Resources

List of Web Resources

Biological Control Resources on the Web

Enhanced BC Project http://www.enhancedbiocontrol.org/

Pest Management Transition Project http://pmtp.wsu.edu/

UC IPM http://www.ipm.ucdavis.edu/

- Natural enemies - galleries http://www.ipm.ucdavis.edu/PMG/NE/index.html

Orchard Pest Management Guide http://jenny.tfrec.wsu.edu/opm/

Cornell University – Guide to Natural Enemies in North America
http://www.biocontrol.entomology.cornell.edu/

IPM Resources Michigan State University – Identifying natural enemies
http://www.ipm.msu.edu/natural-enemies.htm

OSU Integrated Plant Protection Center http://www.ipmnet.org/

- Natural enemy pocket ID guide: http://www.ipmnet.org/Pocket_Guide_of_Natural_Enemies.pdf

Pacific Northwest Insect Management Handbook http://uspest.org/pnw/insects

DAS Home Page http://das.wsu.edu

Association of Natural Biocontrol Producers http://www.anbp.org

Koppert Biological Systems http://www.kopert.mobi

DAS Screen Shot 1

Leafroller Overwintering Generation Management Recommendations

View all Stations with the Oblique-banded Leafroller Model

WSU Sunrise Station

Weather Forecast | View Organic

Oblique-banded Leafroller

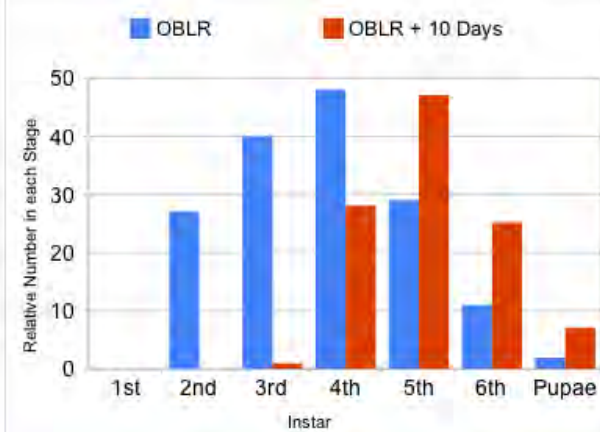
View Data Grid

Last Updated: 05/11/2009
Degree days since January 1st. = 256

Current Conditions:
About 33% of the overwintering generation is in the 4th instar and 22% are in the 5th instar.

Management:
Sample to determine population levels between 180-280 DD. If treatments are needed, apply before 370 DD so that less than 10% of the overwintering generation is in the pupal stage (pupae are insensitive to the pesticide); if using Esteem the first spray must be on between 250-300 DD. For every 20 DD delay in the application, the portion of the population controlled decreases by 3-5%.

Graph of Relative Number in each Stage



Projected Forecast:

+10 days Thu May 21, 2009 : 342

Conditions:
69% of the overwintering generation is in the 5th and 6th instars. 8% of the population is in the pupal stage, and first adults should appear at roughly 550 DD.

Management:
If treatments are needed, apply before 370 DD so that less than 10% of the population is in the pupal stage (pupae are insensitive to the pesticide); if using Esteem the first spray must be on between 250-300 DD. For every 20 DD delay in the application, the portion of the population controlled by Esteem decreases by 3-5%. If sprays are not required for the first generation, sampling can be continued during this period to help determine if the summer generation larvae need to be treated.

WSU Mini Spray guide

Possible **Conventional** materials for **Apple** crops.

Crop Type: apple

Crop Stage: Bloom

Bacillus Thuringiensis Subsp. Kurstaki (DiPel DF)
Methoxyfenozide (Intrepid 2F)

View Full WSU Spray guide

DAS Screen Shot 2

Leafroller Summer Generation Management Recommendations

View all Stations with the Oblique-banded Leafroller Model

WSU Sunrise Station

Weather Forecast | View Organic

Oblique-banded Leafroller

View Data Grid

Last Updated: 06/10/2009
Degree days since January 1st. = 675

Current Conditions:
2% of the 1st instar larvae of the summer generation have emerged. Adult flight should be increasing up to 820 DD.

Management:
Treatments for the summer generation targeting the young larvae should be applied by 750 DD if populations are high to prevent pinhole damage to the fruit. To help conserve biological control agents Bt would be a good option at this time, applied twice 7 days apart. Sampling at this point is not advised because of the difficulty in finding small larvae.

Projected Forecast:
+10 days Sat Jun 20, 2009 : 887

Conditions:
53% of the summer generation is in the 1-3rd instar, and adult flight will drop off after 900 DD and end by about 1120 DD.

Management:
Treatments for summer generation can still be applied, but damage from small larvae is probably already done. It is too early to sample for summer generation larvae.

Graph of Relative Number in each Stage

WSU Mini Spray guide

Possible **Conventional** materials for **Apple** crops.

Crop Type: apple
Crop Stage: Late spring and summer

Bacillus Thuringiensis Subsp. Kurstaki (DiPel DF)
Chlorantraniliprole (Altacor 35WDG)
Emamectin Benzoate (Proclaim 5SG)
Flubendiamide (Belt 4SC)
Methoxyfenozide (Intrepid 2F)
Novaluron (Rimon 0.83EC)
Spinetoram (Delegate 25WG)
Spinosad (Entrust 80W)
Spinosad (Success 2F)

View Full WSU Spray guide

Table 1: Pesticide Effects

Pesticide Effects on Natural Enemies (based on current research)

Laboratory bioassays
(full field rate)

green	< 25% acute mortaility or reduction in r
yellow	25 - 75% acute mortality or reduction in r
red	> 75% acute mortality or reduction in r
white	not yet completed

NE tested / effect measured	Altacor	Cyazypyr	Delegate	Rimon	Warrior	Kumulus	Kocide/ Manzate
Aphelinus mali							
acute mortality, adult parasitoid	yellow	yellow	red	yellow	yellow	green	green
population growth rate, r	green	yellow	red	green	yellow	green	green
Trioxys pallidus							
acute mortality, aphid host	yellow	red	red	green	red	red	green
acute mortality, adult parasitoid	green	red	red	green	red	yellow	green
population growth rate, r	yellow	red	red	green	red	red	green
Deraeocoris brevis							
acute mortality, nymph	green	green	green	red	red	green	green
acute mortality, adult	green	green	green	green	red	green	green
population growth rate, r							
Chrysoperla carnea							
acute mortality, larva	green	green	green	green	yellow	green	green
acute mortality, adult	yellow	red	yellow	green	yellow	green	green
population growth rate, r	yellow	red	green	red	red	green	green
Hippodamia convergens							
acute mortality, larva	green	yellow	green	green	red	green	green
acute mortality, adult	green	green	green	green	red	green	green
population growth rate, r							
Galendromus occidentalis							
acute mortality, immature	green	green	green	green	red	red	green
acute mortality, adult	green	green	red	yellow	red	green	yellow
population growth rate, r	green	yellow	red	red	red	red	red
Pelegrina aeneola							
acute mortality, immature	green	yellow	red	red	red	green	green
acute mortality, adult	green	yellow	red	yellow			
population growth rate, r	green	yellow	red	yellow			
Misumenops lepidus							
acute mortality, immature	green	yellow	yellow	green	red	green	green

r - red (negative values or <25% of range from 0 to control value)
- yellow (25 - 75% of range from 0 to control value)
- green (>75% of range from 0 to control value)

Table 2: Pesticide Effects

Pesticide Effects on Natural Enemies (from WSU spray guide)

Natural Enemy Relative Impact Guide

This table is intended as a guide to the relative impact of commonly applied pesticides to natural enemies that are important components of an integrated pest management program on tree fruits. Use it in conjunction with the Pest Control Program for each fruit crop. These give recommended rates and timing of sprays. The impact of some insecticides may vary considerably with the history of use in a given orchard. This is especially true relative to their effect on the western predatory mite (WPM) and the apple rust mite (ARM).

		Relative impact rating[1]						
Trade Name	**Compound**	**WPM[2]**	**ARM[3]**	***Colpoclypeus florus*[4]**	***Pnigallo flavipes*[4]**	***Aphelinus mali***	**Coccinellids[4]**	**Lacewing**
Acramite 50WS	bifenazate	L	--	--	--	--	--	--
Actara 25WDG	thiamethoxam	L[8]	L[8]	--	--	--	--	--
Agri-Mek 0.15EC	abamectin	H[6]	H[6]	M[6]	L	--	M[6]	--
Altacor 35WDG	chlorantraniliprole	L	--	--	--	L[14]	--	--
Ambush 25WP	permethrin	H	L	M	--	--	--	--
Apollo 4SC	clofentezine	L	L	--	--	--	--	--
Asana 0.66EC	esfenvalerate	H	L	M	M-H	--	--	L
Assail	acetamiprid	M-H[10]	L	H	--	M-H[14]	--	M
Avaunt 30DG	indoxacarb	L[9]	L[9]	--	--	--	--	--
Aza-Direct 1.2%L	azadirachtin	--	--	L	--	--	L	--
Bacillus thuringiensis subsp. kurstaki		L	L	L	L	--	L	--
Calypso 4F	thiacloprid	[10]	L	--	--	M-H[14]	--	--
Carzol 92SP	formetanate hydrochloride	M-H	M-H	H	--	--	L	--
Danitol 2.4EC	fenpropathrin	H	--	--	--	--	--	--
Delegate 25WG	spinetoram	M-H[13]	--	--	--	H[14]	--	--
Diazinon	diazinon	L	L	H	--	--	H	--
Dimethoate	dimethoate	L-M	L	H	--	--	H	--
Dimilin 2L	diflubenzuron	--	--	H	--	--	L	--
Esteem 35WP	pyriproxyfen	--	--	M	--	--	--	L
FujiMite 5%EC	fenpyroximate	--	M	--	--	--	--	--
Guthion 50WP	azinphos methyl	L	L	H	L	H[14]	H	--
Imidan 70W	phosmet	L	L	H	L	--	H	L
Intrepid 2F	methoxyfenozide	L	L	L	L	--	--	L
Lannate	methomyl	H	L	--	--	--	--	--
Lorsban	chlorpyrifos	L-M	L	H	H	H[14]	H	L
M-Pede	potassium salts of fatty acids	M[6]	M[6]	--	--	--	L	L
Nexter 75WSB	pyridaben	M	H	M-H	--	--	--	--
petroleum oil-summer		M[6,7]	L[6]	L	L	--	--	--
Pounce 3.2EC	permethrin	H	L	M	--	--	--	--
Proganic Micronized Sulfur 92%	sulfur, wettable	M	--	--	--	L[14]	--	--
Provado	imidacloprid	L[8]	L[8]	M-H[6]	--	--	M	M-H
Rex Lime Sulfur	lime sulfur/calcium polysulfide	M-H	H	--	--	--	--	--
Rimon 0.83EC	novaluron	M-H[10]	--	[11]	--	M[14]	--	[12]
Savey 50DF	hexythiazox	L	L	--	--	--	--	--
Sevin	carbaryl	M-H	L-M	H	L	H[14]	H	L
Success 2F	spinosad	M	--	M-H	H	--	L	L
Surround WP	kaolin clay	M-H	--	--	M	--	M-H[5]	--
Thionex	endosulfan	L	M-H	M	M	--	M-H	L
Ultor 1.25L	spirotetramat	L	--	--	--	L[14]	--	--
Vendex 50WP	fenbutatin oxide	M	H	L	--	--	L	--
Vydate 2L	oxamyl	M-H	--	H	L-M	--	M	L

[1]Rating system: L = low impact, M = moderate impact, H = high impact, - no data available.

[2]WPM = western predatory mite, *Typhlodromus occidentalis*.

[3]ARM = apple rust mite, *Aculus schlechtendali*. Although ARM is a plant feeding species, its presence is very useful in maintaining populations of *Typhlodromus occidentalis*.

[4]*C. florus* is a wasp parasitoid of leafrollers; *P. flavipes* is a wasp parasitoid of western tentiform leafminer. See Orchard Pest Management for more information.

[5]Coccinellid data based on bioassays of late instar larvae of *Harmonia axyridis, Hippodamia convergens*, and *Coccinella transversoguttata*. Kaolin data based on bioassays using *Stethorus punctum*.

[6]Overall negative impact is reduced due to short residual activity.

[7]Spray volume may be important in determining toxicity.

[8]Preliminary data; based on field trials of 4 cover sprays.

[9]Preliminary data; based on field trials with a single application.

[10]The use of this material has been associated with mite problems, although the effect is inconsistent; there appears to be moderate acute toxicity, but more severe reproductive effects on WPM.

[11]100% mortality/sterility was caused by exposure to novaluron

[12]Novaluron has little or no acute toxicity to lacewing eggs, larvae, or adults; however, this material caused a near-complete shutdown of egg hatch from exposed adults.

[13]While this material is toxic to WPM, it is also somewhat miticidal, and thus may not cause flare-ups of mites.

[14]Preliminary data, based on laboratory acute toxicity tests.

Chart 1: CM & LR Spray Timing

LR (larva) LR&CM (egg)	CM (egg)	CM (larva)	CM (larva)	CM (larva)	CM (larva)	CM (larva)
Petal fall **225-275 DD** (50-100 DD pbf)	**375 DD** (200 DD pbf)	**1st cover** **425 DD** (250 DD pbf)	**Delayed 1st cover** **525 DD** (350 DD pbf)	**2nd cover** **625-675 DD** (450-500 DD pbf)	**Delayed 2nd cover** **725-825 DD** (550-650 DD pbf)	**3rd cover** **875-925 DD** (700-750 DD pbf)
Proclaim Success Delegate Belt Bt	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	→	Delegate Entrust Altacor Assail Calypso Intrepid virus
Proclaim Success Delegate Belt Bt →	**Oil**	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	
Altacor Intrepid Rimon Esteem	→	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	→	Delegate Entrust Altacor Assail Calypso Intrepid virus	
Altacor Intrepid Rimon Esteem	*Tank mix* →	→	Delegate Entrust Assail Calypso virus **+** Altacor Intrepid Rimon Esteem		**May not need 2nd cover**	

pbf = post biofix
Source: Pest Management Transition Project Handbook (*http://pmtp.wsu.edu/handbook.html*)

Table 3: Pesticide Costs

Average Cost of Pesticides Use per Acre

Pesticide name	*$ per acre (full rate)*
Acramite	$38
Actara	$24
Agrimek	$87
Altacor	$40
Assail	$55
Avaunt	$37
Bt	$25
Calypso	$54
Carzol	$56
Centaur	$48
Clutch	$65
CM virus	$30
Danitol	$32
Delegate	$59
Diazinon	$32
Dithane	$35
Envidor	$36
Esteem	$48
FujiMite	$28
Application	$25

Pesticide name	*$ per acre (full rate)*
Guthion	$28
Intrepid	$30
Imidan	$30
Lorsban	$30
Manzate	$35
Nexter	$21
Oil	$5/gal.
Pheromone	$100
Proclaim	$40
Provado	$15
Rimon	$55
Sevin	$34
Success	$54
Sulfur 80W	$28
Surround WP	$40
Thionex	$40
Ultor	$46
Warrior	$25
Zeal	$64

Fact Sheet: BMSB

Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys*

BMSB is native to China, Japan, Korea and Taiwan. It may have been introduced to the US by way of cargo shipments from Asia. It is considered a major economic pest in Asia attacking a variety of high value crops, including tree fruit. The first discovery of BMSB was in Allentown, PA where it quickly spread to other Mid-Atlantic states. It is now found in 29 states across the US, including confirmed detections in northwest OR (Portland south to Corvallis and east just past Hood River) and in southwestern WA.

In the Mid-Atlantic states devastating crop loss has already occurred in commercial orchards with some growers losing entire blocks of stone fruit. Severe injury was also detected in apples and pears. Besides tree fruit it feeds on over 300 host plants, including corn, soy beans, and grapes.

Adults and nymphs feed on fruit beginning in the Spring and continuing through harvest. The images to the left show the effect of stink bug feeding on apple. Dimples and even cat-facing if severe enough, are exterior signs of feeding. When cut, internal damage appears as corkiness similar to bitterpit. There is one generation per year in OR and WA, though it can have more than one generation in warmer areas.

Traps can be used to monitor BMSB, however, the true pheromone for this insect has yet to be identified.

Control of stink bugs has always been a challenge. Native stink bug species spend most of their life cycle outside pome fruit orchards and migrate in as adults in late season to feed on fruit. The BMSB is different in that it can live inside the orchard and complete its life cycle without leaving. Of course it also invades orchards from other crops or wild habitats.

The list of insecticides that are effective against BMSB and other stink bugs is shown in the table below. All of these insecticides either have severe limitations on their use and/or will disrupt biological control.

Insecticide	Negative characteristics	48 h mortality
Carzol	Limited to early season use	88
Lannate	High toxicity risk to humans	100
Thiodan	Closed cab and long PHI	94
Danitol	Problems with secondary pests	94
Warrior	Problems with secondary pests	100