WELCOME TO:

Organic Management of Spotted-Wing Drosophila

A Webinar Presented by Organic SWD Management Project

United States Department of Agriculture
National Institute of Food and Agriculture

Be patient……. the webinar will start at 2.00 pm eastern time

During the webinar: Your microphones will be muted to help ensure good audio quality
Ask questions using the Q&A box, and we will answer those at the end

After the webinar: There will be links to a survey about SWD challenges
The slides and link to the recording will be sent to all attendees

Organic Management of Spotted-Wing Drosophila

United States Department of Agriculture
National Institute of Food and Agriculture

WEBINAR

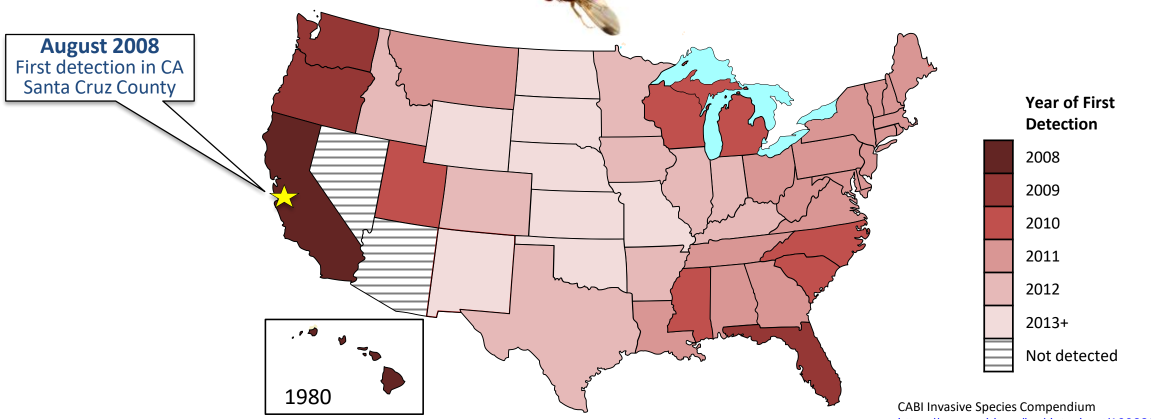
Presented by Organic SWD Management Project

Organic Agriculture Research and Extension Initiative (OREI)
USDA National Institute of Food and Agriculture (NIFA)
Award No. 2018-51300-28434

March 4, 2020

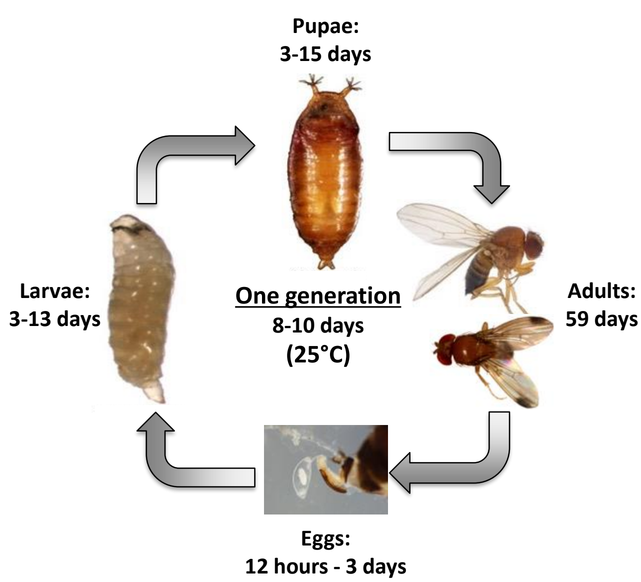
Organic SWD Management

Spotted-Wing Drosophila (SWD)



CABI Invasive Species Compendium
https://www.cabi.org/isc/datasheet/109283

Organic SWD Management



Saw-like ovipositor

Annual Crop Losses
$718 million

Increased Management Costs
$129 million

Organic SWD Management

Project Team

University of Georgia
Ash Sial
Erick Smith (Horticulture)
Kay Kelsey (Impact Evaluation)

Oregon State University
Vaughn Walton
Bernadine Strick (Horticulture)

Michigan State University
Matt Grieshop
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University of Minnesota
Mary Rogers

University of Arkansas
Jennie Popp (Agri. Economics)

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Frank Zalom

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North Carolina State University
Hannah Burrack

University of Maryland
Kelly Hamby

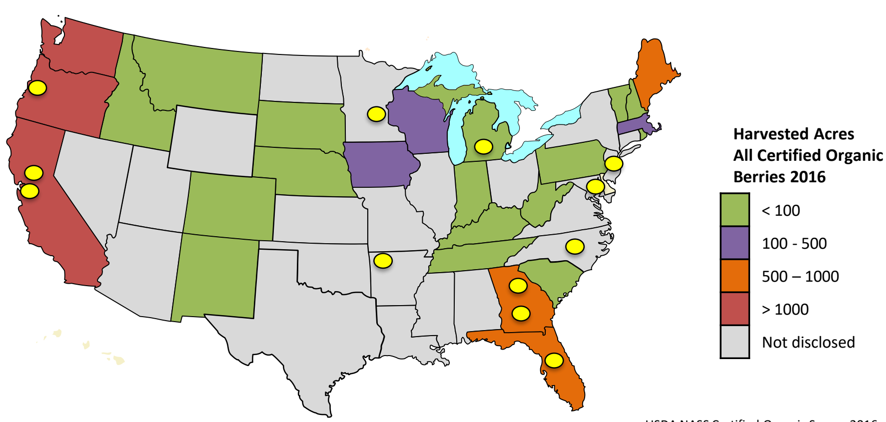
University of California, Berkeley
Kent Daane

USDA-ARS
Jana Lee

Rutgers University
Cesar Rodriguez-Saona

Organic SWD Management

Project Team



USDA NASS Certified Organic Survey 2016
https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Organic_Production/

Organic SWD Management

Project Goal

To develop and implement systems-based organic SWD management programs that are compatible with the USDA National Organic Program (NOP) and true to the ethos of organic agriculture.

These programs will be based on a foundation of cultural, physical, behavioral, and biological control tactics, bolstered by NOP compliant insecticides

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Organic SWD Management

Objectives

1. Evaluate behavioral tactics for organic management of SWD
2. Improve effectiveness and feasibility of cultural strategies for organic management of SWD
3. Incorporate biological control in organic management of SWD
4. Integrate new OMRI-approved products into season-long IPM programs
5. Develop an integrated outreach approach to implement organic SWD management strategies and evaluate their economic impact

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Today's Presenters

Organic SWD Management

Ash Sial
U Georgia

Elena Rhodes
U Florida

Kelly Hamby
U Maryland

Kent Daane
UC Berkeley

Craig Roubos
U Georgia

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Organic SWD Management

Objective 1 – Behavioral Tactics for SWD Management

Oscar E. Liburd and Cesar Rodriguez-Saona (leads)

Elena Rhodes, Pablo Urbaneja, Vaughn Walton

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SPLAT (NOW HOOK)

How HOOK ages in the field

Organic SWD Management

Field Trials: Florida blackberries

Organic SWD Management

Methods

- Organic blackberry farm in Marion Co. FL
- No SPLAT, SPLAT applied every 7 days and SPLAT applied every 14 days with no insecticide programs, Grandevo applications, or Entrust – Grandevo rotation (grower's standard)
- Weekly adult monitoring and fruit sampling

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Organic SWD Management

Plot map

- Standard (Entrust/Grandevo)
- Grandevo
- Untreated Control
- No SPLAT
- SPLAT every 7d
- SPLAT every 14 d

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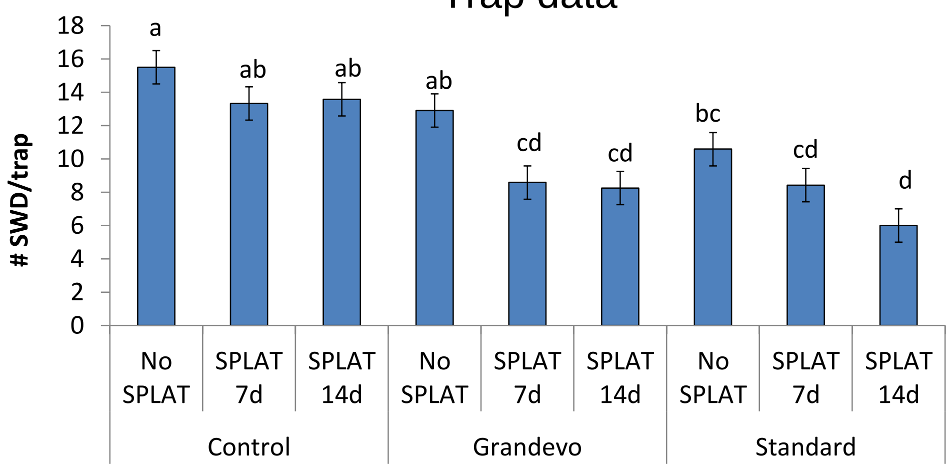
Organic SWD Management

Organic blackberry trial results

Trap data



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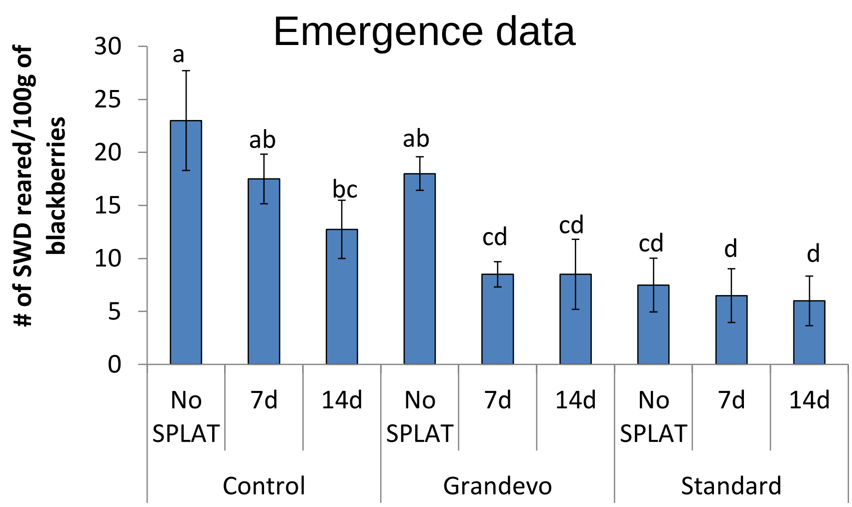
Organic blackberry trial results



Field Trials: New Jersey blueberries

Organic SWD Management

Applications, one on either side of ATV in order to treat two rows, drove down every-other row

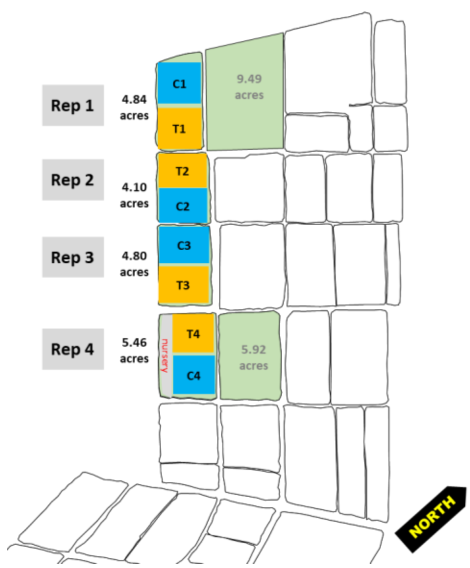
- Studies were carried out on **2 farms**
- **320 samples** (n=20 per field, 160 per farm)/**week**
- Product was **diluted to 80% strength** (pump works better)
- **SWD** emerged after **14 days** of incubation

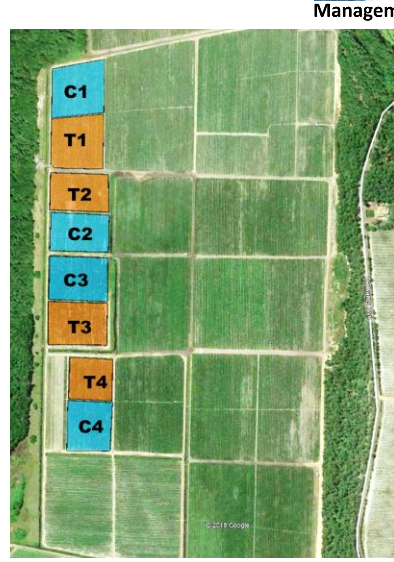
Organic SWD Management

FARM 1 (4 Reps)

HOOK

Control



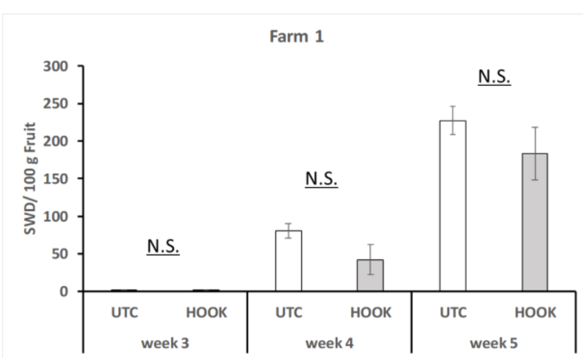


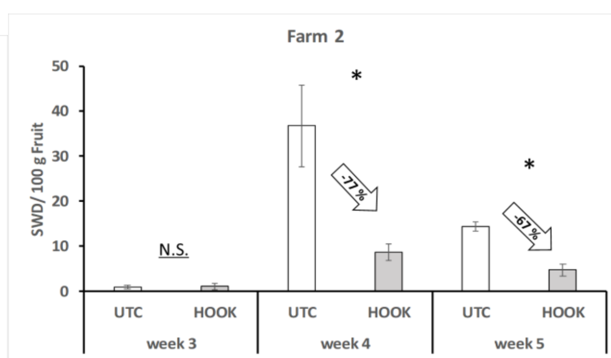
FARM 2 (4 Reps)

HOOK

Control

Effect of SPLAT SWD A&K breaks down with increasing SWD densities





* Significantly different, ANOVA, Fisher LSD ($p<.05$)

Organic SWD Management

HOOK CAGE STUDIES

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Organic SWD Management

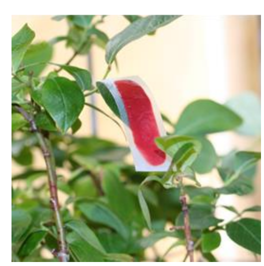
DOES FLY DENSITY MATTER?

- Five fruit clusters (25 fruit) per cage
- Five SWD densities: 0, 20, 40, 60, and 80
- Treatments:

1. Control = No SPLAT SWD A&K
2. Foliage = SPLAT SWD A&K applied to a leaf
3. Bark = SPLAT SWD A&K applied to the bark

- Measured:

1. No. eggs per fruit
2. No. adults emerged
3. No. adults alive in cages (using traps)



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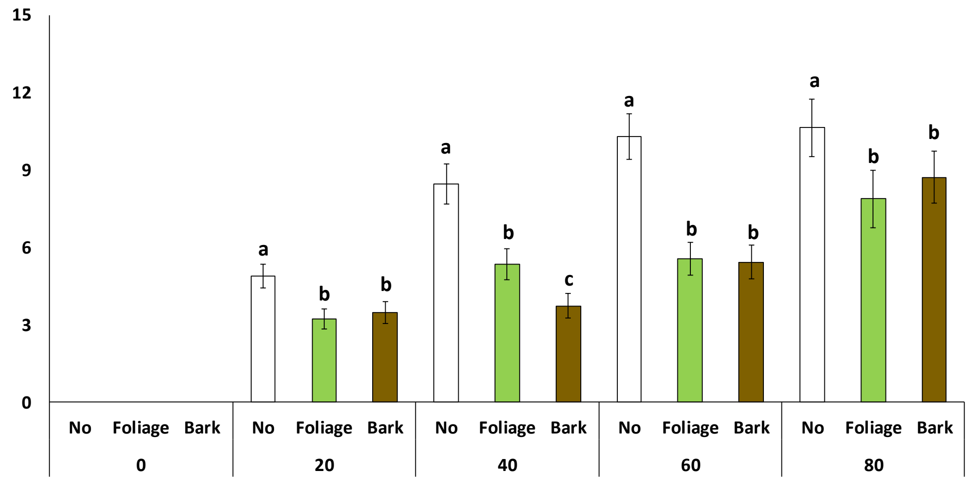
Organic SWD Management

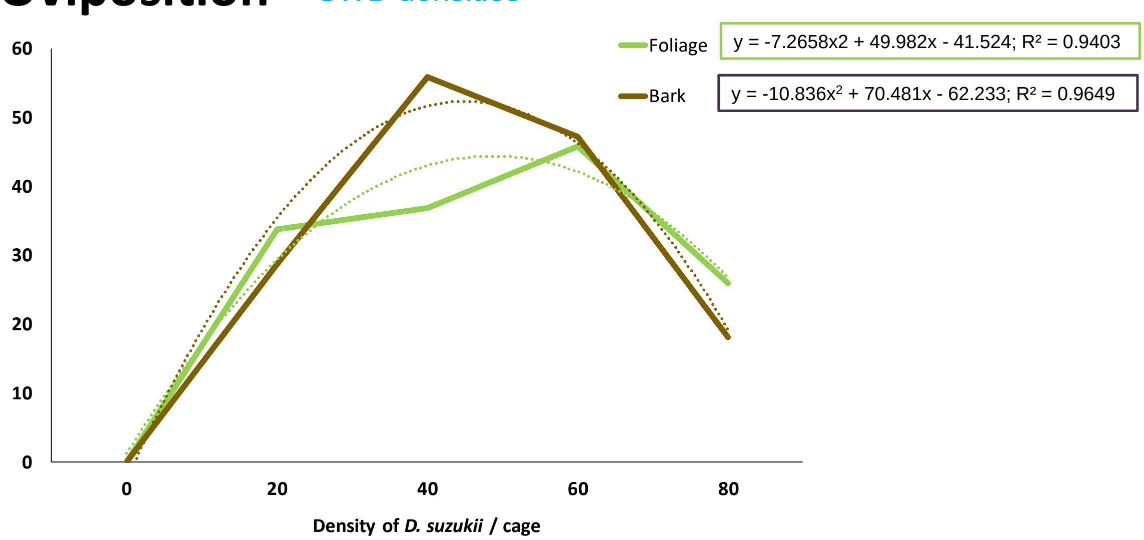
Oviposition (eggs per fruit)



Organic SWD Management

Oviposition

Efficacy of SPLAT SWD A&K breaks down at high SWD densities



Organic SWD Management

Does fruit density matter?

- No HOOK, HOOK on bark, and HOOK on foliage treatments
- 40 females SWD per cage
- 0, 5, 10, or 20 fruit clusters
  - Cluster = 5 fruit
- Measured emergence and adult survival

Organic SWD Management

Examples of treatments

Bark application

Leaf application + berry clusters

Berry clusters

Red sticky trap

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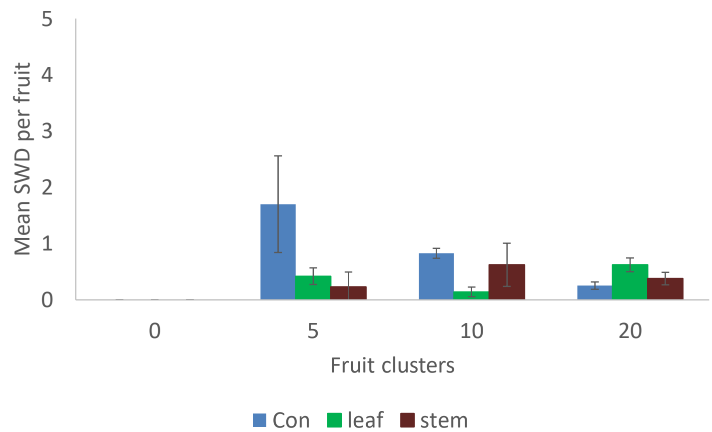
Adult emergence from fruit after 2.5 weeks

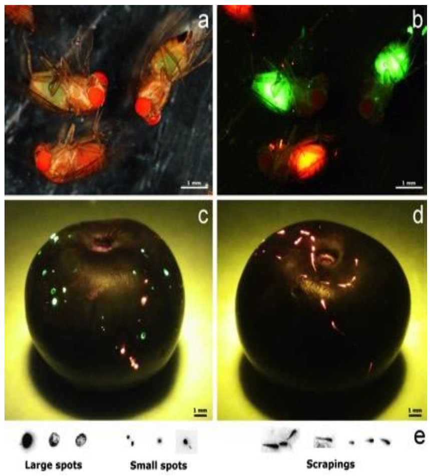


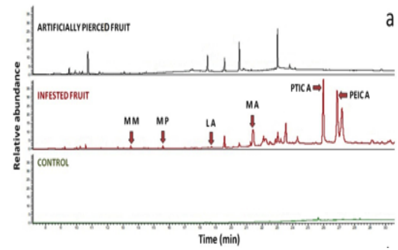
Organic SWD Management

FOOD-GRADE GUM

Reproductive site selection of *Drosophila suzukii* Matsumura (Diptera: Drosophilidae)

Organic SWD Management

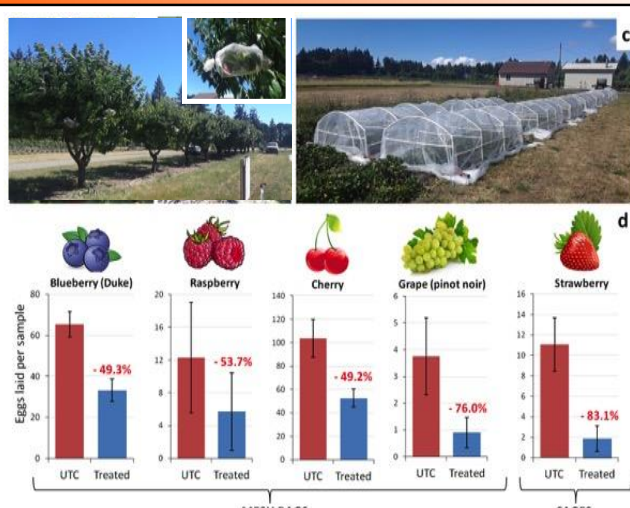




Keesey et al 2016
Tait et al 2018,
Tait et al Envir Entomol 2020
Rossi-Stacconi et al. Econ. Entomol 2020

Season 2018: efficacy trials

Organic SWD Management



Intl. patent
Walton et al 2020

Season 2018: longevity trials

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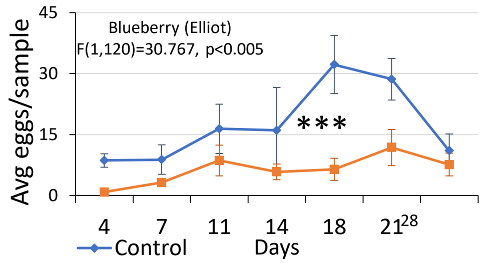
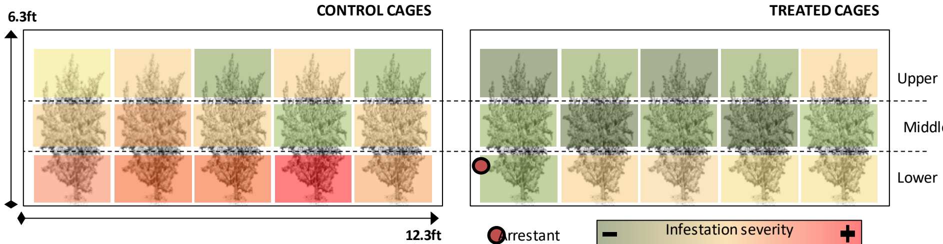


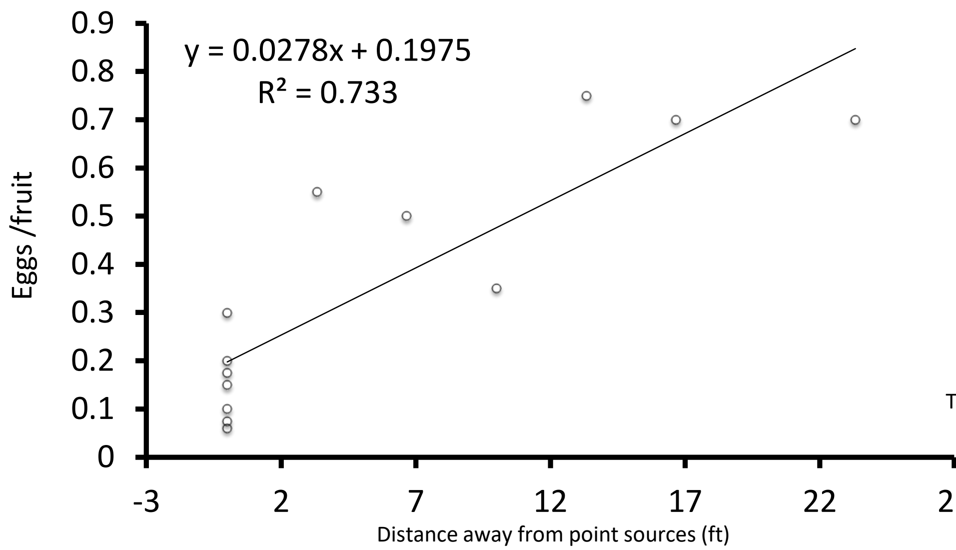
- 21-day persistence
- 67.5% efficacy (range 47.6 - 90.7%)



Rossi-Stacconi et al 2020

Effective range (21-day period)

Organic SWD Management

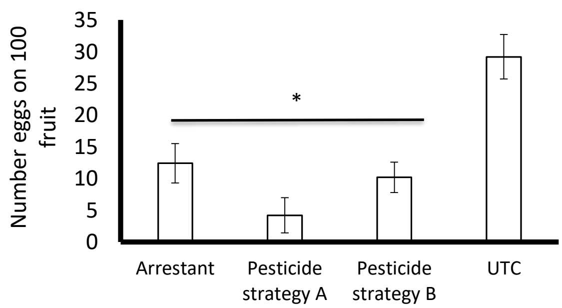


Tait et al in prep

Implementation, comparison with grower standard

- MCAREC, Hood River 2019
- Caged Trees w. fly releases
- Arrestant, UTC, 2 Pesticide strategies
- 21-day period
- Fruit damage assessed twice-weekly

Rossi-Stacconi et al in prep



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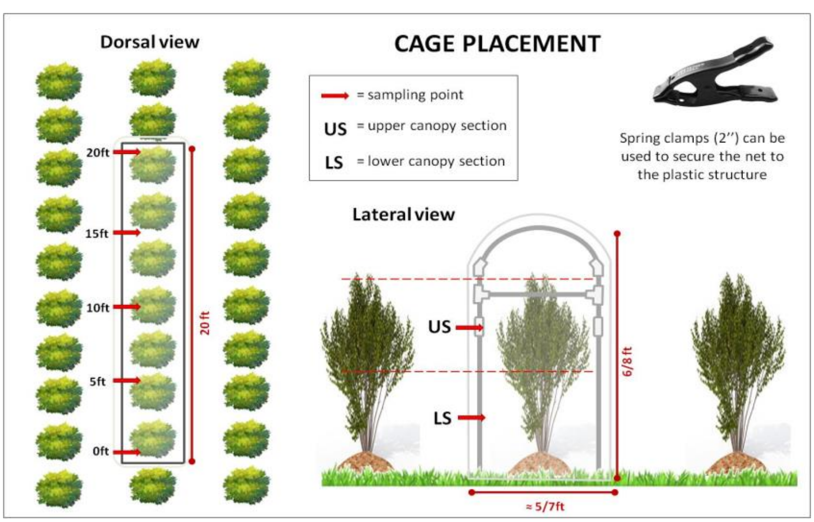
Decoy field trials: Oregon and Georgia 2019 Methods

Organic SWD Management



GEORGIA

Water bottle

OREGON

Drip irrigation

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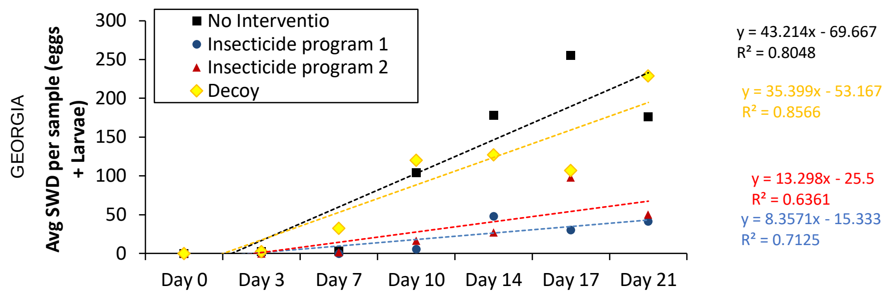
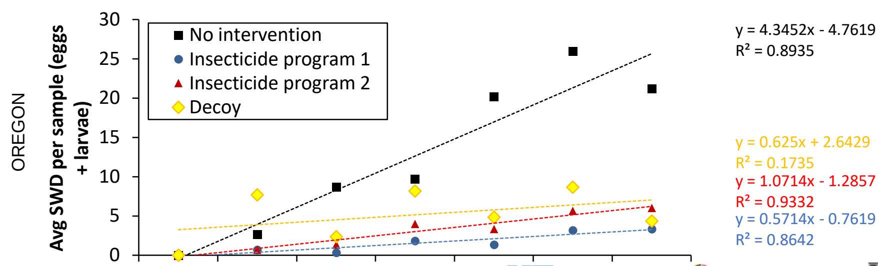
Decoy field trials: Oregon and Georgia 2019 Results

Organic SWD Management

Water bottle



Drip irrigation



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Organic SWD Management

Summary

- SPLAT
  - Reduces SWD fruit infestation in the field
  - Control breaks down at higher SWD and fruit densities
  - May be useful as an early season tool
- Gum
  - Effectively reduces SWD fruit infestation
  - Lasts for 21 days
  - Reduced control farther away from point sources
  - Must be kept moist

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Organic SWD Management

Objective 2 – Cultural control

Purposeful manipulation of the environment to reduce pest population growth and damage.

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Goal: Reduce Habitat Favorability

Organic SWD Management

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Goal: Reduce Habitat Favorability

Don't survive at constant temp >87.6°F, no egg laying at 95°F

Lifespan and egg production increase with relative humidity, do better >70%RH

Ryan et al. 2016 *J. Econ. Ectomol.*; Tochen et al. 2016 *J. Appl. Entomol.*

Goal: Reduce Habitat Favorability

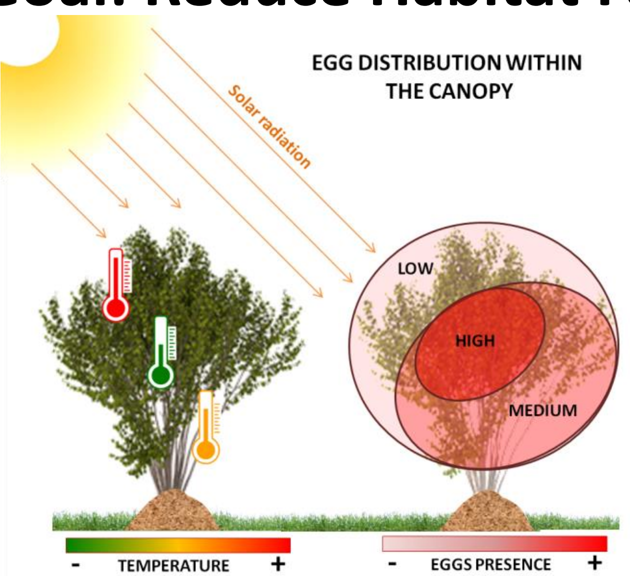


Illustration: Marco Rossi-Stacconi, © OSU

Adult activity and infestation higher in lower and interior canopy

Rice et al. 2017 *J. Insect Behav.*; Diepenbrock and Burrack 2016 *J. Appl. Entomol.*; Rendon et al. 2019 *Pest Manag. Sci.*

Goal: Reduce Habitat Favorability

FACTORS AFFECTING SWD ENVIRONMENT SUITABILITY

1 - Netting
2 - Irrigation type
3 - Presence of weed mat
4 - Pruning intensity
5 - Harvest frequency
6 - Refrigeration

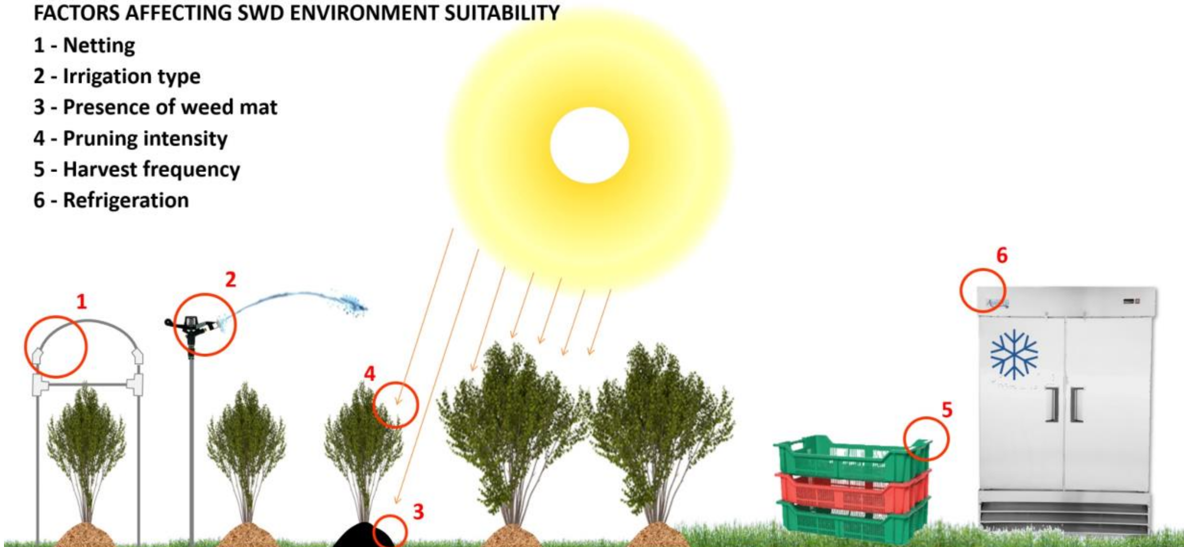


Illustration: Marco Rossi-Stacconi, © OSU

Physical Exclusion

'Himbo Top' primocane raspberries in tunnels, Morris, MN

Mesh netting <1 mm works to exclude flies and infestation — if done right!

Rogers et al. 2016 *J. Pest Sci.*; Leach et al. 2016 *J. Econ. Entomol.*

Physical Exclusion

Organic SWD Management

Entrance vestibule on exclusion tunnels.
Berry Protection Solutions,
Stephentown NY, Dale Illa Riggs

Installed before SWD

Keep flies out of tunnels

Baited traps do not reduce infestation

Rogers et al. 2016 *J. Pest Sci.*;
Leach et al. 2016 *J. Econ. Entomol.*

Physical Exclusion

Organic SWD Management

Entrance vestibule on exclusion tunnels.
Berry Protection Solutions,
Stephentown NY, Dale Illa Riggs

Tunnel grown fruit often higher quality

100% control possible especially in blueberries

Rogers et al. 2016 *J. Pest Sci.*;
Leach et al. 2016 *J. Econ. Entomol.*

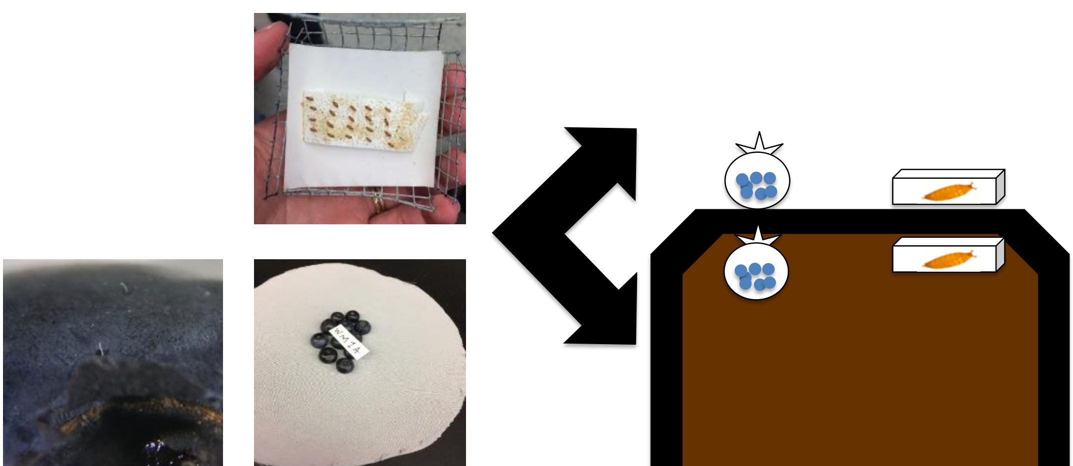
Irrigation

Organic SWD Management

Rendon and Walton 2019 *J. Econ. Entomol.*

Irrigation

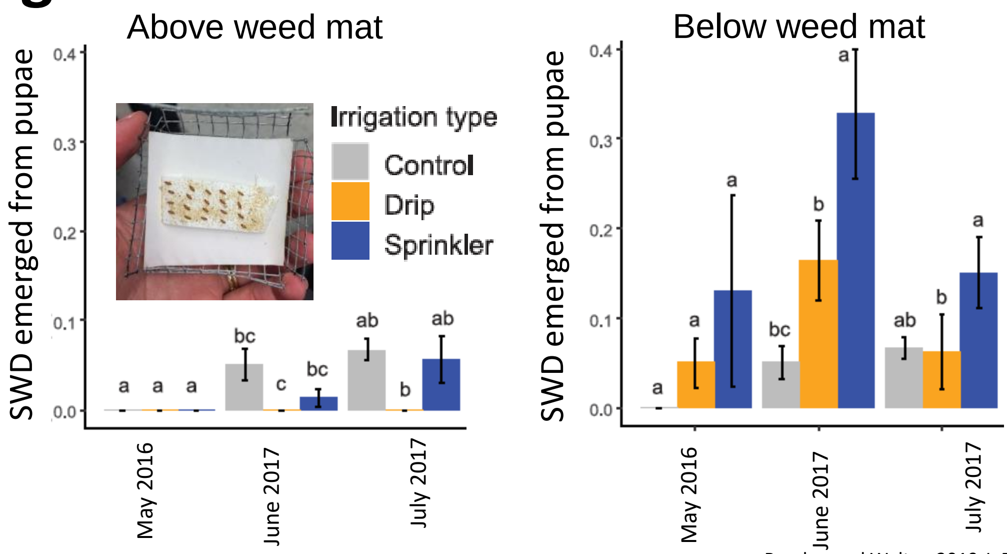
Organic SWD Management



Rendon and Walton 2019 *J. Econ. Entomol.*

Irrigation

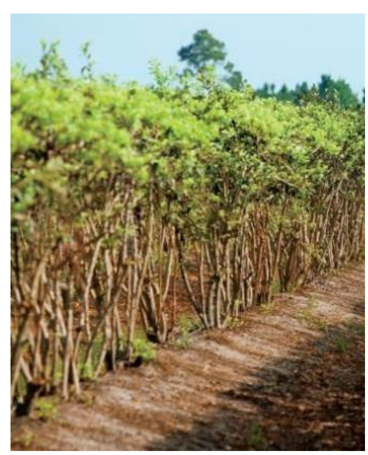
Organic SWD Management



Rendon and Walton 2019 *J. Econ. Entomol.*

Mulch

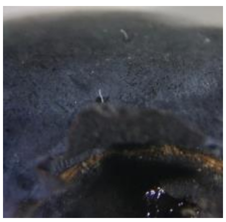
Organic SWD Management

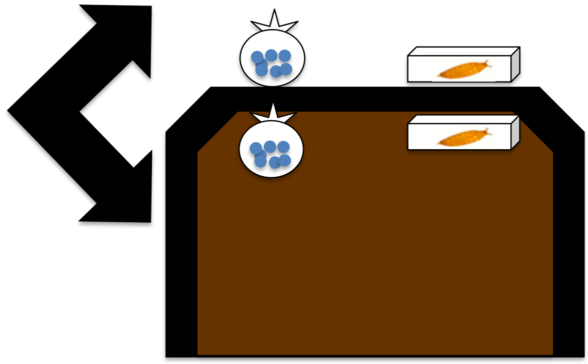


Rendon et al. 2019 *Pest Manag. Sci.*

Mulch

Organic SWD Management

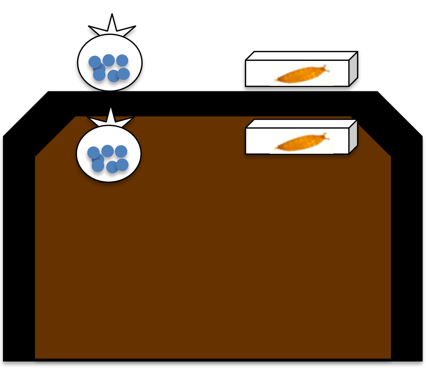




Rendon et al. 2019 *Pest Manag. Sci.*

Mulch

Organic SWD Management



Less survival above mulch

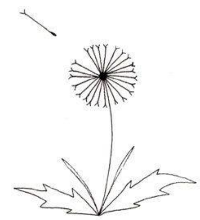
Weedmat sometimes lower survival and infestation

Rendon et al. 2019 *Pest Manag. Sci.*

Mulch

Organic SWD Management

Also acts a barrier for getting below mulch



Rendon et al. 2019 *Pest Manag. Sci.*

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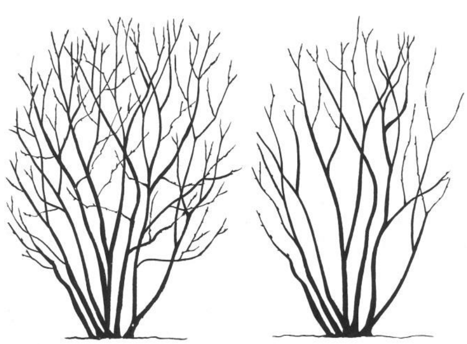
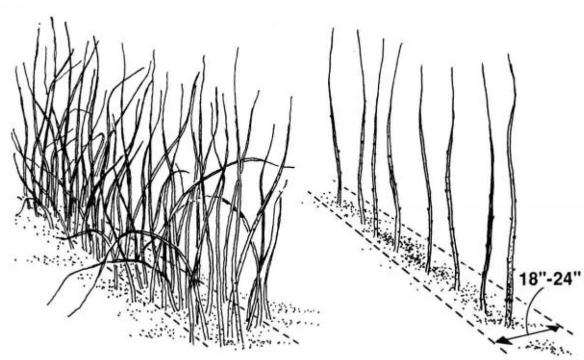
Pruning

Organic SWD Management





Optimize yield and ease of harvesting

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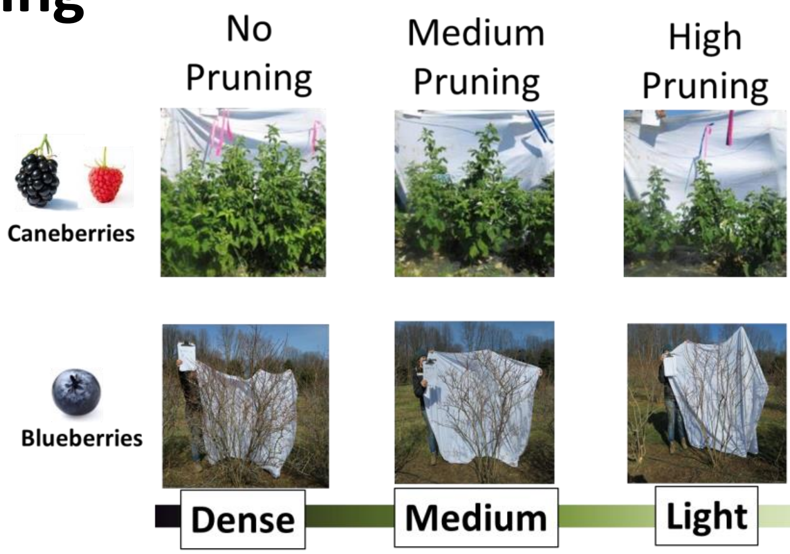
Pruning

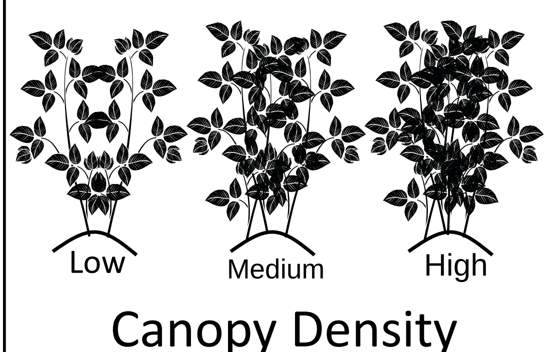
Organic SWD Management



Schöneberg et al. 2020 *Agric. Eco. Environ.*

Pruning

Organic SWD Management



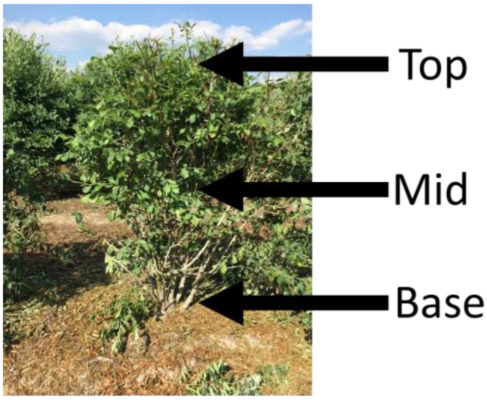
Changed canopy climate

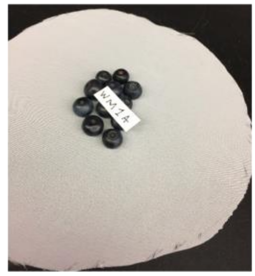
0.2-1.3°F and 0.5-1.3% RH

0.14 fewer larvae per gram fruit (low)

Schöneberg et al. 2020 *Agric. Eco. Environ.*

Pruning





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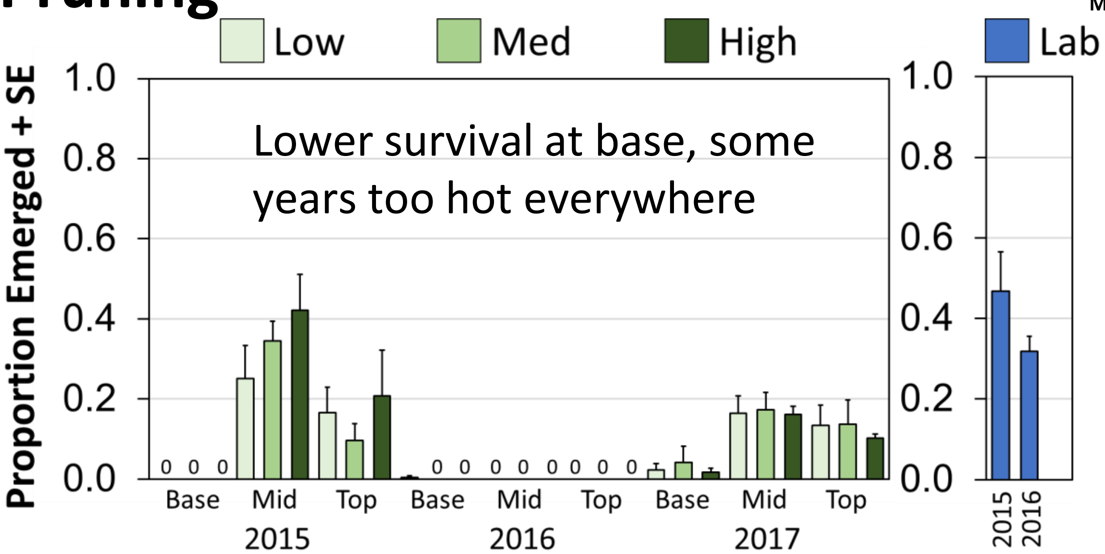
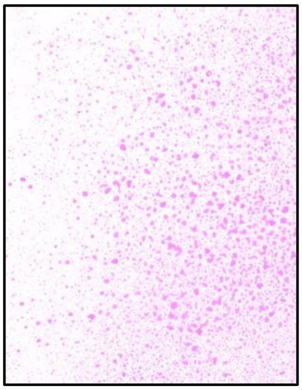
Pruning



Schöneberg et al. 2020 *Agric. Eco. Environ.*

Pruning

Organic SWD Management



No impact on fruit quality or marketable yield

May also improve spray coverage and harvest efficiency

Schöneberg et al. 2020 *Agric. Eco. Environ.*

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Harvest Frequency and Sanitation

Organic SWD Management

Removes resources for SWD from the farm

Leach et al. 2018 *J. Pest Sci.*

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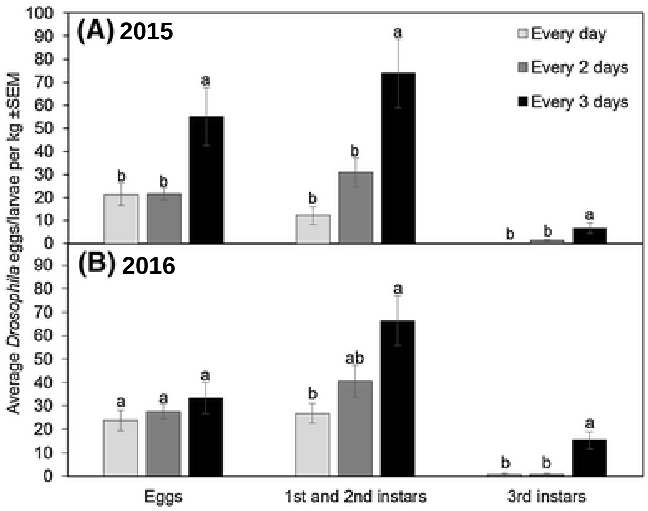
Harvest Frequency

Organic SWD Management



Highest marketable yield per unit effort with a 2-day harvest interval

Leach et al. 2018 *J. Pest Sci.*

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Sanitation

Organic SWD Management

Remove and destroy cull fruit

Leave in a sealed container

2-3 days in direct sun

Bury ≥ 2 ft deep

Leach et al. 2018 *J. Pest Sci.*

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Post Harvest Cold Storage

Organic SWD Management

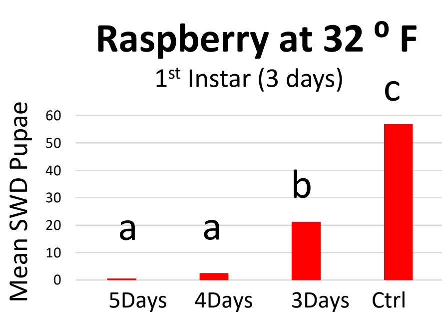
Cool fruit as soon as possible after harvest

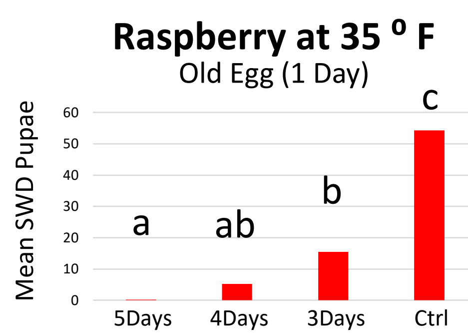
Encourage consumers to refrigerate

Alys et al. 2016 *J. Econ. Entomol.*; Burrack lab NC State

Post Harvest Cold Storage

Organic SWD Management



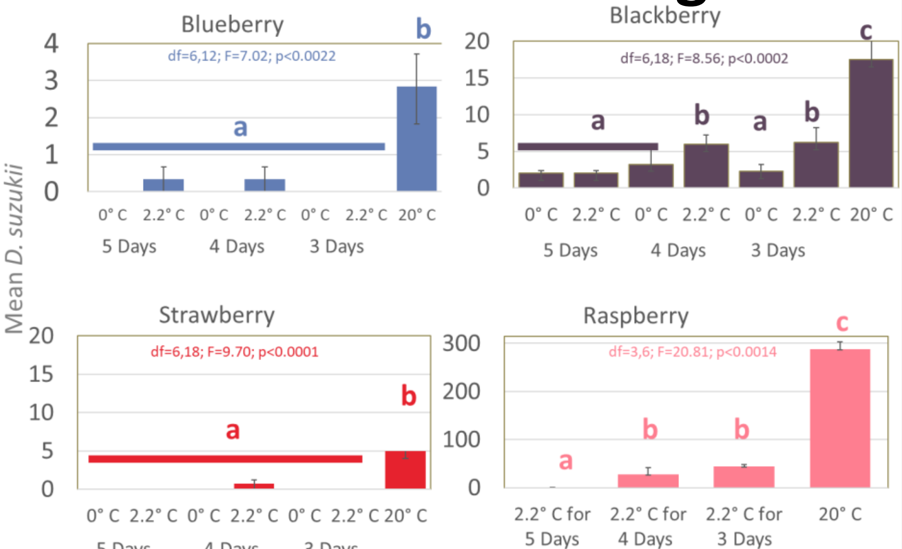


Some variation in time to stop development dependent upon temperature, life stage of SWD, and fruit type

Alys et al. 2016 *J. Econ. Entomol.*; Burrack lab NC State

Post Harvest Cold Storage

Organic SWD Management



0°C = 32°F

2.2°C = 36°F

20°C = 68°F

Alys et al. 2016 *J. Econ. Entomol.*; Burrack lab NC State

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Cultural Controls for SWD

Organic SWD Management

FACTORS AFFECTING SWD ENVIRONMENT SUITABILITY

1 - Netting
2 - Irrigation type
3 - Presence of weed mat
4 - Pruning intensity
5 - Harvest frequency
6 - Refrigeration

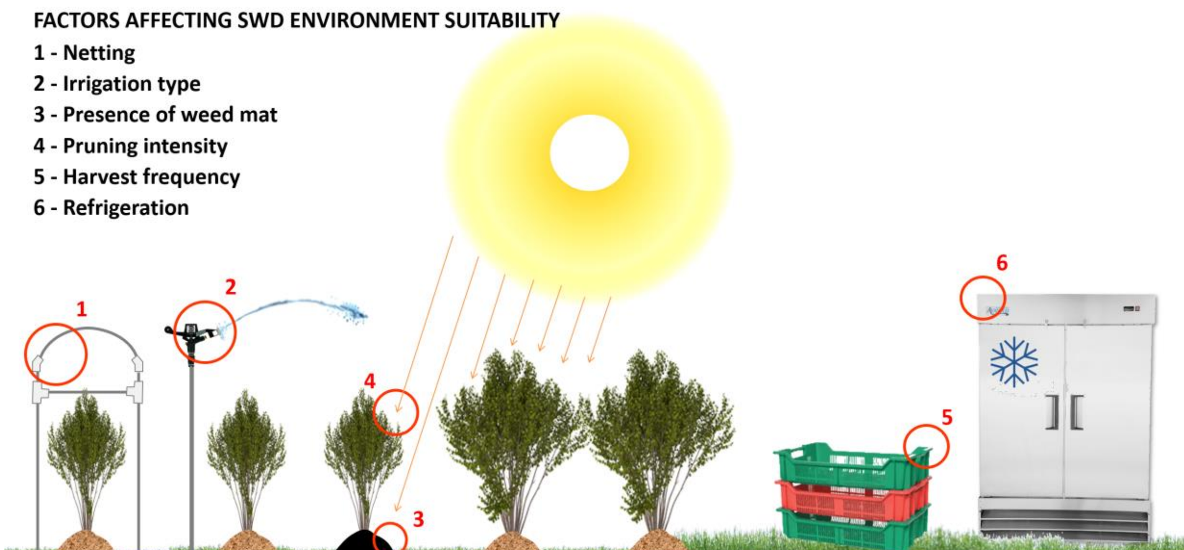

Illustration: Marco Rossi-Stacconi, © OSU

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Organic SWD Management

Objective 3 – Biological Controls

- Review of 75+ papers
- Open access in *Journal of Integrated Pest Management*
- 3 pg Extension bulletin, Oregon SU EM 9269


Journal of Integrated Pest Management, (2019) 10(1): 13; 1–9
doi: 10.1093/jipm/pmz012
Recommendations

OXFORD

Biological Control of Spotted-Wing Drosophila (Diptera: Drosophilidae)—Current and Pending Tactics

Jana C. Lee, Xingeng Wang, Kent M. Daane, Kim A. Hoelmer, Rufus Isaacs, Ashfaq A. Sial, and Vaughn M. Walton

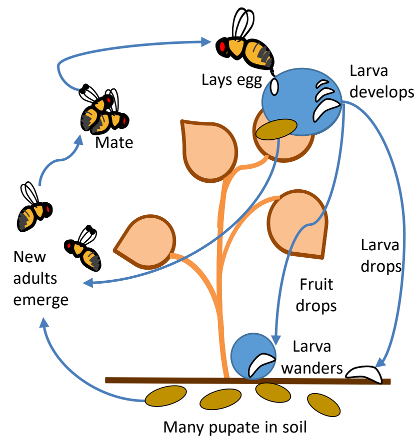

Fig 2, Lee et al. 2019

Organic SWD Management

What biocontrols are available?

- Review of 75+ papers
- Open access in *Journal of Integrated Pest Management*
- 3 pg Extension bulletin, Oregon SU EM 9269


Journal of Integrated Pest Management, (2019) 10(1): 13; 1–9
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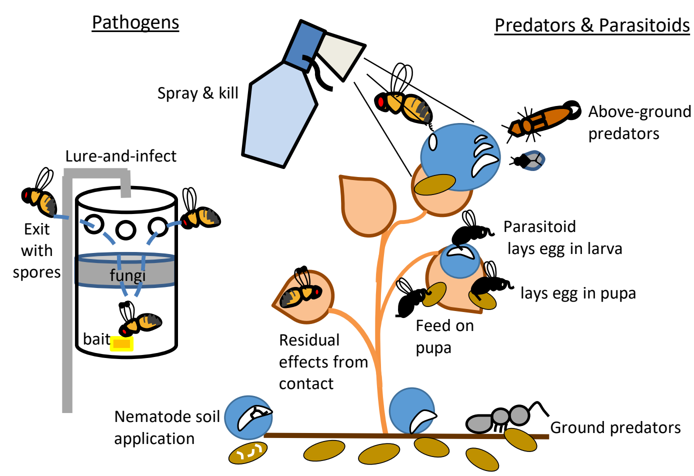

Organic SWD Management

Does something work?

Sortable Excel sheets, 75+ papers

Nematodes	Source	Arena	Delivery & Rate	SWD stage first exposed[1]	SWD location	Duration	Results [2]	Outcome	Reference
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: strawberry plant in 15 cm sandy dome	Pour 18,000 IJ in sand + 2 predator species	Eggs	In strawberry on sand	6 d	Ns larvae-pupae from control	no effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: strawberry plant in 15 cm sandy dome	Pour 27,000 IJ in sand + 1 predator species	Eggs	In strawberry on sand	6 d	~82% c-reduction of larvae-pupae for nema+*Orius* , ns for nema+beetle	effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: strawberry plant in 15 cm sandy dome	Pour 54,000 IJ in sand	Eggs	In strawberry on sand	6 d	Ns larvae-pupae from control	no effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: 15 cm sandy arena	Pour 18,000 IJ in sand + 2 predator species	Eggs	In blueberry on sand	6 d	~63% c-reduction of larvae-pupae	effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: 15 cm sandy arena	Pour 27,000 IJ in sand + 1 predator species	Eggs	In blueberry on sand	6 d	~60% c-reduction of larve-pupae for nema+*Orius* , ns for nema+beetle	effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	Nemasys®G, BASF	Lab: 15 cm sandy arena	Pour 54,000 IJ in sand	Eggs	In blueberry on sand	6 d	Ns larvae-pupae from control	no effect	Renkema & Cuthbertson 2018
Heterorhabditis bacteriophora	USDA Georgia lab	Lab: 1 oz cup	Pipette 125 or 150 µl 100 IJ/cm^2 over diet	Larvae 4 d old	In diet	12 d	No nematode infection	no effect	Woltz et al. 2015
Heterorhabditis bacteriophora	USDA Georgia lab	Lab: 1 oz cup	Pipette 500 µl 100 IJ/cm^2 over blueberry	Larvae 3 d old	In blueberry	12 d	No nematode infection	no effect	Woltz et al. 2015
Heterorhabditis bacteriophora	BASF	Lab: 9 cm Petri dish w/ sand	Add 10,000 IJ/ml	Pupae	On sand	14 d	~38% pupal c-mortality	effect	Cuthbertson & Audsley 2016
Heterorhabditis bacteriophora	BASF	Lab: 9 cm Petri dish w/ sand	Add 10,000 IJ/ml	Larvae 2nd instar	On sand	14 d	~94% pupal c-mortality	effect	Cuthbertson & Audsley 2016

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Organic SWD Management

Drosophilid parasitoid community in the USA

Pupal parasitoids:

Pachycrepoideus vindemiae (Pteromalidae)

Trichopria drosophilae (Diapriidae)

Larval parasitoids:

Leptopilina heterotoma

Leptopilina boulardi (Figitidae)

Asobara tabida (Braconidae)

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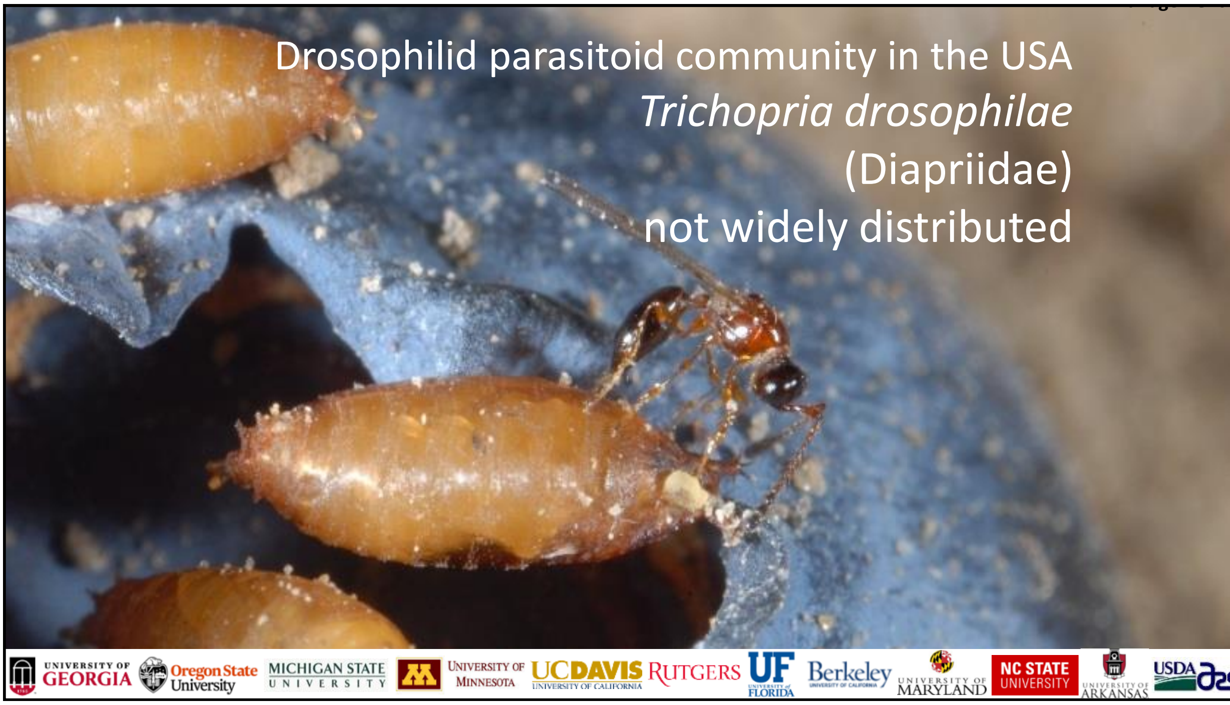

Drosophilid parasitoid community in the USA
Trichopria drosophilae
(Diapriidae)
not widely distributed

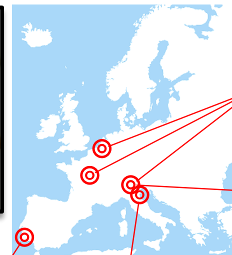

Organic
SWD
Management
Drosophilid parasitoid community in the USA
Pachycrepoideus vindemiae
(Pteromalidae)
widely distributed

Augmentation (or mass-release) of pupal parasitoids

Organic SWD Management

Inoculation ('seeding' a natural enemy into the habitat)
Inundation (releasing many natural enemies, more like bio-insecticide spray)

Muscidifurax raptor for flies in barns, stables, dairy



Biobest — 2018-19
- In Italy, problems with the parasitoid supply (late releases)
- Some encouraging results with the Augmentorium
- Biobest abandoned *T. drosophilae* production

Fondazione Edmund Mach — 2017
- **3000** parasitoids/Ha resulted in **30%** SWD infestation reduction in the surrounding areas (60 Ha).
- Releases were performed **weekly** during 7 weeks (April-May).
- Cost 100-120$ per Ha.

(Rossi Stacconi et al. 2019)

Driscoll's — 2018
- Trials conducted in Algarve
- Possible presence of chemical control
- No reduction in SWD

Università degli Studi di Padova — 2018-19
- Wide-area inoculative releases of *T. drosophilae* (regional level)
- No results available yet

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Augmentation (or mass-release) of pupal parasitoids

Organic SWD Management

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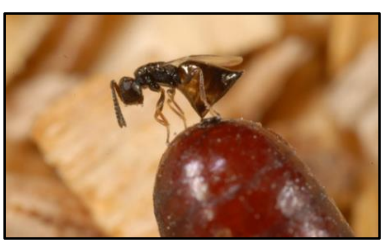
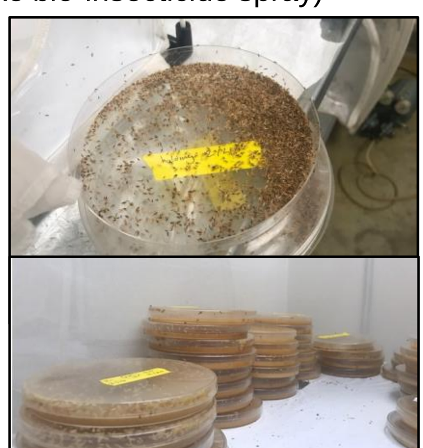


Muscidifurax raptor for flies in barns, stables, dairy

Ongoing studies in USA, but mass production methods are still relatively crude



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Organic SWD Management

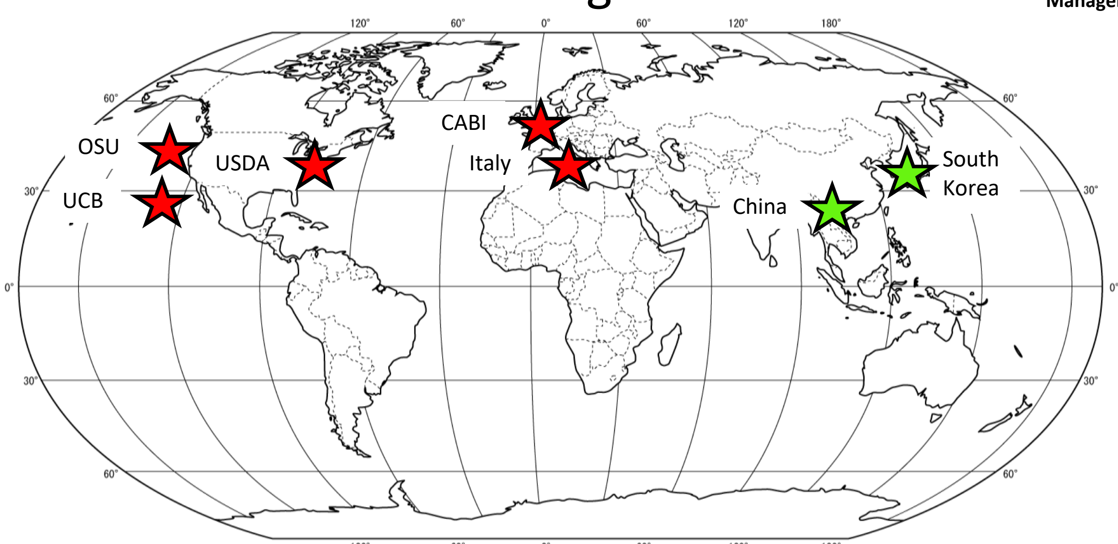
Summary: US Parasitoid Release Trials

Site	Release	Control ?
CA caneberry hoophouses	Tricho & Pachy 1,000+ per release	No diff, Tricho parasitism trended higher than control
OR caneberry hoophouses	~50 Pachy per wk & augmentorium box	Higher parasitism in release vs control sites, no diff in fruit infestation nor SWD adult in traps
OR wild blackberry borders	~50 Pachy per wk & augmentorium box	
MN raspberry hoophouses	500 per wk for 2 wk	No diff in SWD fruit infestation, release sites trended lower

Hogg USDA ARS & Daane UCB (CA), Lee USDA ARS (OR), Rogers UM (MN)

Organic SWD Management

Classical Biological Control



Multi-agency, Multi-national Program

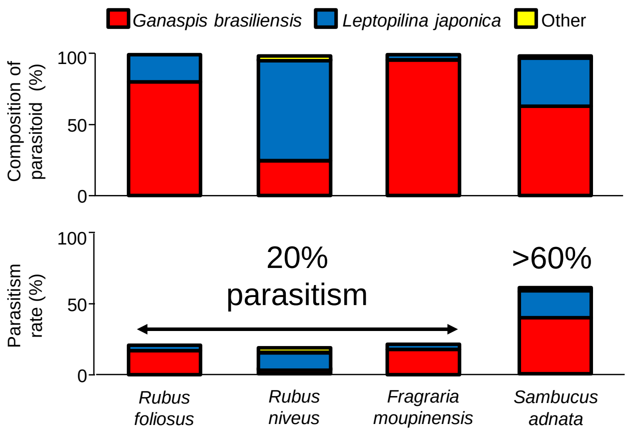
Organic SWD Management

Organic SWD Management

In both China and South Korea three important larval parasitoids attacked SWD: the 'figitids' were more common in early fruit and the 'braconid' was more common later in the season.

Organic SWD Management

Co-existence on different host plants



From Chinese collections (2016, 2017)

1) Determine if the Invasive Pest is a Target for Biocontrol

- 1a) Demonstrate targeted pest causes economic and/or ecological damage that will require long term management
- 1b) Develop arguments to justify biocontrol as a management strategy to suppress targeted pest populations
- 1c) Develop coalitions of stakeholders (i.e., home-owners, farmers, foresters) that support project initiation

2) Initiate a Biocontrol Program

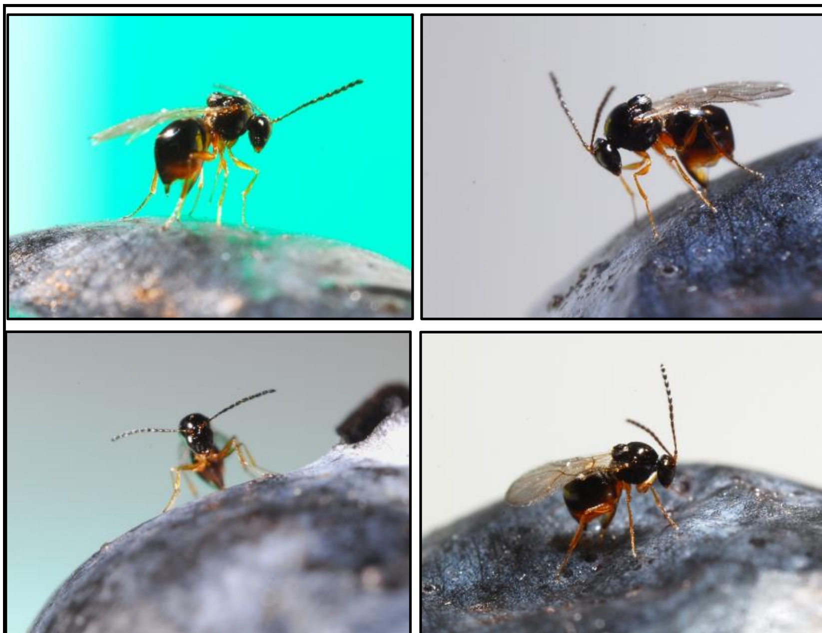
- 2a) Obtain funding, determine pest origin, develop plans to find, import, & screen biocontrol agents
- 2b) Form collaborations at pest's origin to assist with foreign exploration & ecological research
- 2c) Obtain permits to collect & import natural enemies to quarantine
- 2d) Initiate logistical arrangements for travel, search & collection of natural enemies

3) Search, Discover and Screen Natural Enemies

- 3a) Conduct exploration & identification of natural enemies, establish colonies
- 3b) In quarantine test host specificity, host range, efficacy & biology
- 3c) Agent shows no promise and new natural enemies are sought or agent shows promise but additional quarantine studies requested
- 3d) Agent shows promise and release permit is prepared and issued

4) Release and Evaluate Approved Natural Enemies

- 4a) Mass production and release of approved natural enemies
- 4b) Evaluate efficacy & establishment at release sites and biology in released area
- 4c) Evaluate natural enemy's establishment, spread, and biological & economic impact
- 4d) Prepare/publish reports for stakeholder, scientific, economic, regulatory & public audiences



Summary

Organic SWD Management

USDA APHIS petition review is almost complete.

The "G1 strain" of *Ganaspis brasiliensis* will be released.

G1 is found in South Korea, Japan, China, and Canada!

Still to do is to improve mass production methods, determine differences among Gb strains, and initiate release & evaluation

Objective 4 – Chemical Control

Craig Roubos
UGA

Organic SWD Management

- Spinosad (Entrust® SC) is currently the most effective insecticide for organic growers.
- Label restrictions and the risk of insecticide resistance require rotational products.

Entrust® SC Label Restrictions by Crop

Crop	Blueberry	Raspberry, Blackberry	Strawberry	Stone Fruit
Application Rate	4-6 fl oz/acre	4-6 fl oz/acre	4-6 fl oz/acre	4-8 fl oz/acre
PHI	3 days	1 days	1 days	7 days
Retreatment Interval	6 days	5 days	5 days	7 days
Max Amount	29 fl oz per year	29 fl oz per year	29 fl oz per year	29 fl oz per year
Max No. Applications	6 per year	6 per year	5 per year	3 per year

Source:
http://msue.anr.msu.edu/uploads/resources/pdfs/MSU_Organic_SWD_factsheet_Dec2016.pdf

Spinosad Resistance in California

Organic SWD Management

$$\text{Resistance ratio (RR)} = \frac{\text{resistant } LC_{50}}{\text{susceptible } LC_{50}}$$

Lethal concentrations

	LC_{50} (6hr)	RR (6hr)	LC_{50} (8hr)	RR (8hr)
Wolfskill	46.1	1	29.4	1
Watsonville	354.6	7.7	152.6	5.2
Post-selection	423.6	9.2	227.6	7.7

Watsonville LC_{50} 12-22 times higher than MI population

First location SWD was reported in North America

Gress & Zalom (2018) *Pest Management Science*

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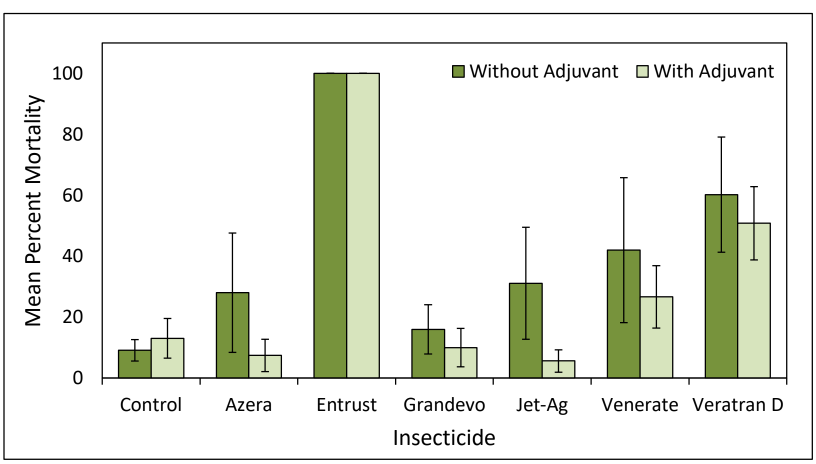
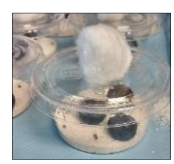
Insecticide Evaluation - laboratory

Organic SWD Management





- Fruit dip assay from Georgia
- Adjuvant: Nu Film P

None of the other products were as effective as Entrust

No effect of adjuvant

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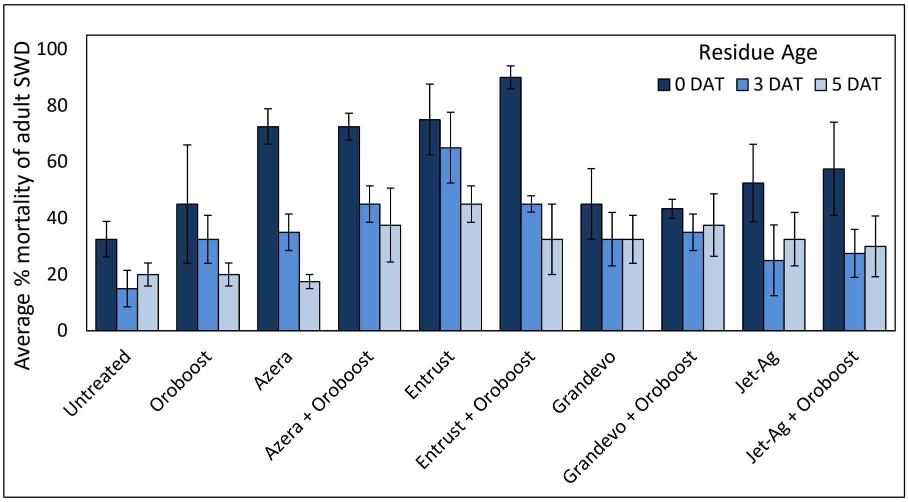
Organic SWD Management

Insecticide Evaluation - field



- Semi-field bioassay from Florida (Southern Highbush Blueberry)
- Adjuvant: Oroboost

Highest mortality with Entrust and Azera

Minimal benefit of adjuvant

Organic SWD Management

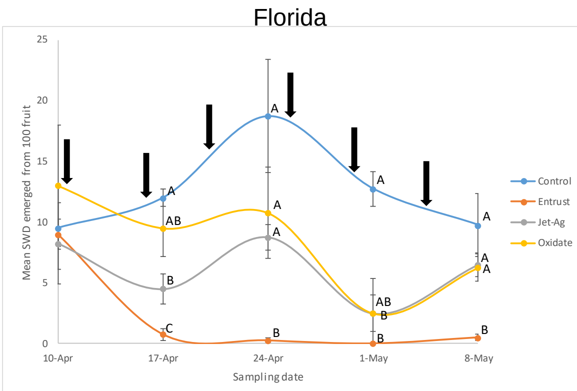
Evaluation of Sterilants

- Sterilants
  - Products containing hydrogen peroxide and peroxyacetic acid
  - Used as fungicides
- Hypothesis
  - Sterilants affect SWD's ability to infest fruit by disrupting the naturally occurring fungi and yeasts on fruit

Photo by S.J. Wold-Burkness https://www.fruitedge.umn.edu/82317swd

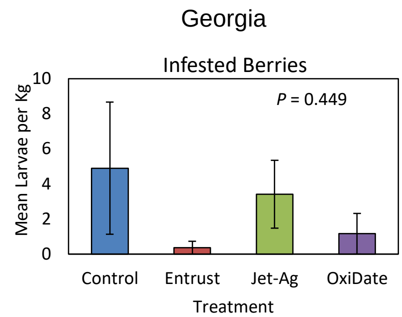
Evaluation of Sterilants

Organic SWD Management



- Mean adult emergence/100 berries for 4 weeks
- 6 pesticide applications indicated by arrows

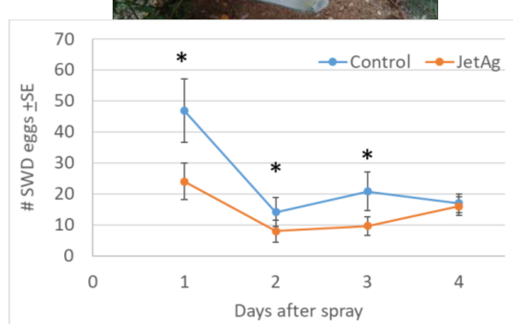
- Small plot trials in Florida and Georgia
  - Repeated applications of sterilants
  - Compared with Entrust



Evaluation of Sterilants

Organic SWD Management

Oviposition on Treated Berries
- USDA, Corvalis, OR
- Pre-bagged berry to prevent natural infestation
  - → spray Jet-Ag/control
  - → bag again with SWD for 1 d
  - → count eggs laid
- Other bags had SWD introduced the 2nd-4th day, 10 reps/treatment/day
- Sprayed berries had fewer eggs laid in them



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Organic SWD Management

Evaluation of Sterilants

- Field trial with blackberries
  - University of Maryland
  - Blackberries sampled before and after (24 hrs) Jet-Ag® application
  - Fruit fungal community was sampled and identified

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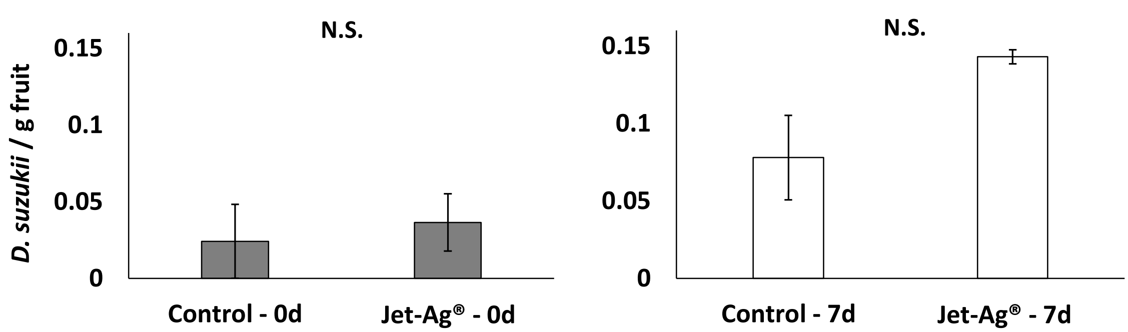
Organic SWD Management

Evaluation of Sterilants - blackberry

Application date: 08/01/19

$F_{(1,4)} = 3.3$; $P = 0.14$; $N = 2$



- No significant differences on SWD infestation between Control and Jet-Ag®
- Repeated in October 2019: same trend

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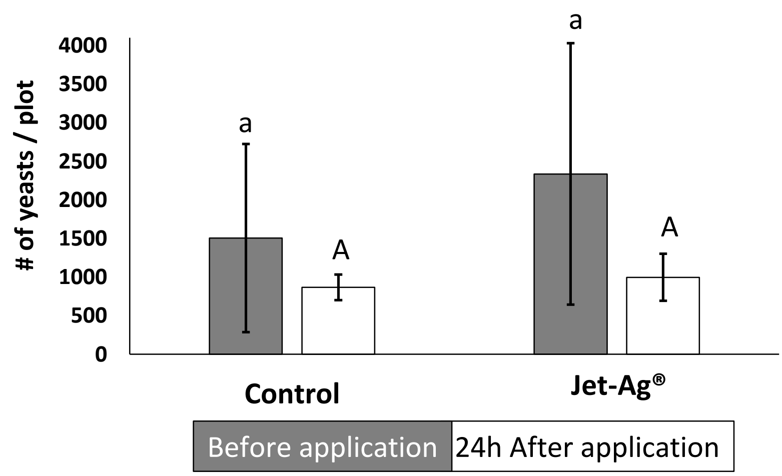
Evaluation of Sterilants - blackberry

Organic SWD Management

Application date: 08/01/19

$F_{(1,70)} = 1.28$; $P = 0.262$; $N = 2$



- No significant differences between Control and Jet-Ag® before AND after application
- Reduction and reduced variability of yeasts after application

Evaluation of Sterilants - blackberry

Organic SWD Management

Control before application	JetAg before application	Control after application	JetAg after application
Aureobasidium			
Candida	*Candida*	*Candida*	*Candida*
	Clavispora		
Cryptococcus		*Cryptococcus*	***Cryptococcus***
	Curvibasidium	***Curvibasidium***	*Curvibasidium*
Filobasidium	*Filobasidium*		
Geotrichum	*Geotrichum*		
Hanseniaspora	*Hanseniaspora*	*Hanseniaspora*	*Hanseniaspora*
		Kodamaea	
Kurtzmaniella		*Kurtzmaniella*	
Malassezia	*Malassezia*	*Malassezia*	*Malassezia*
Metschnikowia	*Metschnikowia*	*Metschnikowia*	*Metschnikowia*
	Moesziomyces		
	Papiliotrema		
Pichia	*Pichia*	*Pichia*	
Saccharomyces			
Sporidiobolus			
	Sporobolomyces		
		Wickerhamiella	***Wickerhamiella***

Application date: 08/01/2019

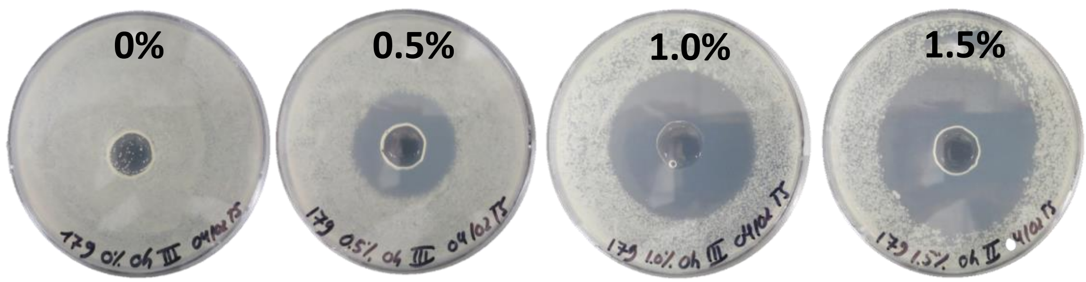
underlined = genus only found before application
bold = genus only found after application

Slight changes in the yeast community after JetAg® application

Organic SWD Management

Evaluation of Sterilants – blackberry

- Efficacy against yeasts was shown in agar plug diffusion assays (Van Timmeren et al. 2019)
- Potential coverage issue on blackberries?
- Lab experiments are planned to check yeast control on blackberries



Organic SWD Management

Chemical Control – Summary

- There is a need to find alternatives to spinosad (Entrust SC)
- Insecticide resistance has been documented in California. Other states should continue monitoring for insecticide resistance.
- Sterilants are being used with some success at reducing SWD infestation
  - We saw differences in efficacy among study sites
  - No differences in total yeast abundance, but slight changes in yeast community
  - How these products work still needs to be determined

Organic SWD Management

CONCLUSIONS

BEHAVIORAL STRATEGIES:

- SPLAT reduced SWD fruit infestation at lower SWD population densities which makes it a useful early season tool
- Food grade gum reduced SWD fruit infestation for up to 21 days. However, efficacy decreased further away from the point source.

CULTURAL STRATEGIES:

- If installed appropriately, physical exclusion using mesh netting <1 mm can provide 100% control of SWD
- Using black weedmat reduces SWD survivorship and fruit infestation
- Heavy pruning increases temperature and decreases humidity in the canopy leading to lower SWD fruit infestation
- Frequent harvests and properly removing & destroying fruit cull reduce the risk of fruit infestation
- If infested, postharvest refrigeration (32-36°F) can kill larvae inside the fruit

Organic SWD Management

CONCLUSIONS

BIOLOGICAL CONTROL:

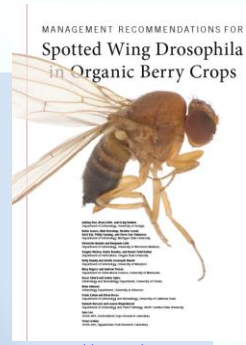
- Native parasitoids are not effective in reducing SWD infestation
- Exotic parasitoids have shown promise in initial lab studies. Once USDA APHIS petition is approved, they will be evaluated and released in the field.

CHEMICAL CONTROL:

- Entrust remains the most effective option of organic SWD control, and other materials including Grandevo, PyGanic, and Azera should be used in rotations
- Resistance to Entrust has been documented in California, and other regions should continue monitoring
- Sterilants such as Jet Ag and Oxidate were effective in reducing SWD fruit infestation in some regions
- While their exact mode of action is unclear, initial studies showed no differences in total yeast abundance, but slight changes in yeast community

Organic SWD Management

Online resources



https://bit.ly/2Lvzy14

Project website
http://eorganic.info/spottedwingorganic
SWD*IPM (western region)
spottedwing.org
NC IPM Center (factsheets)
ncipmc.org
NE IPM Center
SWD Working Group

Arkansas Interactive Budgets for Fruit Crops
http://cars.uark.edu/ourwork/Specialty-Crop-Production-and-Marketing/fruit_budget.aspx

Georgia
blog.caes.uga.edu/blueberry/
Michigan
www.ipm.msu.edu/SWD.htm
North Carolina
swd.ces.ncsu.edu
Minnesota
http://www.fruitedge.umn.edu
Florida
http://entomology.ifas.ufl.edu/liburd/fruitnvegipm/index.htm

Organic SWD Management

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Oregon Blueberry Commission

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USDA NWCSFR Oregon State Blueberry Commission
Washington State Blueberry Commission
Washington State Red Raspberry Commission Washington State Strawberry Commission
Washington State Commission on Pesticide Registration
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Organic SWD Management

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