How to Reduce Water Usage without Affecting Yield on Berry Crops

Camilo Souto E.

Assistant Professor[1] ; Courtesy Faculty[2]

[1] Department of Water Resources, University of Concepción, Chile

[2] Department of Horticulture, Oregon State University, Corvallis, OR 97331, USA

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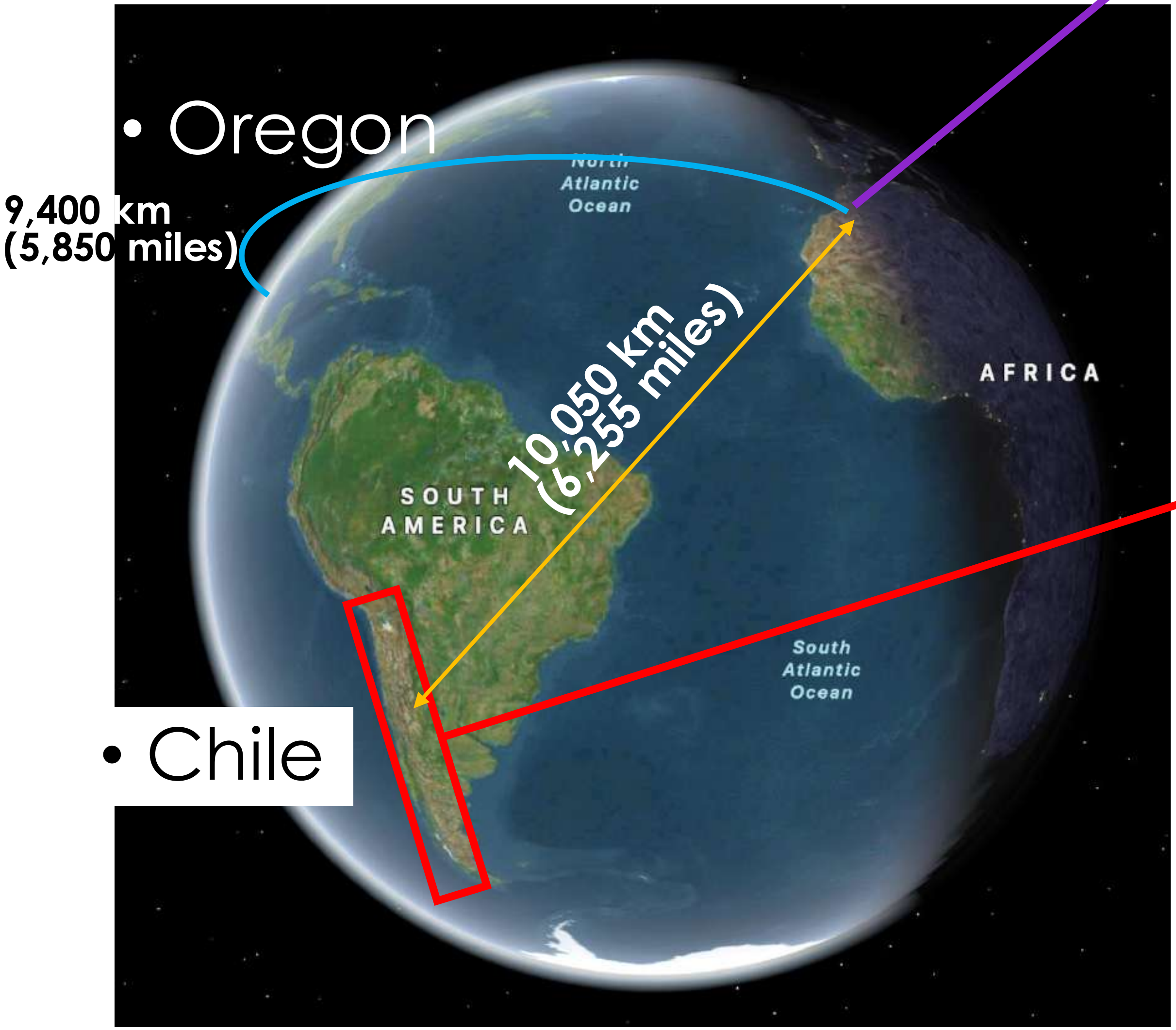
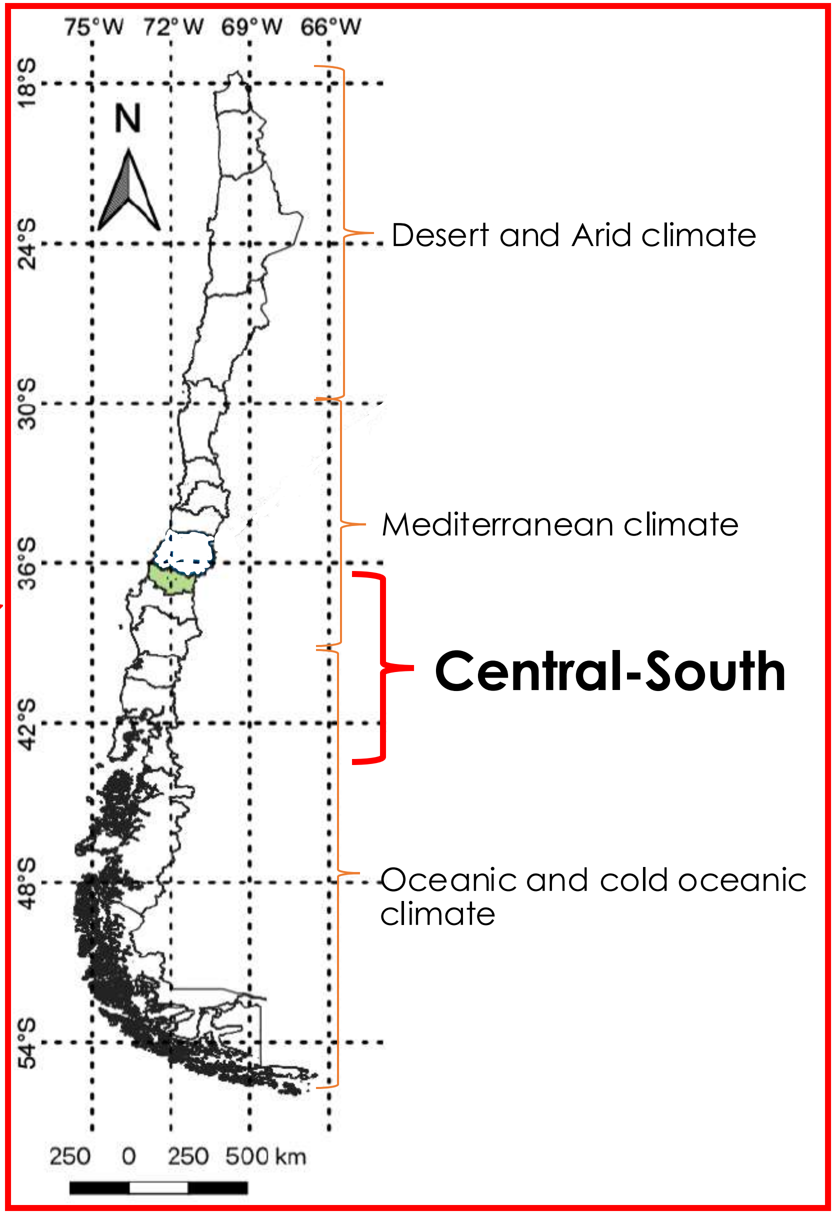
Where is Chile?

- Morocco

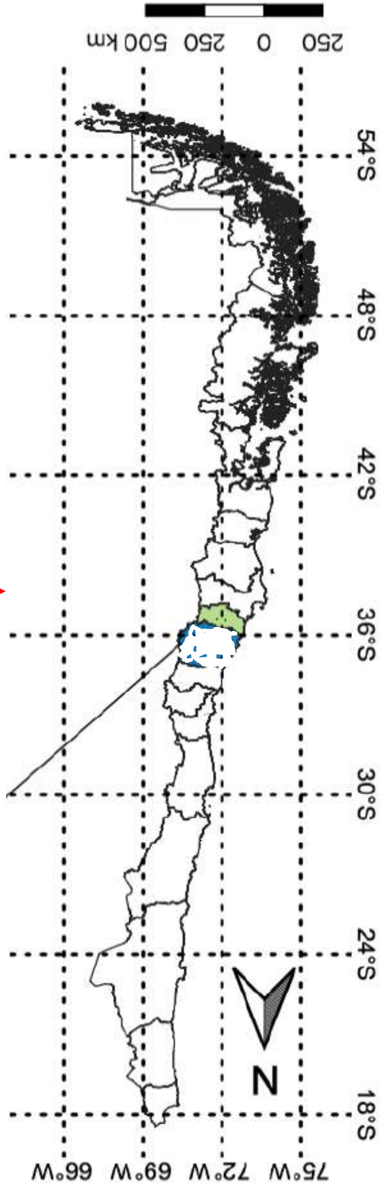


- Chile



How geographically long is Chile?

Rotation



Climate...

Similar to North of Spain

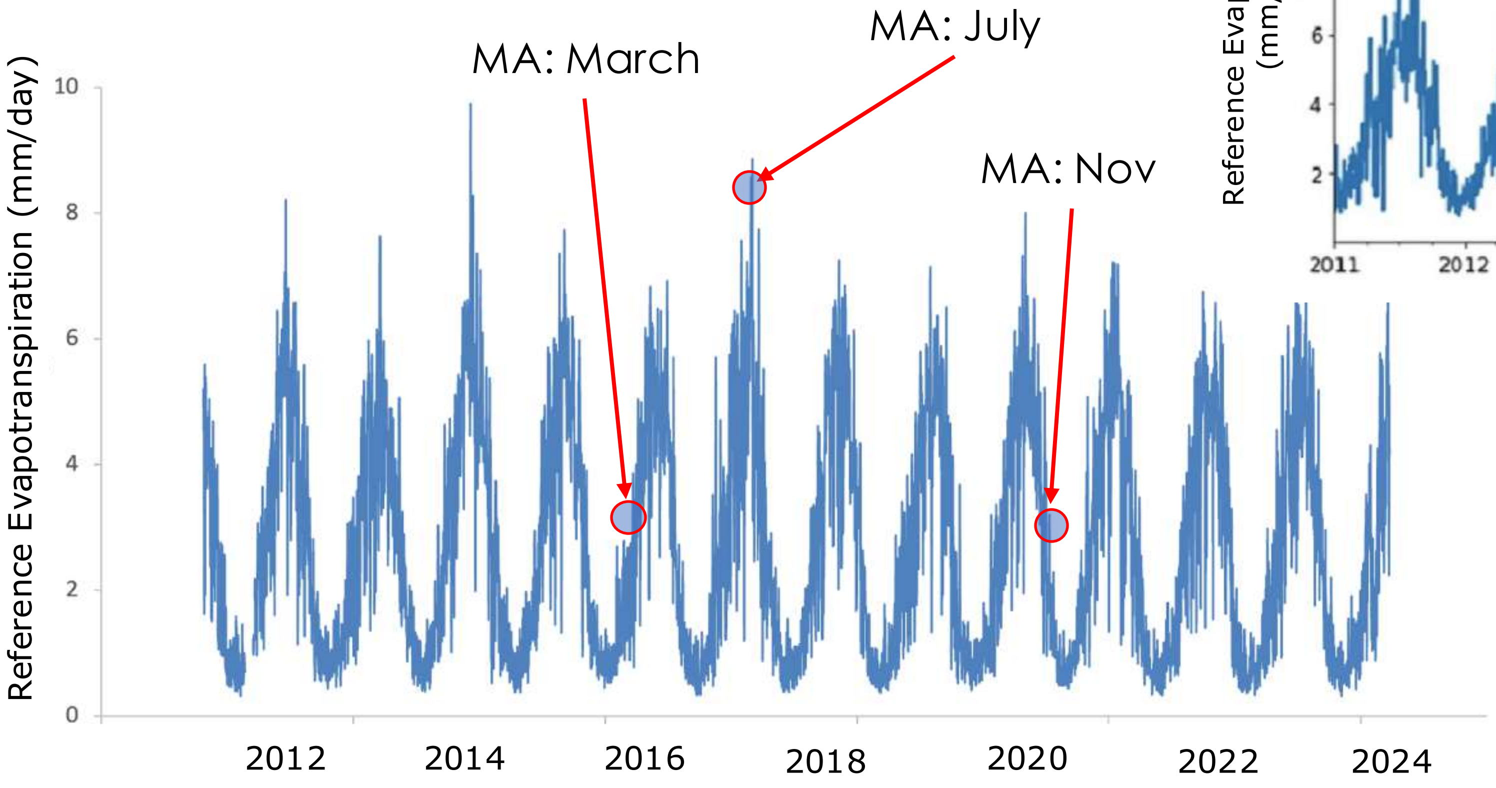
Similar to part of
Spain and Portugal

Similar to North and North-
Central of **Morocco**

Similar to the south and
South-Central of **Morocco**

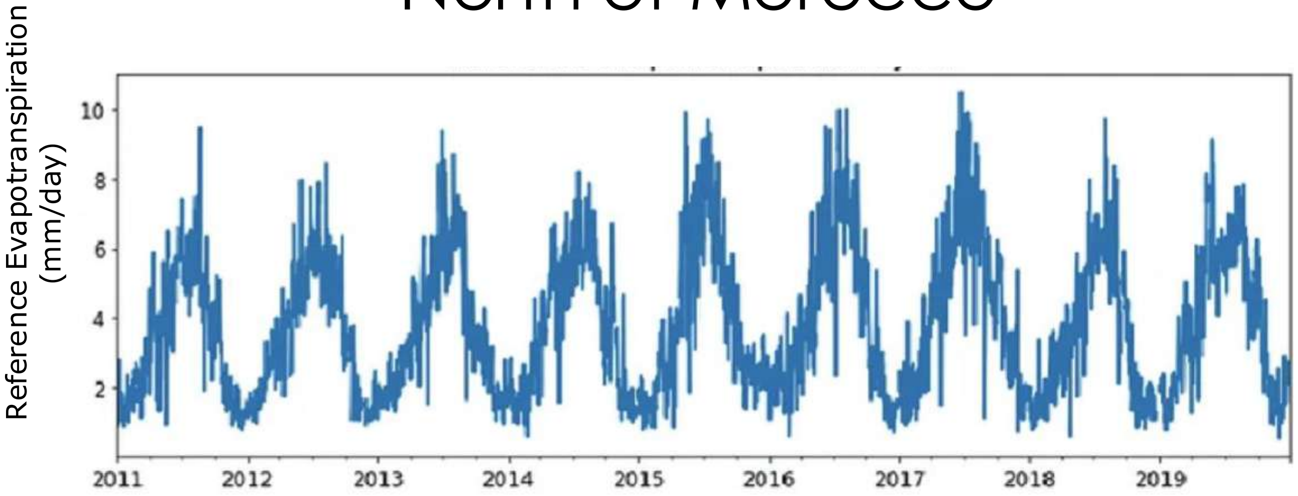
Reference evapotranspiration similitude

Central-South, Chile



Source data: [Agrometeorological Network INIA -Chile]

North of Morocco



Source data: https://link.springer.com/chapter/10.1007/978-3-031-29860-8_11

Outline

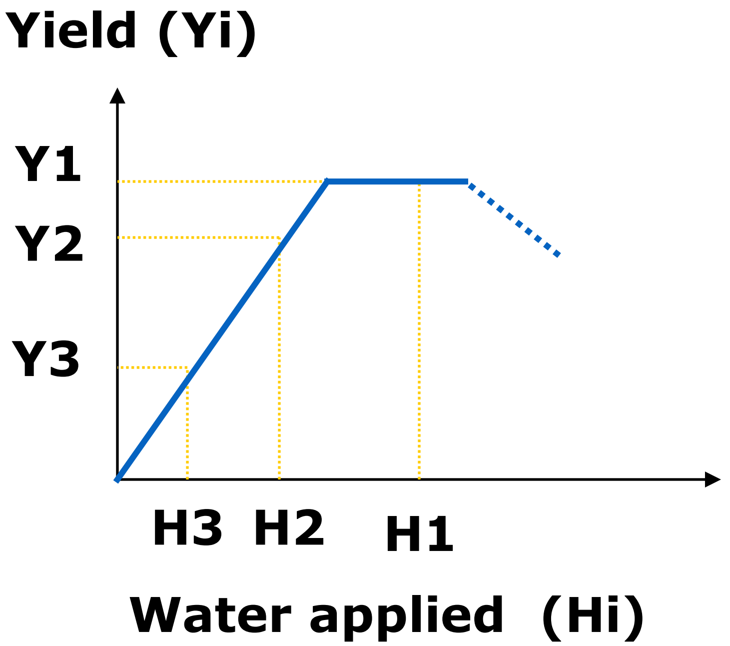
1. **Importance of water management in berries.**
2. **Water management studies in soil and substrate update.**
3. **Learnings from Irrigation Water Management.**
4. **Adaptation to SHB growing systems in growing regions as Morocco.**
5. **Example of strategies for substrate.**
6. **Examples for soil.**
7. **Future challenges.**
8. **Summary.**

1. Importance of water management in berries

- 70 – 80% → Freshwater withdrawals

- ET → Crop transpiration
  → Soil evaporation
  → Evaporation from Plant Canopy

→ Importance?



Why Do We Need to Irrigate?

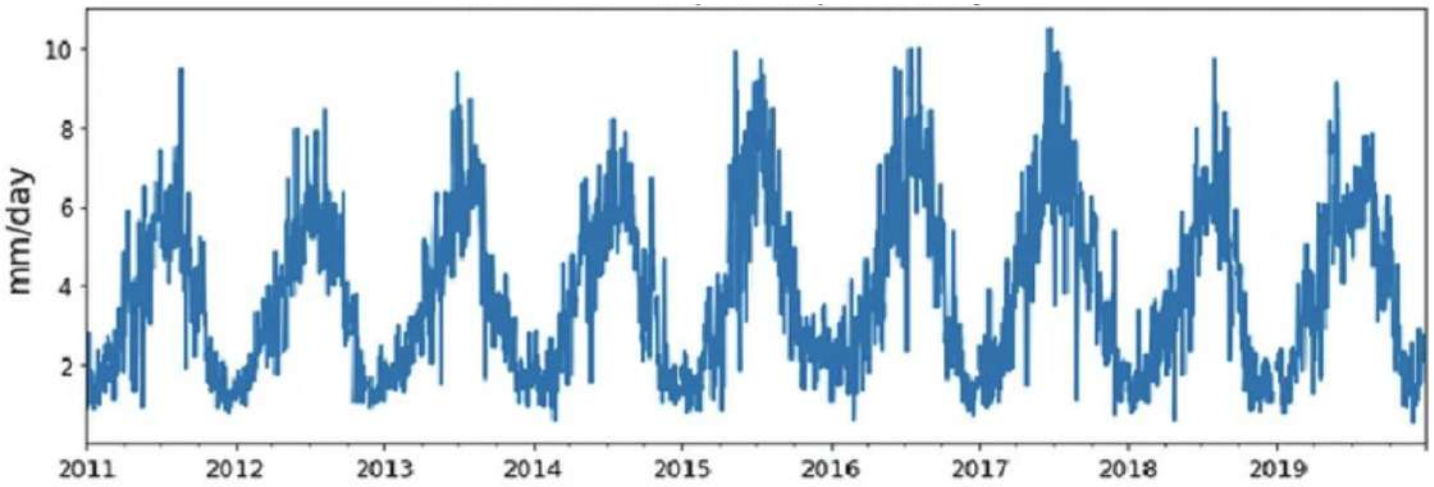
Morocco: Mediterranean and desert climates

- Rain in Winter (some times and depend of the location).
- Water Demand in Summer.

Consideration:

Agricultural production need IRRIGATION.

North of Morocco



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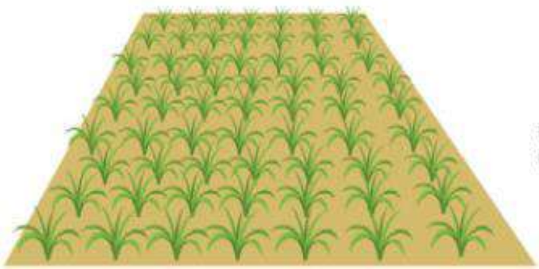
How can estimate irrigation water requirements?

Climate

+

Solar radiation (Rs), air temperature (Ta), wind speed (u), and relative humidity (RH)

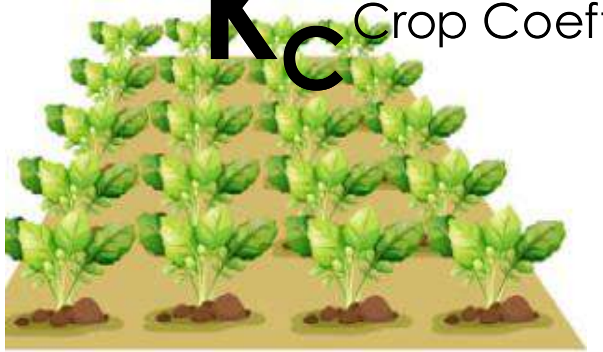


Grass Reference Surface

= **Penman-Monteith Equation** = ET_o

Reference Crop Evapotranspiration

ET_o X K_c Crop Coefficient



Well-irrigated crops and optimal agronomic conditions

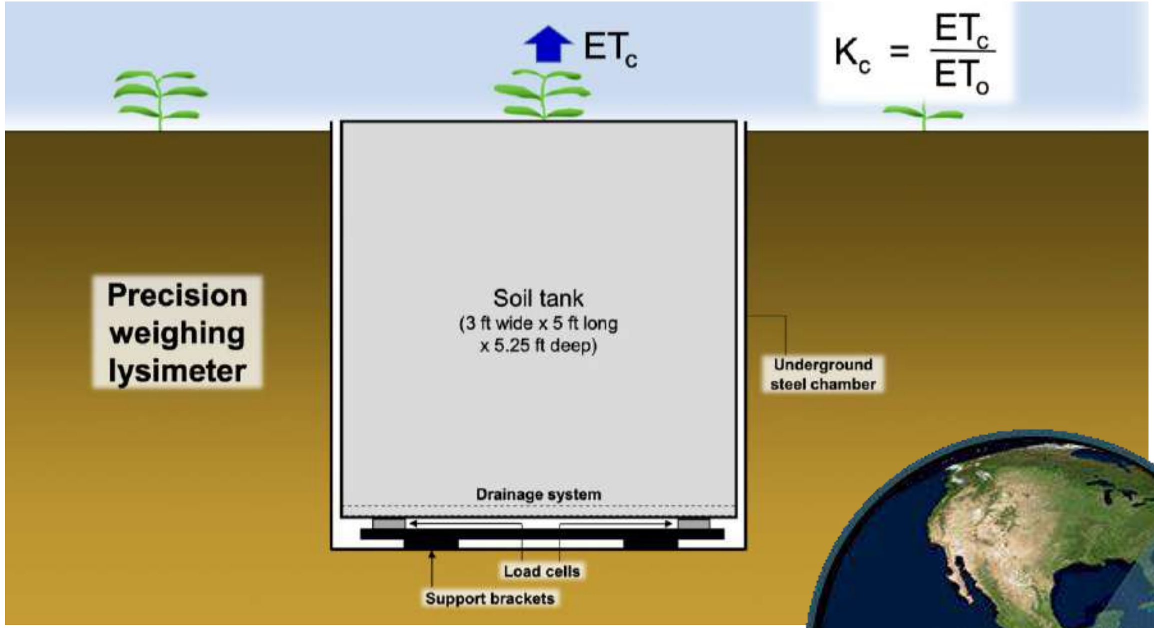
= ET_c

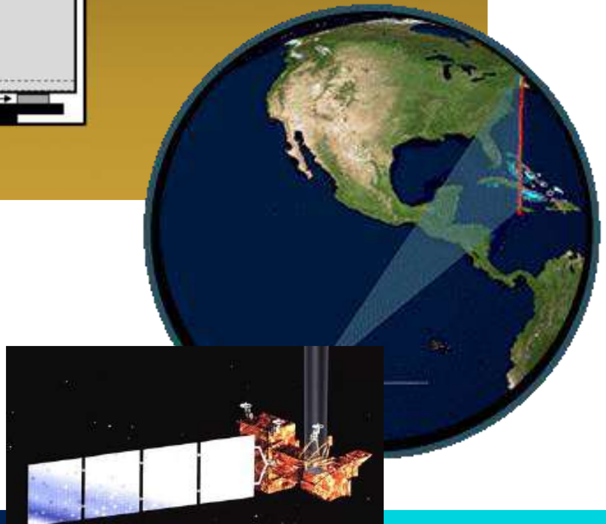
Crop Evapotranspiration

How to Develop Crop Coefficients?

In the past

Since 1970 …





Currently

Eddy Covariance System

Citrus, CA, USA.

Hazelnut, Chile.

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6. Examples for soil.
7. Future challenges.
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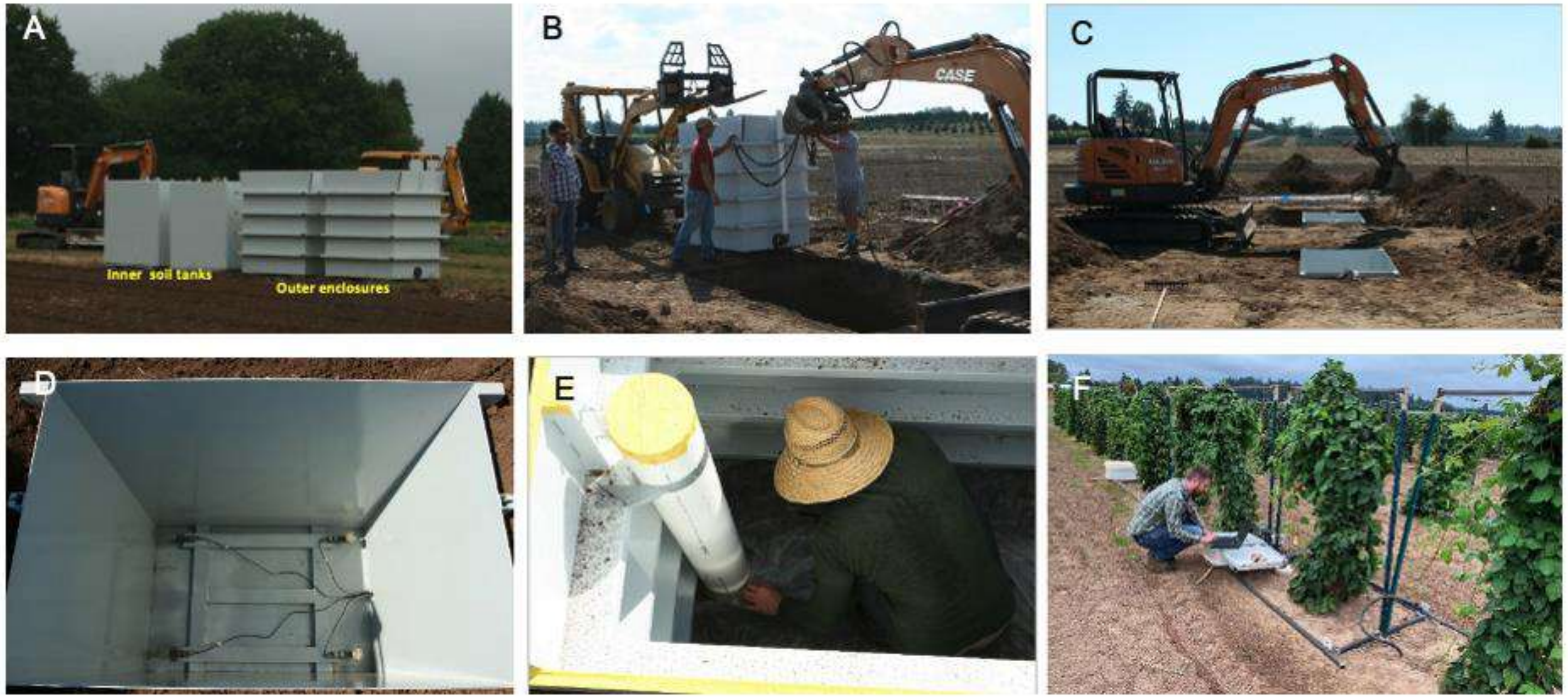
2. Water management studies in soil and substrate update.

In Berries?

North Willamette Valley, OR, USA.

Soil. Since 2020

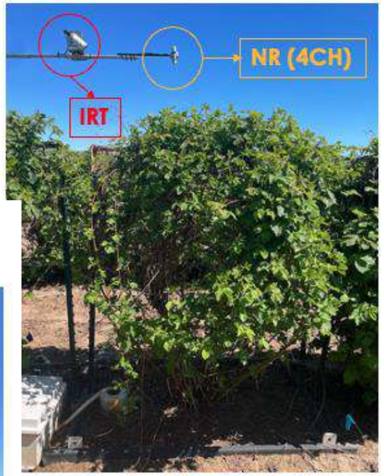
2024?



(A-E) Installation of the weighing lysimeters for 'Columbia Star' blackberry. (F) Crop evapotranspiration is measured continuously using data loggers.

LI-710 ET sensor

IRT and NR (4CH) sensors



Remote Sensing Measurements

Drone flights (Weekly or Bi-weekly)

In Berries?

Soil.

Since 2022

New Blueberry Orchards at the LB Farm.

Corvallis, OR, USA.

2024?

In Berries?

Substrate

A Research Trial on Practices for Improving Drip Irrigation of Blueberry in Substrate

2021

2022

2023

3. Learnings from Irrigation Water Management

Provide answers to three main questions:

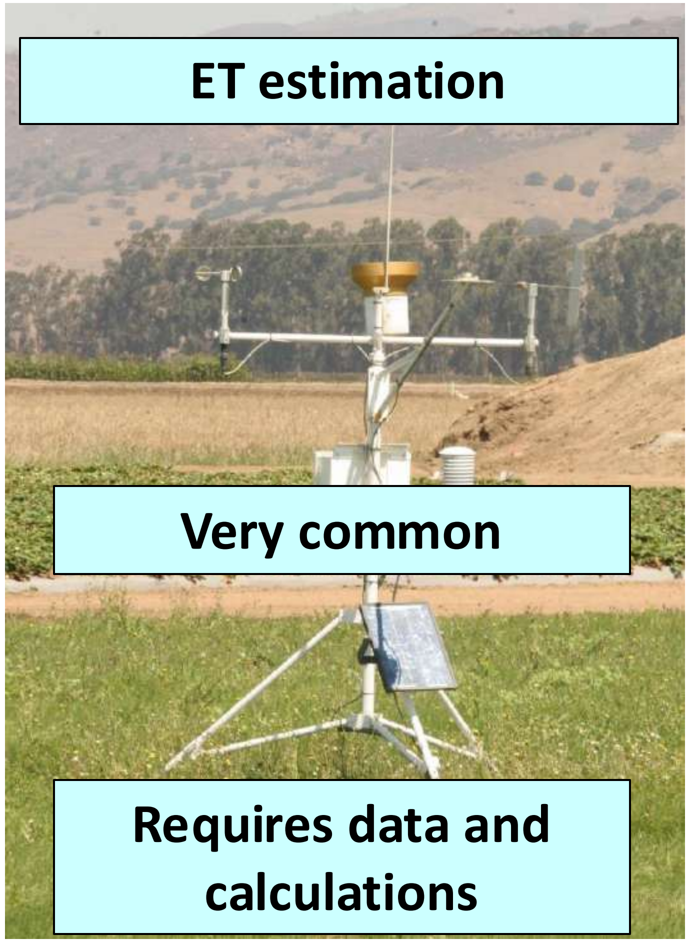
1) When to water our crops? → Before the plants face water deficit (or specific levels of deficit/stress that are beneficial for fruit yield and quality)

2) How much water to apply? → The amount of water used by the plants for ET since the last irrigation or rain (or a portion of ETmax to maintain a target level of water stress for crop quality)

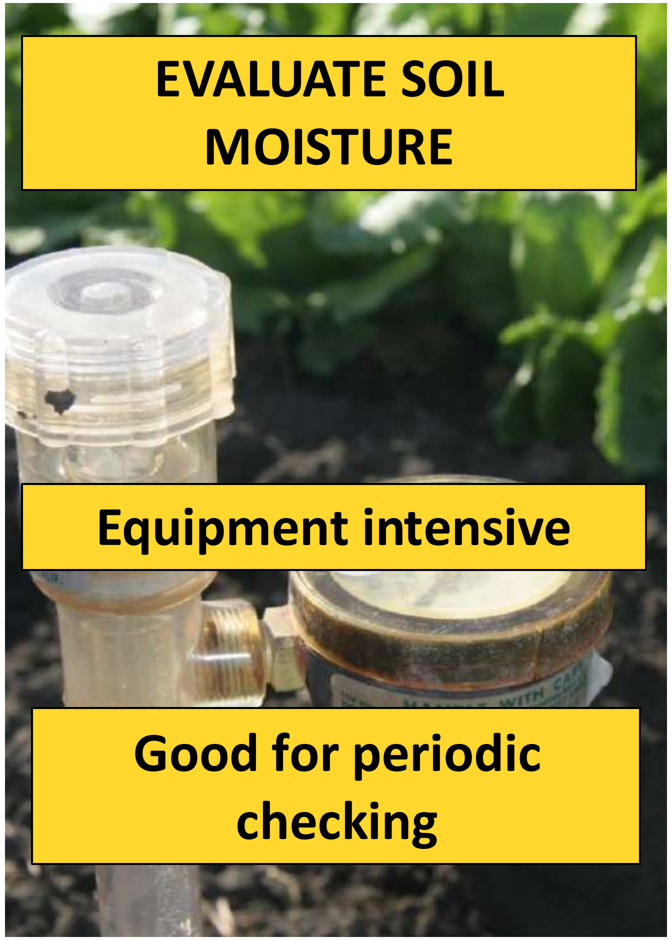
3) How to best apply the necessary amount of water? → Uniform irrigation or site-specific Small and frequent applications or deep irrigations? Application rate and volume compatible with soil infiltration and water retention capacity, or with energy rates/time of use

Methods for Irrigation Management

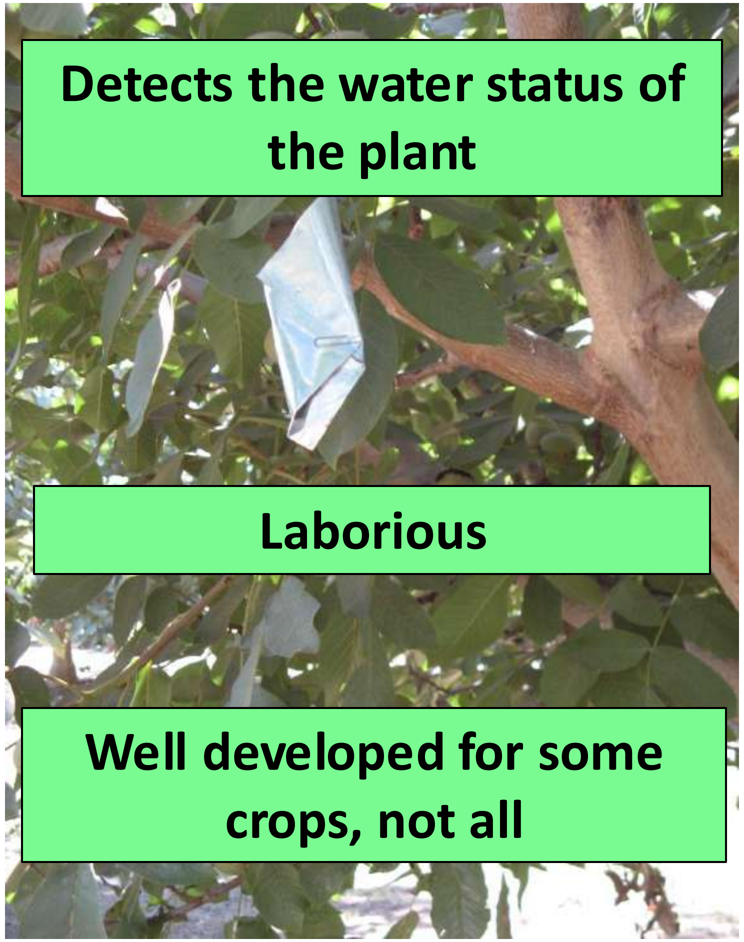
Based on the Climate



Based on the Soil



Based on the Plant



Irrigation Schedule Based on the Climate

Basic Criteria

Replenish the root zone with the amount of water lost through soil evaporation (E) and crop transpiration (T) (i.e., E + T = ETc) since the last irrigation/rain.

$$ET_c = ET_o \times K_c$$

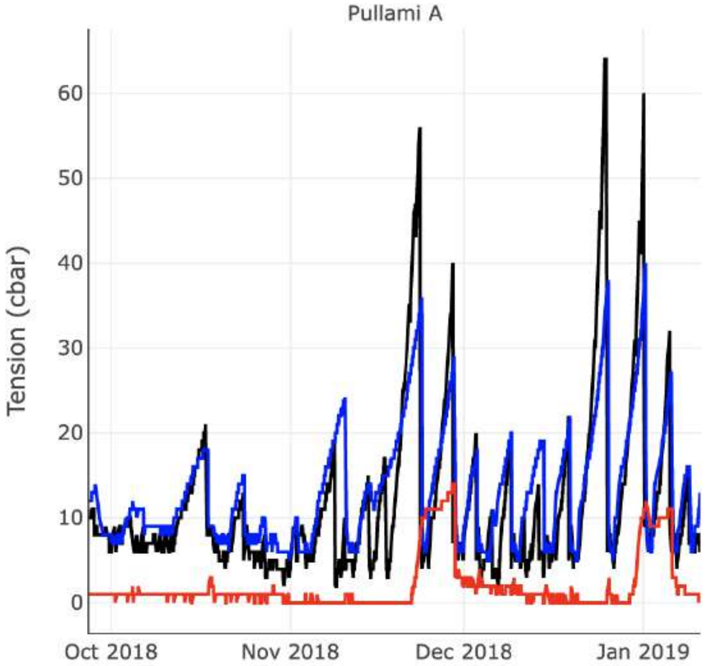
Accurate Kc values are crucial

Irrigation Schedule Based on the Soil

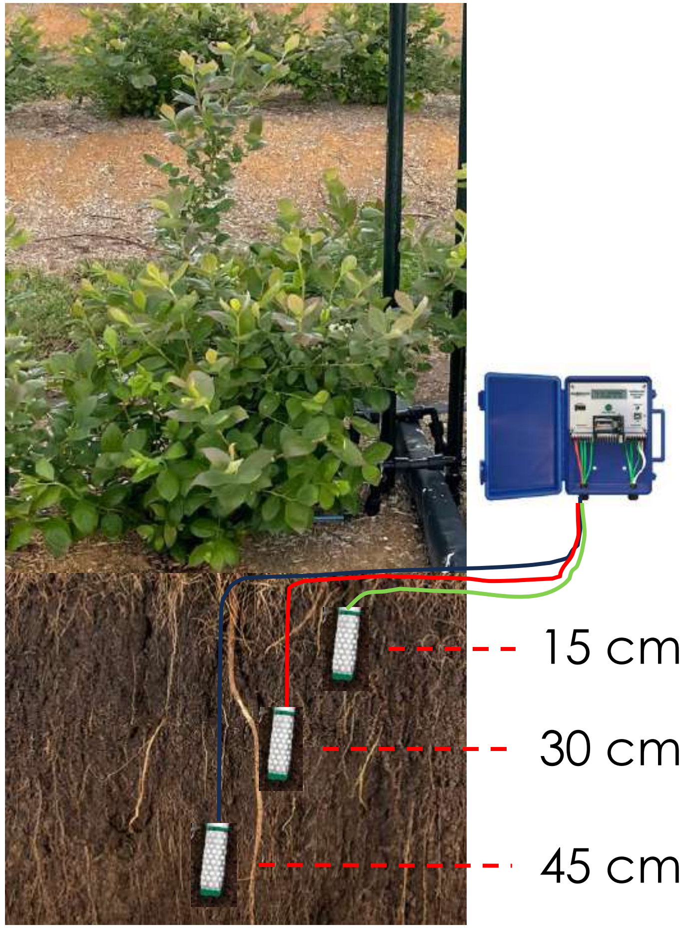
1. Frequently observe soil moisture or continuously monitor it.

2. Start irrigation at the target soil moisture level (management-allowed depletion or allowed negative tension).

3. Stop irrigation when soil moisture reaches the target levels.



Soil Moisture Installation



The majority of water-extracting roots are found within 30 to 40 cm depth in berry plants

These sensors help ensure that the soil moisture is optimal at different root depths, promoting healthy growth and efficient water use.

For micro-irrigated Blueberries, 2-3 sensors installed at appropriate depths (15 cm, 30 cm, and +45 cm) are sufficient.

Irrigation Schedule Based on the Plant

Stem Water Potential

Canopy temperature

Combination Methods

Based on the Plant
(Water Status in the Plant) → Optimal irrigation timing and frequency

Based on the Climate
(Water demand estimation) → Adequate amount of irrigation

Based on the Soil
(Soil moisture monitoring) → Need verification

4. Adaptation to SHB growing systems in growing regions

Four main themes emerged among the alternative production systems used to cultivate SHB:

(a) Production in protected environments such as high tunnels, greenhouses, and factories.

(b) High-density planting production.

(equivalent to from 2154 to 7173 plants/ha). Can reach peak commercial yields in less than 4 years.

(c) Evergreen production.

Plants can be managed to produce berries all year long or to target high-value market windows

(d) Container-based production

Source data: Yang Fang et al. 2020.

4. Adaptation to SHB growing systems in growing regions

Container-based production

- Container size and shape must be carefully selected.
  - 56 to 95 L was the container size commonly used in Florida (first-year yields ranging from 0.9 kg/plant to more than 2 kg/plant based on different cultivars and fertilizer rates).
  - Containers smaller than 38 L have been shown to negatively affect yields

Under high wind conditions, plants in smaller containers (<40 L) might blow over, requiring trellising or other anchorage mechanisms (see Figure).

Adaptation to SHB growing systems in growing regions

Gaps in SHB growing systems in the World?

Irrigation Water Management

Similar condition: Ornamental or vegetable container production

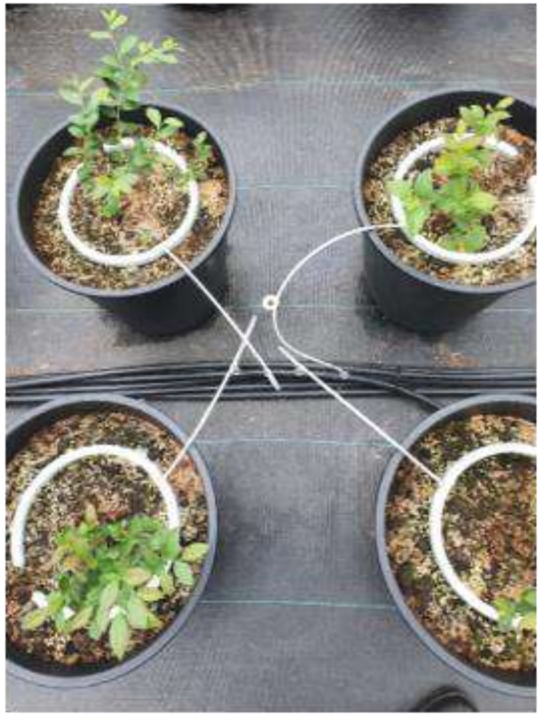
Growers schedule the timing and duration of irrigation events according to substrate matric potential

5. Example of strategies for substrate.

A Research Trial on Practices for Improving Drip Irrigation of Blueberry in Substrate

Main goal: to evaluate the effects of irrigation frequency (pulse length) and number of wetting points (number and distribution of emitters per pot) on growth, mineral nutrition, yield, and fruit quality of highbush blueberry in substrate.

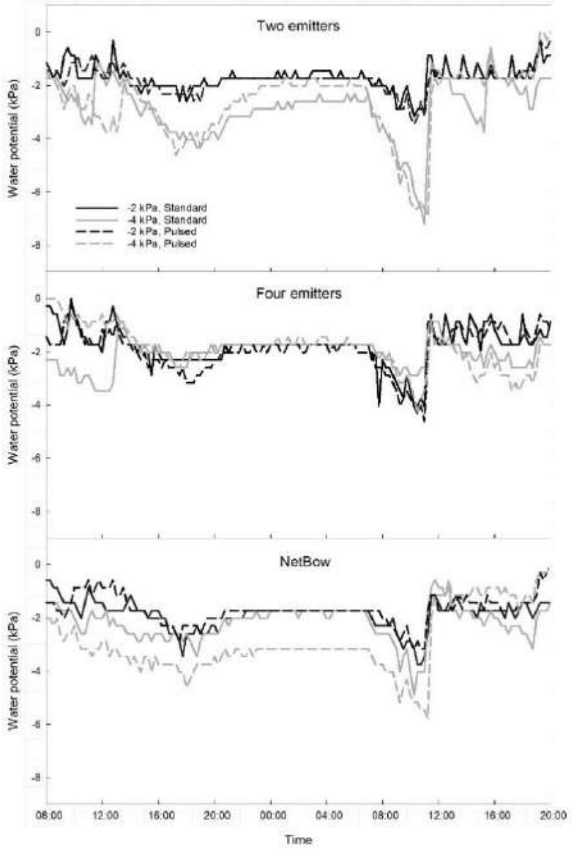
- Commercial mix of peat and coir (Legro USA, Thousand Oaks, California, USA).
- Irrigated/fertigated using two or four drip emitters per pot or a new type of emitter from Netafim (Tel Aviv-Yafo, Israel) called NetBow®.
- Tensiometers (METER Environment, Pullman, Washington, USA) were used to monitor matric potential of the media in each treatment and trigger irrigation at -2 or -4 kPa.



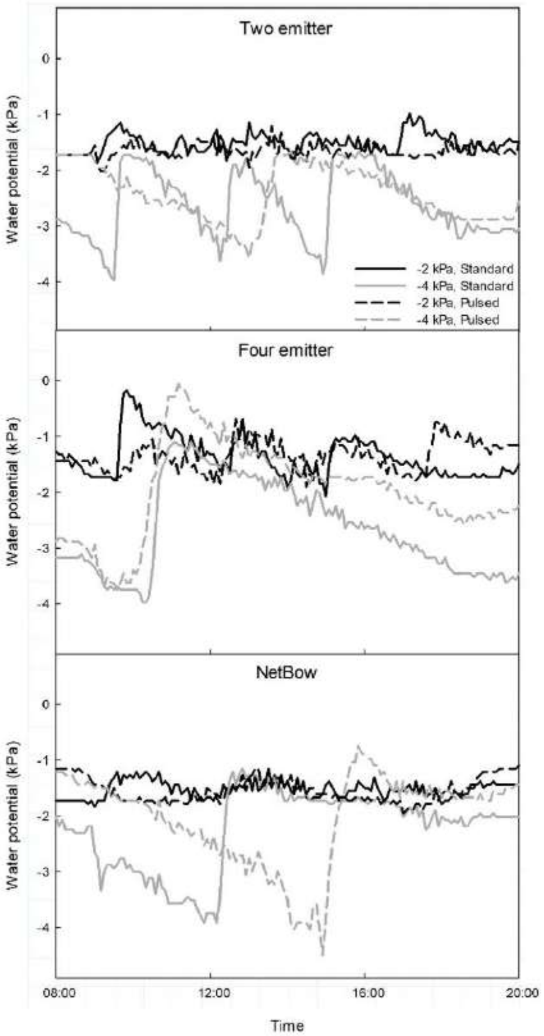
Results?

Matric water potential in each treatment

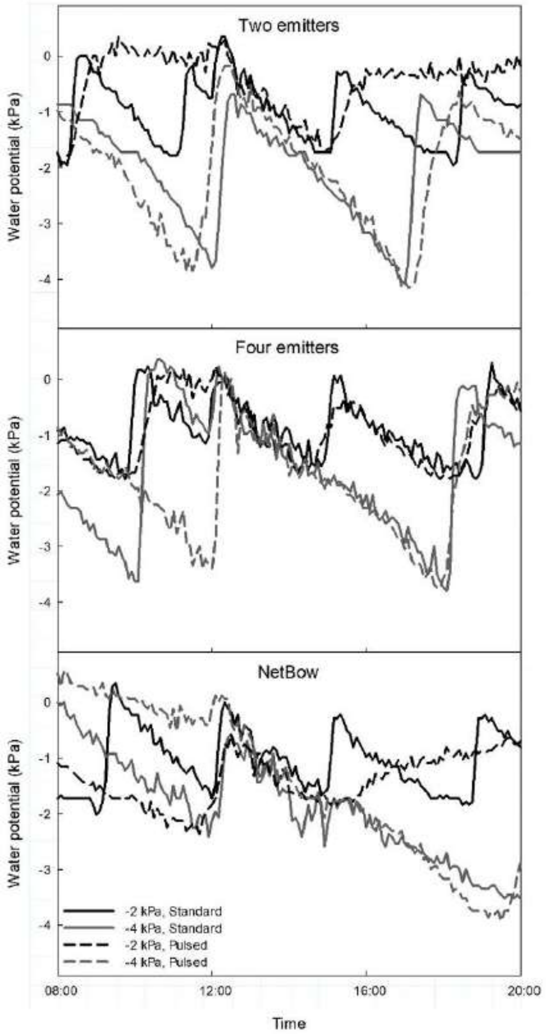
27–28 June 2021 (heat dome).



26 July 2022 (hottest day of the year)



29 June 2023
(one of the hottest days of the year)



Results?

Table 1. Mean shoot growth and yield for two growing seasons and root ranking in final growing season.[1]

Drip configuration	Year 2 Shoot dry wt (kg/plant)	Year 2 Yield (g/plant)	Year 3 Shoot dry wt (kg/plant)	Year 3 Yield (g/plant)	Year 3 Root ranking[3]
Two emitters	0.52 b[2]	126 b	1.32 ns	1108 ns	4.6b
Four emitters	0.53 b	162 ab	1.42 ns	997 ns	5.5b
NetBow	0.59 a	175 a	1.35 ns	1026 ns	9.5a

[1]Means are pooled across two set points (-2 and -4 kPa) and frequencies (standard and pulsed).

[2]Means followed by a different letter within a column are significantly different based on Tukey's test ($P \leq 0.05$).

[3]Root development was visually ranked within each block from smallest (1) to largest (12).

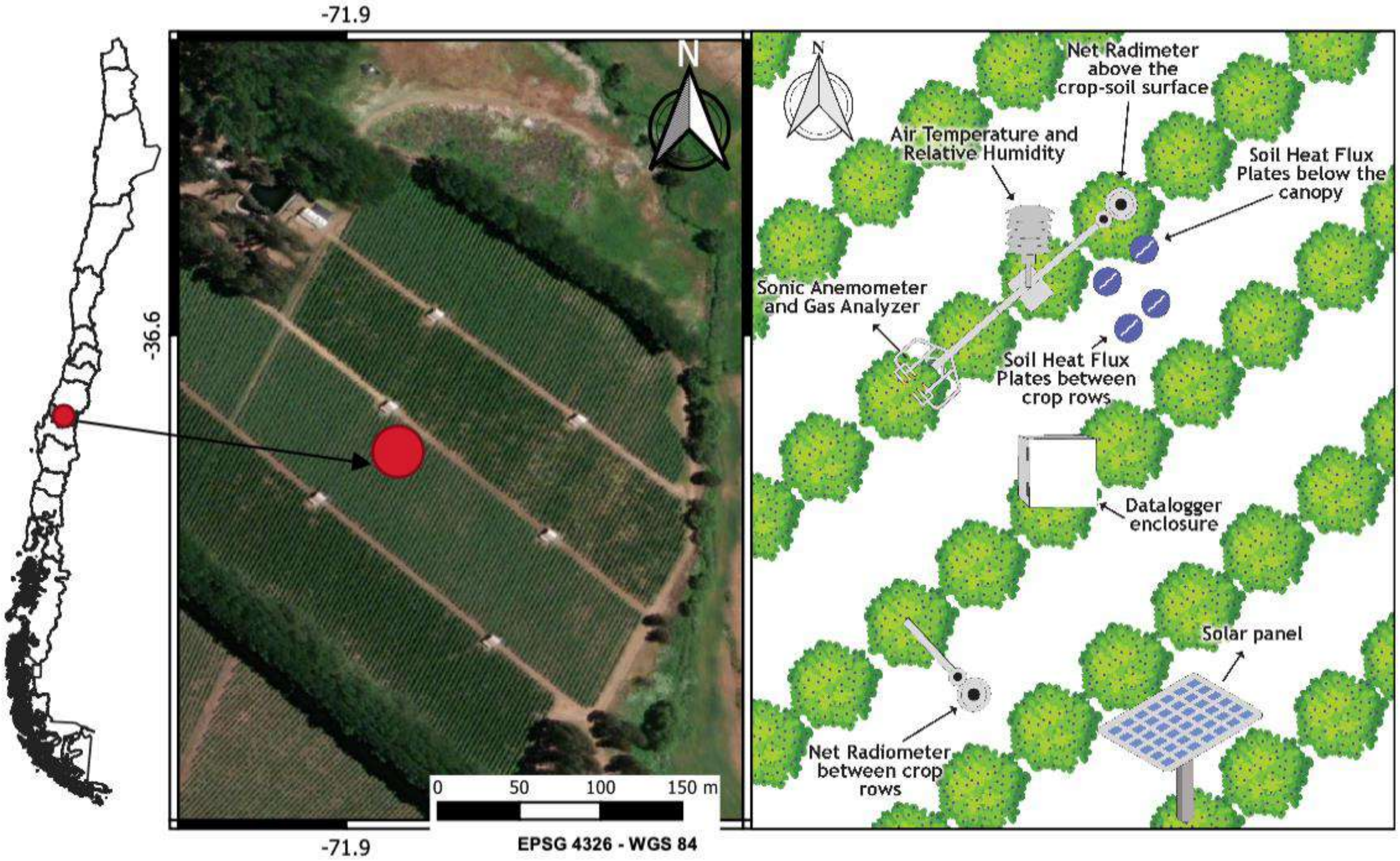
CONCLUSIONS

- NetBow emitters resulted in more shoot growth and higher yields initially than using two or four emitters per pot, although this difference disappeared by year 3.
- Root development was also greater in pots with the NetBow emitters.
- A higher set point of -2 kPa was more effective than -4 kPa, particularly in treatments with two emitters per pot or the NetBow emitters.
- Pulsing did not increase water use efficiency with any of the emitter configurations and, much like the lower set point, was ineffective for meeting plant water demands during hot weather.

6. Example for soil.

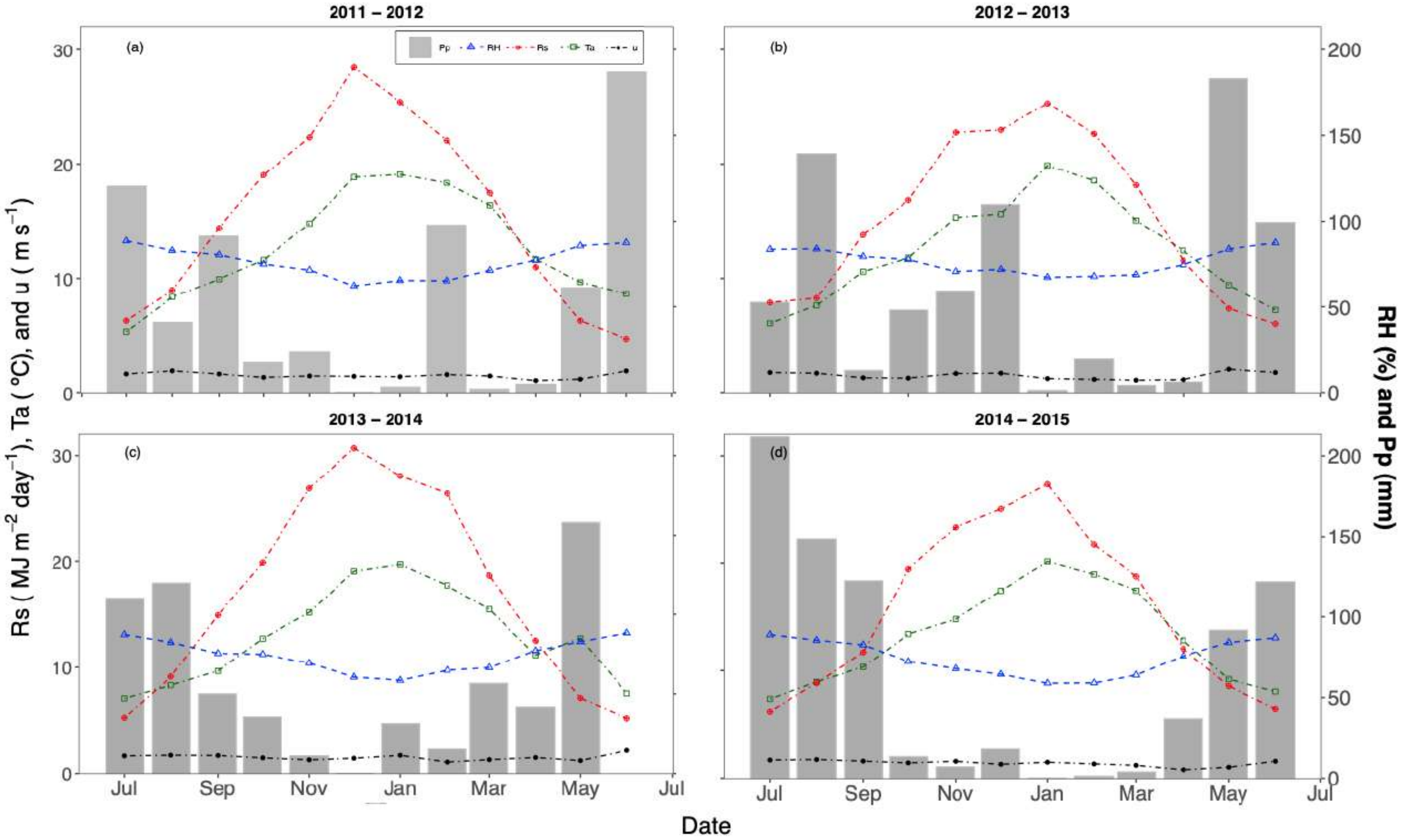
Blueberry study

- Blueberry
  - Planted: 2006
  - 1 x 3 m
  - Irrigation System: Drip
  - Dripper per tree: 2
  - Q dripper: 2.2 L h^{-1}
- $Rn - G - H - LE = \Delta S$



Results

- Blueberry

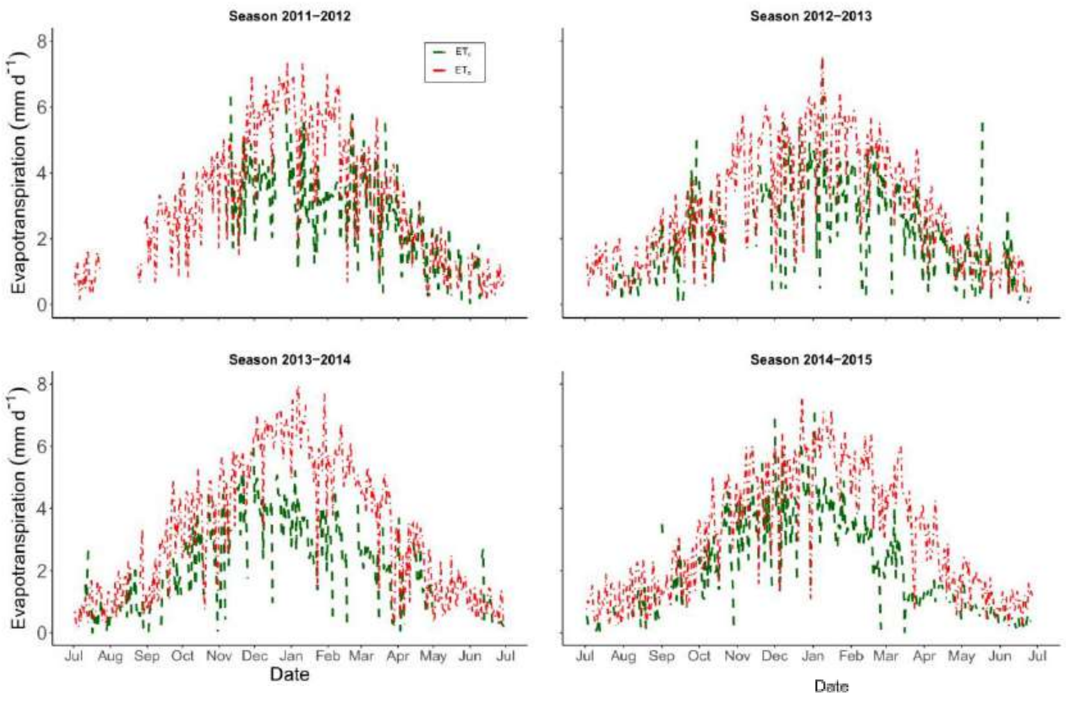


Pp: Precipitation (totalized).
RH: Relative humidity (avg).
Rs: Solar radiation (sum).
Ta: Air temperature (avg).
u: Wind speed (avg).

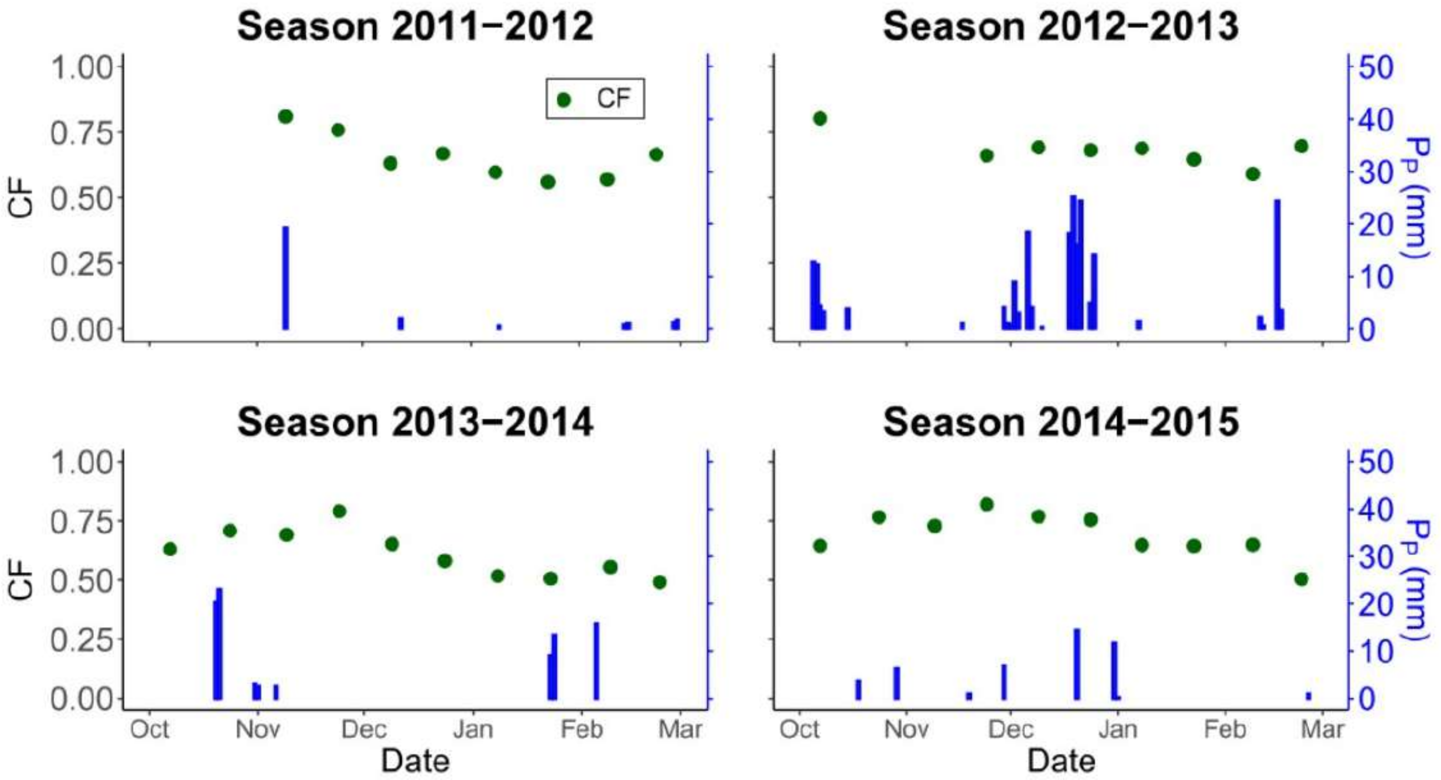
Results

- Blueberry

ETc

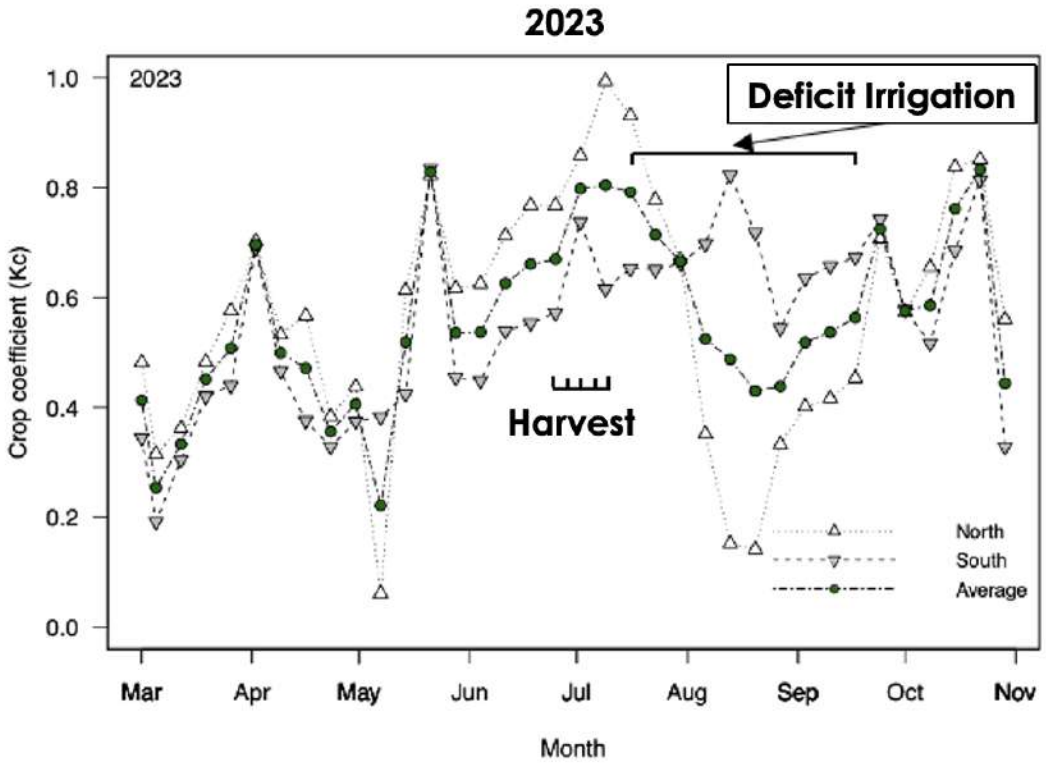


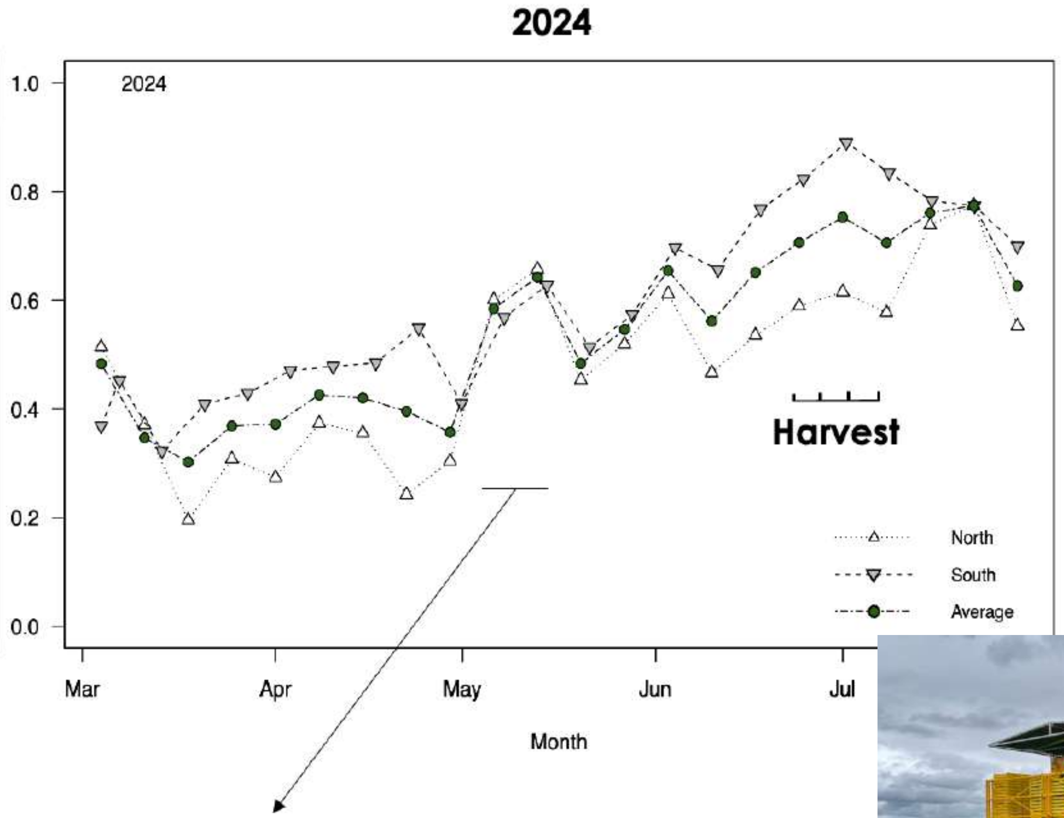
Crop factor



Initial = 0.50 Middle = 0.75 End = 0.45

Blackberry study





2024: Kc increase after a large period of rainy days

How much water does it take to produce blackberries?

Marketable yield and berry weight of 'Columbia Star' trailing blackberry during three years of fruit production in Aurora, OR.

Location [i]	Marketable yield (kg/plant)			Berry wt (g)		
	2022	2023	2024*	2022	2023	2024*
North lysimeter	8.29	5.42	-	7.3	6.4	-
South lysimeter	8.63	7.26	10.96	7.0	6.7	6.2
Full irrigated	-	4.23	7.31	-	6.7	6.2
Deficit irrigated	-	4.47	8.84	-	6.8	6.5

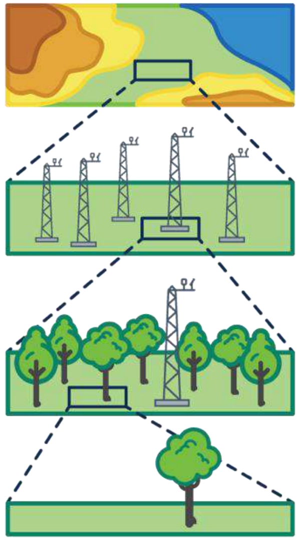
2024*: North lysimeter had not fruit.

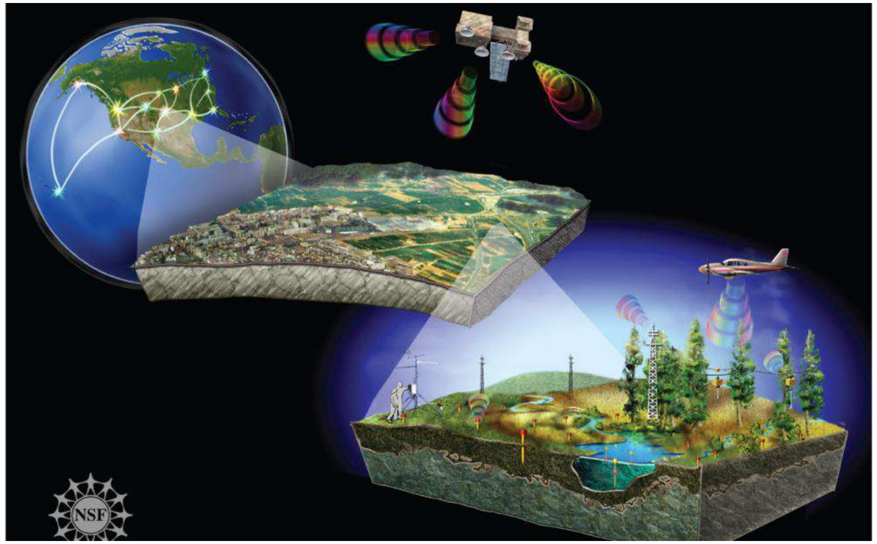
Produce 1 kg of Berry?

250 L_{H2O}/kg

7. Future challenges

- Continue collecting data and develop seasonal Kc curves for mature fields of blueberry, blackberry and others.
- Develop relationships between the Kc, canopy cover, vegetation indexes, and others (can be used to make Kc estimation by the growers).
- Develop an App to schedule the berries irrigation by growers.





Fuente: https://labinstruments.ru/upload/631b22e987ed5-LI-CORBook-EddyCovarianceMethodEdition22022_.pdf

8. Summary

- These studies assisted in understanding how growth and management of berries in soil and substrate affects its water use and can be used to develop more precise irrigation schedules.

- Once these Kc values are adopted, growers will have informed options for reducing water use in the face of uncertain climatic conditions.

- New technologies to estimate crop evapotranspiration and crop coefficient are a challenge to the next years for farmers to be able to use them.

Acknowledgements

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Gracias/Thank you !!

Camilo Souto E.

Assistant Professor[1] ; Courtesy Faculty[2]

[1] Department of Water Resources, University of Concepción, Chile

[2] Department of Horticulture, Oregon State University, Corvallis, OR 97331, USA

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