Irrigation and Soil Water Monitoring in Blackberry and Raspberry

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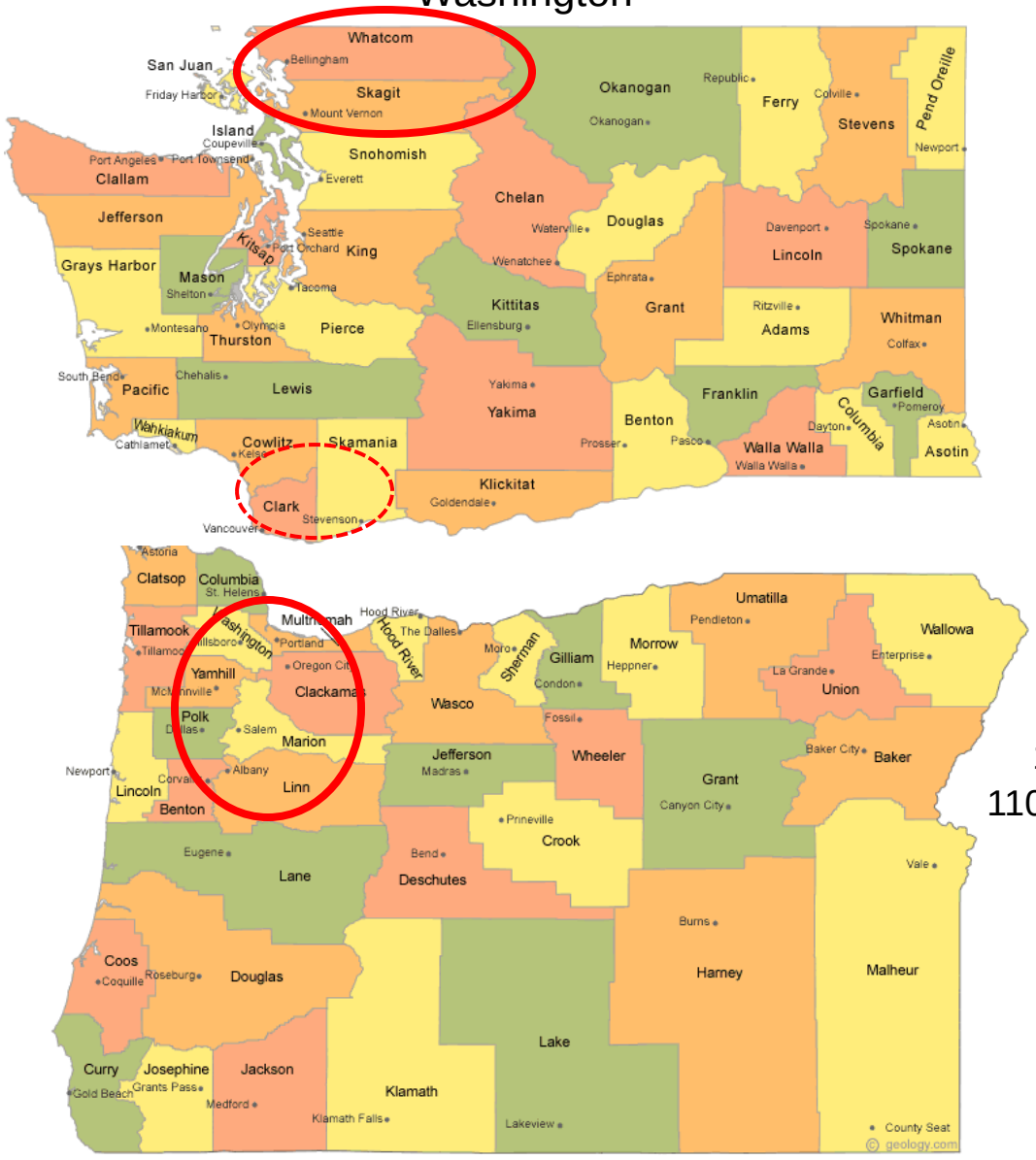
Washington



Oregon

9700 acres raspberries

7900 acres blackberries
1500 acres raspberries
1100 acres black raspberries

Washington/Oregon Raspberry Production

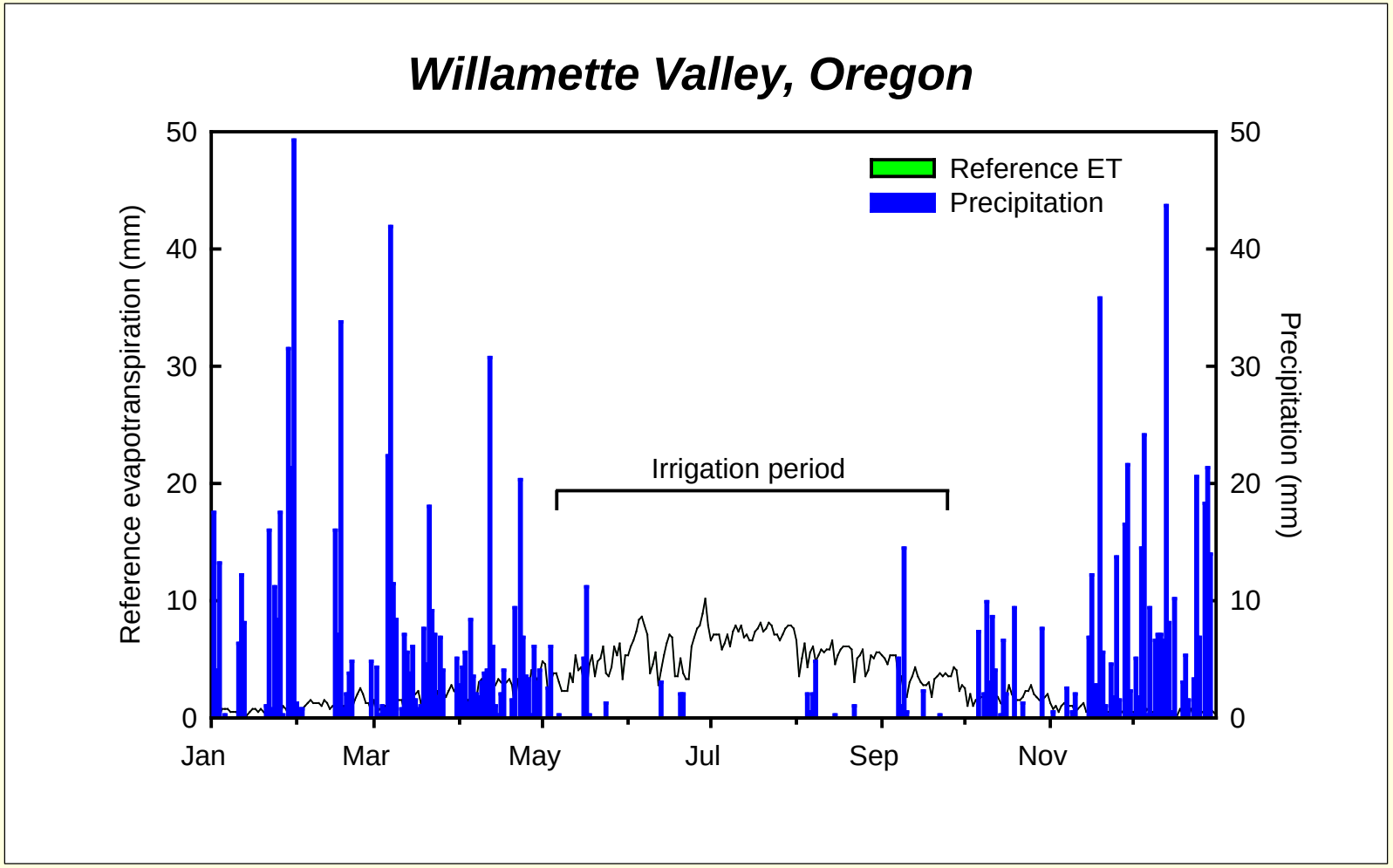
- 2.5 x 10 ft. spacing
- Raised beds
- Arced canes
- Machine harvest

- ‘Meeker’ & ‘Wake TMField’ 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

- Estimating water requirements
  - Background
  - Tools
- System options and configurations
- Feasibility of using pulsed drip

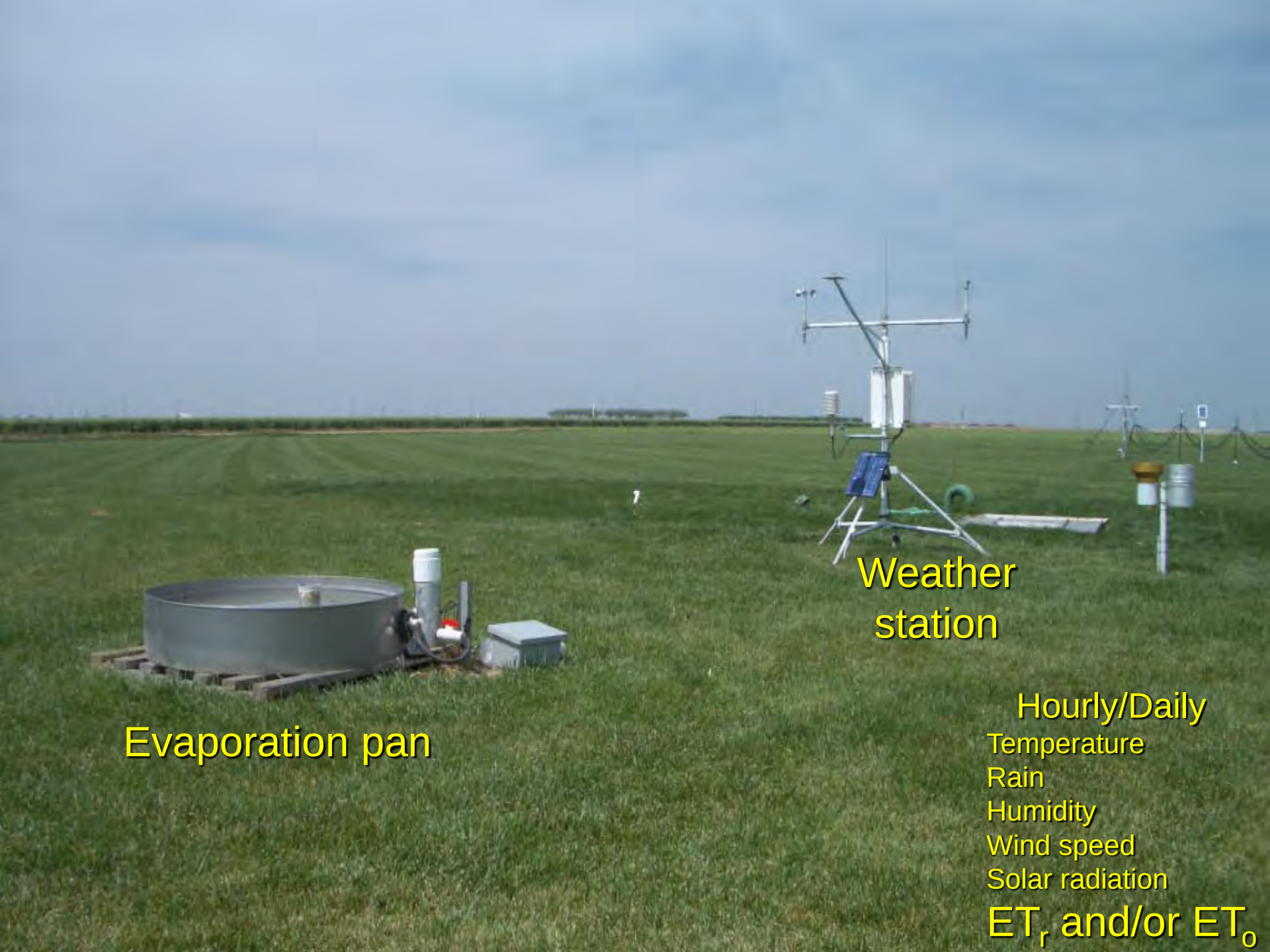
Irrigation Requirements?

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

PN REGION

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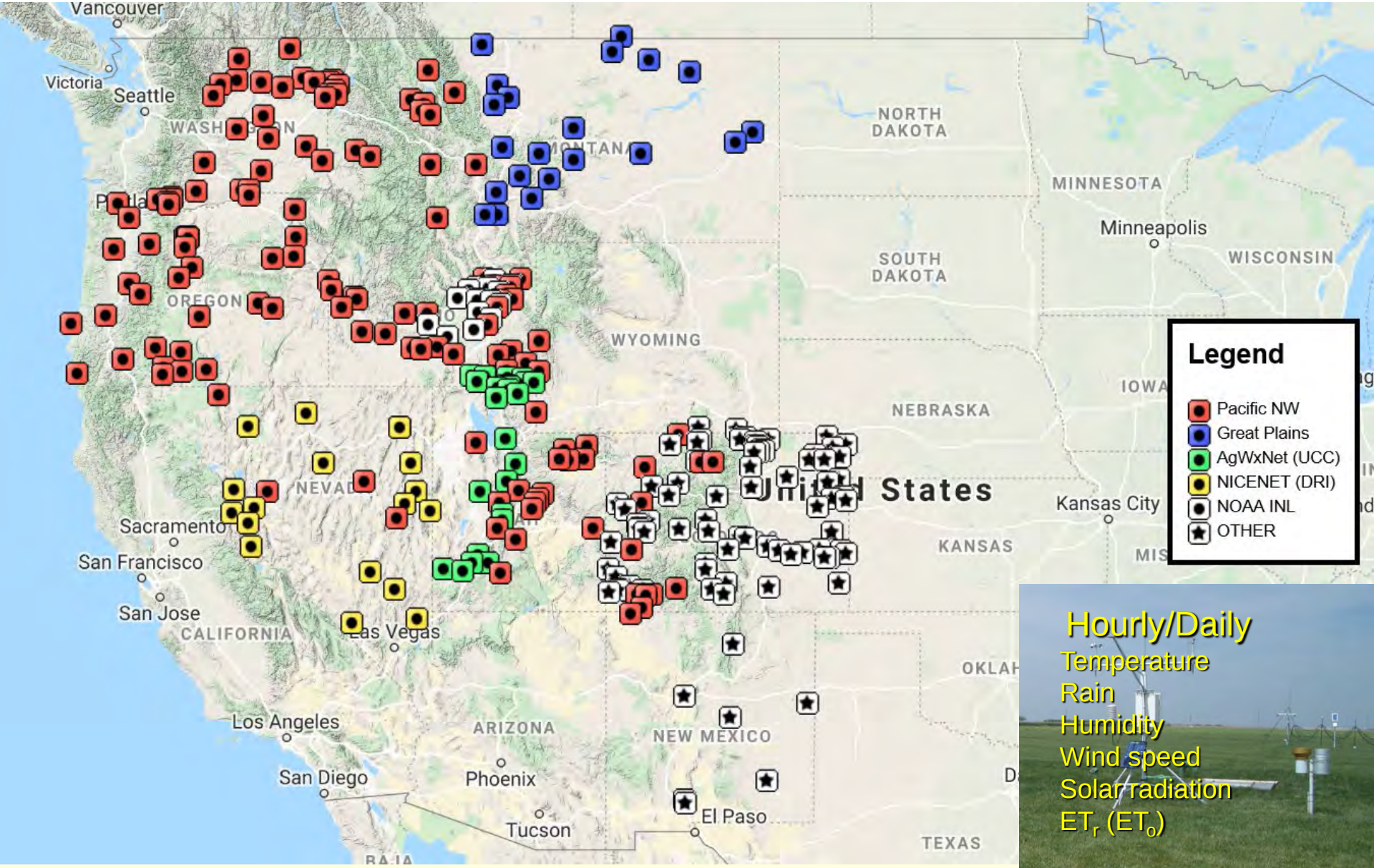
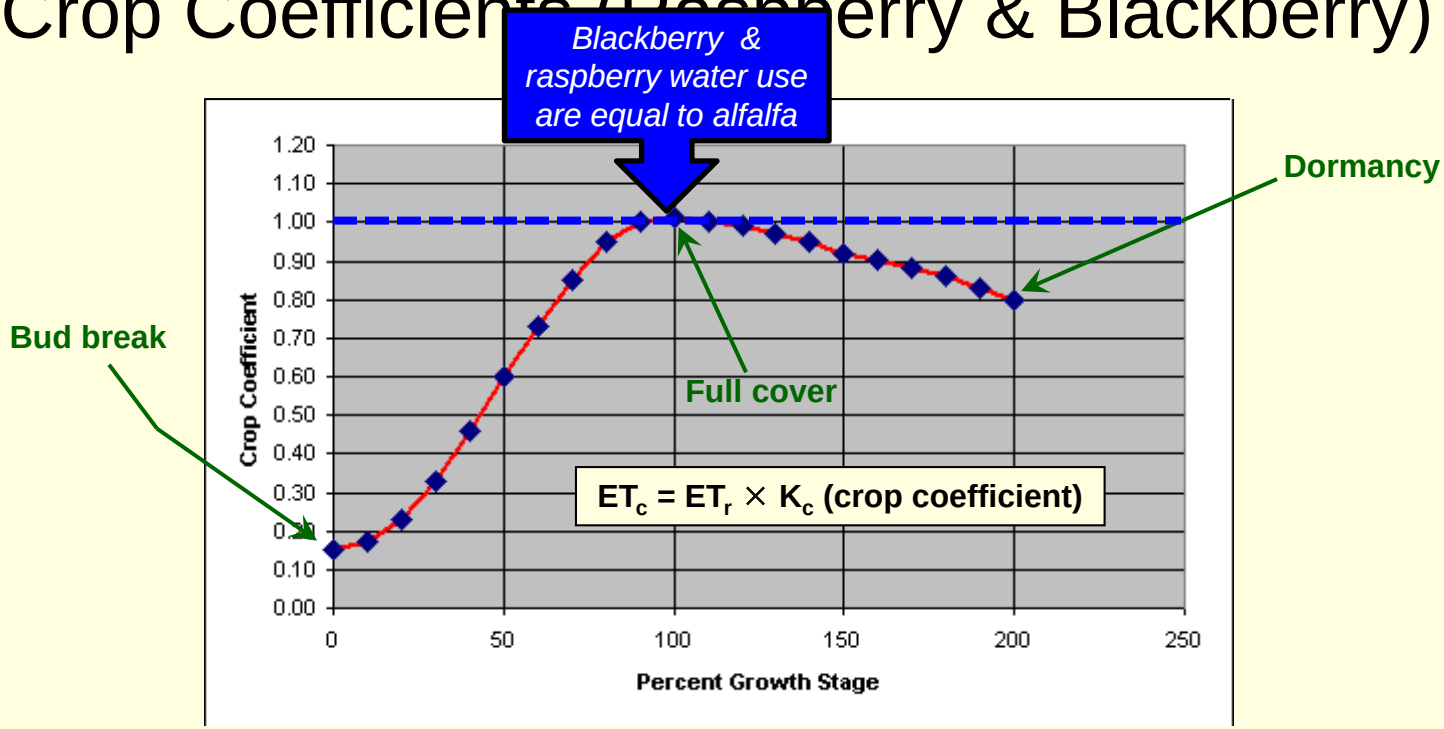
AgriMet Network Map

Hover over the dot for the name and identifier of the AgriMet weather station.
Click on a dot for information specific to that AgriMet weather station.



Crop Coefficients (Raspberry & Blackberry)



Mar. 23

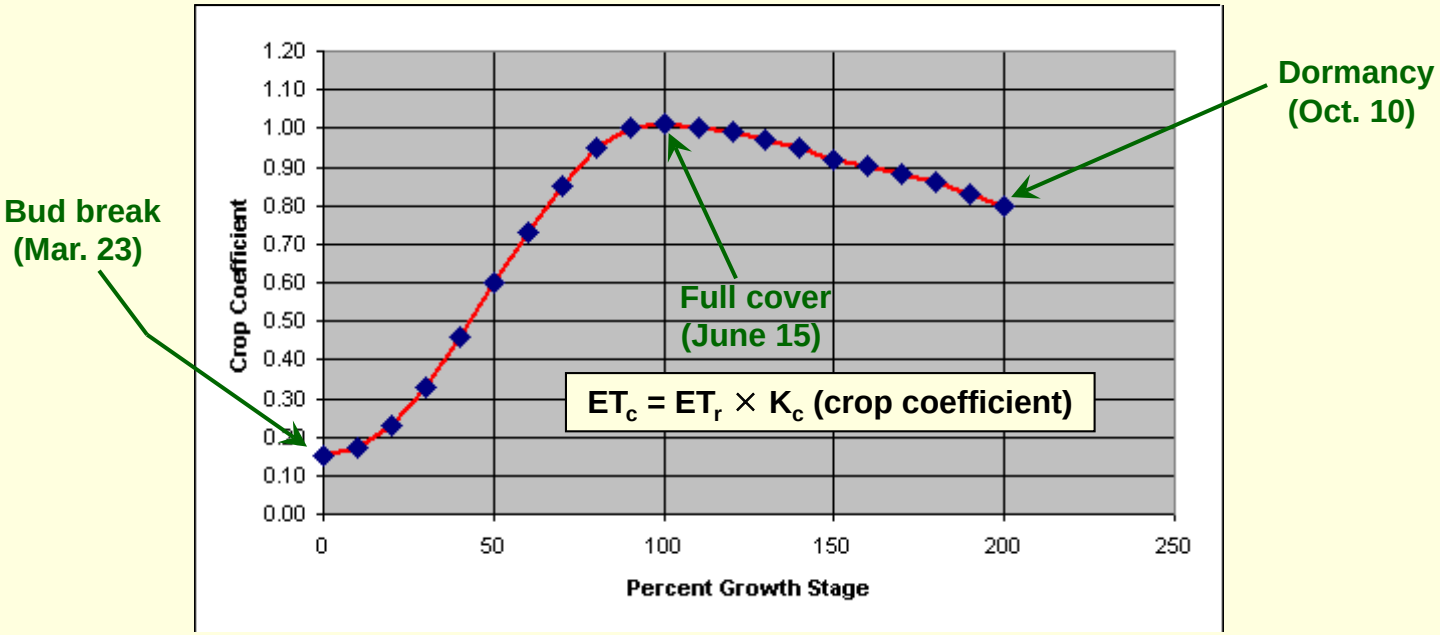
Apr. 21

May 18

June 15

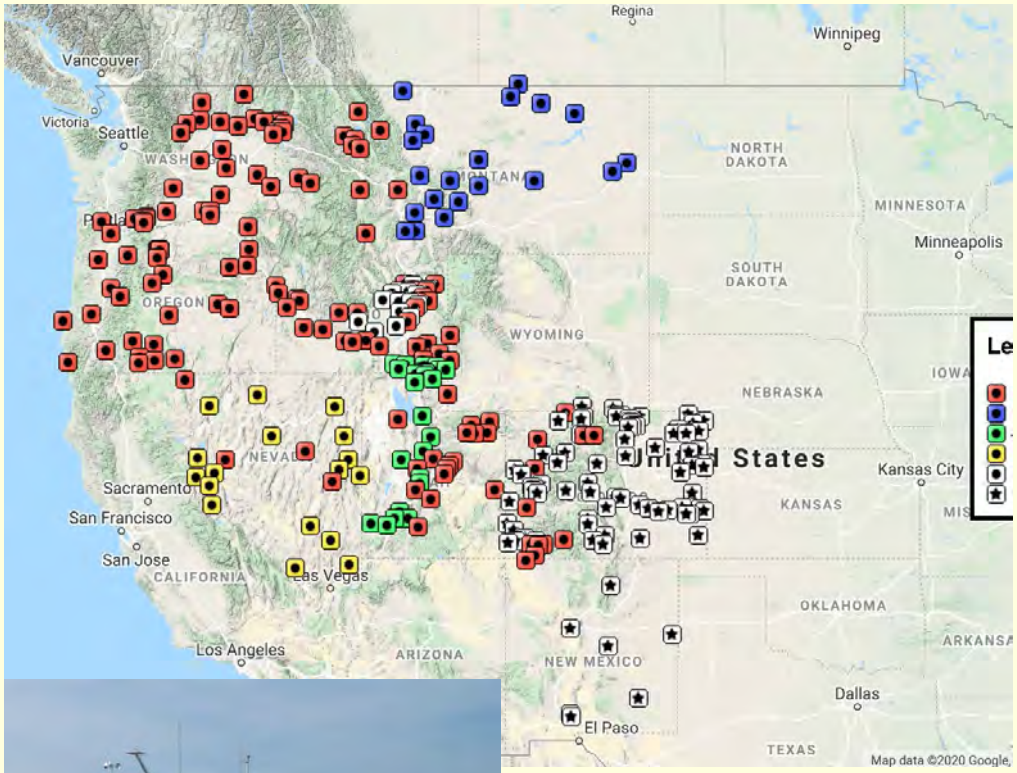
Oct. 10

Example



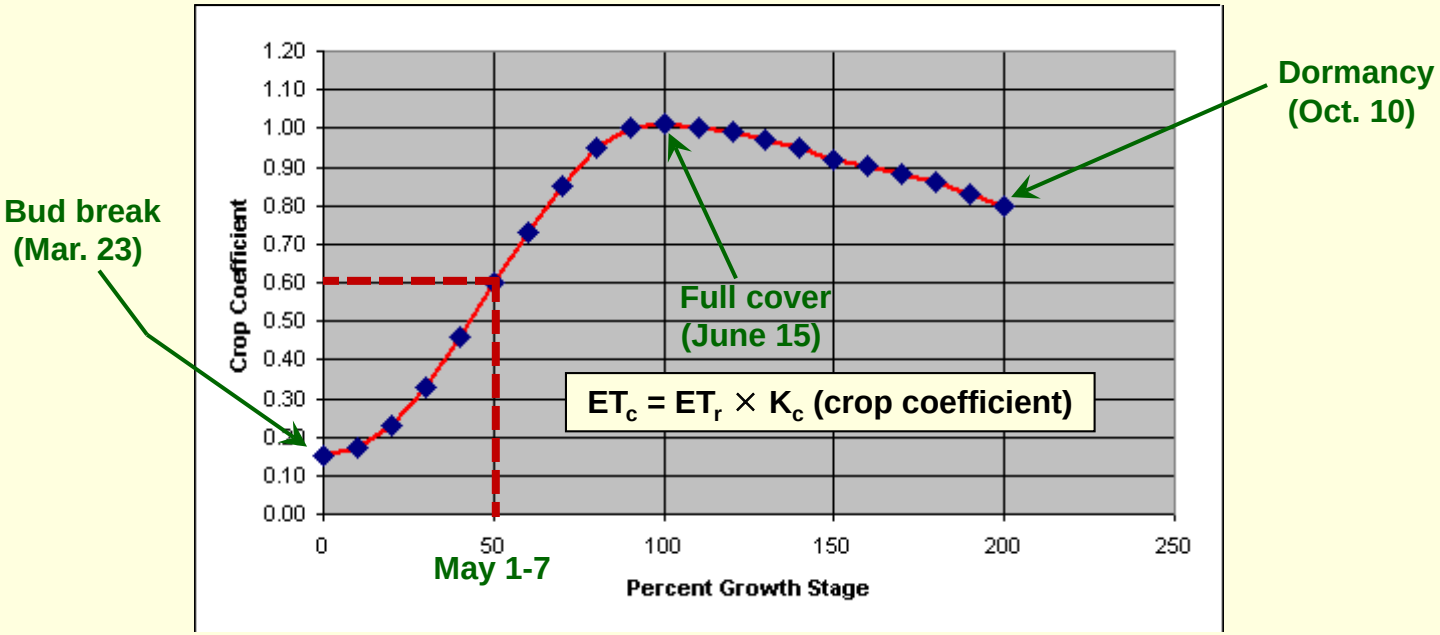
Irrigation requirements during week of May 1-7

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



date	ET_r (inches)	Precipitation (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 Ag Weather site (use nearest weather station)

ET_r = 2.0 inches **Precipitation = 0.5 inches**

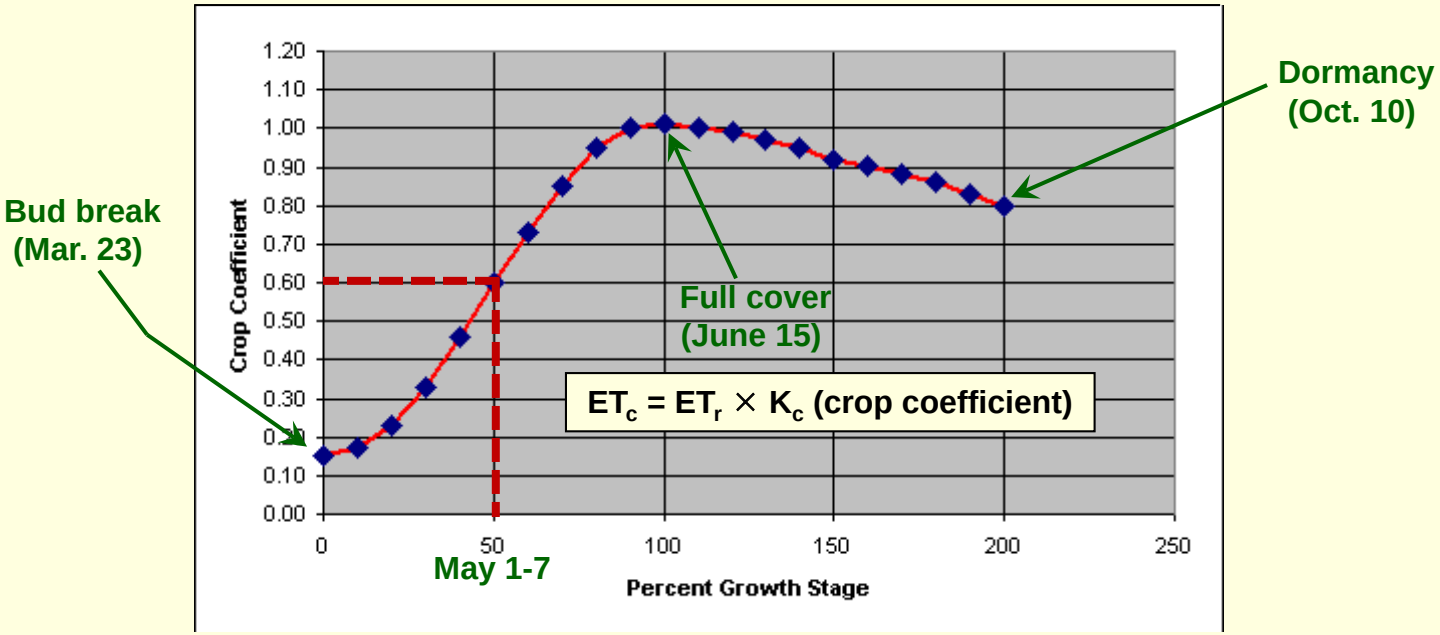
Step 2. Find K_c for raspberry

K_c = 0.6

Step 3. Calculate ET_c

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

Example



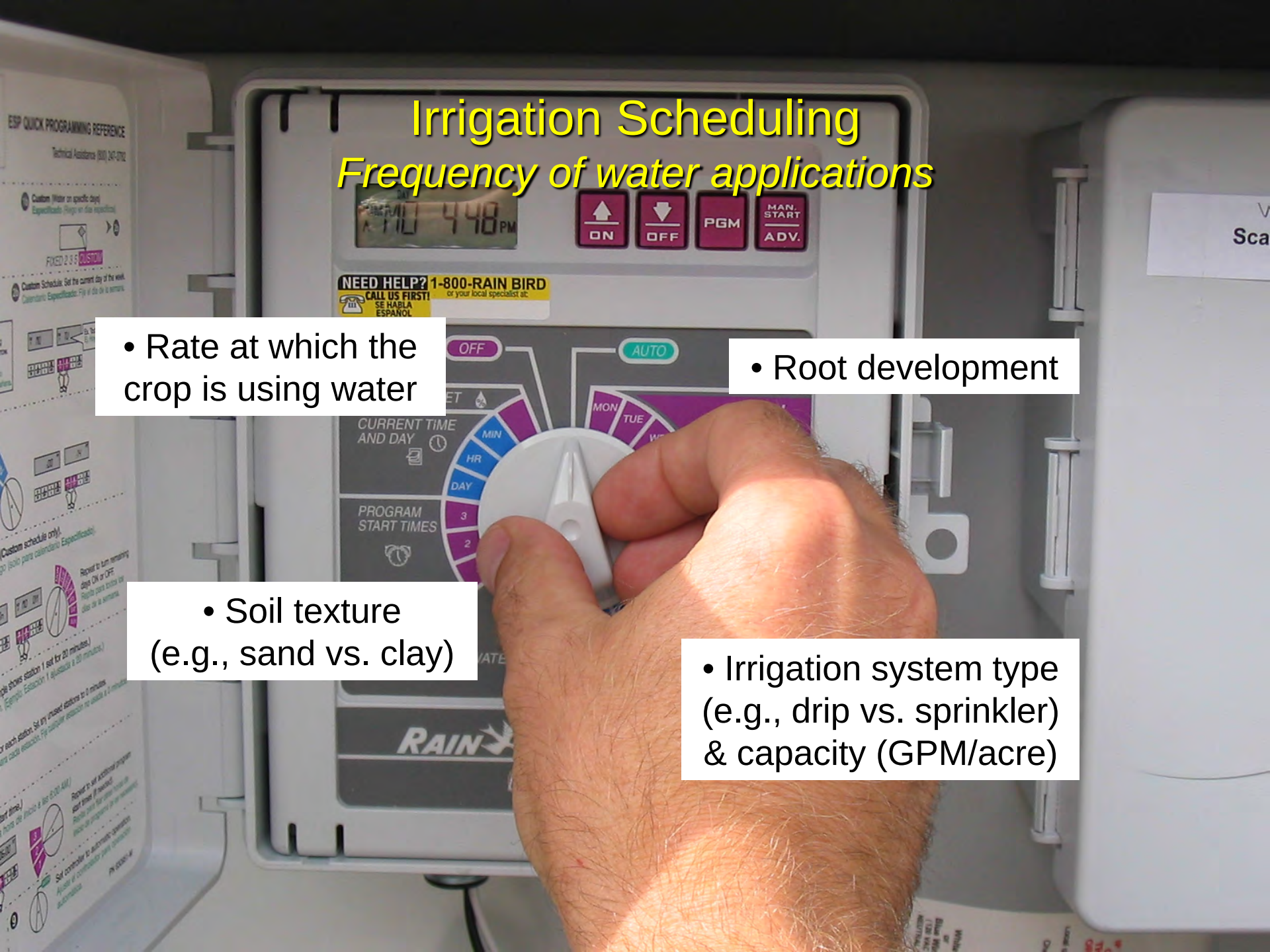
Irrigation requirements during week of May 1-7

Step 4. Determine irrigation requirements

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

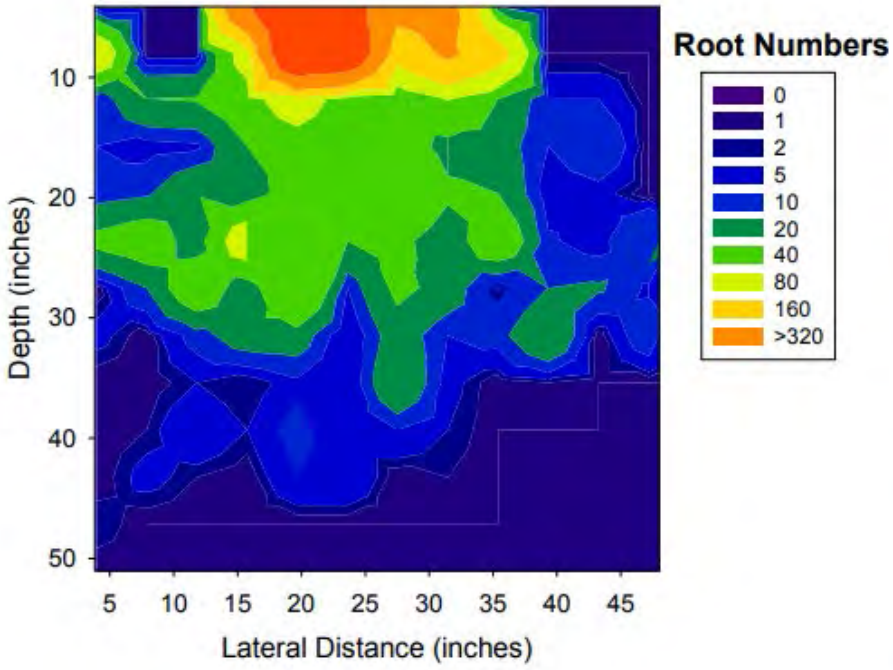
Irrigation Scheduling

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)

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)

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 = 0.3-0.45 inches of water per foot of soil prior to harvest & 0.75 inches after harvest

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)*

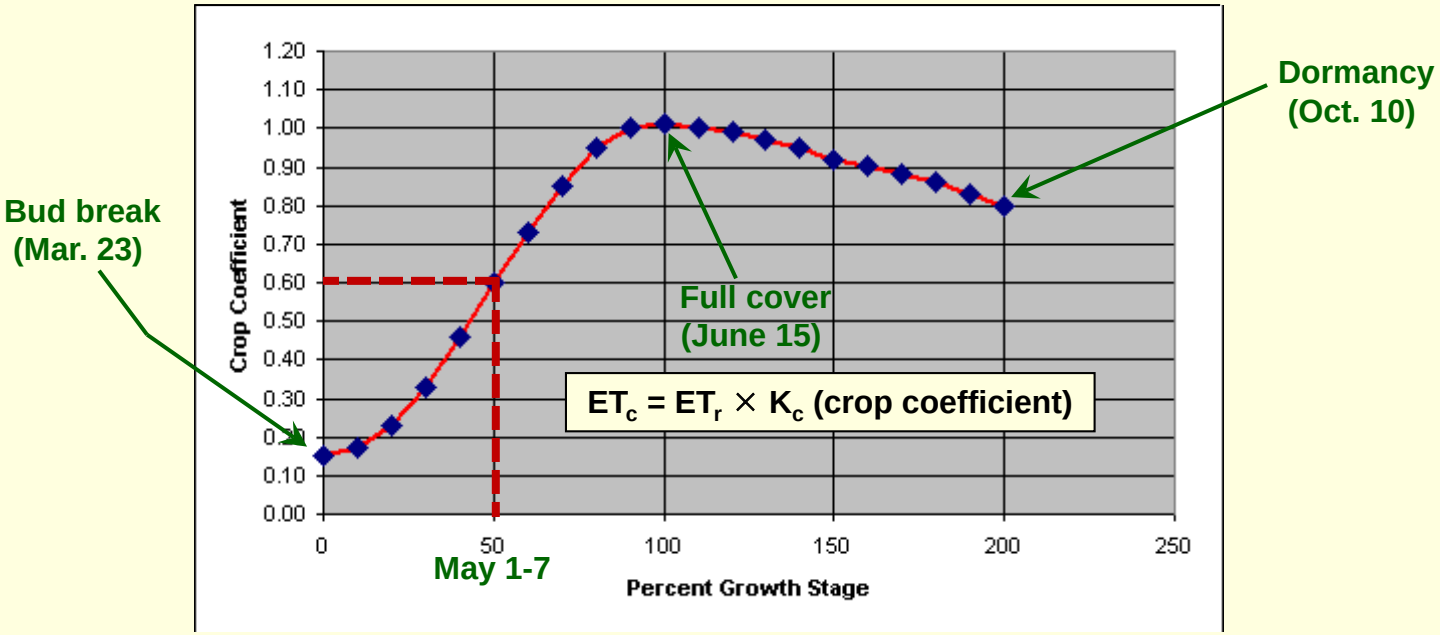
= maximum ET_c between irrigations

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

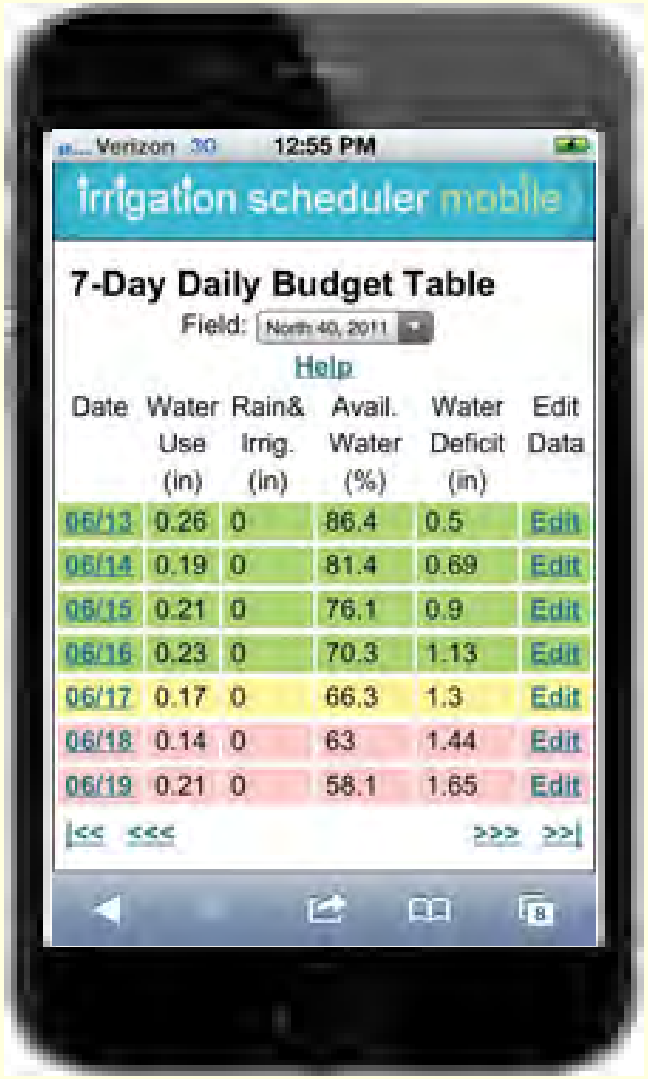
Step 4. Determine irrigation requirements

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)


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
- Heritage

} Fall fruiters

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

STUDY 1

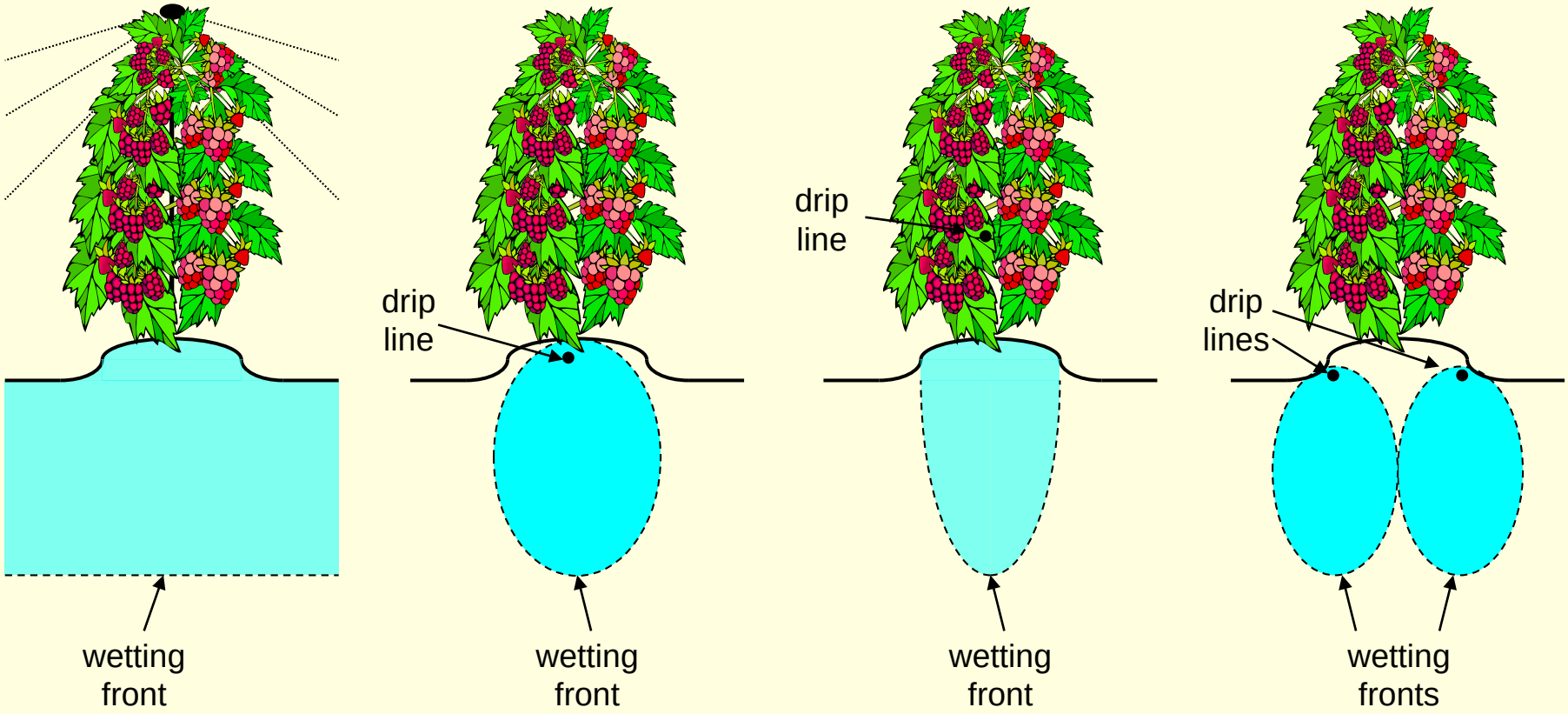
STUDY 2

Overhead sprinkler

Subsurface drip (1 line)

Surface drip

Subsurface drip (2 lines)



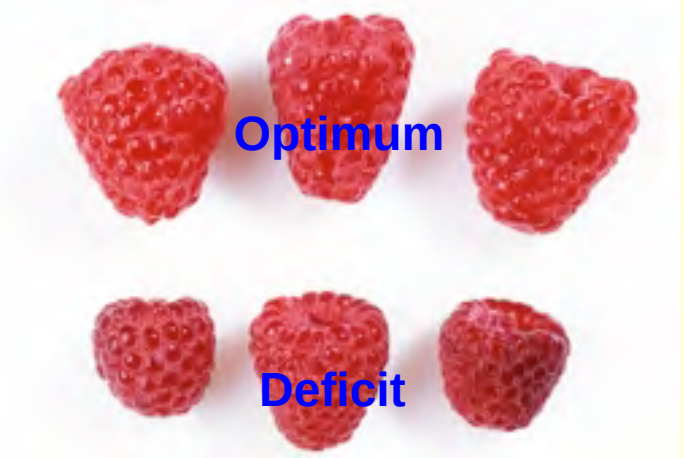
**Applied 2.5x's more water with sprinklers than with drip

Study 1 was machine-harvested

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

STUDY 1

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



	Berry wt. in 2006-09 (g/fruit)		
Cultivar*	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

Irrigation level	Yield in 2007 (ton/acre)		
	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

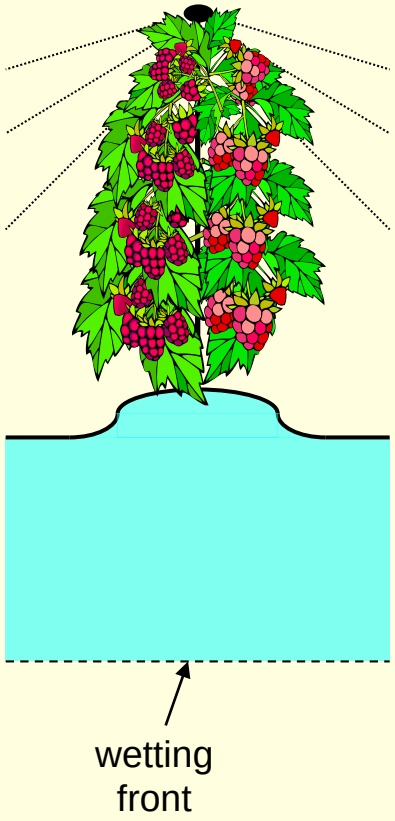
Ratings:

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

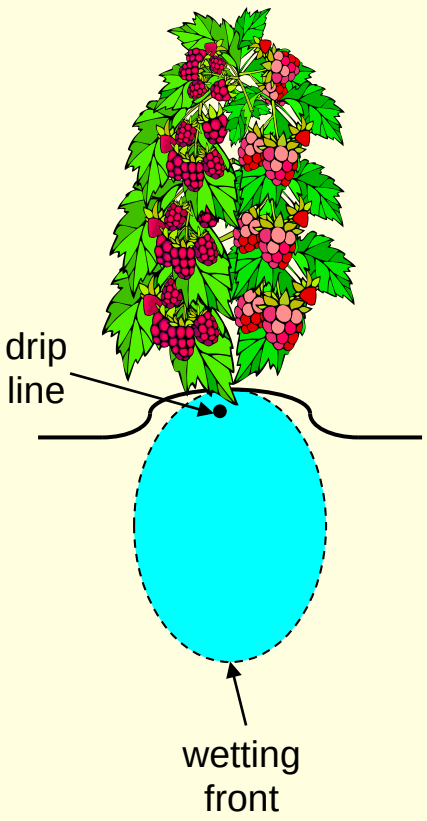
STUDY 1

STUDY 2

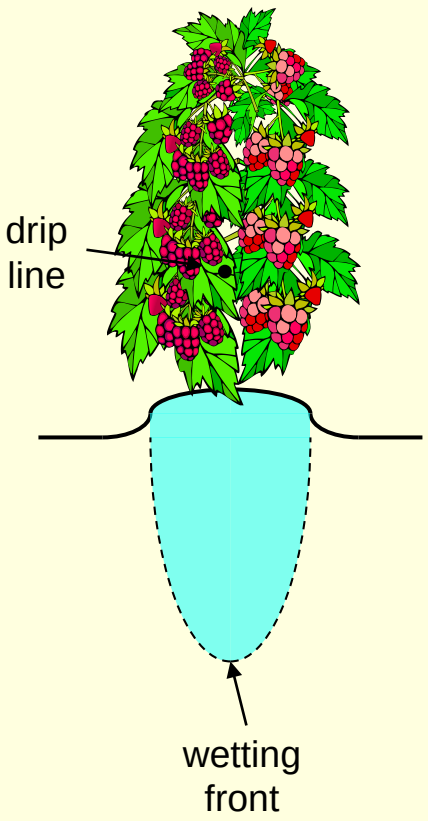
Overhead sprinkler



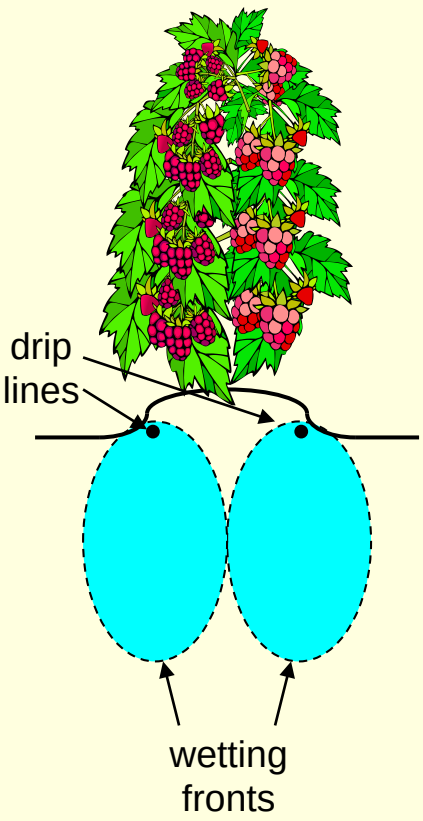
Subsurface drip
(1 line)



Surface drip



Subsurface drip
(2 lines)



**Applied the same amount of water with each method

STUDY 2

Cultivar	Yield (ton/acre) 2007	2008
Cascade Delight	6.6 a	5.7 a
Cowichan	5.6 c	5.4 a
Meeker	5.8 bc	5.2 ab
Tulameen	6.3 ab	4.7 b

Drip configuration	Yield (ton/acre) 2007	2008
Surface drip from trellis wire	6.1 a	5.4 a
Subsurface drip (1 line)	6.3 a	5.1 a
Subsurface drip (2 lines)	5.8 a	5.3 a

No difference

STUDY 2

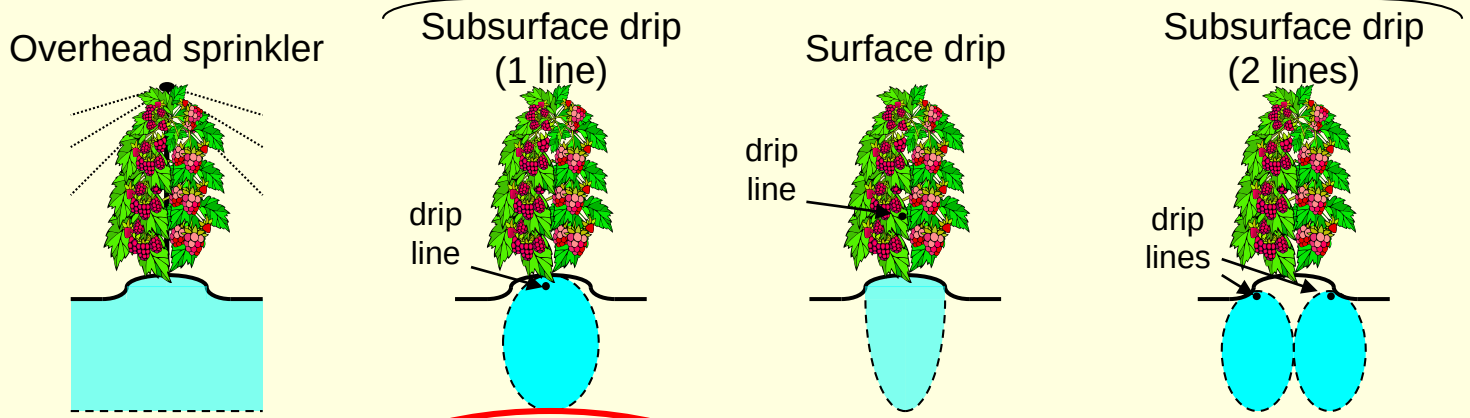
Cultivar	Berry wt. (g/fruit) 2007	2008
Cascade Delight	5.48 a	5.37 a
Cowichan	4.07 c	4.14 b
Meeker	3.56 d	3.65 c
Tulameen	4.68 b	4.19 b

Drip configuration	Berry wt. (g/fruit) 2007	2008
Surface drip from trellis wire	4.58 a	4.12 a
Subsurface drip (1 line)	4.36 b	4.10 a
Subsurface drip (2 lines)	4.40 b	4.03 a

SUMMARY

STUDY 1

STUDY 2



	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		

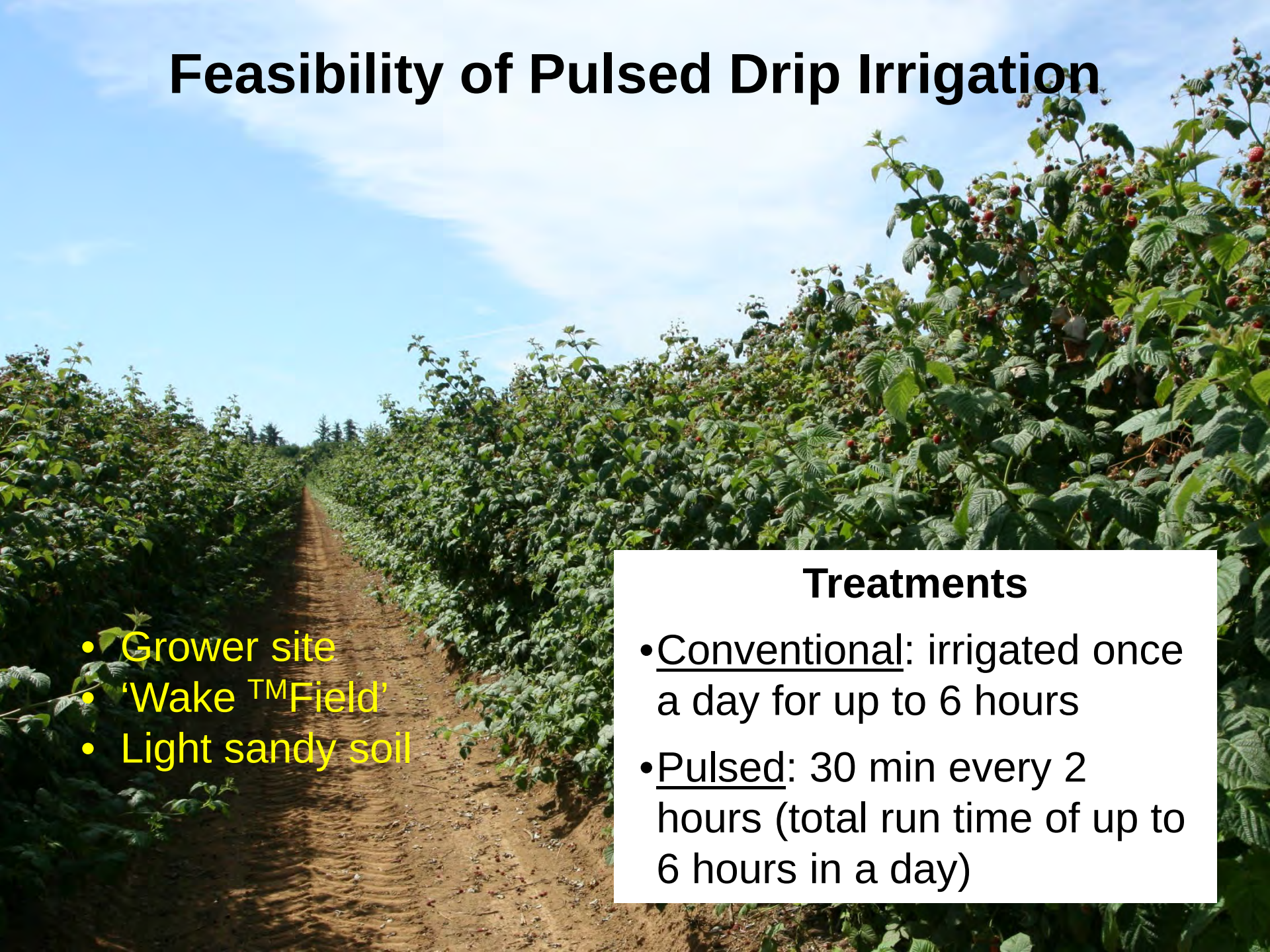
Conclusions

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

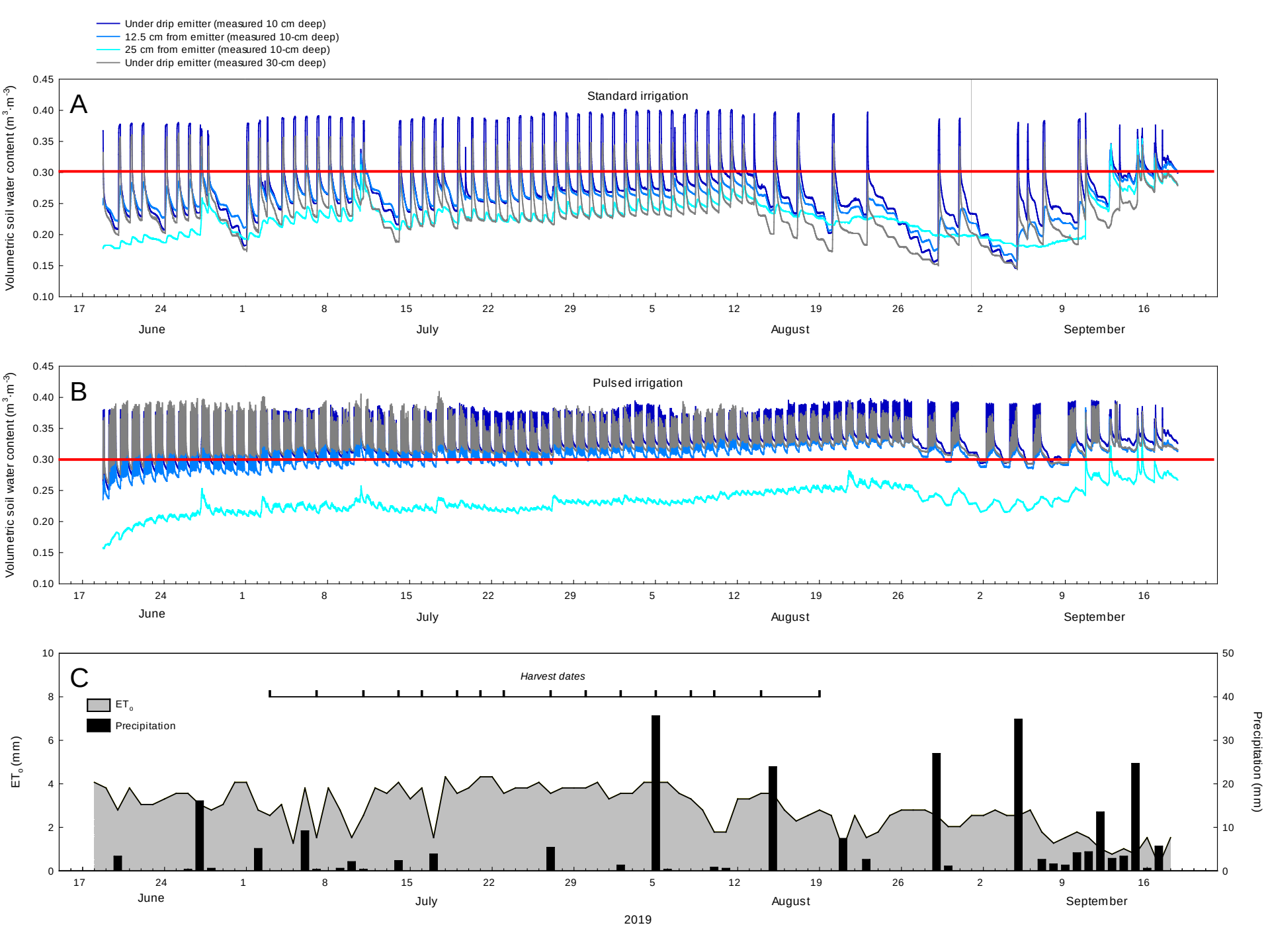
Feasibility of Pulsed Drip Irrigation



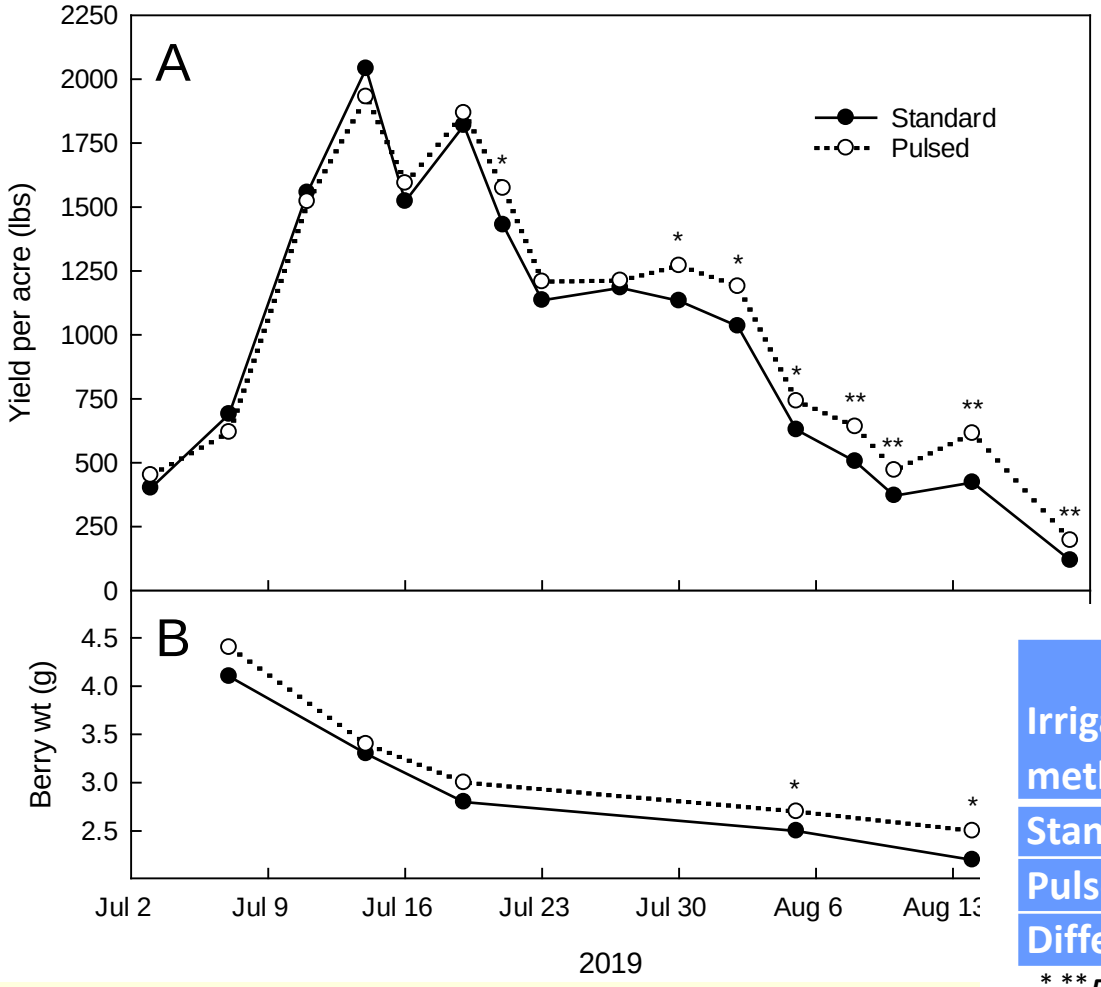
- Grower site
- 'Wake ™Field'
- Light sandy soil

Treatments

- Conventional: irrigated once a day for up to 6 hours
- Pulsed: 30 min every 2 hours (total run time of up to 6 hours in a day)


Under drip emitter (measured 10 cm deep)
12.5 cm from emitter (measured 10-cm deep)
25 cm from emitter (measured 10-cm deep)
Under drip emitter (measured 30-cm deep)
A
Standard irrigation
Volumetric soil water content (m3·m-3)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
17
24
1
8
15
22
29
5
12
19
26
2
9
16
June
July
August
September
B
Pulsed irrigation
Volumetric soil water content (m3·m-3)
C
Harvest dates
ET0
Precipitation
ET0 (mm)
Precipitation (mm)
10
8
6
4
2
0
50
40
30
20
10
0
2019

Benefits of Pulsed Drip



Irrigation method[z]	Total yield per acre (lbs)	Average berry weight (g)
Standard	16,000	3.09
Pulsed	17,100	3.19
Difference	1,100[†]	0.10[†]

[†]$P < 0.10$.

Irrigation method	Soluble solids (%)	Titratable acidity (%)	Sugar:acid ratio
Standard	10.6	2.17	4.87
Pulsed	10.2	2.24	4.56
Difference	0.4[**]	-0.07[*]	0.31[**]

[*,**]$P < 0.05$ and 0.01, respectively.

Benefits of Pulsed Drip

Drone

Irrigation method[z]	Canopy cover (%)	
	Aug. 2019	Sept. 2019
Standard	56.1	48.9
Pulsed	60.0	58.4
Difference	3.9*	6.5**

*,** $P < 0.05$ and 0.01, respectively.

Acknowledgements

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- **Technical Support:** Jim Gartung, Amber Shireman, Ruth Hamlyn, Scott Orr, Jesse Carroll, OSU students
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