


Developing a management strategy for spotted wing drosophila in blueberries

Hannah Joy Burrack
Department of Entomology

entomology.ces.ncsu.edu
facebook.com/NCSmallFruitIPM
@NCSmallFruitIPM

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Strategies for spotted wing drosophila managment

Understand when fruit are at risk

Fly presence and fruit susceptibility

Know which tools will protect fruit

Effective insecticides with appropriate PHIs

Manage harvest for optimal control

Consider post harvest management strategies

Strategies for spotted wing drosophila managment

Understand when fruit are at risk

Fly presence and fruit susceptibility

Know which tools will protect fruit

Effective insecticides with appropriate PHIs

Manage harvest for optimal control

Consider post harvest management strategies

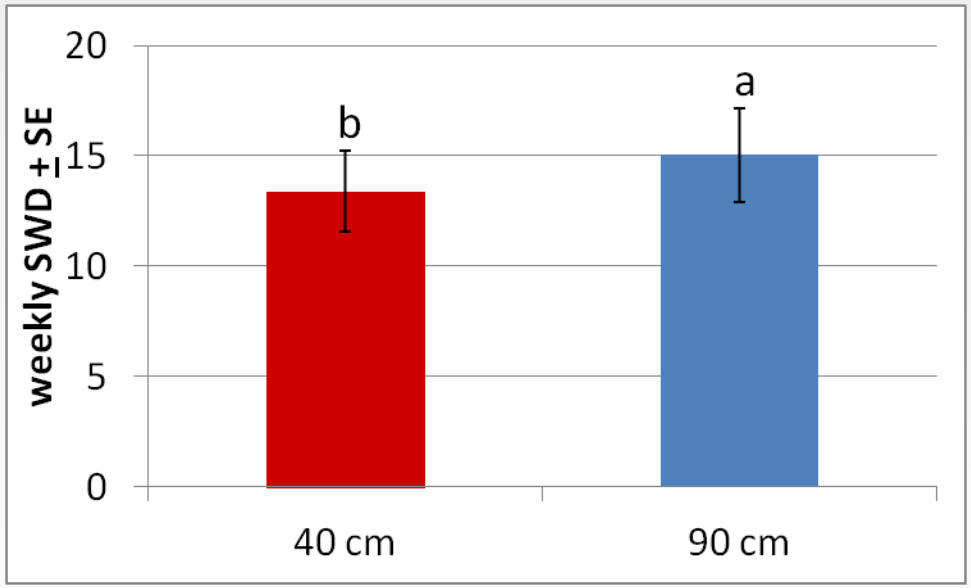
NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Monitoring methods – Trap design

Monitoring tools – Trap design

Trap comparisons conducted at 16 sites in 7 states/provinces during 2012

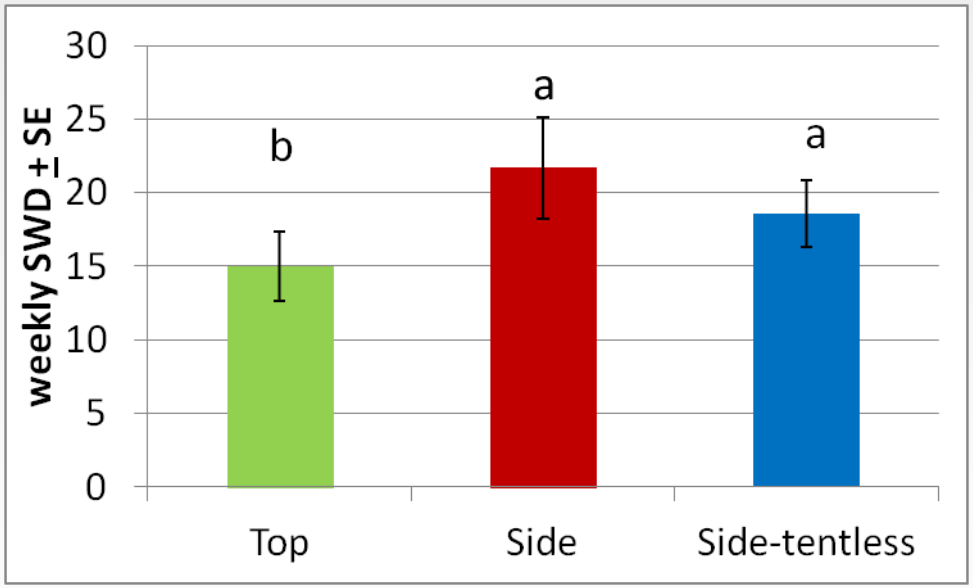


Coordinated by Jana Lee, USDA ARS

Traps with greater bait surface area caught 12% more flies

Monitoring tools – Trap design

Trap comparisons conducted at 16 sites in 7 states/provinces during 2012



Coordinated by Jana Lee, USDA ARS

Traps with side entries caught more flies

Treatment 1
Apple cider vinegar + soap

Treatment 2
Yeast & sugar solution

Treatment 3
Fermenting bait plus ACV

Treatment 4
Droskidrink

Treatment 5
Synthetic lures over ACV

Treatment 6
Synthetic lures over drowning solution

Methods

10 states

Sites in blueberries, caneberries, or grapes

No SWD were captured in strawberry plots

6 treatments

Traps check, lures changed weekly

Male and female SWD and non SWD Drosophilids counted

Statistical analyses

Mixed model ANOVA via SAS Proc Mixed

For pooled data: state, week, and crop = random effects

Trap capture data were log transformed and proportion data were arcsine square root transformed to improve normality.

Satterwaite estimation was used to calculate degrees of freedom due to heteroscedasticity.

Pairwise comparisons of the adjusted means were conducted using the Games-Howell adjustment.

NC STATE UNIVERSITY MICHIGAN STATE UNIVERSITY THE UNIVERSITY OF MAINE RUTGERS Oregon State UNIVERSITY UNIVERSITY OF MINNESOTA Driven to Discover UNIVERSITY OF ARKANSAS Cornell University USDA WISCONSIN

Treatment 1
Apple cider vinegar + soap

150 ml of ACV, 4 ml soap/gal

Treatment 2
Yeast & sugar solution

2 Tbsp yeast, 8 Tbsp sugar, 24 fl oz water, 0.76 ml unscented soap

Treatment 3
Fermenting bait in ACV

69 g whole wheat flour, 8 g sugar, 1.3 g yeast, 4 ml ACV, 100 ml water (4 fl oz per trap) *floating in* 150 ml of a solution of 600 ml, 67 ml 95% ethanol, 3.3 ml soap

Treatment 4
Droskidrink

150 ml of a solution of 450 ml ACV, 150 ml red wine, 12 g muscavado sugar

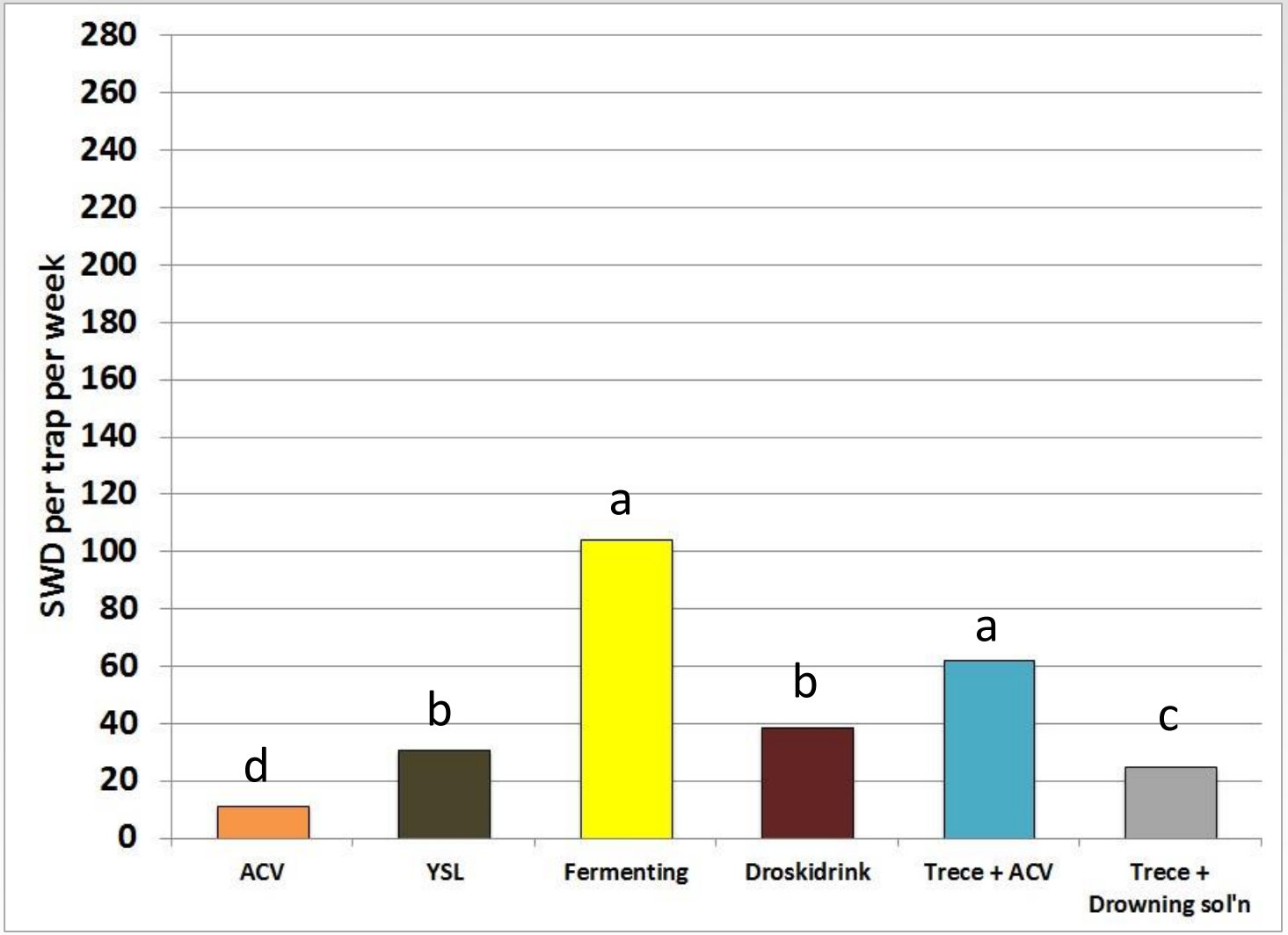
Treatment 5
Synthetic lures over ACV

150 ml of ACV, 4 ml soap/gal

Treatment 6
Synthetic lures over drowning solution

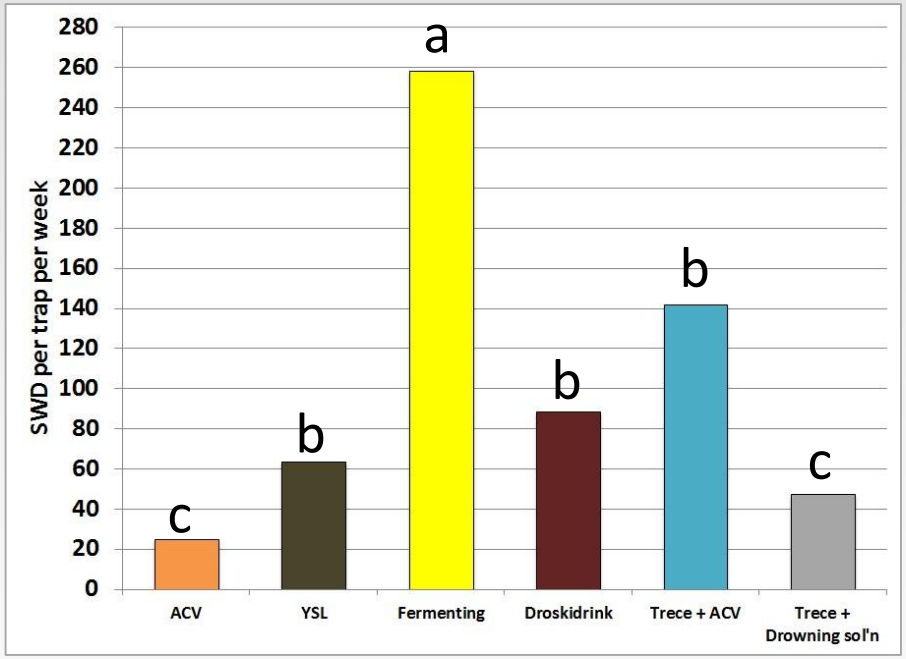
150 ml of a solution of 600 ml water, 6 g borax, and 0.24 ml soap

1. Fermenting bait and synthetic lures over ACV captured more flies when all states and crops were pooled

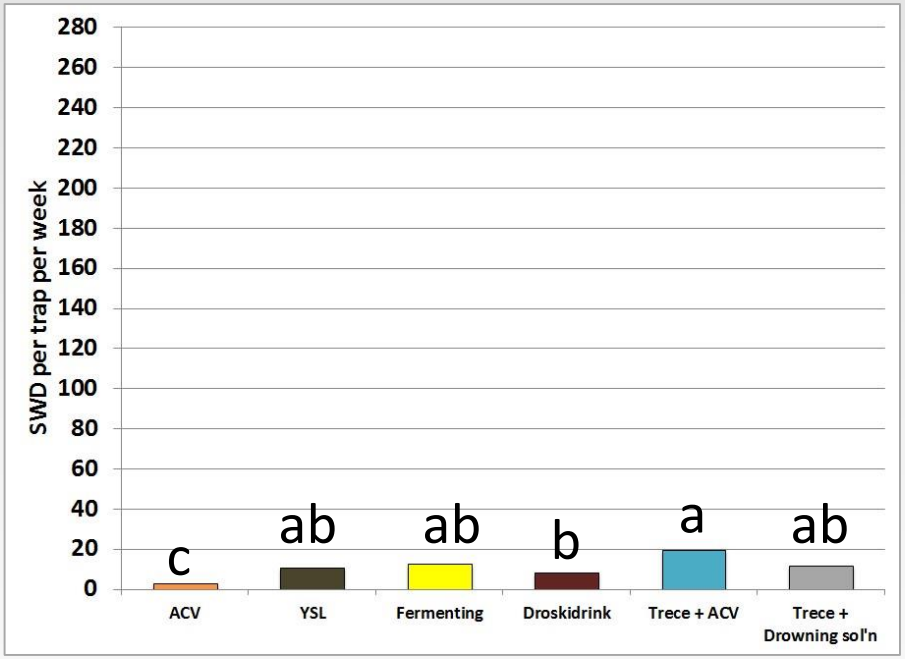


F = 89.57; df = 5, 1937; p < 0.0001

2. More flies were captured in caneberry sites, and fermenting bait was more attractive than synthetic lure over ACV in caneberries.



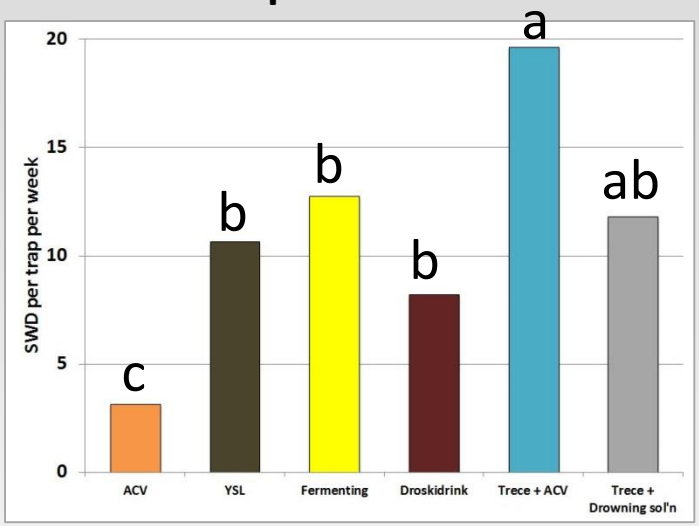
Caneberry sites



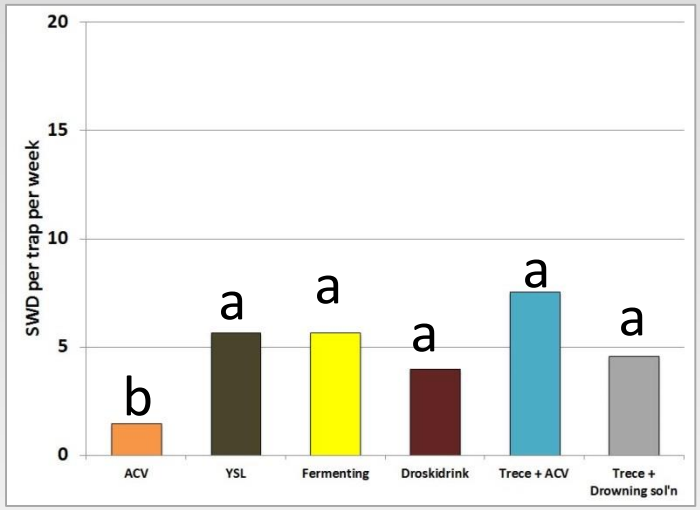
Blueberry sites

$F_{crop*treatment} = 16.41$; df = 10, 1962; $p < 0.0001$

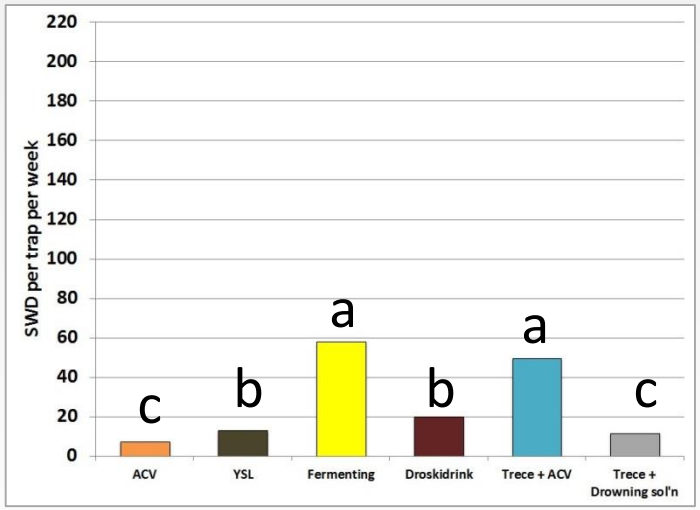
3. Relative captures between males and females differed between crops and baits.



Males, blueberry sites

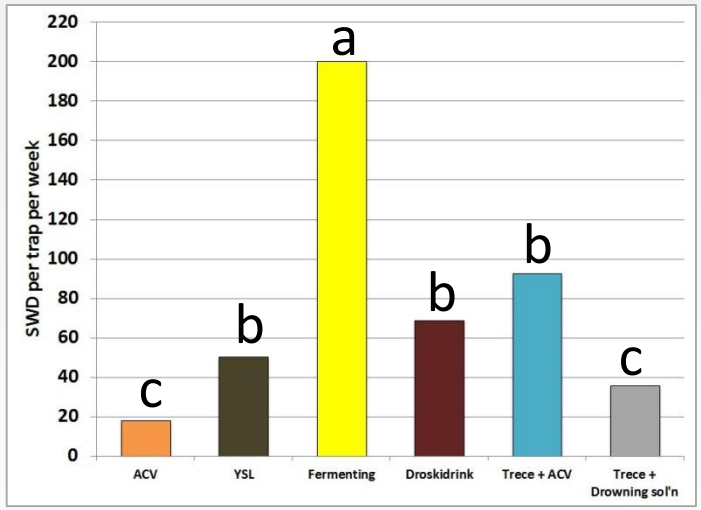


Females, blueberry sites



Males, caneberry sites

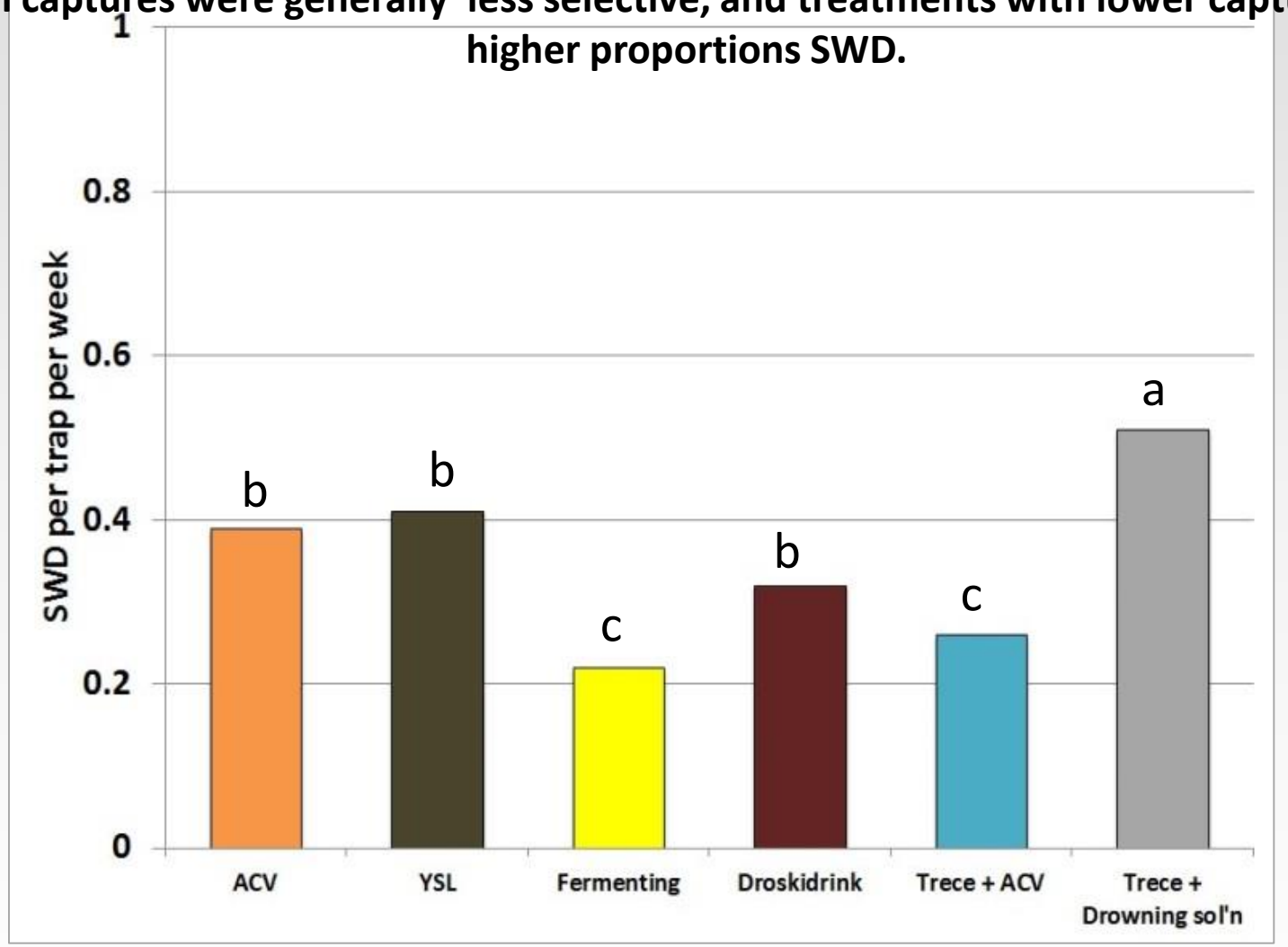
$F_{crop*treatment} = 13.64$; df = 10, 1962; $p < 0.0001$



Females, caneberry sites

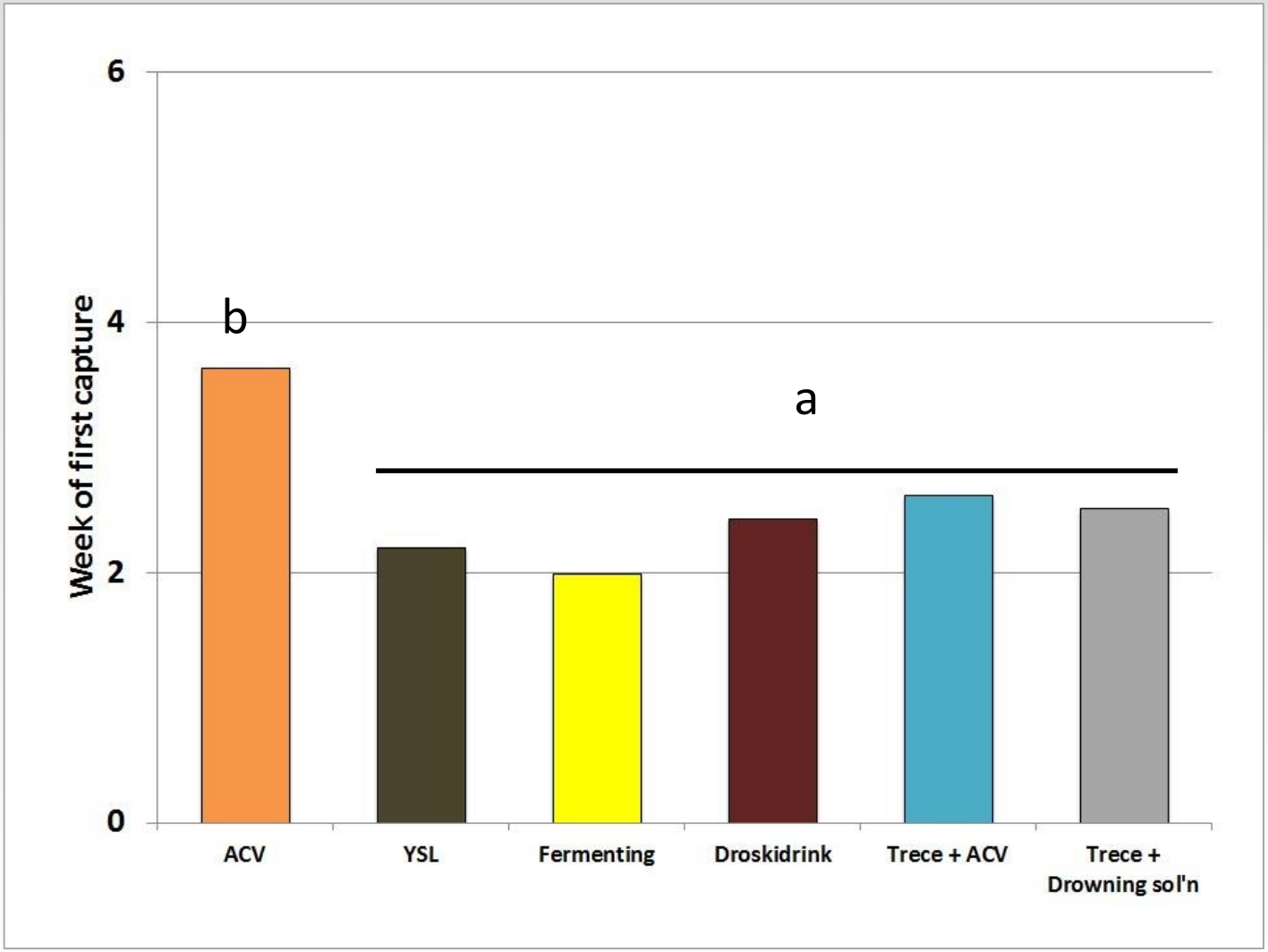
$F_{crop*treatment} = 18.43$; df = 10, 1962; $p < 0.0001$

4. None of the baits were highly selective for SWD, but ACV, YSL and synthetic lure over drowning solution generally caught a larger proportion of SWD. Treatments with high captures were generally less selective, and treatments with lower captures had higher proportions SWD.



Proportion SWD, pooled sites: $F = 71.96$; $df = 5, 1115$; $p < 0.0001$

5. All baits/lures captured flies earlier than ACV.



F = 12.47; df = 5, 138; p < 0.0001

General conclusions

Fermenting baits and synthetic lures over ACV were similar in total trap captures

Differences in attraction between sexes may impact bait efficiency between crops

Synthetic lures had higher trap captures in blueberries and generally had lower trap captures than caneberries

Baits or lures which captured large numbers of SWD may also capture larger numbers of non target insects

All baits captured flies 1 to 2 weeks earlier than ACV

Adult monitoring

Identification tools

Via: http://www.instructables.com/id/10-Smartphone-to-digital-microscope-conversion/

Because no trap/bait/lure combination is selective for SWD:

Be prepared to ID flies if you plan to trap!

© Matt Bertone 2013

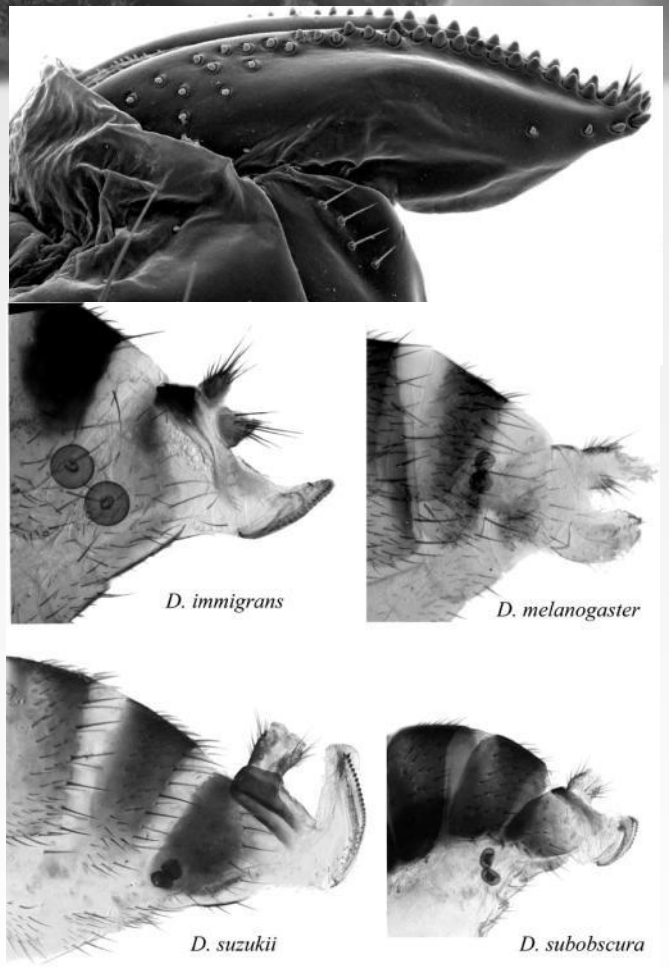
NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Adult monitoring

Identification tools

Via: http://www.instructables.com/id/10-Smartphone-to-digital-microscope-conversion/



(Hauser 2011, Pest Management Science)

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Monitoring tools – Traps and baits
Summary

No trap & bait combination has been demonstrated to consistently capture flies before infestation occurs or has been tested for tracking treatment efficacy

But some new baits/lures are promising

Trap captures indicate presence or absence

When SWD is active, preventative treatments should be applied if susceptible fruit is present

What are other ways growers can monitor SWD?

Monitoring tools – Fruit sampling

Fruit samples should be collected from each field/variety block at each harvest

A “salt test” is a quick way to assess larval presence
¼ cup salt dissolved 1 gal water
Poured over a thin layer of fruit
Larvae should be visible within 15 minutes

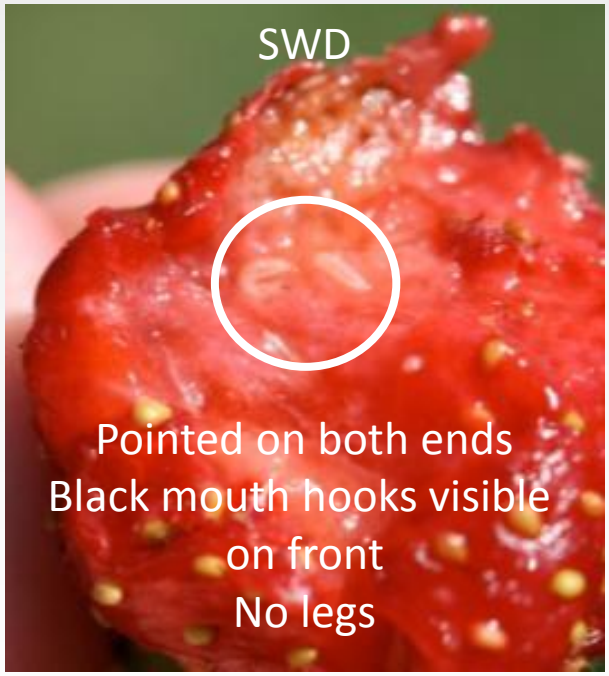
Salt tests may miss small larvae
Drosophila larvae cannot be distinguished by species – do not sample rotting fruit!

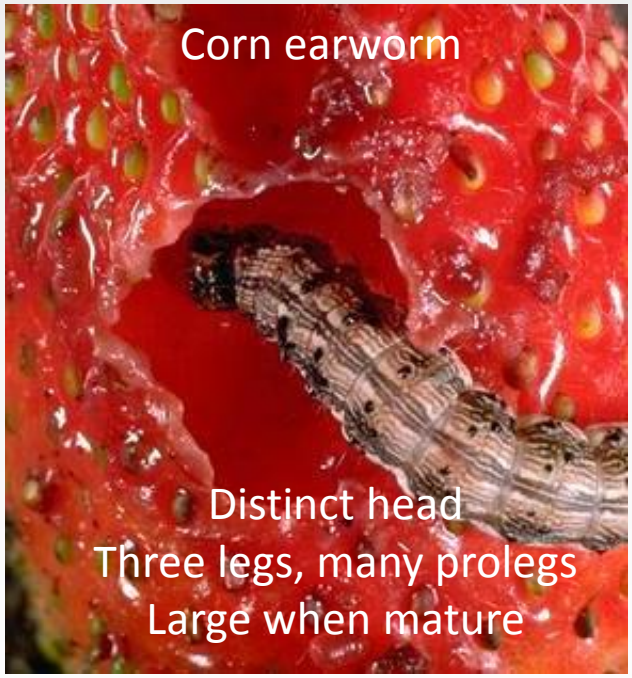
Monitoring tools – Fruit sampling

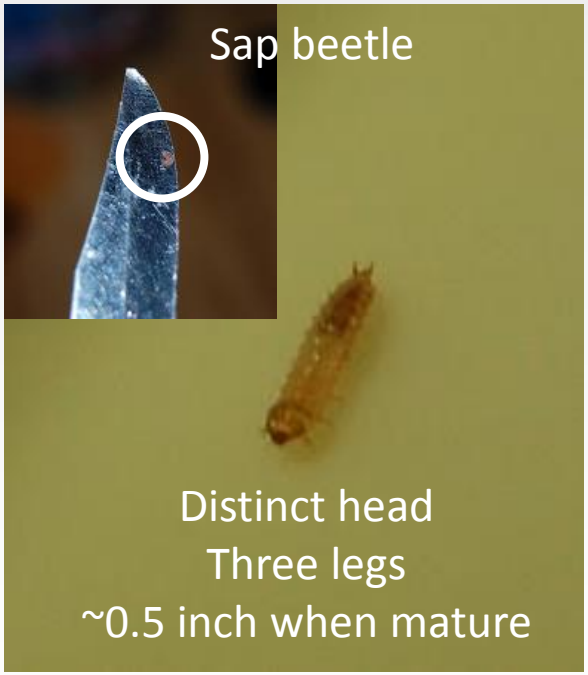
Insert video

Monitoring tools – Fruit sampling

Distinguishing SWD from other larvae present in strawberries





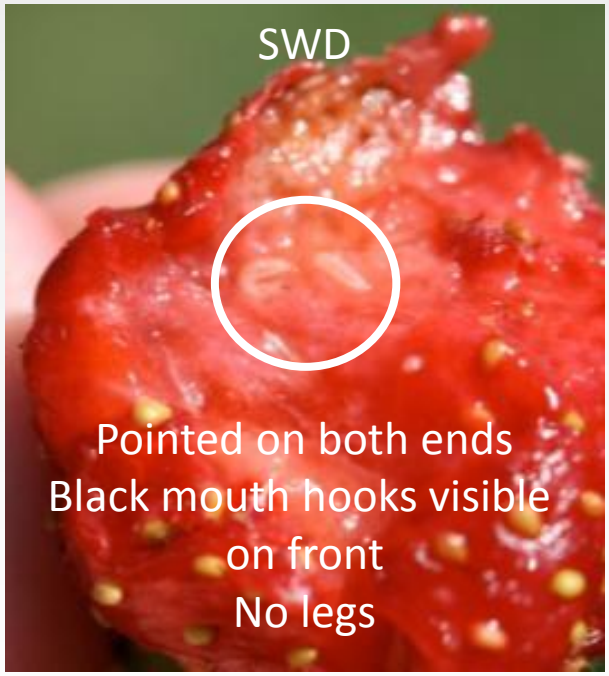


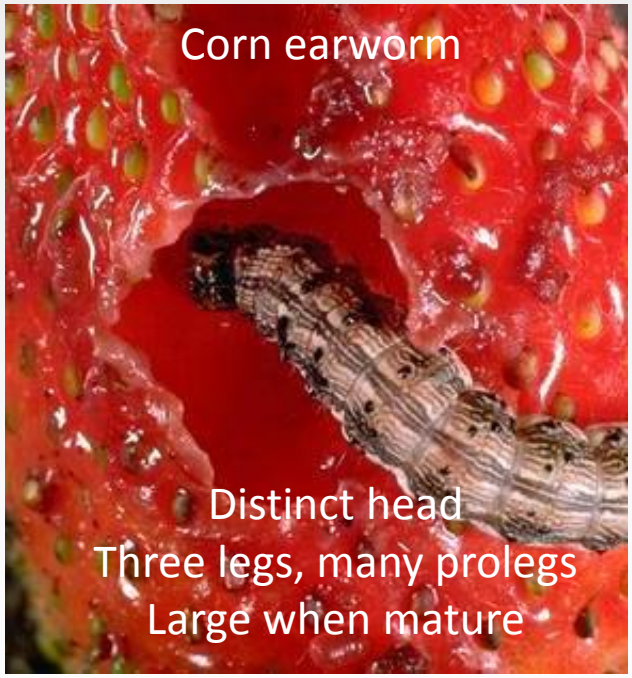
NC STATE UNIVERSITY

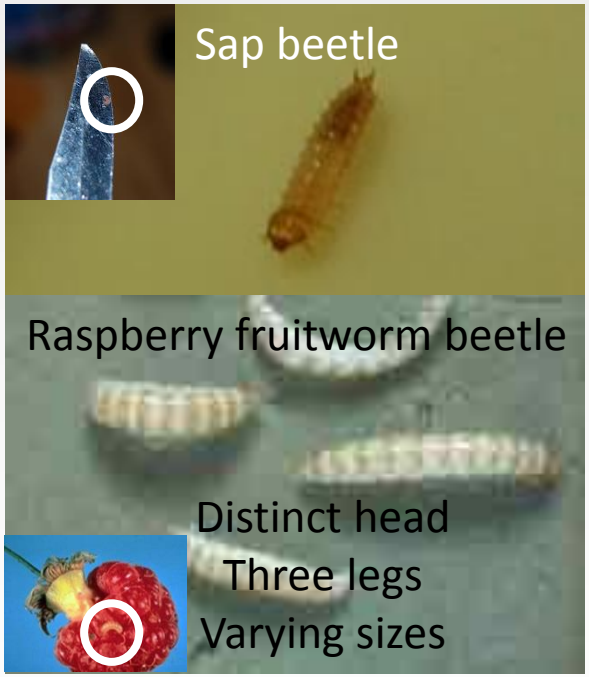
NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Monitoring tools – Fruit sampling

Distinguishing SWD from other larvae present in raspberries







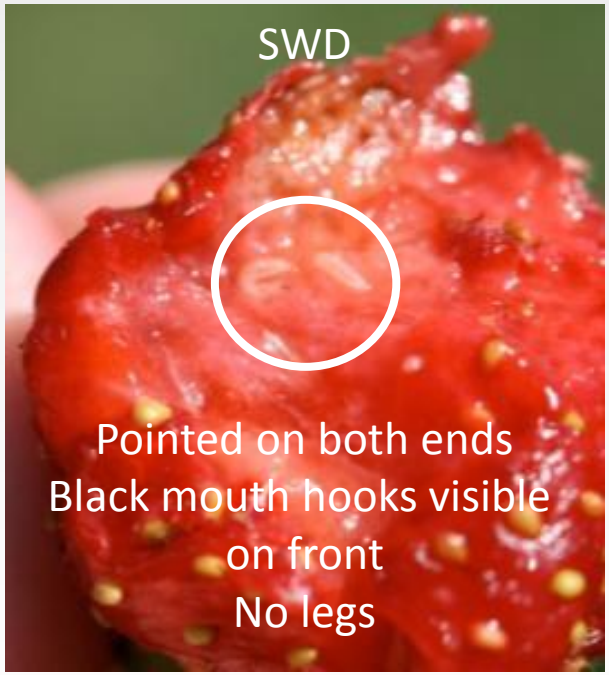
Fruitworm images via: http://www.berriesnw.com/
And http://www.fruit.cornell.edu/

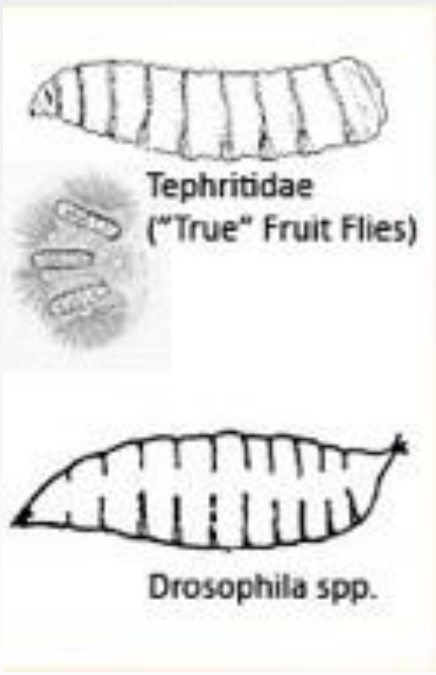
NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Monitoring tools – Fruit sampling

Distinguishing SWD from other larvae present in blueberries





Strategies for spotted wing drosophila managment

Understand when fruit are at risk

Fly presence and fruit susceptibility

Know which tools will protect fruit

Effective insecticides with appropriate PHIs

Manage harvest for optimal control

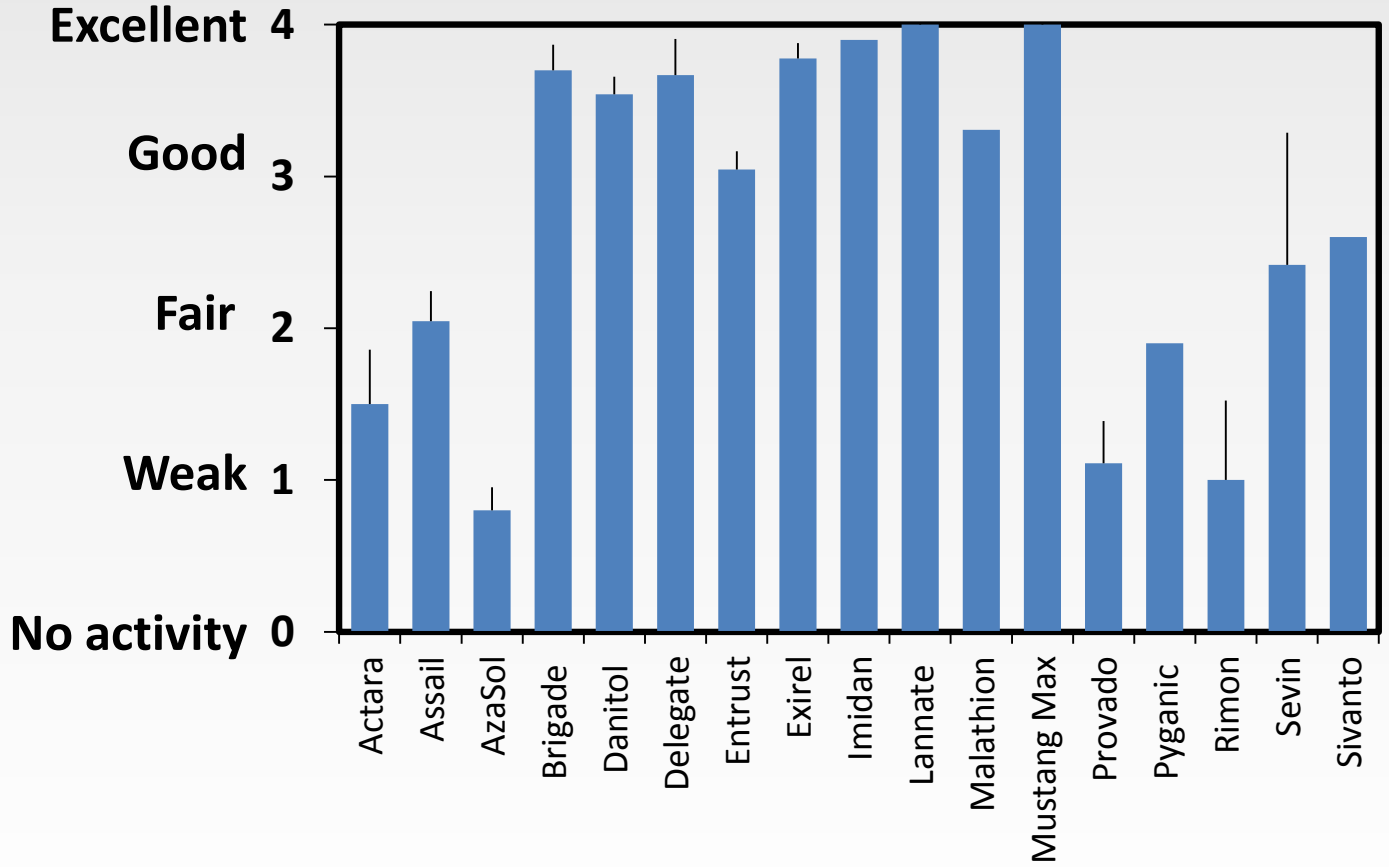
Consider post harvest management strategies

Management tools – Chemical controls

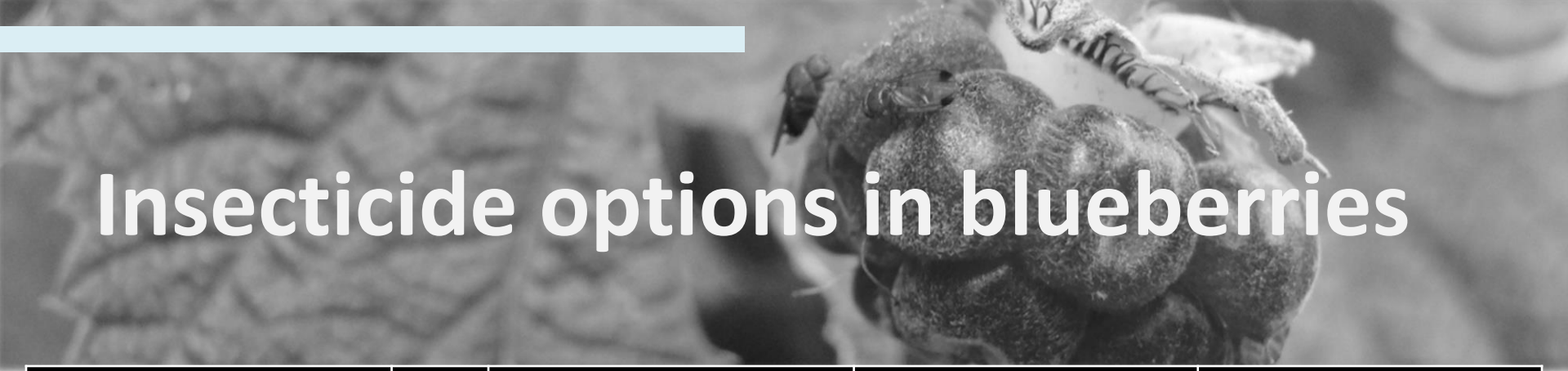
Entomologist's rankings from throughout the US, across crops

Materials with 4 or more responses summarized

Honorable mention (>3.5 score, fewer than 4 entries)
Asana, Bifenture, Diazinon, Dimethoate, Endigo, Hero, Warrior



MICHIGAN STATE UNIVERSITY



Insecticide options in blueberries

Active ingredient	PHI	Application limits	MRL in Canada?	Aerial application volume
Malathion	1	3 applications, ULV	Yes, 8 ppm	ULV: 10 fl oz
Zeta cypermethrin	1	25.8 oz, 7 applications	No	2 gpa
Phosmet	3	7.13 lb, 6 applications	Yes, 5 ppm (US 10 ppm)	5 gpa
Spinetoram	3	19.5 oz, 3 applications	Yes, 0.5 ppm	10 gpa
Methomyl	3	12 pt, 4 applications	Yes, 6 ppm	2 gpa
Bifenthrin	1	80 oz, 4 applications	No	2 gpa
Exirel*	3	0.4 lab AI, 3-4 applications	Yes, 4 ppm	10 or 30 gpa

Insecticide efficacy in blueberries

Field experiments

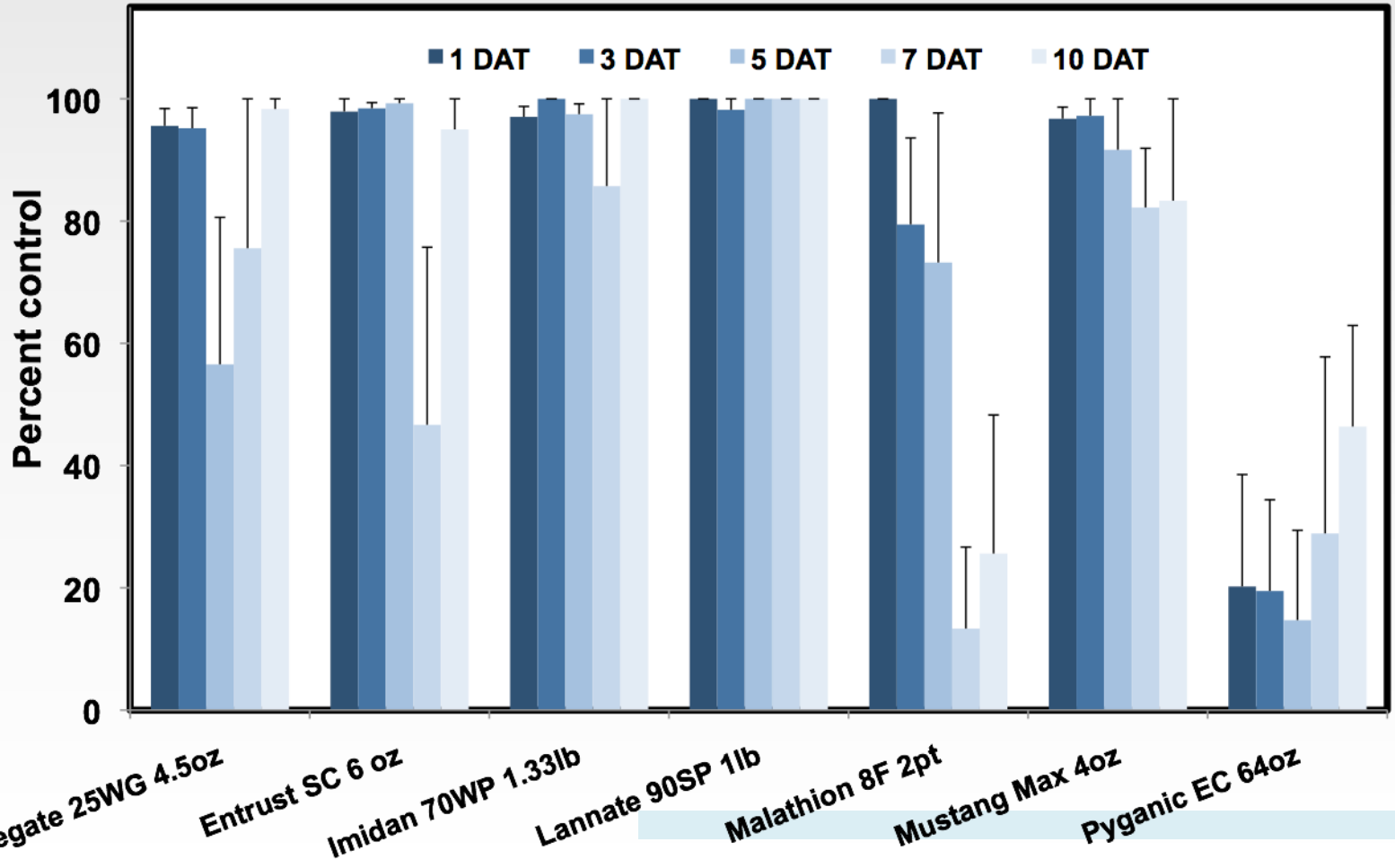
Rufus Isaacs, Michigan State University

Shoots with 20 leaves and 10 fruit picked at 1, 3, 5, 7, 10 DAT

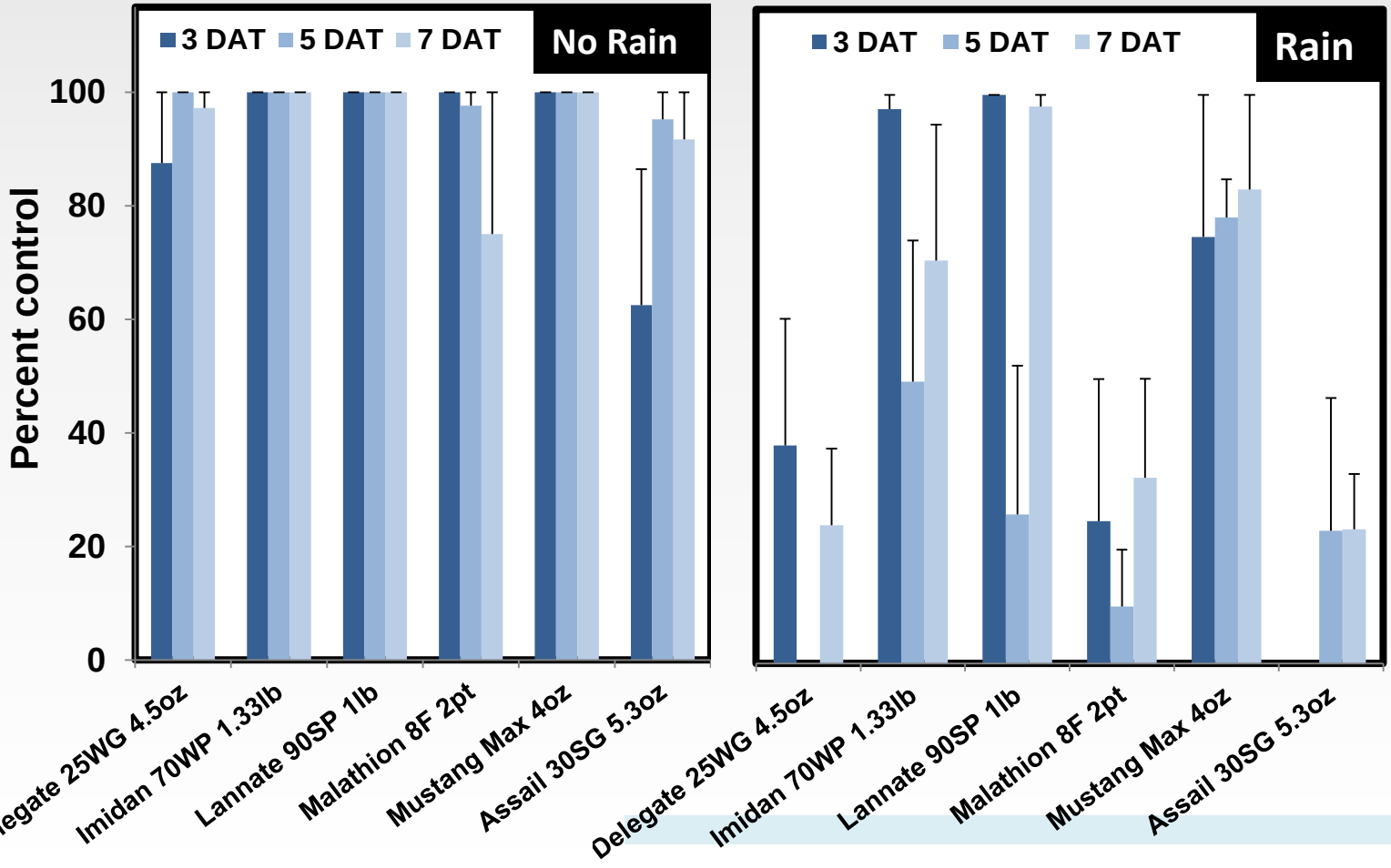
5 male, 5 female SWD for 7 d

Measured % fly mortality at 48 h, number of larvae after 9 days

Insecticide efficacy in blueberries



Insecticide efficacy in blueberries



MICHIGAN STATE UNIVERSITY

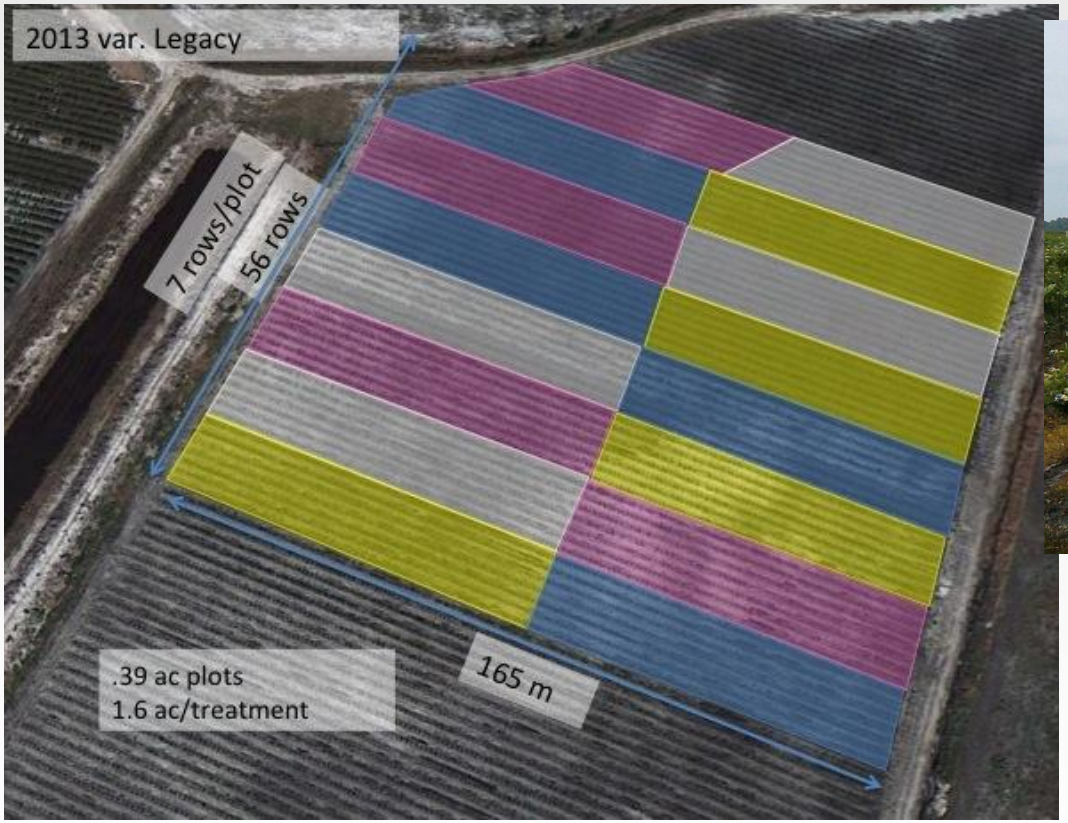
Season-long management programs

Treatment Number	Weekly rotation of Materials		
1. Export: Export “friendly”, maximum modes of action (MOA)	Imidan	phosmet	OP (1B)
	Malathion 8F	malathion	OP (1B)
	Delegate	spinetoram	spinosyn (5)
	Danitol	fenpropathrin	pyrethroid (3A)
2. ShortPHI: Short Preharvest Interval (1d PHI)	Mustang Max	zeta-cypermethrin	pyrethroid (3A)
	Malathion 8F	malathion	OP (1B)
3. Red.Risk: EPA Reduced Risk/OP Alternatives	Delegate	spinetoram	spinosyn (5)
	GA: Exirel	cyantraniliprole	ryanodine (28)
	NC: Assail	acetamiprid	neonicotinoid (4A)
4. UTC: Untreated Control			

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Season-long management programs

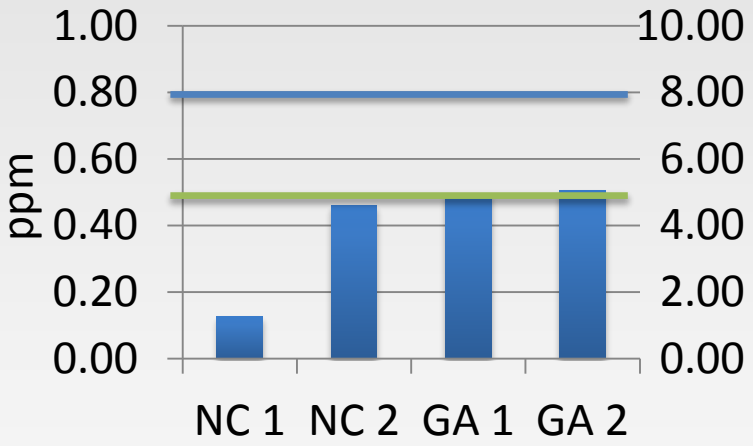


Large scale (0.25 to 1.00 acre) plots
Applications made with grower equipment

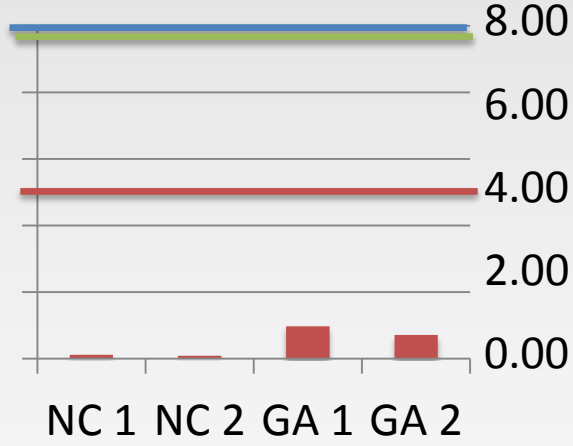
Maximum observed pesticide residues

Blueberries

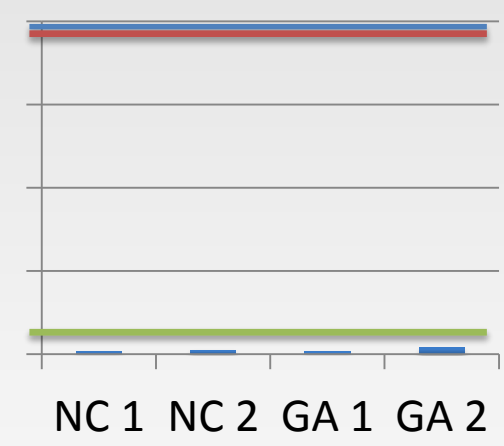
zeta-cypermethrin



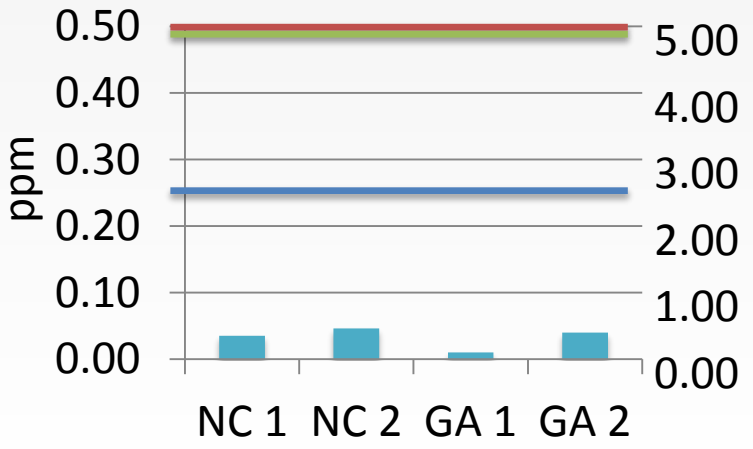
phosmet



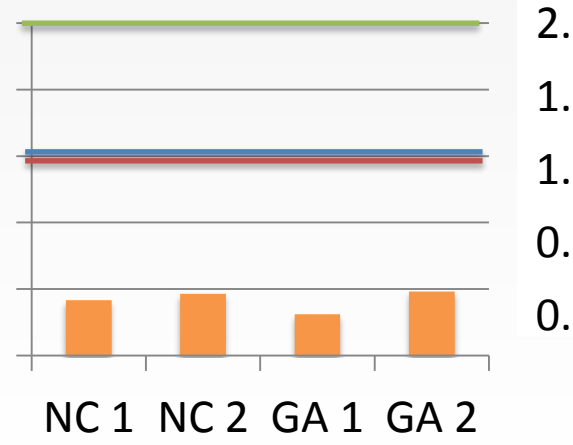
malathion



spinetoram

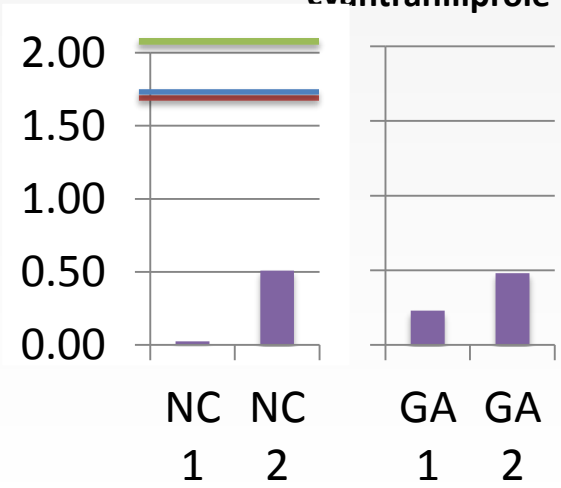


fenpropathrin

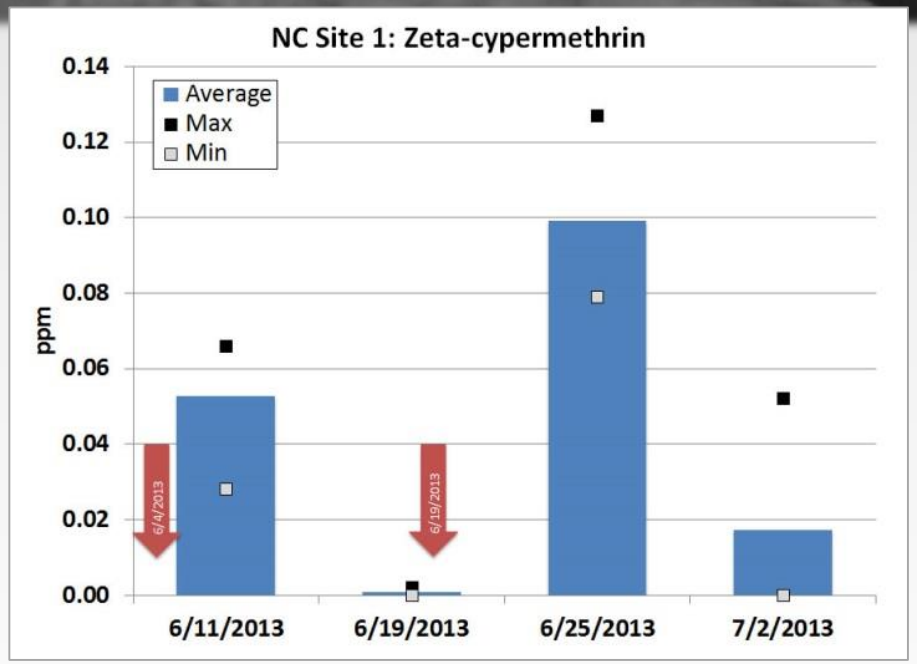


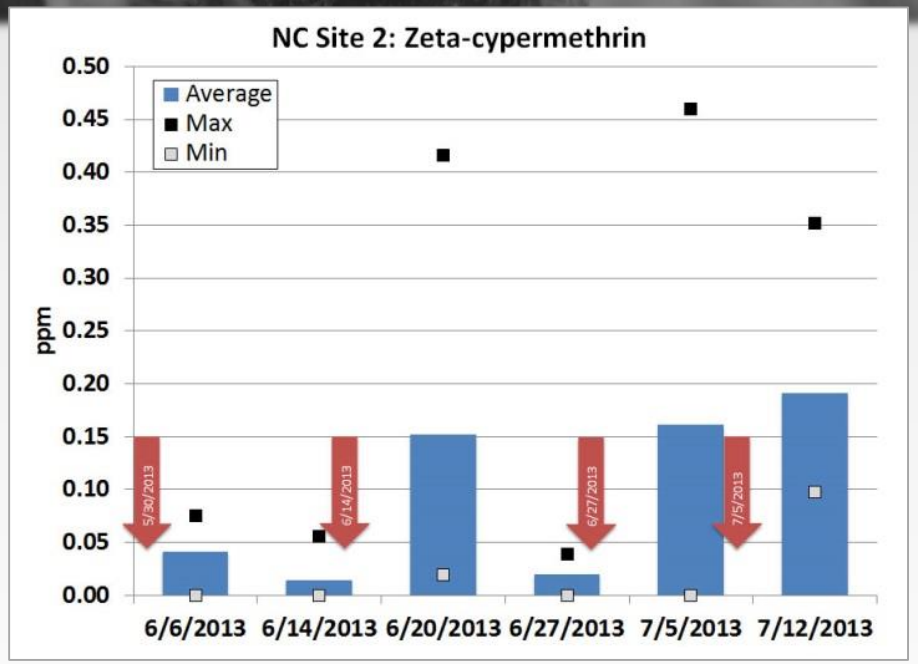
acetamiprid

cyantraniliprole



Season-long management programs
Zeta-cypermethrin residues over time





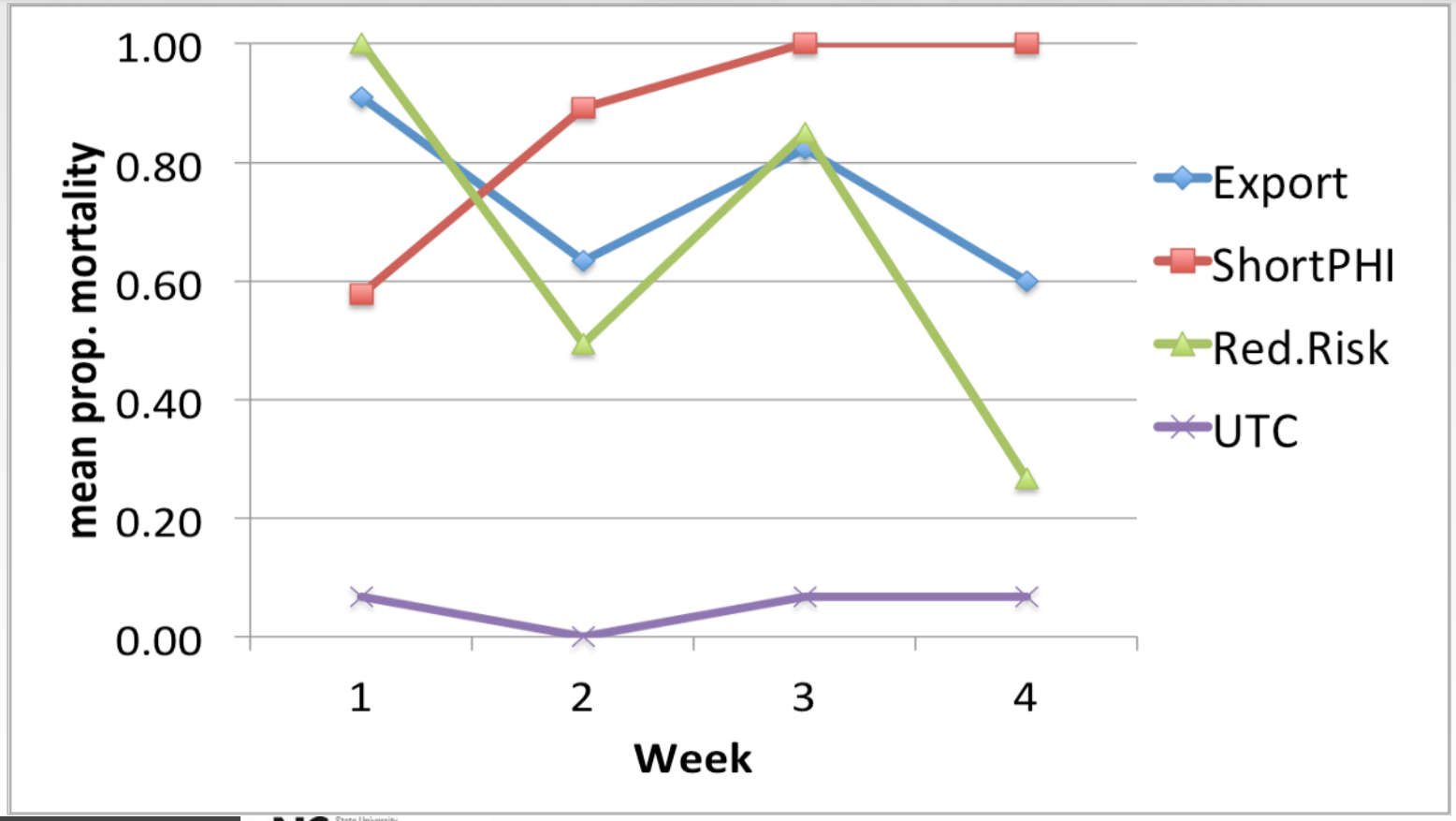
- Average zeta-cypermethrin residues did not reach zero, at least 14 days following treatment
- Maximum and minimum residues may be more important to consider for caneberries than blueberries due to differences in harvest and packing

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

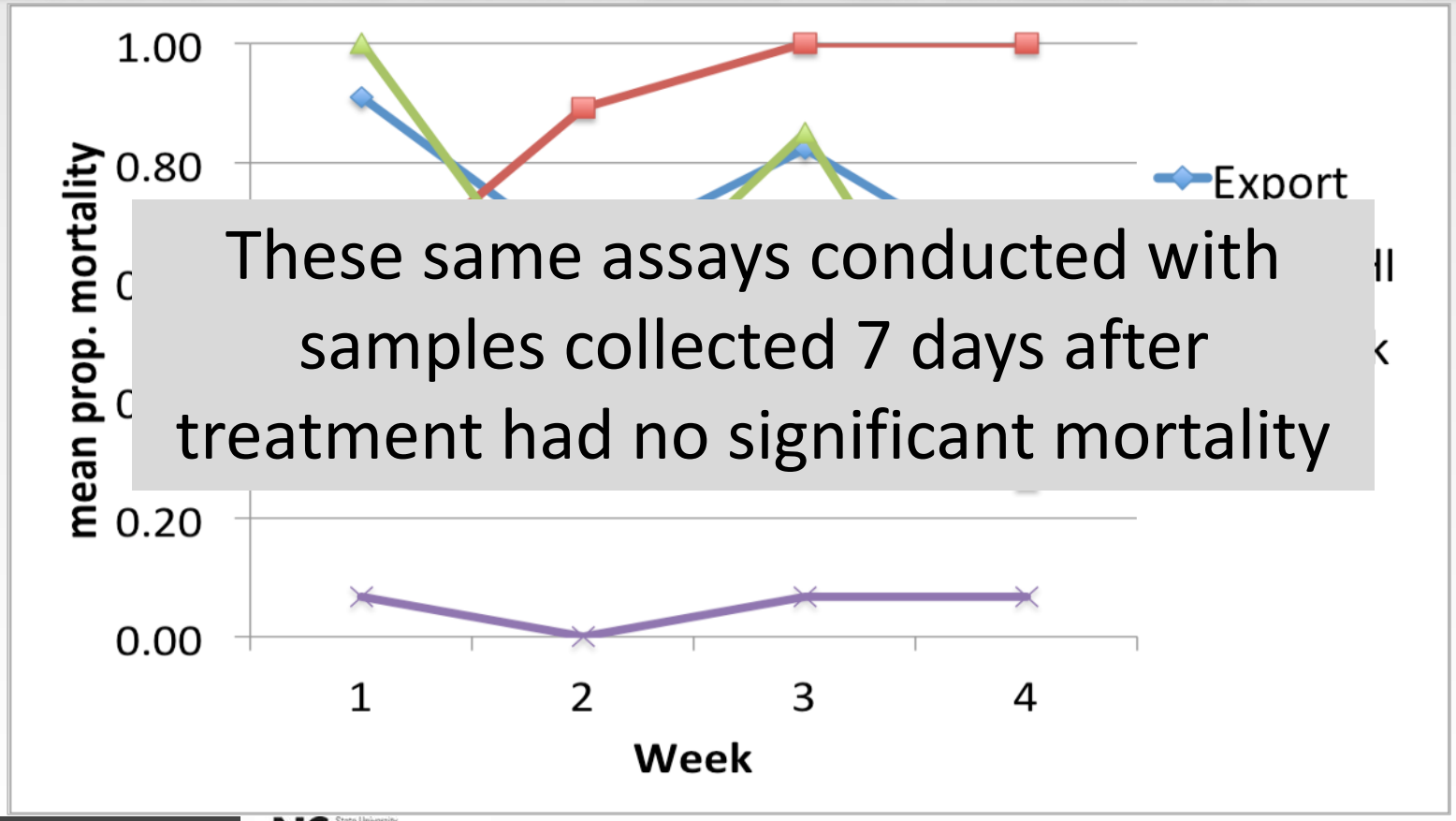
Season-long management programs

NC Site 1 – Female bioassay mortality, samples collected immediately after treatment



Season-long management programs

NC Site 1 – Female bioassay mortality, samples collected immediately after treatment



These same assays conducted with samples collected 7 days after treatment had no significant mortality

Non chemical tactics
Exclusion

Larval counts of *D. suzukii* emerged from overripe blueberries from Kisarazu City submerged in water for one hour (Kawase, et al. 2005; Masanori Seto, Cornell University)

Treatment	Sampling date		# of fruits tested	# of larvae	# of larvae / 100 fruit
0.98 mm	2003	7/6	100	0	0
Insect net	2004	6/16	127	0	0
		6/22	238	0	0
		7/14	84	0	0
		Total	449	0	0
	2005	6/27	211	0	0
		7/4	176	0	0
		Total	387	0	0
	3 yr Total		936	0	0
30 mm	2003	7/6	100	191	191
Bird net	2004	6/16	150	0	0
		6/22	340	3	0.9
		7/14	96	23	24.0
		Total	586	26	4.4
	2005	6/27	219	13	5.9
		7/4	171	120	70.2
		Total	389	133	34.2
	3 yr Total		1076	350	32.5

Strategies for spotted wing drosophila managment

Understand when fruit are at risk

Fly presence and fruit susceptibility

Know which tools will protect fruit

Effective insecticides with appropriate PHIs

Manage harvest for optimal control

Consider post harvest management strategies

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Strategies for spotted wing drosophila managment

Understand when fruit are at risk

Fly presence and fruit susceptibility

Know which tools will protect fruit

Effective insecticides with appropriate PHIs

Manage harvest for optimal control

Consider post harvest management strategies

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People · Providing Solutions

Post harvest storage temperature
Eggs in artificial diet

Methods for cold temperature experiments

Artificial diet

Each life state, temperature, and duration was replicated at least 8 times

10ml of standard diet in 60mm petri dishes; 5-10 eggs per dish

Controls for each temp held at 68F

Orange arrows indicate values significantly different from control for that temperature

Fruit

Fruit infested over the course of 7 days and held at 68F until desired life stage reached

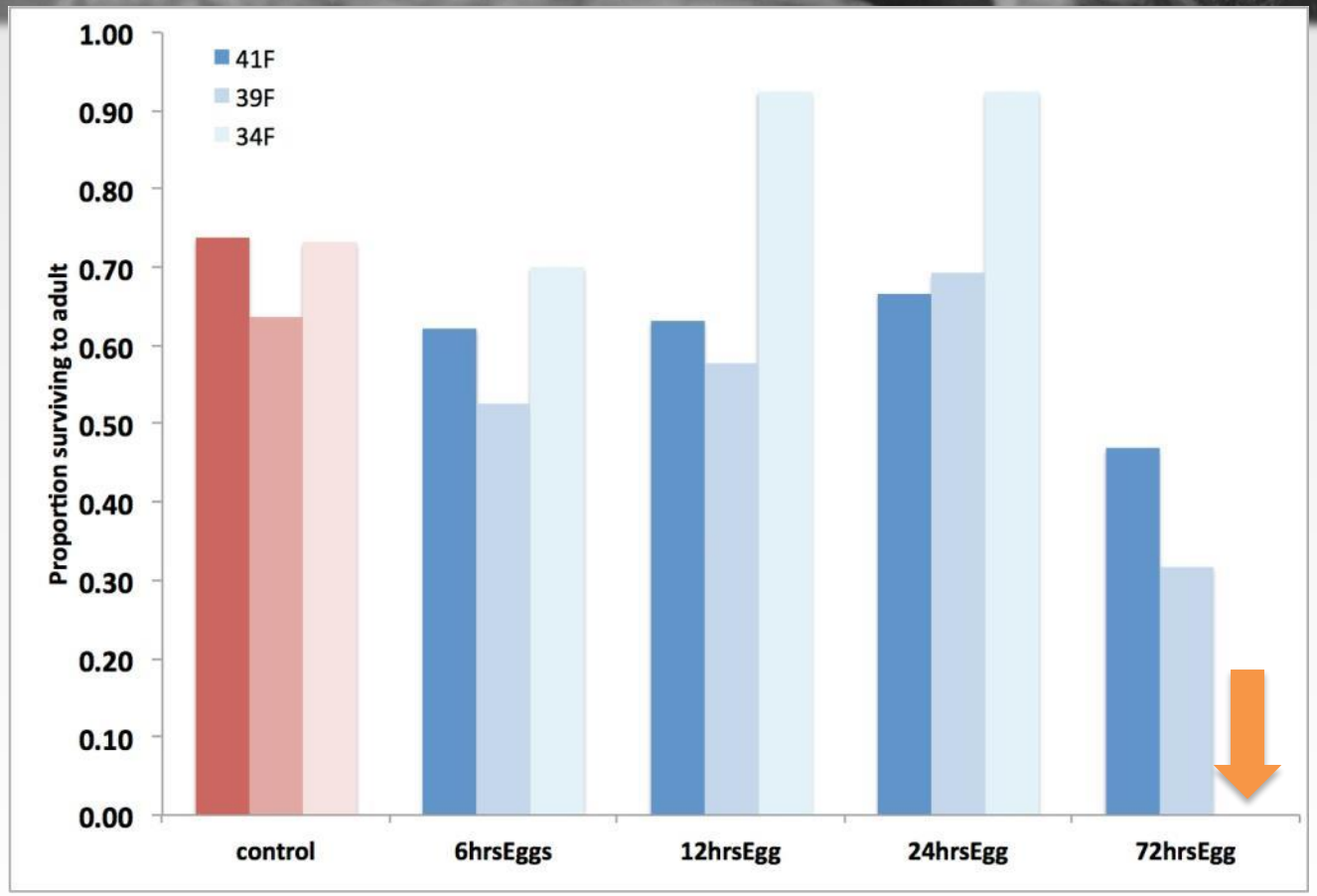
At least 24 treatment replicated and 8 control replicates were conducted for each life stage

Exposed in commercial scale cold room at 35F for 72 hrs

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Eggs in artificial diet



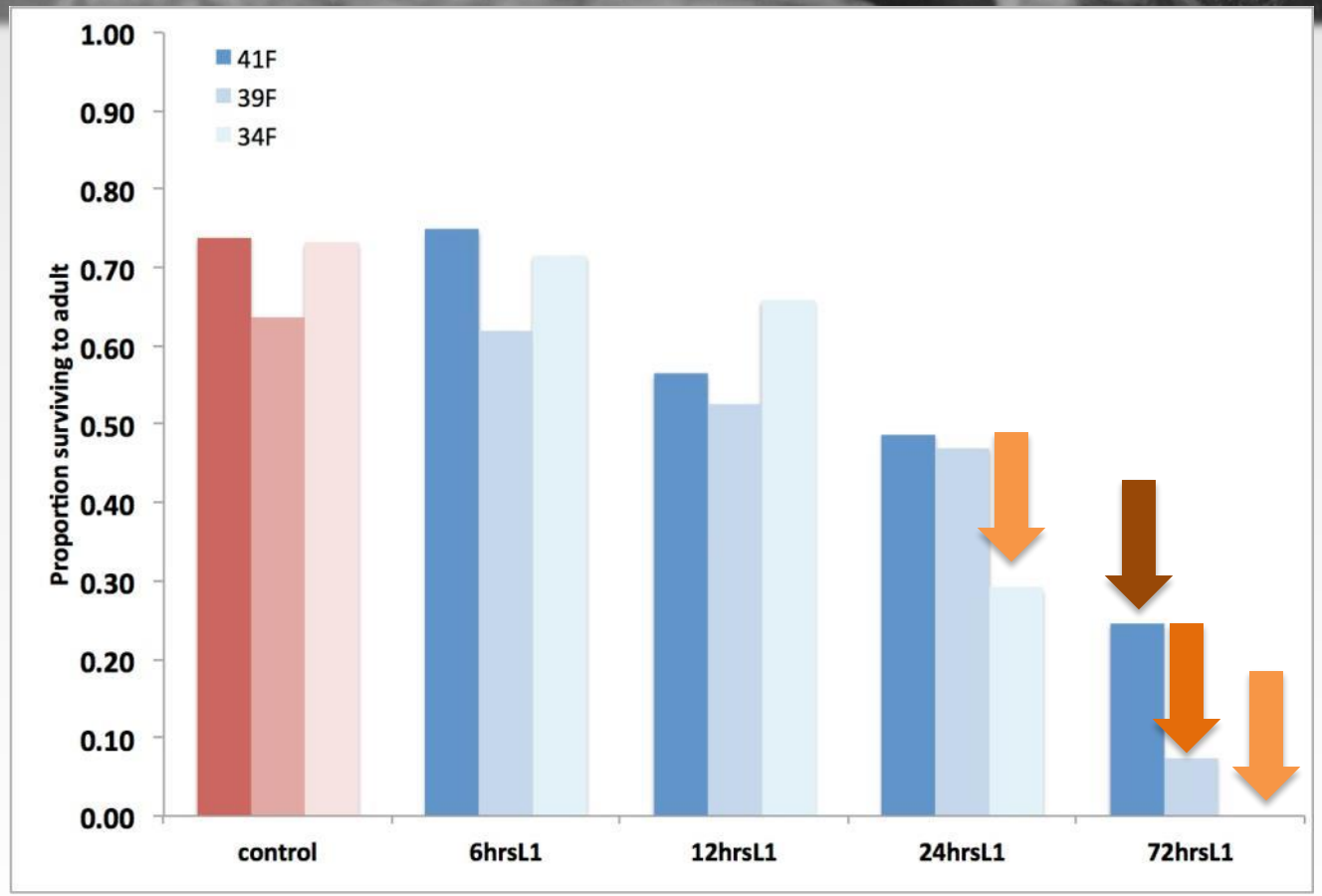
*No eggs held at 34F for 72 hrs survived to adults **in artificial diet***

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature

1st instars in artificial diet



*No first instar larvae held at 34F for 72 hrs survived to adults **in artificial diet***

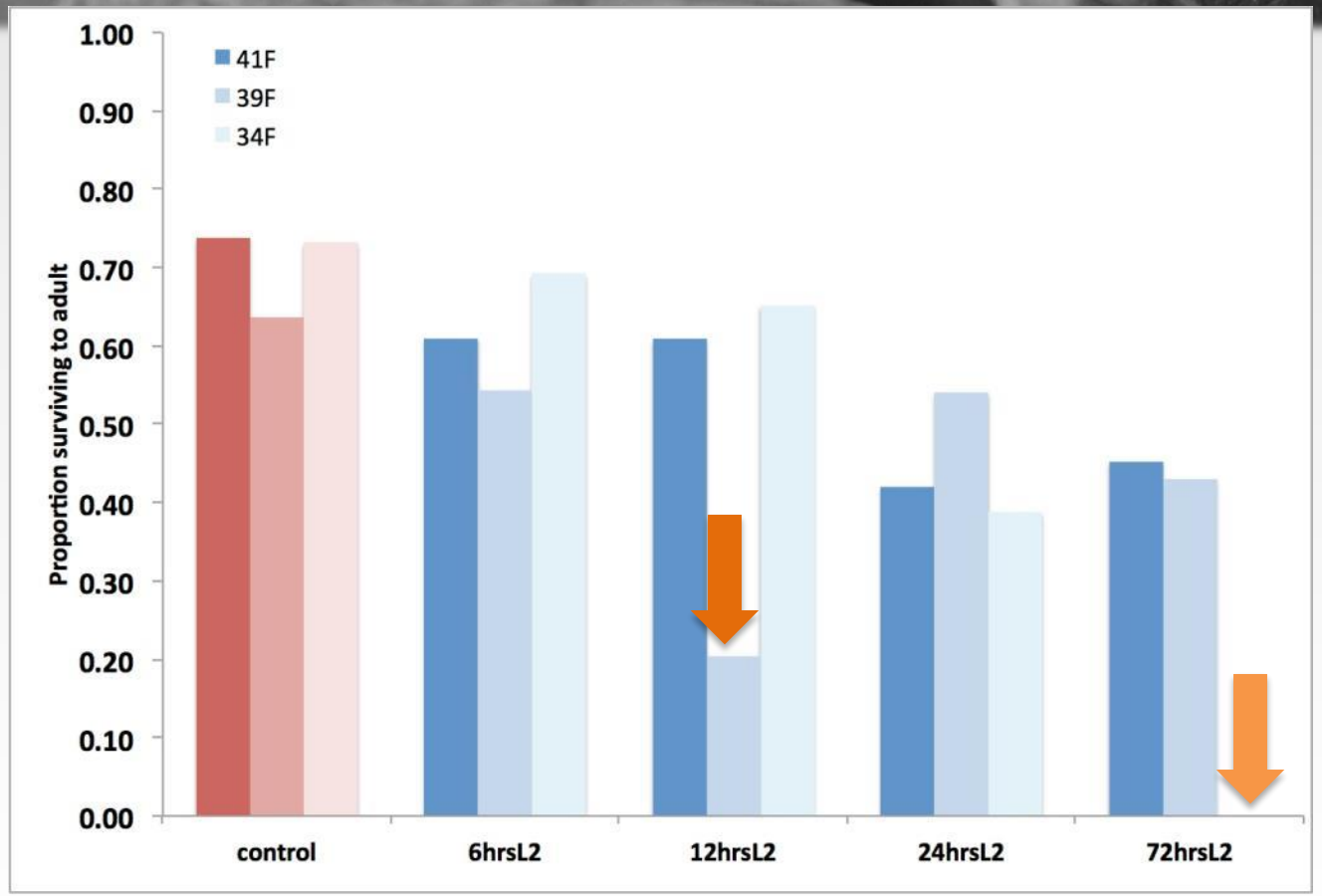
Significantly fewer first instar larvae survived after 72 hrs at 39F and 41F than in untreated controls

Significantly fewer first instar larvae survived after 24 hrs at 34F than in untreated controls

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
2nd instars in artificial diet



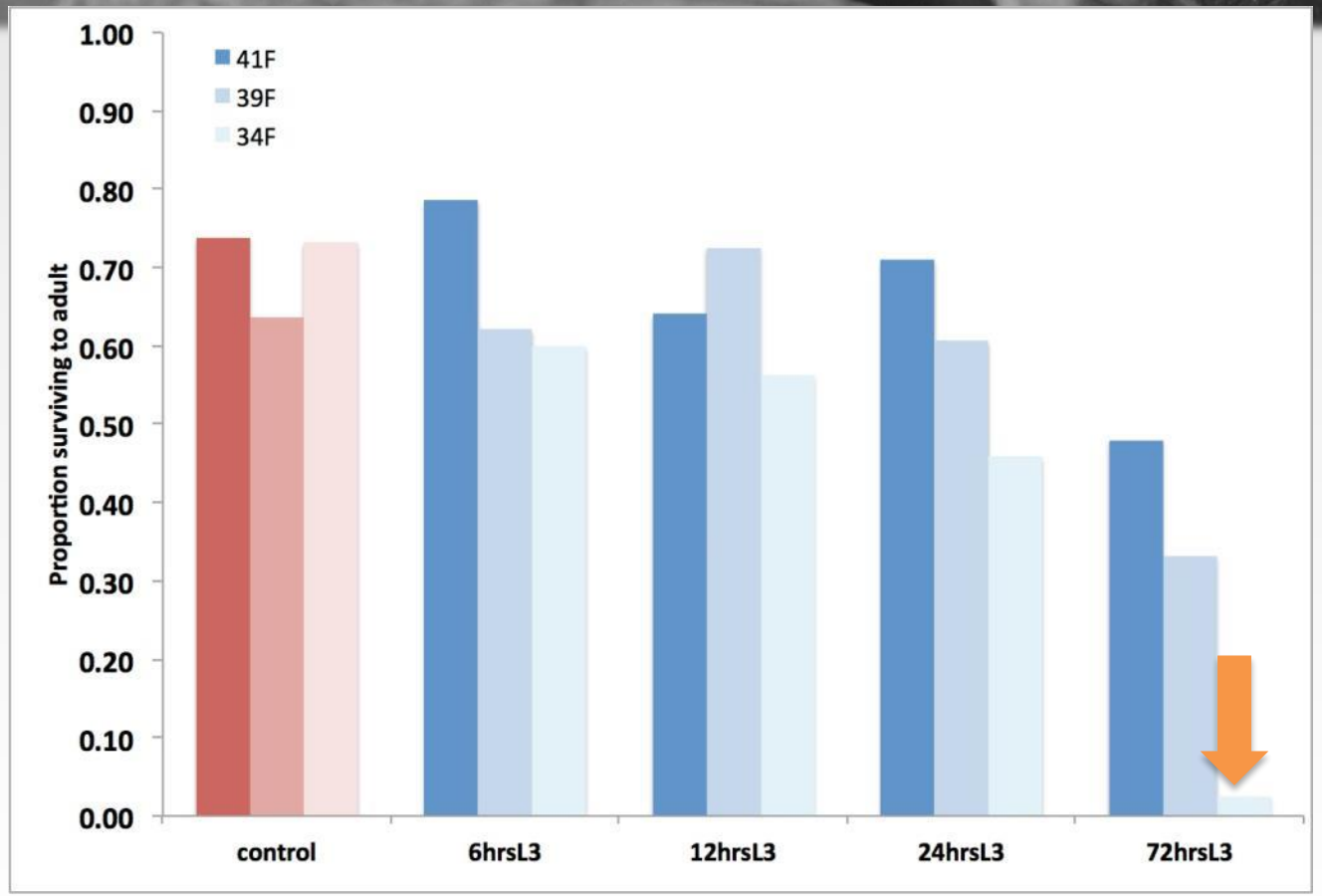
*No first second instar larvae held at 34F for 72 hrs survived to adults **in artificial diet***

Increased mortality of second instar larvae held at 39F for 12 hrs likely experimental issue

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
3rd instars in artificial diet

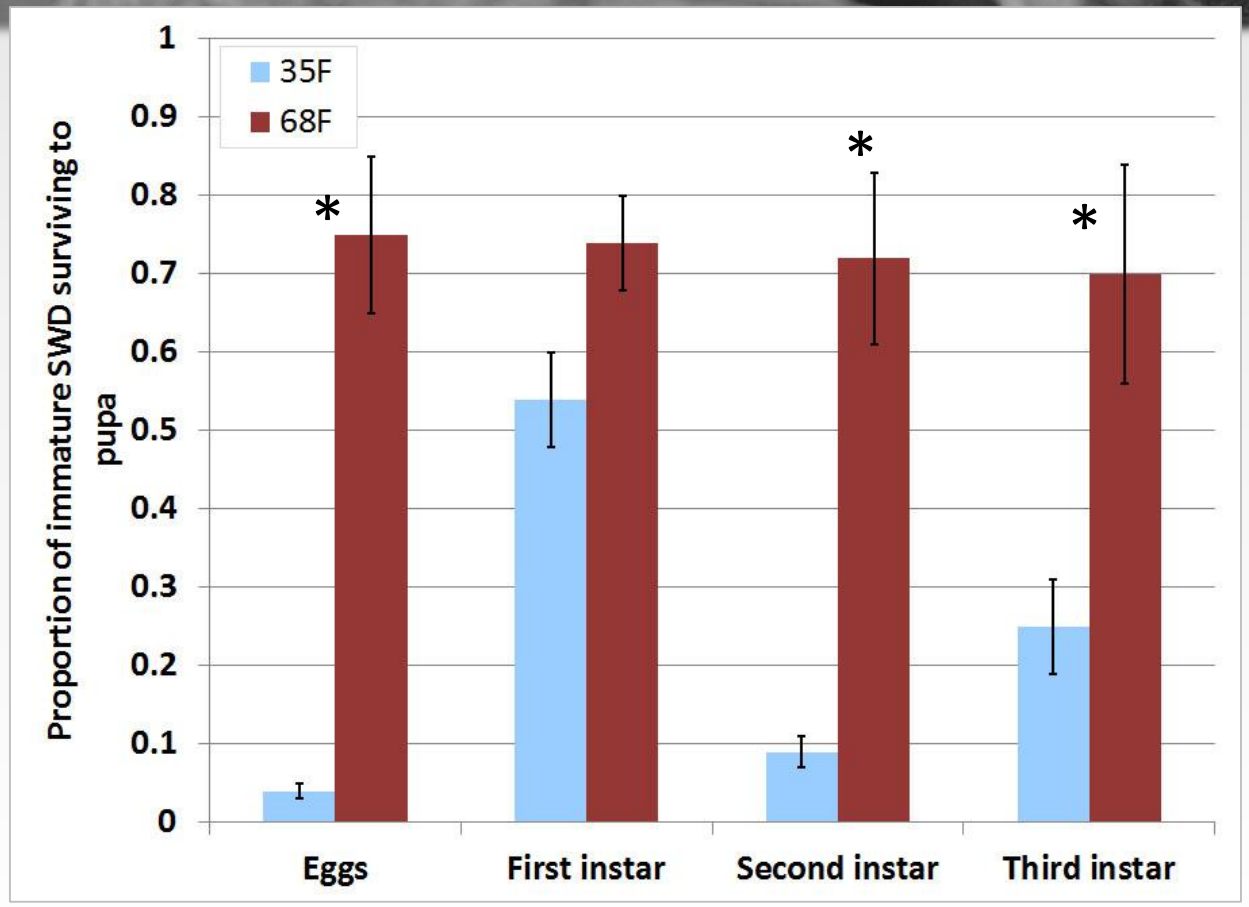


Significantly fewer third larvae held at 34F for 72 hrs survived to adults than untreated controls ***in artificial diet***

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Survival to pupa in raspberries

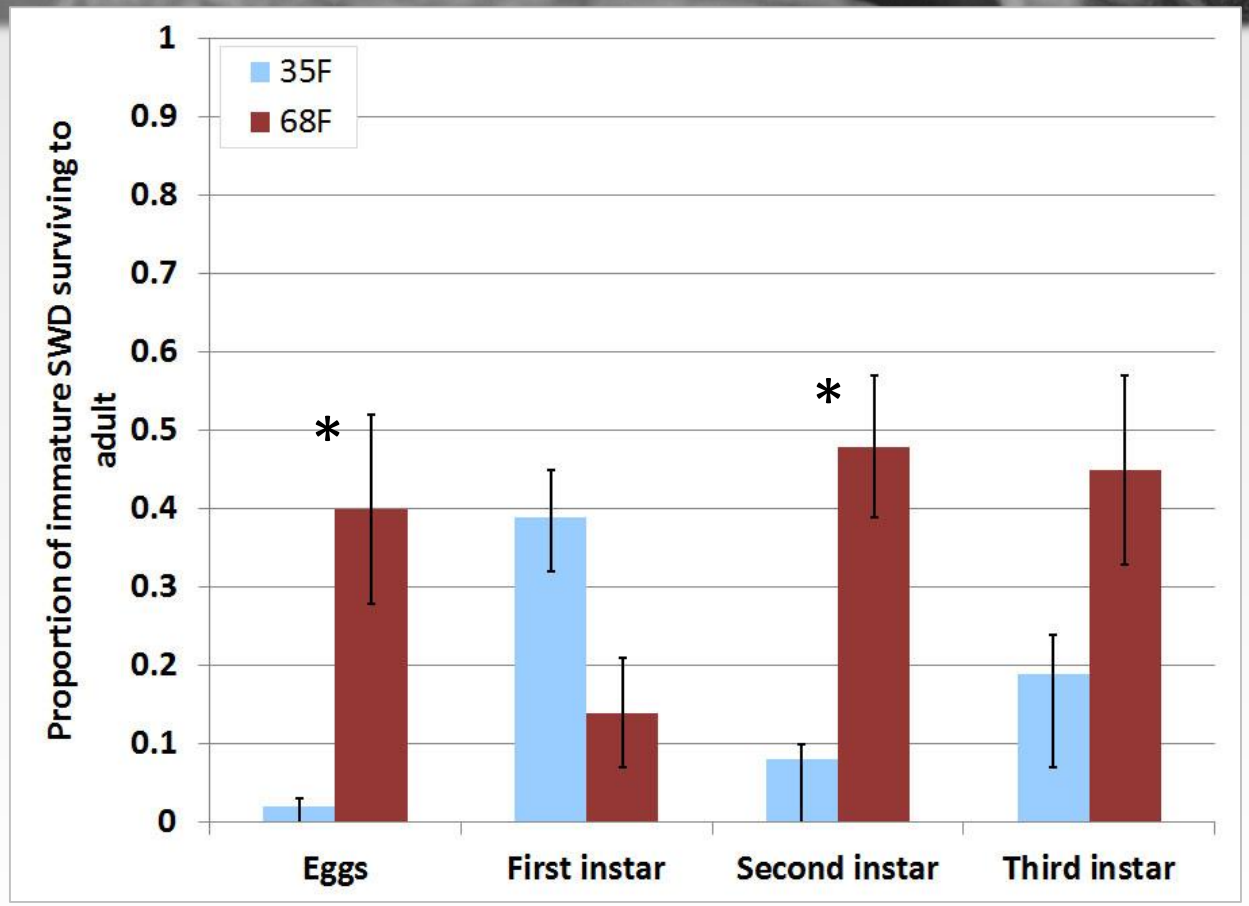


First instar larvae in raspberries were not impacted by storage at ***35F for 72 hrs****, but other life stages were impacted*

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Survival to adults in raspberries

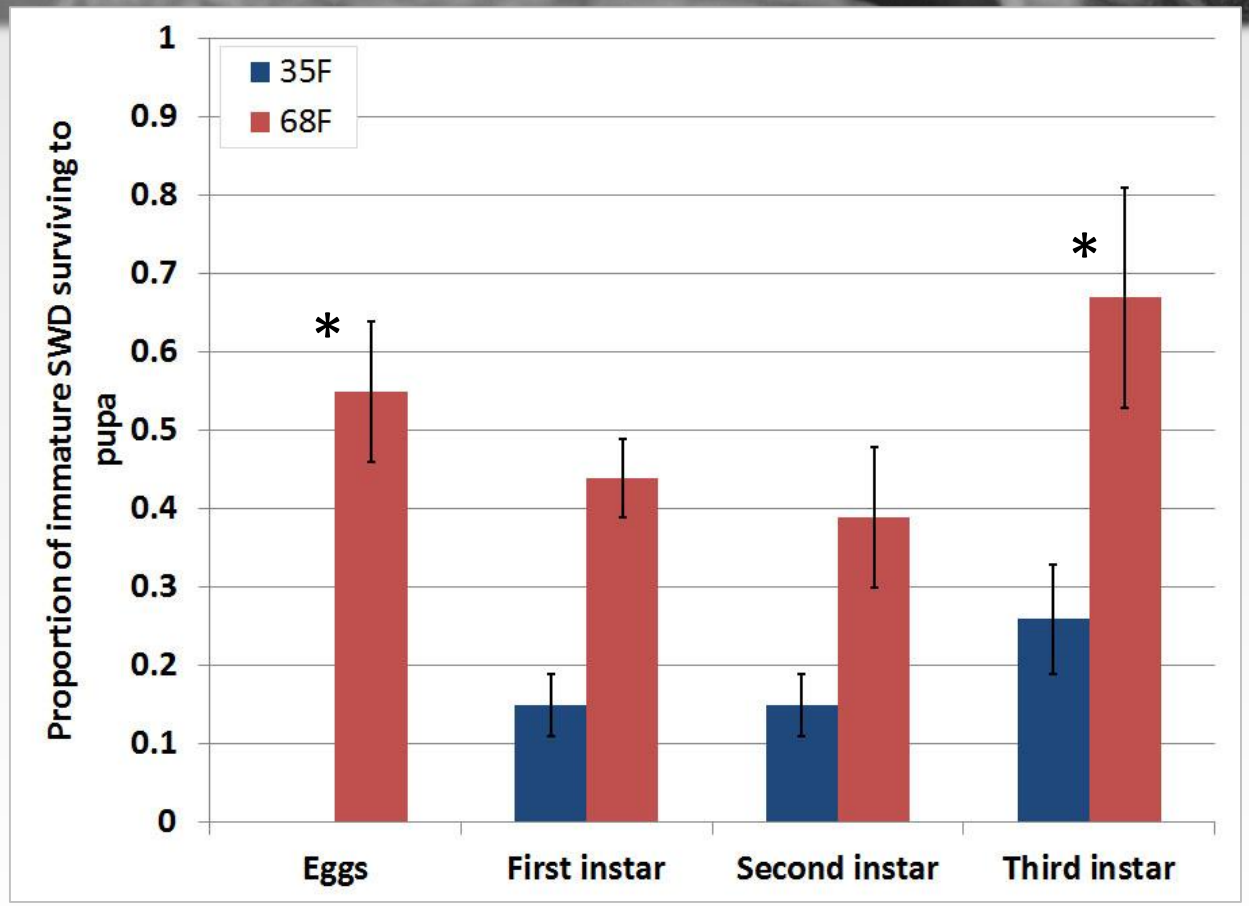


*First instar and third instar larvae in raspberries were not impacted by storage at **35F for 72 hrs**, but other life stages were impacted*

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Survival to pupa in blueberries



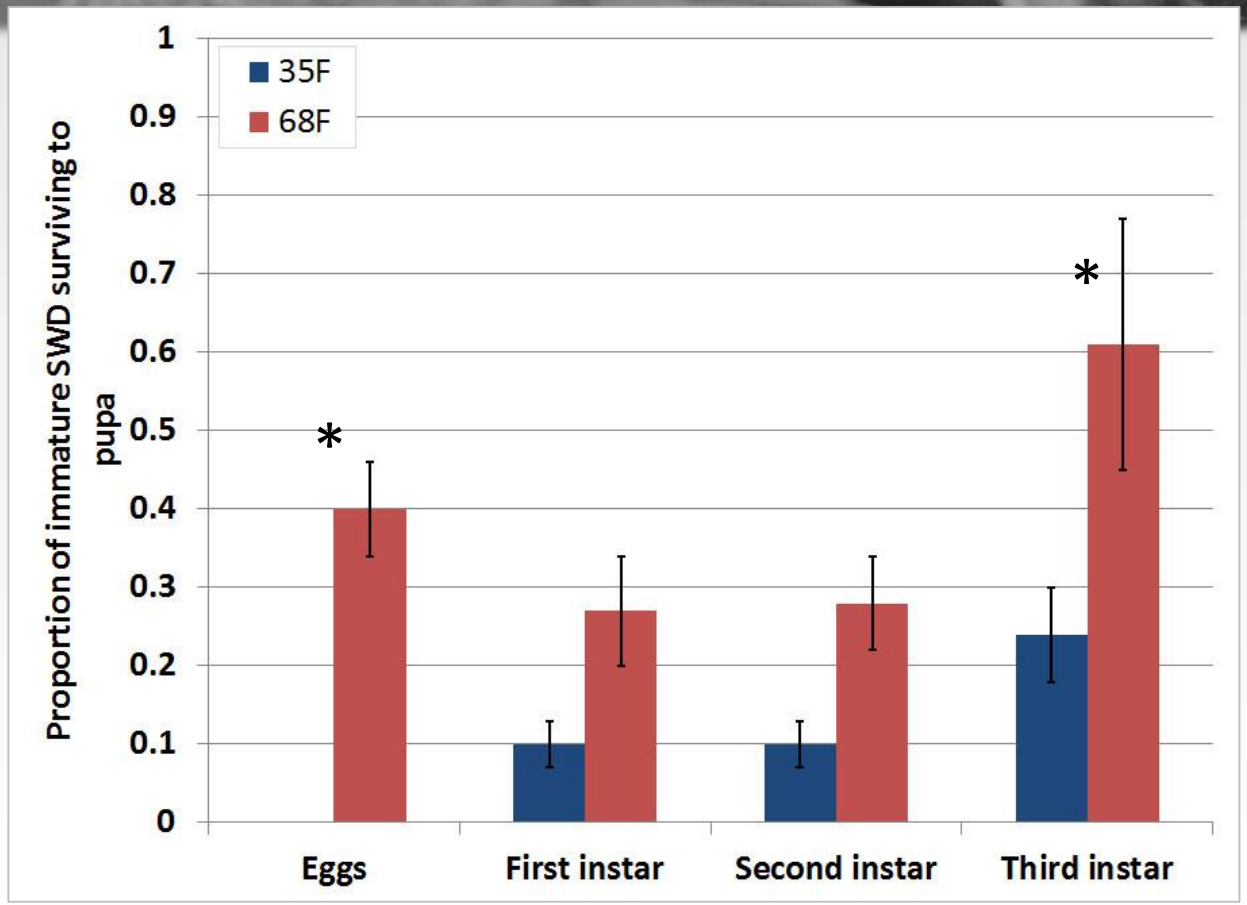
*No eggs survived to pupation in blueberries held at **35F for 72 hrs**, but some of all other life stages did*

No significant difference in survival for first and second instar

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Survival to adult in blueberries



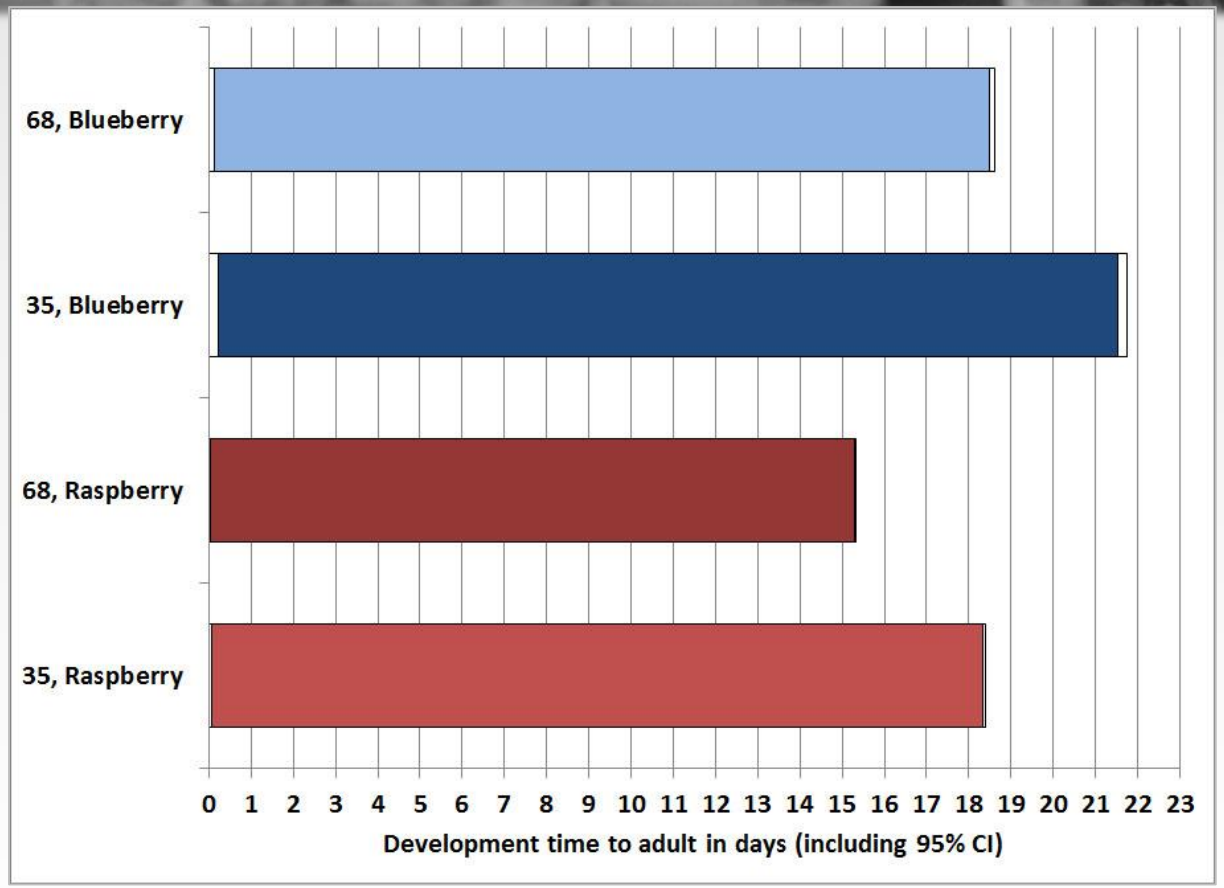
*No eggs survived to adult in blueberries held at **35F for 72 hrs**, but some of all other life stages did*

No significant difference in survival for first and second instar

NC STATE UNIVERSITY

NC State University A&T State University COOPERATIVE EXTENSION Empowering People • Providing Solutions

Post harvest storage temperature
Development time



Development took 3 days longer in cold treated fruit, meaning larvae did not develop at 35F

Similar development time increases for temps in artificial diet

Development was faster in raspberries than in blueberries

Post harvest storage temperature *Summary*

First instar larvae were the most sensitive to cold temperatures in artificial diet and much less sensitive in fruit

Eggs were the most significantly impacted in fruit

Of the 434 eggs exposed to 35F for 3 days in blueberries, none survived

For a treatment to be quarantine acceptable, 93,613 individuals must be tested with no suviviors

Larval development was essentially stopped at potential post harvest temperatures, at least for 3 days

General recommendations *2014*

Plan to preventatively manage SWD

What insecticides will be applied under what conditions?

Plan to monitor fruit along with adults

Consider when fruit will be monitored (e.g. before harvest, after harvest, after sorting, after packing, after storage)

Implement post harvest management strategies

Consider cold storage temperature and duration

Quality control and sanitation practices may also impact SWD presence

Management recommendations *Blueberries*

Conventional, fresh market blueberries

- *Practice good sanitation: thorough harvest & removal of culls*
- *Begin management when susceptible fruit is present*
- *Sample fruit at each harvest, consider adult monitoring*
- *Rotate between effective materials*

Active ingredient (MOA)	Trade name	Preharvest interval
Phosmet (1)	Imidan	3 days
Malathion (1)	Malathion (and others)	1 day
Spinetoram (5)	Delegate	3 days
Fenpropathrin (3)	Danitol	3 days
Zeta cypermethrin* (3)	Mustang/Mustang Max	1 day

Management recommendations *Strawberries*

Spring fruiting strawberries

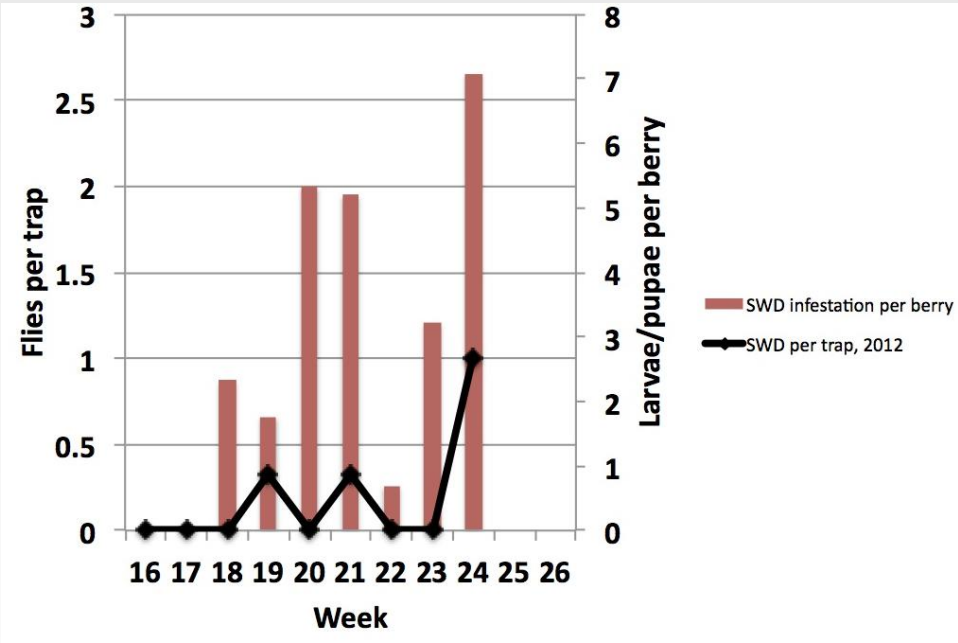
- *Monitor adult flies and sample fruit*
- *Practice good sanitation: thorough harvest & removal of culls*
- *Begin management program if flies are detected*

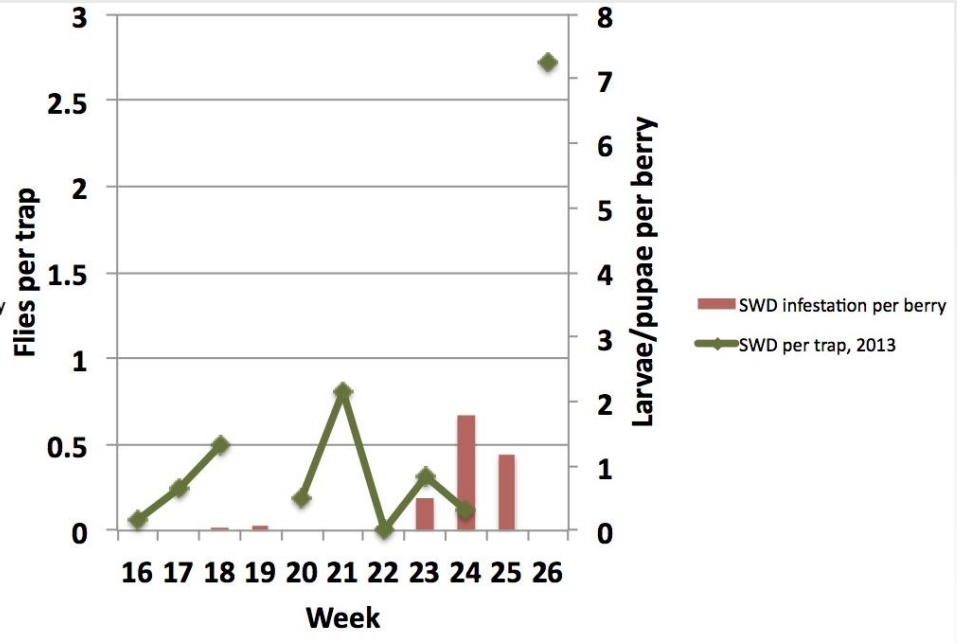
Day neutral/fall fruiting strawberries

- *Monitor fruit, consider monitoring adult flies*
- *Practice good sanitation: thorough harvest & removal of culls*
- *Implement management program*

Active ingredient (MOA)	Trade name	Preharvest interval
Bifenthrin (3)	Brigade (and others)	0 days
Malathion (1)	Malathion (and others)	3 days
Spinetoram (5)	Radiant	1 day

Management recommendations
Strawberries





Management recommendations *Blackberries and raspberries*

Conventional, fresh market blackberries and raspberries

- *Practice good sanitation: thorough harvest & removal of culls*
- *Begin management when susceptible fruit is present*
- *Sample fruit at each harvest, consider adult monitoring*
- *Rotate between effective materials*

Active ingredient (MOA)	Trade name	Preharvest interval
Malathion (1)	Malathion (and others)	1 day
Spinetoram (5)	Delegate	1 day
Zeta cypermethrin* (3)	Mustang/Mustang Max	1 day
Fenpropathrin (3)	Danitol	3 days
Bifenthrin (3)	Brigade (and others)	3 days

Read us @ entomology.ces.ncsu.edu
Like us @ facebook.com/NCSmallFruitIPM
Follow us @NCSmallFruitIPM