-C = GF-120 blank control, GF 5% / 20% = 5 / 20 % GF-120 solution, GF 5% + NH_4 5% = 5 % GF-120 solution + NH_4-carbonat 5%, YS-C = yeast-sucrose control, YSN with / without = yeast-sugar-solution with 5% neem with / without prefeeding of flies, C-C = corn steepwater-control, CS = corn steepwater + spinosad

Because of a different no. of released flies between years, and cherries on trees, the no. of infested fruits/♀ was calculated for the different control treatments. This can be used as an indicator for food bait quality as a minimum food, which still ensures a high intake of insecticidal components. With GF-120 blank, 2.0, yeast-sucrose solution 8.4 and corn steepwater 5.8 fruits were infested/♀, with significant differences between GF-120 blank and the yeast-sucrose control ($P<0.05$).

Quality of food baits

The survival of female cherry fruit flies according to food bait quality is shown in fig. 2. All flies died after about 6 days, when they fed on GF-120 blank and sucrose. The best survival rates occured with YS in the 1:4 and 0.1:4 ratio, as well as with CS (0.5:1), whereas the latter treatment led to a faster death of flies from day 46 on. All other food qualities resulted in a medium survival of flies.

Beside survival of flies, the egg laying behaviour is important for the efficacy of a bait spray formulation. Fig. 3 shows the percentage of fertile eggs (∑ of all eggs per sample = 100%) in dependence on food bait quality. The highest egg laying rate was reached with YS 1:4 and CS 1:1 as well as 0.5:1. Differences are significant on the 5% level between YS 1:4 and 0.1:4, on the 1% level between YS 1:4 and YS 0.01:4 as well as between CS 1:1, CS 0.5:1 and YS 0.1:4 as well as YS 0.01:4.

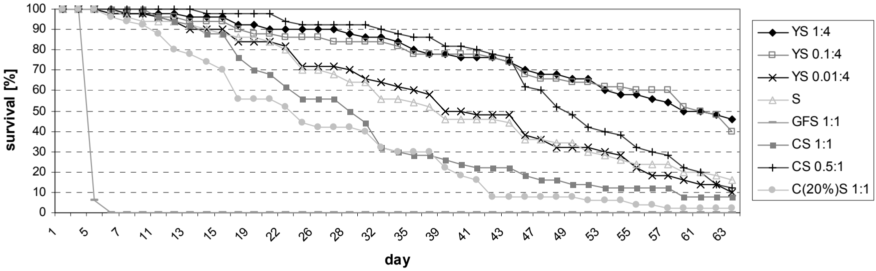

Fig. 2: Survival rates of *R. cerasi*-♀ [%] in dependence on food bait quality; YS 1:4, 0.1:4, 0.01:4 = yeast-sucrose 1:4, 0.1:4, 0.01:4, S = sucrose, GF-S = GF-120 blank-sucrose 1:1, CS 1:1, 0.5:1 = corn steepwater-sucrose 1:1, 0.5:1, C(20%)S 1:1 = corn steepwater (20% solution)-sucrose 1:1

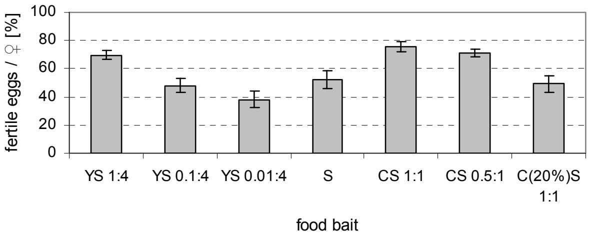

Fig. 3: Percentage of fertile eggs / *R. cerasi*-♀ ± SE [%] in dependence on food bait quality; legend see above

<u>Effect of neem on mortality and fecundity on *R. cerasi* in dependence on age of female flies</u>

Tab. 1 illustrates the life history data of different *R. cerasi* age levels after application of neem (1%, 5%) containing food in comparison with additional insecticide free food. Survival of flies was reduced significantly ($P<0.01$) in both fly ages, when feeding only on neem containing bait (exemption control with younger flies). Furthermore, a significant reduction of ∑ eggs ($P<0.01$), no. of eggs/♀ ($P<0.05$), no. of hatched larvae as well as no. of pupae ($P<0.01$) was obtained. There is no difference in pupation rate, whereas lower or higher values only occur with low no. of pupae. Comparing the two age groups of flies, significant differences in survival and reproduction got obvious, when adult flies were fed with neem in an earlier stage of their pre-oviposition phase.

Tab. 1: Mortality, reproduction and larval hatching of *R. cerasi* [%] ± SE in dependence on age of flies, on neem (1% or 5%) containing food bait with or without additional food

	Survival P-generation [%] ± SE	∑ **eggs**	N eggs / ♀ ± SE	∑ **larvae**	Larval hatching [%] ± SE	∑ **pupae**	pupation [%] ± SE
flies 2 to 5 days old							
control	50,0 ± 5,3	**411**	5,3 ± 1,1	**294**	66,0 ± 6,7	**113**	34,6 ± 6,1
1% neem	26,7 ± 4,1	**2**	0,1 ± 0,0	**0**	-	**-**	-
1% neem +food	86,7 ± 6,2	**144**	1,3 ± 0,6	**44**	15,9 ± 8,8	**11**	32,9 ± 15,1
5% neem	0	**-**	-	**-**	-	**-**	-
5% neem+food	36,7 ± 3,3	**148**	3,0 ± 1,0	**19**	9,7 ± 4,5	**1**	10,0
flies 6 to 9 days old							
control	96,7 ± 3,3	**1555**	5,5 ± 0,6	**705**	47,3 ± 3,9	**232**	32,1 ± 3,9
1% neem	40,0 ± 10,0	**54**	0,8 ± 0,2	**7**	13,6 ± 8,2	**5**	77,8 ± 22,2
1% neem +food	93,3 ± 4,1	**741**	3,7 ± 0,5	**158**	16,4 ± 3,8	**51**	38,6 ± 8,1
5% neem	46,7 ± 12,2	**8**	0,1 ± 0,0	**0**	-	**-**	-
5% neem+food	93,3 ± 6,7	**593**	2,6 ± 0,4	**91**	14,8 ± 4,3	**26**	40,5 ± 10,8

Discussion

The results indicate a high susceptibility of *R. cerasi* to bait sprays. High efficacies in field cage experiments were reached with different bait formulations and insecticides. As the registration of GF-120 is unclear in Germany, own food bait mixtures and insecticides must be investigated. Corn steepwater can be one option for food bait. It was already tested against different fruit fly species (Lee, 1997, Yee, 2006). But further experiments must be undertaken to find the right concentration for maximum attractiveness and intake, but minimum reproduction ability, as the comparison of different food bait qualities showed. Therein, the role of NH_4-salt to increase the attractiveness of bait sprays against *R. cerasi* has to be considered. It is known for *R. cerasi* (e.g. Wiesmann, 1944, Katsoyannos *et al.*, 1980, 2000). Neem can be one of the insecticidal components. It has a significant negative effect on reproduction. This was already shown for different fruit fly species (Adán *et al.*, 1998, van Randen & Roitberg, 1998 (a,b), De Ilio *et al*. 1999, Geipel, 2001, Köppler & Vogt, 2003). Nevertheless, in using neem in a bait spray formulation, the earlier the application during fruit fly pre-oviposition period, the higher efficacies can be reached. It was demonstrated in our field cage trials as well as in the lab experiments. Beside neem, pyrethrines could be further insecticidal components of bait sprays against *R. cerasi* in Germany. For both, the optimal concentration in combination with minimum food bait, which is highly attractive, must be investigated. Furthermore, field experiments under practical conditions are needed to define bait spray effects on natural population and fruit infestation, including the right timing according to the phenology of flies. Beyond, persistence as well as rainfastness of bait spray formulations has to be assured.

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