Developing Integrated Fruitworm Control Strategies for Blueberry in Preparation for Pesticide Restrictions

R. Isaacs and J.C. Wise
Department of Entomology
Michigan State University
East Lansing, Michigan
USA

C. Garcia-Salazar
West Central Region
Michigan State University Extension
Grand Haven, Michigan
USA

Keywords: *Vaccinium corymbosum, Acrobasis vaccinii*, *Grapholita packardii*, integrated pest management, phenology models, biocontrol, insecticides

Abstract

To prevent infestation of highbush blueberries by fruitworms, growers employ pheromone-baited traps to monitor adult moths and apply insecticides to fields at risk from infestation by the larvae of these pests. However, there are increasing restrictions on availability of broad-spectrum insecticides and monitoring traps have not been used to predict optimal timing of controls for these species due to the lack of a degree-day model. We are developing an IPM program that integrates monitoring traps with degree-day models to provide optimal life-stage timing of reduced-risk insecticides for control of fruitworms while maintaining biological control activity. Bioassays with biological control agents provide support for the role of conservation strategies to maintain beneficial insects. This project will help achieve the long-term goal of improving yield and quality while reducing environmental impact and worker risk in blueberry production.

INTRODUCTION

Blueberries produced in eastern North America are at risk of contamination by two lepidopteran insects that infest developing fruit. The cranberry fruitworm (*Acrobasis vaccinii* Riley) and cherry fruitworm (*Grapholita packardii* Zeller) lay their eggs on the young green fruit beginning at petal fall (Beckwith, 1941; Hutchinson, 1954). Young larvae then penetrate the berries causing a risk of contamination to harvested fruit and also yield loss if the population is high enough (Mallampalli and Isaacs, 2002). Cherry fruitworm larvae tend to infest single berries, which often drop prematurely before harvest, thus are not a high risk as a post-harvest contaminant. Larvae of cranberry fruitworm typically infest multiple berries in a cluster, leaving frass in the silken webbing between berries. This is more apparent to inspectors than cherry fruitworm, so early-season insect management programs tend to focus mainly on preventing infestation by cranberry fruitworm.

In response to the risk of crop rejection if larvae are discovered in harvested fruit, broad-spectrum insecticides with long residual control have become the dominant insecticides used to protect blueberries from fruitworm infestation. For example, Guthion (azinphosmethyl), Sevin (carbaryl), and Lannate (methomyl) are used on 58, 33, and 23% of Michigan's blueberry acreage, respectively (USDA-NASS, 2006). Because these compounds can only be used after bloom due to bee safety concerns, the lepidopteran-specific insecticide Confirm (tebufenozide) has increased in use to 34% since its recent registration (USDA-NASS, 2006).

Despite the reliance of this industry on broad-spectrum insecticides, government restrictions on these pest management tools continue to increase, mandating the search for alternative management tactics. With a phase-out of azinphosmethyl proposed by the United States Environmental Protection Agency by 2012, there is increasing urgency for development of an integrated pest management program for fruitworms in blueberry that is not dependent on such insecticides.

Cranberry fruitworm eggs are infested by *Trichogramma minutum* in field conditions in Michigan, and this parasitoid may provide biological control to suppress populations. Since parasitoids tend to be susceptible to insecticides, it is important to document their relative sensitivity to new pesticides being considered for crop protection against fruitworms.

Here we report recent studies to improve the prediction of adult moth emergence and egg-laying by cranberry fruitworm, to improve control of this insect using degree-day-driven timing of insecticide applications and to understand the relative risk of new insecticides to biological control agents.

MATERIALS AND METHODS

To develop a degree-day-driven phenology model, cranberry fruitworm adult emergence and egg distribution were monitored at eight blueberry farms from 2003 to 2007. Adult emergence was monitored using pheromone traps. Weather data to calculate growing-degree-day (GDD) accumulation were collected from weather stations located in the vicinity of the sampling sites. We used GDD to determine the relationships between heat accumulation, emergence of male moths and deposition of eggs on fruit. We employed a base temperature of 50°F because previous analysis had shown this to provide lowest variability among sites and years (C. Garcia-Salazar, unpublished). A non-linear Weibull distribution model was fitted to the moth and egg abundance data to describe the moth emergence and egg-laying dynamics as a function of heat accumulation. Trapping dates were transformed to their GDD equivalents, and cumulative weekly moth catches from all sampling sites were pooled to estimate the corresponding Weibull parameters. The resulting phenology model for predicting adult cranberry fruitworm emergence was: $CumCBFW=1\text{-}exp(CumGDD50\text{-}biofix/422.02)^{2.97}$. In 2007, to validate the accuracy of this model, cumulative captures of cranberry fruitworm from seven blueberry farms were compared to those predicted by the phenology model. GDD accumulation (i.e., CumCBFW) began on March 1st, and the biofix was set as the cumulative GDD base 50°F at which the first sustained captures of moths are found. Temperature data were collected in the proximity of four trapping sites and from nearby automated weather stations close to the other three sites. Predicted and observed cumulative moth captures were compared using paired *t*-tests on data from each site.

To determine the effect of spray timing on the performance of Confirm against cranberry fruitworm in blueberry, an experiment was conducted at the Trevor Nichols Research Complex in Fennville, Michigan in 2007. A mature planting of *Vaccinium corymbosum* cv. Rubel was used, and treatments were applied to twelve bush plots (1.43 m long) arranged in a randomized complete block design with guard rows between each treated plot. We compared the fruitworm infestation in plots that were untreated, treated with Guthion 50 WP (1.12 kg/Ha) immediately post-bloom and 14 days later, or treated with Confirm 2F (1169 ml/Ha) at 100, 200, or 300 GDD post-biofix (first sustained moth catch), with each treatment followed by another application seven days later. Cranberry fruitworm adults were monitored with four traps checked three times per week. Degree days above 50°F were calculated each day after seven moths were trapped on May 21 (set as biofix) and treatments were applied when the target GDD were reached. All treatments were applied using an airblast sprayer, in 467.7 L L/Ha of water. Plots were sampled on 29 June, 2007, by counting the number of single- and multiple-berry infestations on blueberry clusters in each plot indicative of cherry and cranberry fruitworm infestations, respectively.

To determine the potential of new reduced-risk insecticides for control of cranberry fruitworm, a replicated field trial was conducted with four replicate plots of twelve bushes of *V. corymbosum* cv. Rubel receiving each of the treatments listed in Table 1. Insecticides were applied as described above and infestation was assessed on July 3, 2007. The numbers of clusters infested with single- or multiple-berry infestation, and the total, were analyzed using analysis of variance and means separation by Duncan's New Multiple Range Test at $P = 0.05$.

To measure parasitoid sensitivity to registered fruitworm insecticides, ten blueberries, each with a cranberry fruitworm egg parasitized by *T. minutum* were placed in separate Petri dishes lined with floral foam such that eggs were exposed to sprays delivered from above by a Potter spray tower. Applications were made with a 2-ml sample at 20 psi atmospheric air delivered to the tower. Treated berries with eggs were then placed in plastic bags and the number of emerged parasitoids was measured 15 days later. Data were analyzed for normality using the Shapiro-Wilk test and for equal variance across treatments using Levene's test. Data met normality assumptions so no transformation of parasitoid data was necessary. Tukey's test was used for multiple comparisons and the significance level was α=0.05.

RESULTS AND DISCUSSION

The phenology model was able to predict with high accuracy the emergence of adult cranberry fruitworm males at all sampling sites (Fig. 1). Once biofixed with the degree days accumulated until the first moth capture, the phenology model had close agreement with the pattern of emergence of adult cranberry fruitworm detected at these farms (Fig. 1). There was over 93% correlation between the observed and predicted progression of cranberry fruitworm emergence at these sites, with many sites showing 98% correlation, and no significant difference between observed and predicted cumulative moth emergence for the seven farms where the model was validated during 2007. Our predictions of moth emergence were more accurate when temperature data from the monitoring site were use to calculate GDD, compared to nearby weather stations, indicating that the accuracy of the cranberry fruitworm phenology model will depend on growers having access to GDD accumulations calculated from weather data collected in their fields or from weather stations close to their farm.

Confirm applied at 100 GDD post-biofix and the Guthion treatment were the most effective insecticide treatments tested, providing a high level of control compared to the untreated plots for single berry infestations ($F_{4,15}$=6.37, P<0.01) and multiple berry infestations ($F_{4,15}$=3.43, P<0.04) (latter shown in Fig. 2). Confirm applied at 200 or 300 GDD post-biofix did not provide significant fruit protection in terms of either single berry or multiple berry infestations.

Comparison of reduced-risk insecticides for their control of cranberry fruitworm revealed that Altacor (rynaxypyr), Alverde (metaflumizone), Belt (flubendiamide), and Rimon (novaluron) all provided excellent reduction (>95%) of cluster infestation in comparison with the untreated controls, and provided similar levels of control compared with the standard Guthion (azinphosmethyl) treatment (Table 1).

Assays of the side effects of insecticides on the egg parasitoid *T. minutum* indicated significant variation in parasitoid survival among insecticides ($F_{10,106}$=6.37; *P*<0.0001) (Fig. 3). Some insecticides such as Esteem (pyriproxifen), SpinTor (spinosad) and Lannate (methomyl) caused intermediate mortality of this biocontrol agent, while Imidan (phosmet) and Assail (acetamiprid) caused high mortality of *T. minutum.* There was no survival when treated with Guthion (azinphosmethyl).

CONCLUSIONS

Improved accuracy of insecticide application timing is expected to reduce the infestations of fruitworms in blueberry, and will allow growers to maximize the potential of new insecticide options being registered for this crop. Regular checking of monitoring traps to determine biofix, coupled with daily checking of weather data to determine the number of accumulated GDD since biofix, is expected to provide improved timing of insecticide applications to control this insect. Using insecticides that are highly effective against cranberry fruitworm, but have relatively low impact on natural enemies, such as Rimon or Confirm, is expected to provide an effective alternative to Guthion-based control programs. If such a transition is achieved, this will have associated benefits of reduced environmental and worker risk from blueberry production.

Our results presented here are from small replicated trials in a research station and we aim to expand these findings into commercial blueberry farms during 2008 to determine the performance of fruitworm integrated pest management (IPM) programs under commercial conditions. We are also developing a similar approach for management of cherry fruitworm in blueberry. Results of future research will be used to continue improving the IPM program developed for blueberry producers in the Midwest region of the United States.

ACKNOWLEDGEMENTS

We thank the staff of the Trevor Nichols Research Complex, Ryan Vander Poppen, Kevin Schoenborn, Keith Mason, and Steve Van Timmeren for their assistance with this research. This project was funded in part by the Michigan Blueberry Growers Association, by Project GREEEN, and by agrochemical companies.

Literature Cited

Beckwith, C.S. 1941. Control of cranberry fruit worm on blueberries. J. Econ. Entomol. 34:169–171.

Hutchinson, M.T. 1954. Control of cranberry fruitworm on blueberries. J. Econ. Entomol. 7:518–520.

Mallampalli N. and Isaacs, R. 2002. Distribution of egg and larval populations of cranberry fruitworm (Lepidoptera: Pyralidae) and cherry fruitworm (Lepidoptera: Tortricidae) in highbush blueberries. Environ. Entomol. 31:852–858.

USDA-NASS. 2006. Agricultural Chemical Usage – 2005 Fruit Summary. United States Department of Agriculture, National Agricultural Statistics Service. Washington, DC. p.299.

Tables

Table 1. Control of fruitworm infestation in highbush blueberry by azinphosmethyl and four reduced-risk alternative insecticides, 2007.

Treatment and rate applied/Ha			Timing[z]	% clusters with fruitworm damage[x,y]					
				single berry		multi-berry		total	
Untreated control				13.5	a	29.0	a	42.5	a
Guthion 50W (azinphosmethyl)	1.4	kg	B,D	2.0	b	2.0	b	4.0	bc
Altacor 35WG (rynaxypyr)	146.2	ml	B,D	0.5	bc	0.0	b	0.5	c
Alverde EC (metaflumizone)	1169.3	ml	B,D	0.0	C	0.5	b	0.5	c
Belt 4SC (flubendiamide)	292.3	ml	A,C	0.0	c	1.0	b	1.0	bc
Rimon 10 EC (novaluron)	1096.2	ml	A,C	0.0	c	0.5	b	0.5	c

[x]Means followed by same letter are not significantly different (P=0.05, Duncan's MRT).
[y]Analysis of variance performed on arcsine square-root transformed data.
[z]A = 24 May (Egg laying); B = 31 May (Petal Fall); C = 8 Jun; D = 14 Jun.

Figures

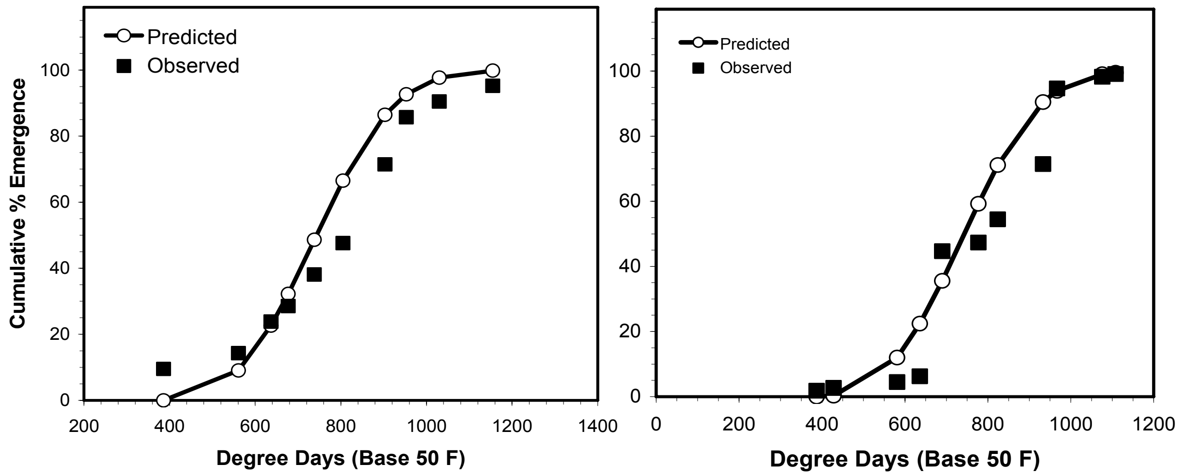

Fig. 1. Predicted and observed cumulative emergence of cranberry fruitworm moths in two representative highbush blueberry fields during 2007. There was no significant difference between observed and predicted values for either farm (paired t-test, $t < 0.09$, $P > 0.05$).

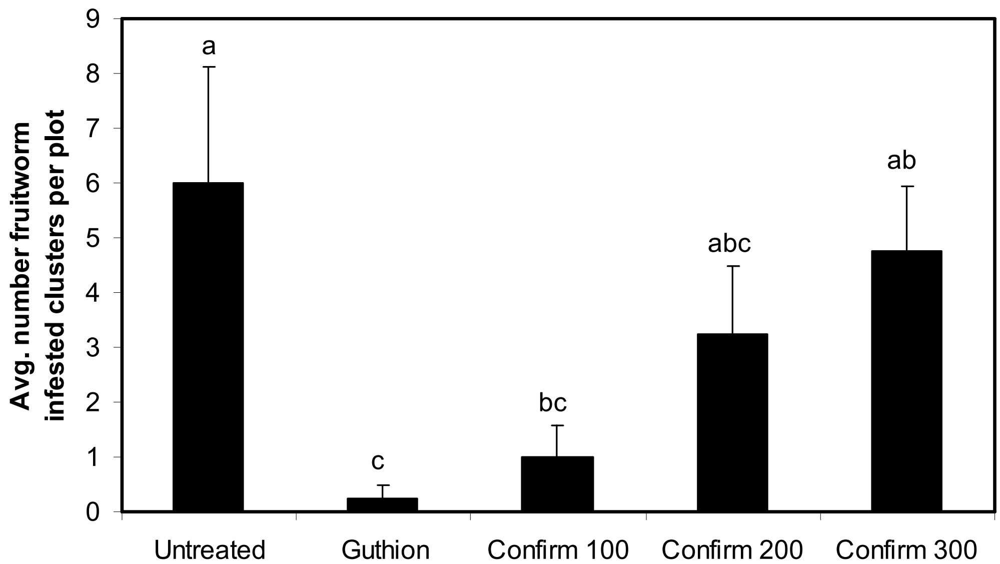

Fig. 2. Multiple-berry infestations of blueberry by fruitworms measured on 22 June 2007 after treatment with Guthion immediately post-bloom and 14 days later, or different timings of Confirm 2F applied at 100, 200, or 300 GDD base 50°F with reapplication 7 days later. Bars with the same letter are not significantly different at $P = 0.05$.

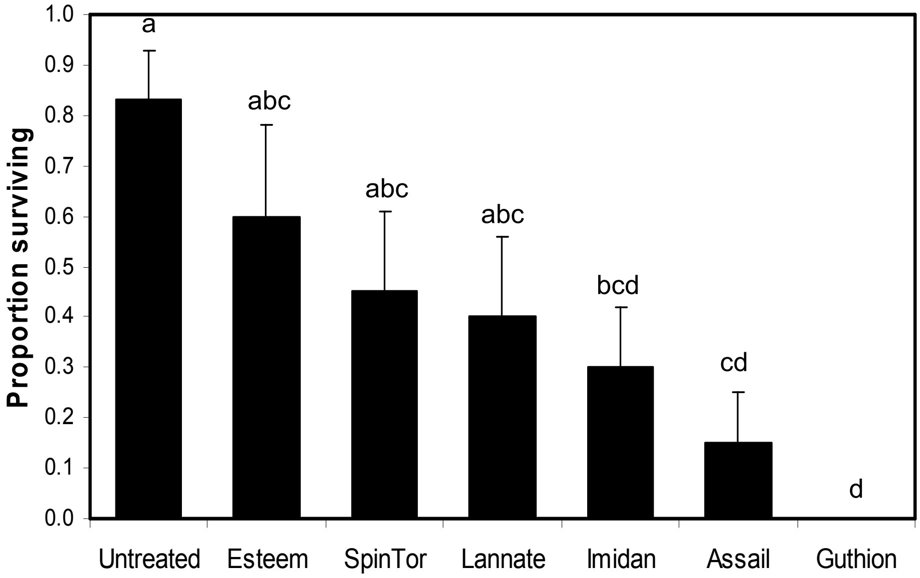

Fig. 3. Proportion of *Trichogramma minutum* surviving in cranberry fruitworm eggs treated with label rates of six registered blueberry insecticides. Bars with the same letter are not significantly different at P = 0.05.