FLORAL BIOLOGY AND POLLINATION SYSTEMS IN SWEET CHERRY

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Seattle
Washington
WSU-Prosser
Portland
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Washington State University Irrigated Agriculture Research And Extension Center (IAREC)

Current/recent research projects:

- Genetic/environ. roles in fruit set/pollination
- Crop load management
- Causes of variability in fruit quality
- PGRs to improve fruit quality
- High efficiency orchard systems
- Genetic control of flowering
- Mechanizing sweet cherry harvest
- Causes & prevention of pistil doubling
- Next generation of dwarfing rootstocks
- Physiol. & hort. benefits of reflective fabric ground covers
- WA/OR breeding and genetics program
- Redefining ‘quality’ for sweet cherries - consumers

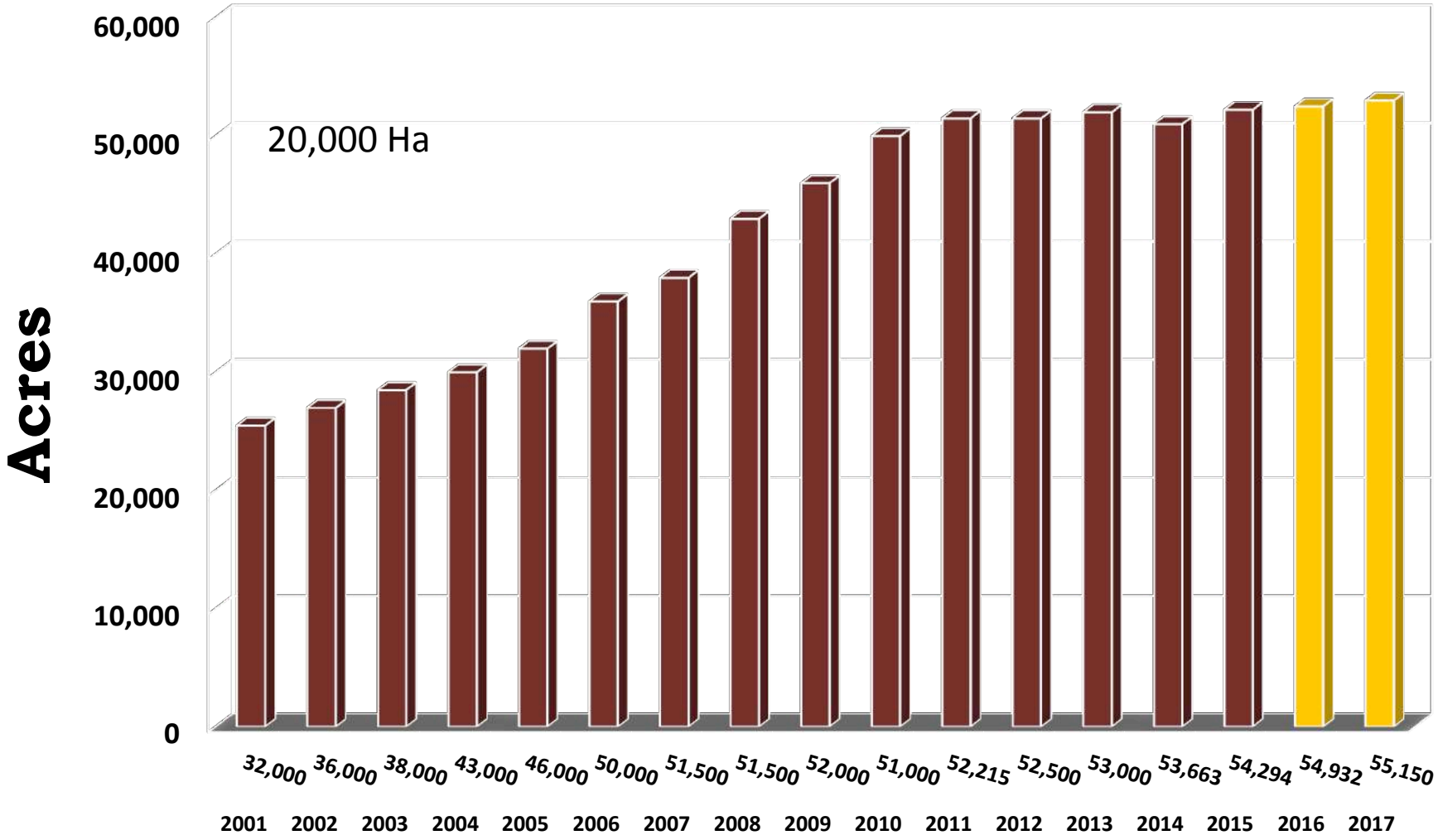
US Sweet Cherry Industry

- General characteristics:
  - Tree density: 600-650 trees/ha (increasing)
  - Yield: 12 – 15 t/ha (50 t/ha)
  - High value specialty crop – great potential profitability: $USD 2.00 – 10.00 per kg
    - Production costs ca. $13,000+/ha
    - harvest costs ca. $0.50.kg


30-40% Export
60-70% Domestic

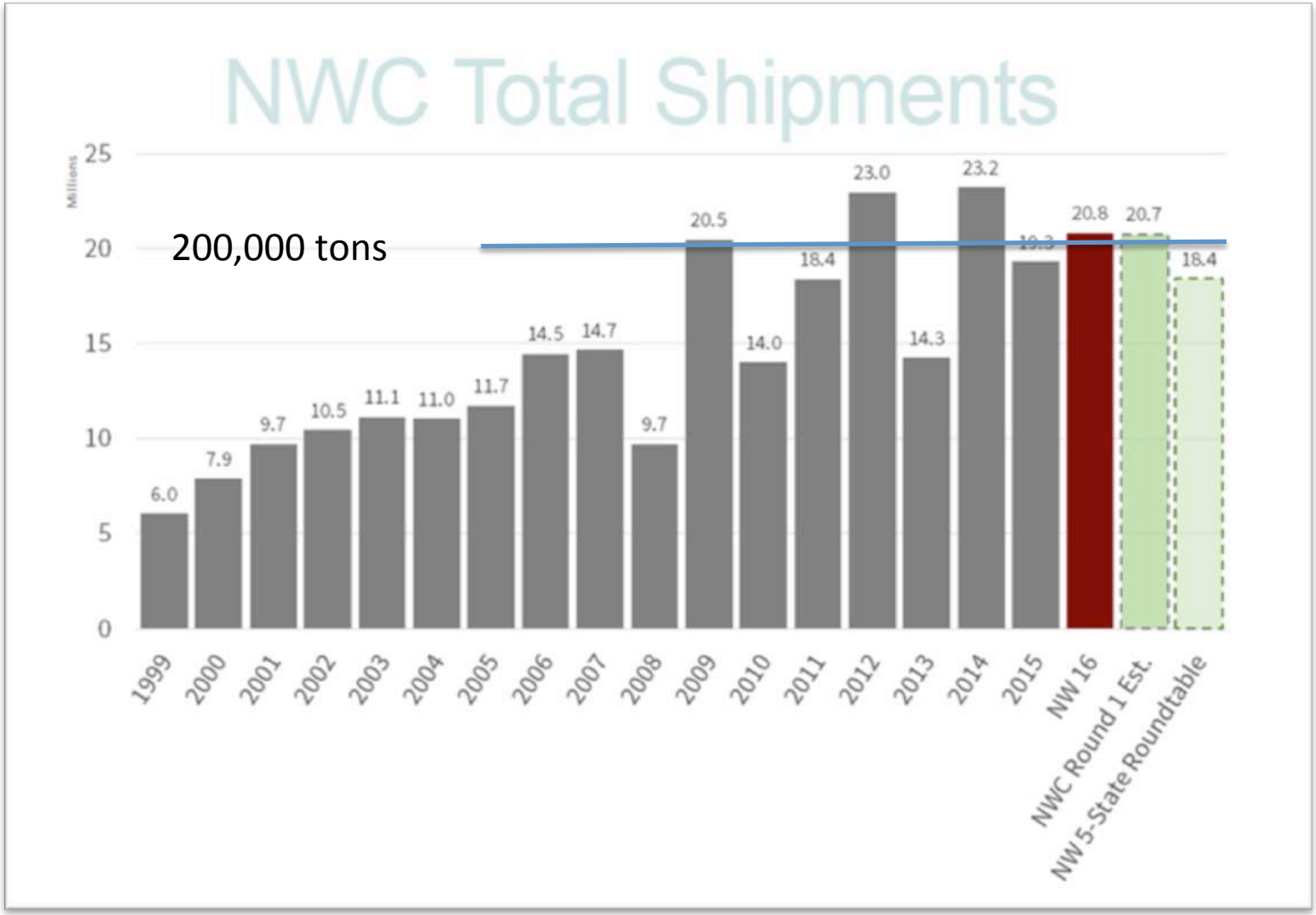
NW Sweet Cherry Acreage

(2016 Est. Oregon, Idaho, Washington, Montana, Utah)



NW Cherry Historical Shipments

(20 lb. box equivalents)



Why so concerned with pollination?

- Pollination (fertilization) is critical step determining fruit yield and quality

Yet……

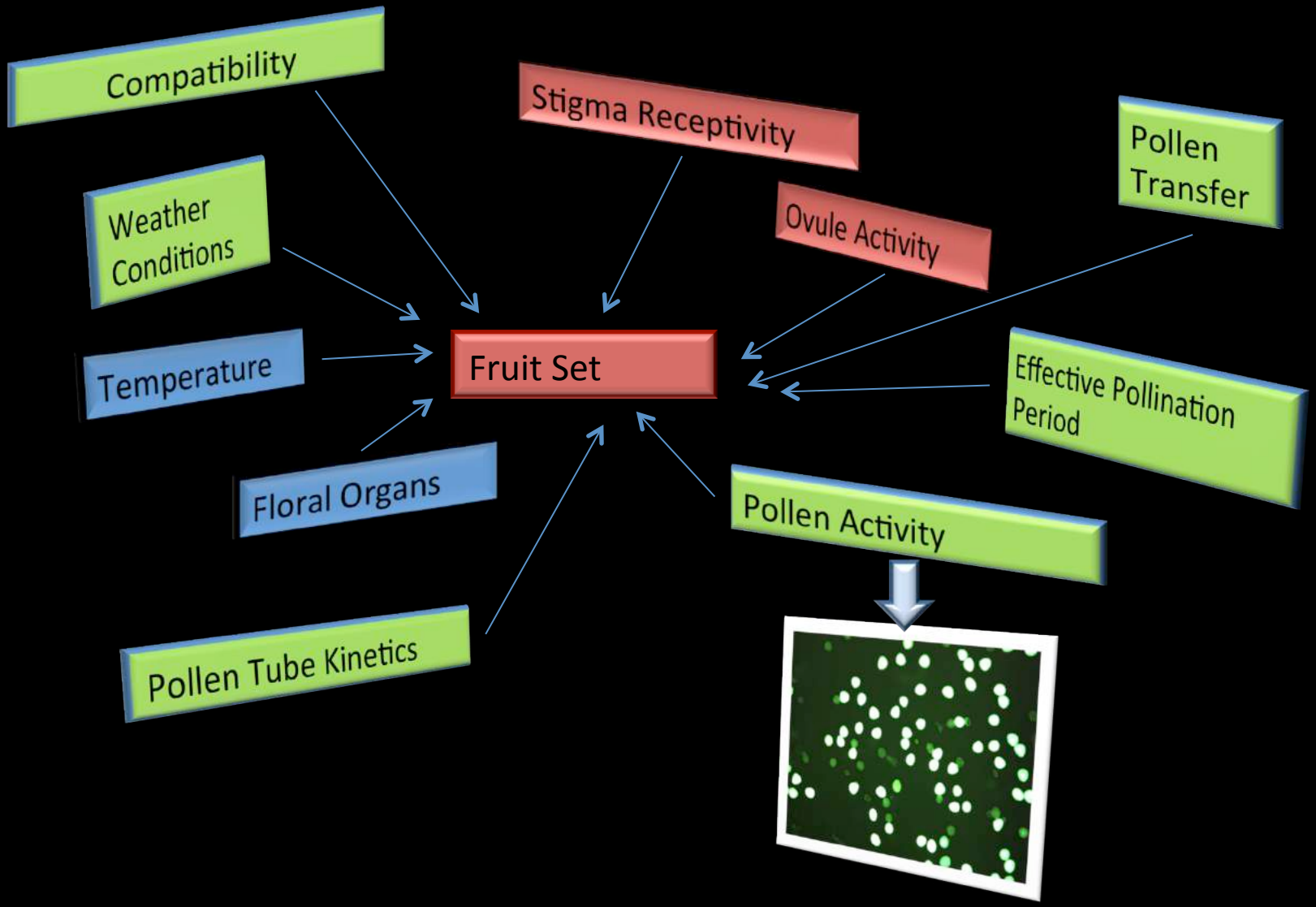
- Pollination process/system in commercial fruit crops unchanged

Growers rent hives → Flowers open → Bees collect pollen → Bees deposit pollen

Target: high yield and quality

What factors determine fruit set (fertilization rate)?

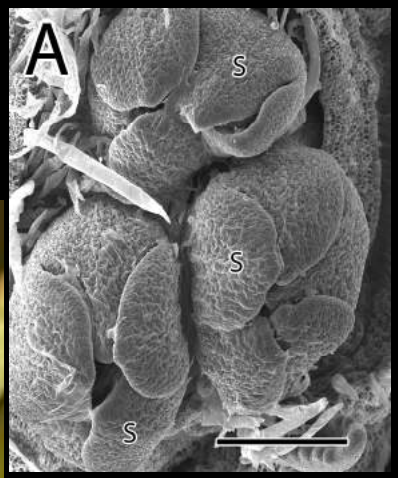
Factors Influence Fruit Set

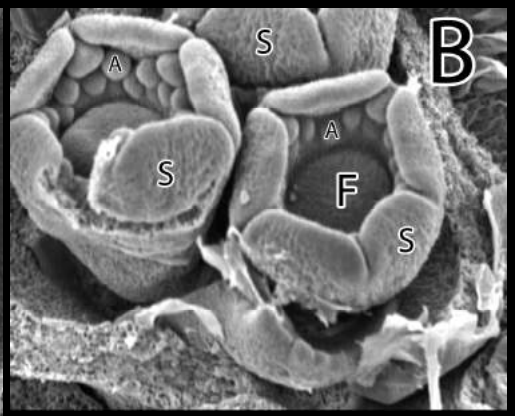


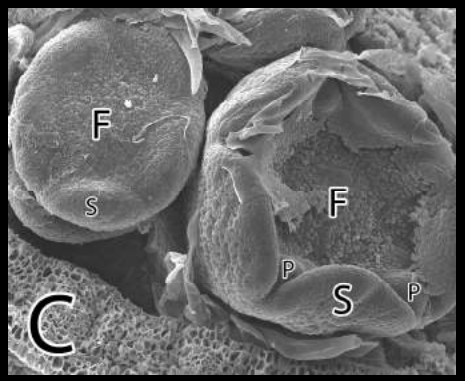
Fruit set daily (%)

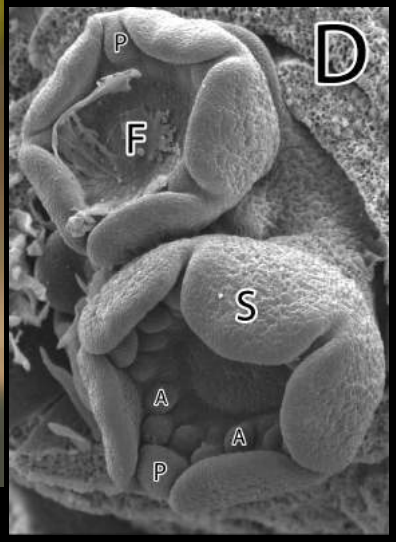
Floral initiation and differentiation

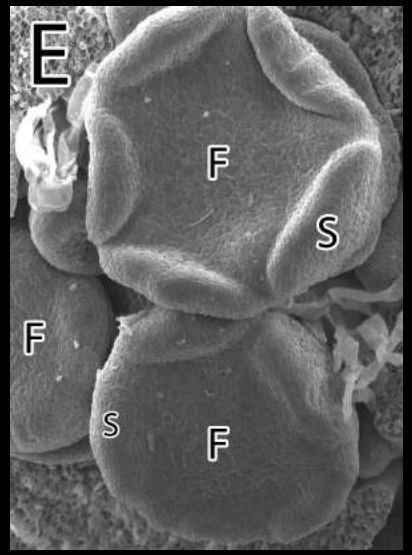
17 Aug
1733 GDU











A - Chelan
B - Tieton
C - Bing
D - Skeena
E - Sweetheart

Goal: build better buds

Why is fruit set so variable?

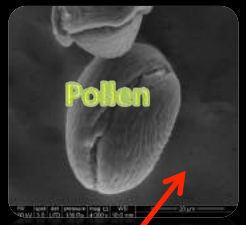
Paternal

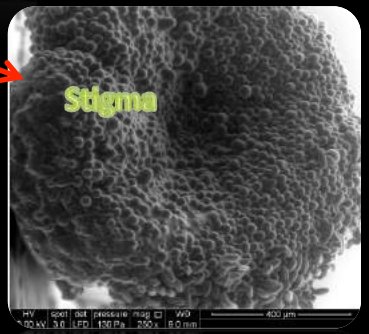
Pollen availability
Pollen viability
Pollen growth rates

Maternal

Stigma receptivity
Ovule longevity

Stigma Receptivity & Ovule Activity





Pistil

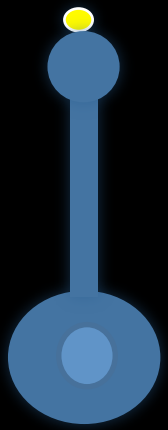
Stigma

Style

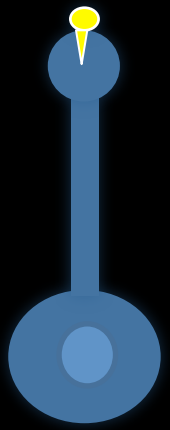
Ovary

Ovule

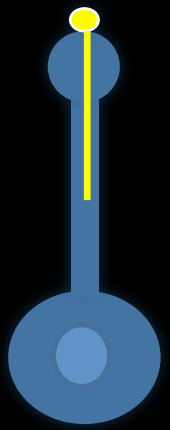
Step1.
Pollen Adhesion on stigma



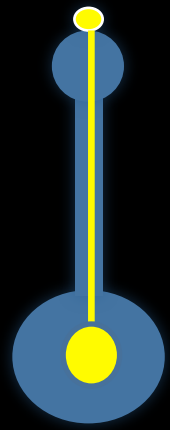
Step2.
Pollen Hydration



Step3.
Pollen Tube Germination



Step4.
Pollen Tube growth



Step 5.
Fertilization

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Assessing the Role of Pistil in Sweet Cherry Fruit Set

In Lab

Location: Prosser (WA), The Dalles(OR)

Cultivars: Benton, Tieton, Rainier, Sweetheart

Temperatures: high, moderate and low

Pollination stages: 0, 1, 2, 3, 4, 5 days after flowering

Sampling intervals: 8hr, 24hr and 48hr

Stigma receptivity and ovule longevity were tested.

In field

Year: 2011, 2012

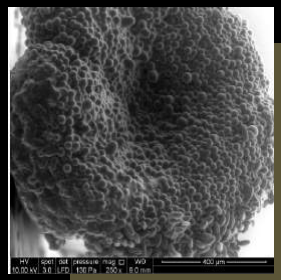
Cultivars: Benton, Tieton, Rainier, Sweetheart

Pollination stages: 0, 1, 2, 3, 4, 5 days after flowering

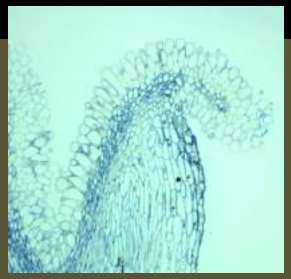
Fruit set was recorded.

Stigma Receptivity

A



Stigma surface



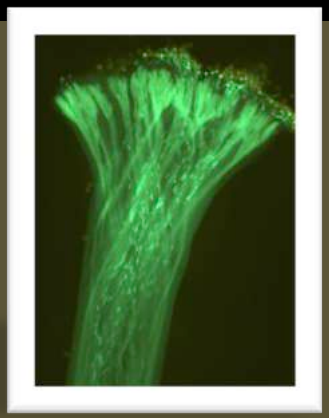
Stigma longitudinal section

B

Stages of pollen hydration *in vivo*.

C

Pollen germination *in vivo*.



Pollen tube growth *in vivo*.

Pollen Hydration Level:

$$\overline{X} = \frac{\sum fc}{N}$$

$\overline{X}$: Hydration level
N: Total number of pollens
f: Pollen amount of different stages
c: Hydration stage

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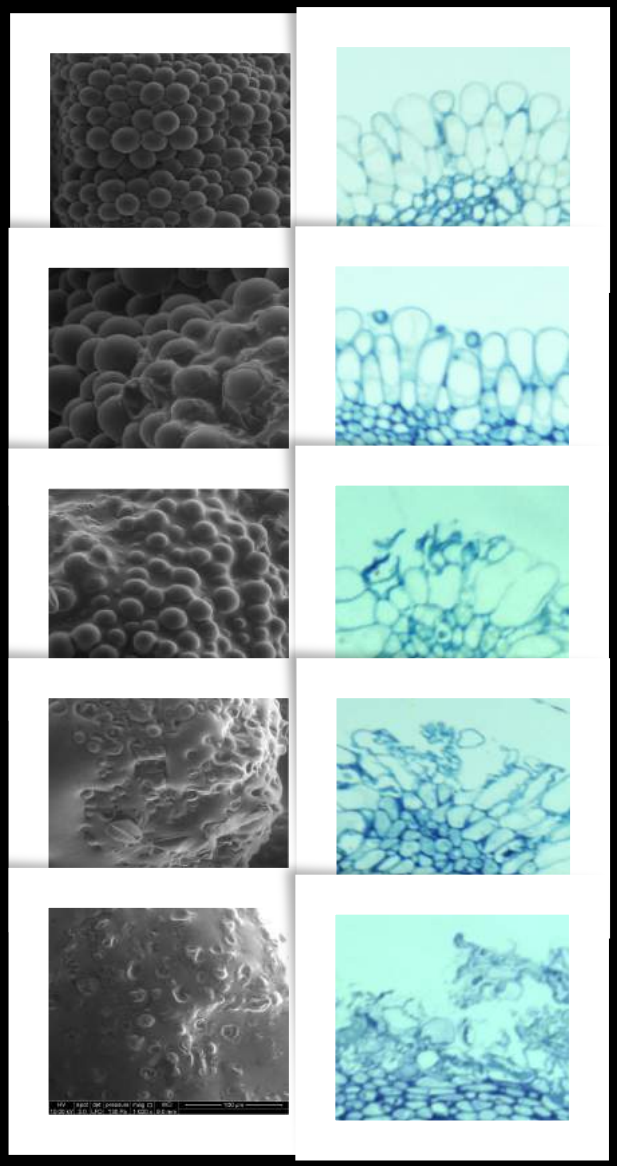
The Development of Stigma Surface



1 day

2 day

3 day

4 day

5 days

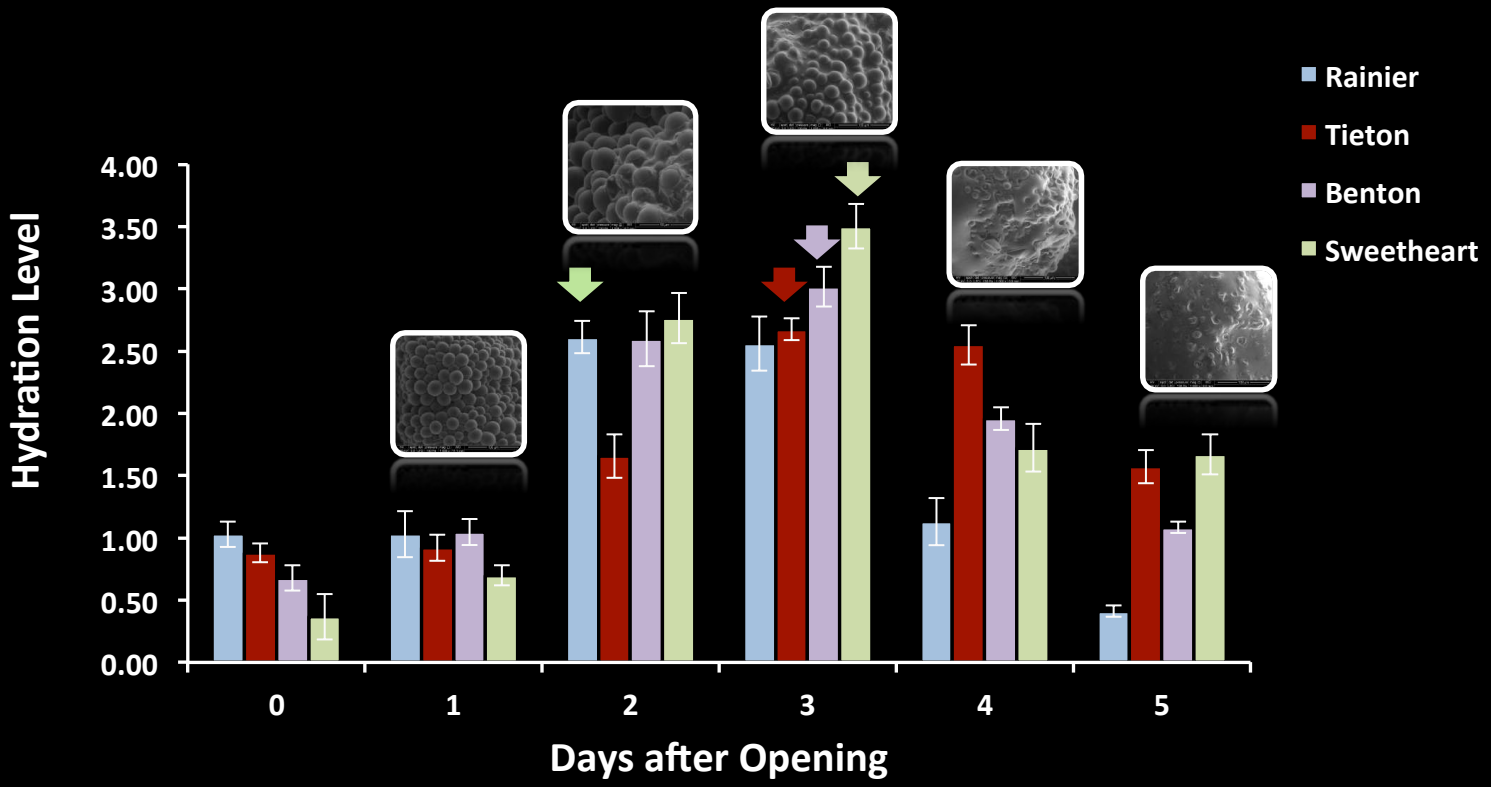
Days After Opening

Results

No differences among genotypes

Pollen Hydration

- Flowers pollinated at 1-day intervals post-anthesis
- Pollen collected from stigma 20 mins post-pollination

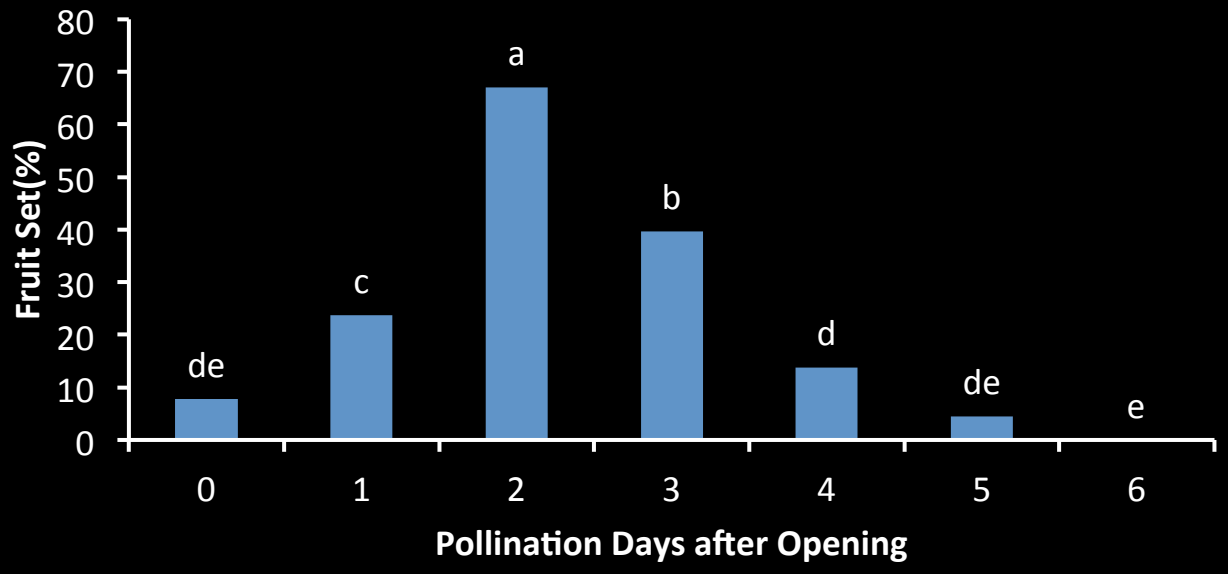


Results

No differences among genotypes

Fruit Set

- Hand pollinations in field at 1-day intervals
- Fruit set assessed at harvest

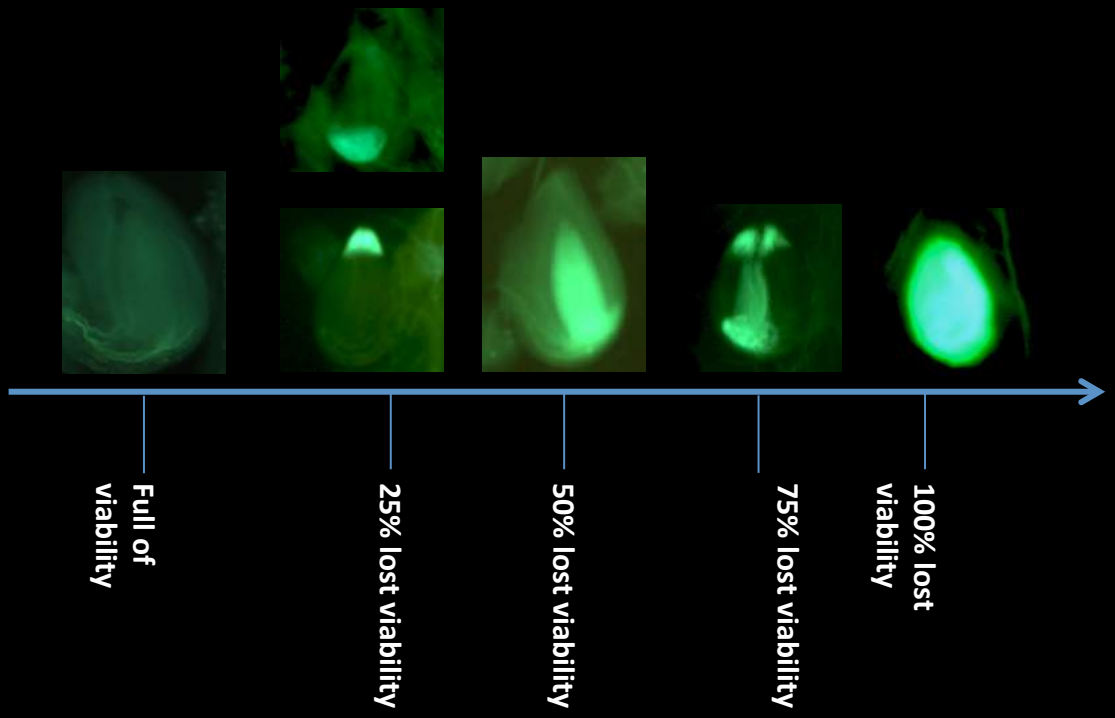


Results

- Maximum fruit set when pollinated 2 days after anthesis

Ovule Activity

Viability of both the primary and secondary ovules. Dead ovules appeared florescence reaction after the stain of Aniline Blue.



Scales of ovule viabilities

ReTain® (AVG) Application

Goals: reduce ovule senescence and improve fruit set

Experiment 1.

Cultivars: Tieton and Regina

ReTain® rates: 166, 333, 499 g/acre and control

Timing: '10% bloom'

Experiment 2.

Cultivar: Regina

ReTain® rates: 333 g/acre and control (water)

Timing: 'popcorn', '10% bloom', '50% bloom' and '100% bloom'

Increasing fruit set

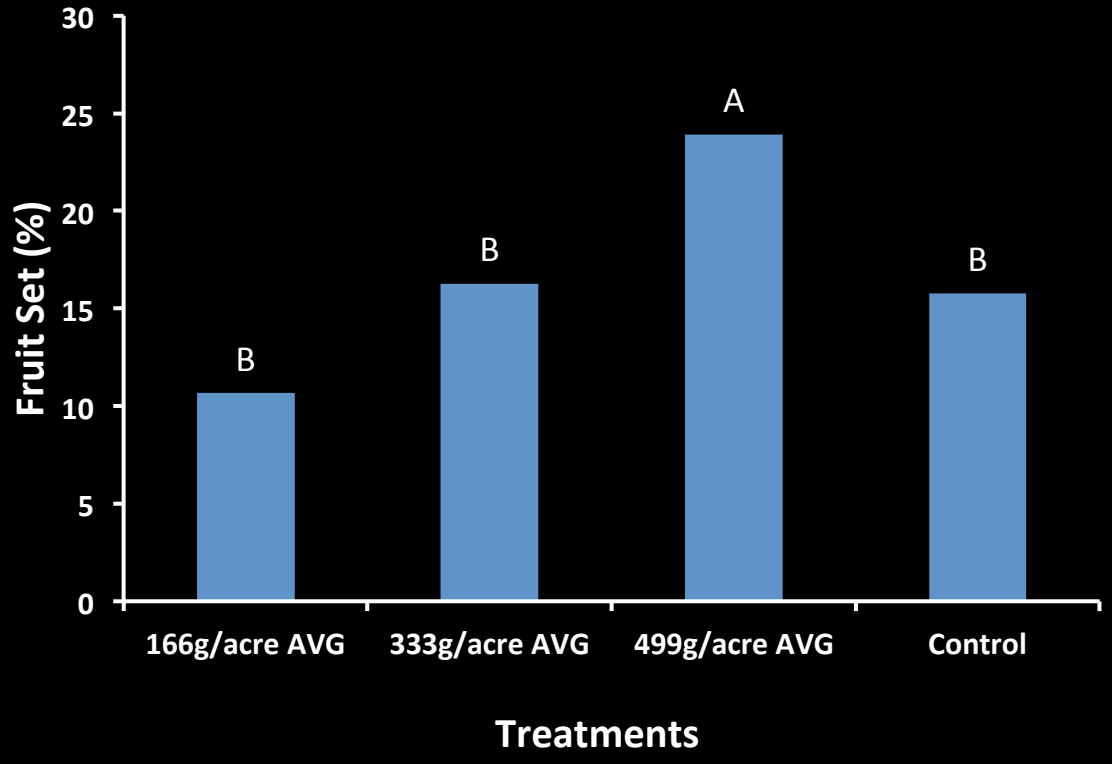
'Kordia' in Tasmania

Collaboration with Dugald Close, Sally Bound; UTas

Treatment	Fruit set (%)	Fruit wt (g)	Cracked fruit (%)
Control	9.7 a	14.5 b	25.1 b
AVG 500 g/ha	15.3 b	12.9 a	14.0 a
(ca. ¾ pouch/ac)			
Rate of AVG	ns	ns	ns
Time of application	ns	ns	ns

Application of AVG- Fruit Set

- Fruit set increased 52% after 499g/acre AVG treatment



Production: 4 tons/ac
Price: $1.53/lb

yield increased 50%
→ 6 tons/ac

Income increase:
$6,000/ac

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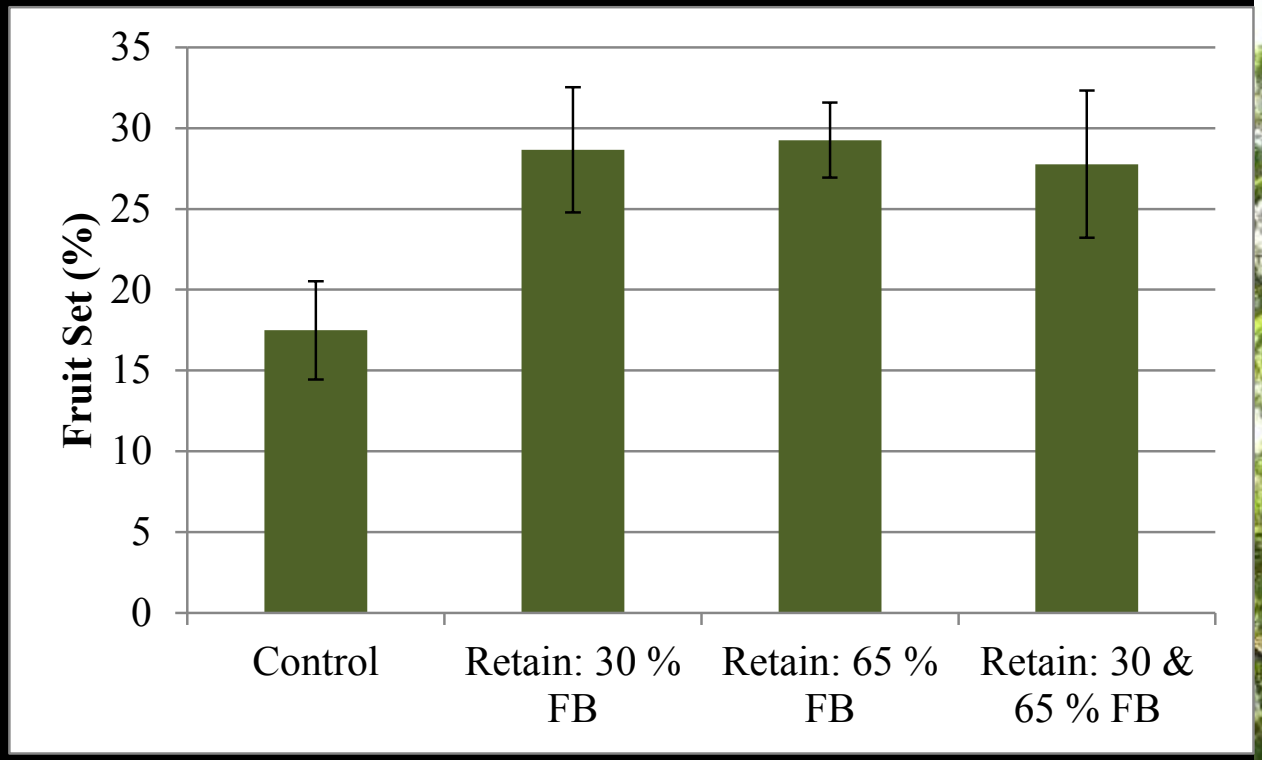
AVG Improves ‘Regina’ Fruit Set

Data from Todd Einhorn, OSU



- Surfactant→ 0.1% v:v
- Rate→ 1 pouch per ac
- Timing between 10 to 80% of full bloom

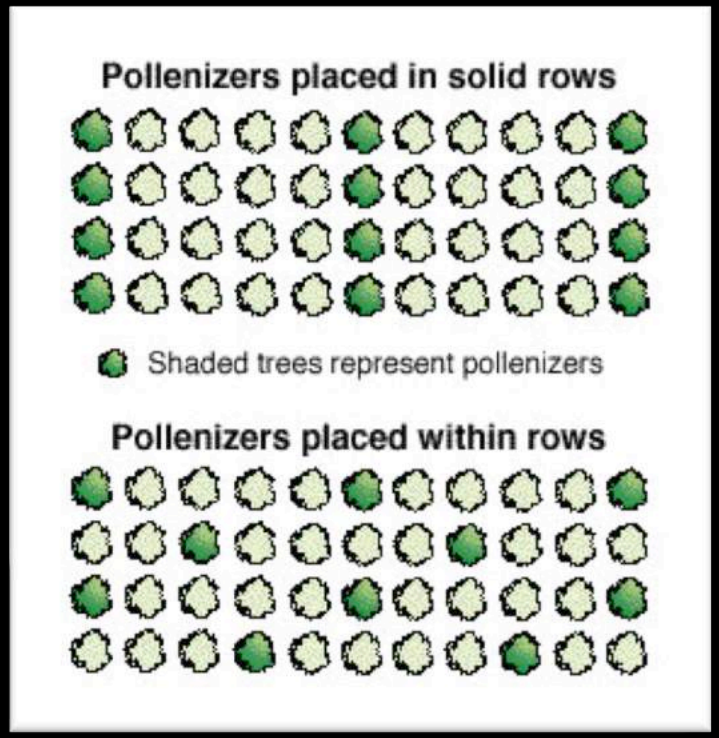
Recommendations:

- ReTain® applied at 10% to full bloom
- 333 g per acre
- Single application
- Particularly during warm weather

Need for precision pollination

Pollenizers

- Insufficient density/distribution
- Lack of overlapping bloom
- Distribution of pollen born viruses
- Harboring pests/diseases



Need for precision pollination

Pollinators

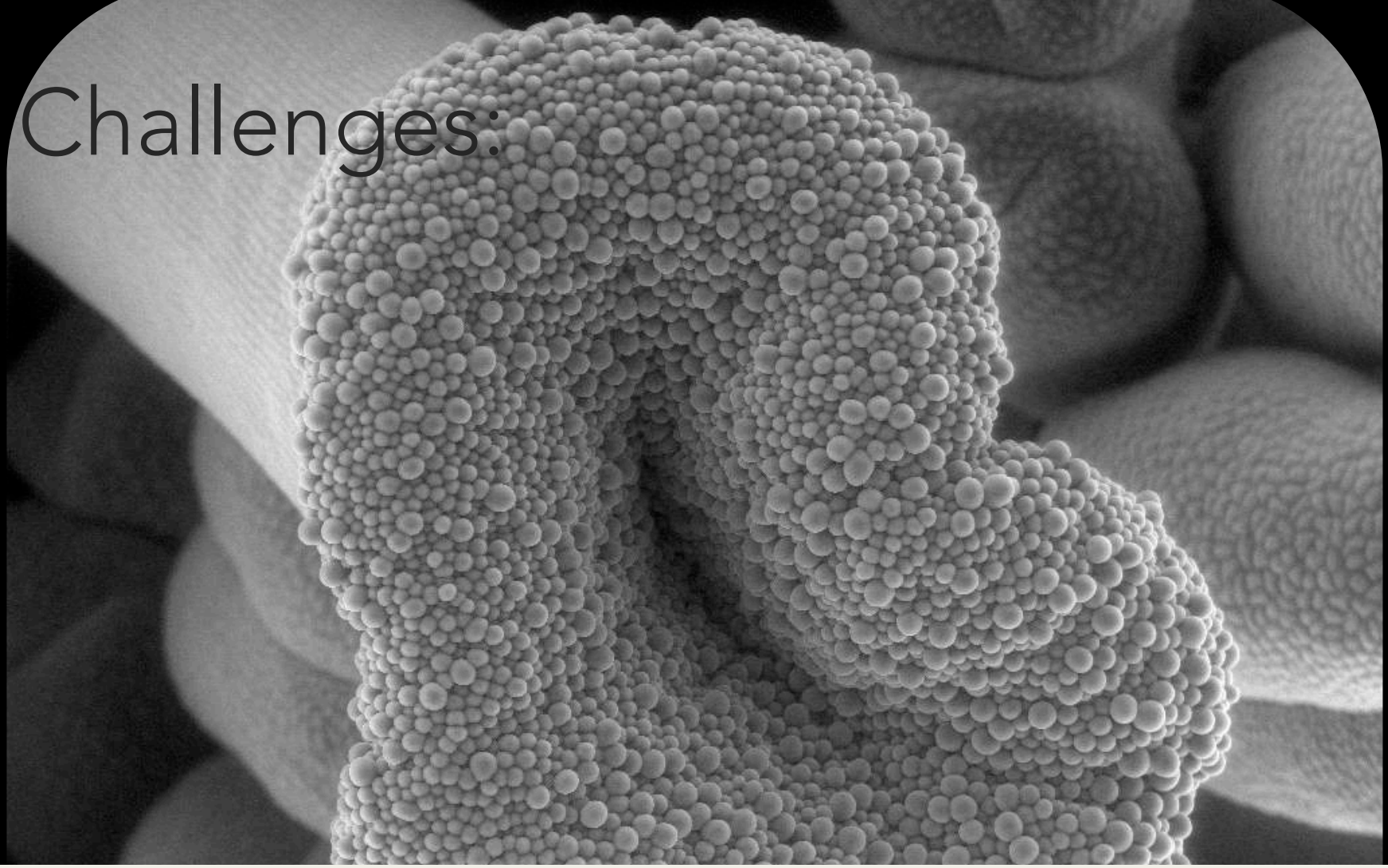
- Colony collapse disorder
- Increasing cost
- Variable colony performance
- Distribution & density
- Variable environmental conditions

Proposed solution:

1. Collect pollen
2. Suspend pollen
3. Apply pollen via sprayer

No pollenizers nor pollinators

Challenges:

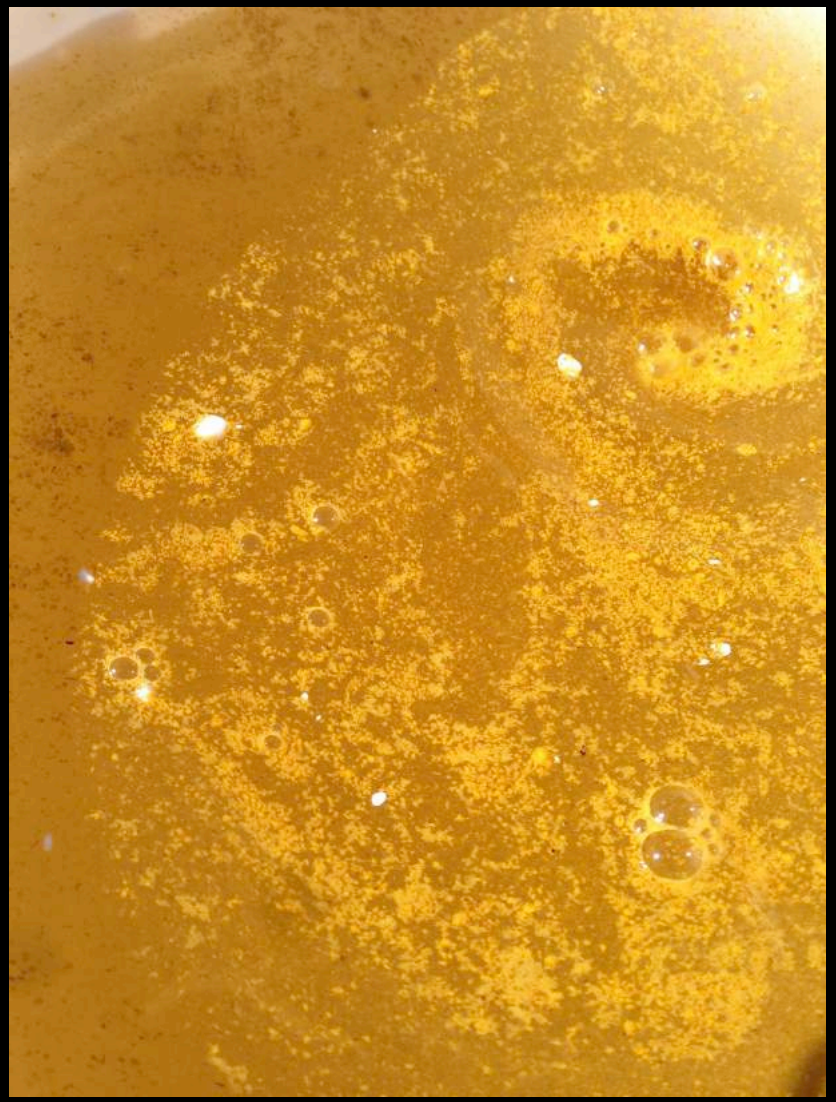


- Stigma is a small target
- Pollen loses viability in liquid
- Our vision isn’t considered ‘green’

Pollen suspension

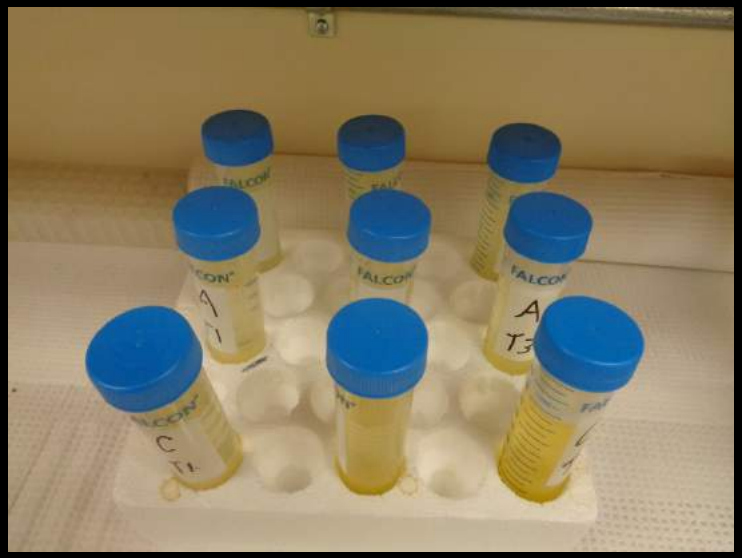
What we have learned:

- Must use pure pollen
- Pollen solubility is improved with several additions
- Can keep pollen alive for 1 hr without loss of germinability



Research approach

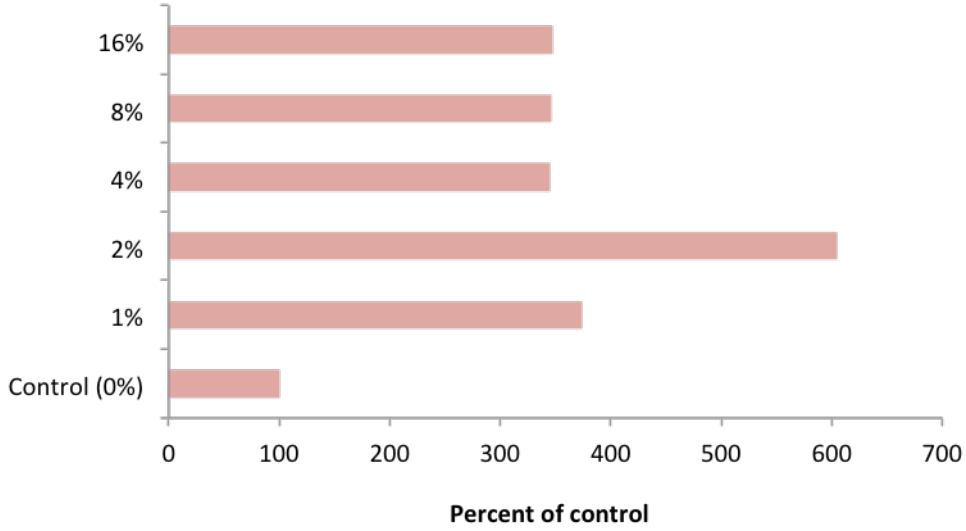
- 3 pollen genotypes per crop (apple, sweet cherry and pear)
- Spray at loading 5, 30 and 60 mins
- Pollen viability assessment at 6hr and 24hr

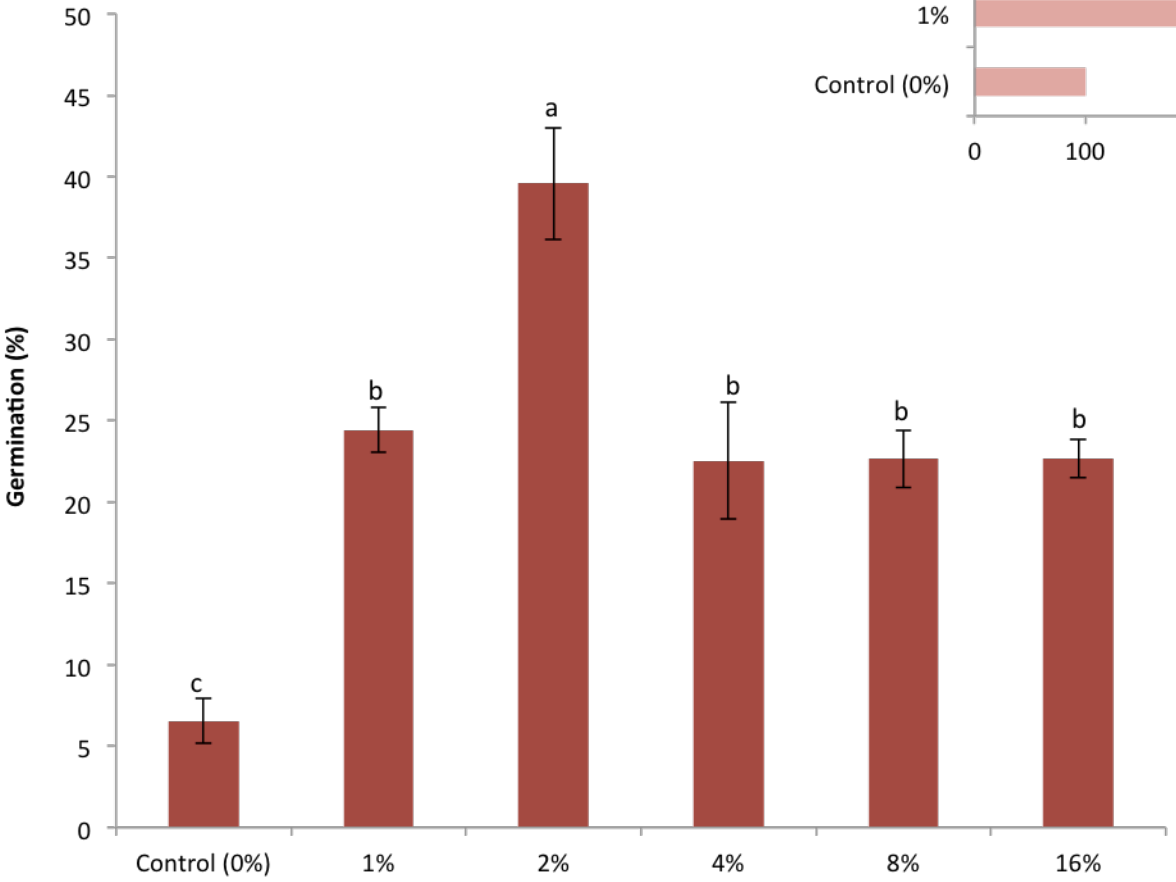


Pollen Suspension Development

Concentration Effect

Cultivar: Rainier
Incubation period: 60 minutes



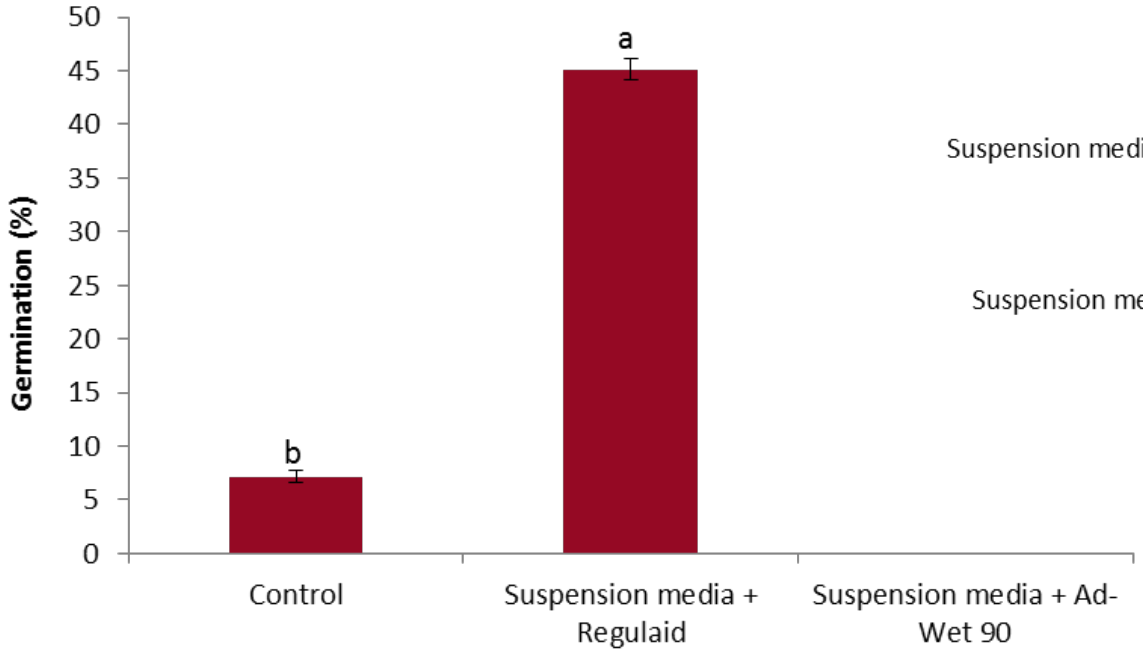


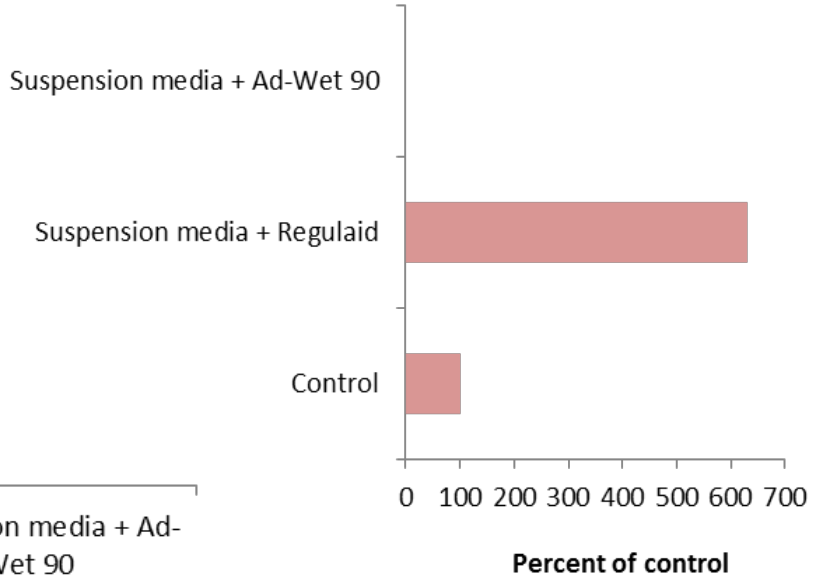
Pollen Suspension Development

Composite solution with surfactants

Cultivar: Rainier

Incubation period: 60 minutes

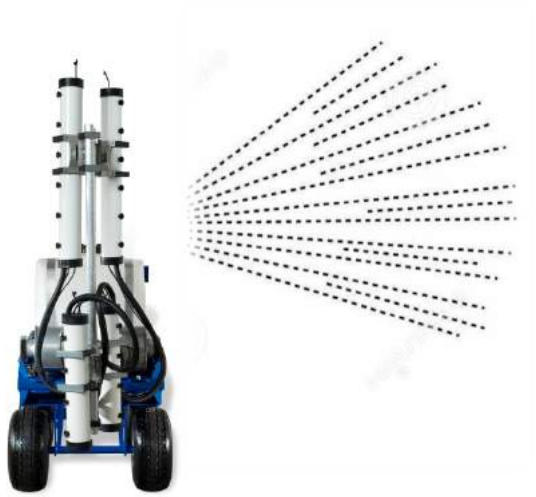




Pollen application

Spring 2014

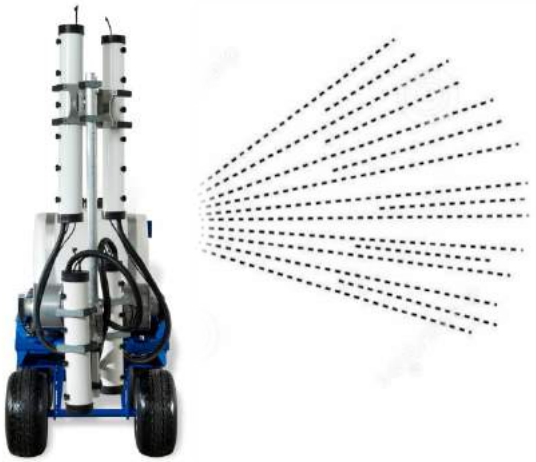
- Pollen
- Proprietary slurry



Viscous droplets

Spring 2015

- Pollen
- WSU-developed slurry



Non-viscous & fine droplets


Electrostatic sprayer
On Target Spray Systems
Low volume applications (95-110 L/ha)
ON TARGET
SPRAY SYSTEMS

Precision pollination

'Tieton'/ 'Gisela 5': 8 years old trained to UFO

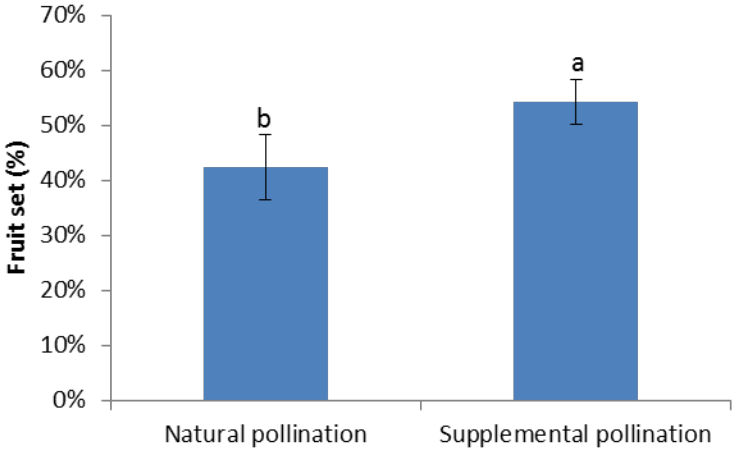
Mechanical pollination

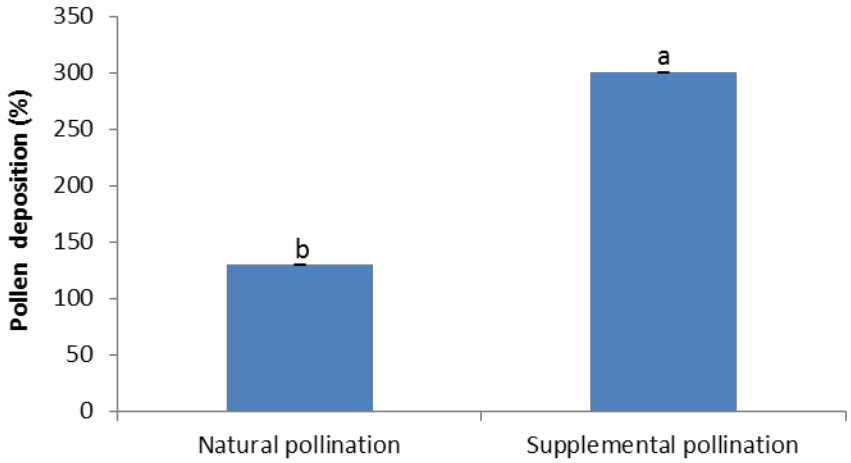
Results: Spring 2014

Cultivar: Tieton/Gi®5

Reps: 10 limbs/treat.

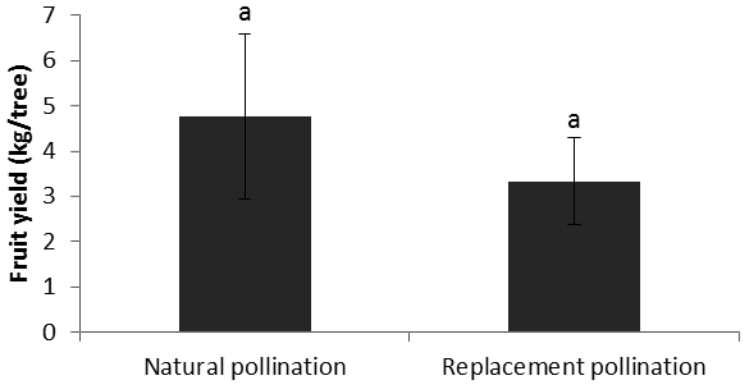
Supplemental





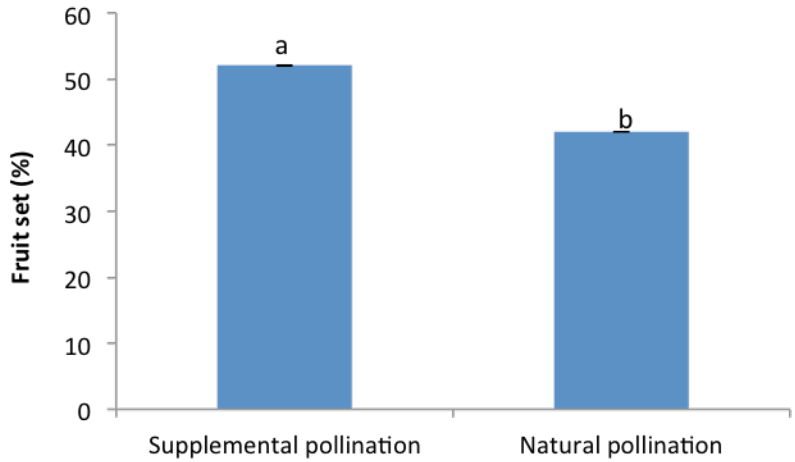
Cultivar: Bing/Gi®6

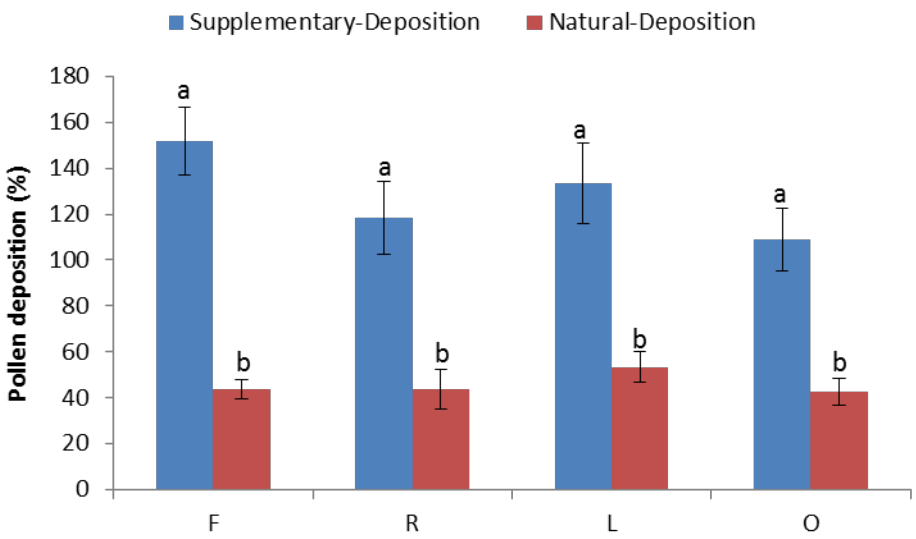
Replacement

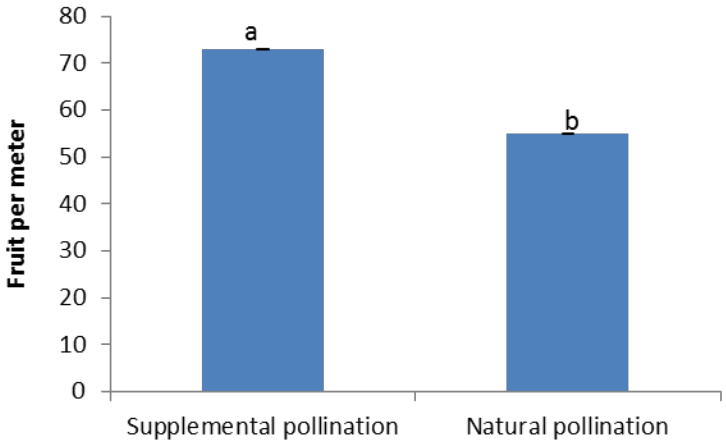


Results: Spring 2015

Tieton/Gisela®6

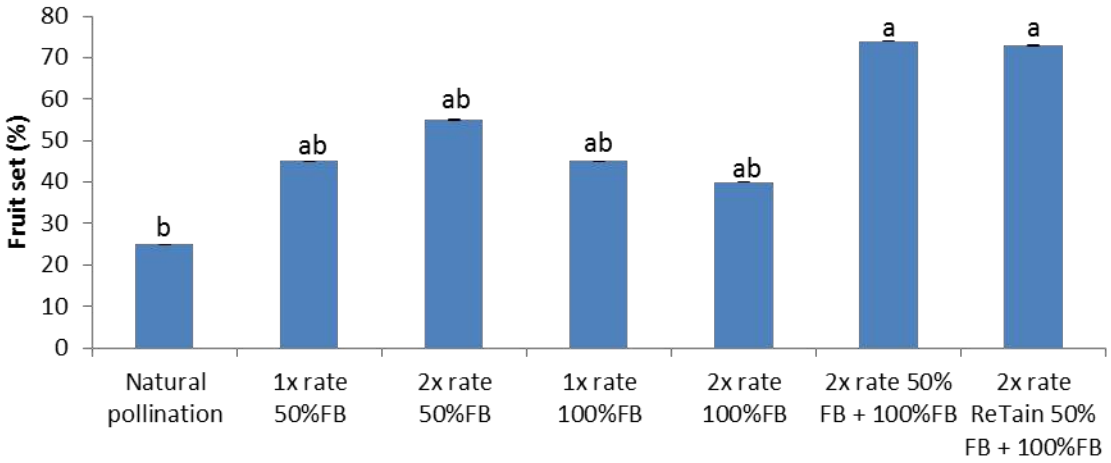


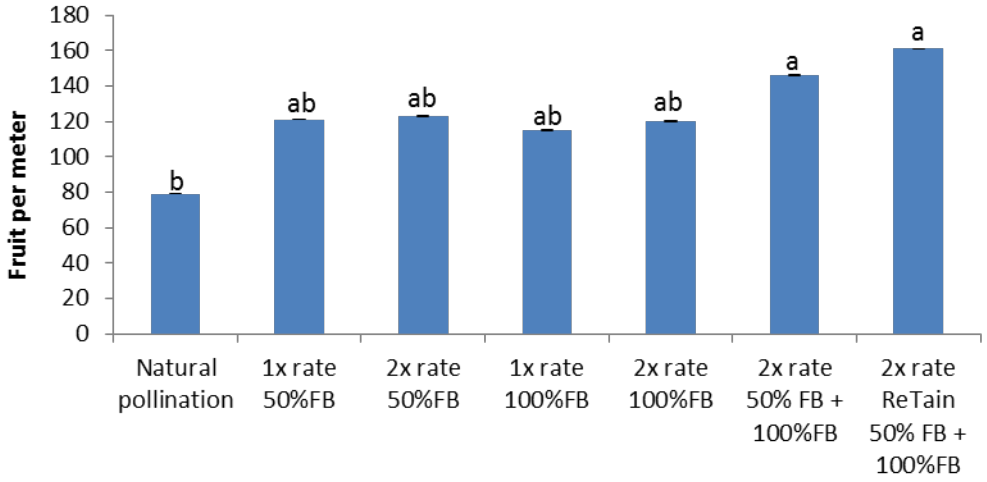




Results: Spring 2015

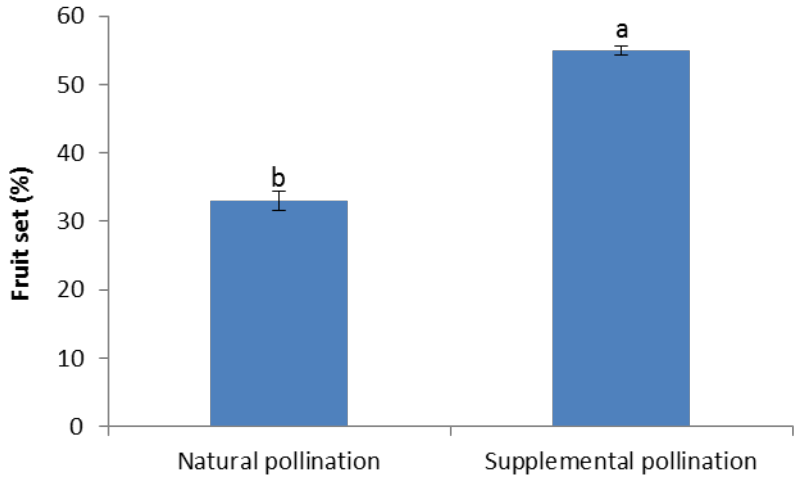
Early Robin/Gisela®12

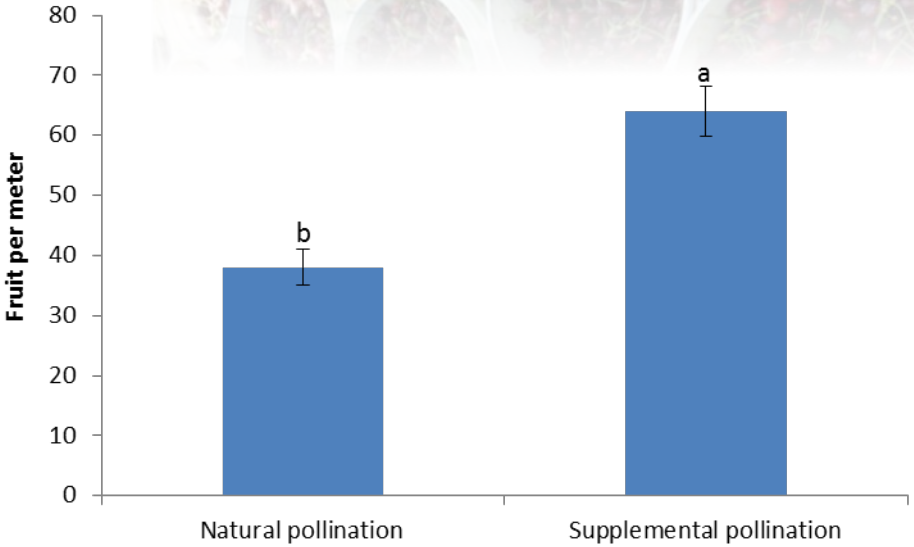




Results: Spring 2015

Regina/Mazzard®





Summary

- Fertilization (pollination) is fundamental to productivity & profitability
- Perennial challenges with pollenizers & pollinators
- Our vision:
  - Precision pollination systems for yield security & resilience to threats

Key results

- New suspension solution performed well with electrostatic application system
- Supplemental pollination increased fruit set in every trial (sweet cherry, pear, apple)
- Further research necessary to:
  - Refine timing and rate of pollen
  - Improve suspension
  - Improve pollen collection systems
  - Control nozzles to target applications & save pollen

Potential to revolutionize crop load management……

Future orchard systems:
Precision pollination for consistent, balanced cropping