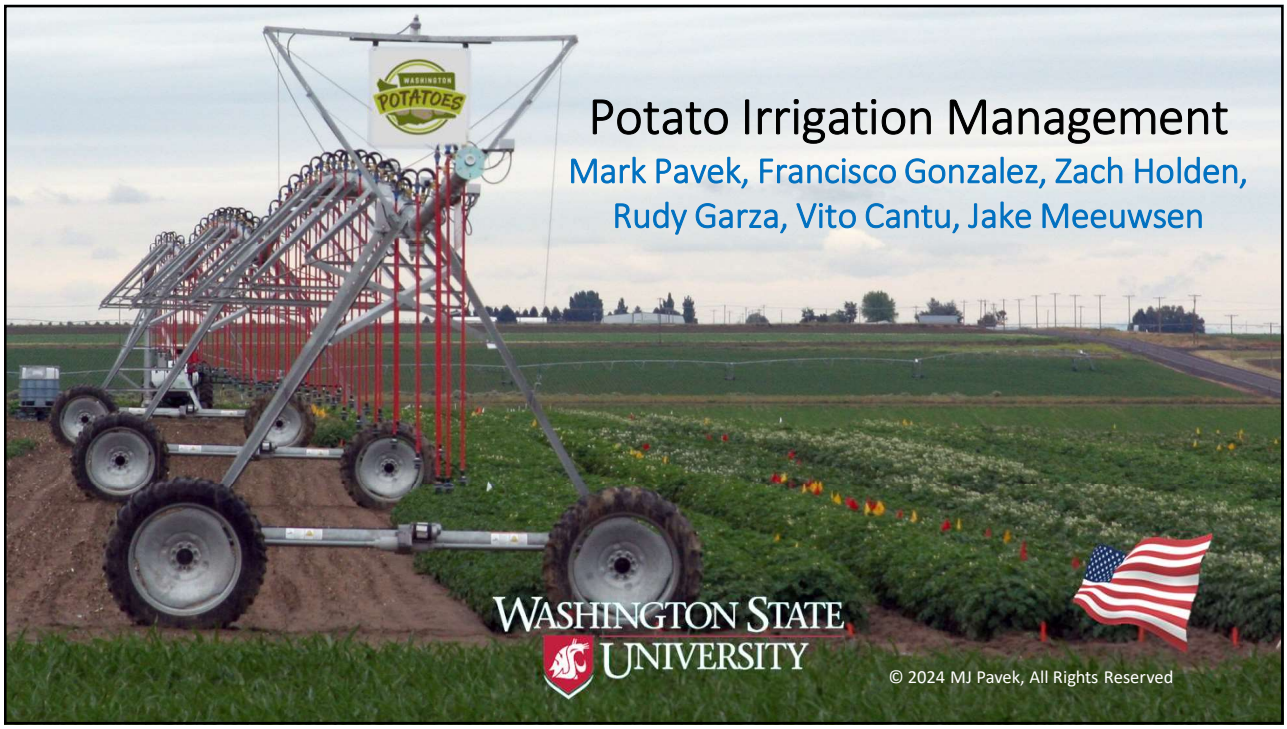


1

Successful Combination leads to Potato Profits

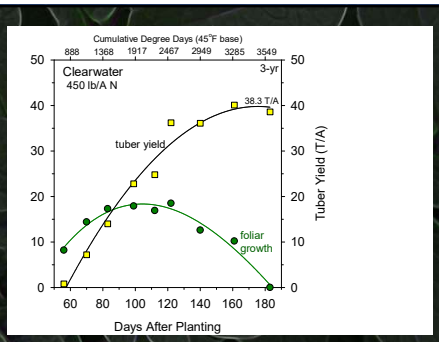
- ***ADEQUATE CANOPY SIZE***
  - Maximize the source (canopy) during a specific time interval, to maximize the economics and quality of the sink (tuber)
    - *Nutrients, irrigation*
- ***CANOPY DURATION***
  - Adequate, healthy canopy early and then maintained as long as possible
  - Remove any limiting factors
    - *Input shortages, diseases/pests, weeds, use proper cultivation & irrigation*

Source (Foliage)

Sink (Tubers)

2

38-Tons/A Potato Crop



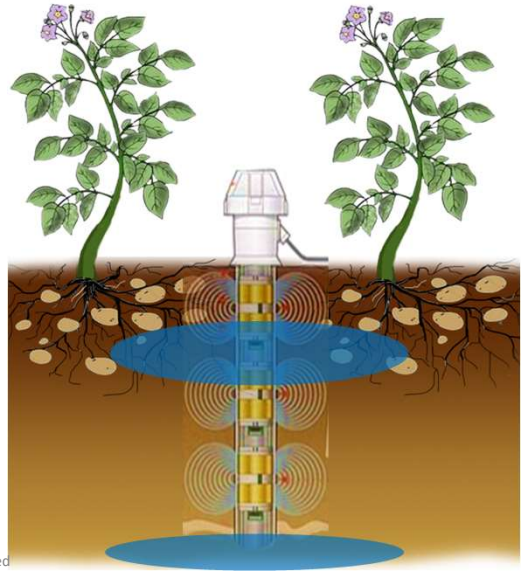
Between 60 and 140 days after planting

- Tuber bulking rate is linear
- 900 lbs/A day tuber bulking rate (9 cwt/acre/day)
- 0.8 oz tuber weight/plant/day (1.2% of final plant yield/day)
- Every 20 days, the plant will add 1 lb in tubers
- Final yield equivalent to 4.1 lbs/plant (34 inch rows, 10 in-row spacing)

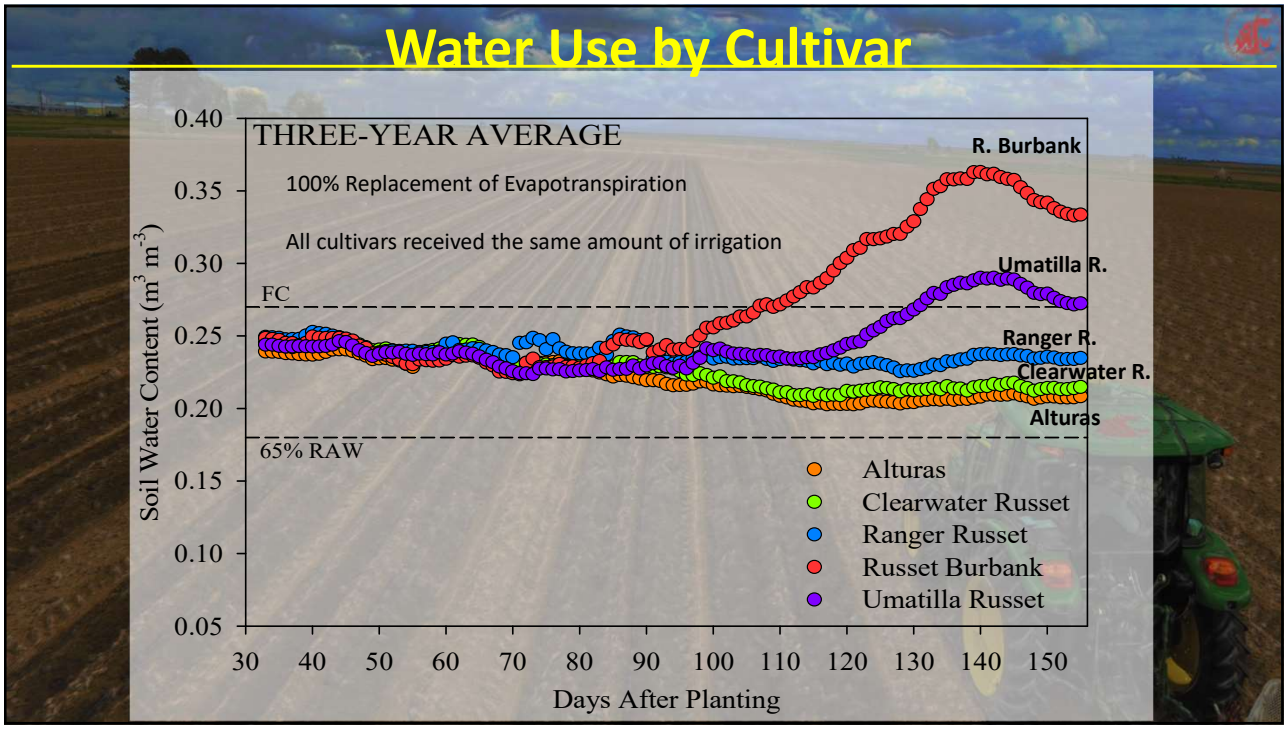
3

How much water does the typical Columbia Basin potato crop use per season?

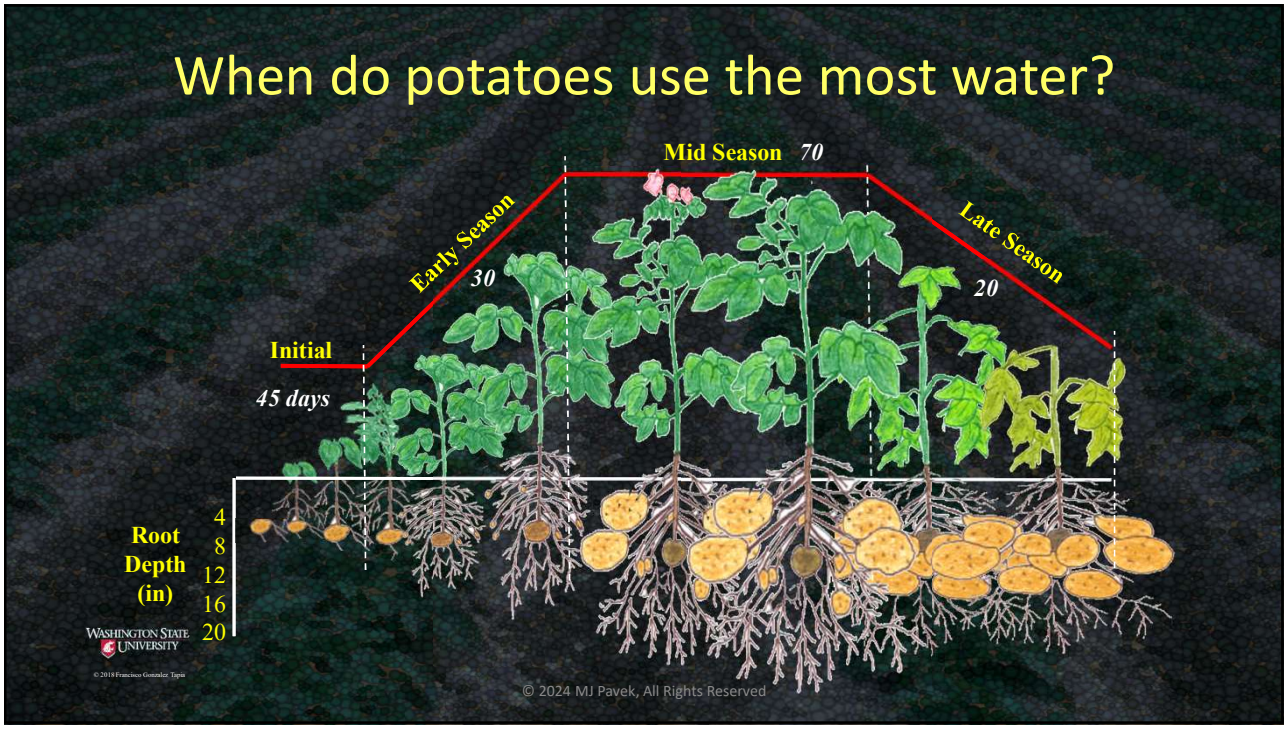
- 25 to 32 acre/inches
- Acre inch = 27,154 gallons/A
- 28 inches = 760,312 g/A
  - 6.34 million lbs/A
- How many gallons to grow one lb of potatoes (yield 33 tons/A)?
  - ~10 gallons/lb of potatoes



4


Water Use by Cultivar
THREE-YEAR AVERAGE
100% Replacement of Evapotranspiration
All cultivars received the same amount of irrigation
FC
65% RAW
Soil Water Content (m3 m-3)
Days After Planting
R. Burbank
Umatilla R.
Ranger R.
Clearwater R.
Alturas
Alturas
Clearwater Russet
Ranger Russet
Russet Burbank
Umatilla Russet

5


When do potatoes use the most water?
Mid Season 70
Early Season
30
Late Season
20
Initial
45 days
Root Depth (in)
4
8
12
16
20
WASHINGTON STATE UNIVERSITY
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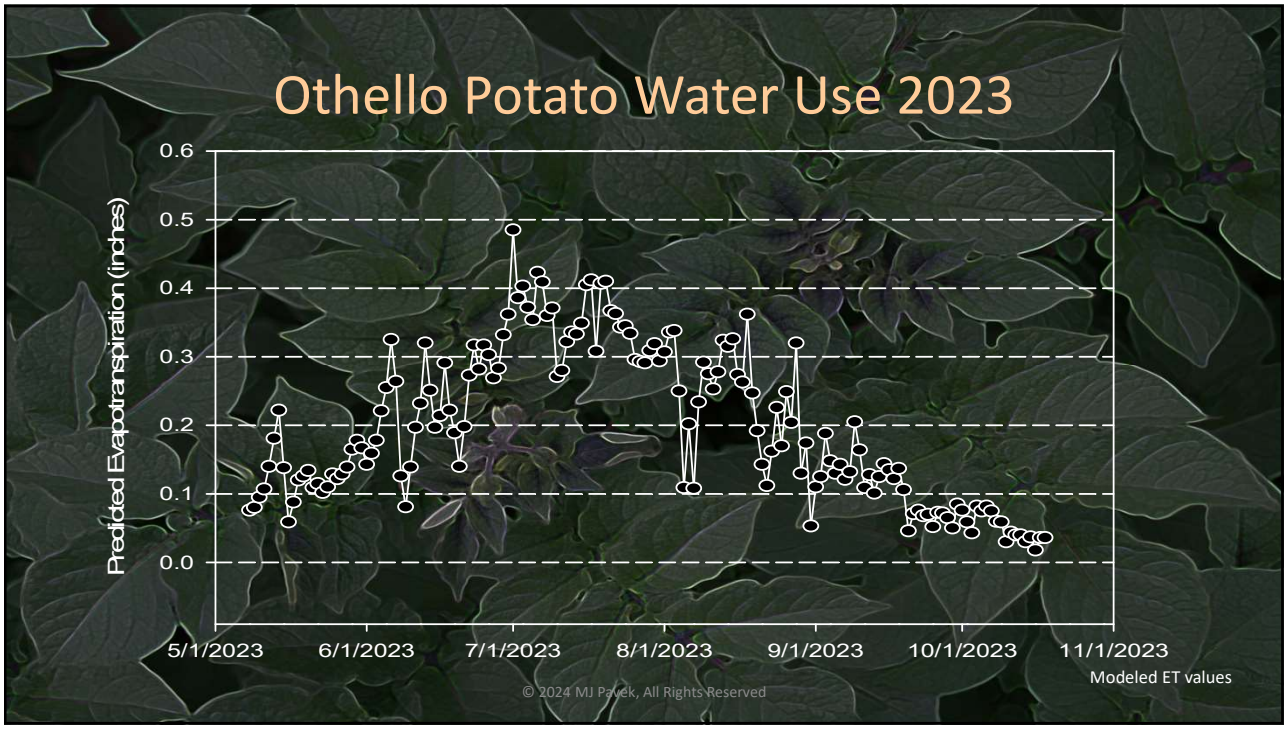
6


Othello Potato Water Use 2023
Predicted Evapotranspiration (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5/1/2023
6/1/2023
7/1/2023
8/1/2023
9/1/2023
10/1/2023
11/1/2023
Modeled ET values
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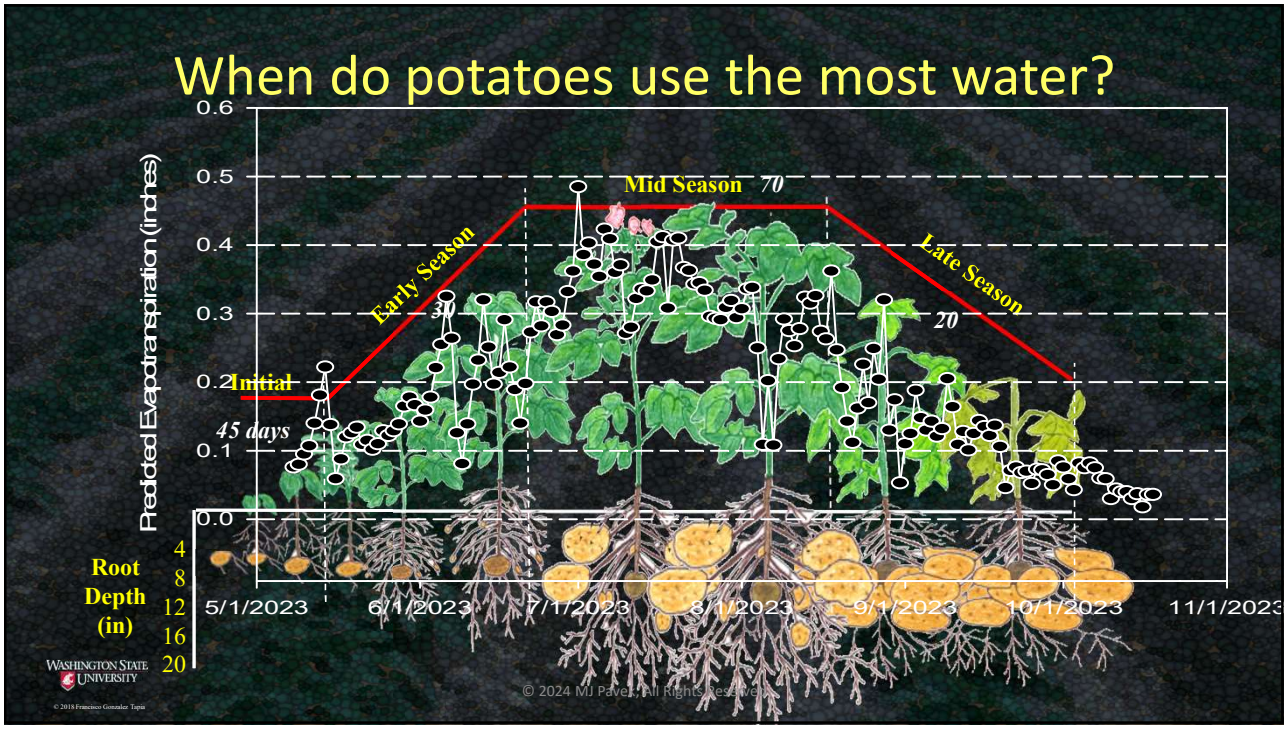
7


When do potatoes use the most water?
Predicted Evapotranspiration (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Mid Season 70
Early Season
Late Season
30
20
Initial
45 days
Root Depth (in)
4
8
12
16
20
5/1/2023
6/1/2023
7/1/2023
8/1/2023
9/1/2023
10/1/2023
11/1/2023
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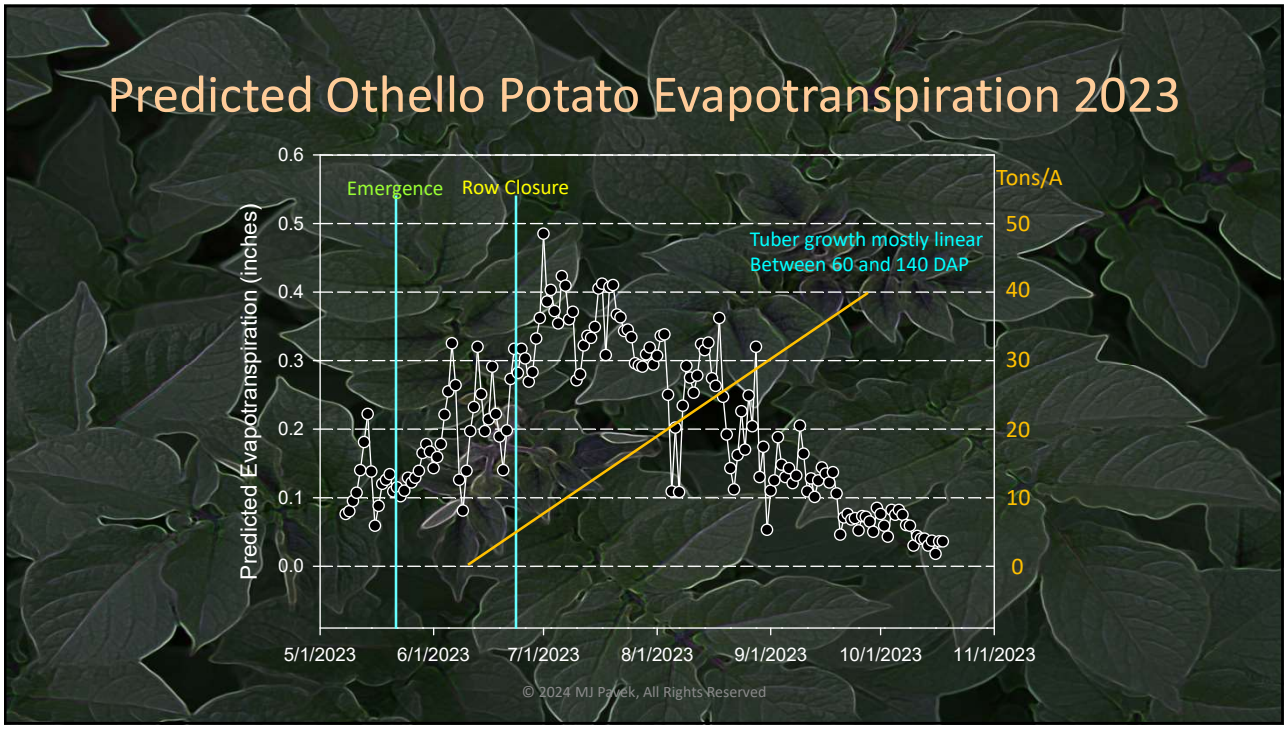
Predicted Othello Potato Evapotranspiration 2023
Predicted Evapotranspiration (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Emergence
Row Closure
Tons/A
50
40
30
20
10
0
Tuber growth mostly linear
Between 60 and 140 DAP
5/1/2023
6/1/2023
7/1/2023
8/1/2023
9/1/2023
10/1/2023
11/1/2023
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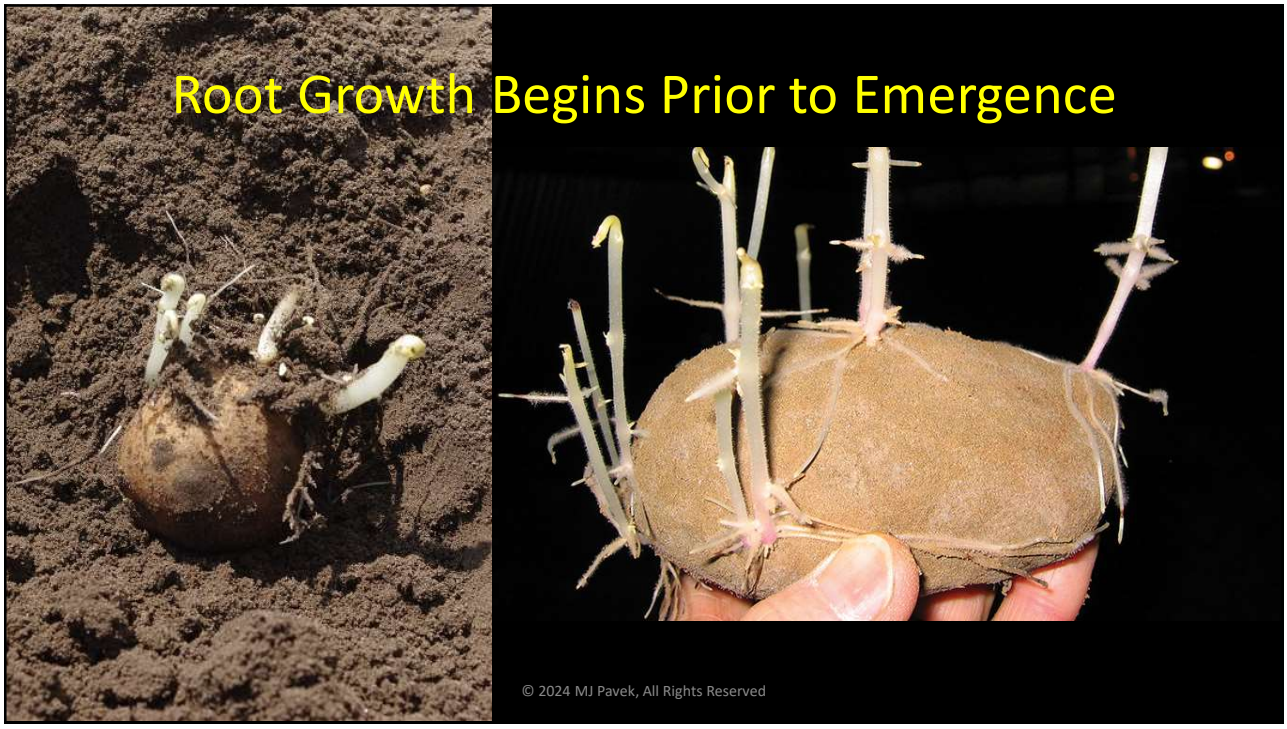
9


Root Growth Begins Prior to Emergence
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10


Misinformation about pre-emergence irrigation or
“watering potato plants up”
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11


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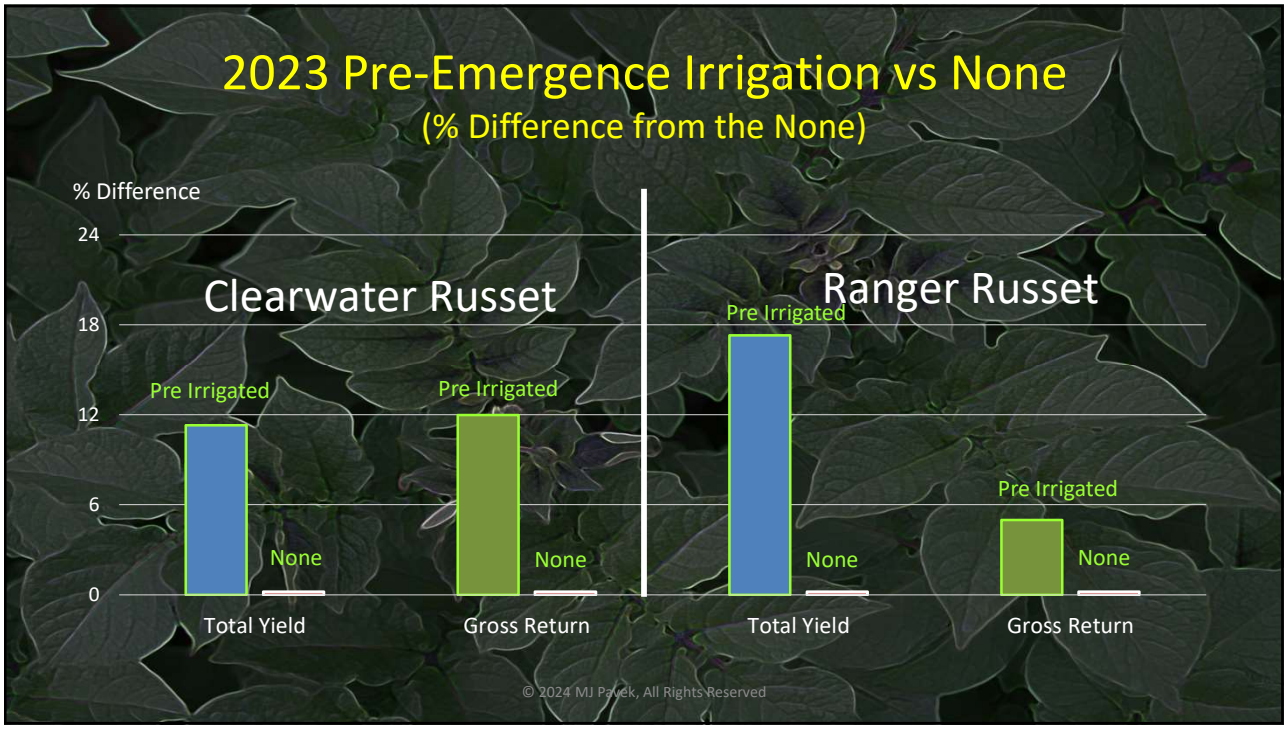
12


2023 Pre-Emergence Irrigation vs None
(% Difference from the None)
% Difference
24
18
12
6
0
Clearwater Russet
Ranger Russet
Pre Irrigated
None
Pre Irrigated
None
Pre Irrigated
None
Pre Irrigated
None
Total Yield
Gross Return
Total Yield
Gross Return
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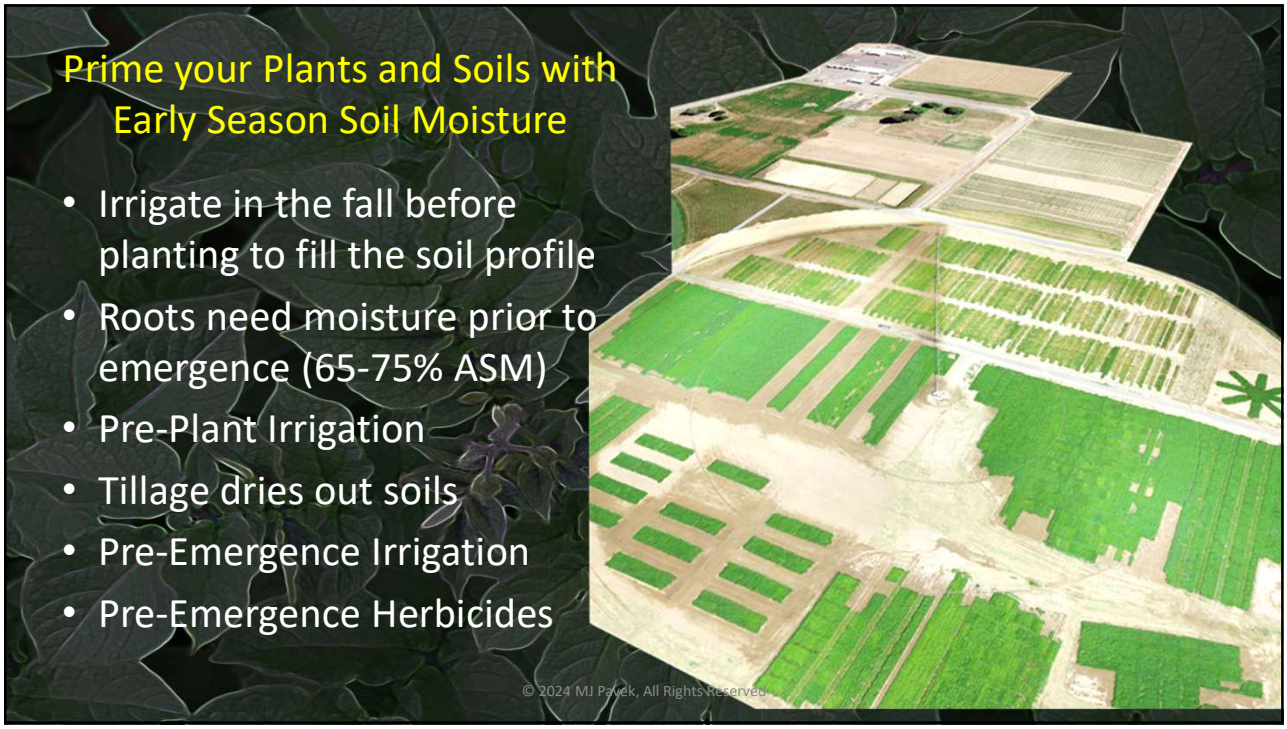
13


Prime your Plants and Soils with Early Season Soil Moisture
• Irrigate in the fall before planting to fill the soil profile
• Roots need moisture prior to emergence (65-75% ASM)
• Pre-Plant Irrigation
• Tillage dries out soils
• Pre-Emergence Irrigation
• Pre-Emergence Herbicides
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14

Irrigation Management

- Obvious – Maintain irrigation equipment, replace worn components
- Understanding your irrigation equipment and capabilities
  - Output, application timeliness, duration
  - Catch water, proof your machine – does the measured output = the control panel

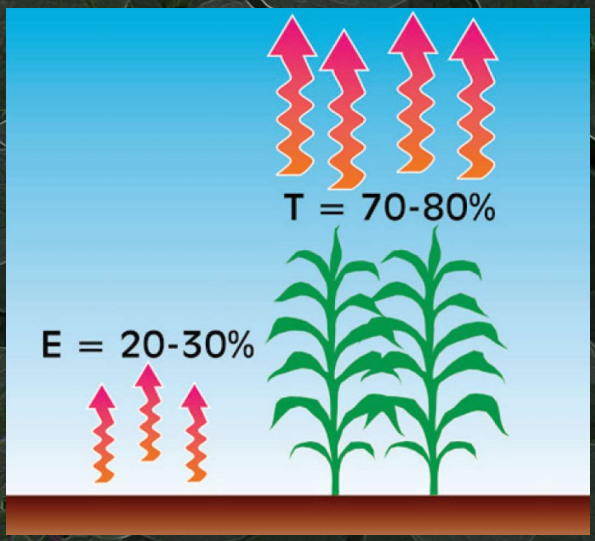
Ideal Irrigation Management is a Combination of:

- Soil moisture monitors
  - Volumetric
  - Soil water potential (potential of a soil to hold water, matric potential)
  - More sights and depths = better
- Predicted irrigation rate
  - Maintaining soil moisture to maximize economic return
  - Soil moisture monitors
- Regular field visits
  - Shovel, hand feel method
- Rain gauges, record actual application rates
- Timely irrigation

15

What is Evapotranspiration?

- Evapotranspiration (ET)
  - Evaporation (E)
  - Plant Transpiration (T)
    - Respiration of plants
    - Passage of water vapor through plant pores into the atmosphere
    - Ratio changes as the crop grows and more of the soil surface is shaded by crop leaves.



16

Predicting Evapotranspiration (ET)

- If we could predict ET, what is it good for/how do we use it?
  - IRRIGATION ROAD MAP
  - Without it, you are driving (irrigating) blind
- Predicted ET gets you very close to actual water demand of the plant & soil, daily
- You could water a crop with predicted ET, never go into the field, and likely produce a profitable crop
  - But should you?

  NO! (WHY?)

AgWeatherNet for ET Values: https://weather.wsu.edu/

17

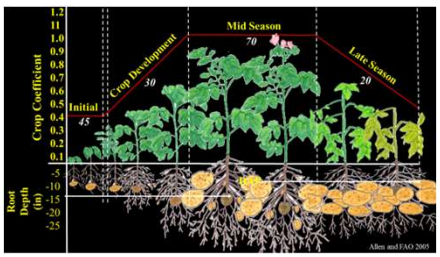
What is modeled ET?

An estimation of crop water consumption based on weather and modeling

Composed of two factors:

- Reference evapotranspiration (**ET_r**)
  - Computed using weather data & modeling based on based on **alfalfa** or grass
- Crop coefficients (**K_c**)
  - Accounts for crop's development characteristics, cultural management, and micro-climates

$$ET_r = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)}$$



- $ET = ET_r \times K_c$

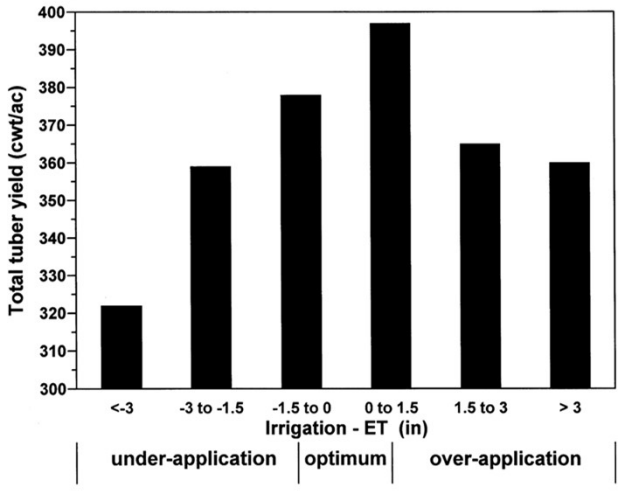
18

Potato ET using Crop Coefficients

Level	Crop Coefficients (K_c) Values		
	$K_{c\text{-int}}$	$K_{c\text{-mid}}$	$K_{c\text{-late}}$
	mean		
Source of K_c Values			
UN FAO	0.50	1.12	0.40
USDA AgriMet	0.30	0.93	0.50
WSU AgweatherNet	0.40	0.99	0.56
WSU Potato Research[a]	0.40	0.95	0.57

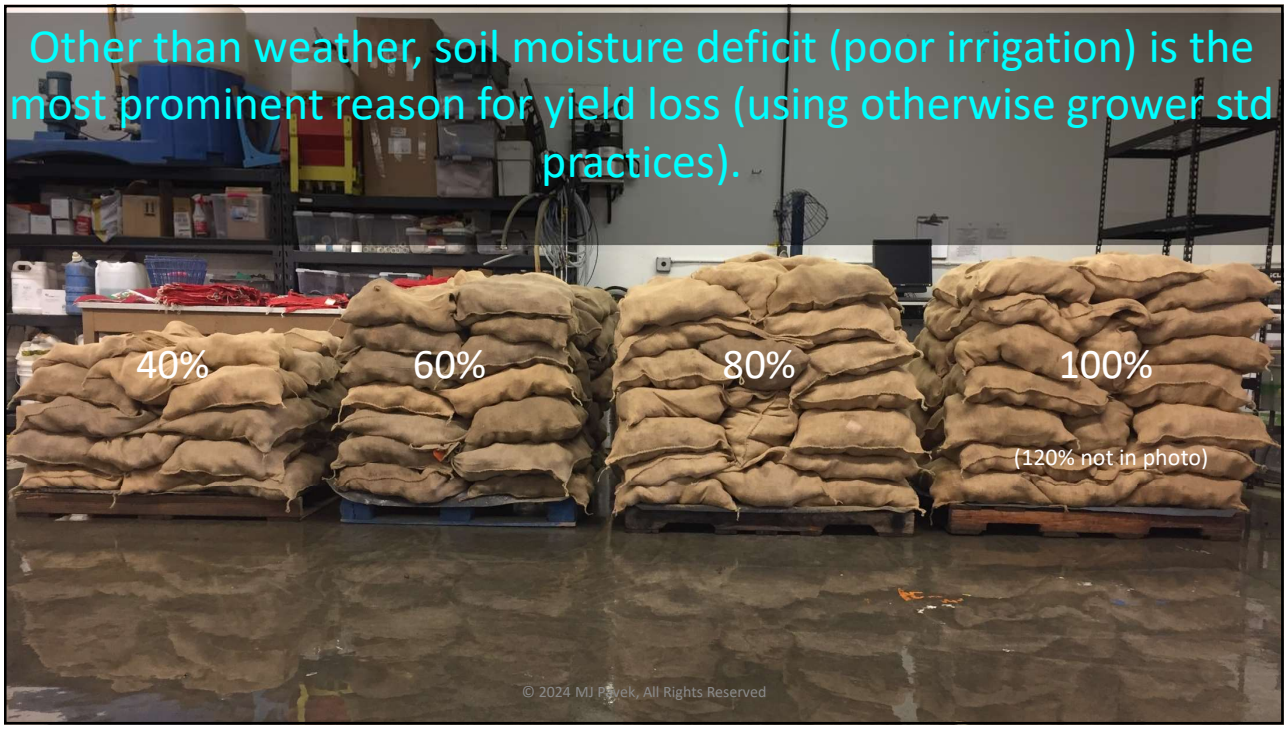
19

Total tuber yield as influenced by the difference between irrigation and ET on 45 commercial potato fields in southeastern Idaho.



Potato Irrigation Management
University of Idaho Ext Bul 789
Bradley A. King and Jeffery C. Stark

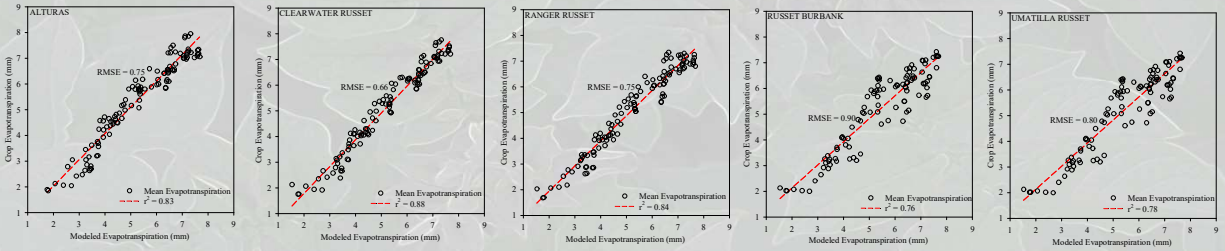
20



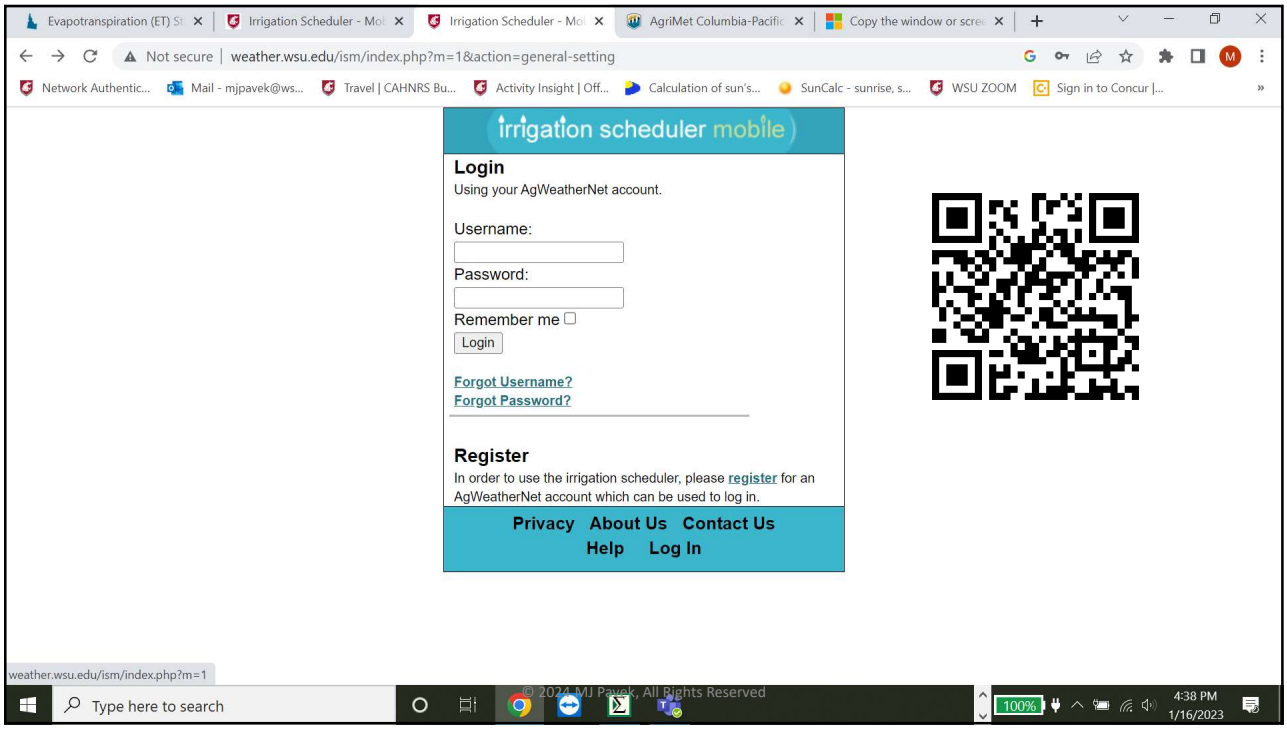
21

Actual vs. Predicted Evapotranspiration

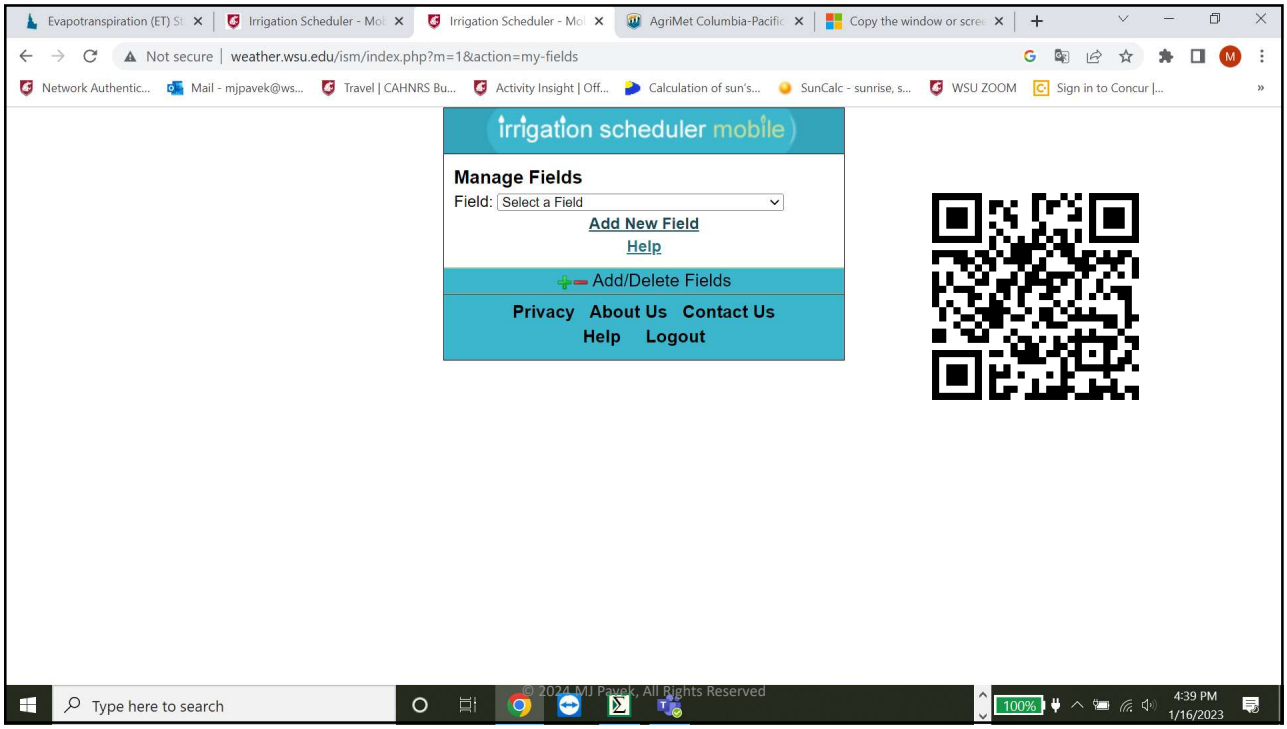
- High correlation
- AgweatherNet is a great resource for modeling ET



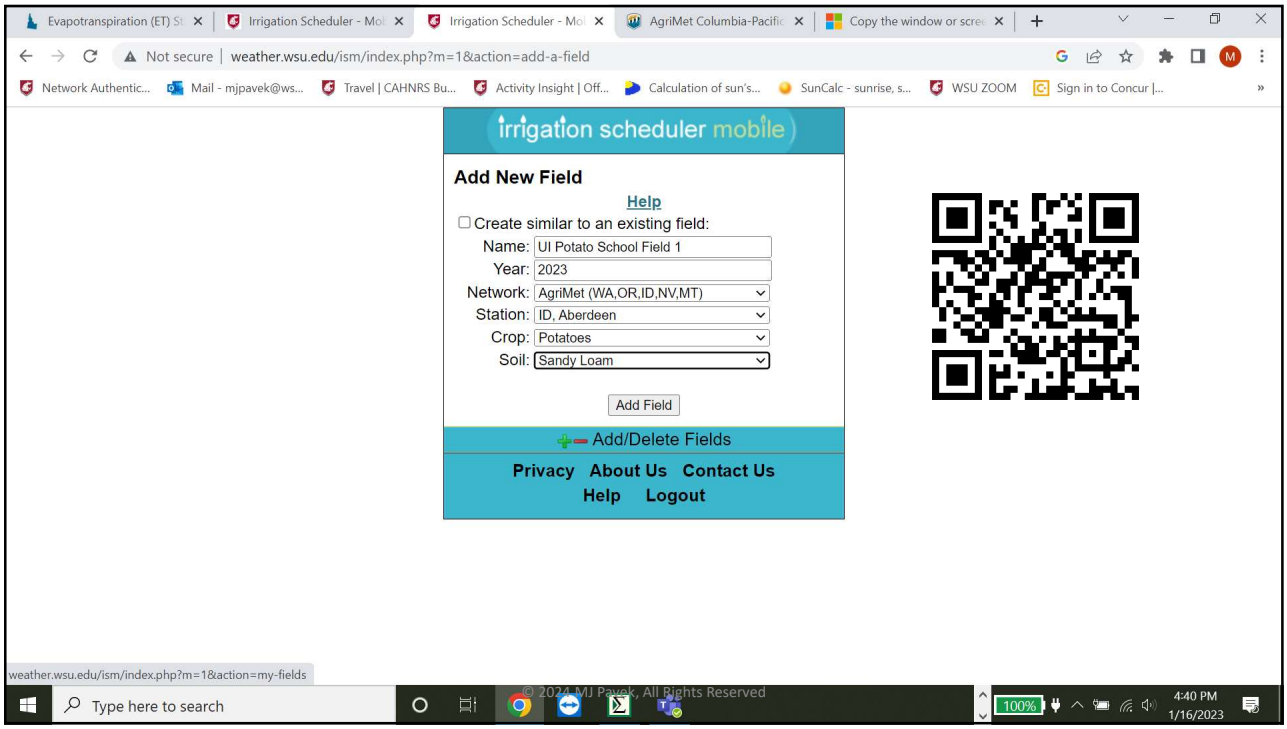
22


Not secure | weather.wsu.edu/ism/index.php?m=1&action=general-setting
irrigation scheduler mobile
Login
Using your AgWeatherNet account.
Username:
Password:
Remember me
Login
Forgot Username?
Forgot Password?
Register
In order to use the irrigation scheduler, please register for an AgWeatherNet account which can be used to log in.
Privacy About Us Contact Us
Help Log In
weather.wsu.edu/ism/index.php?m=1
Type here to search
4:38 PM
1/16/2023

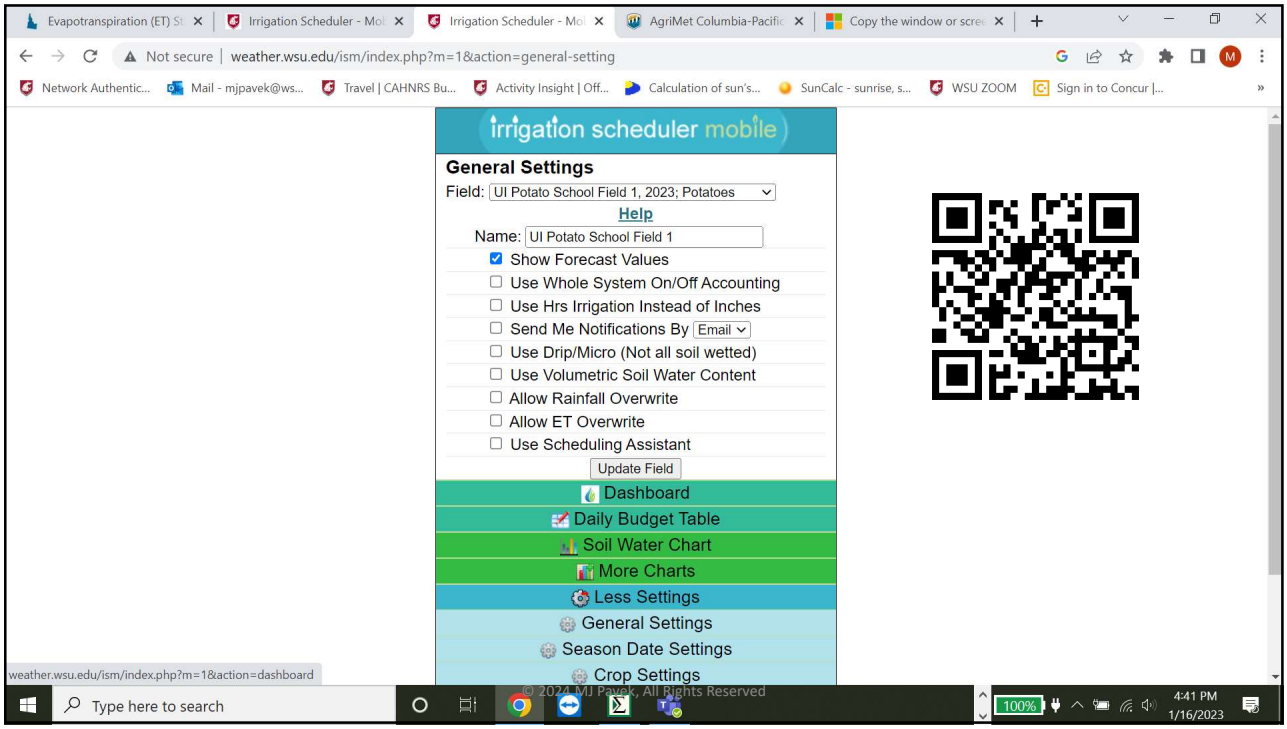
23


Not secure | weather.wsu.edu/ism/index.php?m=1&action=my-fields
irrigation scheduler mobile
Manage Fields
Field: Select a Field
Add New Field
Help
Add/Delete Fields
Privacy About Us Contact Us
Help Logout
Type here to search
4:39 PM
1/16/2023

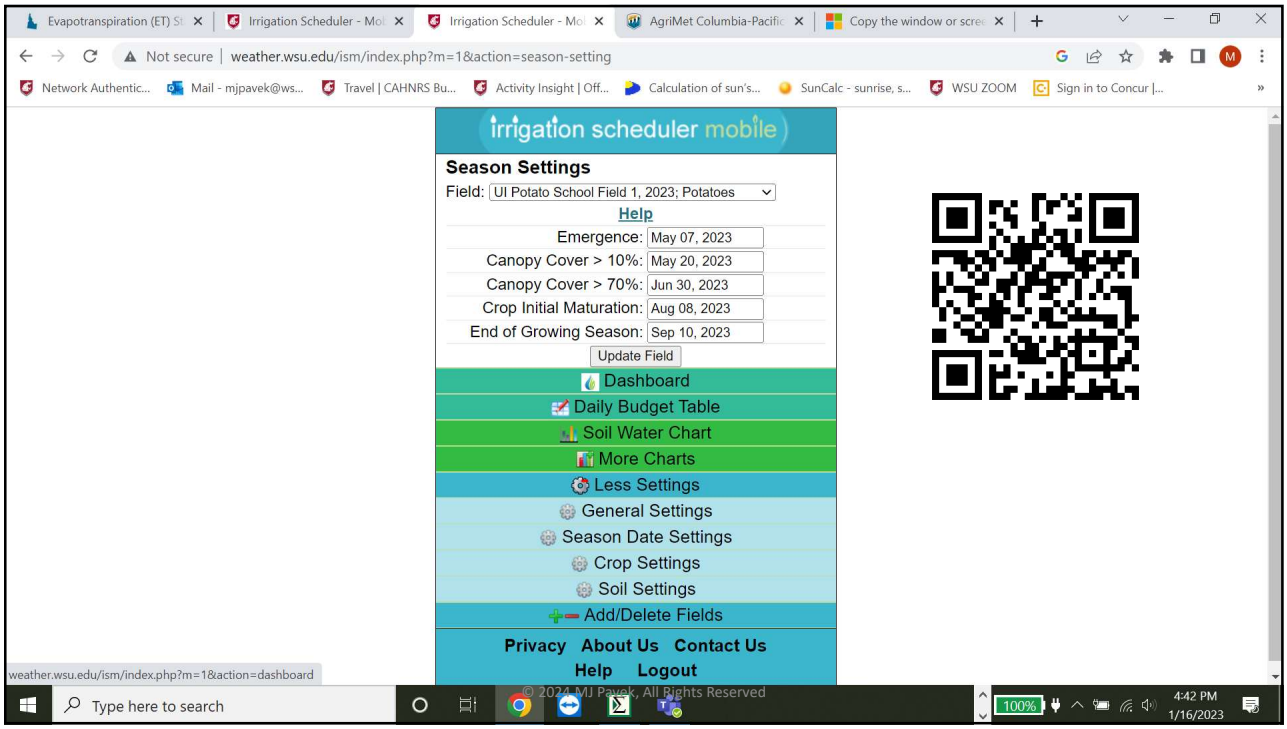
24


irrigation scheduler mobile
Add New Field
Help
Create similar to an existing field:
Name: UI Potato School Field 1
Year: 2023
Network: AgriMet (WA,OR,ID,NV,MT)
Station: ID, Aberdeen
Crop: Potatoes
Soil: Sandy Loam
Add Field
Add/Delete Fields
Privacy About Us Contact Us
Help Logout
weather.wsu.edu/ism/index.php?m=1&action=add-a-field
weather.wsu.edu/ism/index.php?m=1&action=my-fields
Type here to search
4:40 PM
1/16/2023

25


irrigation scheduler mobile
General Settings
Field: UI Potato School Field 1, 2023; Potatoes
Help
Name: UI Potato School Field 1
Show Forecast Values
Use Whole System On/Off Accounting
Use Hrs Irrigation Instead of Inches
Send Me Notifications By Email
Use Drip/Micro (Not all soil wetted)
Use Volumetric Soil Water Content
Allow Rainfall Overwrite
Allow ET Overwrite
Use Scheduling Assistant
Update Field
Dashboard
Daily Budget Table
Soil Water Chart
More Charts
Less Settings
General Settings
Season Date Settings
Crop Settings
weather.wsu.edu/ism/index.php?m=1&action=dashboard
Type here to search
4:41 PM
1/16/2023

26


irrigation scheduler mobile
Season Settings
Field: UI Potato School Field 1, 2023; Potatoes
Help
Emergence: May 07, 2023
Canopy Cover > 10%: May 20, 2023
Canopy Cover > 70%: Jun 30, 2023
Crop Initial Maturation: Aug 08, 2023
End of Growing Season: Sep 10, 2023
Update Field
Dashboard
Daily Budget Table
Soil Water Chart
More Charts
Less Settings
General Settings
Season Date Settings
Crop Settings
Soil Settings
Add/Delete Fields
Privacy About Us Contact Us
Help Logout
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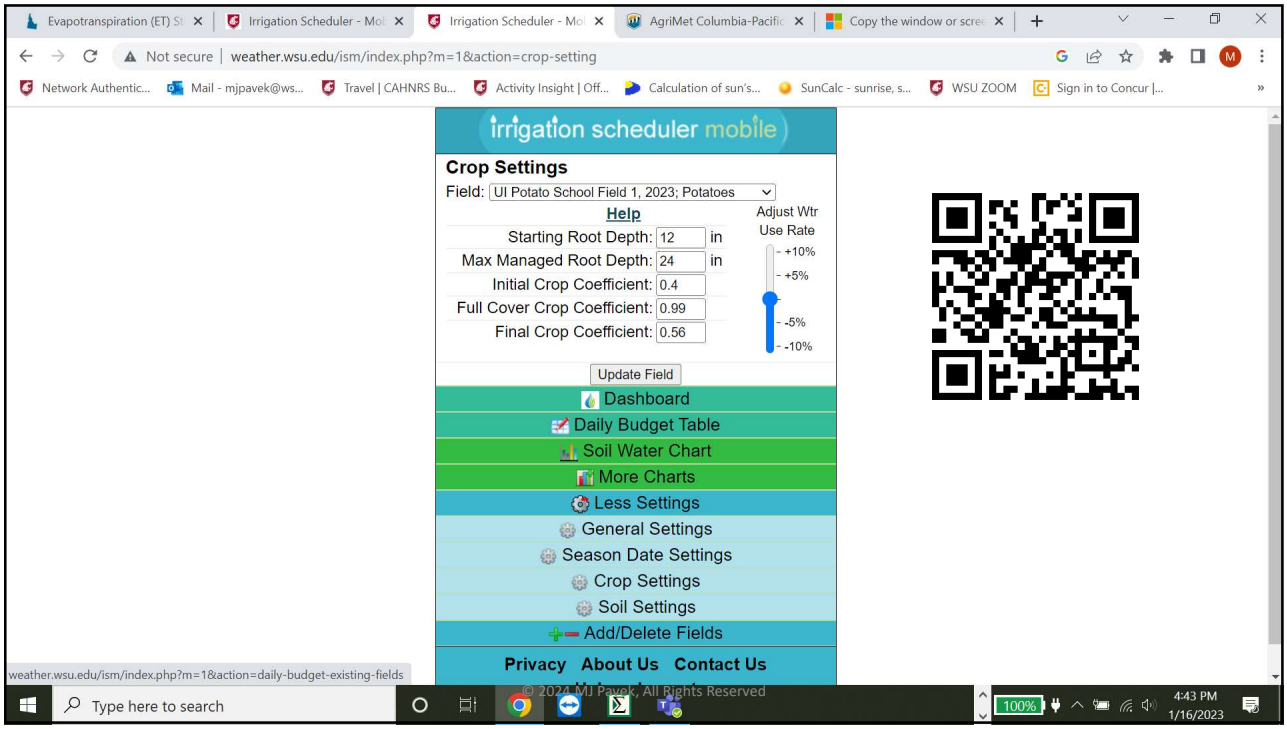
irrigation scheduler mobile
Crop Settings
Field: UI Potato School Field 1, 2023; Potatoes
Help
Adjust Wtr Use Rate
+10%
+5%
-5%
-10%
Starting Root Depth: 12 in
Max Managed Root Depth: 24 in
Initial Crop Coefficient: 0.4
Full Cover Crop Coefficient: 0.99
Final Crop Coefficient: 0.56
Update Field
Dashboard
Daily Budget Table
Soil Water Chart
More Charts
Less Settings
General Settings
Season Date Settings
Crop Settings
Soil Settings
Add/Delete Fields
Privacy About Us Contact Us
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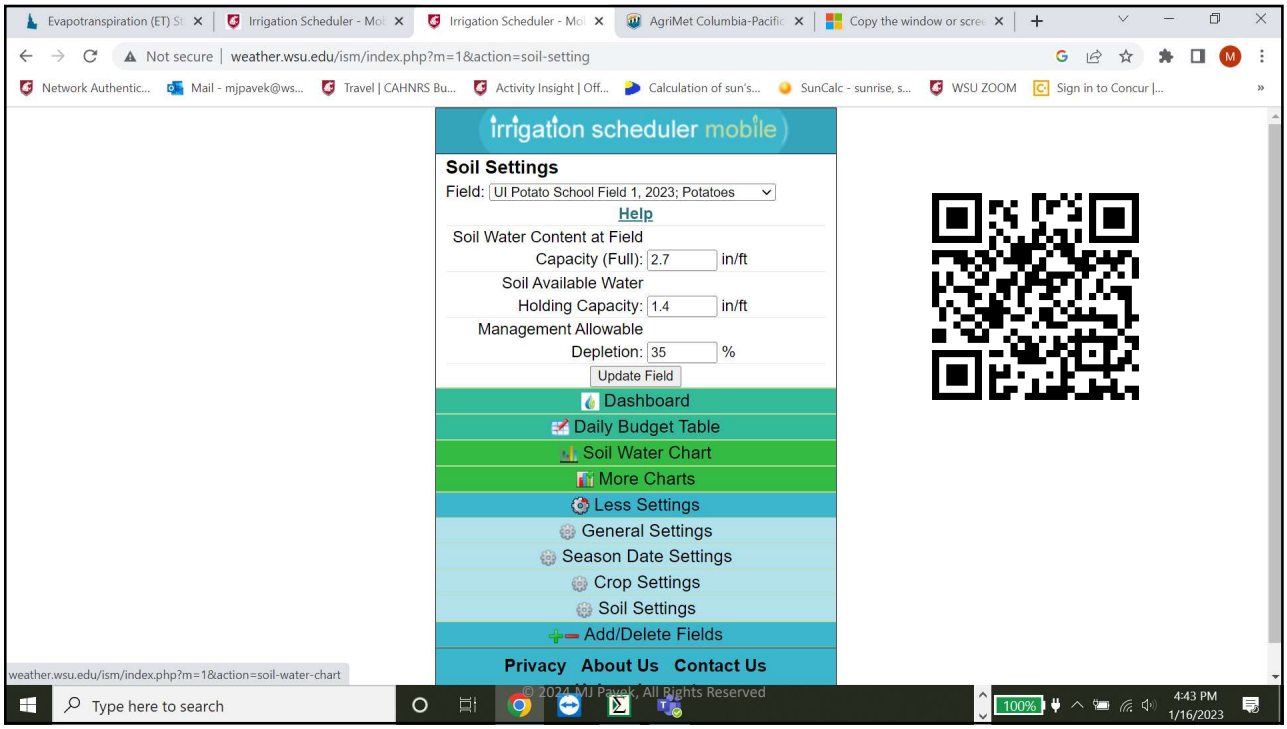

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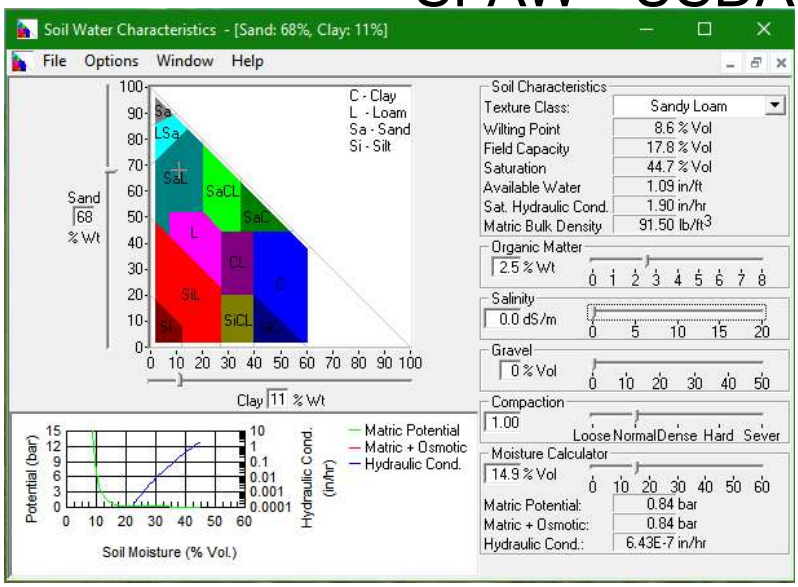
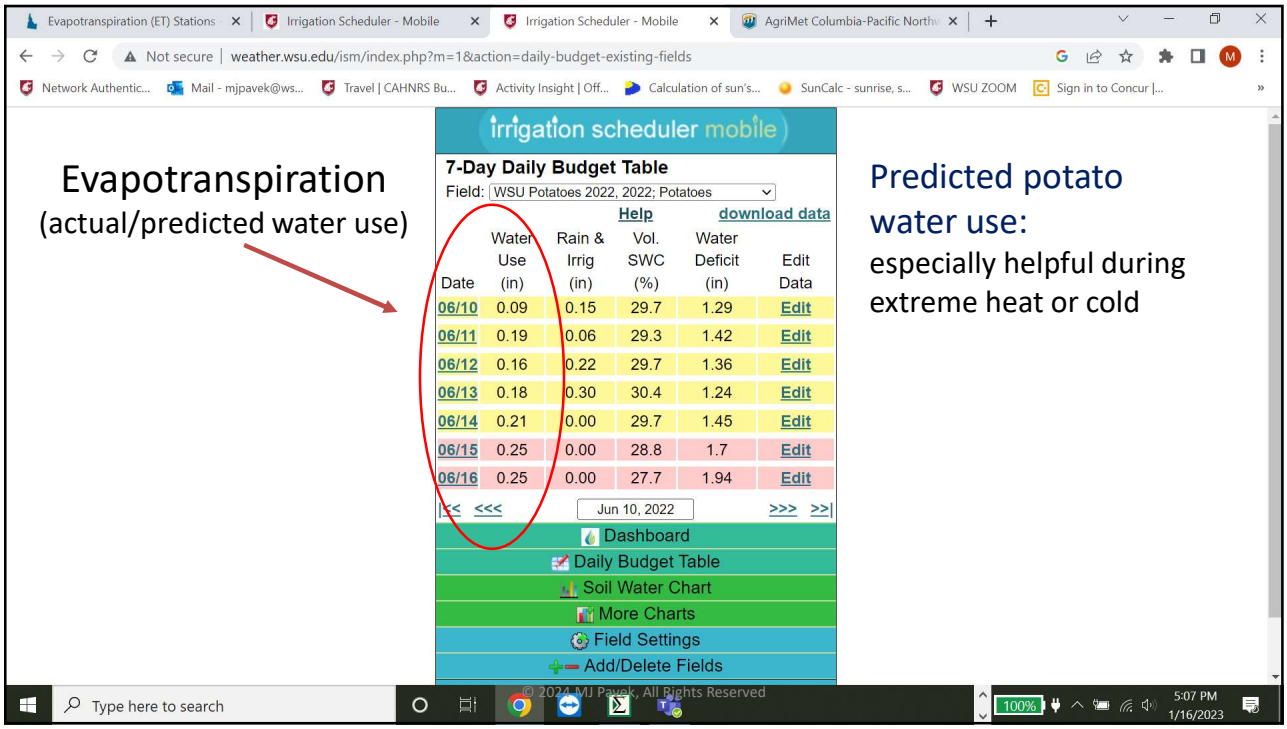
Determining soil-water characteristic SPAW - USDA



Soil Texture	Soil Water Content (in/ft) Field Capacity	Wilting Point	AWC
Coarse Sand	1.2	0.6	0.7
Fine Sand	1.5	0.7	0.8
Loamy Sand	2.2	1.2	1.0
Sandy Loam	2.7	1.3	1.4
Fine Sandy Loam	3.4	1.6	1.8
Sandy Clay Loam	4.0	2.0	2.0
Loam	4.0	1.8	2.2
Silt Loam	4.3	2.0	2.3
Silty Clay Loam	4.6	2.8	1.8
Clay Loam	4.8	3.0	1.8
Silty Clay	4.8	3.2	1.6
Clay	4.8	3.4	1.4
Peat Mucks	5.0	2.6	2.4

30


Evapotranspiration (ET) Stations
Irrigation Scheduler - Mobile
Irrigation Scheduler - Mobile
AgriMet Columbia-Pacific Northw
Not secure | weather.wsu.edu/ism/index.php?m=1&action=daily-budget-existing-fields
Network Authentic...
Mail - mjpavek@ws...
Travel | CAHNRS Bu...
Activity Insight | Off...
Calculation of sun's...
SunCalc - sunrise, s...
WSU ZOOM
Sign in to Concur |...
Evapotranspiration
(actual/predicted water use)
irrigation scheduler mobile
7-Day Daily Budget Table
Field: WSU Potatoes 2022, 2022; Potatoes
Help
download data
Date
Water Use (in)
Rain & Irrig (in)
Vol. SWC (%)
Water Deficit (in)
Edit Data
06/10 0.09 0.15 29.7 1.29 Edit
06/11 0.19 0.06 29.3 1.42 Edit
06/12 0.16 0.22 29.7 1.36 Edit
06/13 0.18 0.30 30.4 1.24 Edit
06/14 0.21 0.00 29.7 1.45 Edit
06/15 0.25 0.00 28.8 1.7 Edit
06/16 0.25 0.00 27.7 1.94 Edit
|<< <<< Jun 10, 2022 >>> >>|
Dashboard
Daily Budget Table
Soil Water Chart
More Charts
Field Settings
Add/Delete Fields
Predicted potato water use:
especially helpful during extreme heat or cold
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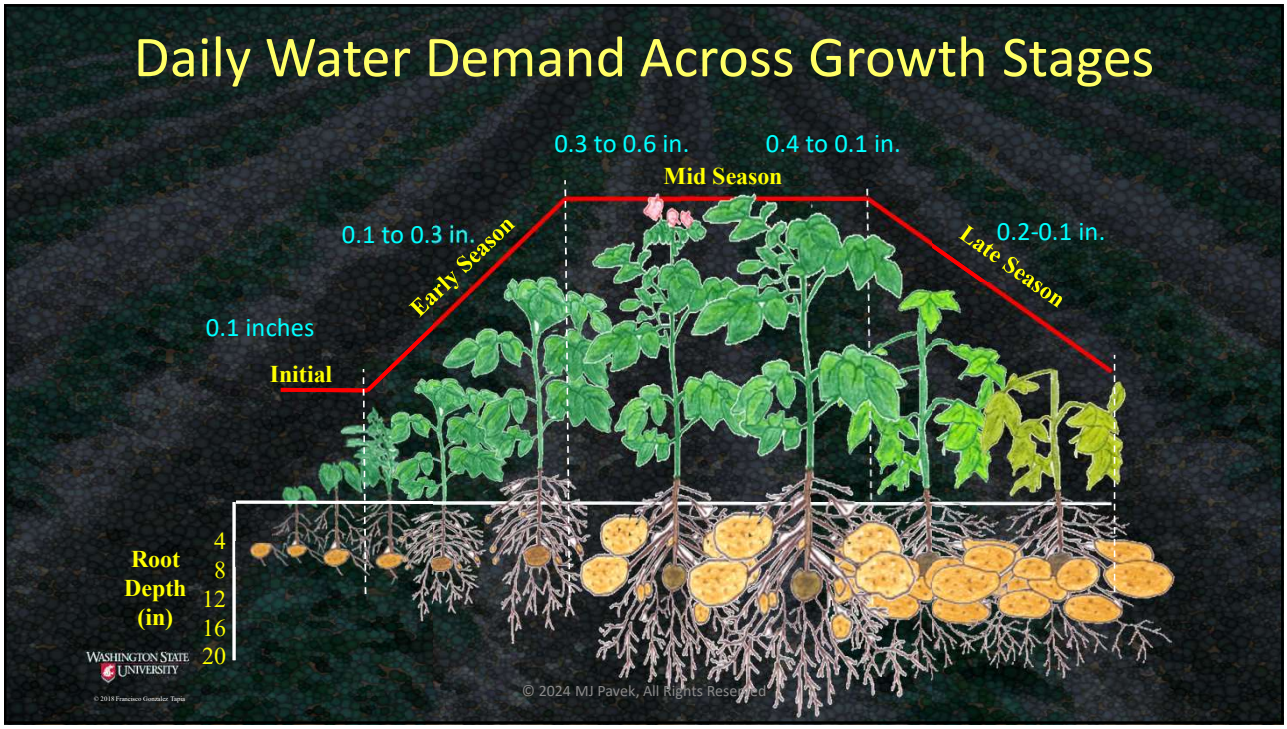
Type here to search
100%
5:07 PM
1/16/2023

31


Daily Water Demand Across Growth Stages
0.3 to 0.6 in.
0.4 to 0.1 in.
Mid Season
0.1 to 0.3 in.
Early Season
0.2-0.1 in.
Late Season
0.1 inches
Initial
Root Depth (in)
4
8
12
16
20
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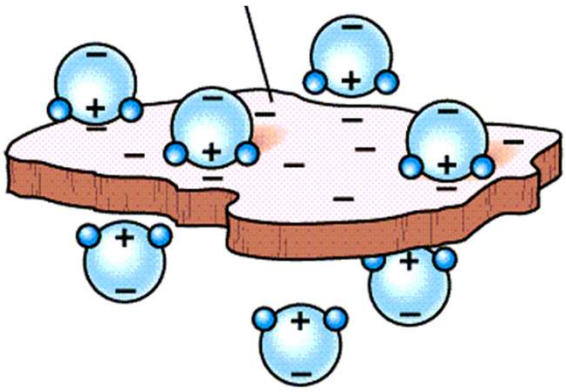
Two methods for measuring soil water status

Volumetric water content (VWC)

- Soil water content used interchangeably
- Percent of water in set volume of soil
- Convert **VWC** to **In/Ft,** = VWC*12

Soil water potential (tension/suction)

- The energy required by the plant to take up the water from the soil
- A measure of the energy by which water is being held by the soil



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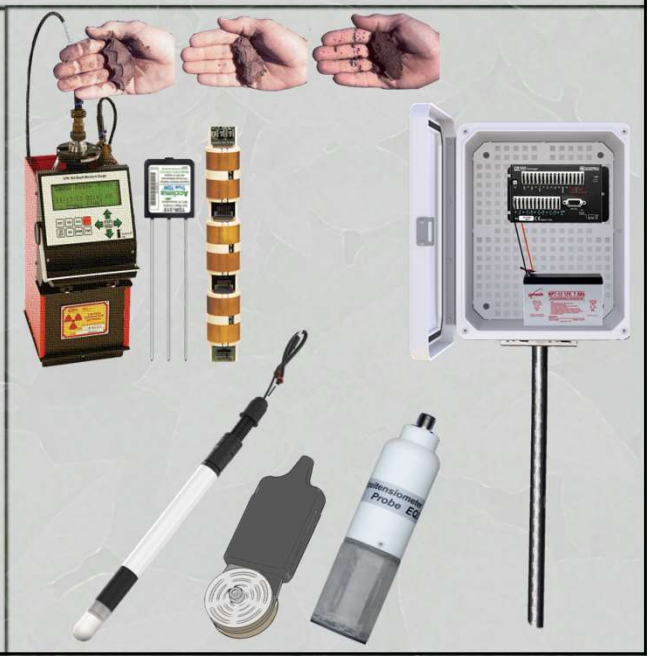
MEASURING SOIL WATER STATUS

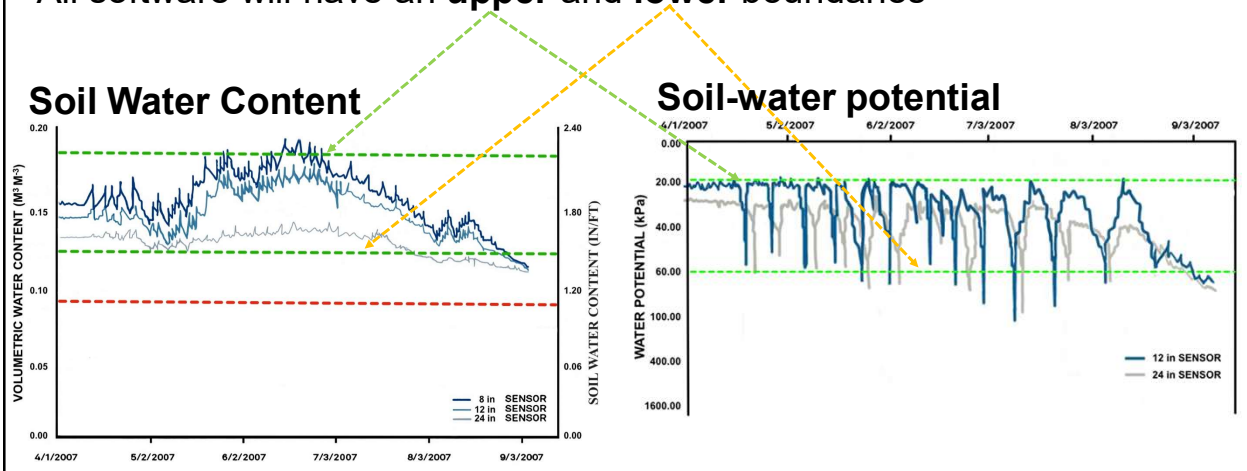
1. Two main approaches
   - A. Volumetric Water Content
     - a) "Hand-Feel" Method
     - b) "Oven" Method
     - c) Neutron Probe
     - d) Time Domain Reflectometry
     - e) Capacitance Probe
   - B. Soil Water Potential
     - a) Tensiometers
     - b) Capacitance w/ calibrated media



34

Monitoring soil-water status software

- All software will have an **upper** and **lower** boundaries



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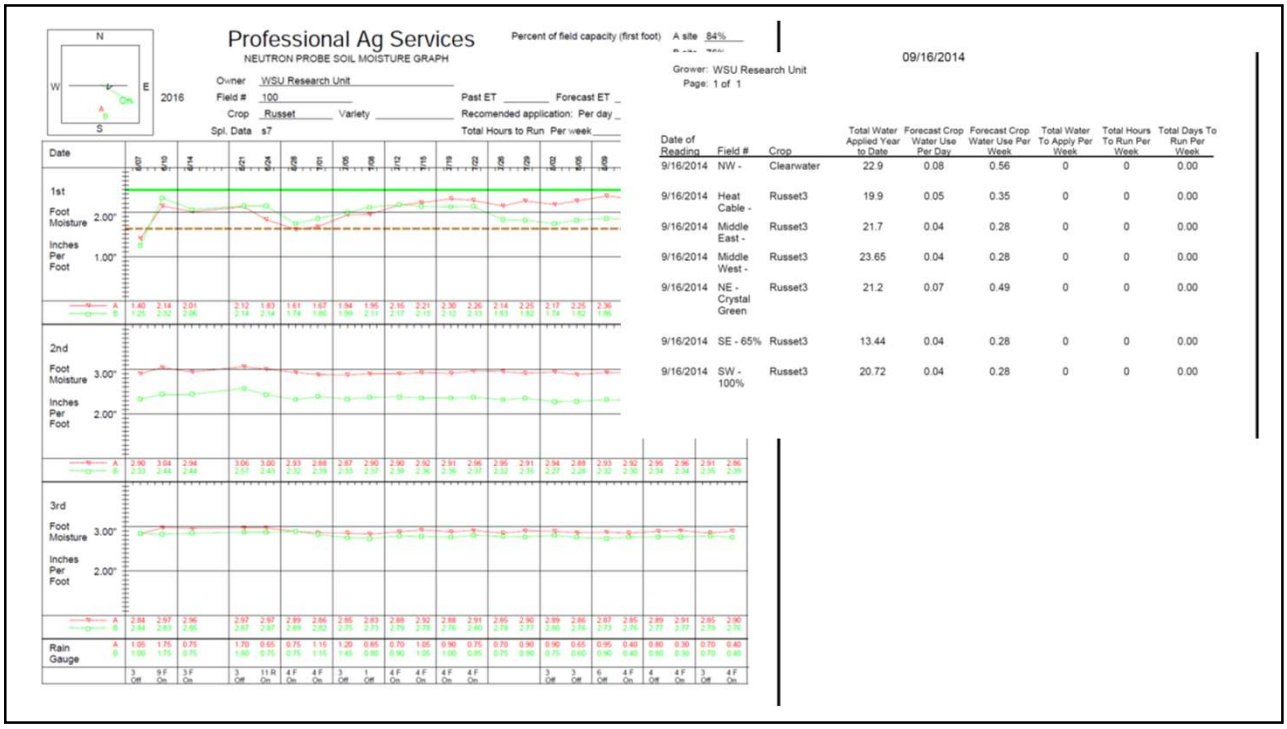

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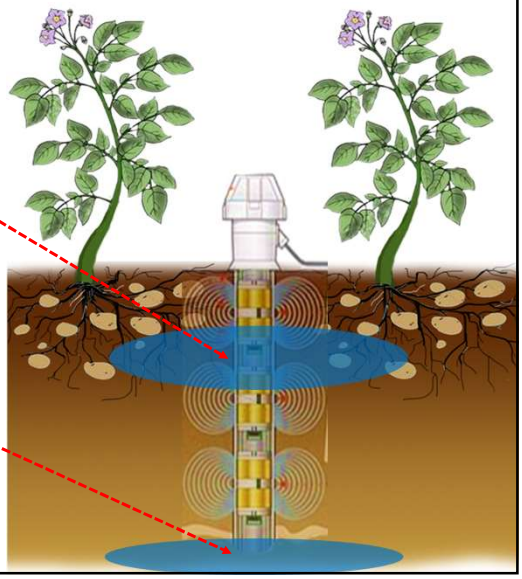
What depths to monitor?

- 1st depth: **10-12 in**
  - Most important - monitors 75% of root zone area
  - Provides insight into SWS conditions at the root zone
  - Most commonly used for irrigation scheduling
- 2nd depth: **18-24 in**
  - Provides insight into deep soil water loss – if there is an increase in SWS → over irrigation



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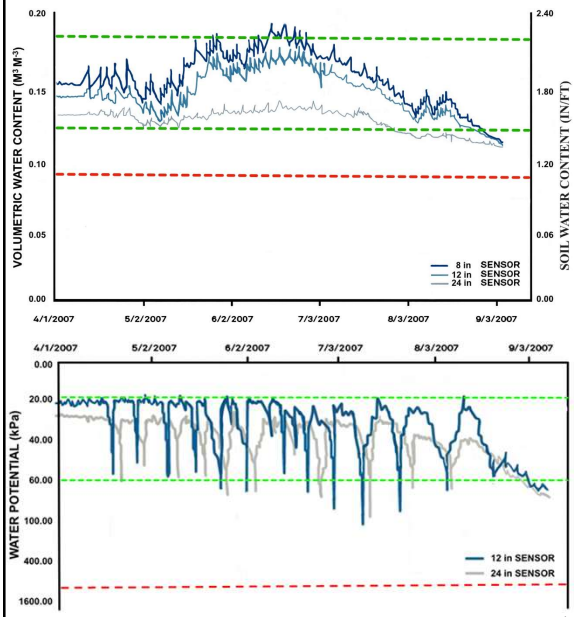
Optimum range for potatoes



- **Soil water content** = 65-100% soil's field capacity
  - Range is dependent on soil type – *more ahead*
- **Dry soil permanent wilting point?**
  - You should never be close
  - > 32% available soil water content
- **Soil water potential** = -50 to -30 kPa
  - Same for all soil types
  - *For reference, potato plants cannot assert tension/suction >1000 kPa -> **Permanent wilting point**

*Source: https://www.environmentalbiophysics.org/do-the-standards-for-field-capacity-and-permanent-wilting-point-need-to-be-reexamined/

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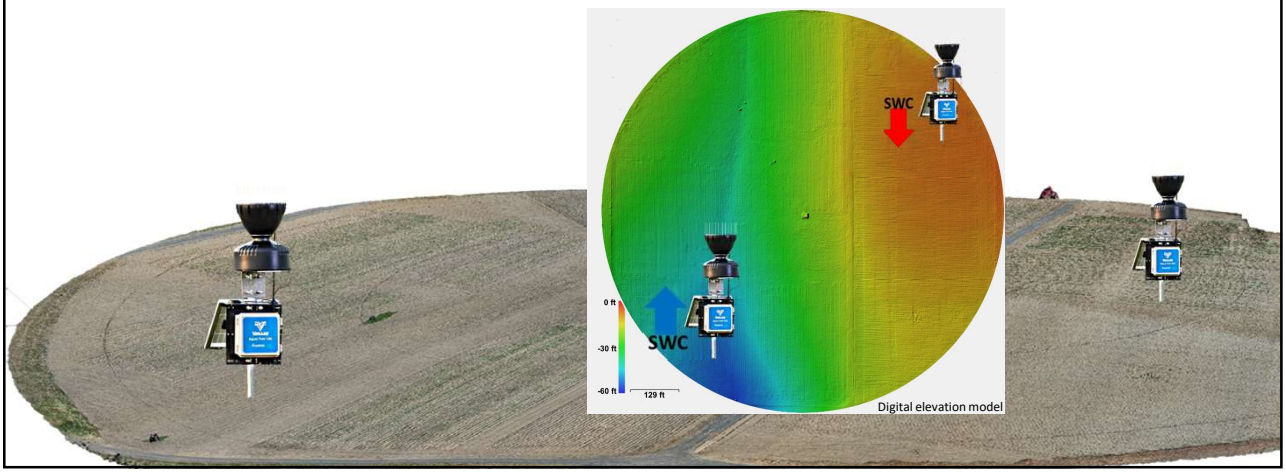
How many sampling locations per field?

- At least two – more is better – improve accuracy in non-uniform fields
- SWS monitoring should represent the field's soil type and topography conditions



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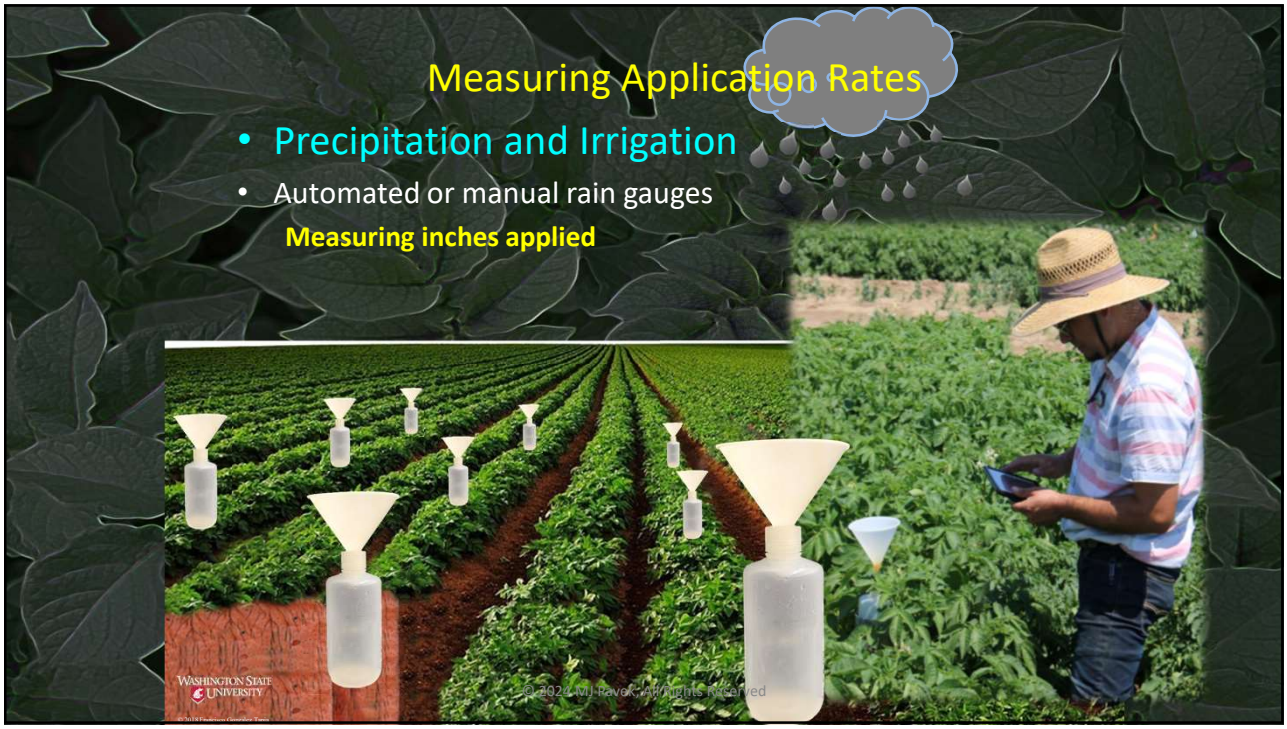

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Narrow it Down - Keep it Simple

Ideal Potato Water Management

- Maintain irrigation equipment
- Calibrate equipment, measure output
- Prime your soil early, anticipate rapid growth
- Real time soil moisture values
  - Volumetric (soil water content)
  - Soil water potential
- Predicted ET
- Rain gauges to record actual application levels
- Field visits

- Management, management, management

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Questions?

- Should I err on the side of too much or too little irrigation, and why?
- What is the best way to keep a potato crop cool during high heat events?
- Explain how you would irrigate during extreme heat
- Explain plant transpiration and how it relates to evapotranspiration
- Complete this sentence: excessive irrigation can lead to…

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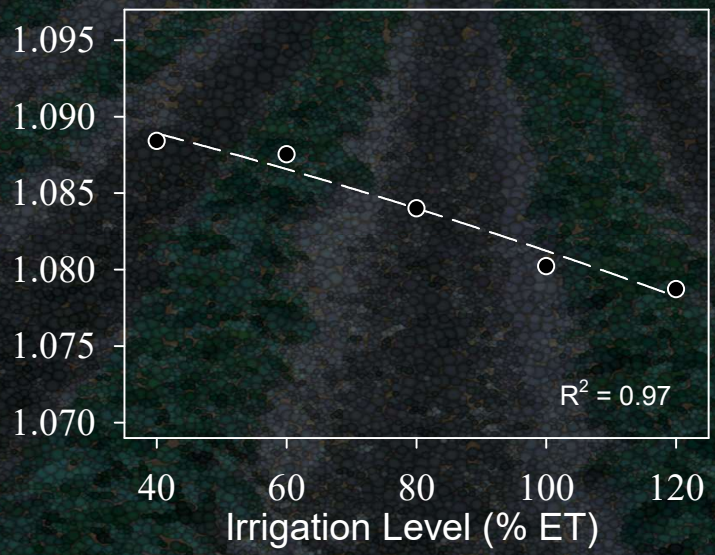
Specific Gravity as Affected by Irrigation Rate

averaged across Alturas, Clearwater R., Ranger R. R. Burbank, Umatilla R., 2018-2020



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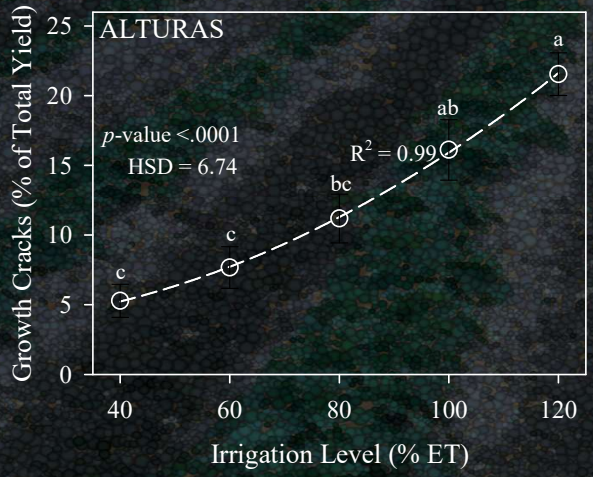
Excessive Late Season Irrigation Increases Growth Cracks



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Avoid Excessive Late-Season Irrigation (cont.)

- Alturas Fry Color fried 90 days after harvest (DAH)

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Swollen Lenticels from Excessive Soil Moisture Act as Open Wounds Allowing Pathogens to enter

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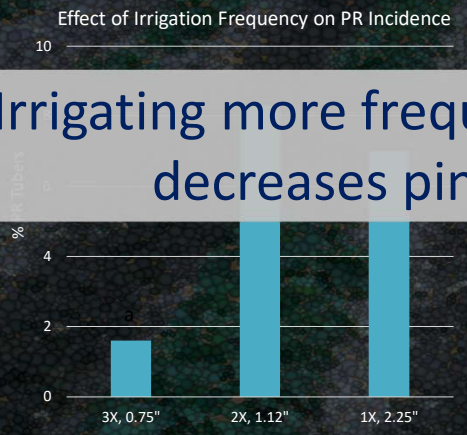
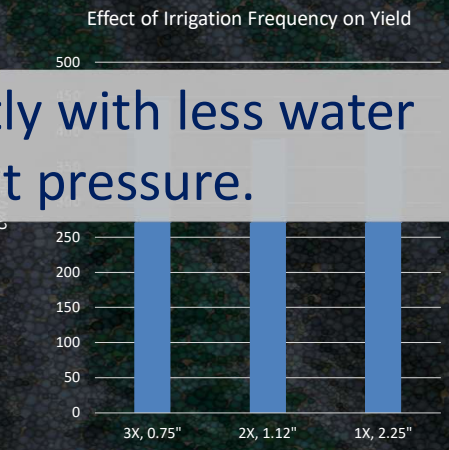
More Frequent Irrigation Cycles reduce Pink Rot





Irrigating more frequently with less water decreases pink rot pressure.

Miller Research 2010, with natural infection.

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Excessive Irrigation Leads to Early Vine Death and Rot

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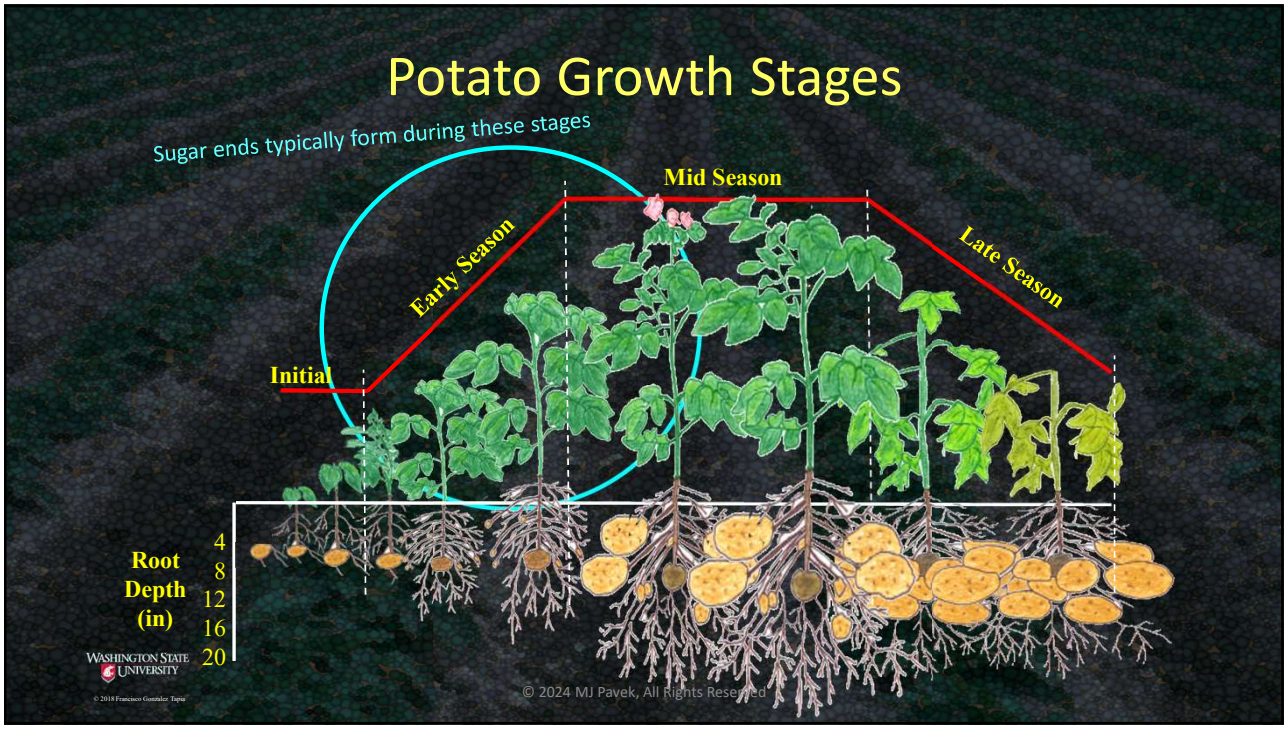
Potato Growth Stages
Sugar ends typically form during these stages
Mid Season
Early Season
Late Season
Initial
Root Depth (in)
4
8
12
16
20
WASHINGTON STATE UNIVERSITY
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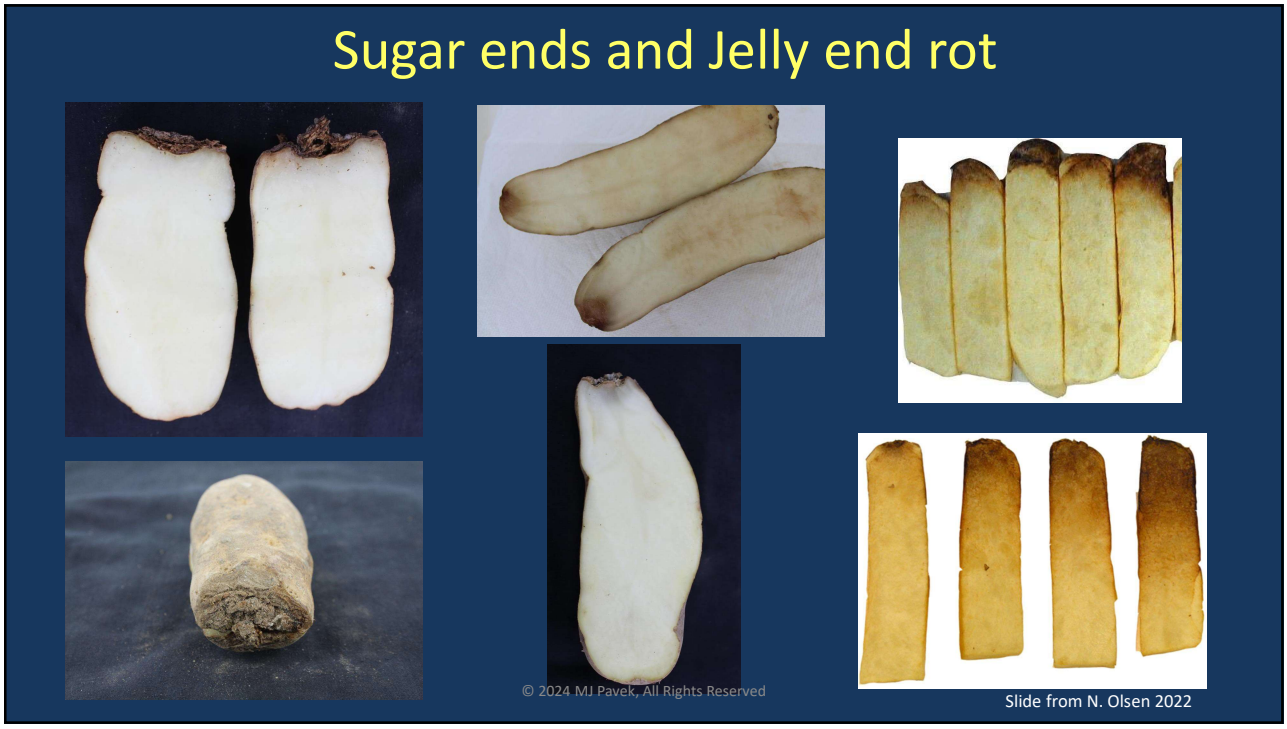
Sugar ends and Jelly end rot
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Slide from N. Olsen 2022

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Sugar Ends: Conditions conducive to the development of sugar ends includes stress from high soil temperatures, transitory soil moisture deficits, and insufficient or excess nitrogen fertilization.

Treatment	#1 (%)	Specific Gravity	Sugar Ends (%)
Control (amb.)	69	1.081	4
Low moisture	53	1.082	0
Low moisture + heat	37	1.071	33
High moisture + heat	39	1.068	23

From Kleinkopf et al. 1988

Slide from N. Olsen 2022

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- Washington State Potato Commission
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    - USDA-ARS, Prosser

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