Urban Small Farms Conference 2019

Thrusday, February 21st, 2019

Time	Utah Berry Growers
8:00	Spreading the Raspberry Production Season - Brent Black, USU **pg. 147**
8:30	Fruit-Eating Insects - Diane Alston, USU **pg. 152**
9:00	Invasive Fruit Pests - Lori Spears, USU **pg. 156**
9:30	Drip Irrigation Management for High Quality Production of Raspberries and Blackberries - David Bryla, USDA ARS **pg. 162**
10:00 - 10:30 Break	
10:30	Chemical Charateristics and Pesticide Movement - Mike Wierda, USU **pg. 170**
11:00	Nutrient Requirements, Leaf Tissue Standards, and Options for Fertigation in Raspberry and Blackberry - David Bryla, USDA ARS **pg. 171**
11:30	Available Resources/Website Updates - Tiffany Maughan, USU **pg. 178**
11:50	Participant Response Survey

Click on a session you would like to view and it will take you there!

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Spreading the Raspberry Production Season

Using tunnels to extend the primocane raspberry production season both earlier and later.

Brent Black
Professor and Extension Fruit Specialist
Utah State University
Brent.black@usu.edu

Dr. Brent Black is Professor and Extension Fruit Specialist at Utah State University. Prior to coming to USU in 2005, Dr. Black was a research scientist with the USDA Agriculture Research Service in Beltsville, Maryland, where he worked on production systems of strawberry and blueberry. Prior to USDA, he studied tree nitrogen metabolism at the University of Maryland in College Park. He holds a B.S. degree from Utah State University in Plant and Soil Science, an M.S. degree in Horticulture from Michigan State University, and a Ph.D. in Plant Physiology from Oregon State University. His current research interests are in high density orchard management, precision orchard irrigation, and strategies for extending the production season of berry crops.

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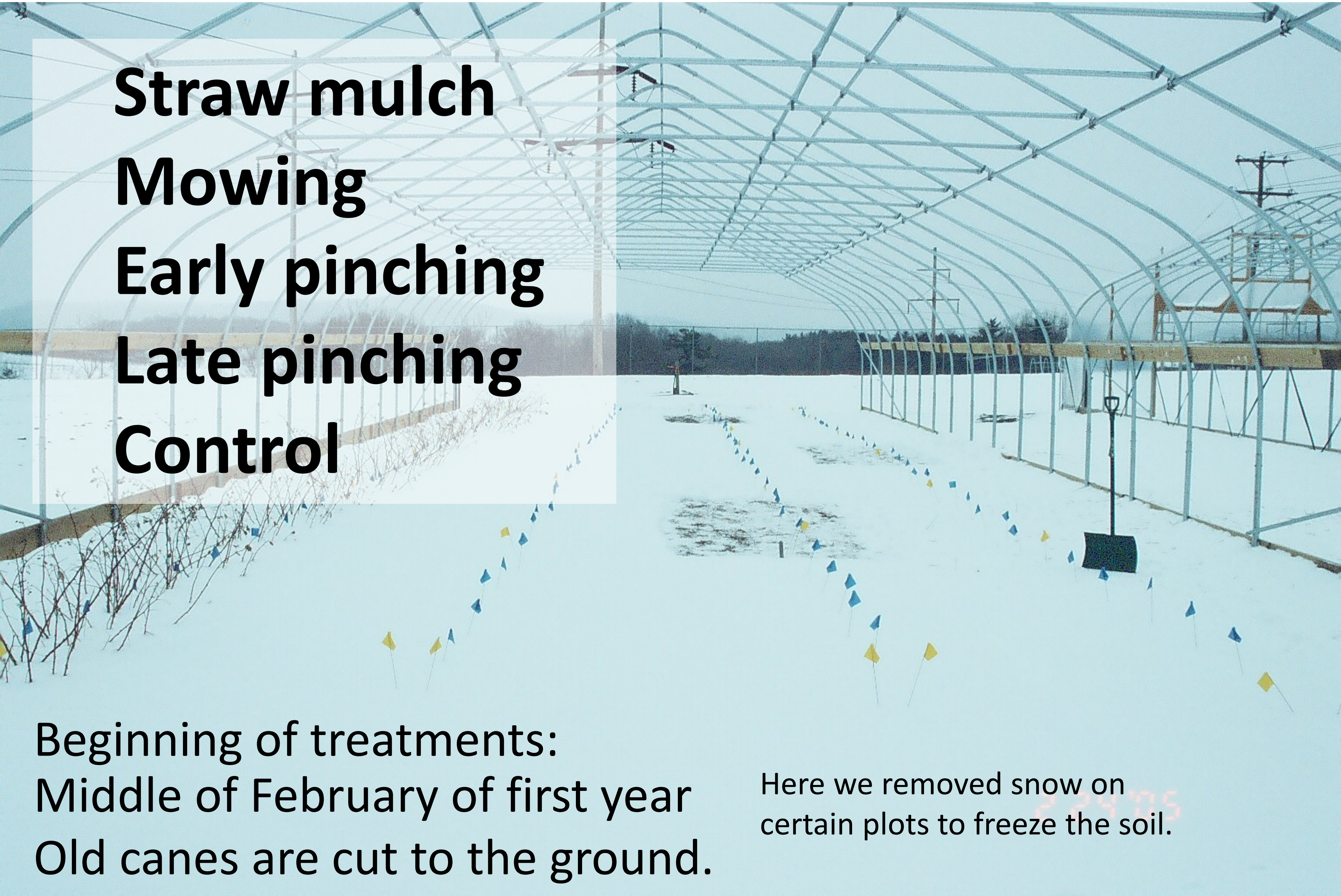
High Tunnel Systems: Raspberries

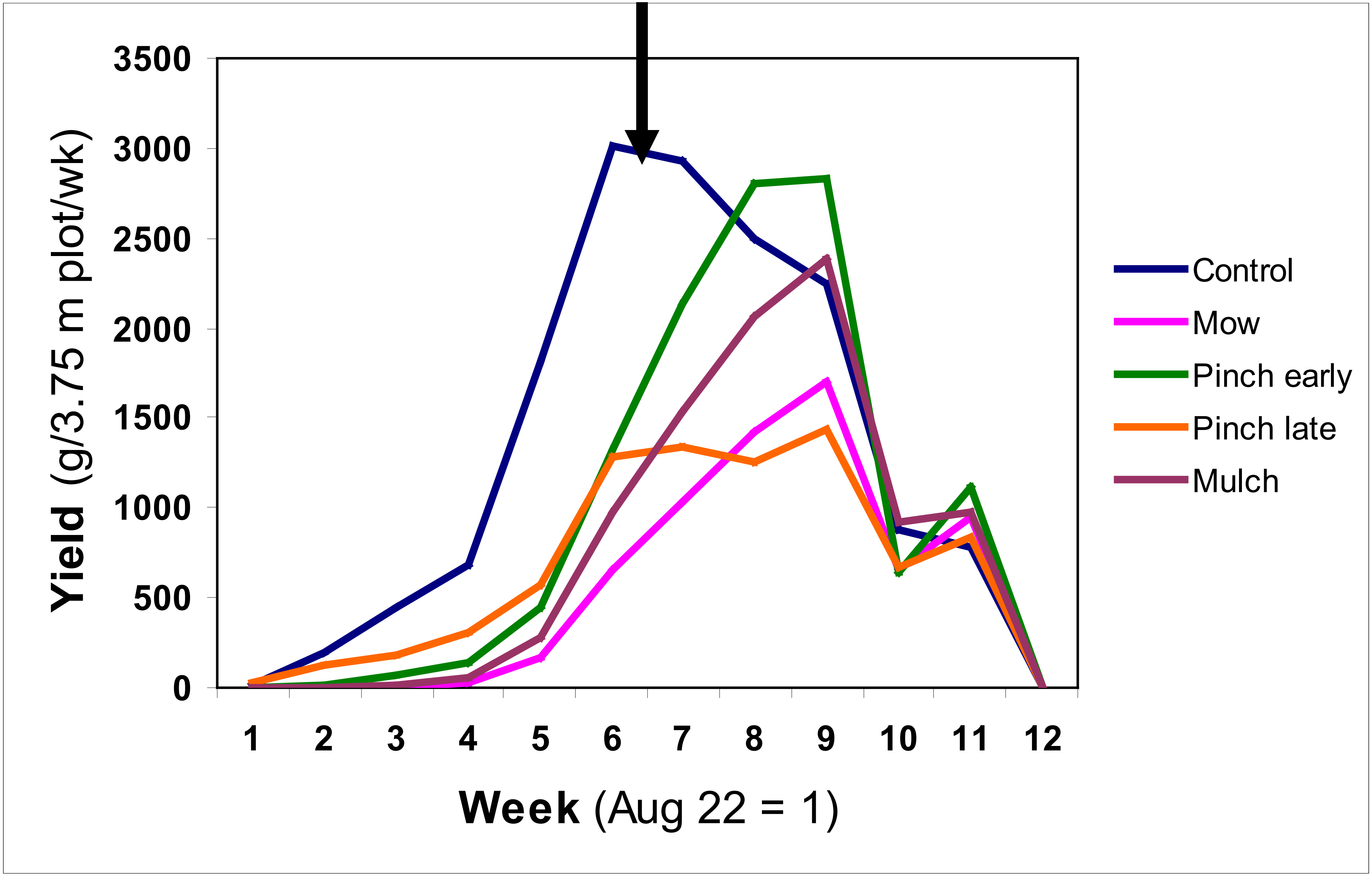
Brent Black,
Extension Fruit Specialist

2019 Urban and Small Farms Conference


2007 Utah Berry Growers Meeting
Dr. Marvin Pritts, Cornell University
New York strategy – Plant late cultivars or delay harvest, protect fruit, and capitalize on high prices


Straw mulch
Mowing
Early pinching
Late pinching
Control
Beginning of treatments:
Middle of February of first year
Old canes are cut to the ground.
Here we removed snow on certain plots to freeze the soil.

2006 data



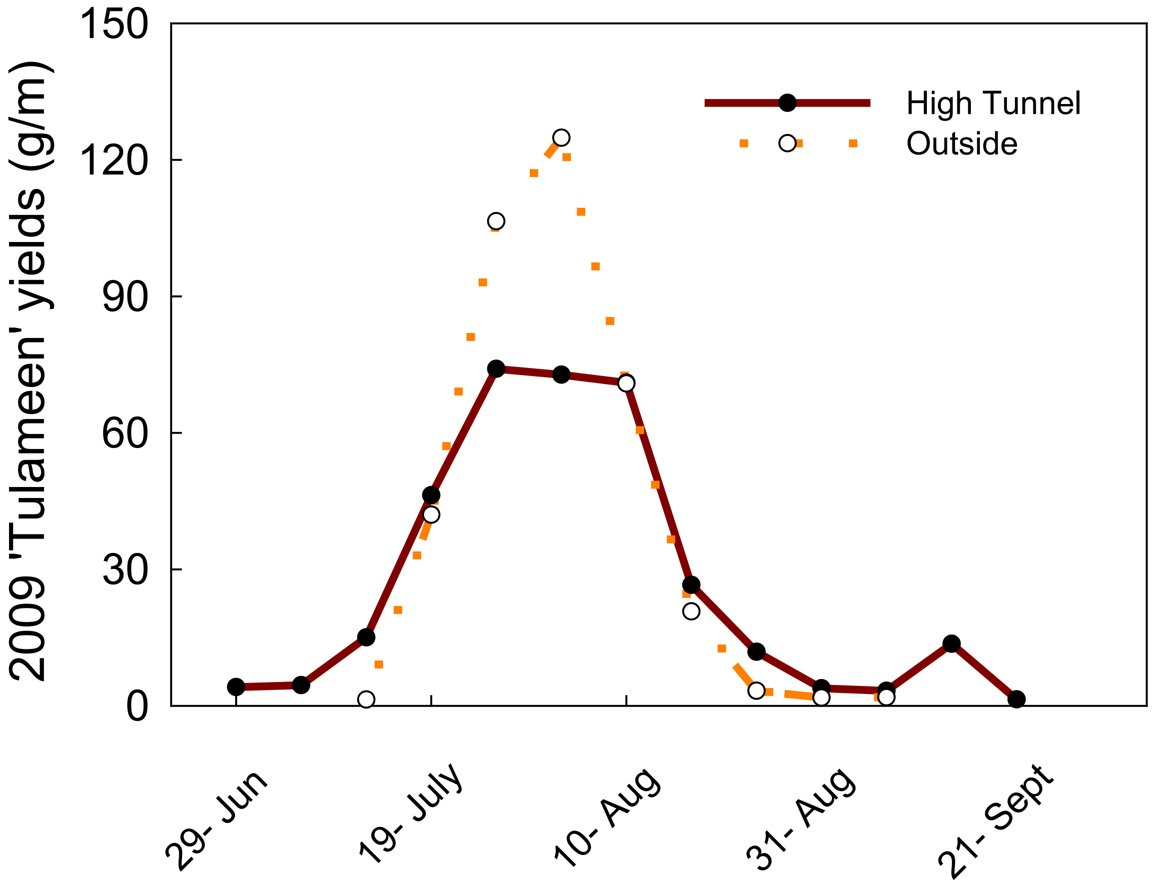
Yield (g/3.75 m plot/wk)
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
Week (Aug 22 = 1)
Control
Mow
Pinch early
Pinch late
Mulch

High Tunnel Raspberries - Utah?

- Improve survival of cold sensitive cultivars?
- Push summer bearers earlier?
- Extend Fall Bearers Later?
- Push Fall Bearers Earlier?

Summer-bearers

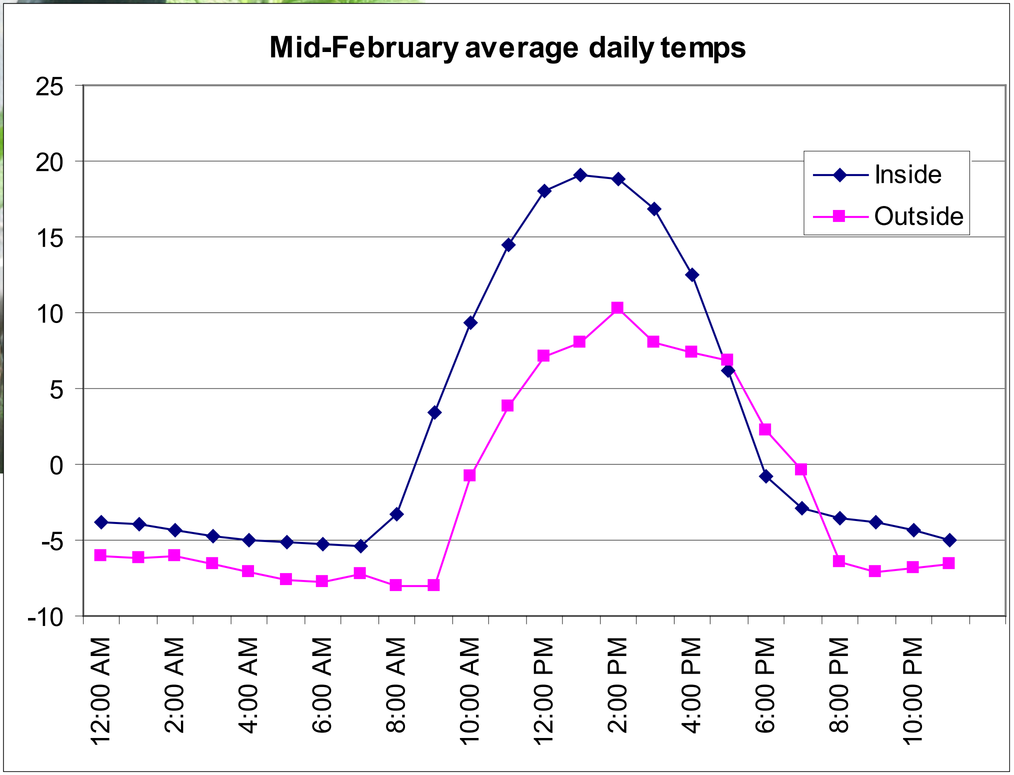
- Tulameen



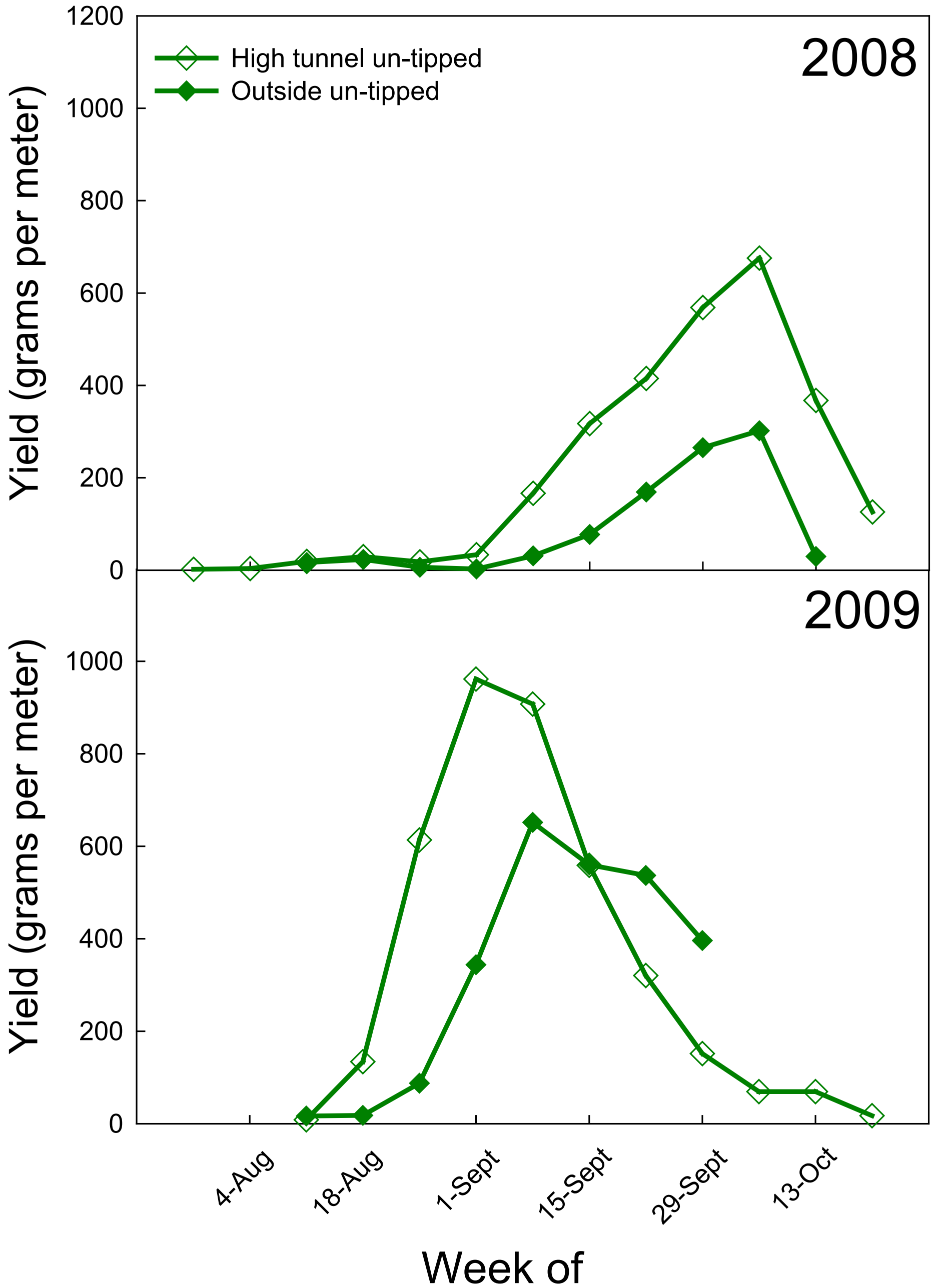
	Yield (g/m)	
	2008	2009
High Tunnel IG	500	1130
Field	80	1222

HT Fall raspberries = 3 to 4 kg/m

Summer Bearing Challenges



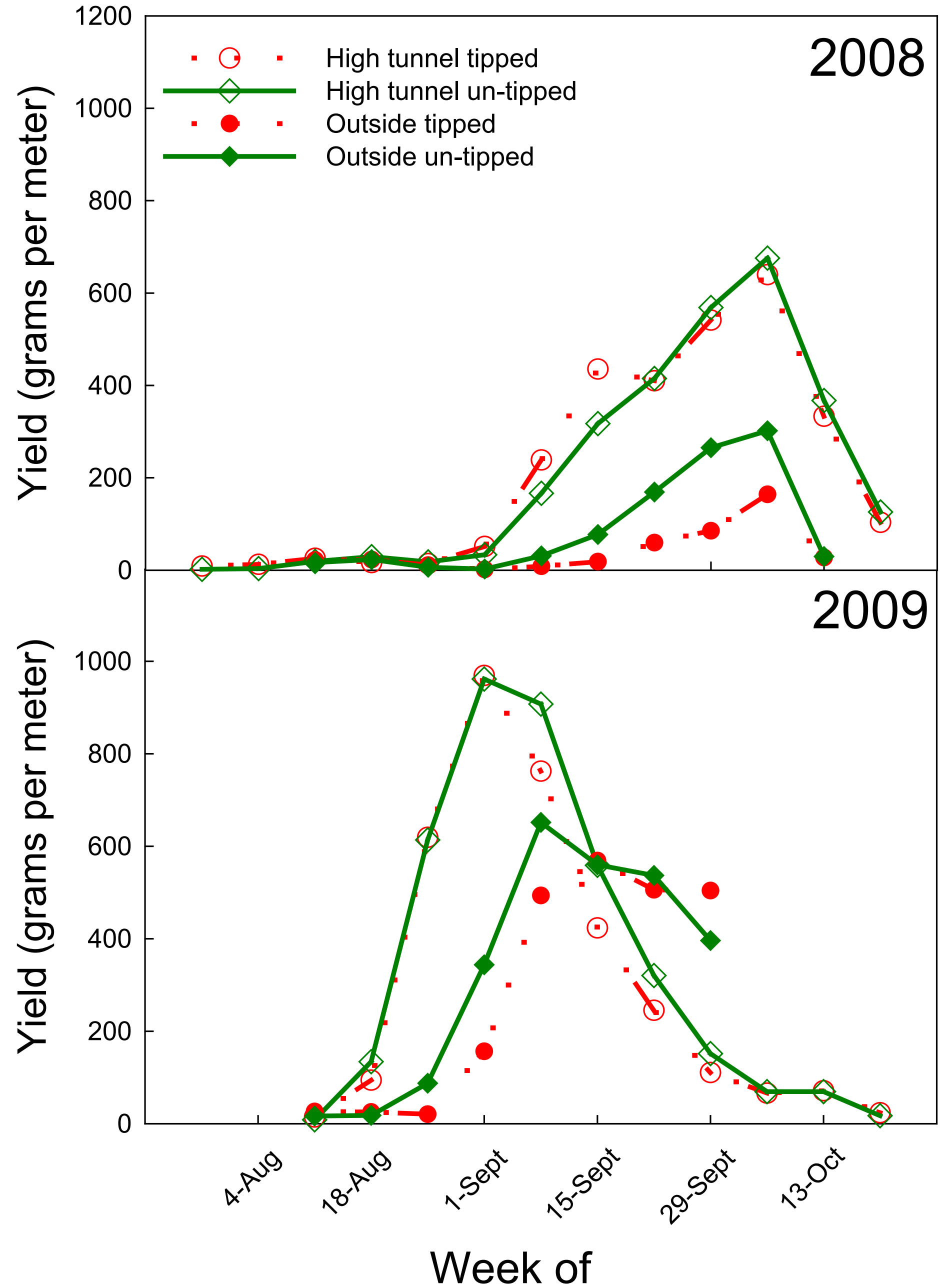
Caroline



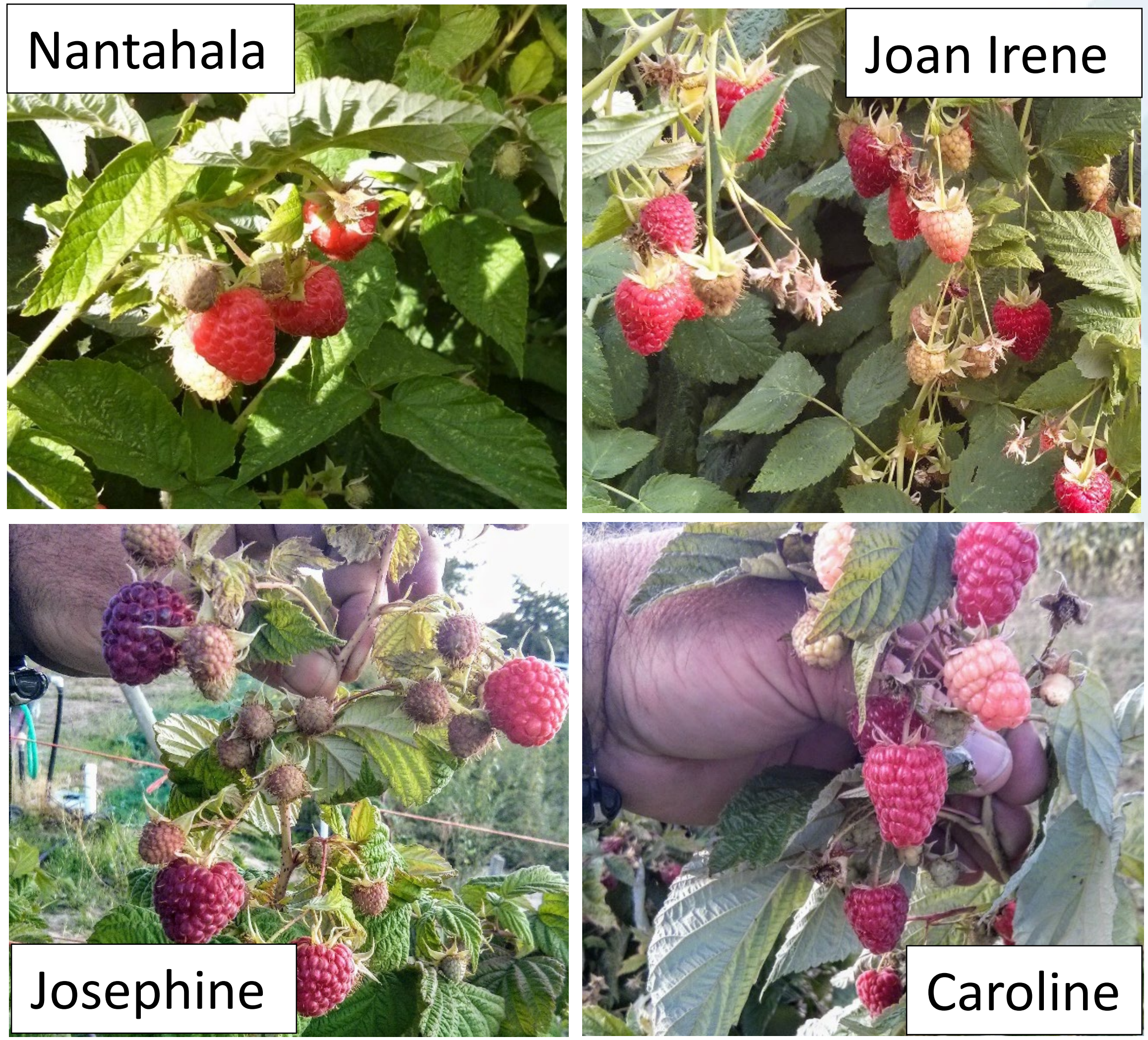
1200
1000
800
600
400
200
0
High tunnel un-tipped
Outside un-tipped
2008
2009
Yield (grams per meter)
Yield (grams per meter)
4-Aug
18-Aug
1-Sept
15-Sept
29-Sept
13-Oct
Week of

Caroline

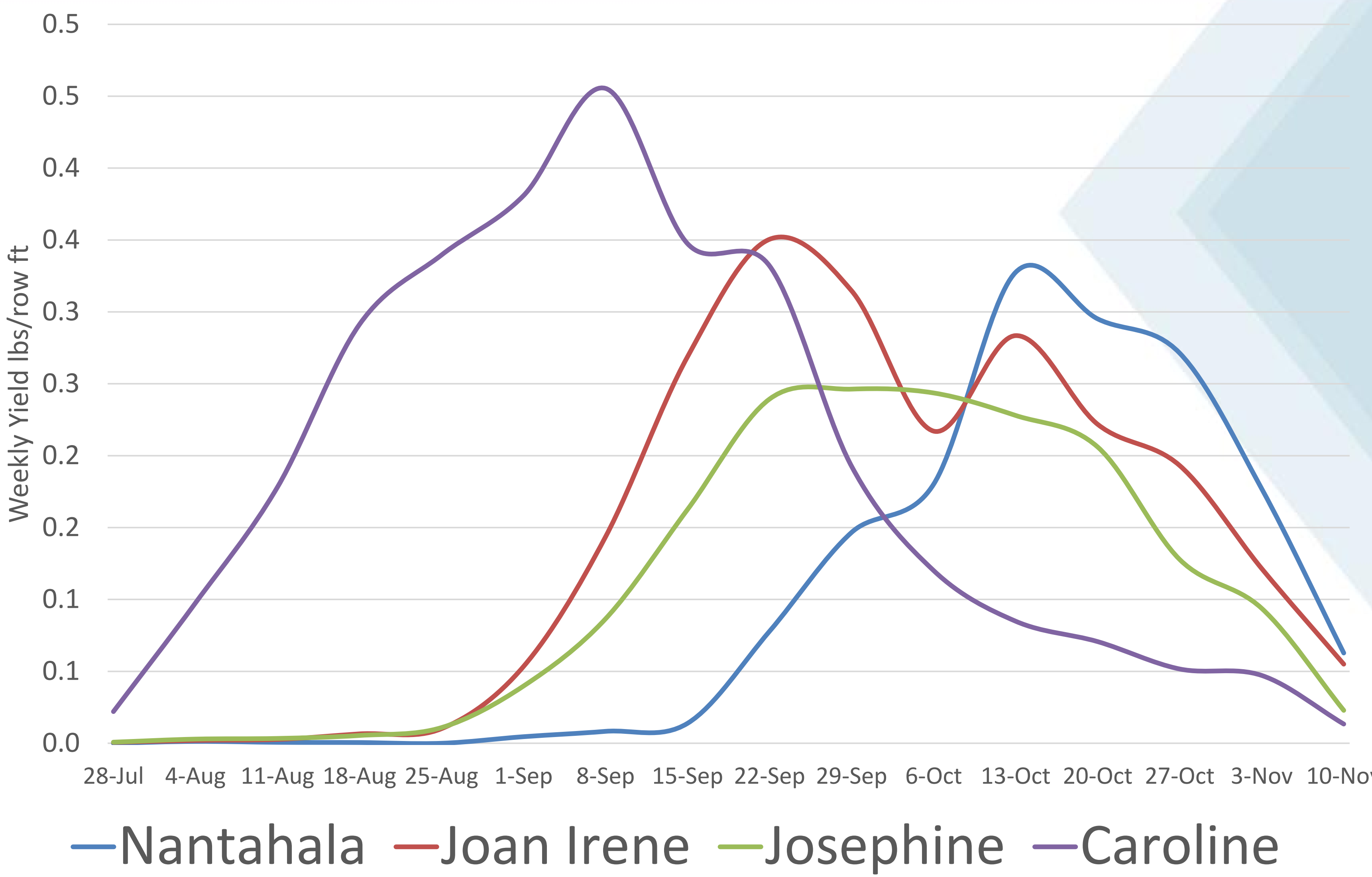
	Yield (kg/m)	
	2008	2009
High tunnel tipped	1.04	3.40
High tunnel un-tipped	1.16	3.81
Field tipped	0.42	2.30
Field un-tipped	0.92	2.61



Late Fall Production



Late Fall Production



Late Fall Production

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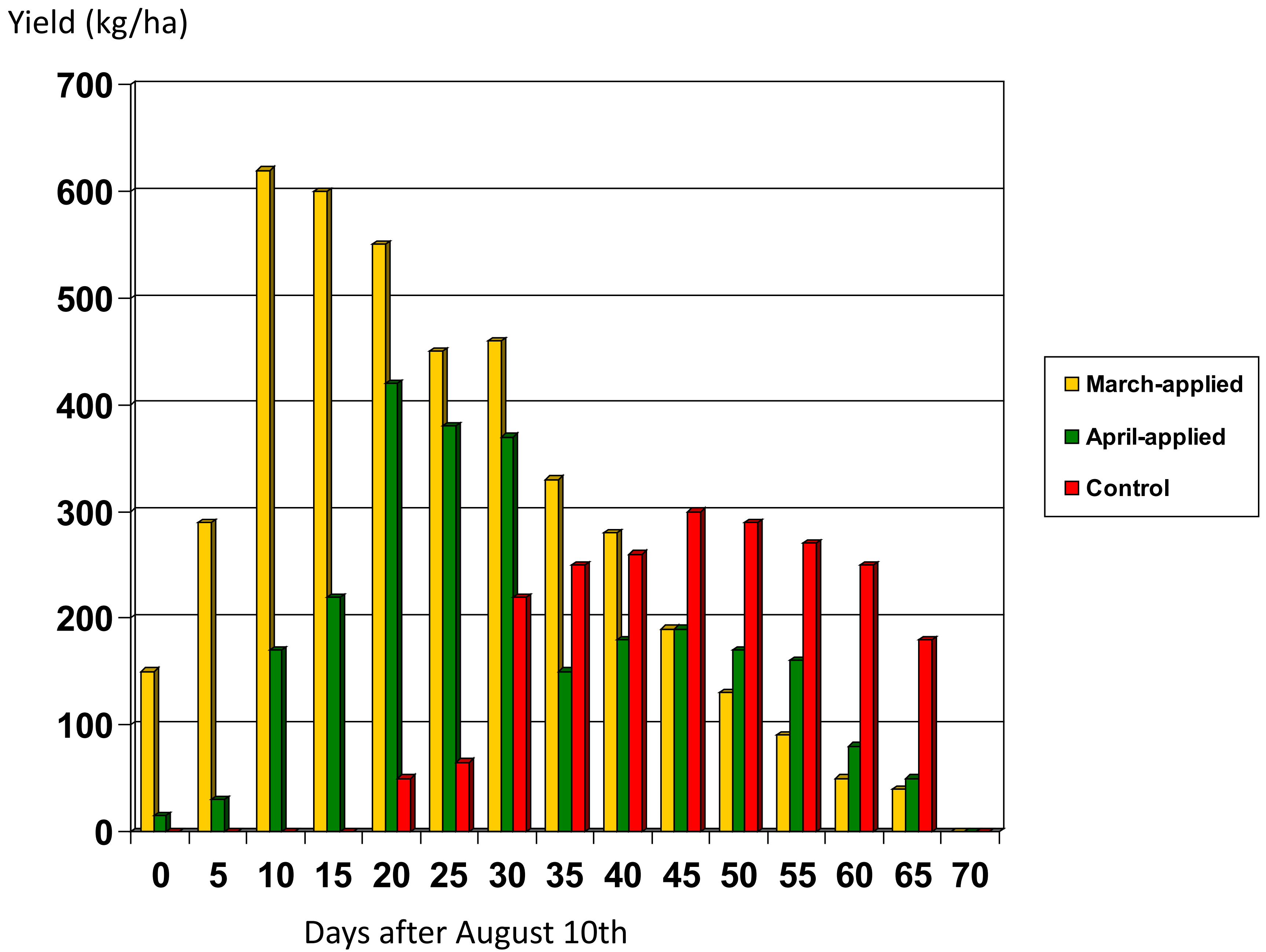
Last date of harvest for the high tunnel and field-grown 'Caroline' and 'Josephine'						
	HT	Field	Extended	< 32°F	< 27°F	< 22°F
2012	15-Oct	12-Oct	3	5-Oct	7-Oct	19-Oct
2013	17-Nov	14-Oct	34	6-Oct	16-Oct	22-Nov
2014	13-Nov	31-Oct	13	22-Oct	29-Oct	13-Nov
2015	6-Nov	6-Nov	0	6-Nov	7-Nov	17-Nov

High Tunnel Raspberries?

- Improve survival of cold sensitive cultivars? NO
- Push summer bearers earlier? NO
- Push Fall Bearers Later? YES
- Push Fall Bearers Earlier?



Yield (kg/ha)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Days after August 10th
March-applied
April-applied
Control

Bear Lake

Laketown (87 frost free days)

Sept 2007

- 'Polana' raspberries
- Spring row covers
- Fall high tunnels

Treatment	2007 marketable yields
No cover or tunnel	= 25 lbs (1,260 lbs/A)
Spring cover, no tunnel	= 122 lbs (6,300 lbs/A)
Cover + fall tunnel	= 242 lbs (12,500 lbs/A)

In Cache Valley?

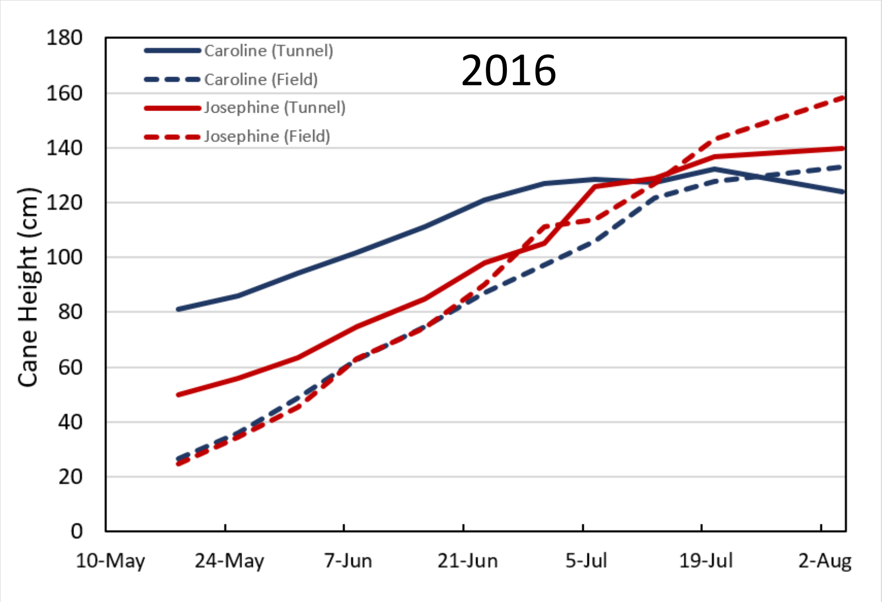
Tunnels with fall bearers

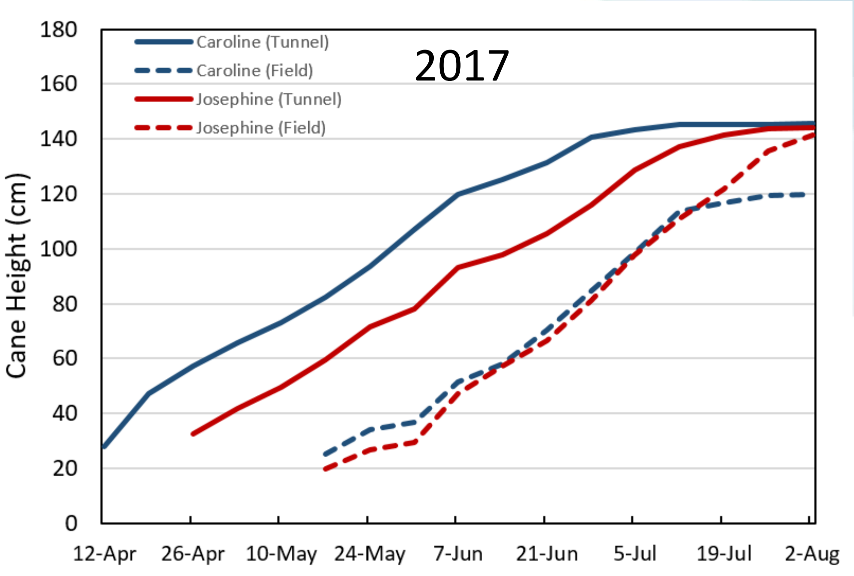
- Caroline and Josephine
- Cut back to ground level
- Tunnels and row covers in mid March
- Shade cloth during fruiting

Early Fall Bearers

- Cane growth

Primocane height on 3-May-2017





Early Fall Bearers

- Production season

Effect of early season tunnel on harvest timing

		Harvest start		
Year	Cultivar	Tunnel	Field	dif.
2016	Caroline	30-Jul	25-Aug	26
	Josephine	6-Aug	28-Aug	22
2017	Caroline	30-Jul	25-Aug	26
	Josephine	8-Aug	26-Aug	18

Early Fall Bearers

- Production season

		Season midpoint		
Year	Cultivar	Tunnel	Field	dif.
2016	Caroline	25-Aug	14-Sep	20
	Josephine	3-Sep	18-Sep	15
2017	Caroline	22-Aug	12-Sep	21
	Josephine	28-Aug	15-Sep	18

Early Fall Bearers

Total season yield

		Yield (lbs/ft)		
		Caroline	Josephine	dif.
2016	Tunnel	1.87	1.10	0.77
	Field	1.68	0.75	0.93
2017	Tunnel	2.21	1.41	0.80
	Field	2.05	1.04	1.01

Early Fall Bearers

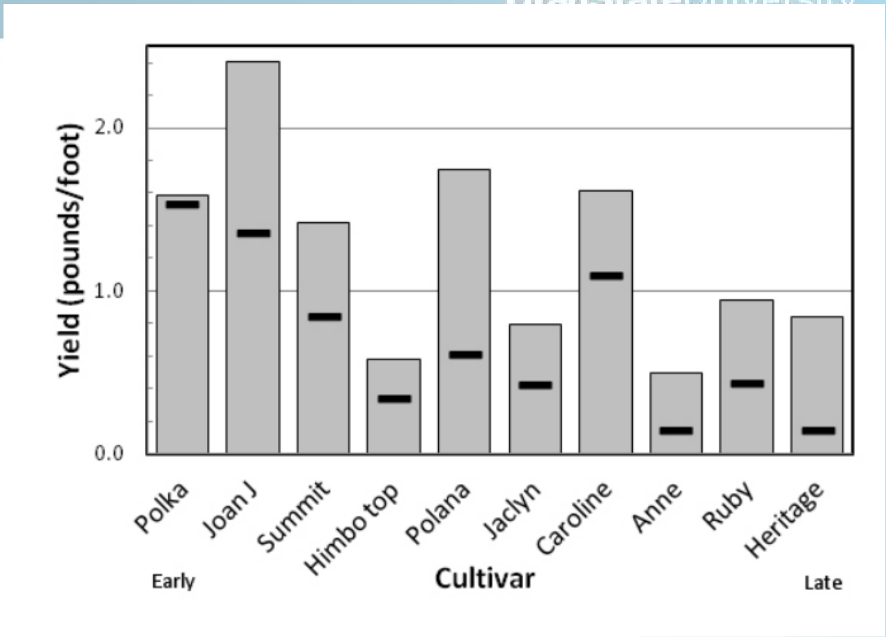
Marketable fruit (%).

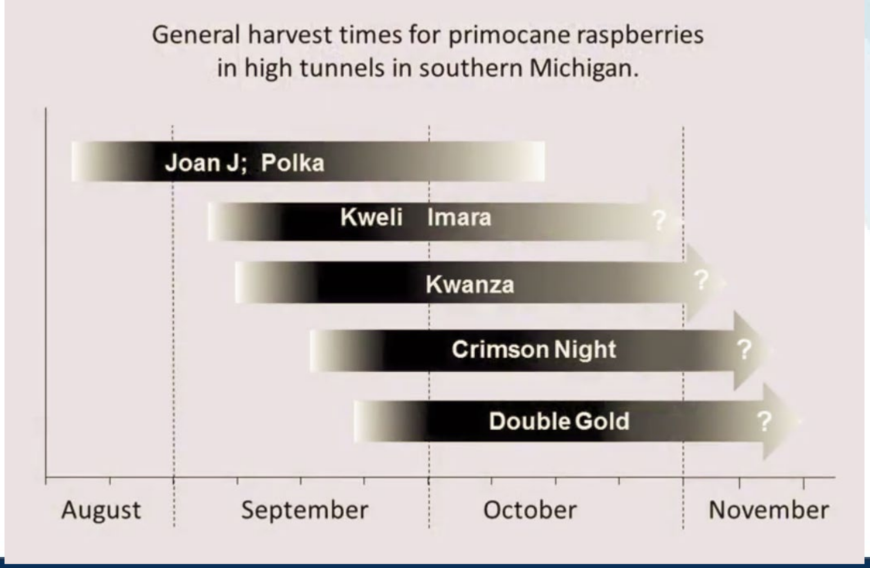
		Marketable (%)		
Year	Cultivar	Tunnel	Field	dif.
2016	Caroline	92.4	81.8	10.6
	Josephine	94.7	85.8	8.9
2017	Caroline	76.6	75.2	1.4
	Josephine	85.4	78.1	7.2

Unmarketable due to sunburn, crumbly

Early Fall Bearers

- Other cultivars?
  - Polka, Polana, Joan J





TunnelBerries
Sponsored by USDA-SCRI

High Tunnel Raspberries?

- Improve survival of cold sensitive cultivars? NO
- Push summer bearers earlier? NO
- Push Fall Bearers Later? YES
- Push Fall Bearers Earlier? YES

Early Fall Bearers

- Low-cost tunnels
  - 45’ $ 960
  - 90’ $1,500
  - 140’ $1,800

Horticulture

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extension.usu.edu

June 2014 Horticulture/HighTunnels/2014-05

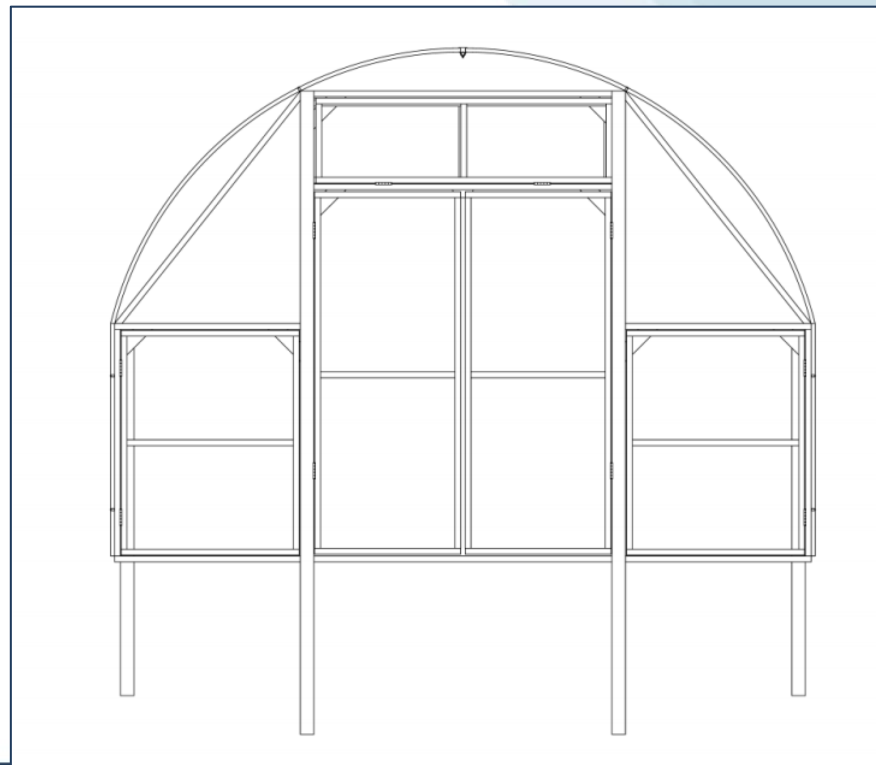
Constructing a Low-Cost High Tunnel for Tall Crops (14.5' wide by 10' tall)

Tiffany Maughan, Research Associate, ***Daniel Rowley***, Former Graduate Student, ***Brent Black***, Extension Fruit Specialist, ***Dan Drost***, Extension Vegetable Specialist

High tunnels can be effective for both season extension and frost protection. There are many different designs and materials used for high tunnel construction. When deciding what high tunnel you

sledge hammer, ladder, and a measuring tape. Table 1 provides the materials list for constructing the tunnels. The cost of wood materials was determined by averaging 2014 prices across three Logan, Utah

- Early heating strategies?
  - Row covers
  - Low tunnels
  - Bed mulches



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Fruit-Eating Insects

I will review the primary insects that feed directly on berry fruits, including grasshoppers, earwigs, European paper wasps, and spotted wing drosophila. I will provide insights on insect biology and ecology, and integrated pest management practices.

Diane Alston
Professor and Extension Entomologist
Utah State University
diane.alston@usu.edu

My responsibilities are in research and extension horticultural entomology (fruit and vegetable insect pests) and integrated pest management. I am a member of the Utah Pests Team at Utah State University. We develop educational programs and outreach materials on effective pest management practices for Utah's producers and home gardeners.

Berry-Eating Insects

Diane Alston, Entomologist
Utah State University
Urban & Small Farms Conference
February 21, 2019
West Valley City, UT

UTAH PESTS

Utah State University

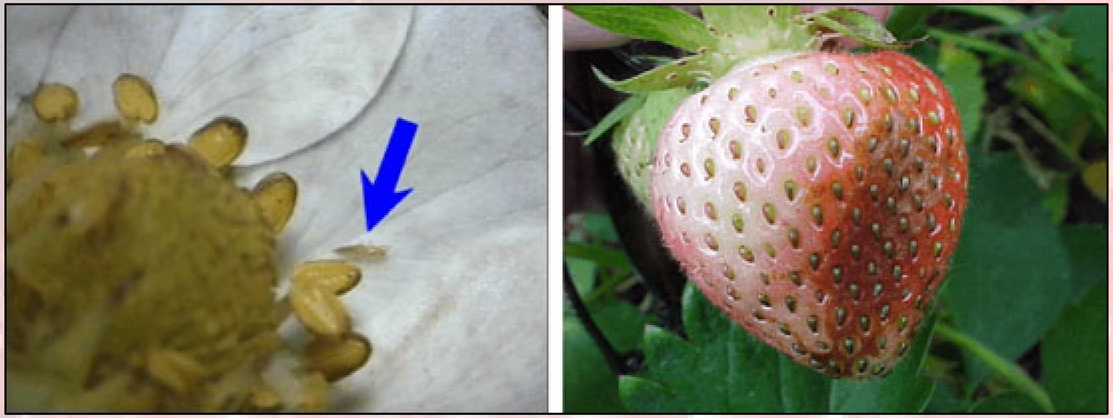
Berry-Feeding Insects

- Early Season – bloom to fruitlet
  - Thrips
  - Lygus bug
- Late Season – mature fruit
  - Stink bugs
  - European earwig
  - European paper wasp
  - Grasshoppers

European paper wasp eating raspberry

Western Flower Thrips

Thrips larva (left) & adults
~1/20 inch long



Thrips feed on flowers & fruit with punch-and-suck mouthparts

Scouting for thrips in blackberry

Thrips blossom blast
on sweet pea

Distorted fruit with
pronounced seeds

Thrips Insecticides - Bloom

- Commercial
  - acetamiprid (Assail; 1 d PHI)
  - imidacloprid (Admire Pro; 3 d)
  - diazinon – prebloom only to prevent bee kill (7 d)
  - spinetoram (Delegate; 1 d)
  - spinosad (Success, Entrust^Org; 1 d)
    - allow to dry ≥ 3 hr before bee activity
- Home use
  - acetamiprid (Ortho Max), azadirachtin^Org, bifenthrin, carbaryl, insecticidal soap^Org, malathion, permethrin, pyrethrin^Org, spinosad^Org

Wild bee pollinating raspberry flowers

Read and follow label directions carefully!

Lygus Bug
Western Tarnished Plant Bug

Lygus hesperus
~1/4 inch long, yellow V on back
Piercing-sucking mouthparts

Early feeding causes fruit distortion: “cat-facing”, due to damaged seeds - piercing

Lygus bug nymphs

Cultural & biological management:
- Alfalfa hay cutting
- Weed suppression & removal
- Flowering trap crop (careful monitoring)
- Natural predators & parasitic wasps
- Bug-vac

Lygus Bug Insecticides - Bloom

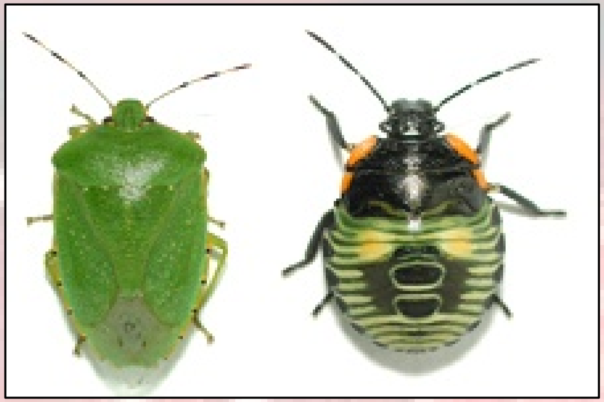
- Commercial
  - *Beauveria bassiana* (Mycotrol[some Org])
  - fenpropathrin (Danitol; 2-3 d PHI)
  - malathion (1 d)
  - thiamethoxam (Actara; 3 d) – post-bloom only
- Home use
  - azadirachtin[Org], bifenthrin, carbaryl, esfenvalerate, kaolin[Org], malathion, permethrin, zeta-cypermethrin

"Cat-faced" strawberry fruits caused by lygus bug

Read and follow label directions carefully!

Stink Bugs

~1/2 inch
shield-shaped



Green stink bug, *Acrosternum hilare,* adult (left) and nymph

Mating consperse stink bugs, *Euschistus conspersus*

Barrel-shaped eggs, laid in masses

Deformed, dry berries; Piercing-sucking mouthparts

Release a foul odor that contaminates berries; Use similar cultural mgmt. practices as for lygus bug

Stink Bug Insecticides – Before Harvest

- Knock-down, contact chemicals & repellents
- Commercial
  - bifenthrin, esfenvalerate, fenpropathrin, malathion, zeta-cypermethrin
- Home use
  - acetamiprid, azadirachtin^{Org}, carbaryl, esfenvalerate, permethrin (raspberry only), insecticidal soap^{Org}, pyrethrin^{Org}
- Adjust air-blast or vacuum-suction cleaner systems on mechanical harvester to reduce insect contamination in berries

European Earwig

Female European earwig (straight cerci)

Nocturnal – feed on fruits & leaves with chewing mouthparts

European Earwig

Earwig Management – Before Harvest

- Same insecticides as for stink bugs
- Insecticidal soap + pyrethrin[Org]
  - reapply every 3-5 days
  - suppressive
  - combine with trapping & habitat management
- Predation by fowl
  - chicken, turkey, duck

Dense & moist ground covers, such as birdsfoot trefoil, can provide attractive daytime refuge for earwigs (not as much for wheat straw & paper mulch)

Earwigs prefer dense, moist refuge

European Paper Wasp
Polistes dominula

European paper wasp (left) has a more slender waist than a yellow jacket (right)

E. paper wasp likes to feed on ripe fruit, but is also a predator

Deformed wing disease

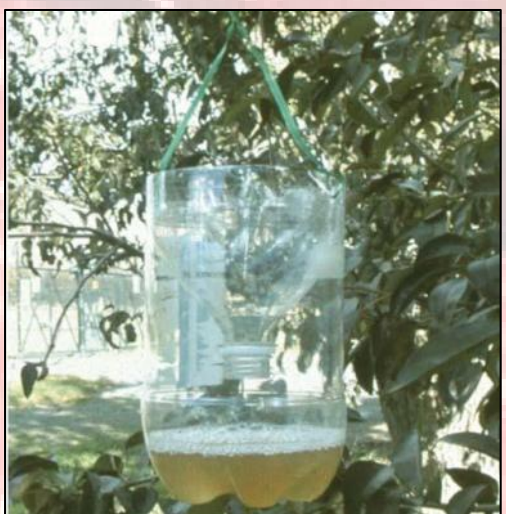
EPW in Utah since 1990s

European Paper Wasp Management

Spring and early summer: beneficial predator of caterpillars

Treat nests with aerosol wasp sprays & remove nests to eliminate larvae developing in cells

Mid summer to early fall: feed on ripe fruit
Trap: fruit juice/yeast bait in pop bottle
Protect fruit with insecticide sprays (same as earwig & SB)



Yellow jacket traps ineffective

USU Extension video fact sheet

utahpests.usu.edu slideshows

Grasshoppers on Berries

Strip the foliage
Some eat fruit: e.g., Differential grasshopper, *Melanoplus differentialis*

Late summer to early fall
Hot, dry conditions

Grasshopper Management

- Floating row cover fabric
- Cultivate around plants in fall and/or spring to disrupt overwintering eggs in soil
- Predation by fowl
- Insecticides
  - similar products as for earwigs, wasps, and stink bugs
  - treat a larger area around farm/garden
    - insecticides and baits
      - *Nosema locustae*, carbaryl

UTAH PESTS fact sheet

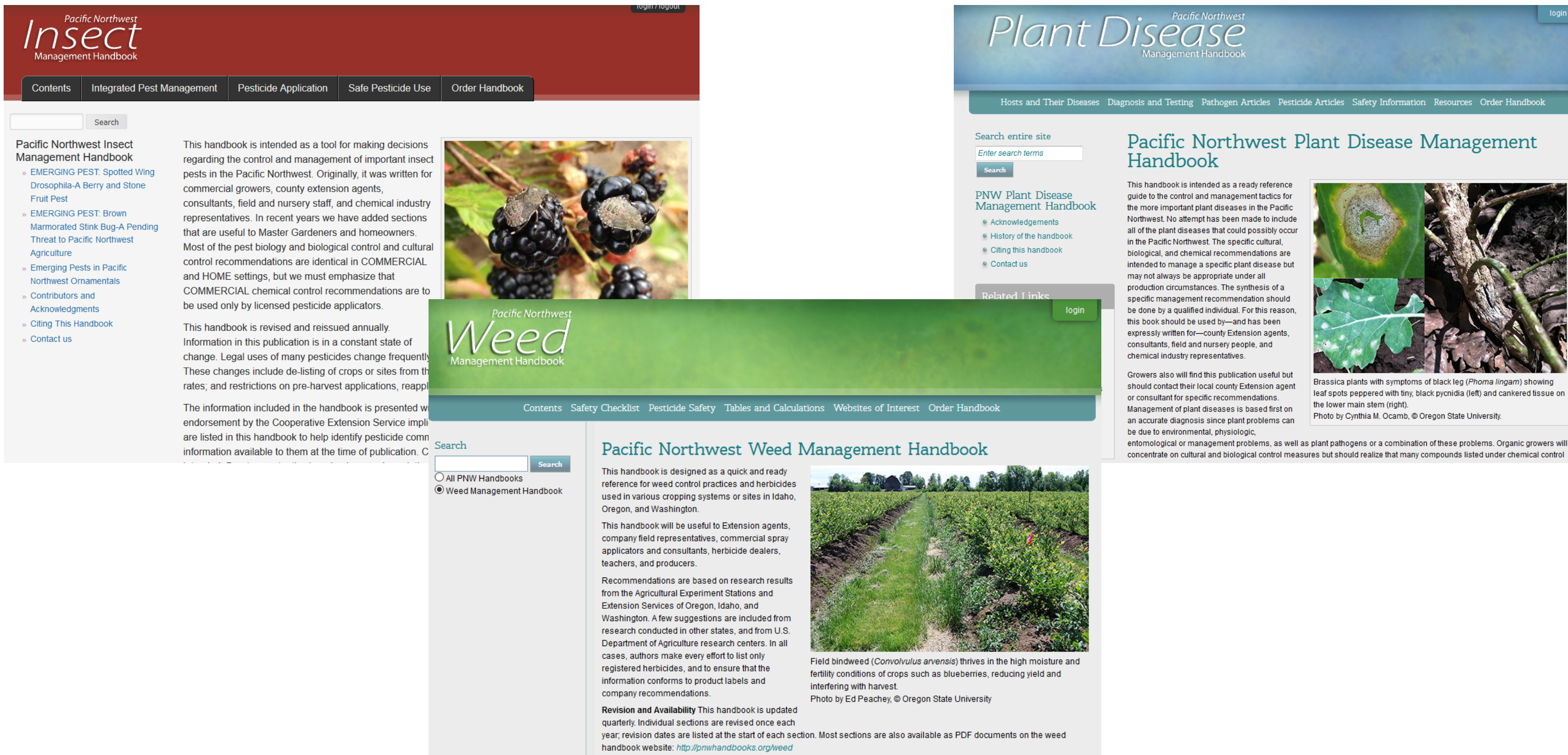
Community-Wide Grasshopper Control

HOW TO IDENTIFY NYMPHS

Community-Wide Grasshopper Control Fact Sheet

utahpests.usu.edu Fact sheets

Pacific Northwest Pest Management Handbooks
Google: PNW Handbook for links



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Invasive Fruit Pests

I will present on the monitoring and management of spotted wing drosophila and brown marmorated stink bug.

Lori Spears
Professional Practice Assistant Professor
Utah State University
lori.spears@usu.edu

My main role at Utah State University is to lead surveys for invasive pests of fruits, vegetables, and field crops (alfalfa, corn, and small grains). I then relay survey data to Utah stakeholders through newsletter articles, fact sheets, conference presentations, and farmer field days (see Education and Outreach below). My research focuses on the ecology of spotted wing drosophila and brown marmorated stink in Utah. I have a BS degree in Anthropology from Weber State University and a PhD in Ecology from Utah State University.

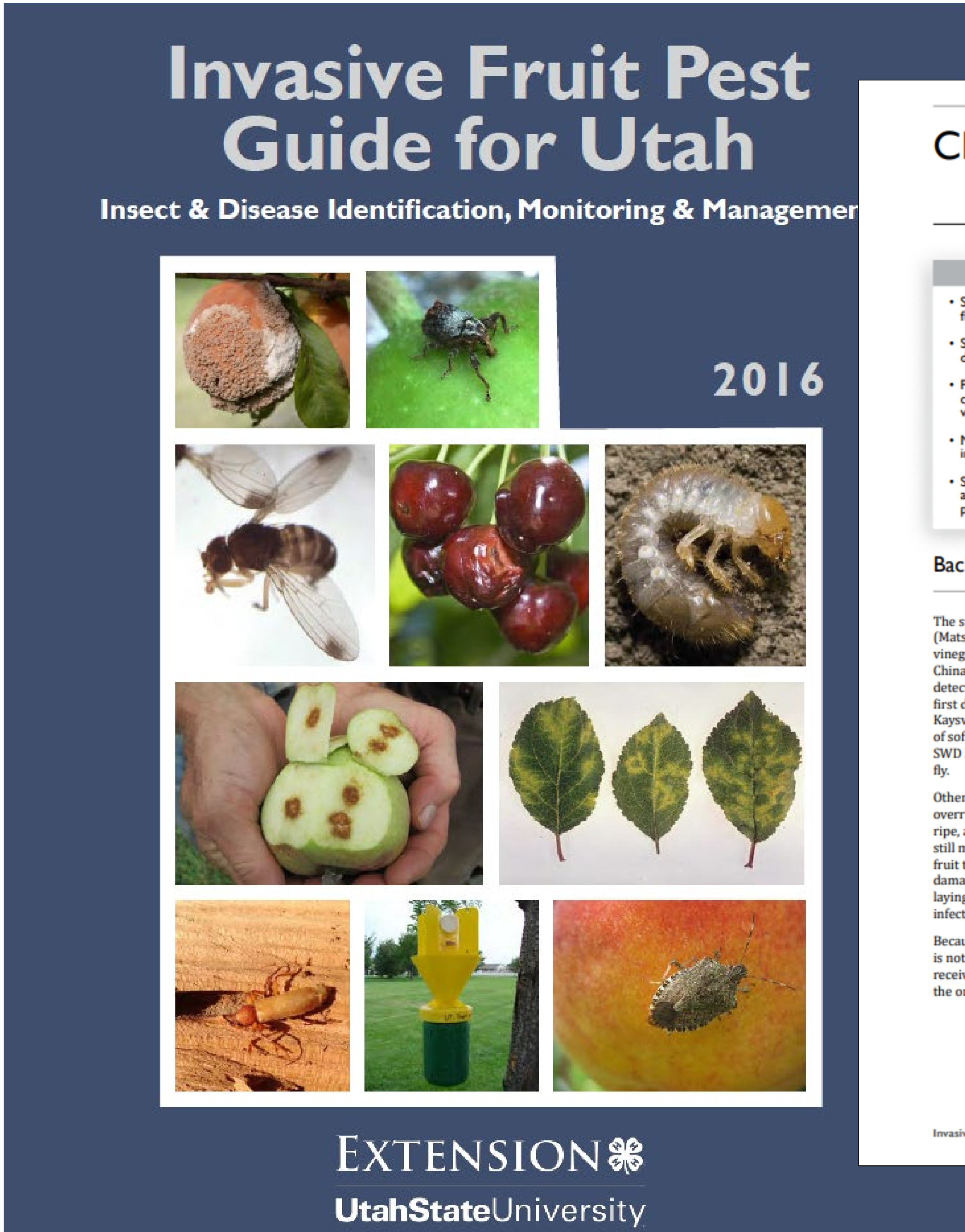
Spotted Wing Drosophila & Brown Marmorated Stink Bug

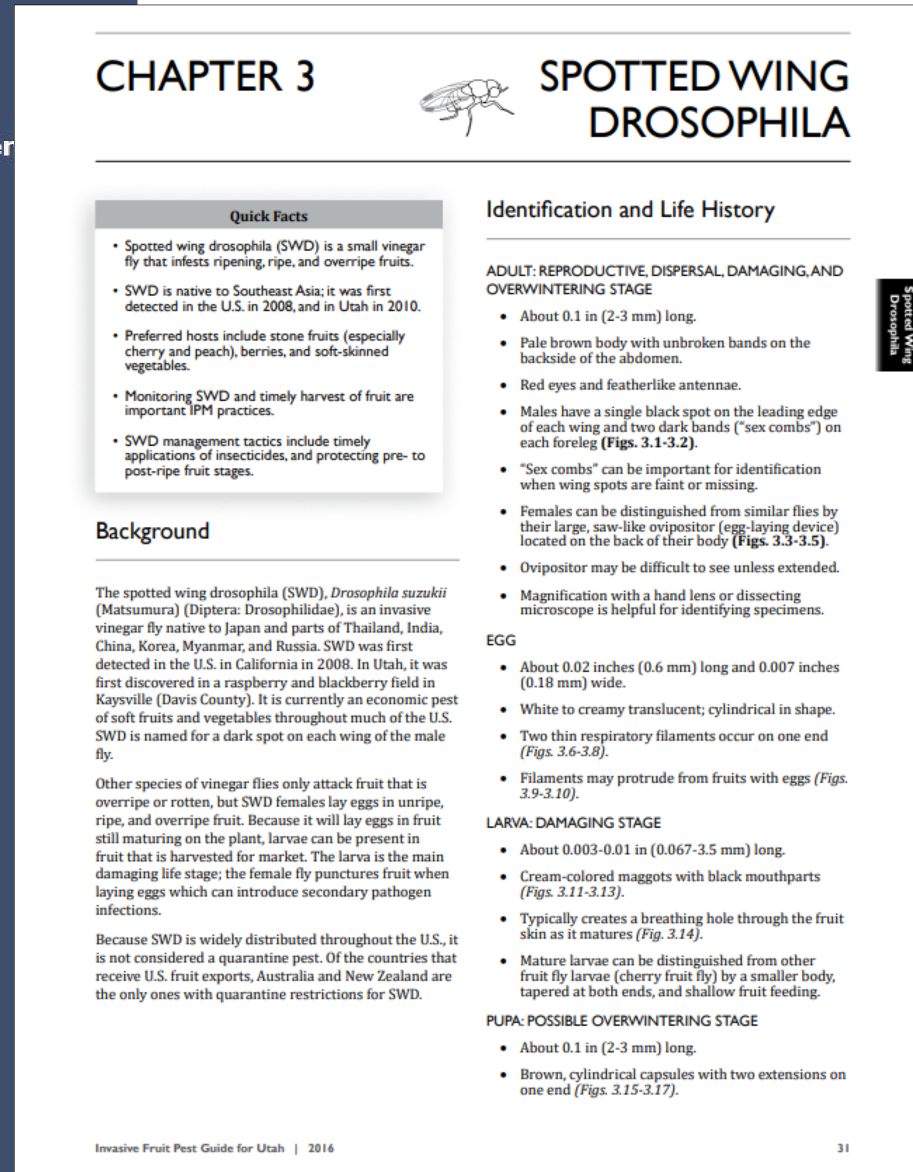
Lori Spears
Utah State University
Urban and Small Farms Conference
February 21, 2019

Save the Date

Invasive Fruit Pest Workshop

March 6: 9:00 AM – 2:00 PM
Spanish Fork Fairgrounds
$10 registration fee includes lunch
Speakers include Drs. Nikki Rothwell and Tracy Leskey
Register at bmsb.eventbrite.com





CHAPTER 3 SPOTTED WING DROSOPHILA

Quick Facts

- Spotted wing drosophila (SWD) is a small vinegar fly that infests ripening, ripe, and overripe fruits.
- SWD is native to Southeast Asia; it was first detected in the U.S. in 2008, and in Utah in 2010.
- Preferred hosts include stone fruits (especially cherry and peach), berries, and soft-skinned vegetables.
- Monitoring SWD and timely harvest of fruit are important IPM practices.
- SWD management tactics include timely applications of insecticides, and protecting pre- to post-ripe fruit stages.

Background

The spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), is an invasive vinegar fly native to Japan and parts of Thailand, India, China, Korea, Myanmar, and Russia. SWD was first detected in the U.S. in California in 2008. In Utah, it was first discovered in a raspberry and blackberry field in Kaysville (Davis County). It is currently an economic pest of soft fruits and vegetables throughout much of the U.S. SWD is named for a dark spot on each wing of the male fly.

Other species of vinegar flies only attack fruit that is overripe or rotten, but SWD females lay eggs in unripe, ripe, and overripe fruit. Because it will lay eggs in fruit still maturing on the plant, larvae can be present in fruit that is harvested for market. The larva is the main damaging life stage; the female fly punctures fruit when laying eggs which can introduce secondary pathogen infections.

Because SWD is widely distributed throughout the U.S., it is not considered a quarantine pest. Of the countries that receive U.S. fruit exports, Australia and New Zealand are the only ones with quarantine restrictions for SWD.

Identification and Life History

ADULT: REPRODUCTIVE, DISPERSAL, DAMAGING, AND OVERWINTERING STAGE

- About 0.1 in (2-3 mm) long.
- Pale brown body with unbroken bands on the backside of the abdomen.
- Red eyes and featherlike antennae.
- Males have a single black spot on the leading edge of each wing and two dark bands ("sex combs") on each foreleg **(Figs. 3.1-3.2)**.
- "Sex combs" can be important for identification when wing spots are faint or missing.
- Females can be distinguished from similar flies by their large, saw-like ovipositor (egg-laying device) located on the back of their body **(Figs. 3.3-3.5)**.
- Ovipositor may be difficult to see unless extended.
- Magnification with a hand lens or dissecting microscope is helpful for identifying specimens.

EGG

- About 0.02 inches (0.6 mm) long and 0.007 inches (0.18 mm) wide.
- White to creamy translucent; cylindrical in shape.
- Two thin respiratory filaments occur on one end *(Figs. 3.6-3.8)*.
- Filaments may protrude from fruits with eggs *(Figs. 3.9-3.10)*.

LARVA: DAMAGING STAGE

- About 0.003-0.01 in (0.067-3.5 mm) long.
- Cream-colored maggots with black mouthparts *(Figs. 3.11-3.13)*.
- Typically creates a breathing hole through the fruit skin as it matures *(Fig. 3.14)*.
- Mature larvae can be distinguished from other fruit fly larvae (cherry fruit fly) by a smaller body, tapered at both ends, and shallow fruit feeding.

PUPA: POSSIBLE OVERWINTERING STAGE

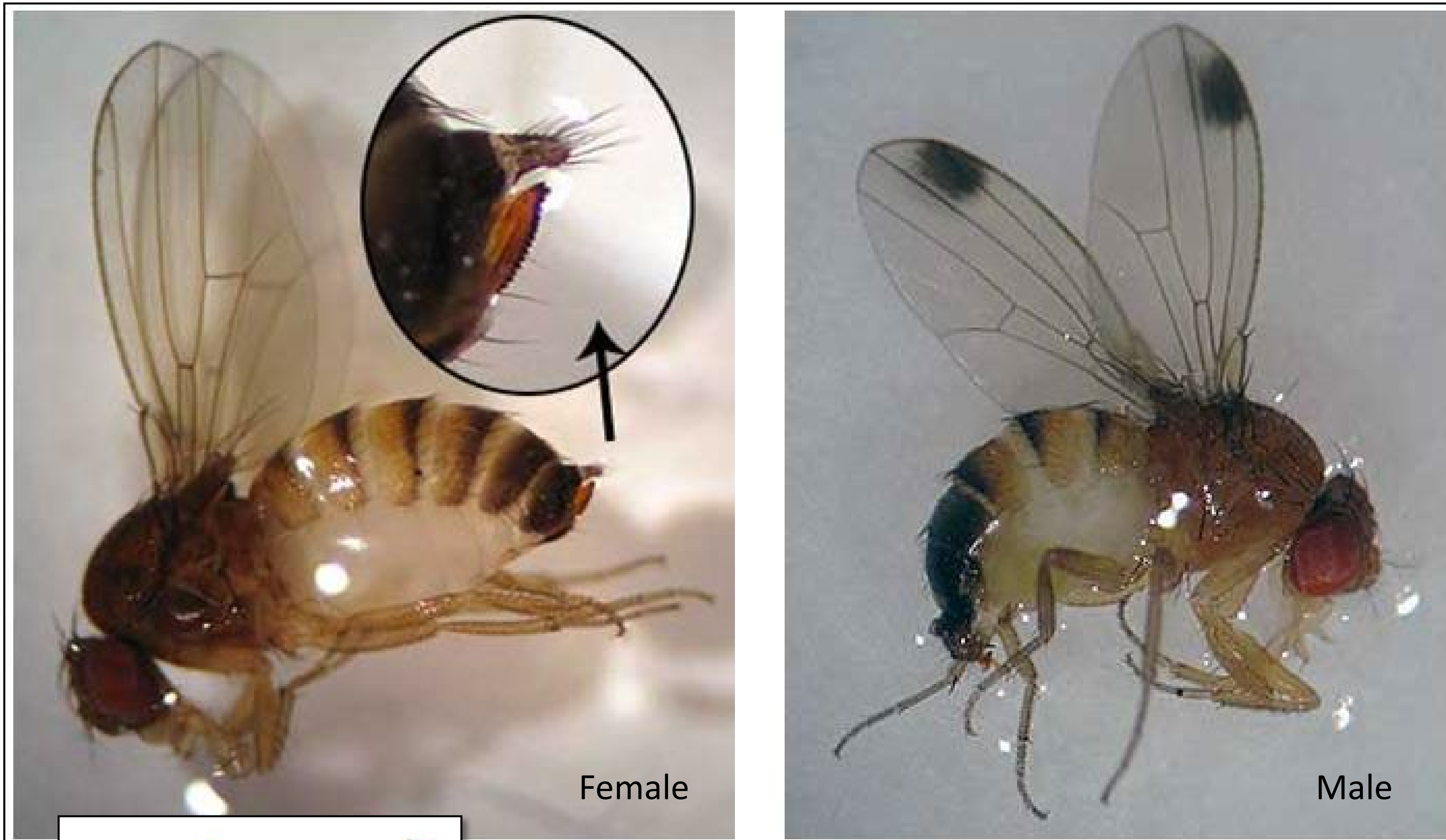
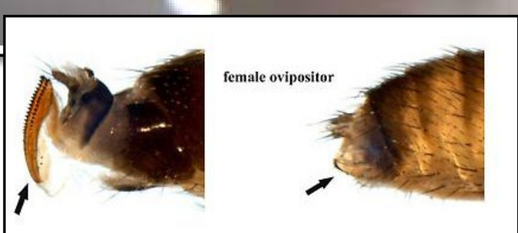
- About 0.1 in (2-3 mm) long.
- Brown, cylindrical capsules with two extensions on one end *(Figs. 3.15-3.17)*.

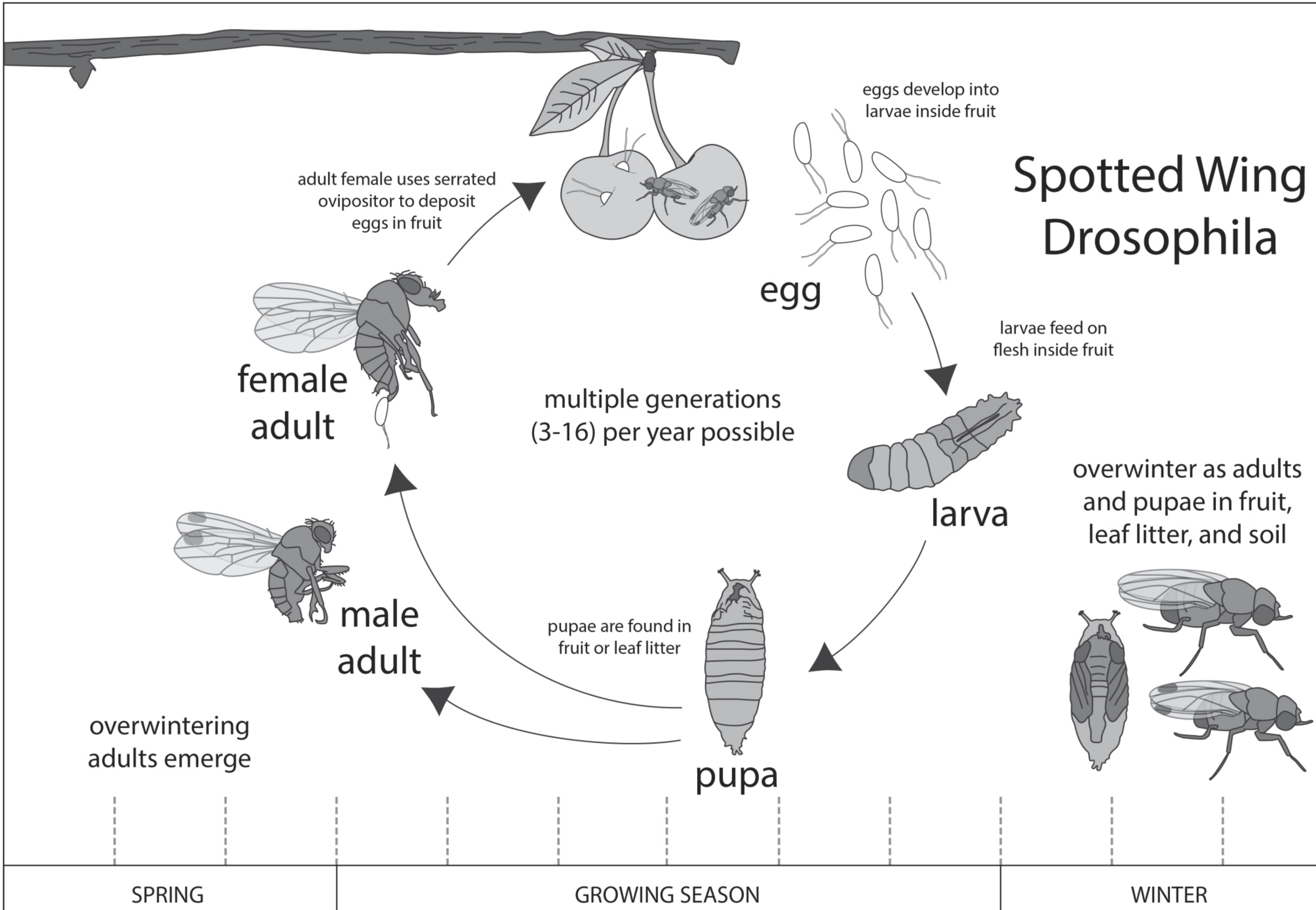
Spotted Wing Drosophila

Spotted Wing Drosophila

- Native to southeast Asia
- Infests ripening, ripe, & overripe soft-skinned fruit
- Detected in the U.S. in 2008
- Detected in Utah in 2010
- Very abundant in wild habitats & backyard gardens
- No damage reports


Millipede on strawberry
SWD larva in raspberry


Female
Male

female ovipositor


Spotted Wing Drosophila
adult female uses serrated ovipositor to deposit eggs in fruit
eggs develop into larvae inside fruit
egg
larvae feed on flesh inside fruit
female adult
multiple generations (3-16) per year possible
larva
overwinter as adults and pupae in fruit, leaf litter, and soil
male adult
pupae are found in fruit or leaf litter
overwintering adults emerge
pupa
SPRING
GROWING SEASON
WINTER

Monitoring for SWD

- Scentry lure; water + a few drops of unscented dish soap
- Begin monitoring as fruit ripens
- Place trap in cool, shaded area
- Service trap weekly

Low trap numbers may not accurately indicate first fly activity

Cultural Control of SWD

- Focus on early fruiting varieties
- Early or timely harvest
- Chill fruit (34-38°F) (12-72 hrs.)
- Nets of fine mesh (1 mm)
- Eliminate fallen & infested fruit
- Minimize overhead irrigation; repair leaking drip lines
- Maintain open canopy
- Mow row middle

Biological Control of SWD

- In SWD's native range, a wide number of natural enemies keep SWD numbers in check
  - *Ganaspis brasiliensis*
  - *Leptopilina japonica*
  - *Asobara japonica*

- Native parasitoids rarely parasitize SWD
  - *Leptopilina boulardi, L. heterotoma*
  - *Asobara tabida*
  - *Pachycrepoideus vindemiae*
  - *Trichopria drosophilae*

- Parasitoids attack pupae in fruit and soil

Most common predators include ants, crickets, ground beetles, and spiders

- Mulching type does not affect level of predation
- Some predators prefer certain mulches
- High-input systems have lower numbers of natural enemies

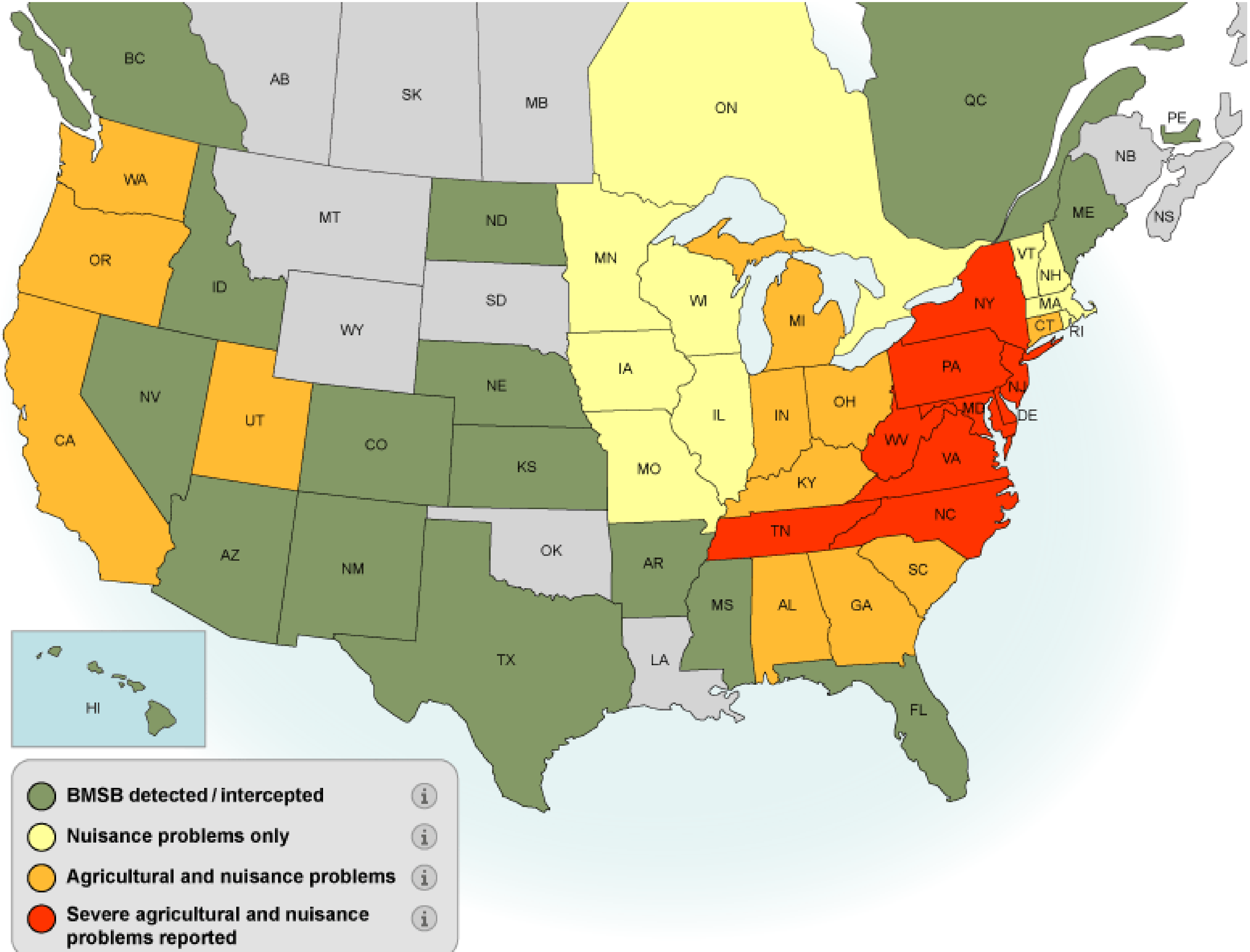
Chemical Control of SWD

- Target adults before they lay eggs in fruit
- Special care must be taken to prevent killing bees
- Insecticides*
  - acetamiprid (Assail)
  - malathion (Malathion)
  - spinosad (Entrust^O^)

*more insecticide options available in the SWD fact sheet and Invasive Fruit Pest Guide for Utah

Brown Marmorated Stink Bug

- Native to eastern Asia
- Detected in the U.S. in 1990s
- Detected in Utah in 2012; first crop damage reported in 2017
- Broad host range; poses significant risk to specialty crops
- Invades structures for overwintering
- Strong dispersal capacity



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GA
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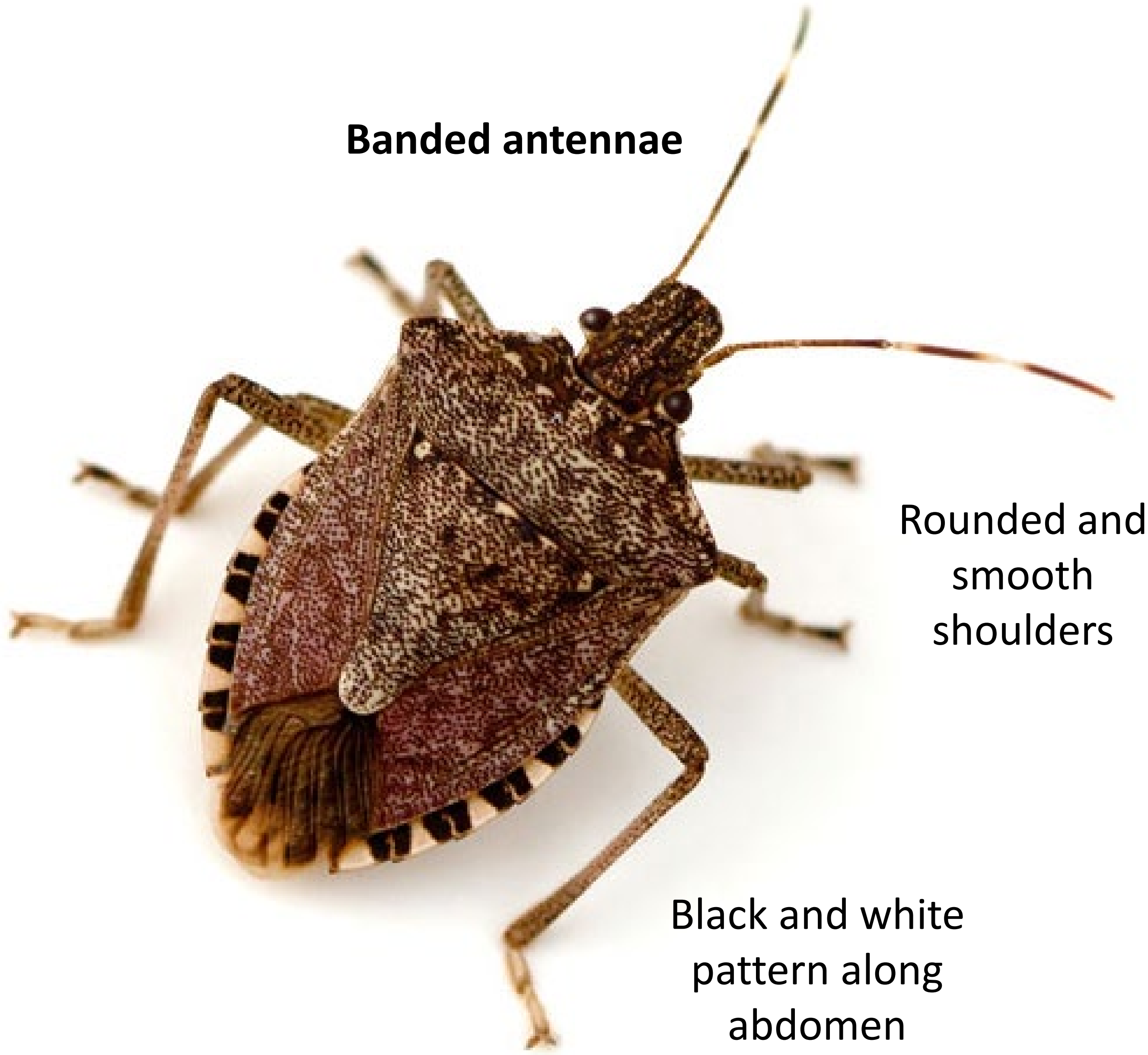
LA
FL
HI
BMSB detected / intercepted
Nuisance problems only
Agricultural and nuisance problems
Severe agricultural and nuisance problems reported
Updated: 1/18/2018

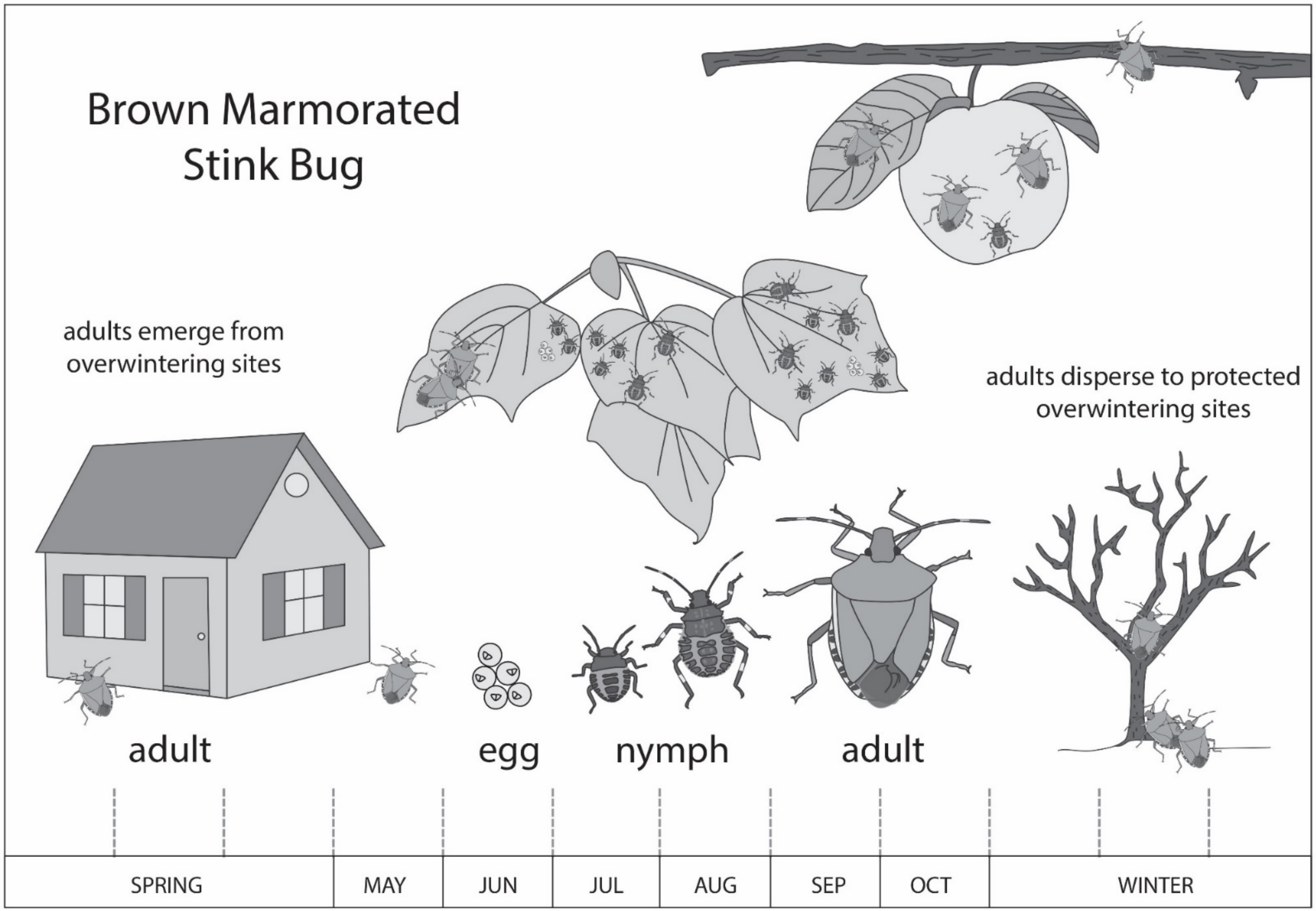



Banded antennae
Rounded and smooth shoulders
Black and white pattern along abdomen

Life History and Biology

All except stage 1 are damaging

Spring emergence of adult bugs from overwintering sites is usually very extended

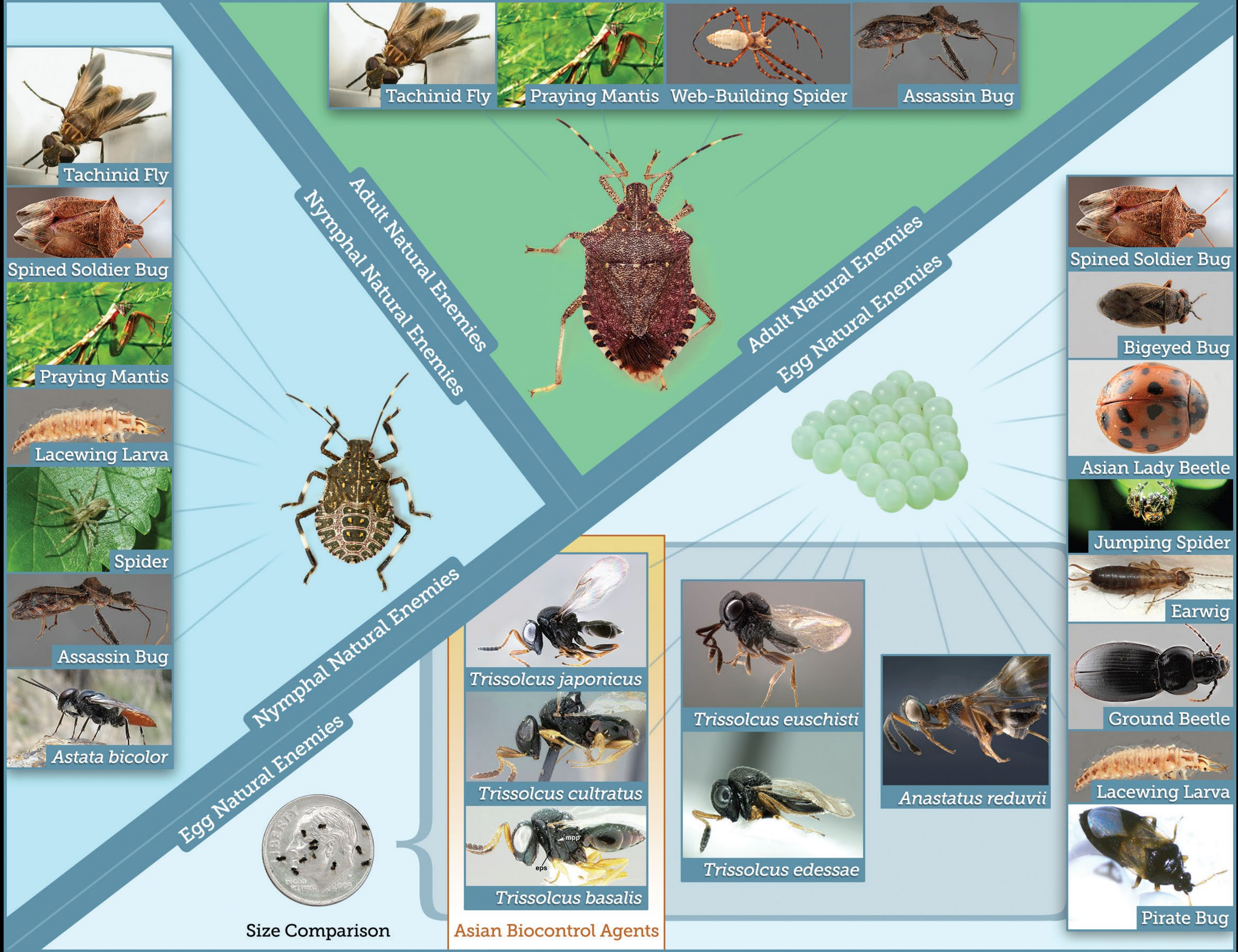


Successful BMSB management depends on a reliable pest detection and monitoring strategy

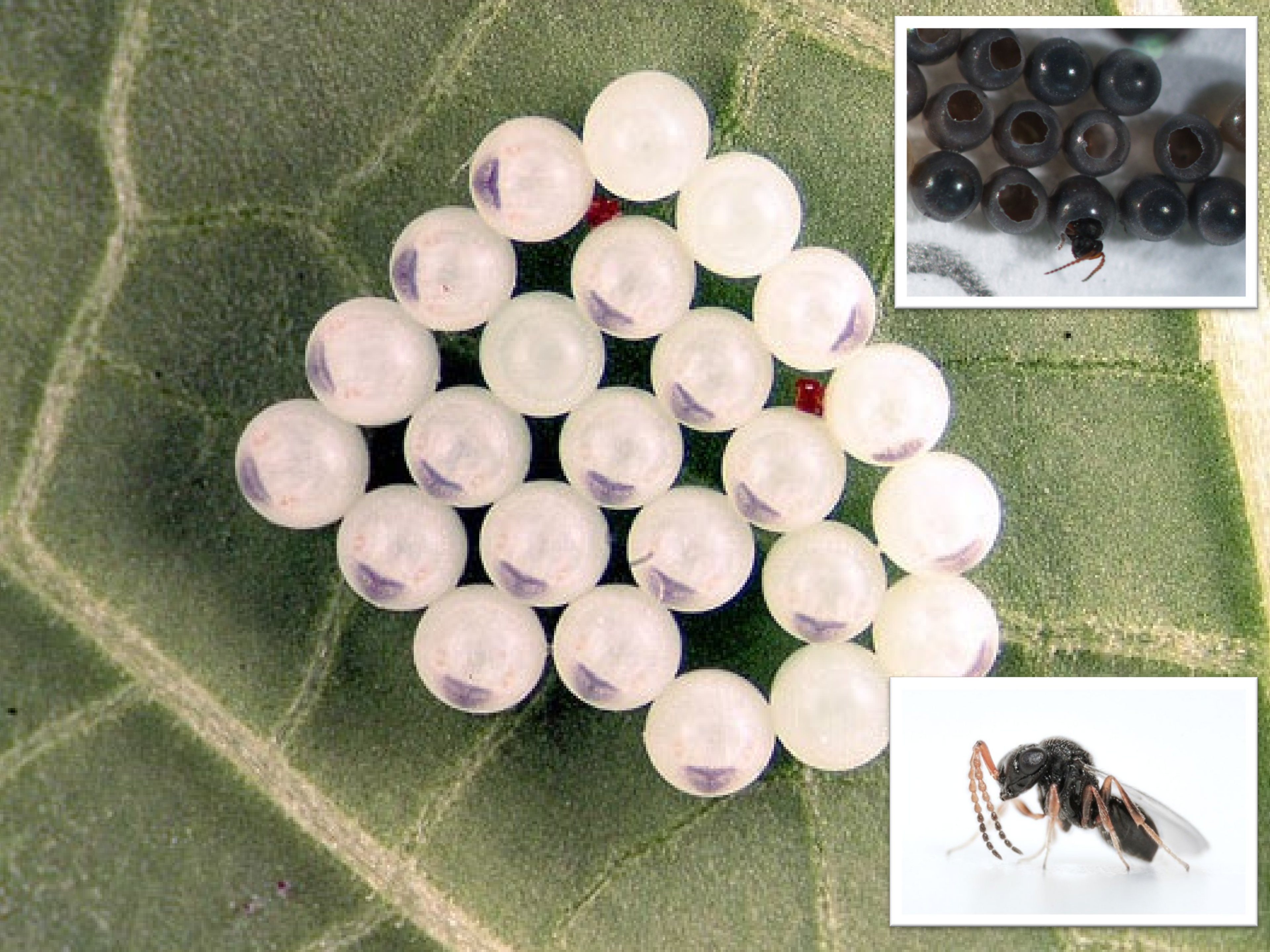
- Visual stimulus
  - Tall black pyramid trap (trunk-mimicking stimulus)
- Capture mechanism
  - Inverted funnel jar with insecticide-treated net/kill strip
- Olfactory stimulus
  - PHER + MDT (Trécé Dual Lure)
- Deployment strategy
  - Trap placed in peripheral row or border area

Cultural and Mechanical Control

- Trap crops
- Row covers (LLIN)
- Attract-and-kill



Tachinid Fly
Praying Mantis
Web-Building Spider
Assassin Bug
Adult Natural Enemies
Nymphal Natural Enemies
Adult Natural Enemies
Egg Natural Enemies
Tachinid Fly
Spined Soldier Bug
Praying Mantis
Lacewing Larva
Spider
Assassin Bug
Astata bicolor
Nymphal Natural Enemies
Egg Natural Enemies
Spined Soldier Bug
Bigeyed Bug
Asian Lady Beetle
Jumping Spider
Earwig
Ground Beetle
Lacewing Larva
Pirate Bug
Trissolcus japonicus
Trissolcus cultratus
mpp
eps
Trissolcus basalis
Trissolcus euschisti
Trissolcus edessae
Anastatus reduvii
Size Comparison
Asian Biocontrol Agents



Chemical Control of BMSB

- Intensive spray programs are still seeing high levels of damage
- Do not spray when pollinators are active
- Populations are typically highest on field edges
- Reserve the most efficient products for later in the season
- Insecticides*
  - acetamiprid (Assail)
  - thiamethoxam (Actara)
  - fenpropathrin (Danitol[R])

*more insecticide options available in the BMSB fact sheet and Invasive Fruit Pest Guide for Utah

Acknowledgments

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- Anna Fabiszak
- Carson Wise
- Taryn Rodman

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- USHA Research Committee
- USDA
- Utah Specialty Crop Block Grant
- Western IPM Center
- USU Extension
- WSARE / Utah IPM
- Utah Agricultural Experiment Station

Management of BMSB in US Specialty Crops

Funding

Specialty Crop Research Initiative

Collaborators

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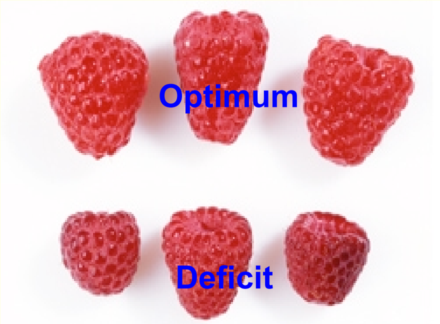
Drip Irrigation Management for High Quality Production of Raspberries and Blackberries

Good irrigation practices are critical for profitable production of raspberries and blackberries. Irrigation helps produce larger fruit, higher yields, and more and larger canes. The amount of irrigation water to apply varies dramatically across soil types and climates. In this presentation, I will discuss methods to estimate the water requirements, irrigation scheduling, and design and management of drip irrigation systems.

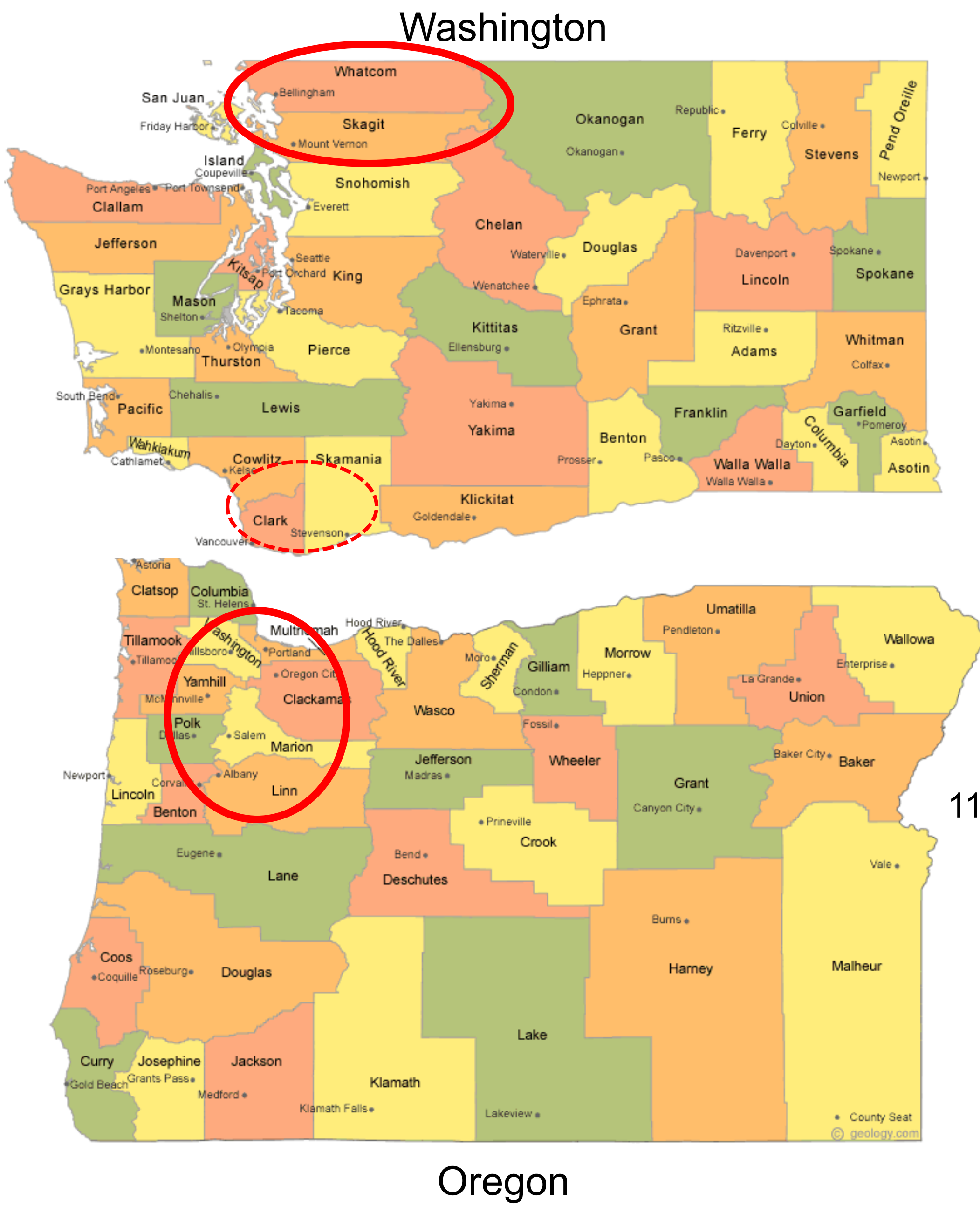
David Bryla
Research Horticulturist
USDA ARS
david.bryla@ars.usda.gov

Dr. Bryla's research focuses on irrigation and nutrient management in berry crops. The goal is to identify practices that increase plant growth and yield potential; enhance fruit quality and food safety; promote efficient use of water, fertilizer, and soil resources; reduce problems caused by plant pests and diseases; and limit labor requirements associated with pruning, weeding, and harvest. A few of his current projects include the use of drones to monitor crop growth and water requirements in blueberry and raspberry, design and management of fertigation systems, deficit irrigation strategies for reducing water use during drought, and benefits of soil amendments such as humic acids and biochar.



Drip Irrigation Management for High Quality Production of Raspberries and Blackberries

David Bryla
USDA-ARS Horticultural Crops Research Unit
Corvallis, Oregon



9700 acres raspberries

7900 acres blackberries
1500 acres raspberries
1100 acres black raspberries

Washington/Oregon Raspberry Production

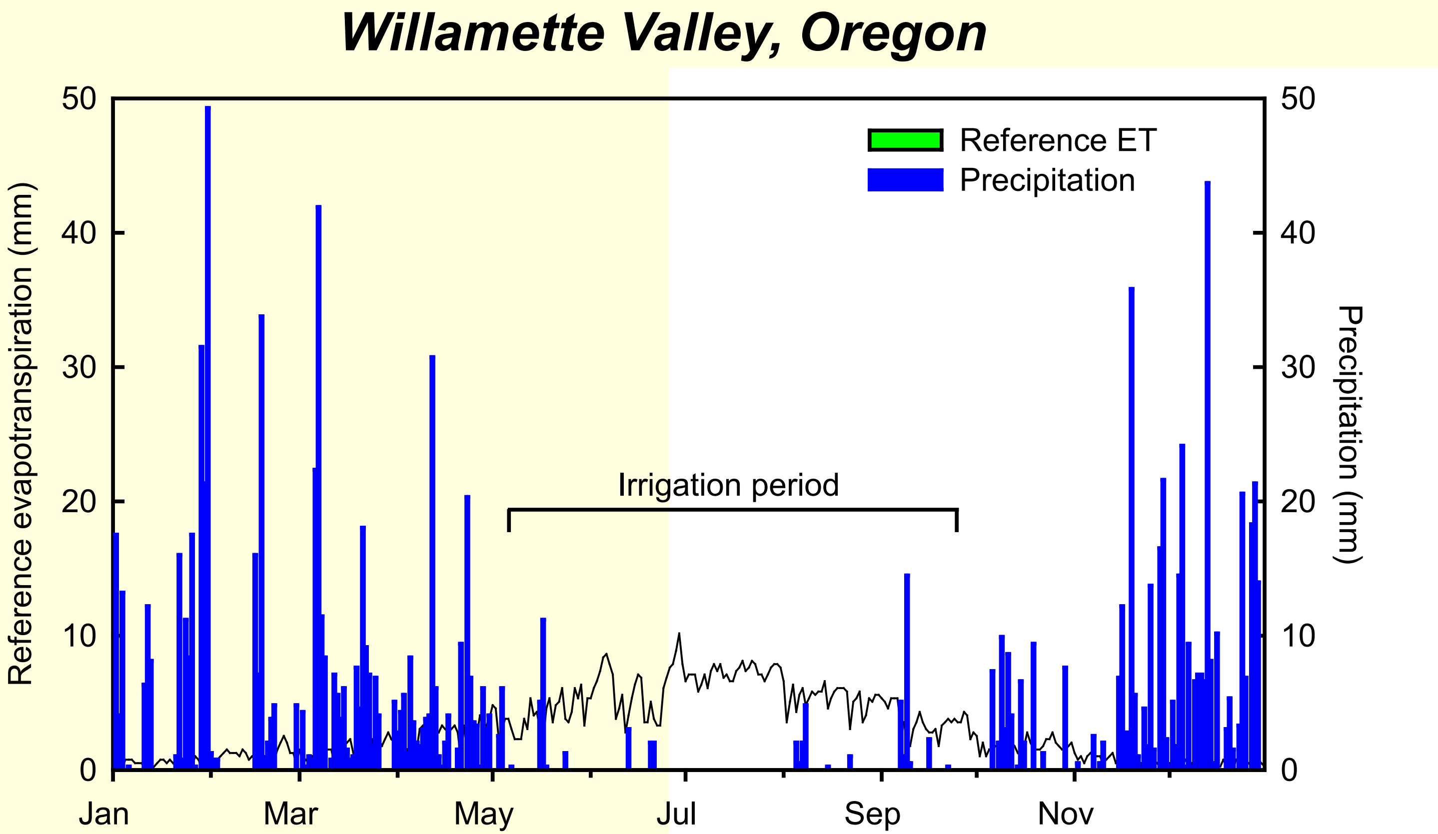
- 2.5 x 10 ft. spacing
- Raised beds
- Arced canes
- Machine harvest

- 'Meeker' & 'Wake ™Field' are the primary cultivars
- Surface/subsurface drip (WA) & sprinklers/guns (OR)
- Granular fertilizers/fertigation

Oregon Blackberry Production

- 5 x 10 ft. spacing
- Flat ground
- Two-wire trellis
- Every or alternate year production
- Machine harvest
- ‘Marion’, ‘Black Diamond’, ‘Columbia Star’ are top cultivars
- Drip & sprinklers/guns
- Granular fertilizers/fertigation

Water requirements



Irrigation methods and considerations for water applications

- System options and configurations
- Estimating water requirements
  - Background
  - Tools


What's the Best Way to Irrigate Raspberries?
How much water is needed and how is it best applied?
Sprinklers?
Drip?
Aurora, Oregon

Two irrigation studies were planted

STUDY 1

Cultivars
- Coho
- Meeker

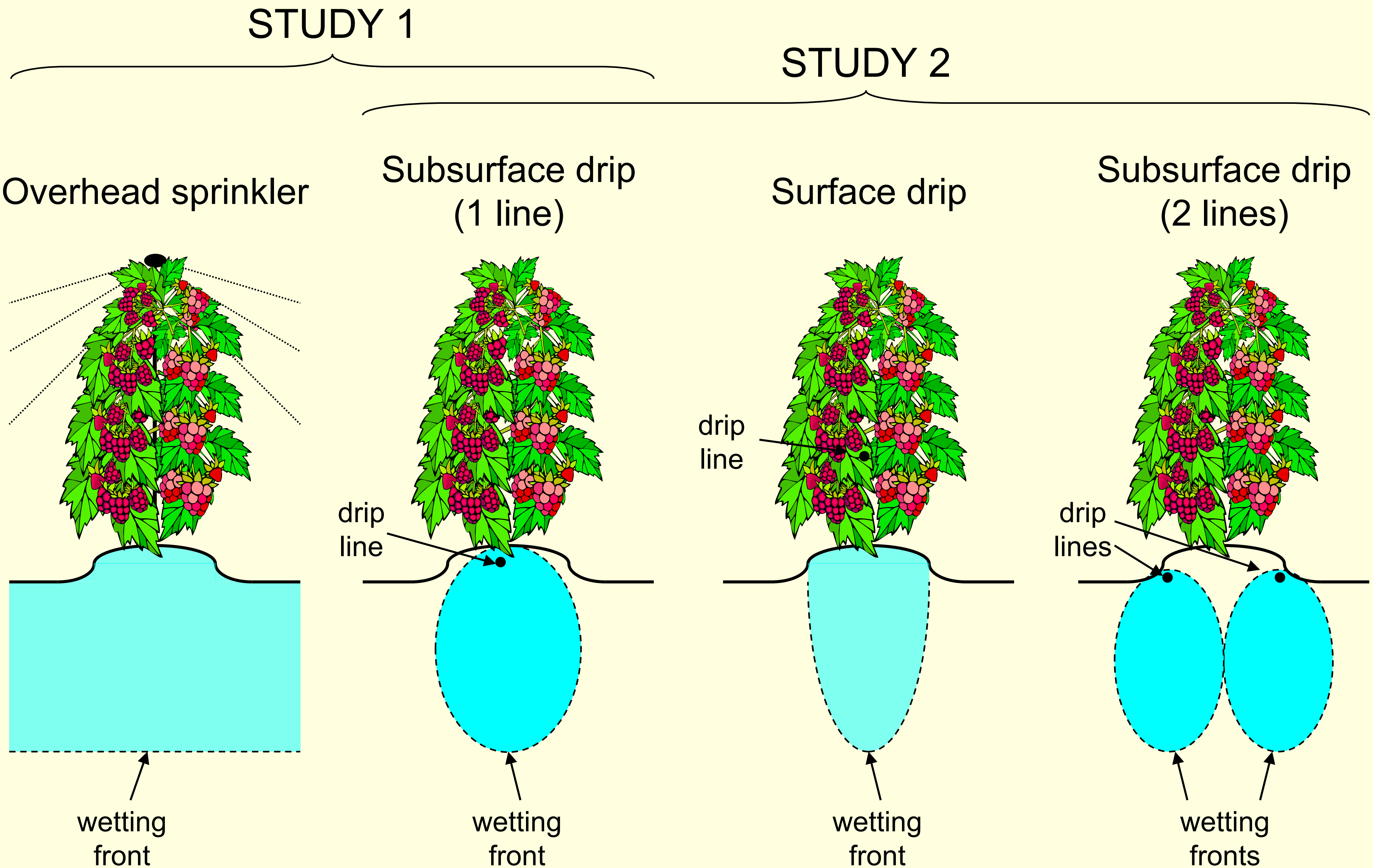
Irrigation methods
- Sprinklers
- Drip

Irrigation levels (% of crop ET)
- 50% (deficit)
- 100% (optimum)
- 150% (excess)

STUDY 2

Cultivars
- Cascade Delight
- Cowichan
- Meeker
- Tulameen
- Caroline } Fall fruiters
- Heritage }

Drip configurations
- Surface drip
- Subsurface drip (1 line)
- Subsurface drip (2 lines)

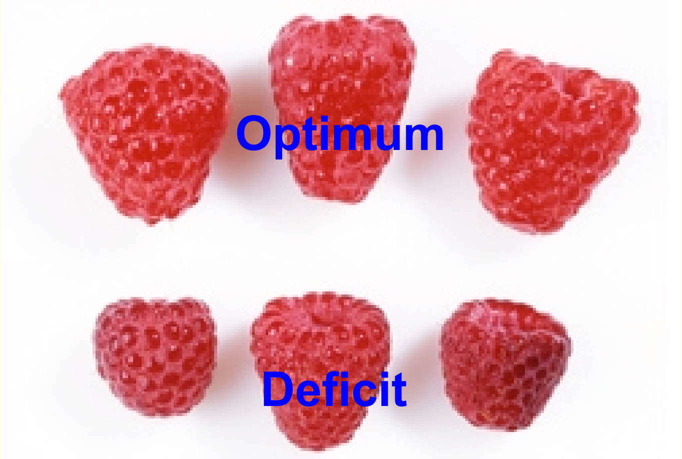


**Applied 2.5x's more water with sprinklers than with drip

Study 1 was machine-harvested

**2006 was “baby crop” & 2007 was first year of full production*

Irrigation level	Berry wt. (2006-09) (g/fruit)
50% ETc (deficit)	3.76 b
100% ETc (optimum)	3.89 a
150% ETc (excess)	3.97 a



Cultivar*	Berry wt. in 2006-09 (g/fruit)		
	Sprinkler	Subsurface drip	%Difference
Coho	3.98 b	4.24 a	7%
Meeker	3.66 c	3.62 c	-1%
%Difference	9%	17%	

STUDY 1

	Yield in 2007 (ton/acre)		
Irrigation level	Sprinkler	Subsurface drip	%Difference
50% ETc (deficit)	5.3 b	5.3 b	0%
100% ETc (optimum)	5.2 b	6.1 a	18%
150% ETc (excess)	5.2 b	5.8 a	12%

STUDY 1

Cultivar	Irrigation system	Irrigation level (%ET_c)	Yield (ton/acre) 2006*	2007	2008	2009	Total
Coho	Sprinkler	50	2.5 a	5.4 b-e	2.0 b	1.8 d	11.7 ef
Coho	Sprinkler	100	2.4 a	5.2 c-e	2.0 b	1.5 d	11.1 f
Coho	Sprinkler	150	2.4 a	5.4 b-e	2.3 b	2.1 cd	12.2 e
Coho	SDI	50	2.4 a	5.7 a-c	2.1 b	2.3 cd	12.5 e
Coho	SDI	100	2.6 a	6.3 a	2.3 b	2.6 c	**13.8 d**
Coho	SDI	150	2.4 a	6.0 ab	2.4 b	2.7 c	13.5 d
Meeker	Sprinkler	50	2.4 a	5.2 c-e	3.7 a	4.8 b	16.1 bc
Meeker	Sprinkler	100	2.4 a	5.2 c-e	3.7 a	4.5 b	15.8 c
Meeker	Sprinkler	150	2.2 a	5.0 de	3.8 a	5.0 ab	15.7 c
Meeker	SDI	50	2.3 a	4.9 e	3.5 a	4.8 b	15.5 c
Meeker	SDI	100	2.7 a	5.9 ab	4.0 a	5.7 a	**17.4 a**
Meeker	SDI	150	2.3 a	5.6 b-d	3.7 a	5.2 ab	16.8 ab

*"Baby crop" year

‘Coho’ was severely affected by root rot beginning in 2008 (year 3)

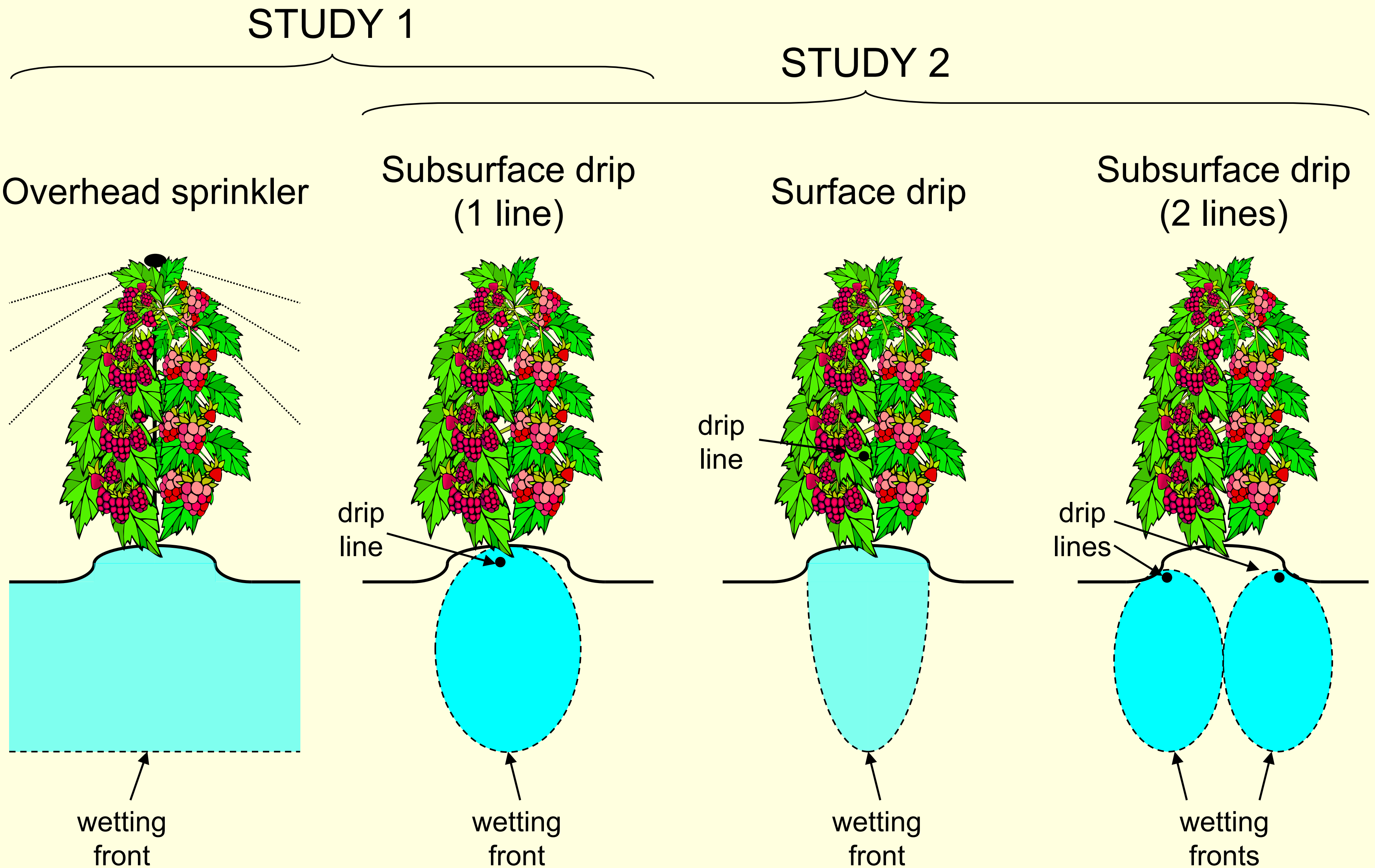

Root rot was most prevalent in the lower areas
where water tended to pool

Root rot was also greater with sprinklers & under-irrigation

Irrigation level (%ET_c)	Root rot rating			
	Coho		Meeker	
	Sprinkler	SDI	Sprinkler	SDI
50	3.6 de	3.9 cd	4.9 a	4.9 a
100	2.9 e	4.0 b-d	4.8 a	5.0 a
150	4.2 bc	4.5 ab	5.0 a	5.0 a

Ratings:

1 = >50% of the plants collapsed
2 = some plant death but <50% of the plants collapsed
3 = at least half the plants were severely stunted & yellowing
4 = mild stunting and yellowing
5 = completely healthy



**Applied the same amount of water with each method

STUDY 2

Cultivar	Yield (ton/acre)	
	2007	2008
Cascade Delight	6.6 a	2.7 a
Cowichan	5.6 c	2.4 a
Meeker	5.8 bc	2.2 ab
Tulameen	6.3 ab	1.7 b

Drip configuration	Yield (ton/acre)	
	2007	2008
Surface drip from trellis wire	6.1 a	2.4 a
Subsurface drip (1 line)	6.3 a	2.1 a
Subsurface drip (2 lines)	5.8 a	2.3 a

No difference

Cultivar	Berry wt. (g/fruit) 2007	Berry wt. (g/fruit) 2008
Cascade Delight	5.48 a	3.37 a
Cowichan	4.07 c	3.14 b
Meeker	3.56 d	2.65 c
Tulameen	4.68 b	3.19 b

Fruit size was affected by drip placement

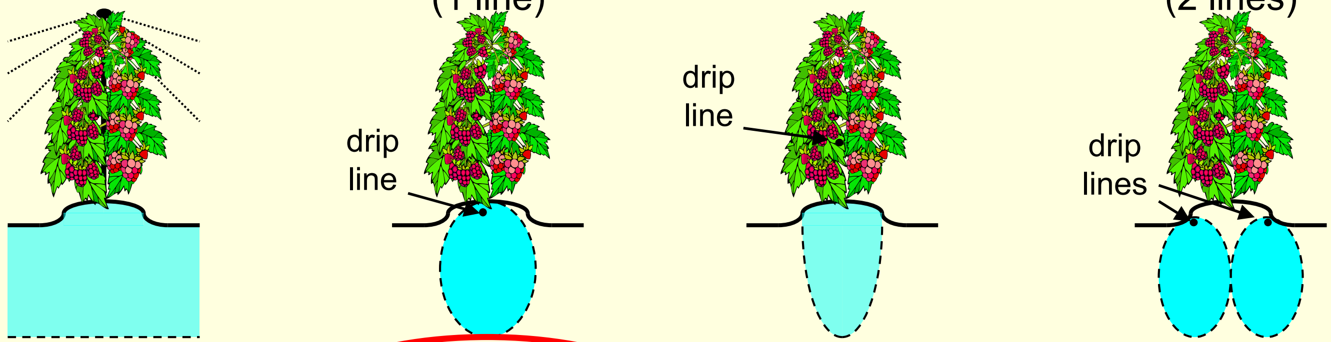
Drip configuration	Berry wt. (g/fruit) 2007	Berry wt. (g/fruit) 2008
Surface drip from trellis wire	4.58 a	3.12 a
Subsurface drip (1 line)	4.36 b	3.10 a
Subsurface drip (2 lines)	4.40 b	3.03 a


The cultivar trial was also affected by root rot, but
root rot was not related to irrigation treatment

SUMMARY

STUDY 1: Overhead sprinkler; Subsurface drip (1 line)

STUDY 2: Subsurface drip (1 line); Surface drip; Subsurface drip (2 lines)



	Overhead sprinkler	Subsurface drip (1 line)	Surface drip	Subsurface drip (2 lines)
Yield		Increased yield by up to 18% over sprinklers	Yield was similar to other drip treatments	
Fruit size		Increased fruit weight by 7% over sprinklers – but only in 'Coho'	Produced larger fruit on average than other drip configurations	
Root rot	Root rot was higher with sprinklers and lower rates of water application		Root & fruit rot were not affected by drip placement	
Fruit rot	Fruit rot was higher with sprinklers than with drip			
Water use		Maximum production at 100% ET_c		

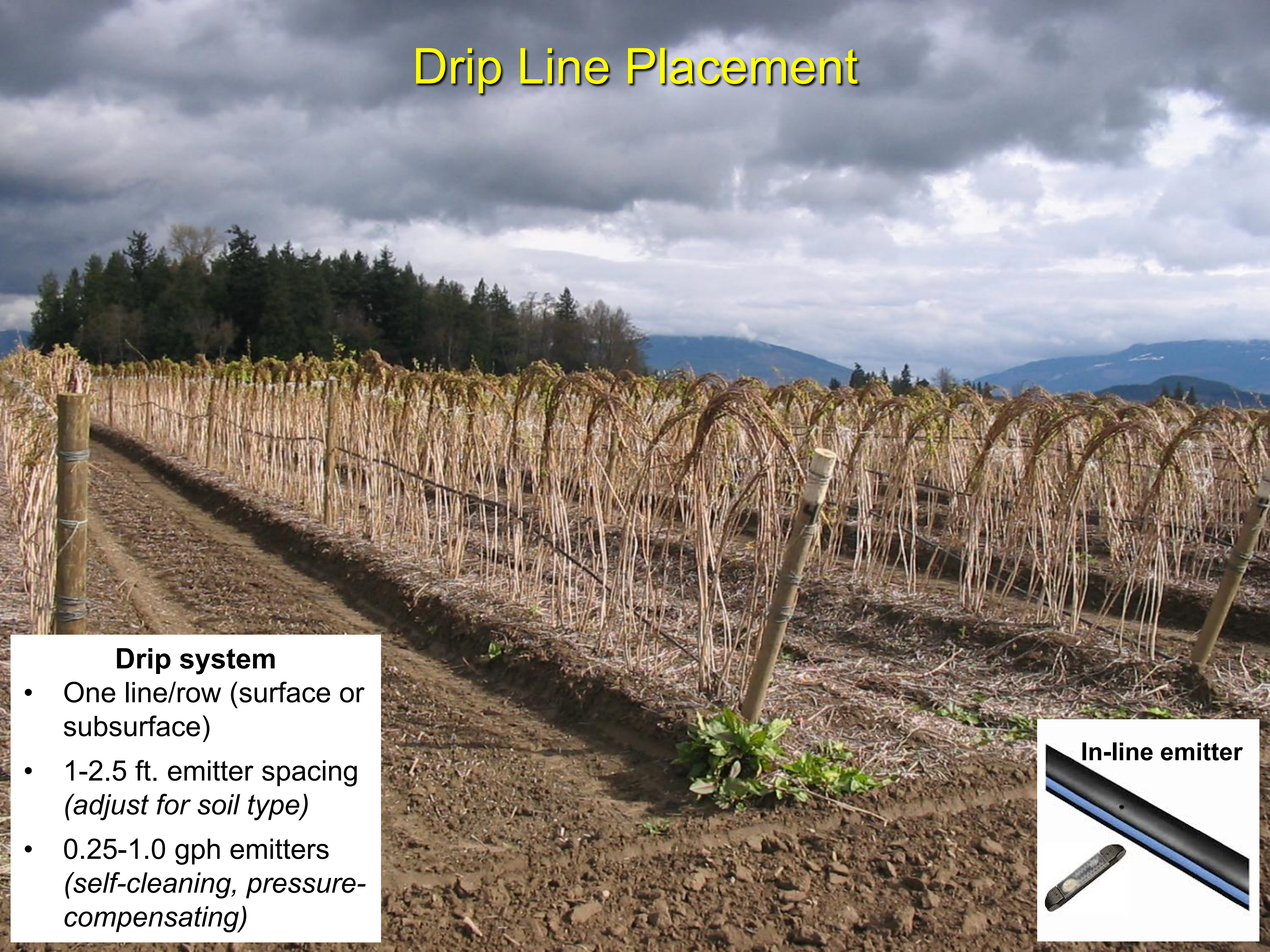
Conclusions

Drip is better than sprinklers (even in heavy soil)

- Much lower water requirements
- Higher yield
- Larger berries
- Less fruit & root rot

Placement of the drip lines is flexible

Drip Line Placement



Drip system

- One line/row (surface or subsurface)
- 1-2.5 ft. emitter spacing *(adjust for soil type)*
- 0.25-1.0 gph emitters *(self-cleaning, pressure-compensating)*

Irrigation Requirements?

Horticulture

Utah State University Cooperative Extension

March 2008 Horticulture/Fruit/2008-04pr

Caneberry Irrigation

Dr. Brent Black, USU Extension Fruit Specialist, *Dr. Robert Hill*, USU Extension Irrigation Specialist, and *Dr. Grant Cardon*, USU Extension Soils Specialist

Proper irrigation of caneberries (raspberries and blackberries) is essential to maintaining a healthy and productive planting. Over irrigation slows root growth, increases iron chlorosis on alkaline soils, and leaches nitrogen sulfur and boron out of the root zone leading to nutrient deficiencies. Excessive soil moisture also promotes root rot, particularly in raspberry. Applying insufficient irrigation water results in drought stress. Drought stress during fruit development results in reduced fruit size and yield, and poorer fruit quality. Drought stress also reduces primocane vigor and flower bud development, which then negatively affects the following season's crop.

Properly managing irrigation is analogous to managing a bank account. In addition to knowing the current bank balance (soil water content), it is important to track both expenses (evapotranspiration) and income (rainfall and irrigation).

Bank Balance (Soil Water Content)

How big is my bank account? – Water holding capacity

First, some terminology:

- Field Capacity is the maximum amount of water that can be held in the soil after excess water has percolated out due to gravity.
- Permanent Wilting Point is the point at which the water remaining in the soil is not available for uptake by plant roots. When the soil water content reaches this point, plants die.
- Available Water is the amount of water held in the soil between field capacity and permanent wilting point. (Figure 1.)
- Allowable Depletion is the point where plants begin to experience drought stress. For caneberries, the amount of allowable depletion, or the *readily available* water represents about 50% of the total available water in the soil. (Figure 2.)

The goal of a well-managed irrigation program is to maintain soil moisture between field capacity and the point of allowable depletion, or in other words, to make sure that there is always readily available water.

The amount of readily available water is related to the effective rooting depth of the plant, and the water holding capacity of the soil. The effective rooting depth for raspberries and blackberries in Utah's climate and soils is typically between 1.5 and 2 feet. The water holding capacity across that rooting depth is related to soil texture, with coarser soils (sands) holding less water than fine textured soils such as silts and clays. (See Table 1.) A deep sandy loam soil at field capacity, for example, would contain 1.2 to 1.5 inches of readily available water in an effective rooting depth of 2 feet.

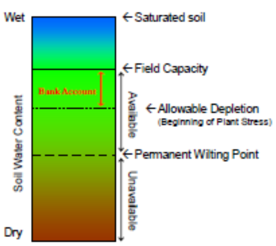


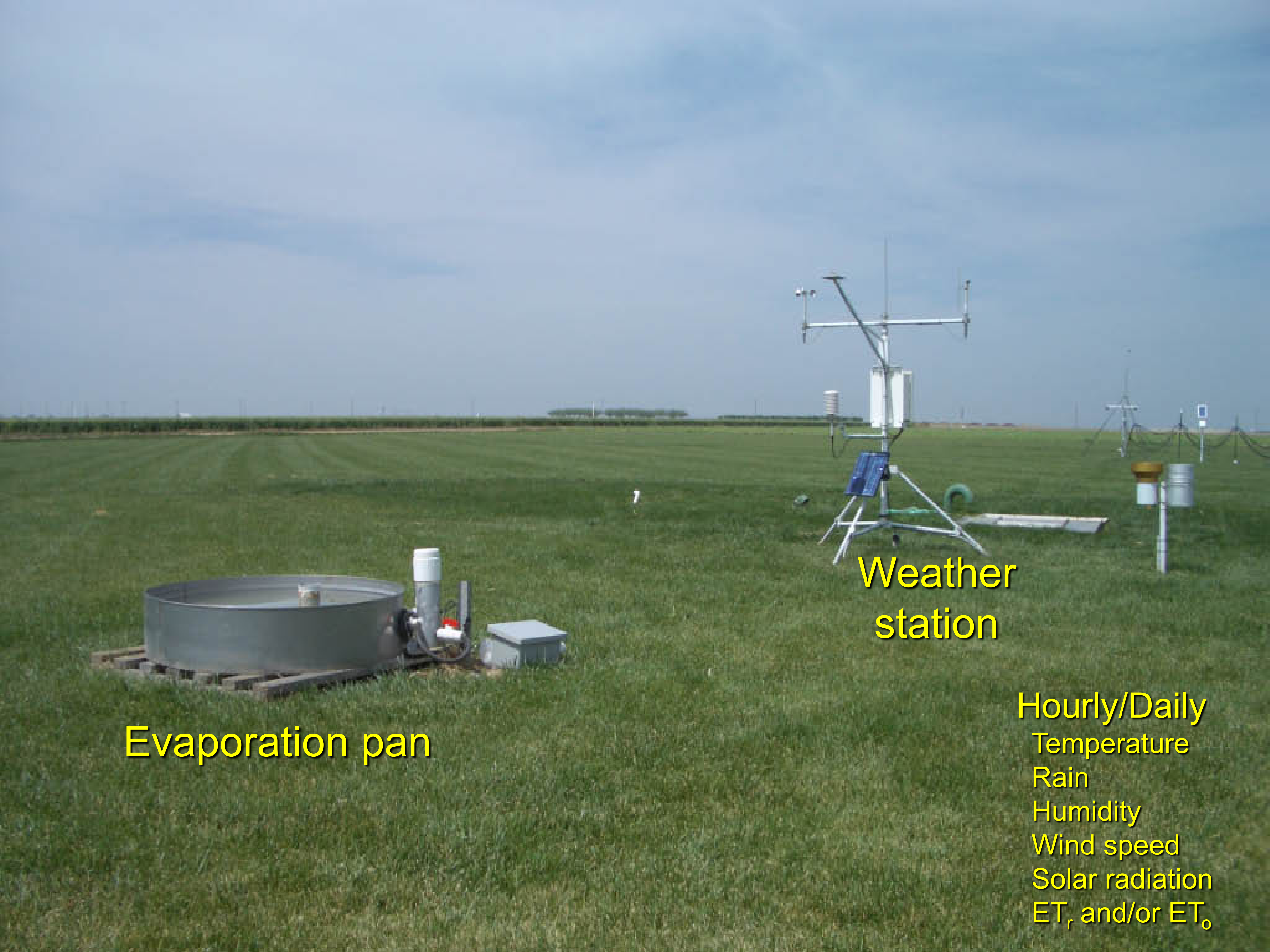
Figure 1. Soil water content from saturated to dry. Optimal levels for plant growth are between field capacity and allowable depletion.

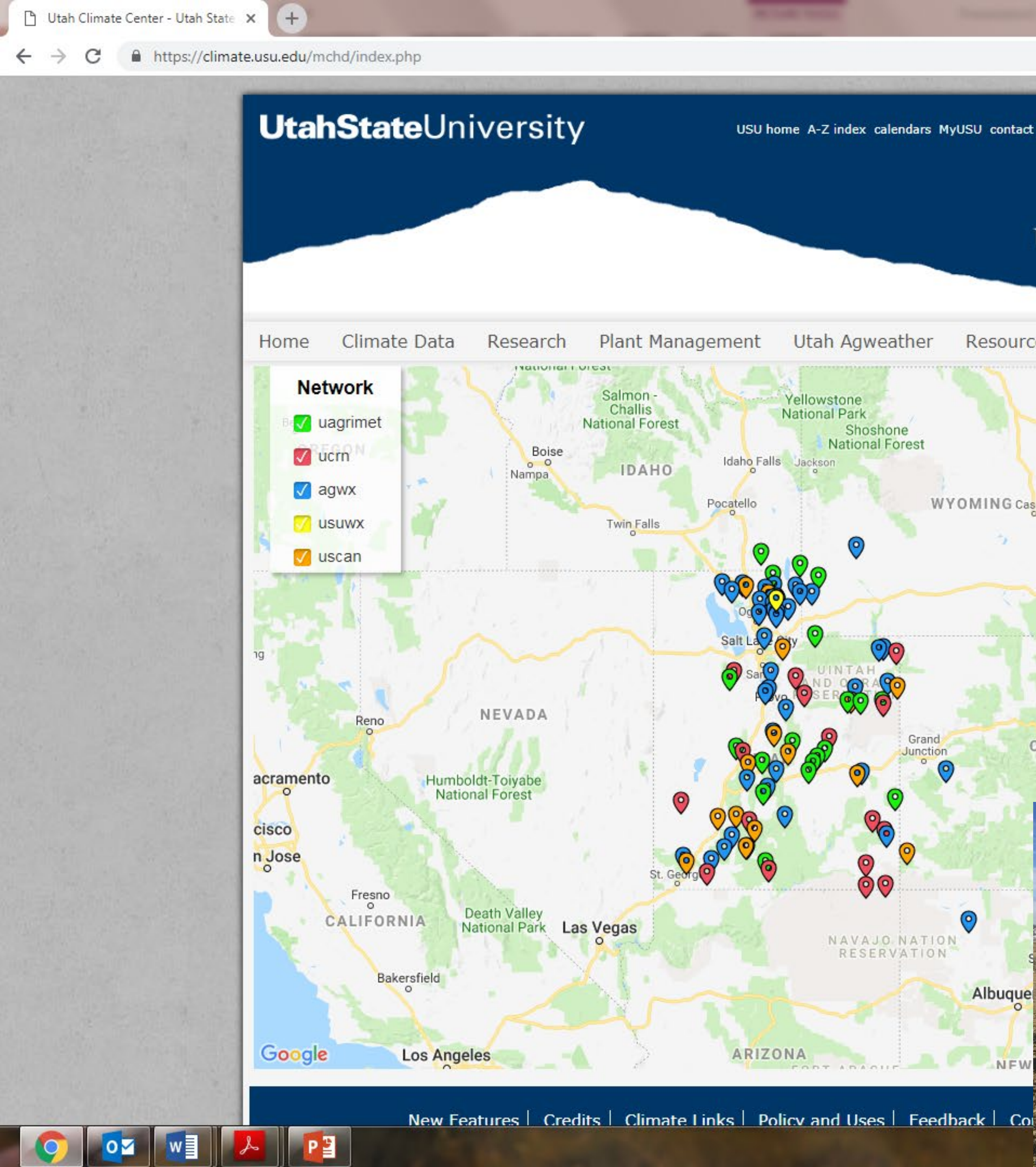

Irrigation Requirements?
Soil moisture sensors

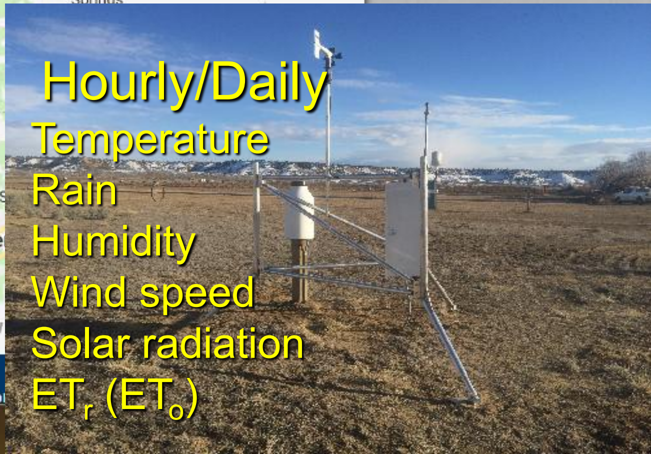
Weather-Based Irrigation Scheduling

$$ET_c = ET_r \times K_c$$

- ET_c = crop evapotranspiration (water use)
- ET_r = reference evapotranspiration
  - From Ag weather station network
- K_c = crop coefficient


Weather station
Evaporation pan
Hourly/Daily
Temperature
Rain
Humidity
Wind speed
Solar radiation
ET_r and/or ET_o





Hourly/Daily

Temperature

Rain

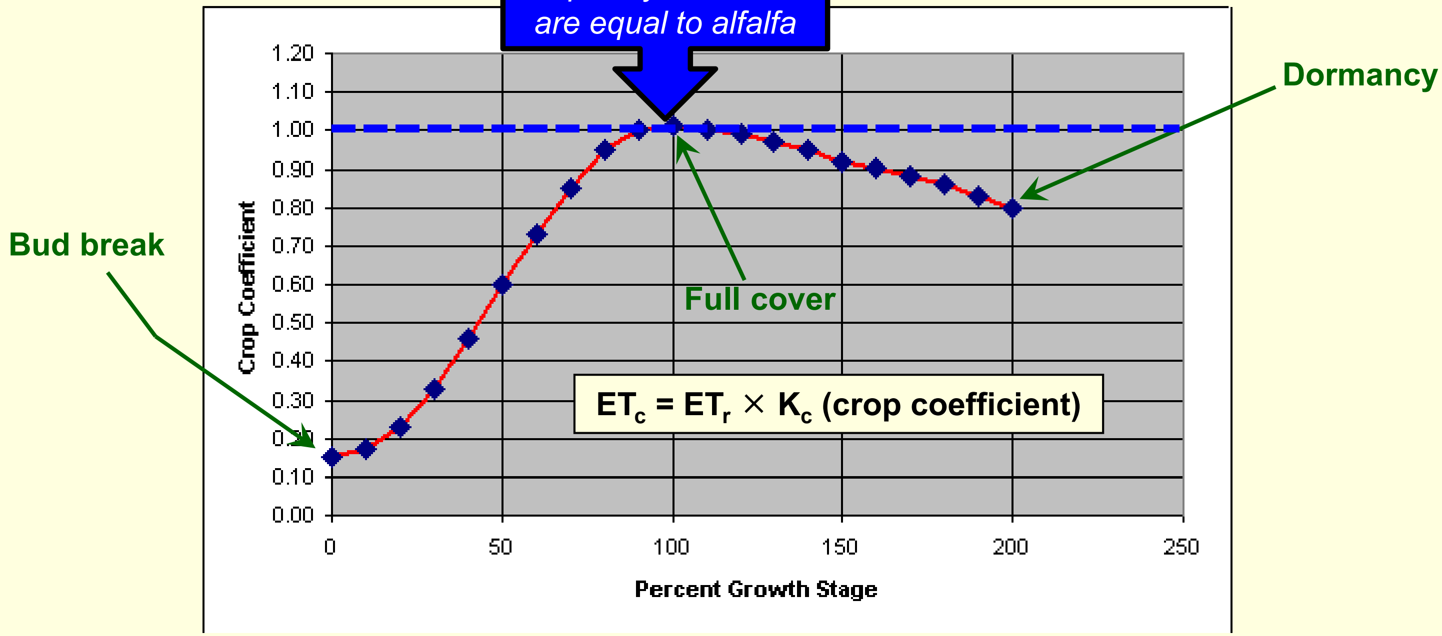
Humidity

Wind speed

Solar radiation

ET_r (ET_o)

Crop Coefficients (Raspberry & Blackberry)



Mar. 23

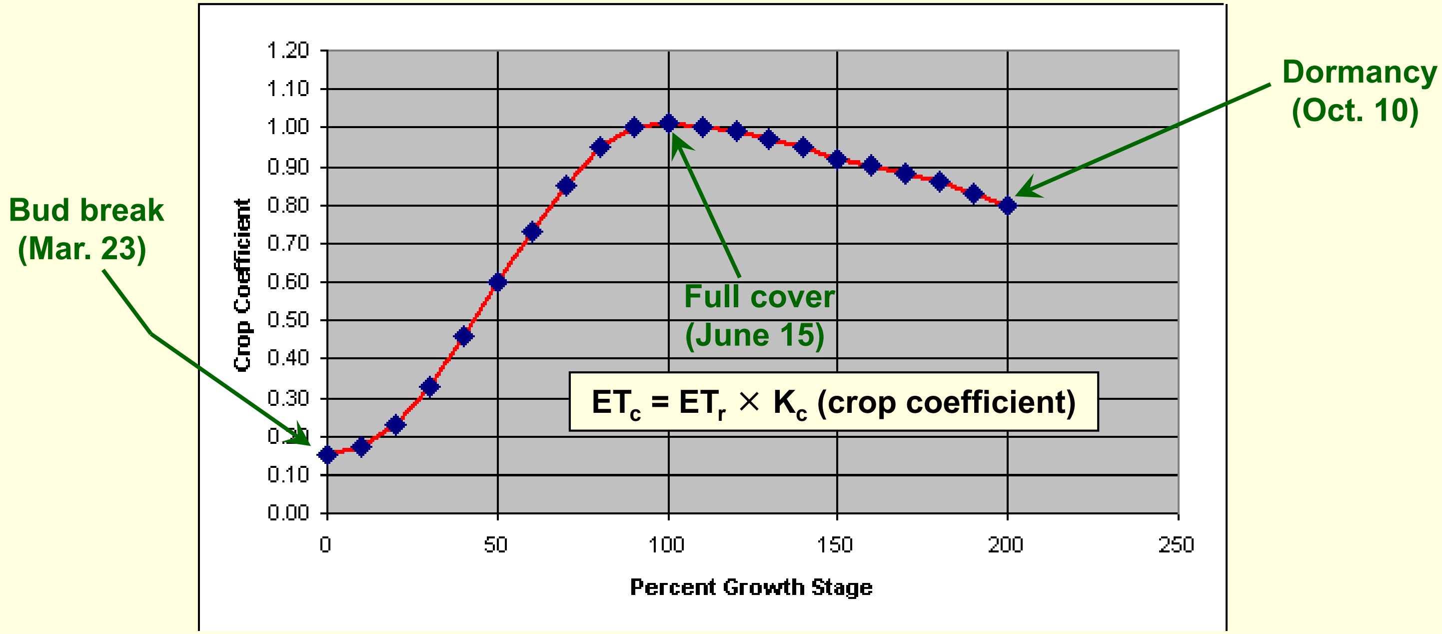
Apr. 21

May 18

June 15

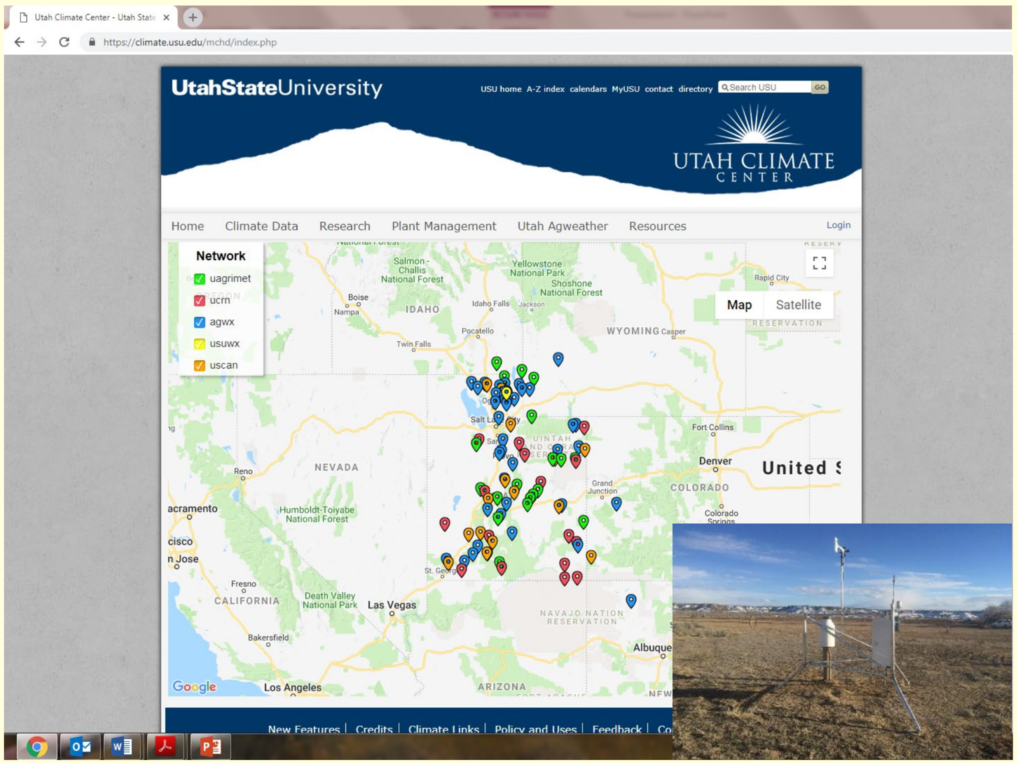
Oct. 10

Example



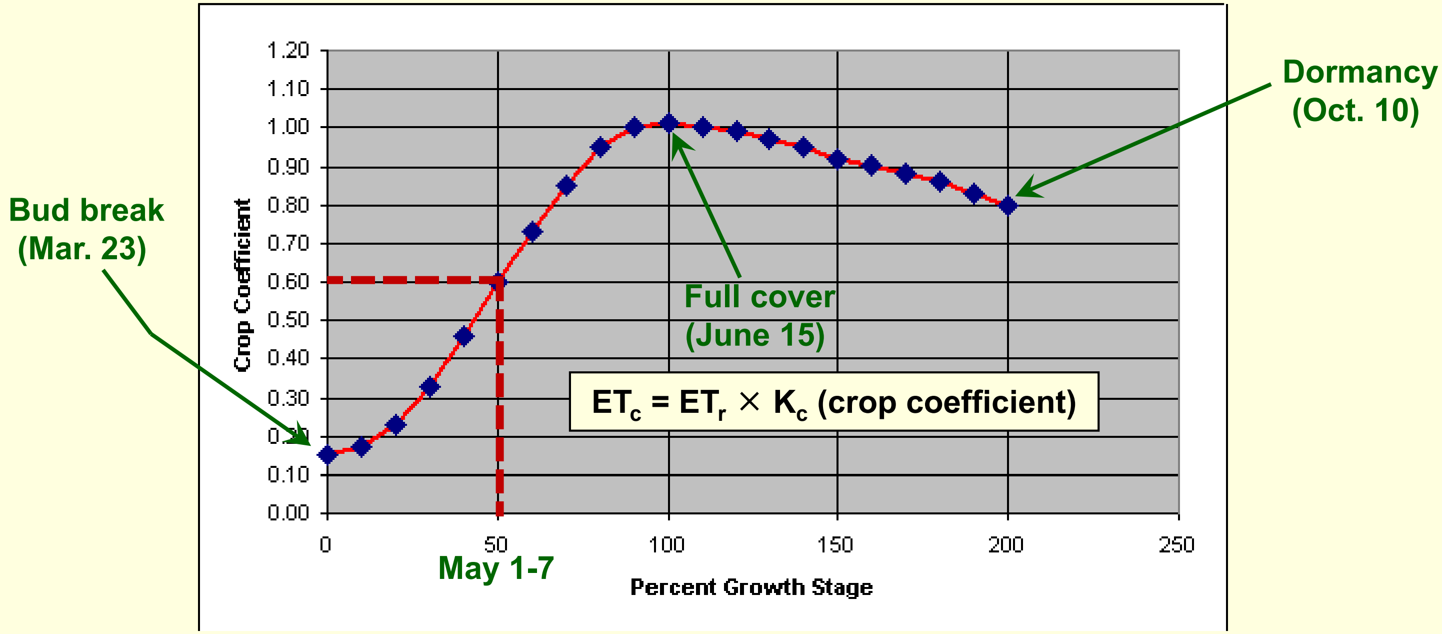
Irrigation requirements during week of May 1-7

Step 1. Obtain ET_r and rainfall from Utah Ag Weather site (use nearest weather station)



date	ET_r (inches)	precip (inches)
1-May	0.27	0
2-May	0.32	0
3-May	0.47	0
4-May	0.43	0
5-May	0.08	0.37
6-May	0.17	0.14
7-May	0.26	0
Total	**2.01**	**0.51**

Example



Irrigation requirements during week of May 1-7

Step 1. Obtain ET_r and rainfall from Utah Ag Weather site (use nearest weather station)

ET_r = 2.0 inches **Precip. = 0.5 inches**

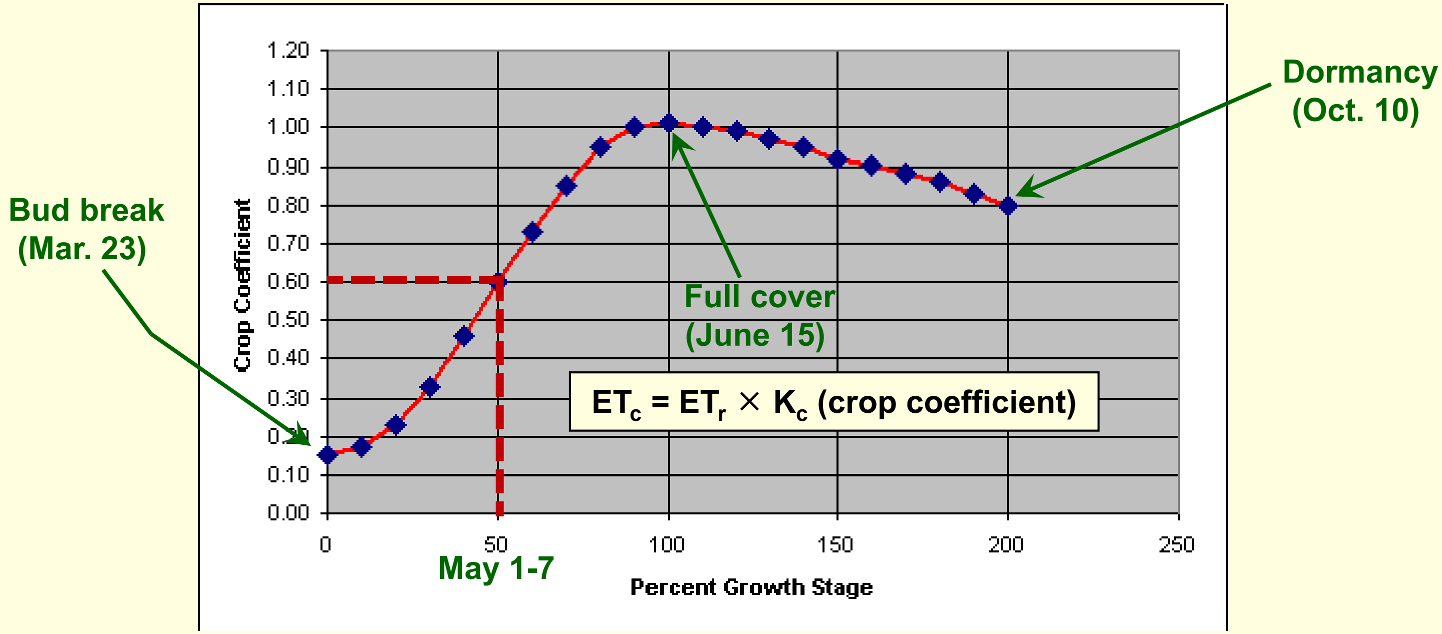
Step 2. Find K_c for raspberry

K_c = 0.6

Step 3. Calculate ET_c

$ET_c = ET_r \times K_c$ = 2.0 inches × 0.6 = <u>1.2 inches</u>

Example



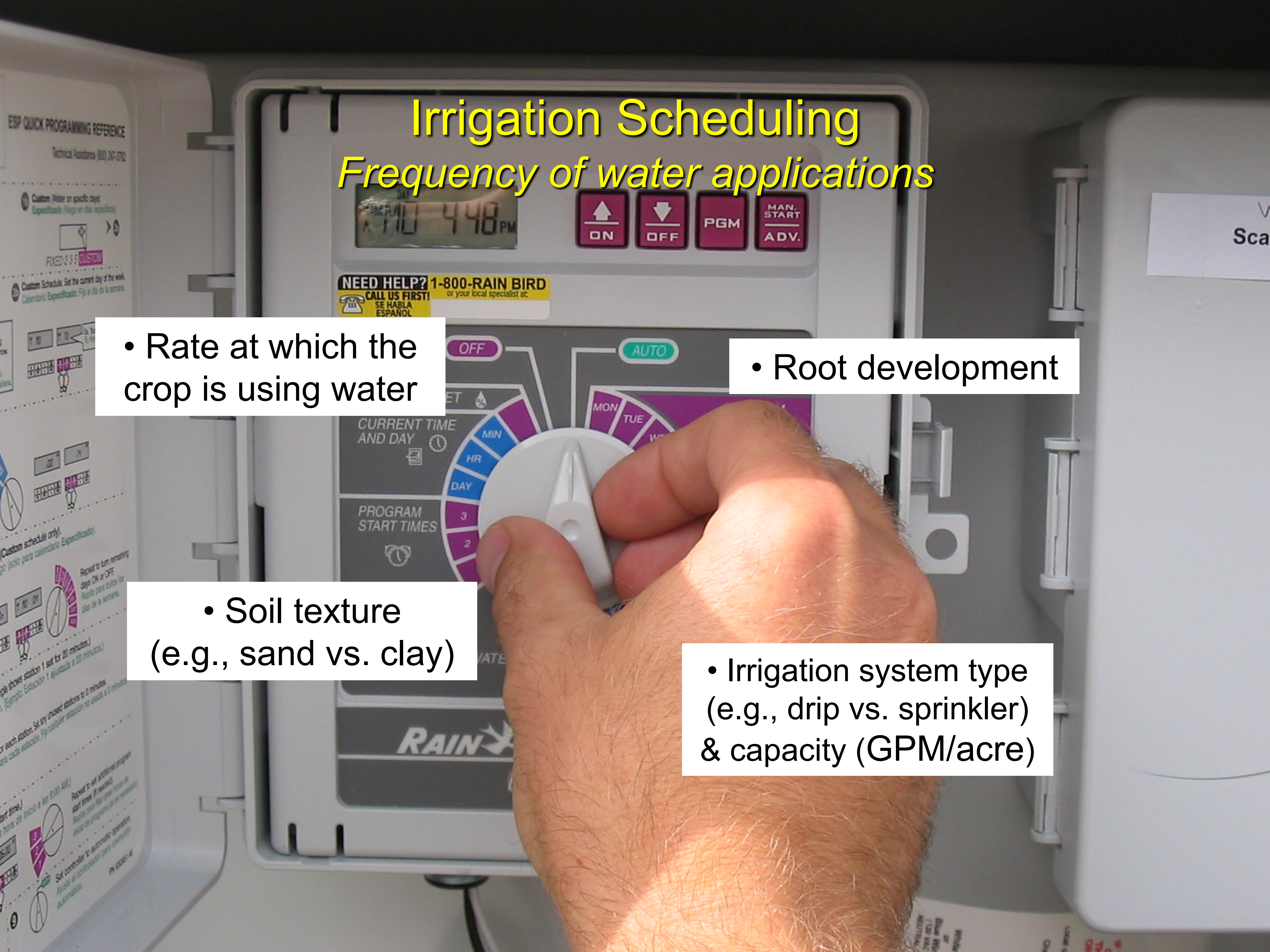
Irrigation requirements during week of May 1-7

Step 4. Determine irrigation requirements

Irrigation requirements = ET_c – Precip. = 1.2 – 0.5 = 0.7 inches/week

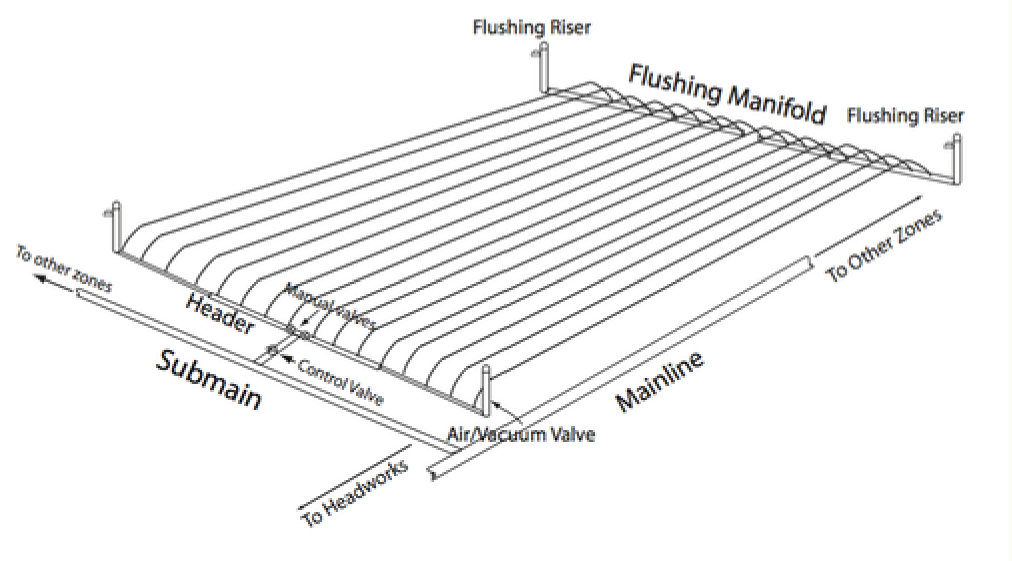
Irrigation Scheduling

Frequency of water applications



- Rate at which the crop is using water
- Root development
- Soil texture (e.g., sand vs. clay)
- Irrigation system type (e.g., drip vs. sprinkler) & capacity (GPM/acre)

Hours of irrigation



1 – 2.5 hours to apply
1 inch of water

- emitter flow rate
- distance between emitters
- row spacing
- laterals per row
- operating pressure

Volume applied should be confirmed with a water meter

Soil texture

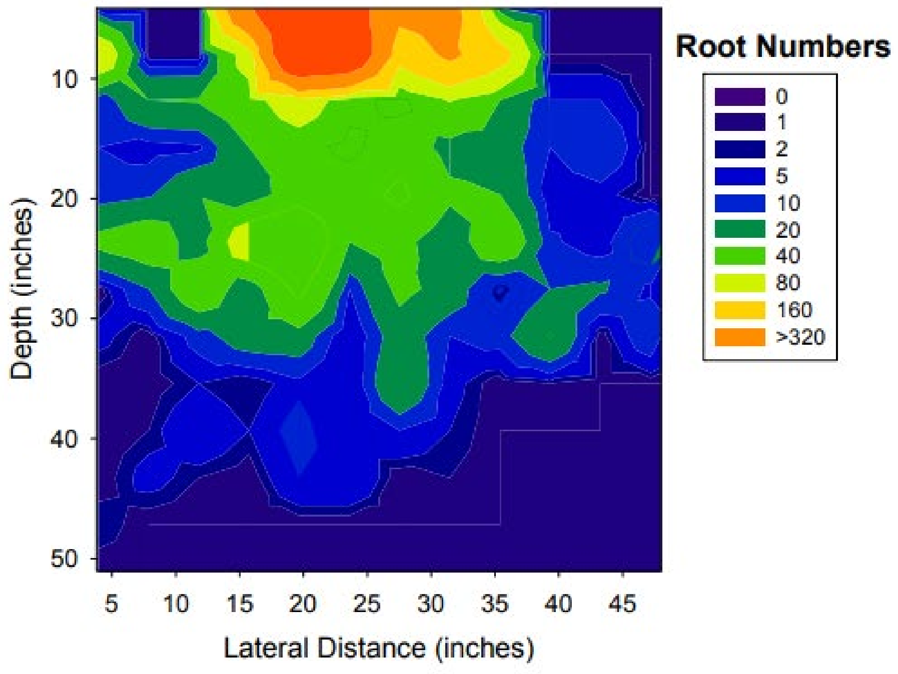
Soil		Available moisture per foot soil (inches)
General description	**Texture class**	
Light, sandy	Coarse sand	0.7
	Fine sand	0.9
	Sandy loam	1.2
Medium, loamy	Fine sandy loam	1.5
	Loam	1.8
	Silt loam	2.0
Heavy clay	Clay loam	2.2
	Clays; peats/mucks	2.4

*Values are for deep, uniform soil profiles. Layering or changes in soil texture within the profile may increase or decrease effective available water.

Management allowable depletion (MAD) = 20-30% prior to harvest & 50% after harvest

E.g., fine sandy loam = 0.3 inches of water per foot of soil prior to harvest & 0.75 inches after harvest

Distribution of Raspberry & Blackberry Roots



First year – 24” deep, 40” wide (33% of a 10-ft wide row)

Second year – 30” deep, 50” wide (42% of the row)

Cahn et al. (2008)

Determining irrigation frequency

How much water loss (ET_c) can the plants tolerate between each irrigation?

Effective rooting depth (m)

X *soil water holding capacity (available inches per foot of soil)*

X *fraction of soil volume wetted (proportion of soil in the field)*

X *management allowable depletion (proportion of soil water)*

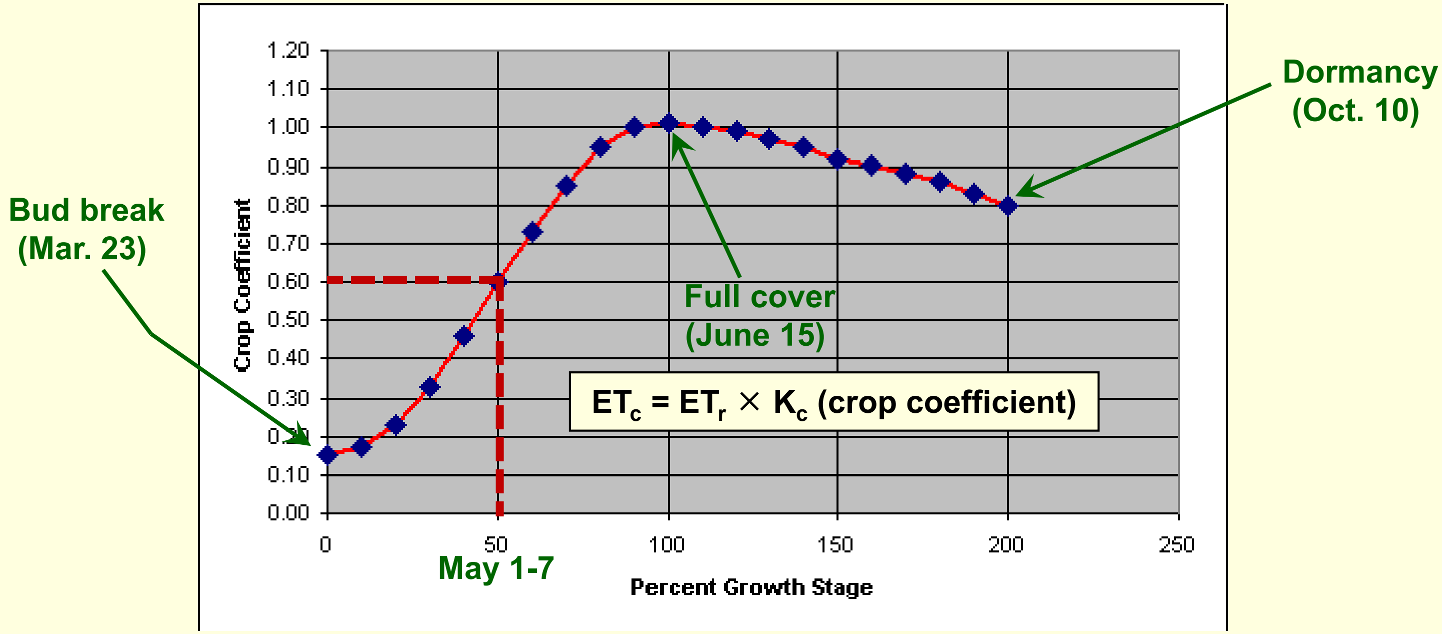
= maximum ET_c between irrigations

Example: Fine sandy loam soil with mature raspberry plants

2.5 ft. rooting depth **X** *1.5 in. of H_2O per ft.* **X** *0.4 (10 ft. row spacing)* **X** *0.25 (i.e., 25% MAD)* **=**

≈0.375 inches per irrigation

Example



Irrigation requirements during week of May 1-7

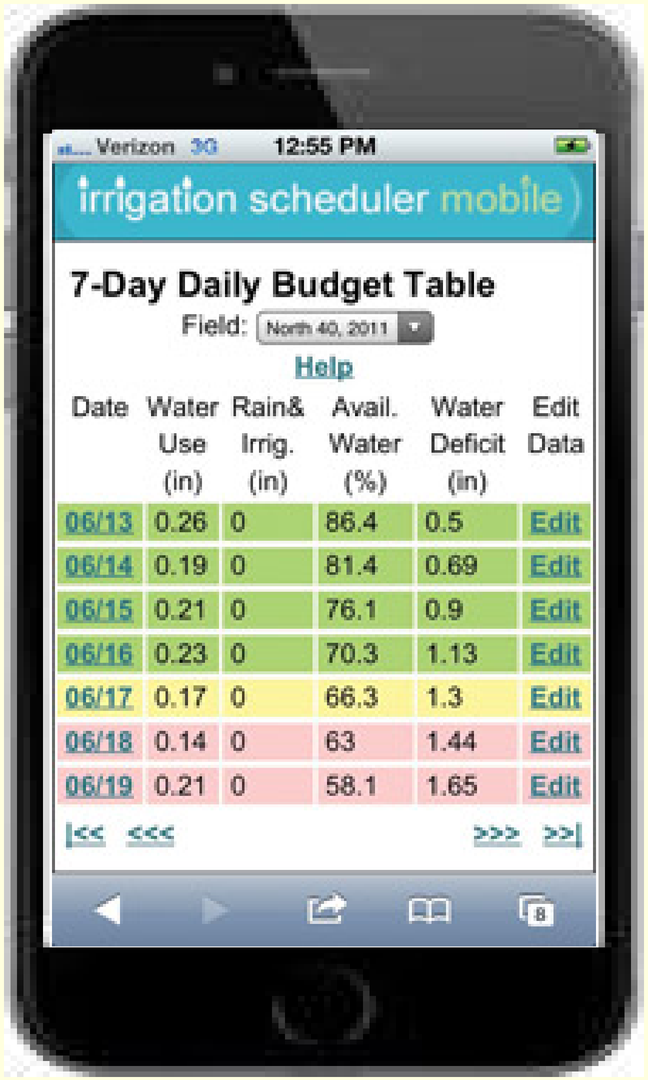
Step 4. Determine irrigation requirements

Irrigation requirements = ET_c – Precip. = 1.2 – 0.5 = 0.7 inches/week

Step 5. Determine irrigation frequency

≈0.375 inches per irrigation → **Irrigate twice per week**

Mobile App
Irrigation Scheduler

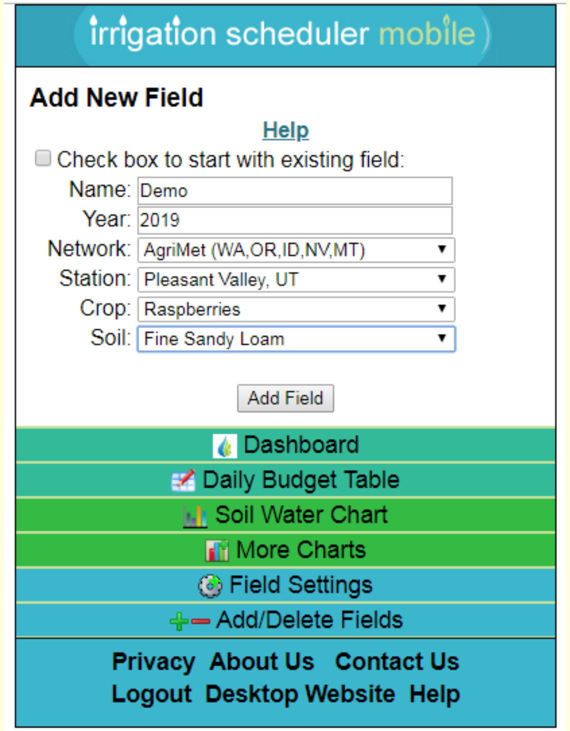


Download from AgWeatherNet
http://weather.wsu.edi/is/

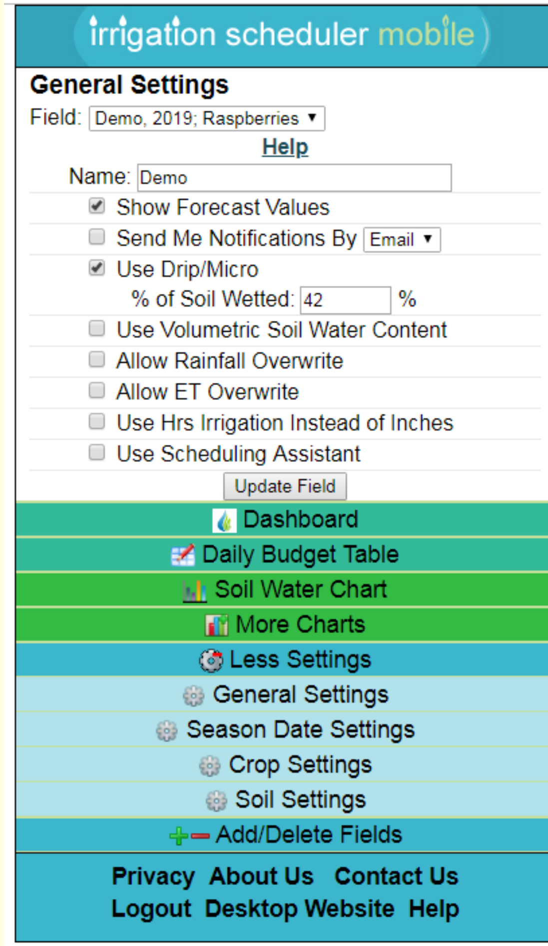
Developed by Dr. Troy Peters (WSU)

Setting up the App

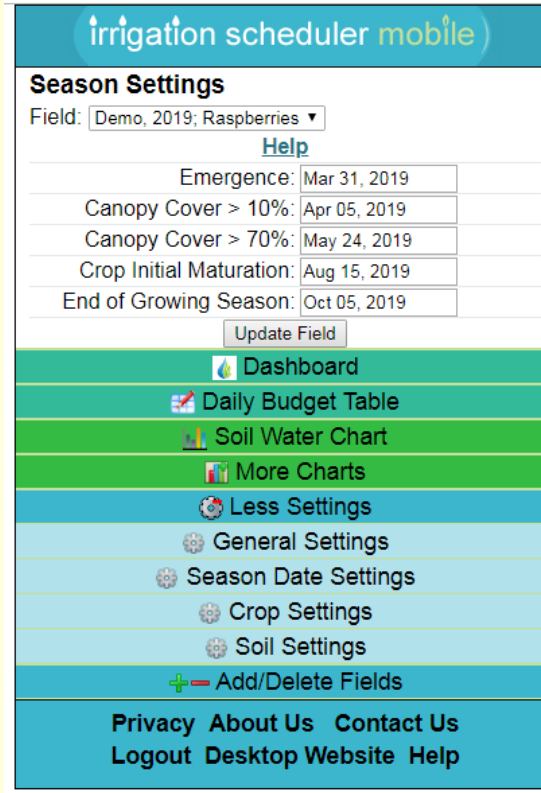
Step 1. Add new field



Step 2. Select general settings

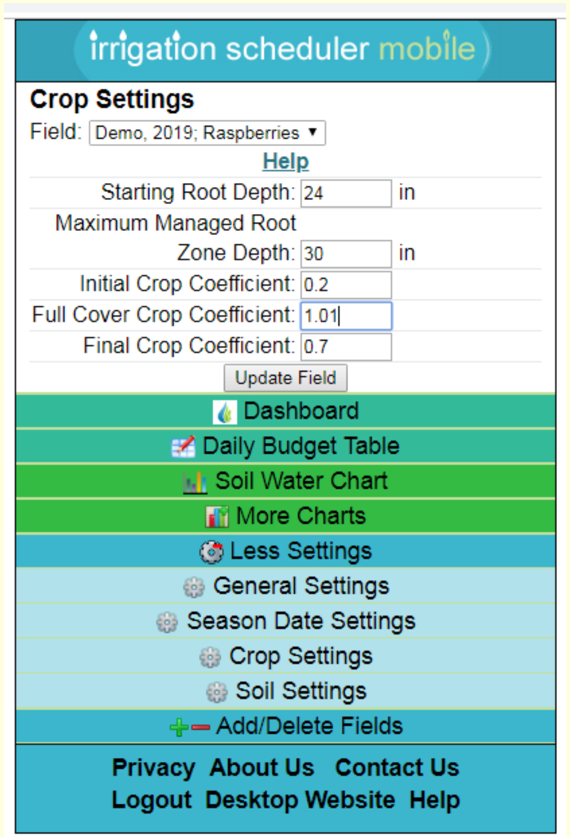


Step 3. Enter season settings

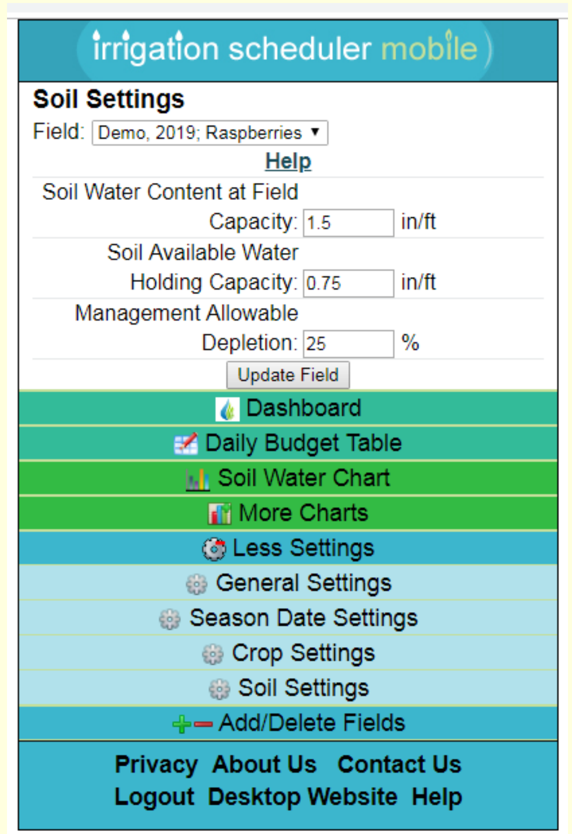


Setting up the App

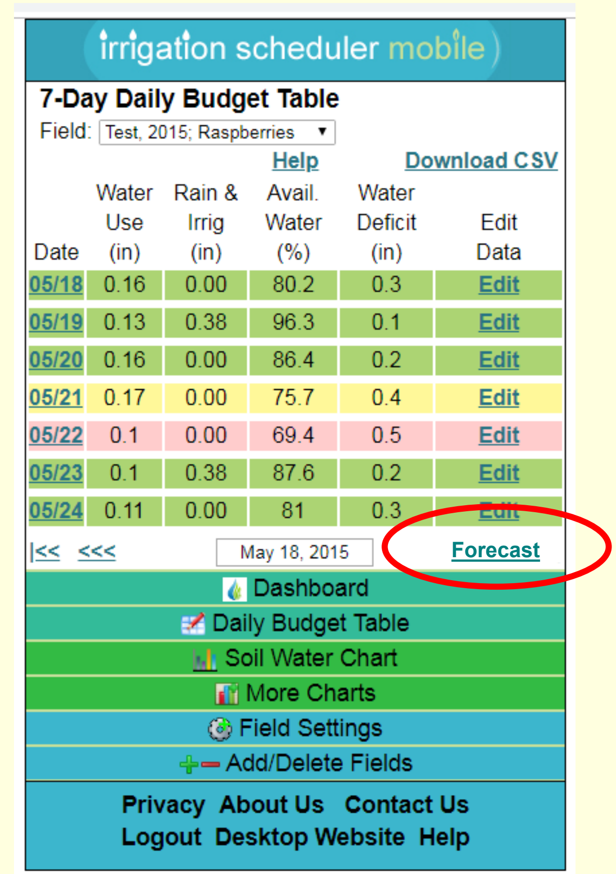
Step 4. Enter crop settings



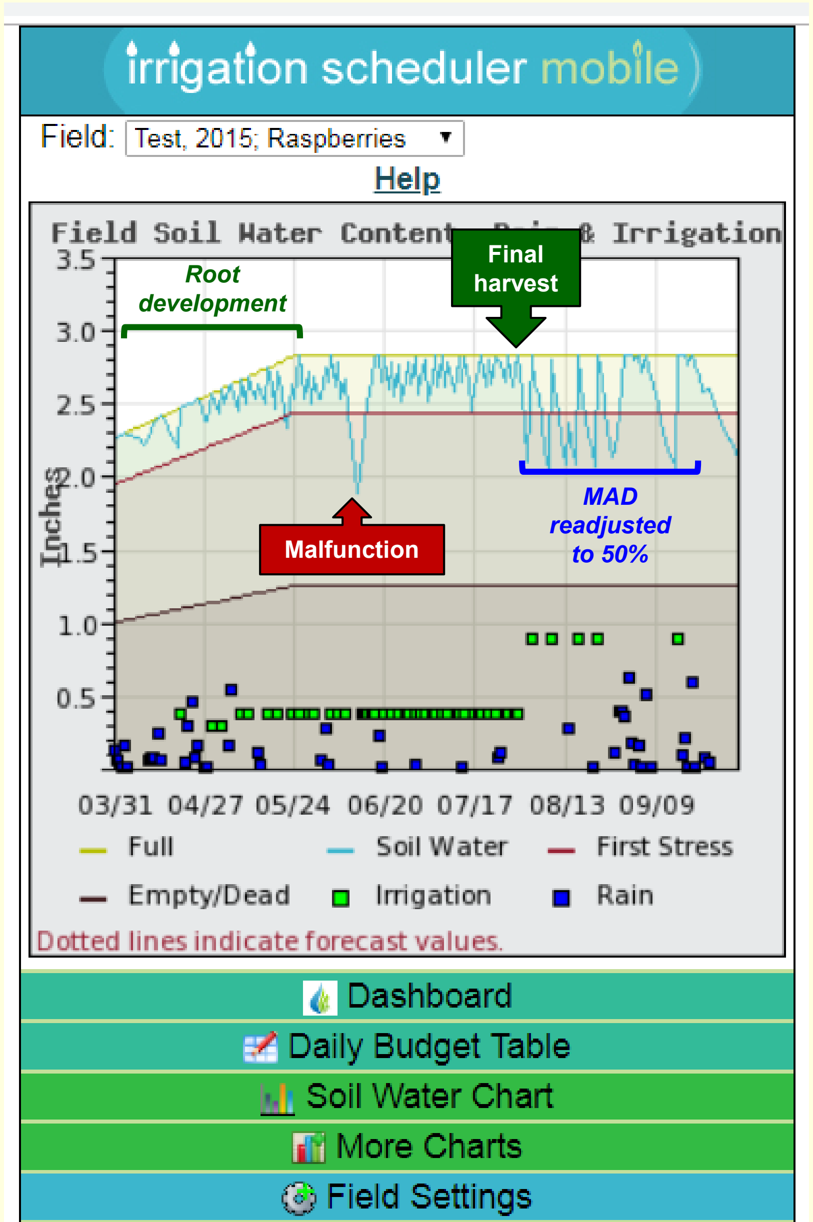
Step 5. Enter soil settings



Step 6. Schedule irrigations



Date	Water Use (in)	Rain & Irrig (in)	Avail. Water (%)	Water Deficit (in)	Edit Data
05/18	0.16	0.00	80.2	0.3	Edit
05/19	0.13	0.38	96.3	0.1	Edit
05/20	0.16	0.00	86.4	0.2	Edit
05/21	0.17	0.00	75.7	0.4	Edit
05/22	0.1	0.00	69.4	0.5	Edit
05/23	0.1	0.38	87.6	0.2	Edit
05/24	0.11	0.00	81	0.3	Edit



For more information, see:

User's Manual and Documentation

R. Troy Peters, P.E., Ph.D.

http://weather.wsu.edu/is/ISMManual.pdf

Acknowledgements

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Adapted from: DeVetter et al. 2019. Commercial Red Raspberry Production in the Pacific Northwest. PNW 598.

Water Management of Raspberries

David Bryla, USDA-ARS Horticultural Crop Research Unit, Corvallis, OR

Depending on where you are at in the Pacific Northwest, raspberries usually require irrigation from early April or May to the end of September. A mature of field of raspberry will use an average of anywhere between a 0.5 inch to 2 inches of water per week. That water must come from either rain or irrigation and is calculated on per area basis. In other words, it’s the amount of water needed to cover the entire field, and not just the plant rows. To apply one inch of irrigation to an acre of raspberries requires 27,154 gallons of water. An irrigation system should be designed to exceed the peak or *maximum* irrigation requirements needed during the growing season, and not the average irrigation requirements. For example, if the maximum amount of irrigation water required is 0.3 inches per day, then the system must be capable of supplying that much water plus any water loss due to inefficiencies in the system. Usually, the highest water requirements occur in late July in the Pacific Northwest, but peaks may vary from year to year, depending on the weather conditions, the location of the field, the cultivar, and the stage of fruit development.

Example

You have 10 acres of drip-irrigated raspberries planted 2.5 feet apart within the rows and 10 feet apart between the rows (= 1740 plants/acre).

Peak water use in July is 0.24 acre-inches per day.

How many gallons of water must be applied each day?

Field (gal/acre/day) = 0.24 inches/day x 27,154 gallons/inch = 6,517 gallons/acre/day or 65,170 gallons/day for the entire 10 acres

How long does the irrigation system need to run?

Pump capacity		**Hours of**
GPM (gal/min)	GPH (gal/hr)	**daily operation**
300	18,000	3.6 (4.7)*
150	9,000	7.2 (9.4)*
75	4,500	14.5 (18.8)*

*Note: 30% extra water is needed with sprinklers (evaporation and water loss between rows)

Water Source and Quality

There are various sources of water that can be used for irrigation, ranging from very clean but expensive municipal water sources to water from lakes and ponds. In any case, the water should be carefully evaluated to assess any potential clogging problems. Contact the laboratory that will be doing the analysis and ask for guidance on how to collect the samples. Usually, the laboratory will provide sample bottles and necessary additives such as acid for the samples. Depending on your location, the samples should be analyzed for pH and EC (electrical conductivity), suspended solids, total dissolved salts, carbonate and bicarbonate (CO_3 and HCO_3), calcium, magnesium, iron, manganese, sulfate, sodium, chloride, and biological populations of algae and bacteria.

Table 1 provides criteria for assessing whether the water source will cause clogging in a drip system. For example, if suspended solids in the water are < 50 ppm, there is little potential for clogging and perhaps less need for an expensive filtration system. On the other hand, if the solids are > 100 ppm, good filtration will be needed to prevent clogging in the system. Labs may also include hardness and alkalinity values in the water analysis. While not normally used to assess emitter plugging, hard water tends to precipitate calcium carbonate. Alkalinity is a measure of its ability to neutralize acids and is caused mostly by carbonates and bicarbonates. Thus, to lower pH of highly alkaline water requires more acid than a less alkaline water.

Table 1. Drip emitter clogging hazards.

Type of problem	Minor	Moderate	Severe
Physical			
Suspended solids (ppm)	50	50-100	> 100
Chemical			
pH	7.0	7.0-7.5	> 8.0
Dissolved solids (ppm)	500	500-2,000	> 2,000
Magnesium (ppm)	0.1	0.1-1.5	> 1.5
Total iron (ppm)	0.2	0.2-2.0	> 2.0
Hydrogen sulfide (ppm)	0.2	0.2-2.0	> 2.0
Hardness (ppm)	150	150-300	> 300
Biological			
Bacterial populations	10,000	10,000-50,000	> 50,000

Injection of sulfuric acid (H_2SO_4) into the drip system has become a popular practice in regions with high soil pH and/or a high percentage of carbonates and bicarbonates in the irrigation water (e.g., California and eastern Oregon and Washington). Alternatively, acetic and citric acid can also be used to reduce water and soil pH in organic systems, but these acids are considerably more expensive. Because acid materials are hazardous and highly corrosive, a number of growers are now using sulfur dioxide (SO_2) generators, often referred to as "sulfur burners", in place of acid injectors for acidifying the irrigation water and reducing soil pH. Elemental sulfur is burned in the generators to convert it to sulfurous acid (H_2SO_3) and mix it with the irrigation water to lower the pH. Sulfur burners are certified for organic production and used by many organic growers in western United States.

The amount of acid needed to lower the pH of the irrigation water depends on the alkalinity of the water and the target pH. Two approaches can be used to determine the amount of acid needed. The first is to develop a titration curve, which shows the amount of acid needed to lower the pH of the water to the desired value for a particular water source. This is usually done by a laboratory and requires samples of the water and the acid. The second approach is trial-and-error. In this case, acid is added to the water in increments and measuring the pH until the desired level is reached. Litmus paper, colormetric test kits, or portable pH meters can be used to determine the water's pH. When the amount of acid needed is determined, the injection rate of the acid can be calculated by multiplying the gallons of acid per acre-foot of water needed to lower the pH by the irrigation flow rate in gallons per minute by 60, and dividing it by 326,000. Monitor the injection rate to ensure that it does not go much below 5. All waters are buffered differently due to the salts they contain, and one water, for example, might require an acid injection rate of 10 GPH, while another might require an injection rate of 2 GPM. Acid requirements might also change from year-to-year and over the course of the growing season.

Irrigation Systems

Both overhead and drip irrigation systems are used in commercial raspberry production in the Pacific Northwest. The type of irrigation system depends on planting size, slope of the land, water quality, and the availability and the cost of the water.

In terms of advantages, sprinklers are relatively simple to install and maintain, and when designed properly, provide fairly uniform water applications during irrigation. Sprinklers, however, tend to be inefficient in raspberry fields as a result of excessive water evaporation during and after irrigation and because a significant portion of the water applied to the crop ends up between the rows and out of reach of the plant root systems. Sprinklers also tend to result in more weeds than drip irrigation and may lead to fruit diseases in humid conditions. Currently, a major concern with using sprinklers is food safety. Good agricultural practices, or GAP, requires that any irrigation water applied by sprinklers is tested periodically to ensure that there no pathogens coming from the water source.

Drip systems are somewhat more complicated to install than sprinklers and often more difficult to maintain. However, they are much more efficient because there is very little soil evaporation with drip, and the water is applied directly to the roots. Other advantages of drip include lower energy costs; the ability to inject and apply fertilizers and other chemicals through the drip lines, which is referred to as fertigation and chemigation; improved cultural practices, including the ability to irrigate during harvest; fewer weed and disease problems; and reduced food safety concerns. A disadvantage of drip is that the water run through the system must be very clean and, therefore, requires a good filtration system to avoid serious issues with clogged emitters. Drip systems also require regular maintenance throughout the season and usually result in a smaller root system. Smaller root systems are usually not a problem unless the drip system fails during the summer and requires more than a few days to repair it.

Research has shown that drip irrigation produces larger berries and higher yields in raspberry than sprinklers. These benefits are a result of higher soil water content and greater soil nutrient availability in the vicinity of the roots with drip.

The basic components of any drip system include a pump to supply the water from the water source; a chemical injection system for adding fertilizers and maintenance products such as acid and chlorine, if needed; filters, which is usually the most costly part of the irrigation system; valves, pressure regulators, and air vents; monitoring devices such as water meters and pressure gauges; distribution lines, including main and submain lines and the drip laterals, to get the water into the field; and plug-in or in-line drip emitters. Drip emitters are available in a variety flow rates and are selected based on the crop, the soil, and the water source.

Filtration

Selecting the appropriate filter for a drip system requires considering the water quality factors mentioned previously. Particulate matter such as sand in the water can be removed with vortex filters, which are commonly referred to as “sand separators”. When needed, vortex filters are installed prior to other filters to remove the larger particles of sand from the water. Screen, disc, and sand filters are usually used for removing particulate matter finer than that which can be removed with a sand separator. Screen filters are effective at removing particulate matter and usually the least expensive method of filtration. Since organic matter can quickly clog a screen filter and is difficult to flush from the screen, sand or disc filters are the usual choice for filtering wells or surface waters containing slimes and algae.

Disc filters are often the choice for very small flow rates (<25 GPM) because they have much larger dirt holding capacity than screen filters, and media filters are not typically available at a reasonable price for low flow rates. The small units must be disassembled and cleaned manually with a hose. Larger units of disc filters are available in batteries of parallel cylinders. Both disc and media filters must be backwashed. A pressure drop across the filters indicates when backwashing is required. Backwashing can be done manually or automatically, with the latter taking place on a defined schedule or when the system senses a pre-determined pressure drop across the filter. The water used for backwashing is typically discharged out of the system.

Chemical Injection Systems

Drip systems are well suited to injecting chemicals such as fertilizers and chlorine. Chemical injection requires three basic components: a chemical supply tank, an injector, and safety and anti-pollution devices to prevent any potential contamination of the water source. Various types of injection devices, such as Venturi injectors and electrically driven or water-driven pumps, can be used to inject chemicals into the irrigation water.

Adequate backflow prevention is required to protect the water source from chemical contamination. If an injection pump remains operating while the irrigation water is turned off, then there is good chance that contamination will occur unless a backflow prevention device is installed. Many types of backflow prevention are available. These include double-check valves, atmospheric vacuum breakers, swing-check valves, and others. Check with state and local codes and manufacturer instructions for the best selection for each installation. The injection pump must shut off if the irrigation pump fails or is shut off. If the injection pump is electrical, then the control panels for the two pumps should include an electrical interlock so that the injector will not receive power when the irrigation pump is off.

In large irrigation systems, the backflow prevention device should be combined with a low-pressure drain, a vacuum relief device, and an inspection port. The vacuum breaker allows air to enter the downstream line when the line pressure is reduced to zero and should be installed upstream of the backflow device. An inspection port allows for easy access to the backflow device for testing and maintenance. The low-pressure drain will dispose of small volumes of water that leak past the check valve after an irrigation event.

Water Meters

Water meters are an important part of every irrigation system. They are used to measure the volume of water flowing through the system pump or irrigation zone and are needed to evaluate the system and ensure that water and fertilizers are delivered to the field accurately in the right amounts. A sufficient length of straight pipe is usually required on either side of a flow meter for correct performance. Check with manufacturer specifications for proper installation of the flow meter.

Main and Submains Lines, Valves, and Air Vents

Main and submain pipes are usually made from PVC and are used to deliver water to the lateral lines and emitters. The mains and submains must be sized carefully, with cost of the pipe balanced against pressure losses caused by friction as water moves through the pipe. The layout of the irrigation system, including the main and submain lines, should be designed by a qualified irrigation designer.

Valves are the control mechanisms for the drip system and include several common types such as solenoid valves for controlling when water is run through the system and flush valves used to clean the system.

Air vents are commonly used downstream of valves, primarily at manifolds, to break vacuum caused by system draining; on sloping terrain to prevent collapsing of pipes and soil from getting sucked into the emitters when the system drains; and upstream of valves for air discharge during system start-up.

Drip Lines and Emitters

Drip tubing or tape with inline emitters, which is the best choice for large installations, is usually made from polyethylene, in a range of diameters and emitter flow rates. The emitters come in a variety of spacings, from 12-60 inches. Soil characteristics, crop water demands, and susceptibility to clogging influence the choice of the emitter flow rate and spacing. Filters or filter systems with at least 80 mesh or an 80-mesh equivalent is needed to prevent clogging of the drip emitters.

Drip emitters are available with or without pressure compensation capabilities. For systems without pressure compensating emitters, pressure differences must be kept within allowable limits to achieve high irrigation uniformity. Pressure compensating emitters, on the other hand, maintain constant discharge rates across a wide range of pressures, ensuring good irrigation uniformity, even on slopes and with longer runs. However, they're also more expensive than non-pressure compensating emitters. In most situations, it usually best to use pressure compensating emitters in raspberry, especially given the number of years the system will be used.

For a particular emitter discharge rate and emitter spacing, frictional pressure losses are related to the lateral line length and the inside diameter of the tubing or tape. For example, let's say a grower uses tubing that has an inside diameter of 0.54 inches, an emitter flow rate of 0.42 GPH, and an emitter spacing of 18 inches. If the lateral length is 400 feet, there will be a pressure loss of 11 psi. In order to maintain at least 10 psi in the drip lines, we then need 21 psi of pressure. Larger dimeter tubing will have less frictional pressure loss than smaller tubing and, therefore, allows longer lateral runs. If the laterals lines are too long or the wrong diameter, the emitters may discharge water at different rates, resulting in non-uniform irrigation.

Usually one line of drip tubing or tape is installed in each row of raspberries. Many raspberry growers use drip lines with 0.25-1 GPH emitters and 12- to 24-inch emitter spacings. Closer spacings and lower flow are typically used on sandy soils, and higher flow rates of up to 1 gallon per hour are used when emitter clogging is a major issue. The lines may be buried a few inches deep or installed on top of the soil, or they might be suspended from a trellis wire.

Irrigation Uniformity

Uniformity is important in any irrigation system because the more uniformly the water is applied, the more efficient the irrigation. If every emitter in a drip system discharged water at the exact same rate, uniformity would be 100% in the field. However, the reality is that every irrigation system, no matter how well designed and maintained, distributes water unevenly in the field. Consequently, if water uniformity in the field is not accounted for during irrigation, some plants will be under-irrigated and eventually will develop water stress, while others will be over-irrigated, whereby a portion of the water will deep percolate below the root zone. Since the goal is maximize growth and production, a certain portion of the field will have to be over-irrigated so that others areas receive enough water to avoid water stress in the plants. A well-designed and well-maintained drip system will have a distribution uniformity of 85-93% in a raspberry field. Uniformity will decline with age, as parts wear out and the emitters become clogged.

To evaluate the distribution uniformity in a drip system, first check and record the flow rate and pressure at the pump. Be sure to check the pressure before and after filtration. Again, a large pressure drop across the filter may indicate that you need to backwash more frequently. By monitoring the flow rate for each irrigation zone and comparing it week after week and year after year, you will quickly identify any problems with leaking or plugging. Focus your scrutiny on the zone or zones farthest from the pumping station or zones with the longest runs. In that zone, plan to check the pressure and flows in a section farthest from the pump, mid-way from the pump, and closest to the pump.

To measure pressures in a drip line, a pressure gauge with a Pitot tube are needed. These can be purchased from an irrigation equipment supplier for about $20. The Pitot tube should be connected to the pressure gauge with flexible tubing, making it easier to use. With the zone turned on and fully charged, punch a hole in the tube. Insert the Pitot tube pointing the tip “downstream”. Ensure the pressure gauge is held at the same height as the drip line. Take the reading, and then remove the Pitot tube and plug the hole with a “goof plug”. For a complete assessment, repeat this measurement several times in the zone, including at the inlet, middle, and end of about two lines or so near the start of the zone, near the middle of the zone, and again furthest from the pump. To measure the flow coming from drip emitters, use small bowls or cups to collect the drips for 5 minutes. Measure about 15-20 emitters at the farthest end of the most distant line, in the mid-point of a line mid-way in the zone, and near the inlet of a line closest to the inlet of the zone. Use a graduated cylinder to measure the volume of water from each emitter over the 5 minutes. You may need some plastic or rubber rings to keep the drips going into each individual cup instead of running along the drip line.

A simple "Distribution Uniformity" of the system can be calculated by taking the average of the lowest quarter of flow measurements and dividing by the average of all the flow measurements. Distribution uniformity should be measured periodically. The first measurement, which should occur shortly after the system is installed, will reveal the quality of the irrigation system design and installation, and provide a baseline by which future uniformity measurements can be compared. Future evaluations showing a decrease in distribution uniformity provide a warning for problems developing and provide an opportunity to correct the problems before they become so severe that entire system will need to be replaced.

A good drip system will have a distribution uniformity > 85%. If the uniformity drops below 80%, it’s a warning sign that something is wrong, and filtration and pressure regulation systems need to be carefully evaluated and perhaps updated. Otherwise, the uniformity will drop, and eventually, the entire system will need to be replaced. So, for example, if uniformity drops to 70%, this means that an average of half the plants are under-irrigated by 30%, while the other half are over-irrigated by 30%. Clearly, this will result in a loss of production. Uniformity should also be evaluated in a sprinkler system, but note, in this case, that uniformity is likely to be somewhat lower than in drip.

Based on evaluation of a number of drip systems in berry fields in Washington, a study found that non-uniform distribution stemmed from three main causes. Not surprisingly, the first was clogged drip emitters. In older systems, drip emitters become clogged with particulate matter, such as sand and silt, chemical precipitates, and biological matter. The second major cause of poor uniformity was mismatched drip lines and emitters. Often, when drip lines are repaired or replaced, the person fixing the lines will grab whatever supplies are available. If the replacement lines have a different diameter, emitter spacing, or emitter flow rate than the original drip lines, then uniformity of the system will be affected. The third problem was large differences in zone and hose pressures. Differences in operating pressure within the irrigation system will cause the emitters to discharge at different rates. These differences are usually caused by elevation changes, improper pipe sizing, and incorrect pressure regulators.

Irrigation Scheduling

Irrigation scheduling, which is a key element of proper water management, is the accurate forecasting of water applications for optimal crop production. The goal is to apply the correct amount of water at the right time to minimize irrigation costs and maximize crop production and economic return. Many techniques and technologies can forecast the date and amount of irrigation water to apply. The appropriate technique or technology is a function of the irrigation water supply, technical abilities of the irrigator, the irrigation system, the value of the crop, the response of the crop to irrigation, cost of implementing the technology, and personal preference.

Estimating Irrigation Needs

Water use by the plant itself is fairly complicated to estimate and will depend on numerous factors, including weather, plant cultivar and age, plant and soil conditions, and cultural practices such as trellising and mulching. Water is also lost from the soil surface by evaporation, particularly within the first few days after rain or sprinkler irrigation. Because plant water use (referred to as transpiration) and soil evaporation occur simultaneously, there is no easy way of distinguishing between the two processes. Therefore, crop water requirements are typically estimated as the combination of the two processes, collectively termed crop evapotranspiration (ET).

Daily estimates of crop ET are accessible on the internet from weather-based websites such as AgWeatherNet (AWN; http://weather.wsu.edu/awn.php) and AgriMet (Pacific Northwest Cooperative Agricultural Weather Network; http://www.usbr.gov/pn/agrimet/). These sites obtain data from a network of automated agricultural weather stations located throughout Washington and Oregon. Search the site for a nearby weather station and use the *crop water use* link to obtain daily estimates of crop ET for raspberry. These sites also have a link to a mobile app called *Irrigation Scheduler*, which can be used download crop ET to a smartphone. Similar networks and apps are available throughout the country and are easily found by searching for agricultural weather data on the internet.

Normally, irrigation should be scheduled to replace any water lost by crop ET. Keep in mind that these are ET estimates for mature, healthy, well-irrigated raspberry plants. Adjustments to these values are needed when the plants are young or stressed (e.g., nutrient deficient). In young plants, this is fairly easy to do because crop ET is directly related to canopy cover. A rough estimate based on shaded area at midday is adequate to adjust for water use in young plants.

Under stressed circumstances, irrigators should reduce the amount of irrigation water applied but pay close attention to soil moisture conditions to avoid under- or over-irrigation. There are numerous devices available for monitoring soil moisture, although some are more accurate and reliable than others. These include:

Tensiometers consist of hollow, water-filled tubes that have a pressure gauge on top and a porous, ceramic tip on the bottom. The tensiometer is buried in the soil within the crop row so that only the gauge and top of the tube are exposed. The gauge registers the difference in head pressure or water potential between the soil and the water inside the tube. When soils are saturated with water, there is no almost difference in water potential between the soil and the inside of the tube (i.e., the reading equals close to zero). As the soil dries, its water potential decreases (becomes more negative), and the tensiometer registers the difference in water tension. As the soil continues to dry, the tensiometer reading increases. Tensiometers are most effective for moderate- to heavy-textured soils.

Electrical conductance units have been used for years and are increasing in popularity as small, inexpensive, easy-to-operate units have become commercially available. A sensor block, often containing gypsum, is buried within the root zone in the crop row. Several blocks often are buried at different depths. Wires extend from the block to the soil surface and attach to a portable unit that resembles a volt/ohm meter. With some grower experience and calibration for soil type, electrical conductance units provide rapid, easy estimations of soil water status and irrigation needs. Electrical units also lend themselves to computer-assisted monitoring and automated irrigation systems.

Dielectric probes estimate soil moisture by measuring the dielectric constant of the soil. The dielectric constant of water is much higher than that of air or mineral components of the soil. Some units combine dielectric probes with temperature probes (to measure air and soil temperatures) and rain gauges. Some models allow the information to be broadcast to handheld or office computers or monitors.

Many of these monitoring devices need to be calibrated to a particular site so that the gathered data can be related to actual soil moisture conditions. Soil moisture monitors should be installed within the root zone of a representative plant and should not be located directly beneath an irrigation emitter. A simpler alternative is to sample the soil using a soil probe. Insert the probe to a depth of at least 12-18 inches, and examine the soil to ensure it remains wet (but not too wet) between irrigations and is watered completely (reaches the bottom of the soil sample).

Adjusting Water Applications for Irrigation System Efficiency

It is important to understand that a crop’s irrigation requirements differ from its actual water requirements. Crop water requirements indicate the total amount of water directly used by a crop but do not account for any extra water needed to compensate for non-beneficial water use or loss, e.g., run-off, deep percolation, evaporation, wind drift, ground cover, weeds, etc. For example, irrigation systems do not apply water with 100% uniformity as mentioned previously. Therefore, for accurate irrigation scheduling, these losses must be evaluated for each system. For example, a system with 75% efficiency will require an extra inch of water for every 3 inches of water used by the crop (i.e., 3 inches/.75 = 4 inches).

Average irrigation application efficiencies for well-maintained solid set sprinkler systems generally range from 65-75%, which largely depends on the quality of sprinkler overlap. Close spacing and newer sprinkler heads help to improve sprinkler water application efficiency. Brand new drip systems, on the other hand, are generally designed with 85-93% efficiency, except in cases with major changes in elevation. Beware that neglected drip systems may have an actual efficiency closer to 60-80% or less. Primary causes for low efficiencies include flow variation due to poor system design, emitter plugging, and pressure differences within the field.

Frequency of Water Applications

The timing or frequency of water applications will depend not only on the rate at which the plants are using water each day (as just discussed) but also on the overall development of the root system of the plants, soil texture (e.g., sand versus clay), and the irrigation system used (e.g., drip versus sprinkler).

The texture of soil to be irrigated is very important in determining when and how much to irrigate. Table 2 lists the abilities of different soil types to store and make water available to plants. The maximum allowable depletion for raspberry is about 40-50% of the available water. Anything more than that will result in water stress in the plants.

Table 2. Water holding capacity of different soil types.

General description	Texture class	Water holding capacity (acre-inches of water per foot of depth)
Light, sandy soil	Coarse sand	0.7
	Fine sand	0.9
	Sandy loam	1.2
Medium, loamy soil	Fine sandy loam	1.5
	Loam	1.8
	Silt loam	2.0
Heavy, clay soil	Clay loam	2.2
	Clays; peat/mucks	2.4

Frequent water applications are especially important when using drip, which tends to restrict soil wetting and thus produces a smaller root system. However, irrigators should be careful to avoid the temptation to over-irrigate, which is especially easy to do with drip. Over-irrigation wastes water, leaches out soil nutrients, and depletes the root zone of much-needed oxygen, thus reducing both root growth and nutrient uptake. It can also lead to disease problems such as phytophthora root rot.

Raised beds, which are commonplace in raspberry fields, hold less water and therefore must be irrigated more frequently than flat ground plantings. Depending on the soil type, irrigate raspberries at least once every day or two during the summer with drip and at least once or twice a week with sprinklers. Note that weekly irrigation may be difficult to accomplish with sprinklers during harvest. This is often the reason why yields are greater with drip irrigation in raspberry.

Maintenance and Evaluation

Irrigation systems may require a significant amount of maintenance to continue operating at maximum efficiency. Routine maintenance includes checking for leaks, backwashing filters, periodically flushing mainlines and laterals, chlorinating, acidifying, and cleaning or replacing clogged emitters. Drip systems should be inspected regularly for leaks, a task that can be done at the same time as checking for clogged emitters. Leaks can occur in hardware or when the aboveground tubing is damaged by farm equipment, by pruning and harvesting activities, or by animals.

Backwashing Filters

Filters, whether screen, disc, or media, should be backwashed periodically to clear out any collected particulate or organic matter. Clogged filters can reduce pressure to the system, lowering the water application rate. As mentioned earlier, backwashing can be done either manually or automatically. Depending on the design of the screen filter, manual backwashing is accomplished either by physically removing and cleaning the screen or by opening a valve to allow the system's water pressure to scrub the screen clean. To manually backwash a disc media filter, you need to initiate a backwash cycle in which the filter circulates water from bottom to top, causing the media to be suspended and agitated, which washes the particulate matter out of the media or the stacked filter discs. Automatic backwashing of filters accomplishes the same task, but on a settable, automatic, time basis. For example, the filters may be set to automatically backwash every 8 hours. Most automatic backwash systems have an overriding pressure-sensing system that will initiate backwashing if a preset pressure differential across the filter is exceeded. Check with the filter manufacturer or dealer for recommendations on the allowable pressure differential for your filters.

Checking the sand in media filters is a frequently neglected maintenance task. You need to inspect the sand in sand media filters periodically to see that the sand is not caking and cracking and that it is being adequately cleaned during the automatic backwash cycles. In addition, the unit will lose some sand during the backwash cycles, so even if the filter is in good shape, it may require additional sand from time to time. During inspection, you should also feel the sand. The sand grains should be sharp edged, and not rounded smooth like beach sand. The sharp edges promote better filtration, but backwash cycles will wear the sand smooth over time. If this has occurred, replace the sand. The rounding of sand edges may take a number of years, but it will eventually happen.

Flushing the Lines

Flushing the system lines removes accumulated debris, reduces potential for emitter clogging, allows for diagnosis of any potential issues with the system, and removes air that may have accumulated and become trapped in the drip lines.

The first step in flushing the lines is to flush the mainlines and submains. Flush valves should be installed on each mainline and submain during the initial setup. The drip laterals are generally flushed by hand. When flushing the laterals, make sure to open no more than a few lines at once (usually fewer than 10). Otherwise, there may be insufficient flow to thoroughly flush the lines.

Begin by flushing the lateral furthest from the pump, and see how much debris comes out. If the water runs dirty for 5 seconds or more, all of the laterals should be flushed. The key to adequate flushing is to provide adequate flushing velocity at the end of the drip line. For example, a 5/8-inch-dimeter drip line positioned 1 foot above the ground should discharge water at 2 inches beyond the end of the line (equals 1 foot/second). Higher velocities are needed to flush drip lines with larger diameters. Examine the debris to identify if it is bacterial buildup, chemical precipitate, or soil and sand. Bacterial buildup may be addressed by chlorinating. If it is sand and soil, you may need to verify that the filtration system is working adequately. If the lines are buried, it could also be a question of more air release valves, so that the drippers don’t aspirate soil particles when the water supply is turned off and the system is draining.

Next, examine the emitters to visually check for plugging. Emitter plugging can be monitored by measuring the flow rate for each zone and comparing it over time. A decreasing flow rate may be a sign of plugging. Inspect the emitters and the flush debris to determine the cause.

Finally, check to see that the filtration system is working correctly, as this may be the reason for the reduced flow rate.

Cleaning the System (Chlorinating, Acidifying).

Water with high organic loads, such as algae, moss, and bacterial slimes, should be chlorinated with chlorine gas, sodium hypochlorite (bleach), or calcium hypochlorate, either by continuous chlorination, maintaining about 1-2 ppm free chlorine at the end of the lateral line, or by periodically injecting sufficient chlorine to achieve approximately 10 ppm free chlorine at the lateral end. Continuous chlorination is usually necessary when the clogging potential is severe. Surface water is usually more likely than ground water to cause organic clogging, although iron bacteria can also be a nuisance in well water in the Pacific Northwest. Well water pumped into and stored in a holding pond or reservoir should be considered a surface water source. Acidification is also often required to prevent precipitates such as lime or iron rust from forming.

Fertigation

Fertigation is the practice of applying soluble fertilizers to the plants directly through the irrigation system. It is often a very efficient way to apply fertilizers because most roots in drip irrigated fields are located near the drip emitters. Some advantages of fertigation include reduced application costs (there's no need for tractors or spreaders), greater control of where and when the fertilizers are placed, the ability to target application of specific nutrients during particular stages of crop development, and the potential to reduce fertilizer losses by supplying only small amounts of fertilizer to the plants as needed. However, fertigation requires specialized equipment to inject the fertilizer, as well as higher quality and generally more expensive fertilizers than granular applications.

Contamination is also possible issue with fertigation. Contamination can occur in two situations. One is if the irrigation pump shuts down while the injector unit keeps running. This will cause the fertilizer to flow into the water source. The other is if irrigation water flows backwards through the fertilizer injector. This can cause the fertilizer tank to overflow. A backflow prevention device and an electrical interlock should be installed in the irrigation system to avoid such issues (see section on “water management”).

Fertilizer Injectors

The main types of injection systems used for fertigation include Venturi injectors and piston and diaphragm pumps.

Venturi injectors rely on the pressure drop principle. The way they work is that water is diverted from the main irrigation line and run through the injector. When this happens, pressure decreases in the neck of the injector and sucks the fertilizer into the irrigation system. Flow rate of Venturi injectors are generally inconsistent because it is easily affected by pressure changes in the system and by the viscosity of the liquid being injected. In order apply fertilizers accurately with a Venturi, a volume of fertilizer either needs to be measured out prior to each injection, or a sensor needs to be placed in the fertilizer tank to shut the flow off to the injector after a required amount of fertilizer is added.

Piston and diaphragm pumps are classified as positive displacement pumps. These types of fertilizer systems are much more accurate than Venturi injectors but are also much more expensive. The pumps are powered by electricity or gasoline or are water driven. Flow rate of these pumps remains constant regardless of the irrigation pressure or the viscosity of the liquid fertilizer.

Fertilizers for Fertigation

Ammonium nitrate and urea ammonium nitrate solutions are commonly used for fertigation. The latter contains the highest concentration of N of all the N solution products. Calcium ammonium nitrate solution is also used and is high in NO_3-N, low in NH_4-N, and supplies calcium (Ca). Calcium may increase the pre- and postharvest quality of fruit crops, including raspberry.

There are also many products available for fertigation in organic raspberries. These products vary in price and in the amount of N and other nutrients and often contain significant amounts of P, K, and Mg. When fertigating with organic products, it is important to dilute the product so the viscosity is suited to fertigating. Also, pressurize the system prior to injecting the fertilizer and run the irrigation after injection to ensure the system flushes well.

Liquid fertilizers should be injected in small and frequent applications (e.g., once a week). Fertigation can be initiated at leaf emergence in raspberry, but many growers using drip apply granular fertilizers in March and April, and then switch to fertigation in May once irrigation is required on a regular basis. Fertigating with N is not recommended after harvest as the plants take up the majority of this nutrient in the spring and early summer.

Safety Precautions

These general guidelines and safety precautions should be followed when using liquid fertilizers for fertigation.

- Avoid mixing a concentrated solution of one fertilizer with a concentrated solution of another, unless is it is specifically stated that you can do so on the manufacturer's instructions. For example, urea sulfuric acid can be mixed with some fertilizers, but a proper order of mixing must be followed.
- Do not add acid acidified fertilizers to chlorine compounds such as sodium hypochlorite (which is bleach), calcium hypochlorite, or chlorine gas.
- Store and handle fertilizers according to the manufacturer's instructions and state and local regulations.
- Provide adequate work protection, such as goggles, aprons, and rubber gloves.
- Use backflow prevention devices, including check valves and air relief valves.

ADDITIONAL RESOURCES

Crop Evapotranspiration. Guide for Computing Crop Water Requirements. 1998. Allen, Pereira, Raes, and Smith. FAO.

Fertigation. A Tool for Efficient Fertilizer and Water Management. 2011. Intl. Fert. Ind. Assn., Paris, France/Intl. Potash Inst., Horgen, Switzerland.

Western Oregon Irrigation Guides. 1998. Smesrud, Hess, Selker, Strik, Mansour, Stebbins, and Mosley. Ore. St. Univ. Ext. Serv. Publ. EM8713.

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Chemical Characteristics and Pesticide Movement

How chemical characteristics of pesticides, soils, and the environment affect pesticide movement.

Michael Wierda
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Dr. Michael Wierda is the Pesticide Safety Education Program Director for USU based out of Davis County. Dr. Wierda earned his Ph.D. in Environmental Toxicology using bald eagles as a tool to track legacy pollutants in Michigan's aquatic ecosystems. Dr. Wierda's #1 goal is for you; the applicator, manager, owner, technician, etc. to understand personal, family, community, and environmental health concerns related to pesticides. This includes but is not limited to how pesticides move, work, persist, and breakdown in you, your family/community, and the environment.

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Todays topics

- Chemical characteristics & their effects on mobility
- Hazard, Routes of Entry, First Aid & Emergency #s
- Personal Protective Equipment

Pesticides in the Environment

i.e., chemical characteristics effects on pesticide movement

Chapter 7

National Pesticide Applicator Certification Core Manual

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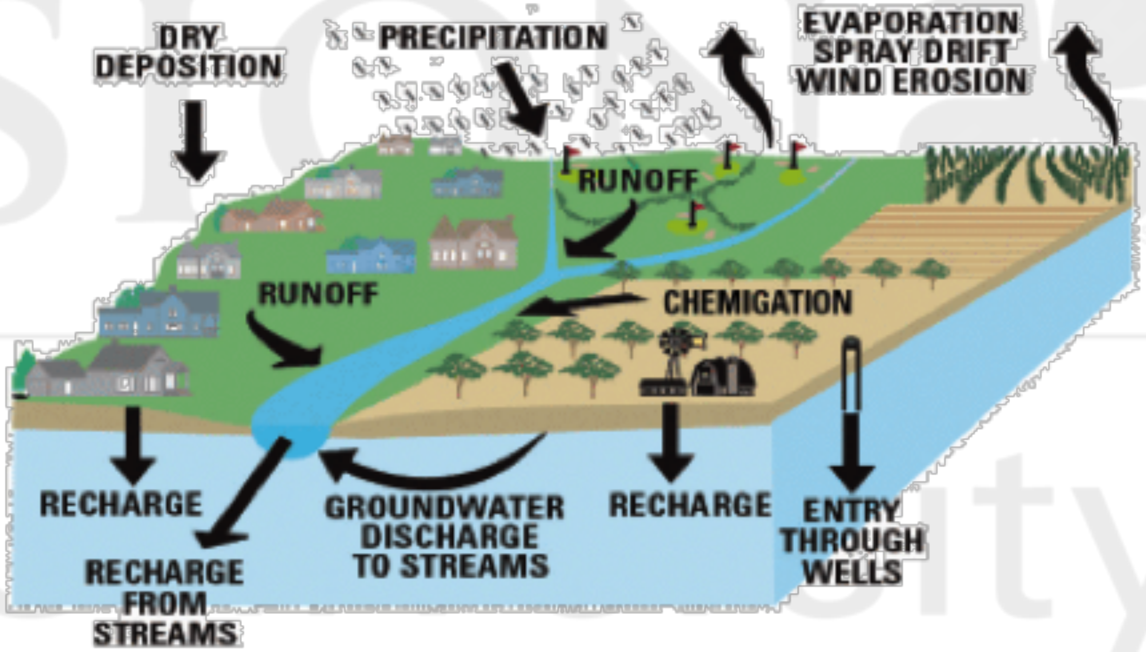
Understanding How Pesticides Move in and Impact the Environment

- Chemical characteristics of pesticides
- Degradation methods
- Pesticide movements during and after application



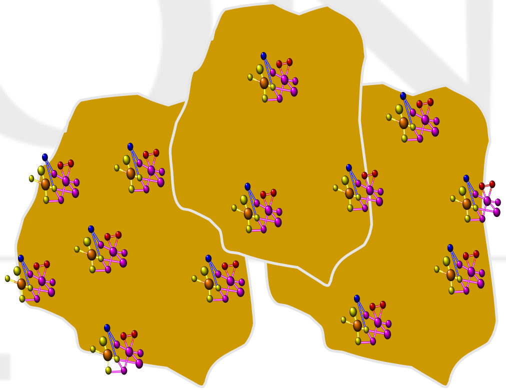
https://pubs.usgs.gov/fs/2009/3093/

Pesticide Characteristics: Solubility

- The **ability** of a substance **to dissolve** in a solvent, usually water
- Soluble pesticides can (1) move in surface water runoff or (2) soak through soil into groundwater or (3) drift in the air as tiny water droplets.

Pesticide Characteristics: Adsorption
(binding of chemicals to soil particles)

- More adsorption with oil-soluble pesticides
- Clay and organic matter increase binding capacity
- Reduces the potential for a pesticide to move laterally or vertically through soil



Pesticide Characteristics: Persistence

- Ability of a pesticide to remain present and active for a long time
- Provides for long-term pest control, but may harm sensitive plants and animals
- May lead to illegal residues on rotational crops

Pesticide Characteristics: Volatility

- Fumigants volatilize and move gas through soil, structures or stored commodities
- Several herbicides are quite volatile and pose harm when the vapor moves off target
  - Labels may state **cut-off temp**eratures for application
  - Labels may require pesticide to be incorporated into the soil

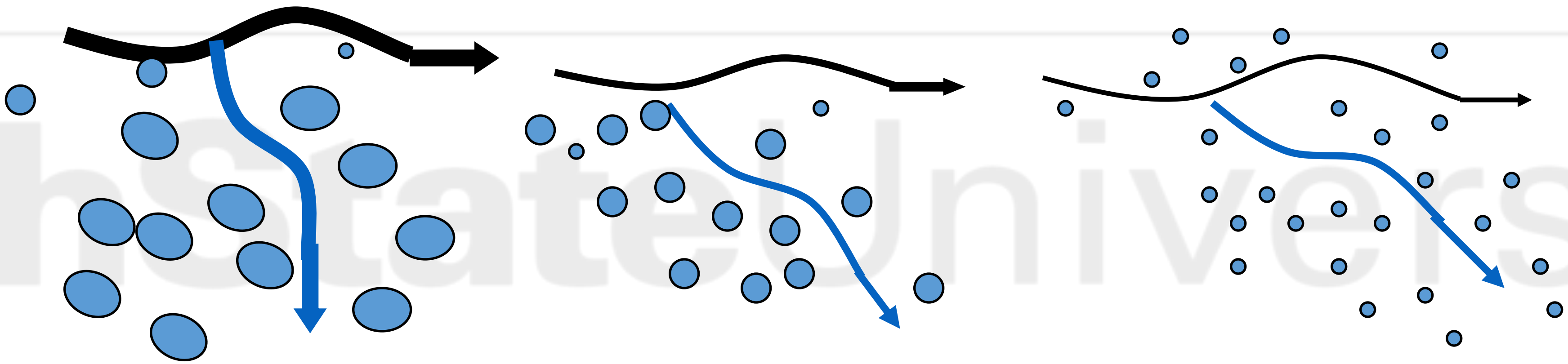
Temperature ↑
Wind ↑ = Higher Volatility
Humidity ↓

***LABELS* may specify maximum temperatures for spraying operations**

DRIFT – movement of pesticides from a treated area during or after spraying operations

Droplet Size During Spray Operations

The Larger the Spray Droplet Size



The Less Distance a Droplet Can Drift

Spray Drift Factors

- **Weather Conditions** – Read the Wind
  - What's downwind?
    Direction
  - How far will it move?
    Speed
    - 0-3 mph:
      could be very stable with airflow, just not sure which direction the air is moving
    - 3-7 mph:
      manage for off-target movement downwind
    - >7 mph:
      carries more material off-target

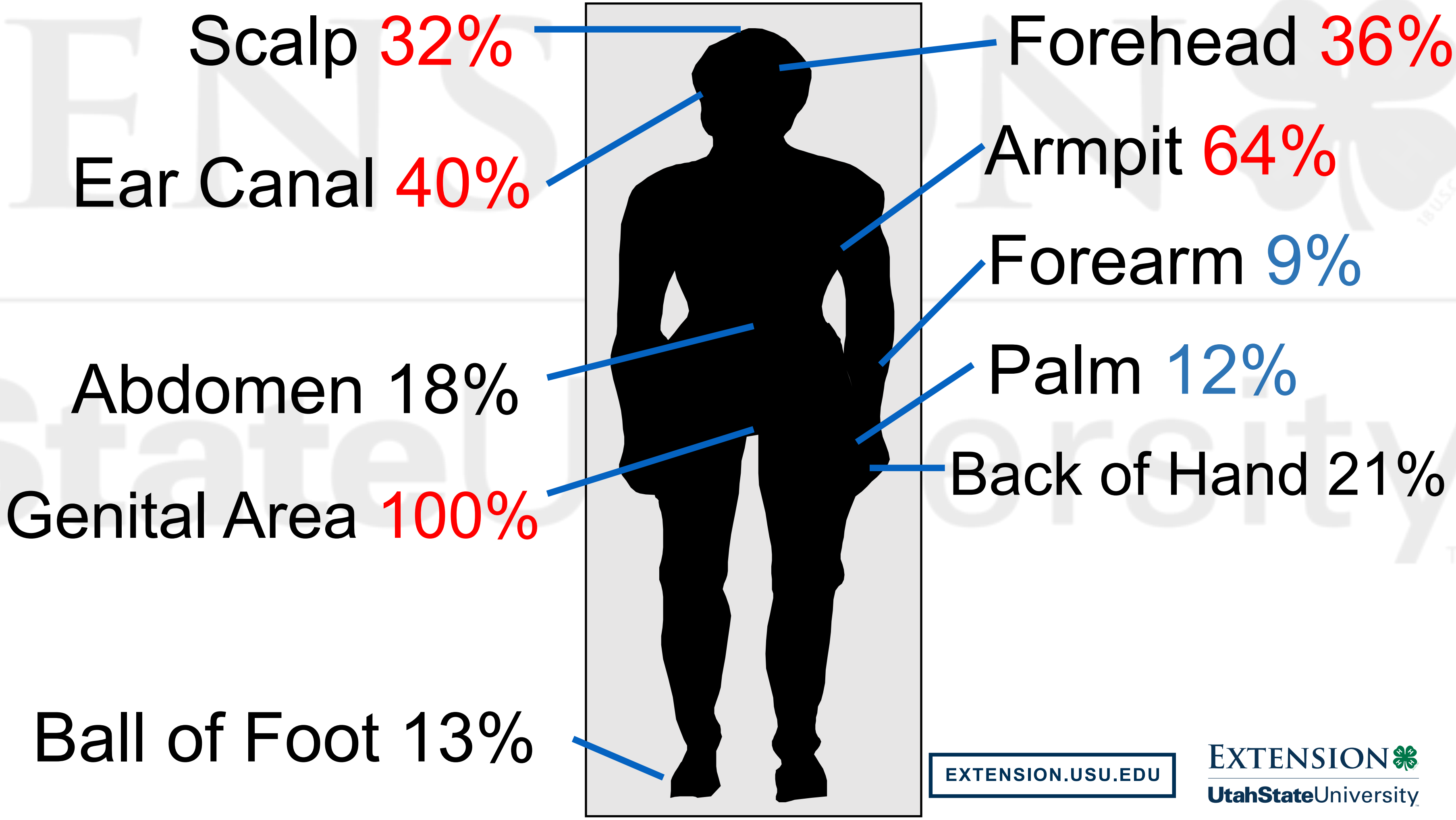
Routes of entry

How it gets into you, your family, your children, your pets, etc.

Routes of Entry: Skin (Dermal)

97% of all body exposure during spraying is by skin contact!

Different parts of the body vary in their ability to absorb pesticides.



Percent Dose Absorbed
Chemical -parathion
Maibach 1974

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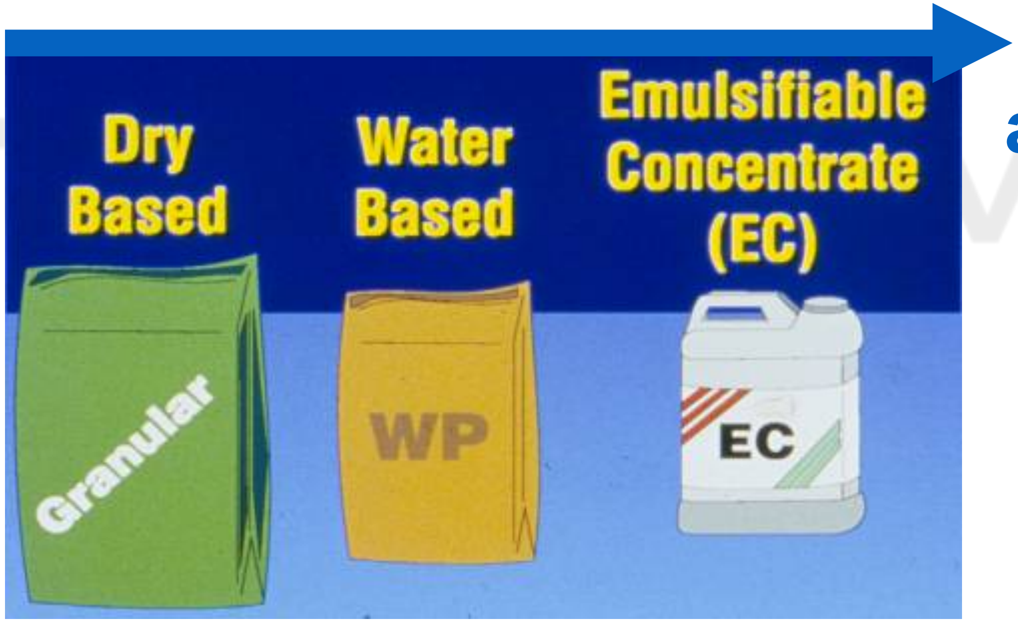
Greater dermal absorption

- Warm, moist areas: groin, armpits, head, neck
- Cuts, abrasions, and rashes
- Pesticide formulations affect absorption

Least absorbed



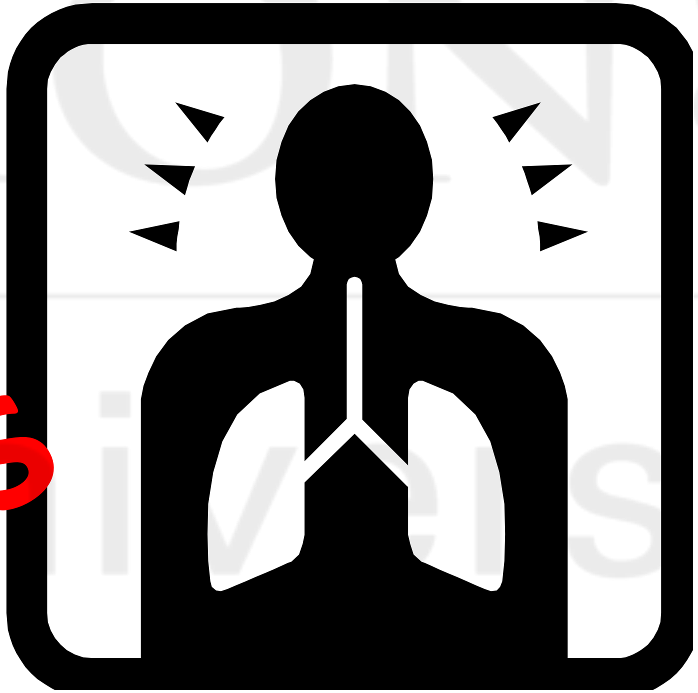
Most absorbed

Routes of Entry: Lungs (inhalation)

Inhalation exposure can occur:

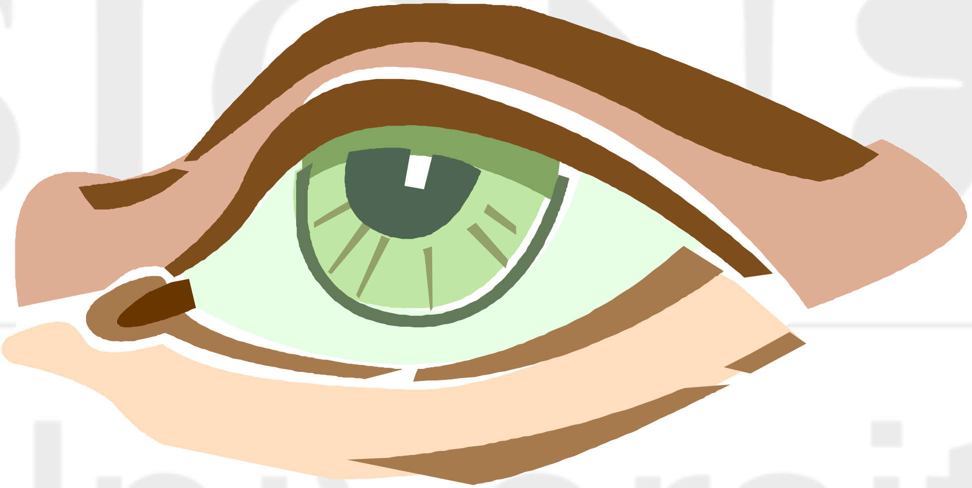
- When using
  - Wettable powders
  - Dusts
  - Gases, vapors
  - Sprays
- While mixing and loading
- During applications

pesticides



Routes of Entry: Eyes

Eyes are able to absorb surprisingly large amounts of chemical



Routes of Entry: Oral

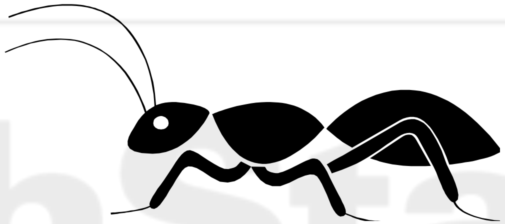
Wash your hands!

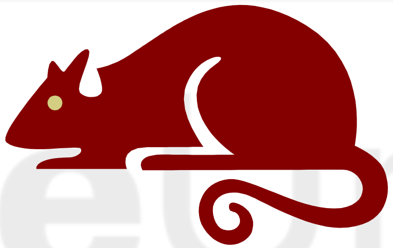
…before eating, drinking smoking, or going to the bathroom at breaks!!

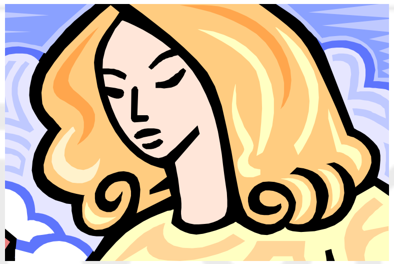
University of Maryland

Pesticides and Humans

- Plants, insects, rodents, and humans have similar cellular, nervous, circulatory, and respiratory systems, so pesticides can affect people too!







- You are special … just like Mom said …
  - just not really all that special
    - Plants, insects, rodents are also special?

If Exposure Occurs, Administer First Aid

- **Dilute the pesticide**

- **On skin:** remove contaminated clothing, wash skin, **gently** dry and loosely cover
- **In eyes:** wash *across* eyes for 15 minutes
- **If inhaled,** get victim to fresh air and laid down
- **If ingested,** induce vomiting and administer activated charcoal in water **EXCEPT…**

DO NOT USE syrup of ipecac– ineffective!

DO NOT Induce Vomiting If...

- victim is unconscious or convulsing
- petroleum products (kerosene, gasoline, oil) were involved
- emulsifiable concentrates used
- corrosive poisons, or strong acids or bases were ingested

- **Seek medical attention**

  Take the labeling

- Bring copies of the **label (and SDS)**
  - The ones you keep in your vehicle!

Post Emergency Numbers!

National Poison Control Center 1-800-222-1222
National Pesticide Information Center (NPIC) 1-800-858-7378 npic.orst.edu
Utah Poison and Drug Information Center 1-800-222-1222 Open 24/7

Area Code
Dependent

Personal Protective Equipment (PPE)

Chapter 6

National Pesticide Applicator Certification Core Manual

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Read the label!!

- Follow directions for PPE
  - Handlers
  - Applicators
  - Early entry workers
- *Minimum* requirements are given – you can wear more!!!

PERSONAL PROTECTIVE EQUIPMENT (PPE)

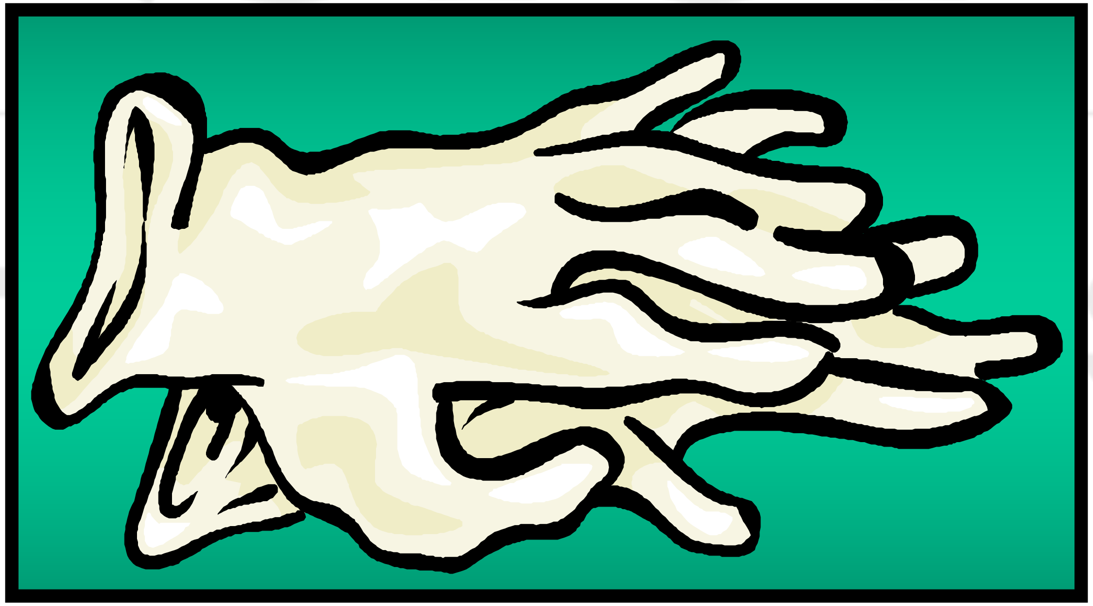
Some materials that are Chemical-resistant to this product are listed below. If you want more options, follow the instructions for category F on an EPA chemical resistance category selection chart.

Applicators and other handlers must wear: A) Long-sleeved shirt; B) Long pants; C) Chemical-resistant gloves such as Barrier Laminate, Butyl Rubber, Nitrile Rubber or Viton; D) Shoes plus socks.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Chemical-resistant Materials

- Watch for signs of wearing and degrading:
  - color change
  - spongy
  - swollen
  - jelly-like
  - cracked
  - brittle



Cotton, Denim, Leather:

Not recommended for most pesticide applications!

Personal Protective Equipment (PPE)

Minimum:

- Long-sleeved shirt
- Long trousers or coveralls
- Gloves
- Shoes plus socks
- Hat??

Protect Yourself!

Coveralls

- Wear loosely over clothing
- Zippers should be covered
- Two-piece: top should extend well below the waist and remain untucked

Use Gloves!

- Especially during mixing & loading
- Unlined and waterproof
- Check for holes
- If spraying overhead, tuck sleeves inside gloves…

… and fold the cuffs up

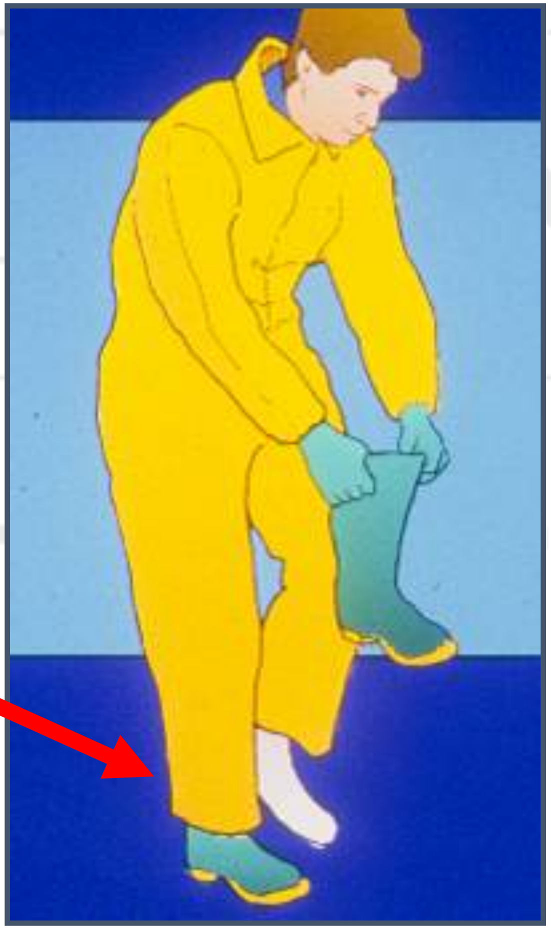
Gloves reduce dermal exposure by <u>**99%**</u> when mixing, loading, and applying

____ of all body exposure during spraying is by skin contact!

<u>Check the label</u>
to determine if you need specific chemical-resistant gloves and what kind

Footwear

- No sandals or flip flops!
- Consider wearing unlined, rubber boots... even if not required
- Hang pant legs outside the boots!



Hats & Hoods

- Liquid-proof with a wide brim
- No absorbent materials!
- Chemical-resistant hoods on jackets

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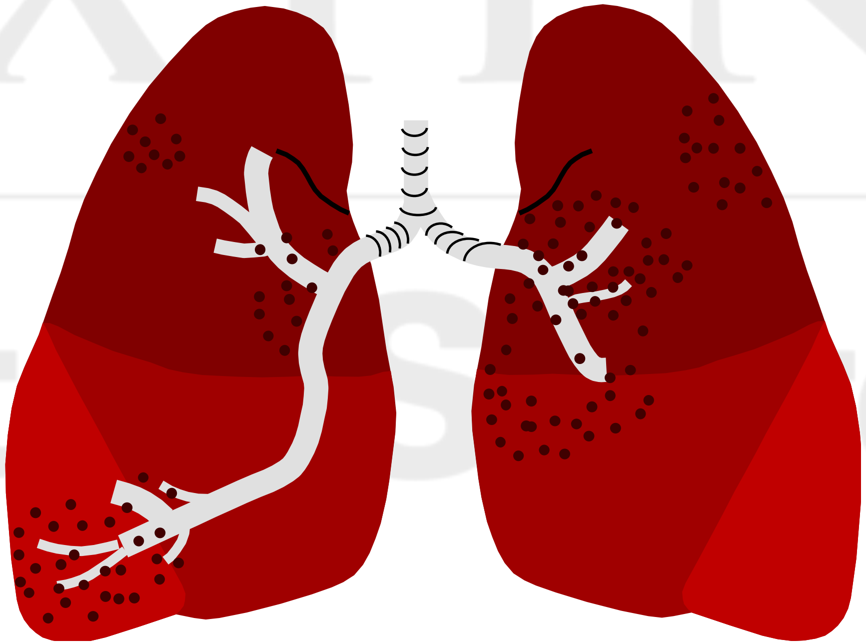
Protect your eyes when mixing concentrates or handling dusts or toxic sprays

Eyewear should have shields on all sides!

Respirators

Prevent pesticide exposure through the respiratory system



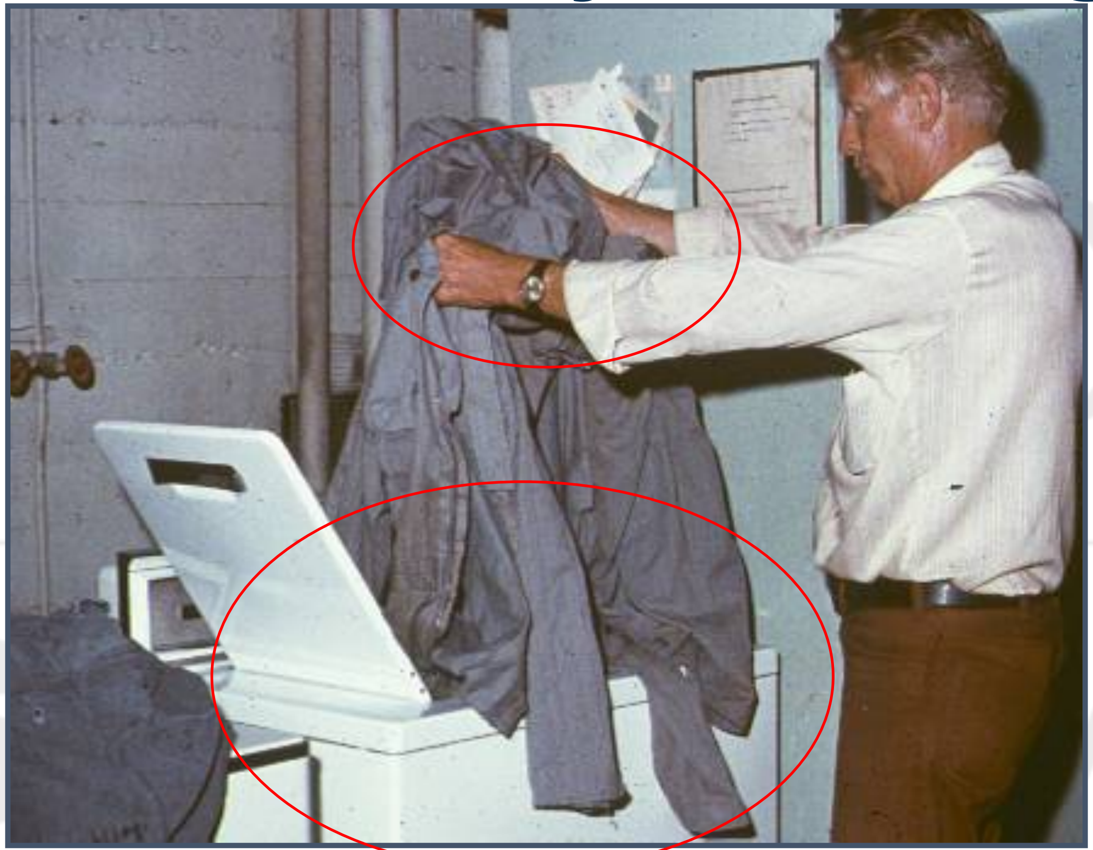
When should a respirator be used?

- When the **label** requires it
- When exposed to spray mist
- When working in confined spaces
- When using dusts, gases, vapors, or fumigants

PPE Clean Up!

- Discard disposables and worn-out items!
- Wash at the end of each day, including gloves and all PPE
- Launder pesticide clothing

Separate from family clothing

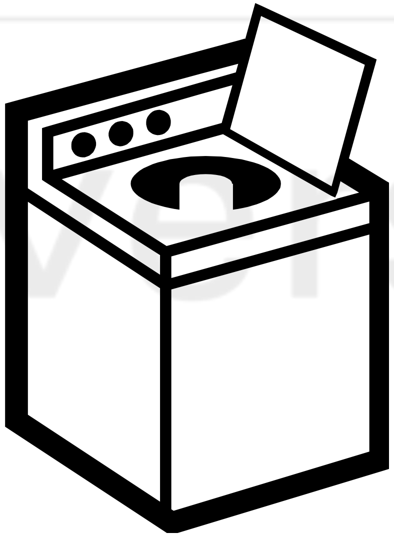


What should this guy do immediately after starting the washing machine?

Wash contaminated clothing in hot water with detergent

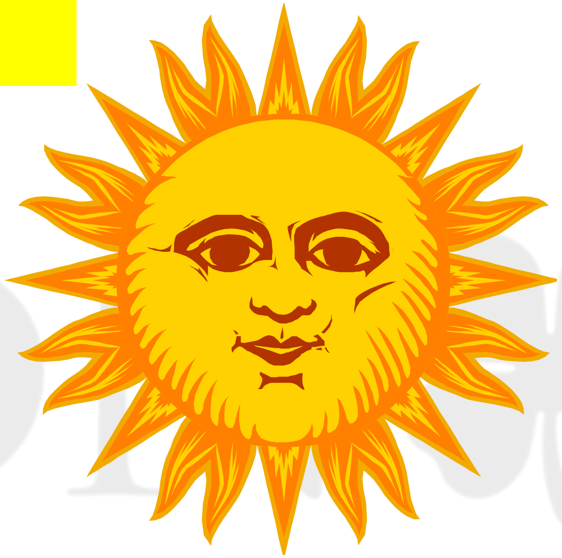
Laundering Pesticide Contaminated Clothing

- Use heavy-duty liquid detergent for ECs
- Use 2 cycles for moderate to heavy contamination
- Rinse the washer with an "empty load"



Photodegradation

- Line dry if possible
- **Breakdown of pesticides by sunlight photons = photodegradation**



Store all PPE separate from pesticides!!

Questions?

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Nutrient Requirements, Leaf Tissue Standards, and Options for Fertigation in Raspberry and Blackberry

Raspberry and blackberry plantings have a relatively low nutrient requirement compared with many other perennial fruit crops. Knowledge of annual accumulation of nutrients and periods of rapid uptake allows for better management of fertilization programs. In this presentation, I will present information on nutrient uptake and implications for timing of fertilizers, changes in leaf nutrient concentrations throughout the season, and recent studies on fertigation with conventional and organic fertilizers.

David Bryla
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Dr. Bryla's research focuses on irrigation and nutrient management in berry crops. The goal is to identify practices that increase plant growth and yield potential; enhance fruit quality and food safety; promote efficient use of water, fertilizer, and soil resources; reduce problems caused by plant pests and diseases; and limit labor requirements associated with pruning, weeding, and harvest. A few of his current projects include the use of drones to monitor crop growth and water requirements in blueberry and raspberry, design and management of fertigation systems, deficit irrigation strategies for reducing water use during drought, and benefits of soil amendments such as humic acids and biochar.



Nutrient requirements, leaf tissue standards & options for fertigation in raspberry & blackberry

David Bryla
USDA-ARS Horticultural Crops Research Unit
Corvallis, Oregon

USDA ars

Mar. 23

Apr. 21

May 18

June 15

Oct. 10

Fertilizer Management

Goal: apply <u>appropriate</u> fertilizers at the optimum <u>rate</u>, <u>time</u>, and <u>place</u> to maximize production (plant growth, yield, and fruit quality) and minimize costs *(economical & environmental)*

4R Principle

- "Right" source – use the proper fertilizer
- "Right" amount – apply it at the proper rate
- "Right" time – add it when most needed
- "Right" place – place it where it is accessible to the plant

Nutrient Management Guidelines

1. **Tissue testing**
   - Collect leaf samples in early August
   - Fifty new, fully expanded primocane leaves, 12 inches from the tip

2. **Leaf N recommendation** – 2.3% to 3.0%

3. **N rate**
   - 30-50 lb/acre during establishment
   - 50-80 lb/acre in subsequent years

EM 8903-E
January 2006

Caneberries

J. Hart, B. Strik, and H. Rempel

Several types of caneberries are produced commercially in Oregon, including summer-bearing and primocane-fruiting red raspberries, black raspberries (blackcaps), and blackberries. This publication addresses nutrient assessment and application for caneberries produced in western Oregon.

In this area, caneberries typically are planted on Aloha, Jory, Newburg, Willamette, Woodburn, or Saum soils. Spacing usually is 2.5 ft x 10 ft for raspberries and 4 to 6 ft x 10 ft for blackberries. Recommendations in this publication are based on research and experience with caneberry production in this setting.

The use of fertilizer should be part of a complete management package. Nutrient application influences yield, fruit quality, fruit maturity, and sustained plant vigor. Management practices—from selection of certified plants to pre- and postharvest irrigation—must be performed in an appropriate and timely manner so that plants can benefit from applied nutrients.

Nutrient application is not a substitute for poorly timed irrigation, late harvest, or failure to control insects, diseases, rodents, or weeds. Soil properties such as low pH and/or poor drainage can be significant limiting factors in obtaining high berry yields. Increasing fertilizer rates or adding nutrients already in adequate supply will not correct these limiting factors.

Growers, with the assistance of county Extension faculty and field representatives, should consider nutrient needs of each field. Routine collection and analysis of soil and tissue samples are helpful in determining the need for nutrient applications.

To assist with interpretation of soil and tissue analysis data, keep records of weather, disease problems, nutrient application rates, and timing. Observations of annual growth (cane number, diameter, height, fruiting lateral length), yield, leaf color, and fruit quality (amount of rot and drupelet set) are also helpful in determining nutrient needs.

The goal of fertilization for any high-value crop is to remove limitations to yield and quality by supplying the crop with ample nutrition in advance of demand. Nutrient application should be based on soil and plant analyses and grower experience. Consider potential returns from your fertilizer investment, as well as environmental stewardship and governmental regulation. A fertilizer application should be "bio"logically sound and produce a measurable change in plant growth or nutrient status. The biological change caused by a fertilizer application is expected to increase fruit yield or quality and produce a return on your investment.

Caneberry plants require chemical elements from air, water, and soil to ensure adequate vegetative growth and fruit production. When levels of these nutrients in the plant are low, growth and yield may be affected. Severely reduced nutrient supply can lead to visible nutrient deficiency symptoms such as leaf discoloration and distortion (Figures 1 and 2). Routine collection and analysis of tissue

Figure 1.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

Figure 2.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

John Hart, Extension soil scientist and Bernadine C. Strik, Extension berry crops professor, both of Oregon State University; and Hannah Rempel, research technician, USDA-ARS, Corvallis, OR. This publication replaces FG 51-E, *Caneberries Fertilizer Guide*.

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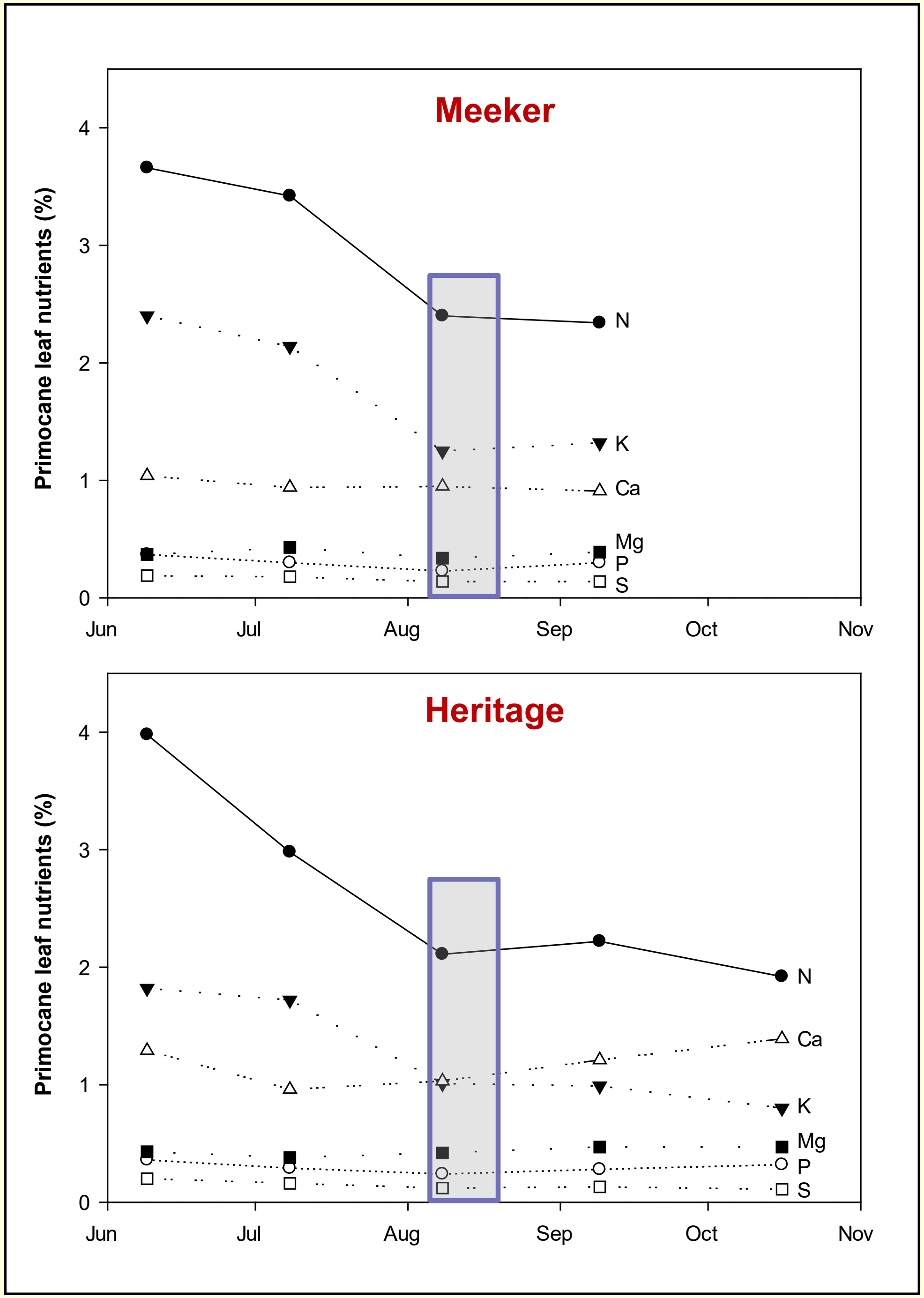

When to sample the leaves

Primocane leaf nutrient concentrations in 'Meeker' (floricane-fruiting) and 'Heritage' (primicane-fruiting) raspberry

Tissue sampling should be done when leaf nutrient concentrations are stable

Tissue Testing
Interpreting results

Low leaf N

- *Weak cane growth* – increase N fertilizer to rate recommended by OSU extension
- *Abundant cane growth* – do not apply extra N

Normal leaf N – continue with current fertilizer program

High leaf N

- *Weak cane growth* – check for other stresses (drought, pests, frost damage, disease, etc.)
- *Abundant cane growth* – reduce N rate

NUTRIENT MANAGEMENT guide

EM 8903-E
January 2006

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J. Hart, B. Strik, and H. Rempel

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Growers, with the assistance of county Extension faculty and field representatives, should consider nutrient needs of each field. Routine collection and analysis of soil and tissue samples are helpful in determining the need for nutrient applications.

To assist with interpretation of soil and tissue analysis data, keep records of weather, disease problems, nutrient application rates, and timing. Observations of annual growth (cane number, diameter, height, fruiting lateral length), yield, leaf color, and fruit quality (amount of rot and drupelet set) are also helpful in determining nutrient needs.

The goal of fertilization for any high-value crop is to remove limitations to yield and quality by supplying the crop with ample nutrition in advance of demand. Nutrient application should be based on soil and plant analyses and grower experience. Consider potential returns from your fertilizer investment, as well as environmental stewardship and governmental regulation. A fertilizer application should be "bio"logically sound and produce a measurable change in plant growth or nutrient status. The biological change caused by a fertilizer application is expected to increase fruit yield or quality and produce a return on your investment.

Caneberry plants require chemical elements from air, water, and soil to ensure adequate vegetative growth and fruit production. When levels of these nutrients in the plant are low, growth and yield may be affected. Severely reduced nutrient supply can lead to visible nutrient deficiency symptoms such as leaf discoloration and distortion (Figures 1 and 2). Routine collection and analysis of tissue

Figure 1.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

Figure 2.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

John Hart, Extension soil scientist and Bernadine C. Strik, Extension berry crops professor, both of Oregon State University; and Hannah Rempel, research technician, USDA-ARS, Corvallis, OR. This publication replaces FG 51-E, *Caneberries Fertilizer Guide*.

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*** ***Collect at least 50 newly expanded primocane leaves in early August*** ***

N sufficient (left) and N deficient (right) raspberry leaves

Nutrient	Sufficiency range[1]	Deficiency symptoms
Major elements		
Nitrogen (N)¶*	2.3-3.0%	Yellow older leaves; poor growth & fruit production
Phosphorus (P)¶	0.19-0.45%	Purplish older leaves & dark green younger leaves
Potassium (K)¶	1.3-2.0%	Marginal leaf necrosis
Calcium (Ca)*	0.6-2.0%	Leaf tip burn; soft fruit
Magnesium (Mg)	0.3-0.6%	Interveinal leaf chlorosis (yellowing)
Sulfur (S)	0.1-0.2%	Reddish leaves; poor plant vigor
Minor elements		
Iron (Fe)	60-250 ppm	Yellow new leaves
Boron (B)¶*	30-70 ppm	Small, crumbly fruit; decreased yield
Copper (Cu)†	6-20 ppm	None
Manganese (Mn)†	50-300 ppm	Poor growth with no distinguishing symptoms
Zinc (Zn)	15-50 ppm	"Little leaf" or rosette type growth

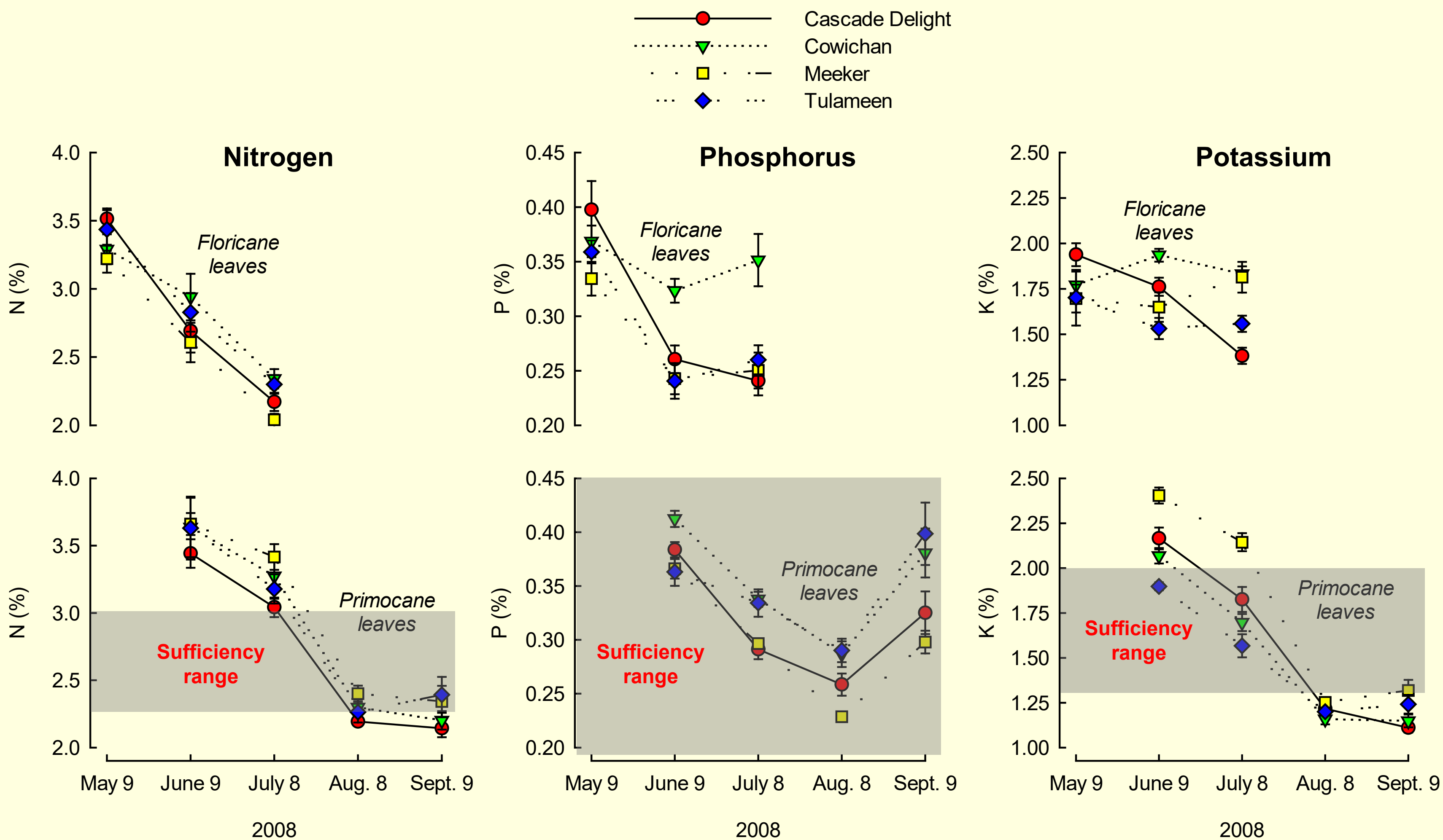
¶Only nutrients of concern in the Pacific Northwest

*Readily leached

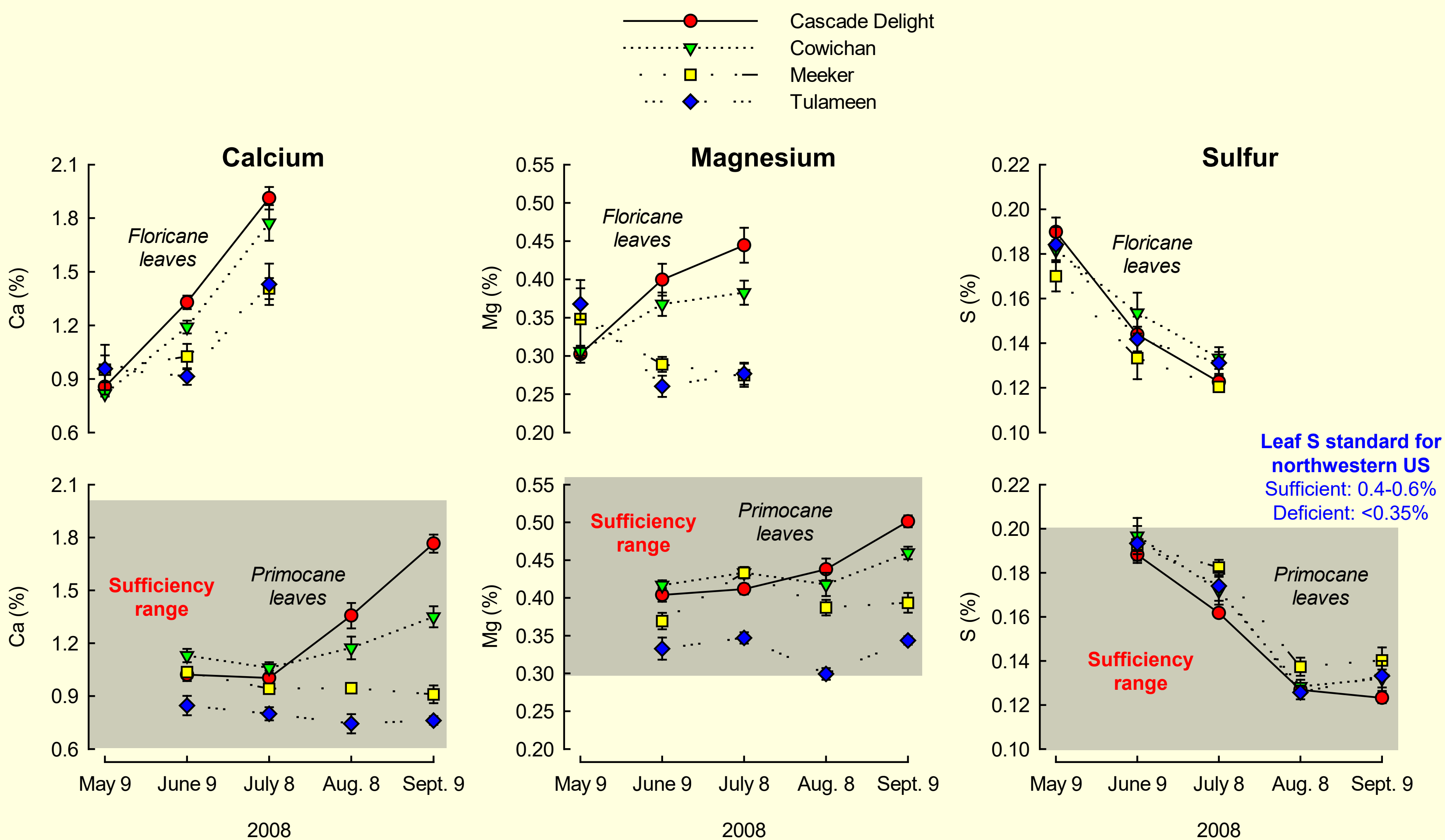
†Can sometimes reach toxic levels

[1]*Hart et al. (2006)*

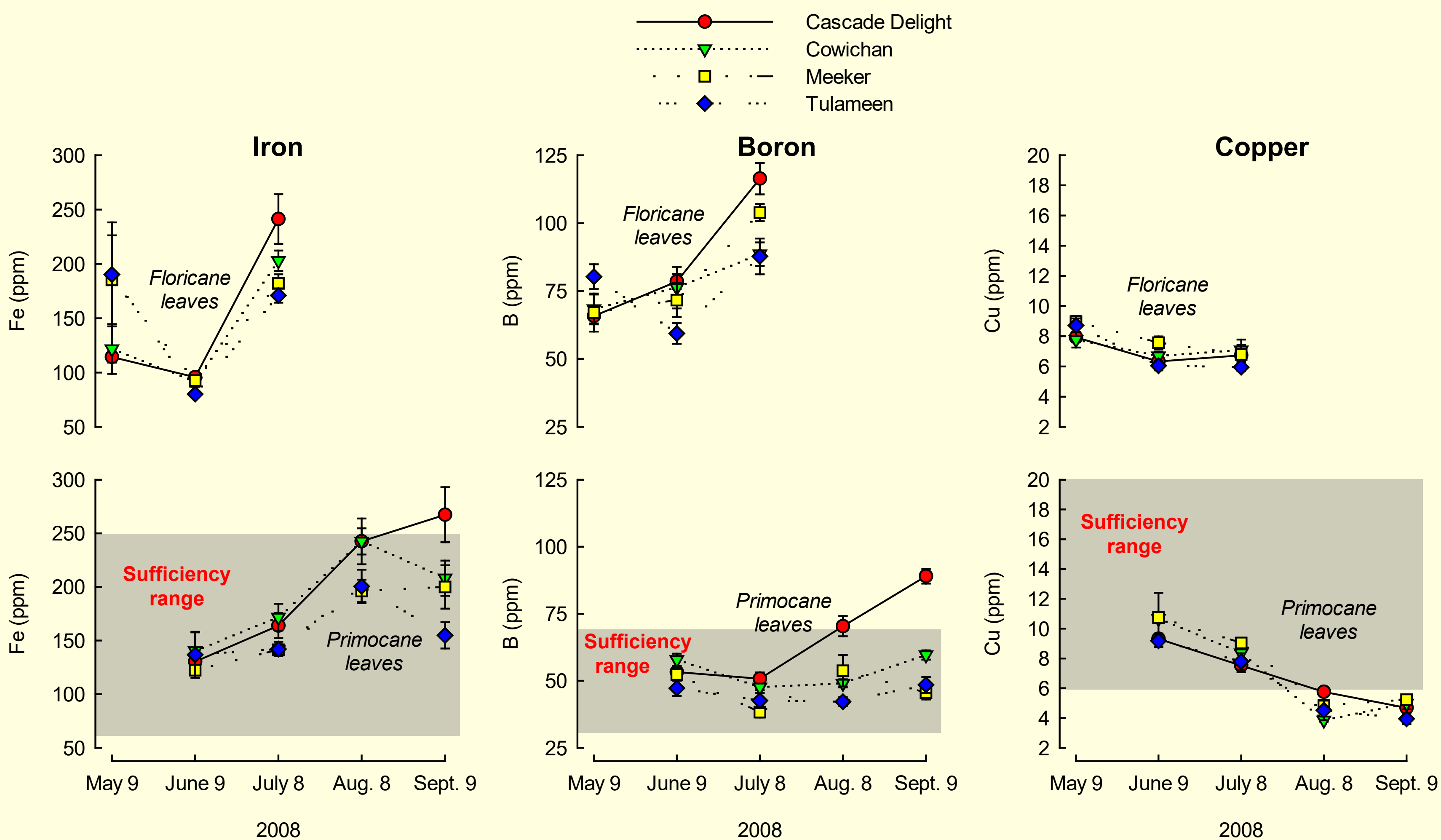
Major nutrients in summer-bearing red raspberries



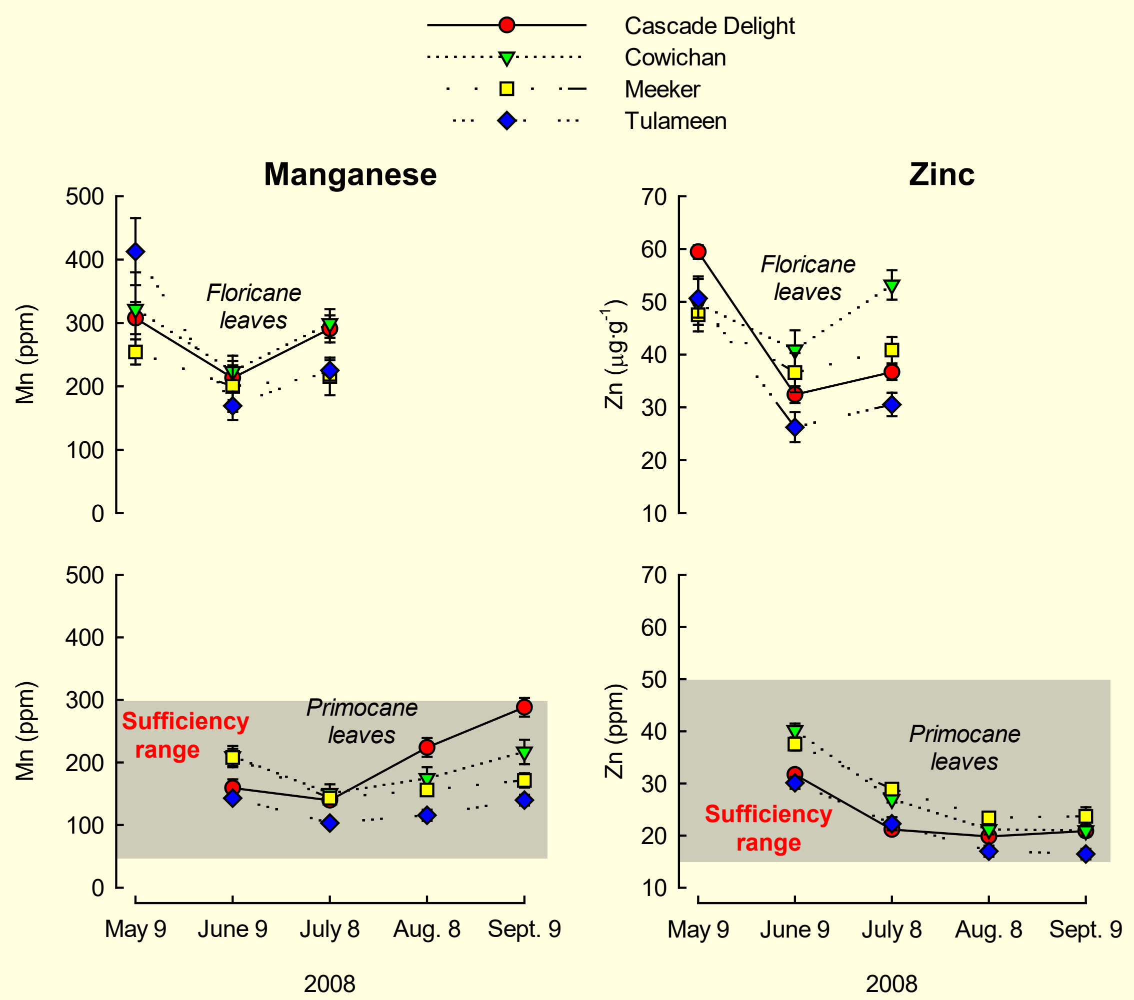
Major nutrients in summer-bearing red raspberries



Minor nutrients in summer-bearing red raspberries



Minor nutrients in summer-bearing red raspberries



*** Current guidelines appear accurate for most nutrients except K ***

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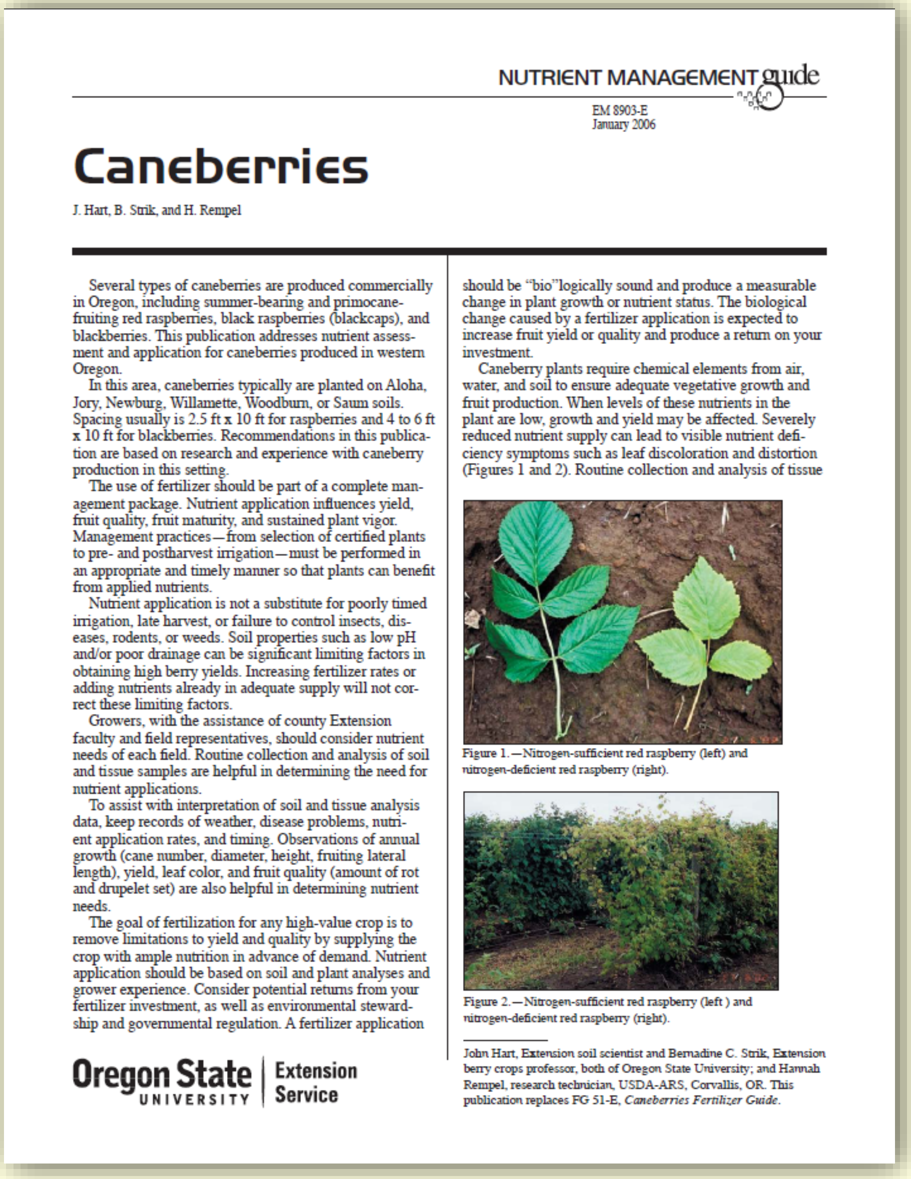
Nutrient Management Guidelines

1. **Tissue testing**
   - Collect leaf samples in early August
   - Fifty new, fully expanded primocane leaves, 12 inches from the tip

2. **Leaf nutrient recommendations** – 2.3% to 3.0%

3. **N rate**
   - 30-50 lb/acre during establishment
   - 50-80 lb/acre in subsequent years

4. **Timing**
   - Apply ½ a week before primocane emergence and ½ a month before harvest
   - For fall fruiters, apply an extra 20 lb/acre of N at bloom



NUTRIENT MANAGEMENT guide
EM 8903-E
January 2006

Caneberries

J. Hart, B. Strik, and H. Rempel

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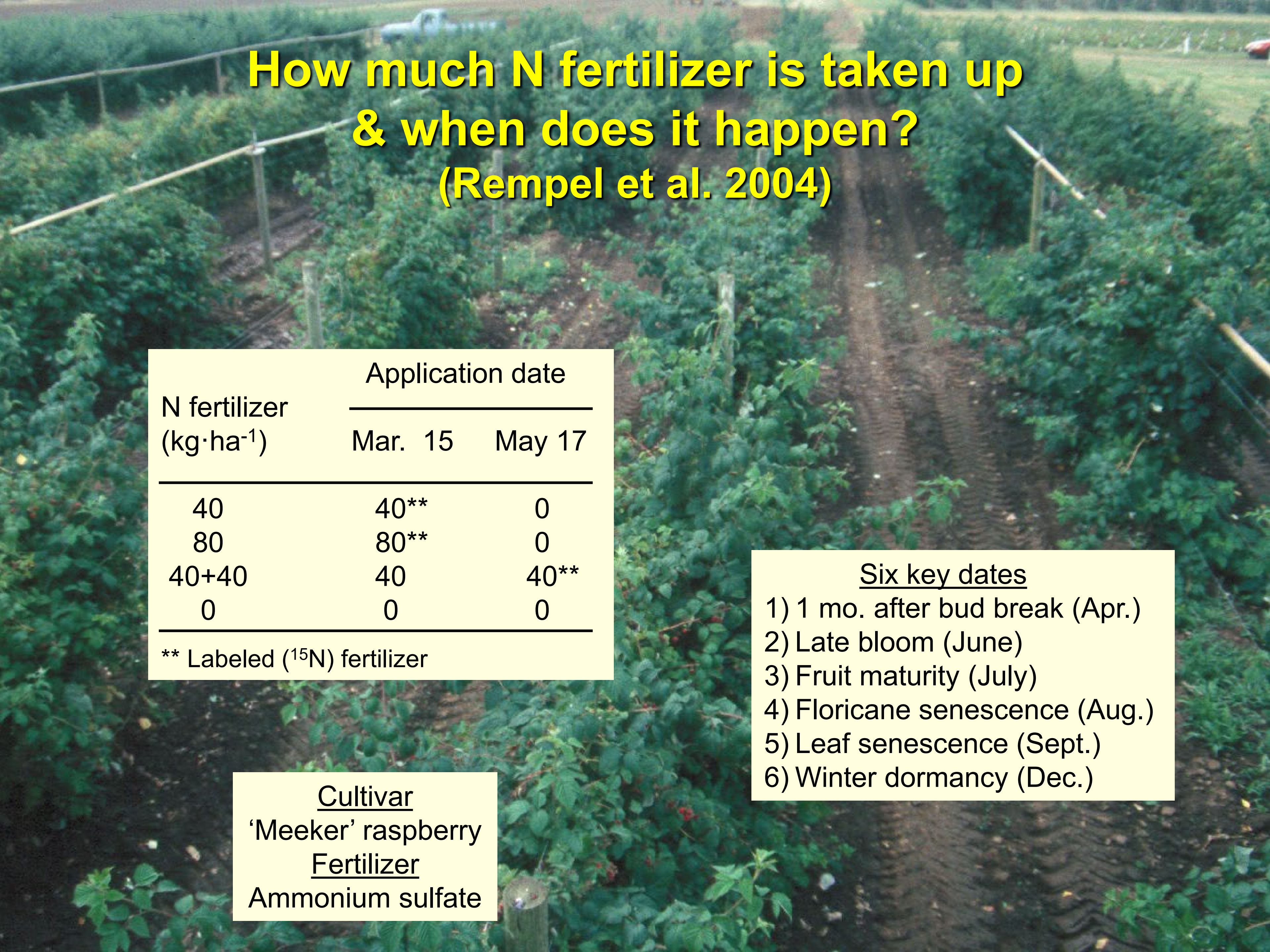


How much N fertilizer is taken up & when does it happen?
(Rempel et al. 2004)

N fertilizer ($kg \cdot ha^{-1}$)	Application date	
	Mar. 15	May 17
40	40**	0
80	80**	0
40+40	40	40**
0	0	0

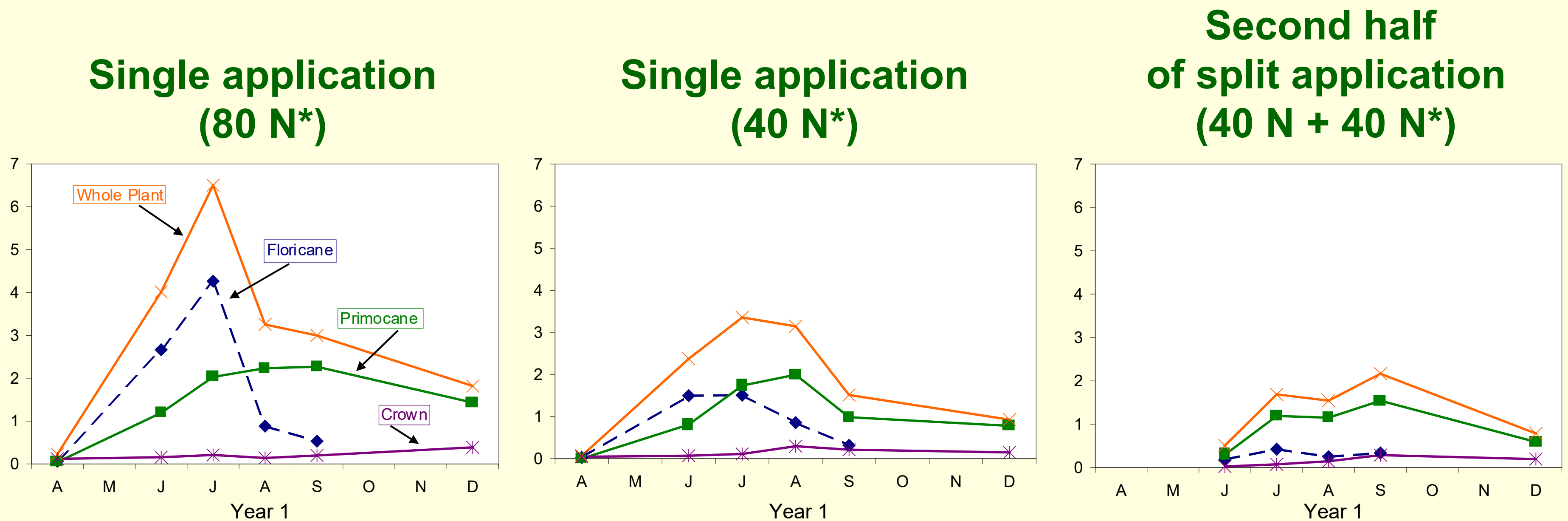
** Labeled (^{15}N) fertilizer

<u>Cultivar</u>
'Meeker' raspberry
<u>Fertilizer</u>
Ammonium sulfate

<u>Six key dates</u>

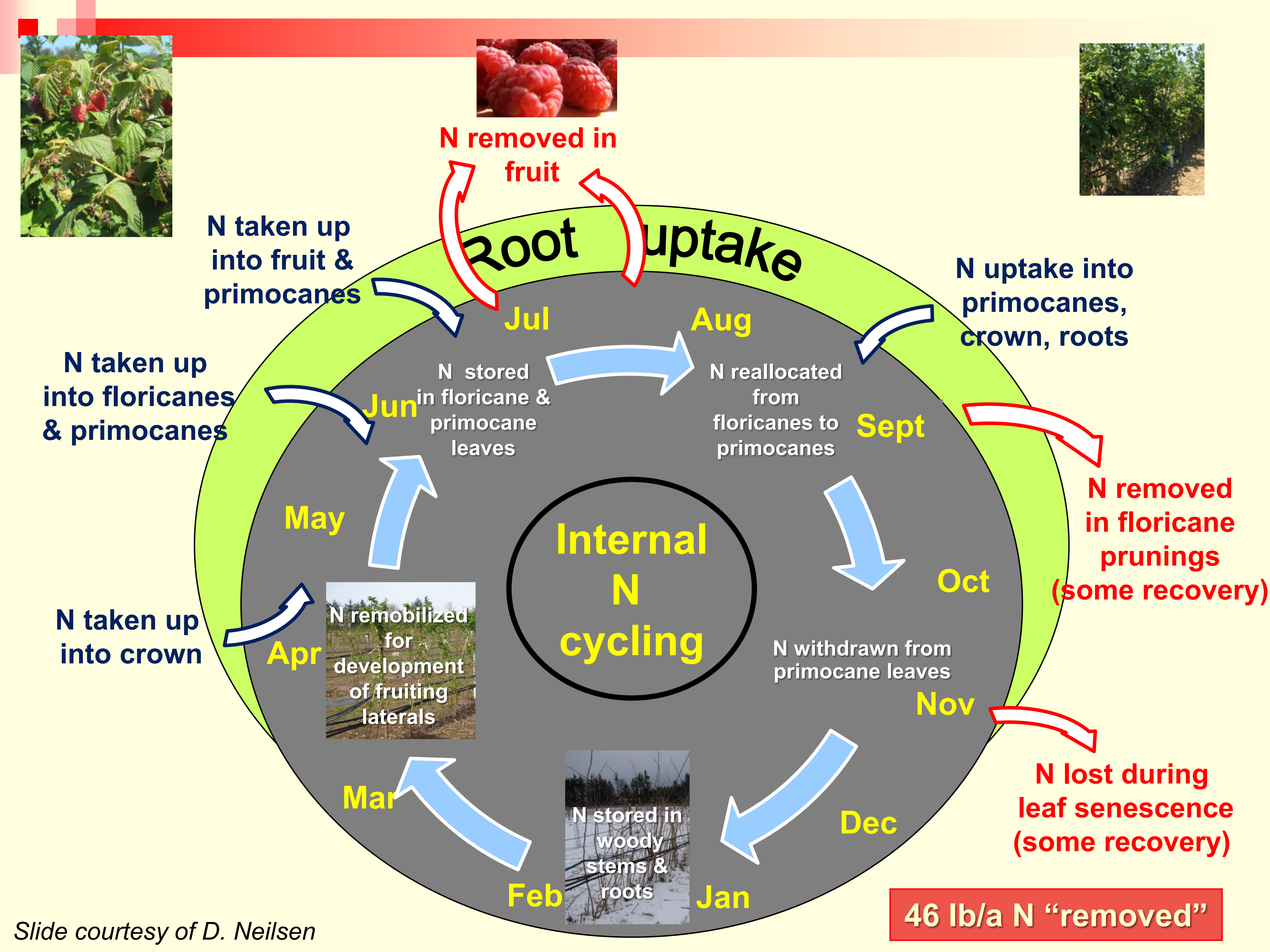
1) 1 mo. after bud break (Apr.)
2) Late bloom (June)
3) Fruit maturity (July)
4) Floricane senescence (Aug.)
5) Leaf senescence (Sept.)
6) Winter dormancy (Dec.)

N derived from fertilizer (g/plant)



36% **37%** **24%**

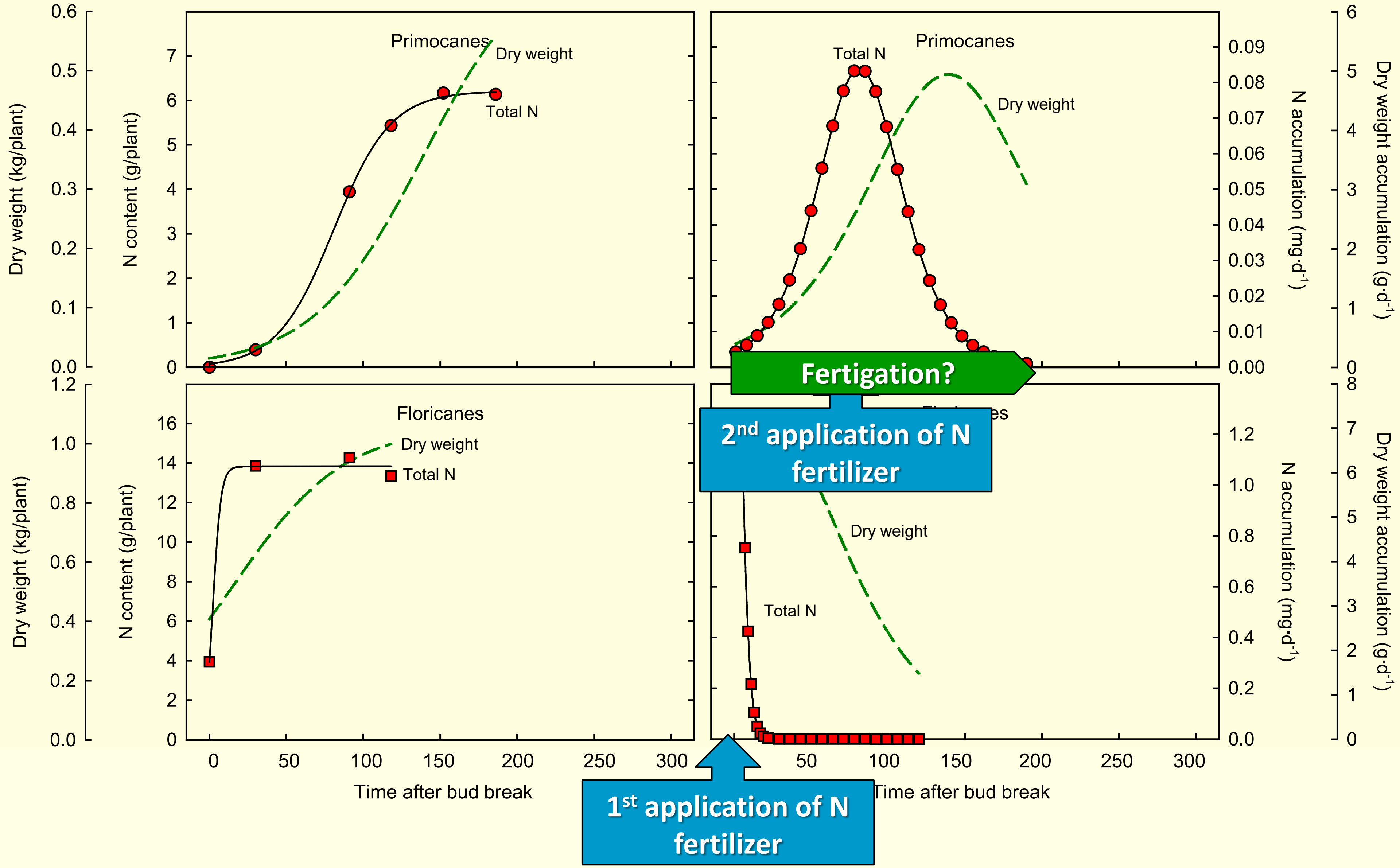
Fertilizer recovery


N removed in fruit
Root uptake
N taken up into fruit & primocanes
N uptake into primocanes, crown, roots
N taken up into floricanes & primocanes
Jul
Aug
Jun
N stored in floricane & primocane leaves
N reallocated from floricanes to primocanes
Sept
N removed in floricane prunings (some recovery)
May
Internal N cycling
Oct
N taken up into crown
Apr
N remobilized for development of fruiting laterals
N withdrawn from primocane leaves
Nov
N lost during leaf senescence (some recovery)
Mar
N stored in woody stems & roots
Dec
Feb
Jan
46 lb/a N "removed"
Slide courtesy of D. Neilsen

Nitrogen fertilizer recommendations for floricane-fruiting raspberries

- 50–80 lb/acre of N per year
  - Leaf N of 2.3–3.0%
  - Normal cane growth
- Wide band (granular fertilizer) centered on the row
- Split application of the fertilizer
  - Apply first half a week before primocane emergence
  - Apply second half a month before harvest

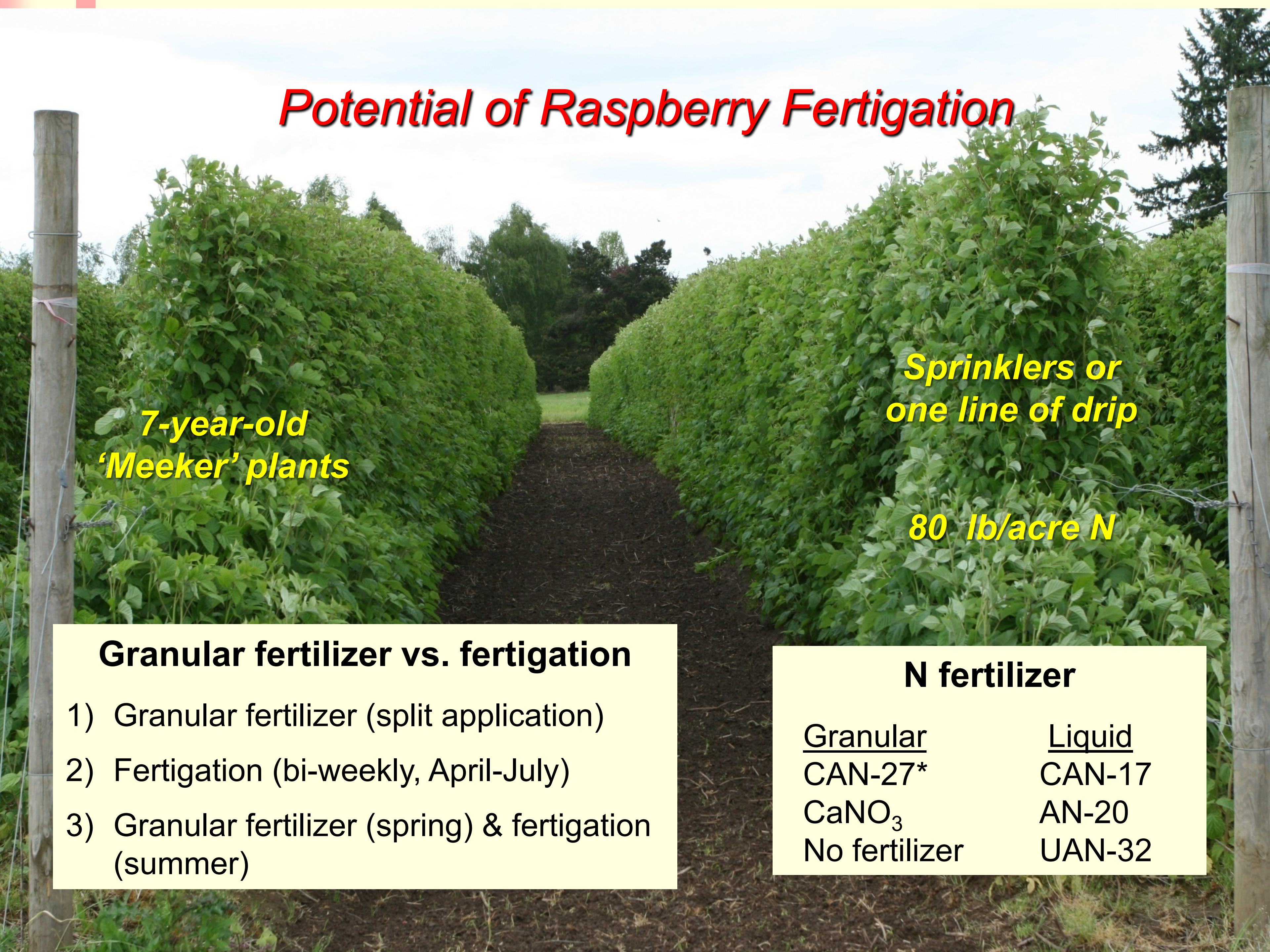
Growth and N Uptake in Raspberry



Water & nutrient management are linked

- Retention of nutrients in the root zone for as long as possible can improve nutrient use efficiency, environmental sustainability and reduce fertilizer costs if:
  - Water applications are scheduled to meet evaporative demand
  - Nutrient applications are timed and sufficient to meet plant demand

Potential of Raspberry Fertigation



Granular fertilizer vs. fertigation

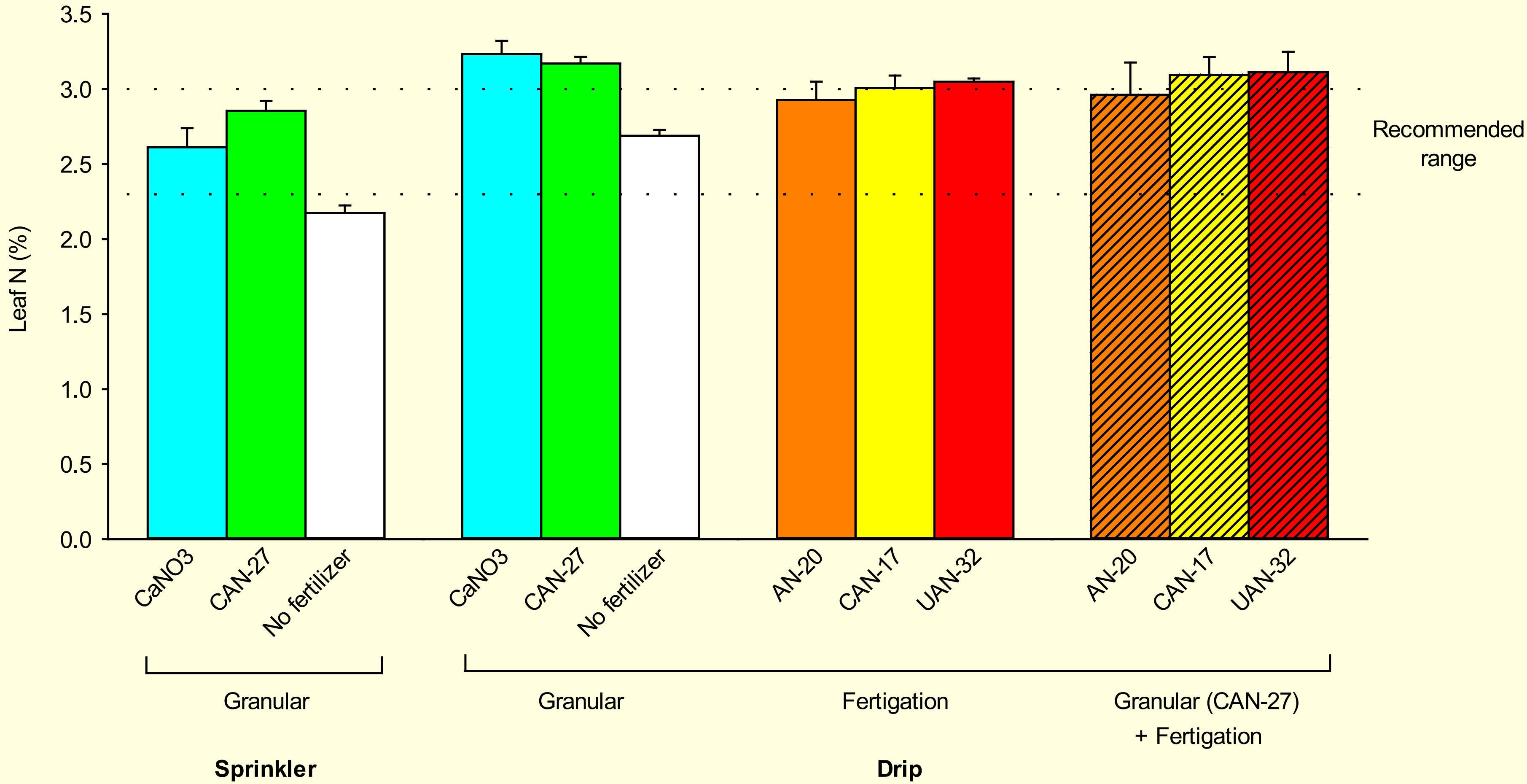
1) Granular fertilizer (split application)
2) Fertigation (bi-weekly, April-July)
3) Granular fertilizer (spring) & fertigation (summer)

N fertilizer

Granular	Liquid
CAN-27*	CAN-17
$CaNO_3$	AN-20
No fertilizer	UAN-32

Fertigation effects on leaf N

Year 7



N rate reduced to 50 lb/acre in Year 8

Primocane leaves were sampled early August


7/13/11
Sprinkler
$CaNO_3$
Sprinkler
CAN-27
Sprinkler
No fertilizer
Drip (fertigation)
CAN-17

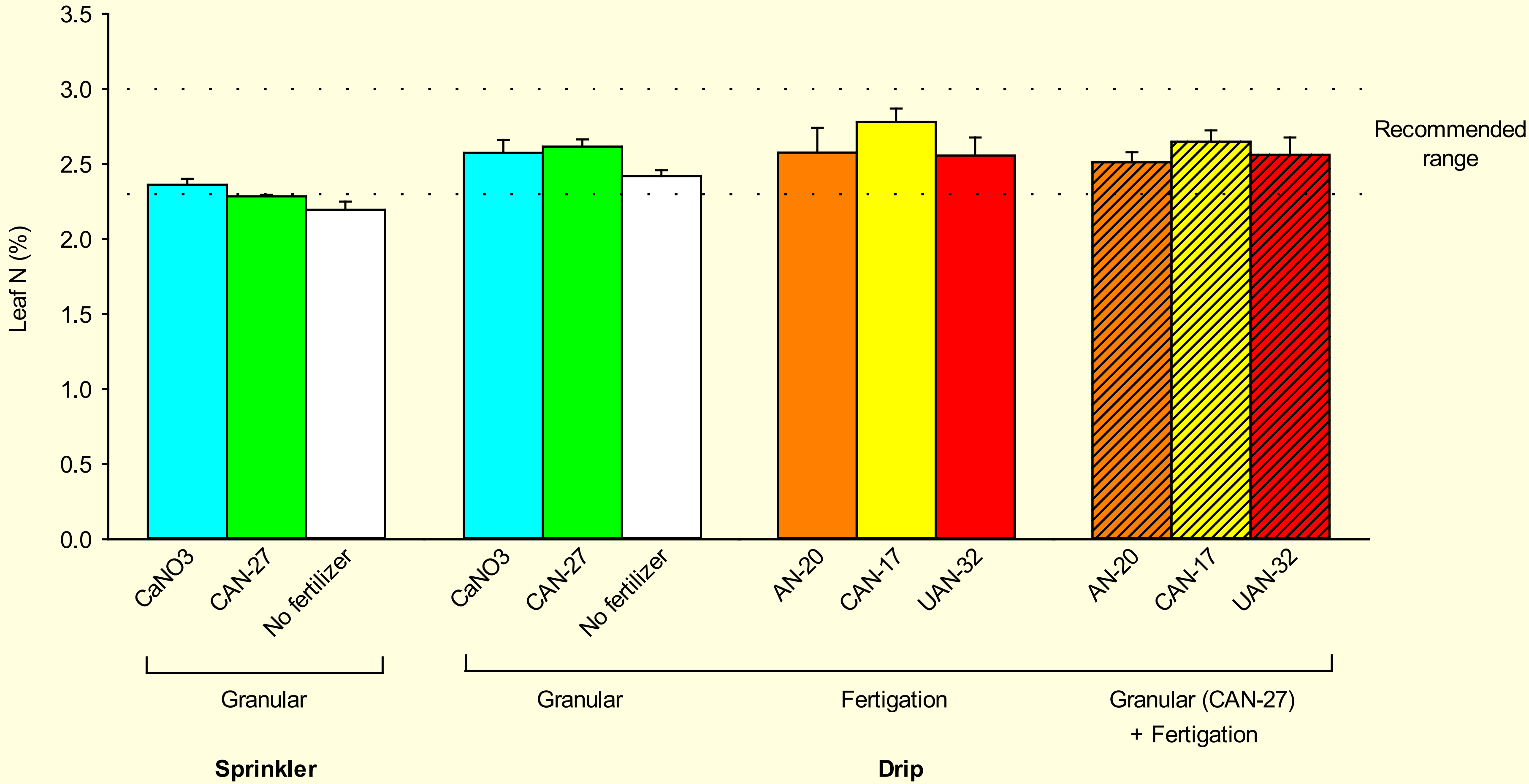
Fertigation effects on fruit production
Year 7

Irrigation method	**Fertilizer source**[1]	**Fertilizer placement**	**Yield (ton/acre)**	**Fruit size (g/berry)**
Sprinkler	CAN-27 (gr.)	Banded	4.8 b	3.1 b
Drip	CAN-27 (gr.)	Banded	6.5 a	3.4 a
Drip	CAN-17 (liq.)	Fertigation	6.7 a	3.5 a
Drip	CAN-27 (gr.) + CAN-17 (liq.)	Banded + fertigation	6.2 a	3.3 ab

[1]Each treatment was fertilized with a total of 80 lb/acre N.

Hand-harvested

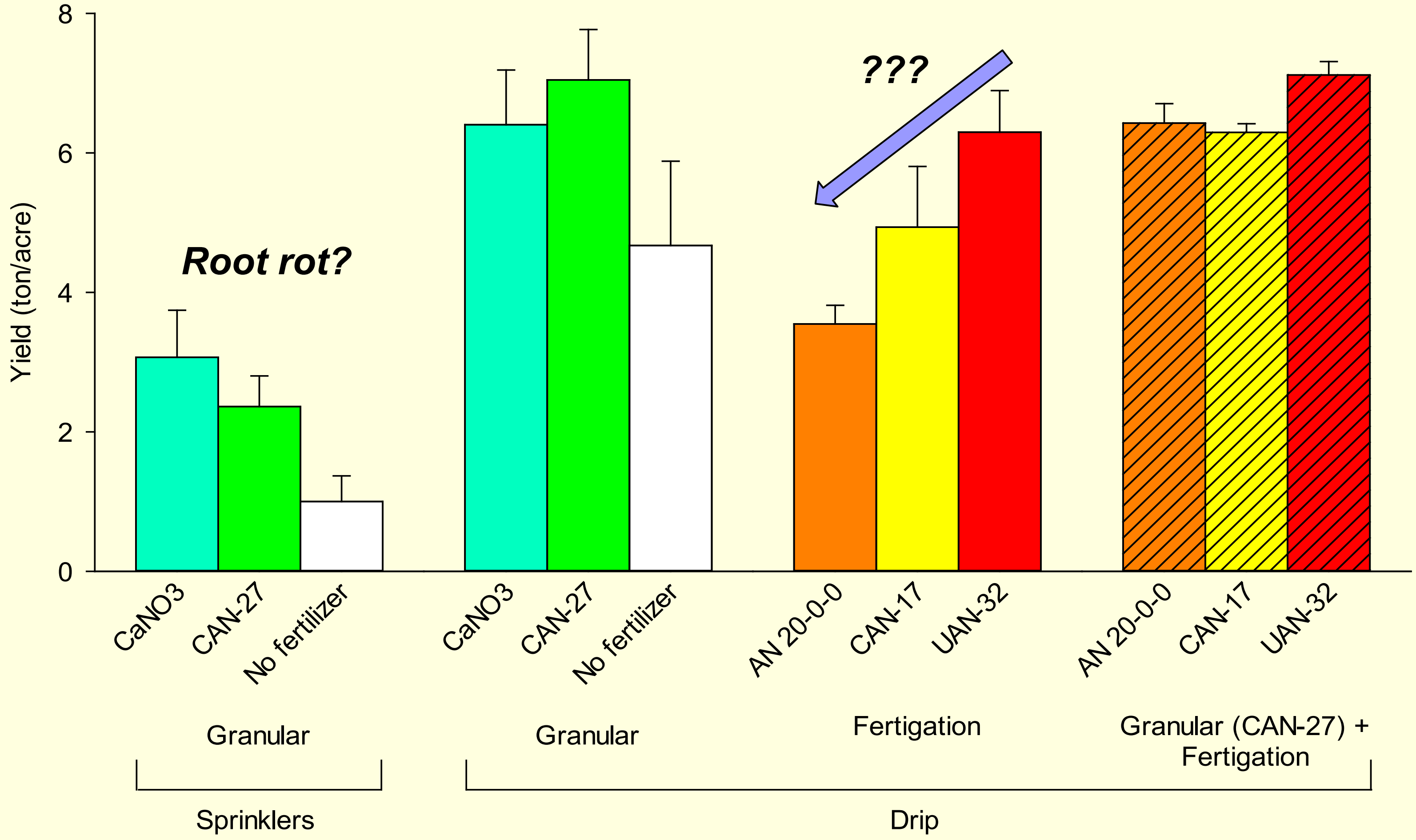
Fertigation effects on leaf N
Year 8



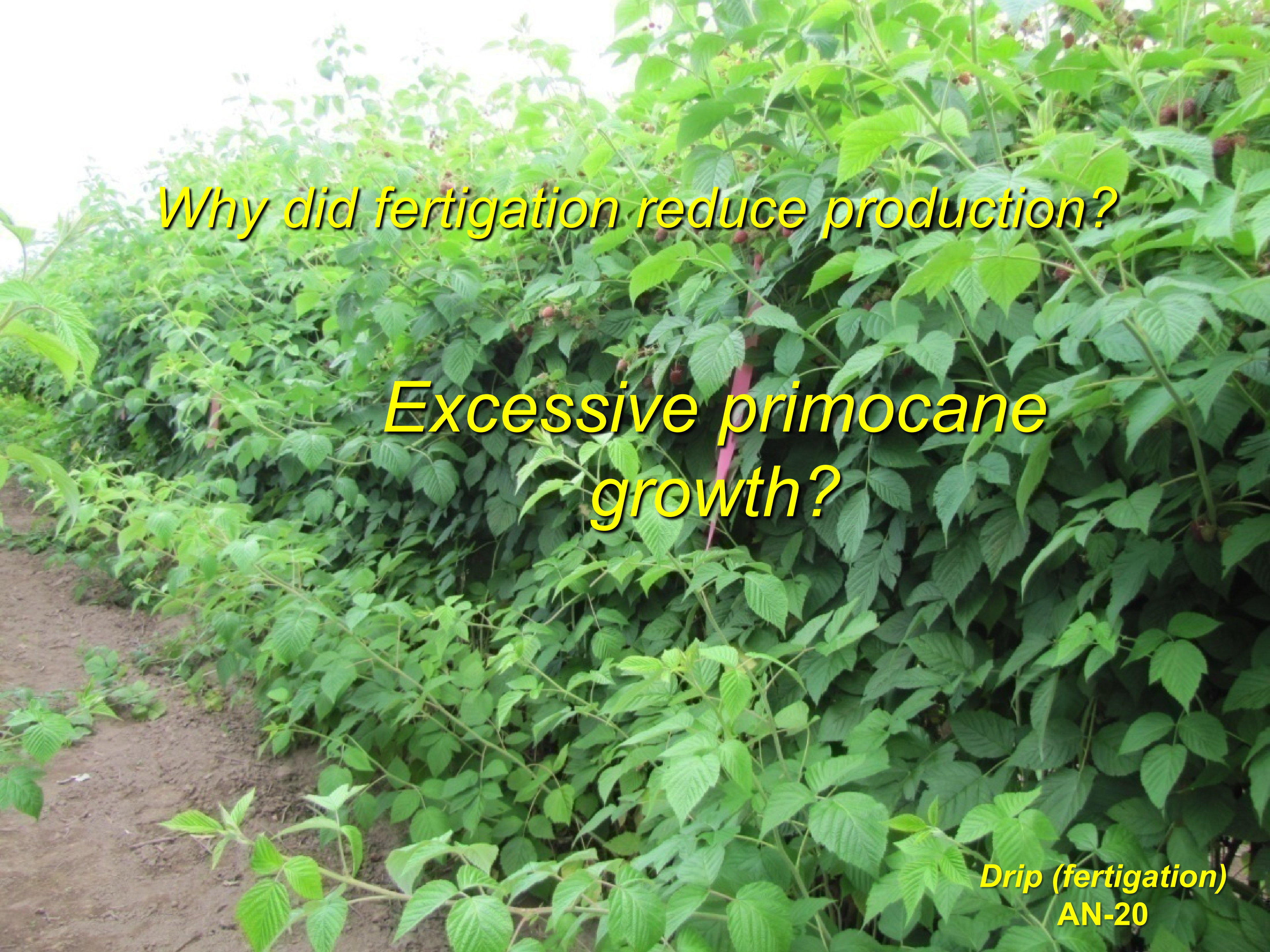
Primocane leaves were sampled in mid-August

Fertigation effects on fruit production

Year 8



Machine-harvested


Why did fertigation reduce production?
Excessive primocane growth?
Drip (fertigation)
AN-20

What about other nutrients?

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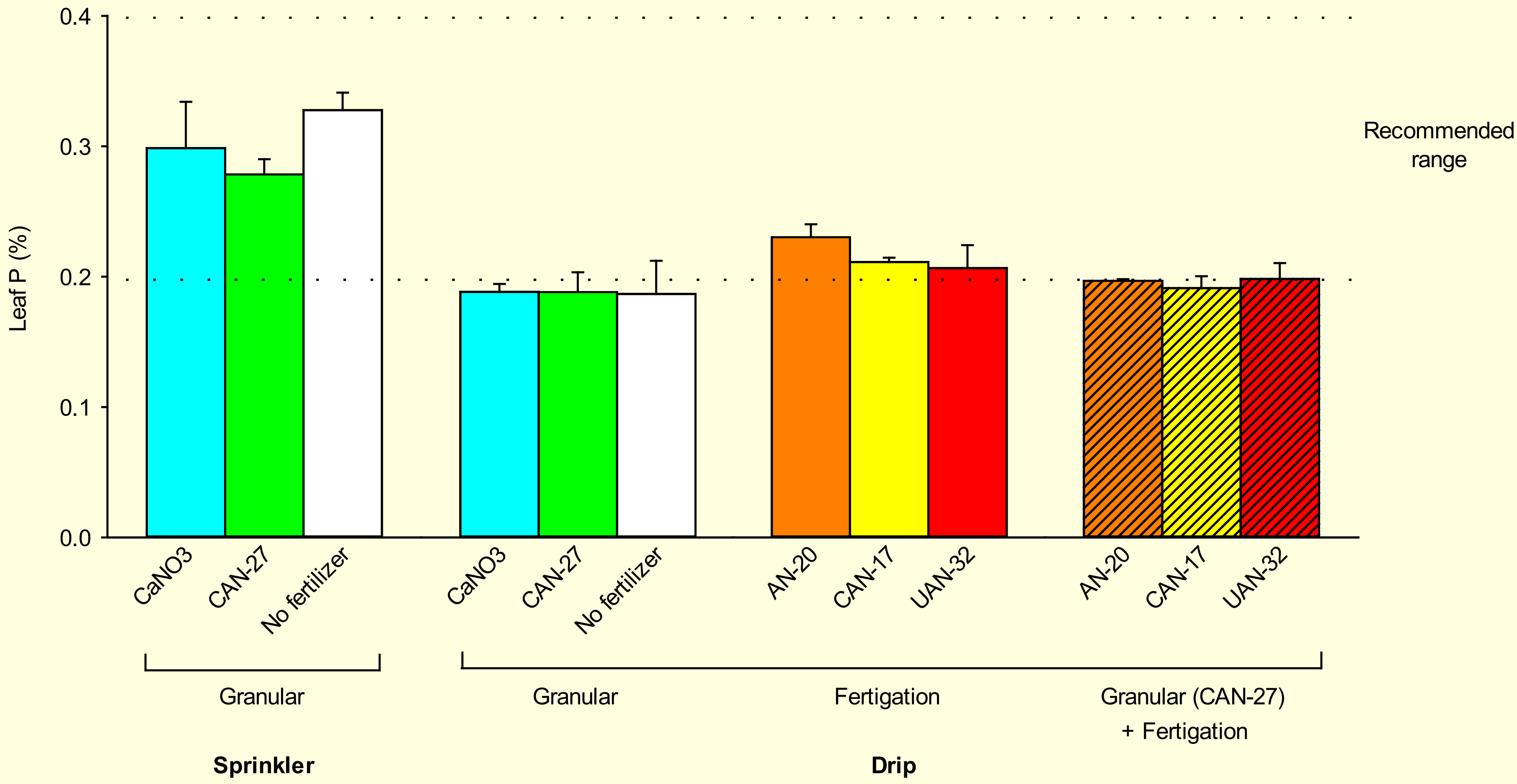
Other macronutrients

No difference among treatments

K – 1.33%
Ca – 0.79%
Mg – 0.37%
S – 0.14%



Micronutrients

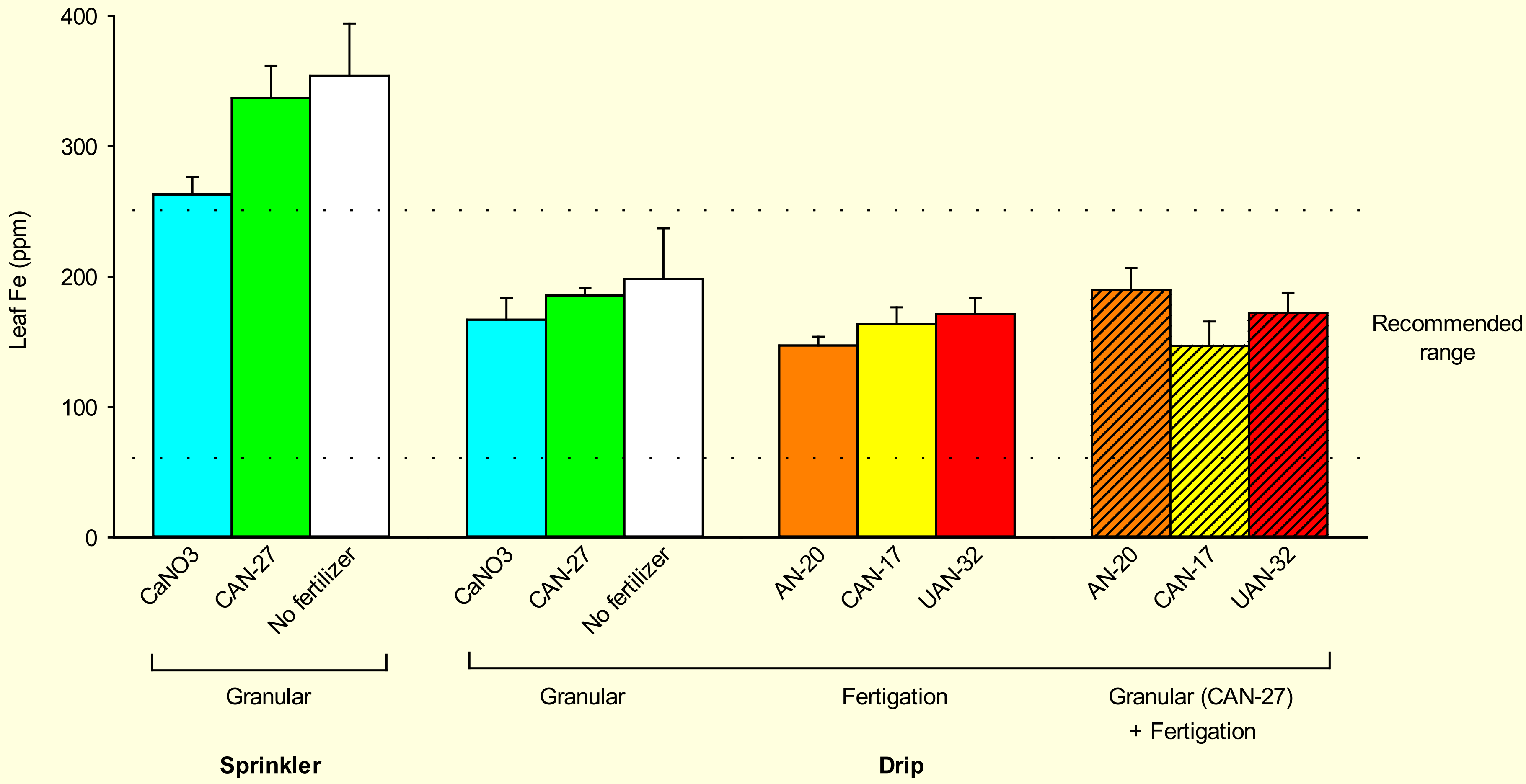
No difference among treatments

B – 30 ppm

Cu – 5 ppm

Mn – 120 ppm

Zn – 26 ppm



Conclusions

- Fertigation was similar to or less effective than granular fertilizer
  - Use granular fertilizer in the spring
  - Avoid liquid fertilizers with high NO_3-N
- Fertigation reduced P uptake
- Ca in the fertilizer (liquid or granular) had no effect on leaf Ca

Conclusion & Recommendations

Fertigation: Same as or worse than granular fertilizers

- Use granular fertilizers or a combination of granular fertilizers (spring) + fertigation (summer)

- Avoid fertigation with fertilizers containing high levels of NO_3-N

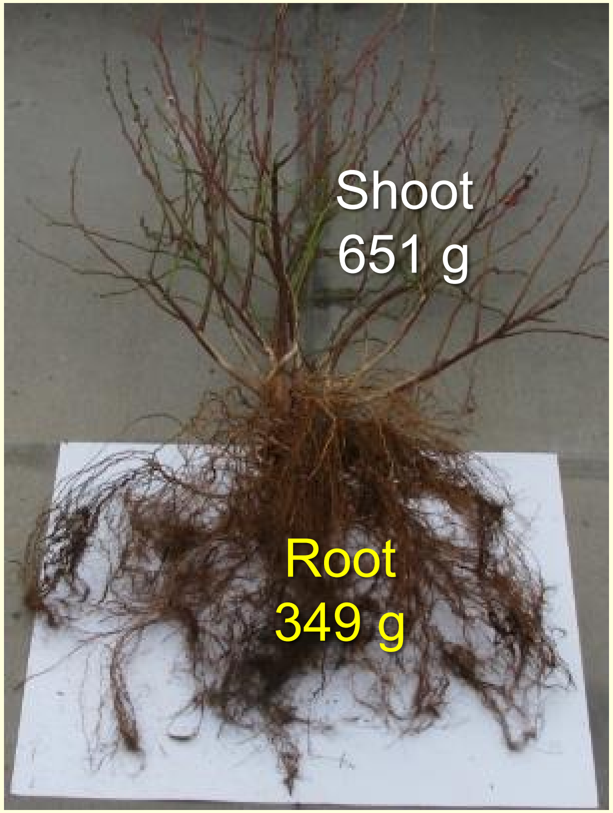
What’s next?

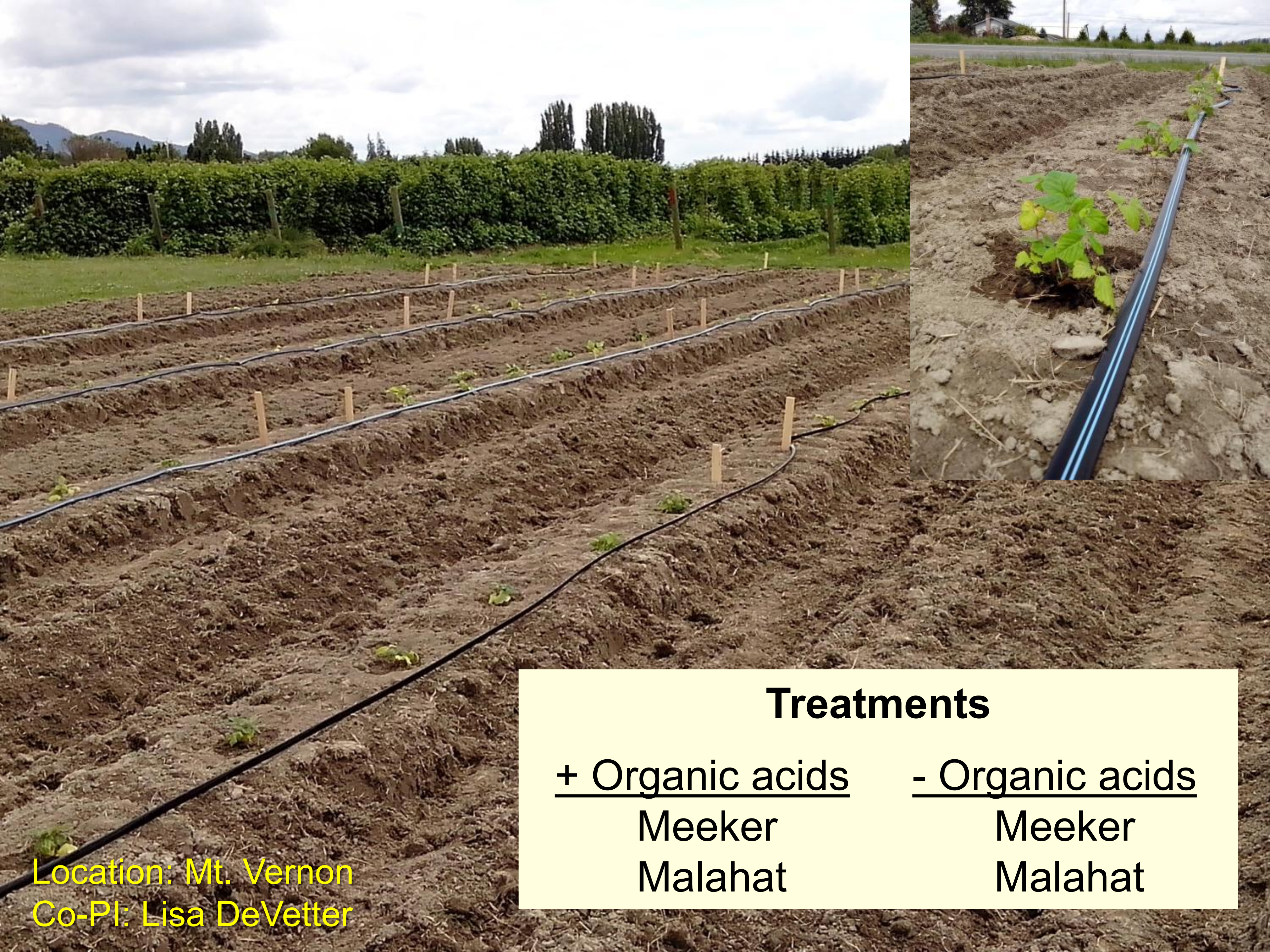
Fertigation with organic acids

Response of Blueberry to Organic Acids

Fertigation with liquid urea

Fertigation with liquid urea + organic acids (humic + fulvic)





Treatments

+ Organic acids	- Organic acids
Meeker	Meeker
Malahat	Malahat

Location: Mt. Vernon
Co-PI: Lisa DeVetter

+ Organic acids | - Organic acids

Meeker

Malahat

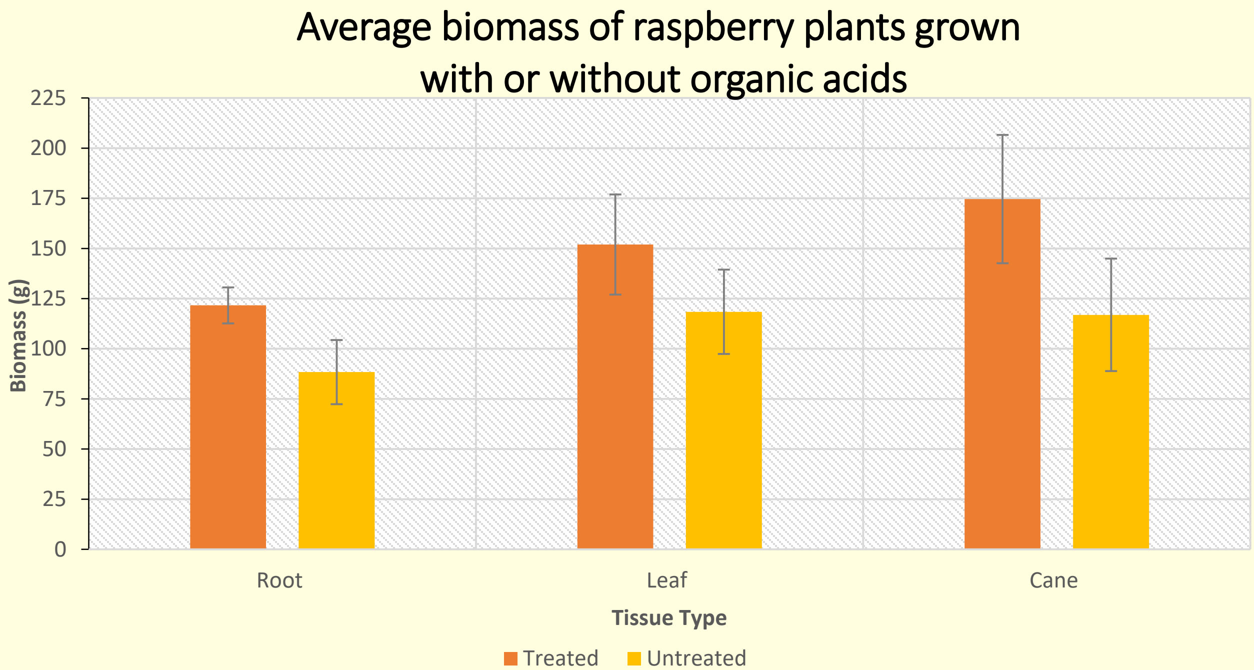
17 days after transplanting

+ Organic acids

- Organic acids

Meeker

1 month after transplanting



End of first growing season

Acknowledgements

- Collaborators: Drs. Bernadine Strik & Lisa DeVetter
- Technical Support: Amber Shireman, Ruth Hamlyn, OSU students
- Financial Support: Oregon Raspberry & Blackberry Commission, Washington Red Raspberry Commission, Northwest Center for Small Fruit Research, USDA Organic Research & Extension Initiative

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Available Resources/Website Update

This presentation will go over several resources available to berry growers in Utah. The Production Horticulture website will be featured along with other valuable resources.

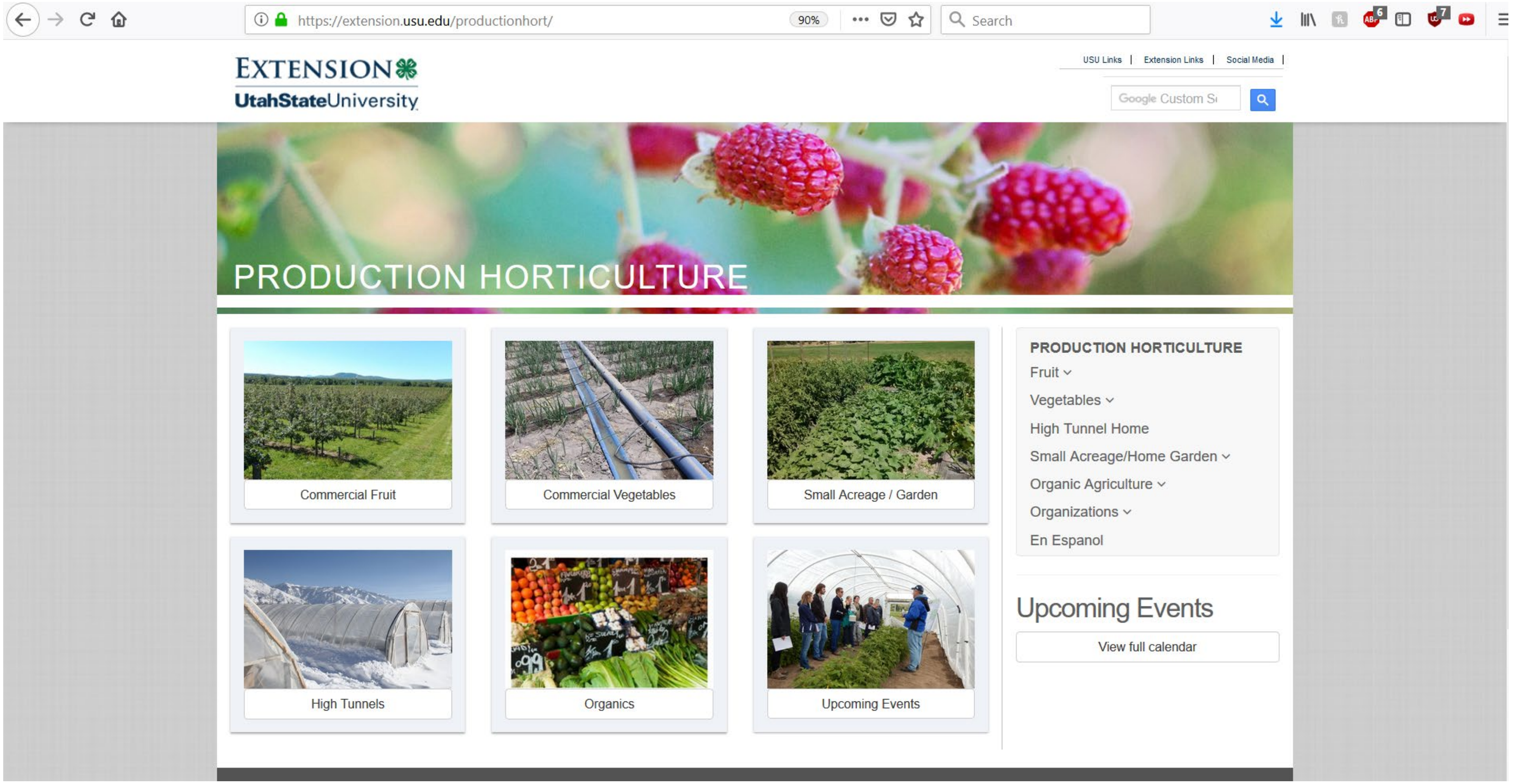
Tiffany Maughan
USU Extension Research Associate
Utah State University Extension
tiff.maughan@gmail.com

Tiffany is an extension research associate for Utah State University. Her work primarily includes composing fruit, vegetable, and flower fact sheets, collaborating on horticultural research projects, and maintaining the Production Horticulture website. She is also the owner of a small cut flower farm, Hammock & Spade Flowers. Tiffany graduated from USU with a B.S. in horticulture in 2012 and a M.S. in plant science in 2013.

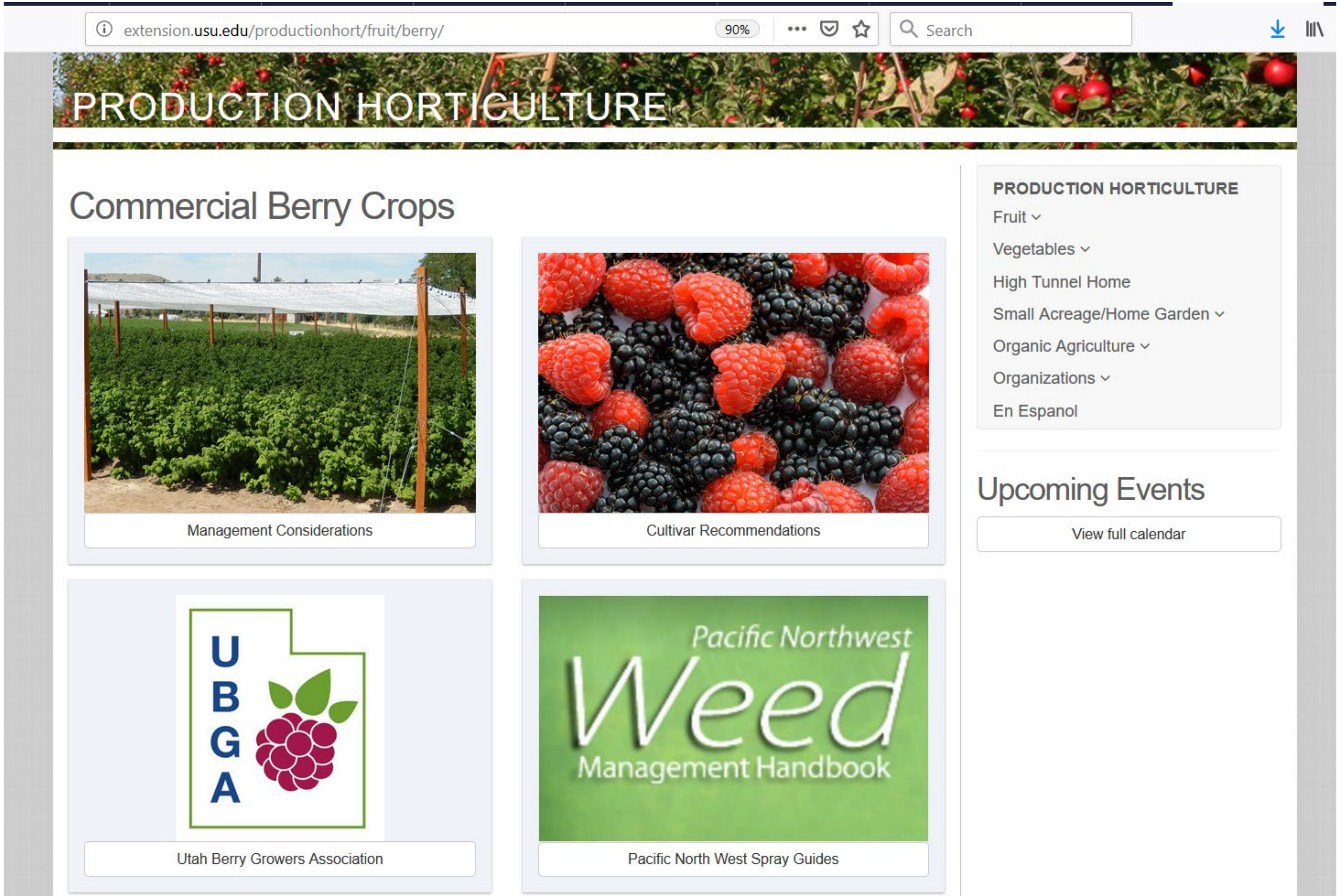
Available Resources and Production Horticulture Website Update

extension.usu.edu/productionhort

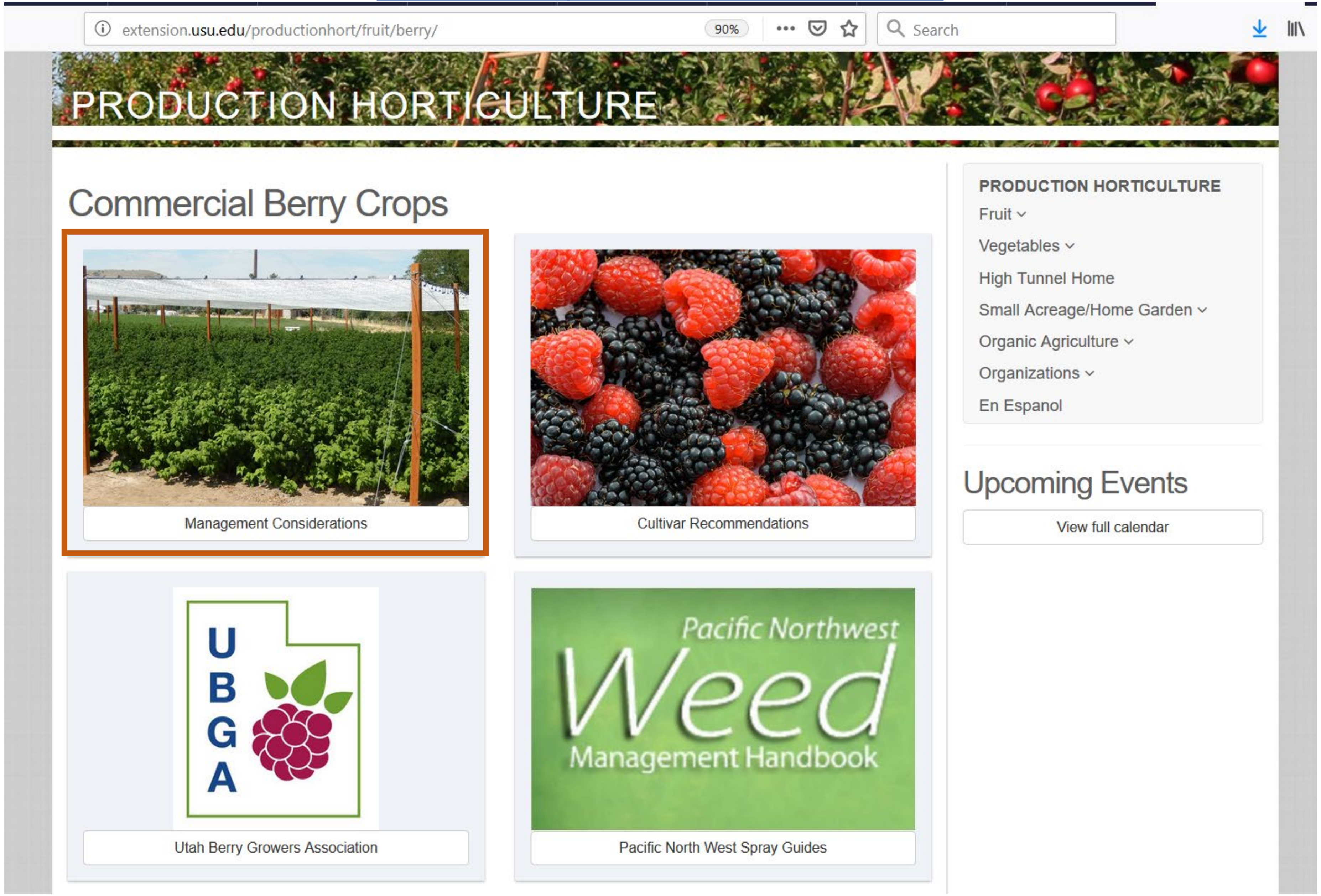
- OR…
- fruit.usu.edu
- vegetable.usu.edu
- tunnel.usu.edu



Get to the Commercial Berry Page



berry.usu.edu



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Management

General Management

- Using Shade for Fruit Production
- Constructing Shade Structures: Small Area
- Food Safety
- Iron Chlorosis in Berries

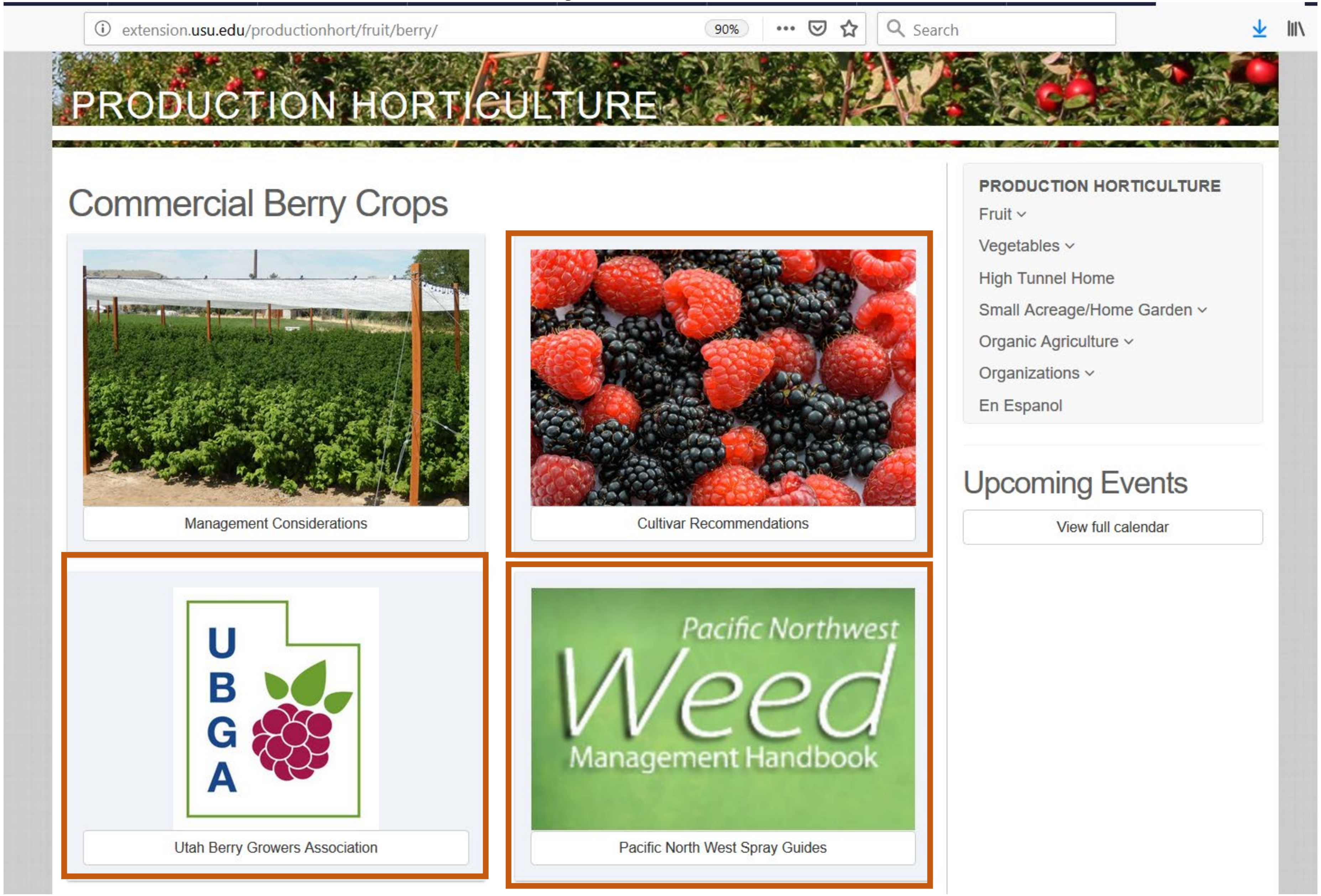
Individual Crops

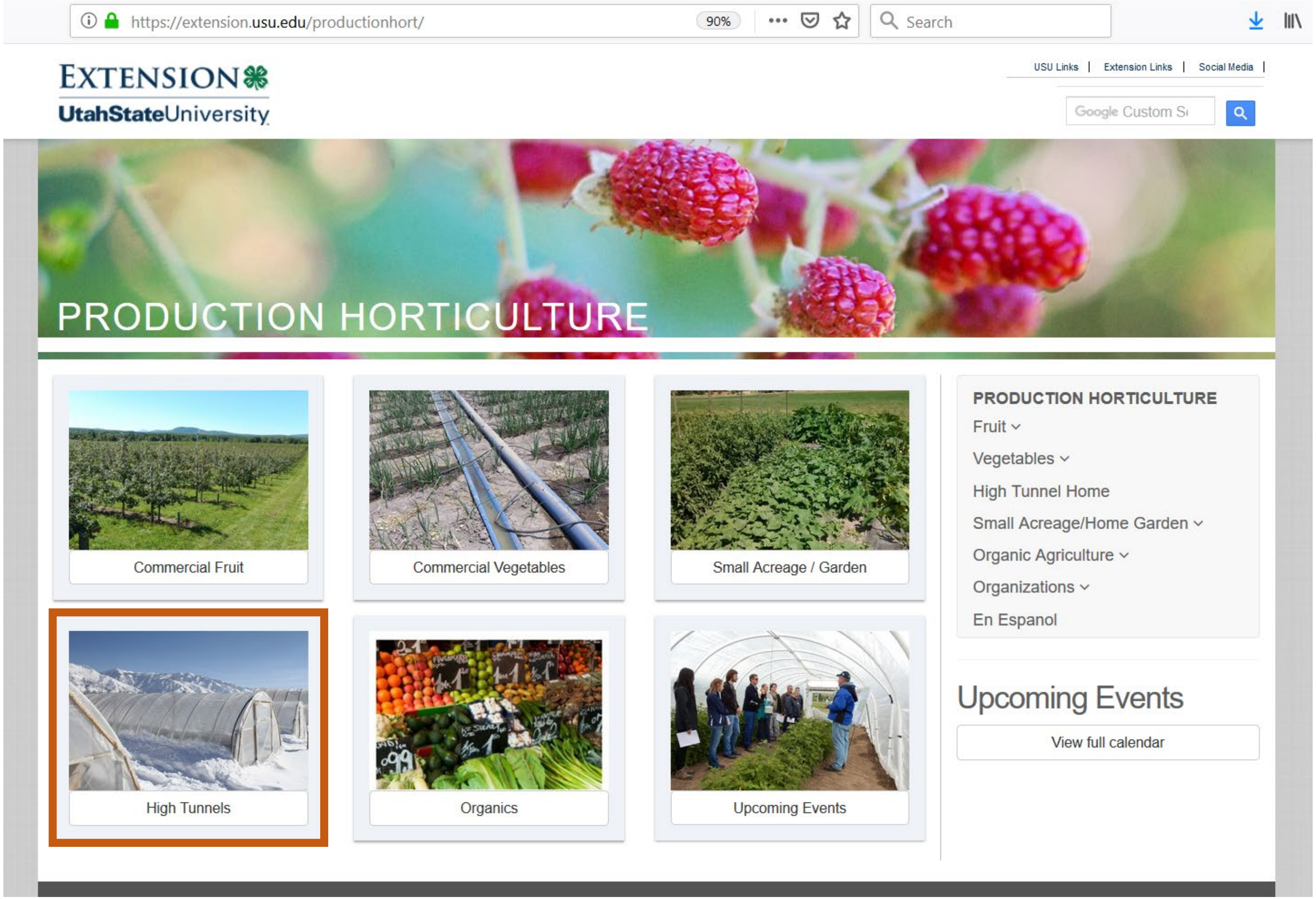
- Strawberry Management
- Raspberry Management
- Blueberries in Utah
- Blackberry Management

Irrigation

- Irrigation Brambles
- Irrigation Strawberries
- Drip Irrigation Guide

berry.usu.edu

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Small Acreage / Garden
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Organics
Upcoming Events
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High Tunnel Home
Small Acreage/Home Garden
Organic Agriculture
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Upcoming Events
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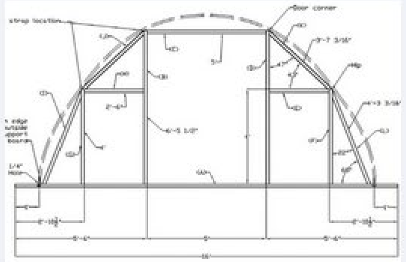
https://extension.usu.edu/productionhort/high-tunnel/

High Tunnel



Construction and Modifications

Small Fruits

Summer Squash and Cucumbers

Leafy Greens

Tomato and Pepper

Cut Flowers

Legumes

Management and Marketing

PRODUCTION HORTICULTURE

- Fruit
- Vegetables
- High Tunnel Home
- Small Acreage/Home Garden
- Organic Agriculture
- Organizations
- En Espanol

Upcoming Events

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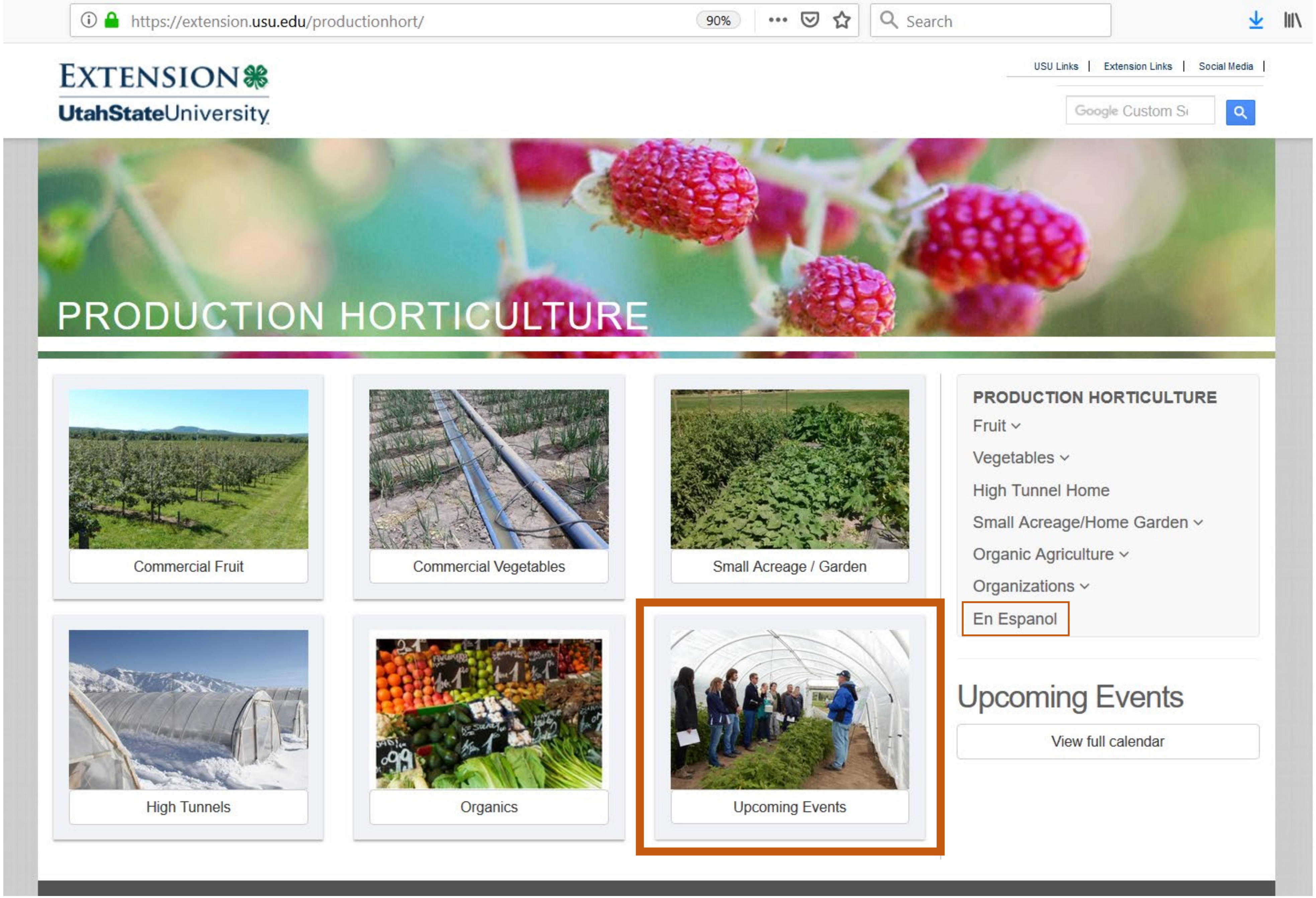
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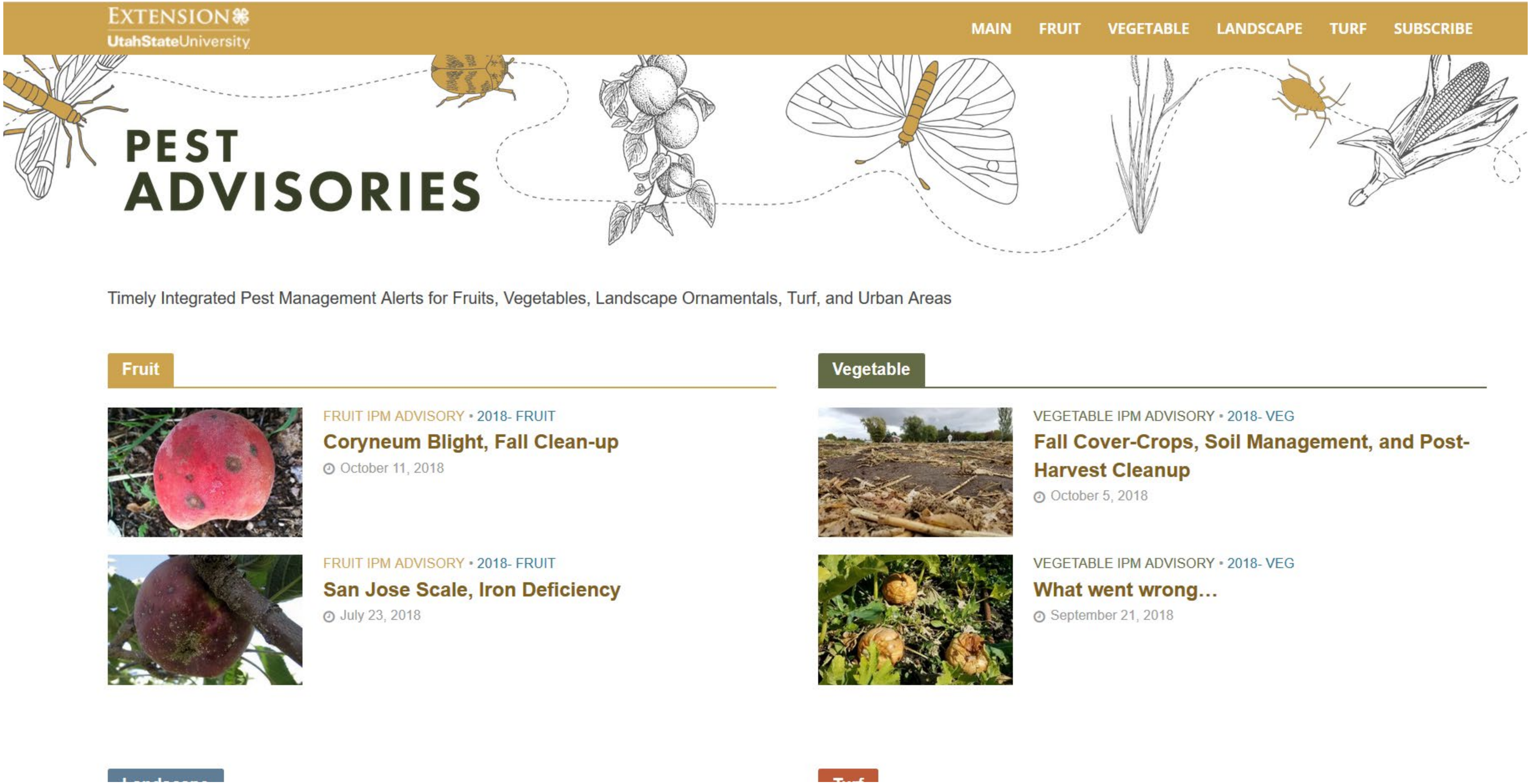
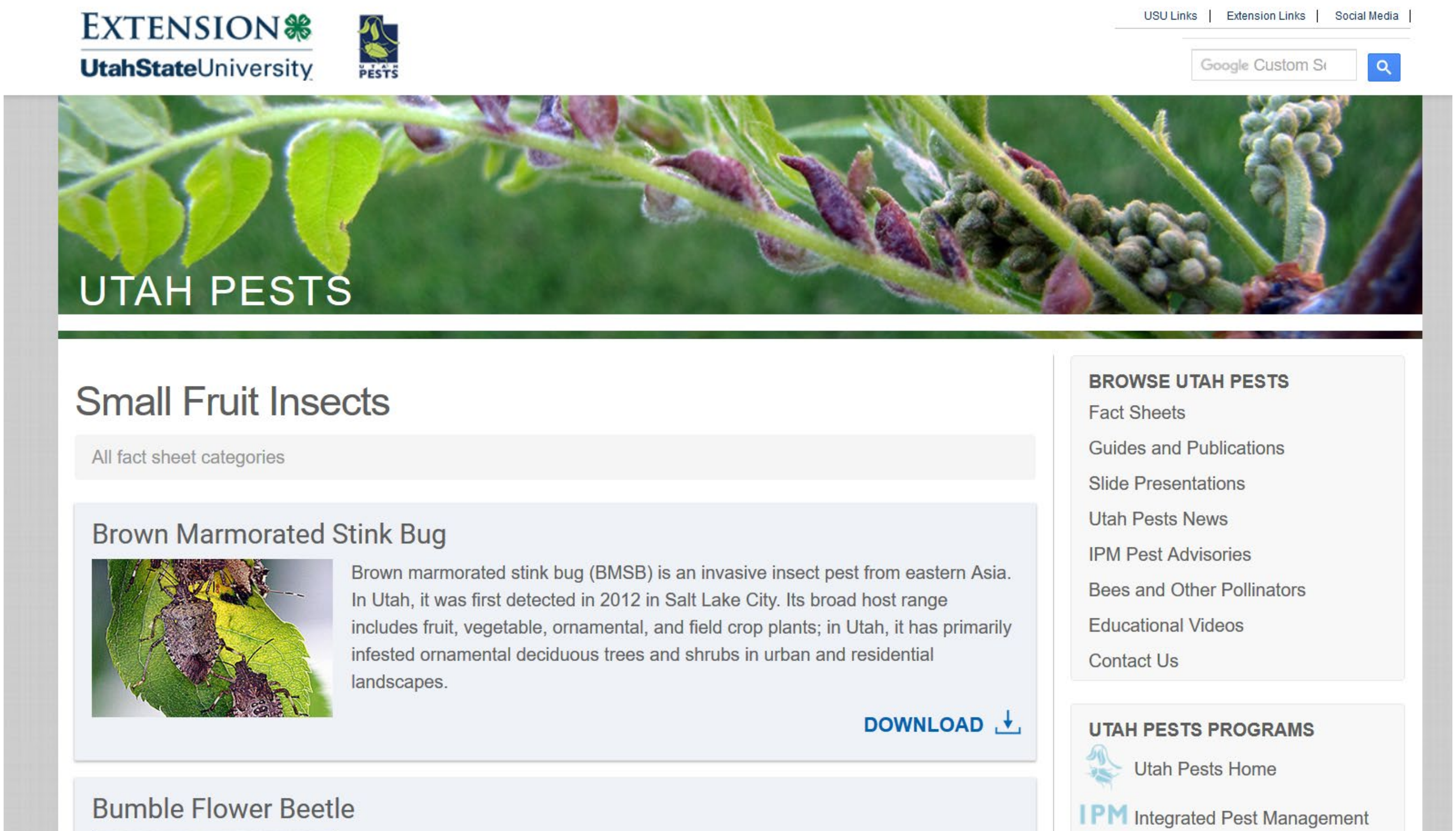
pestadvisories.usu.edu



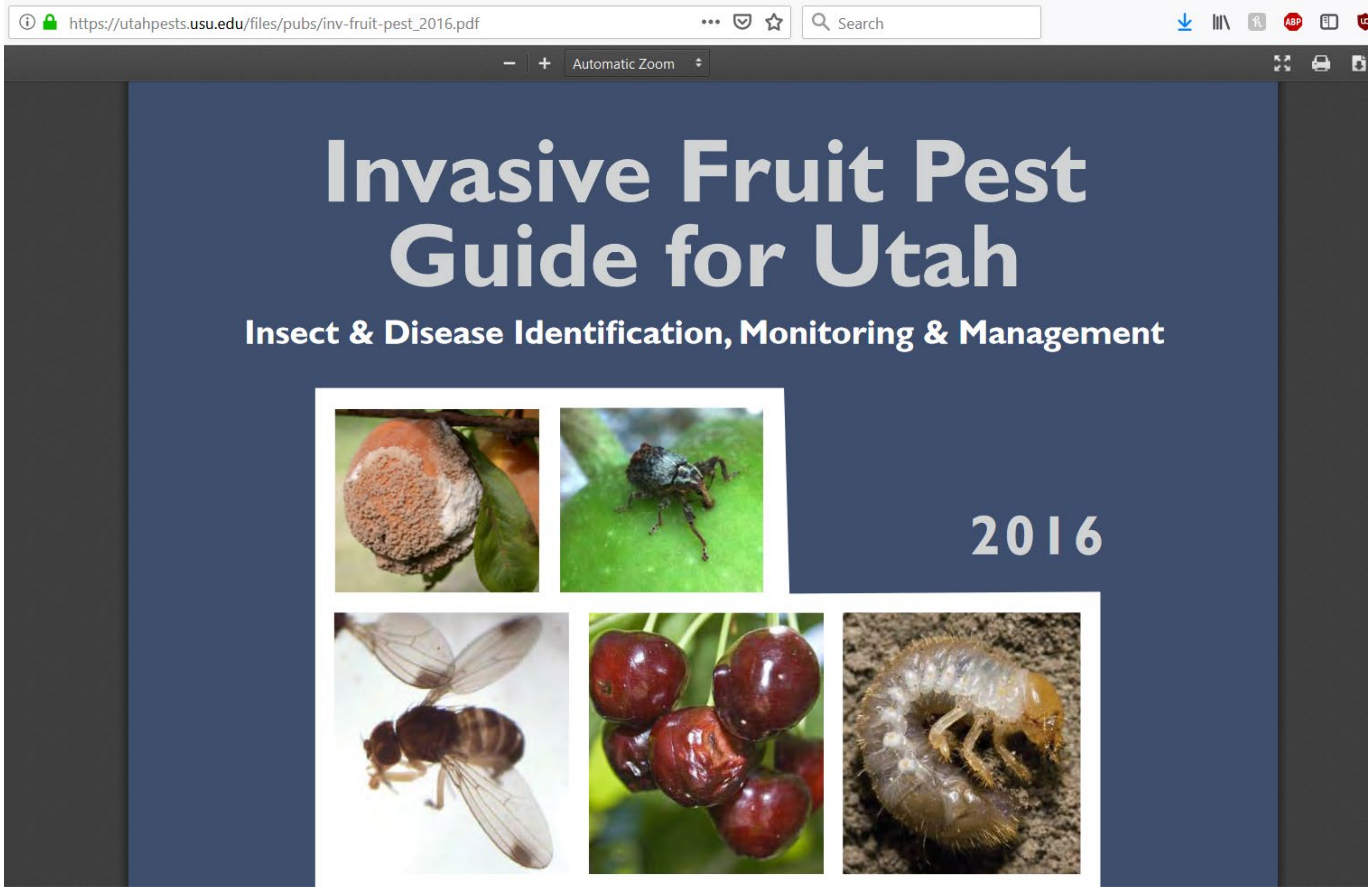
Small Fruit Insect Pest Fact Sheets

utahpests.usu.edu/factsheets/insects-smallfruit



Invasive Fruit Pest Guide

utahpests.usu.edu/files/pubs/inv-fruit-pest_2016.pdf



Beneficial Insects in Utah

utahpests.usu.edu/files/pubs/Beneficial-ID-guide-web.pdf