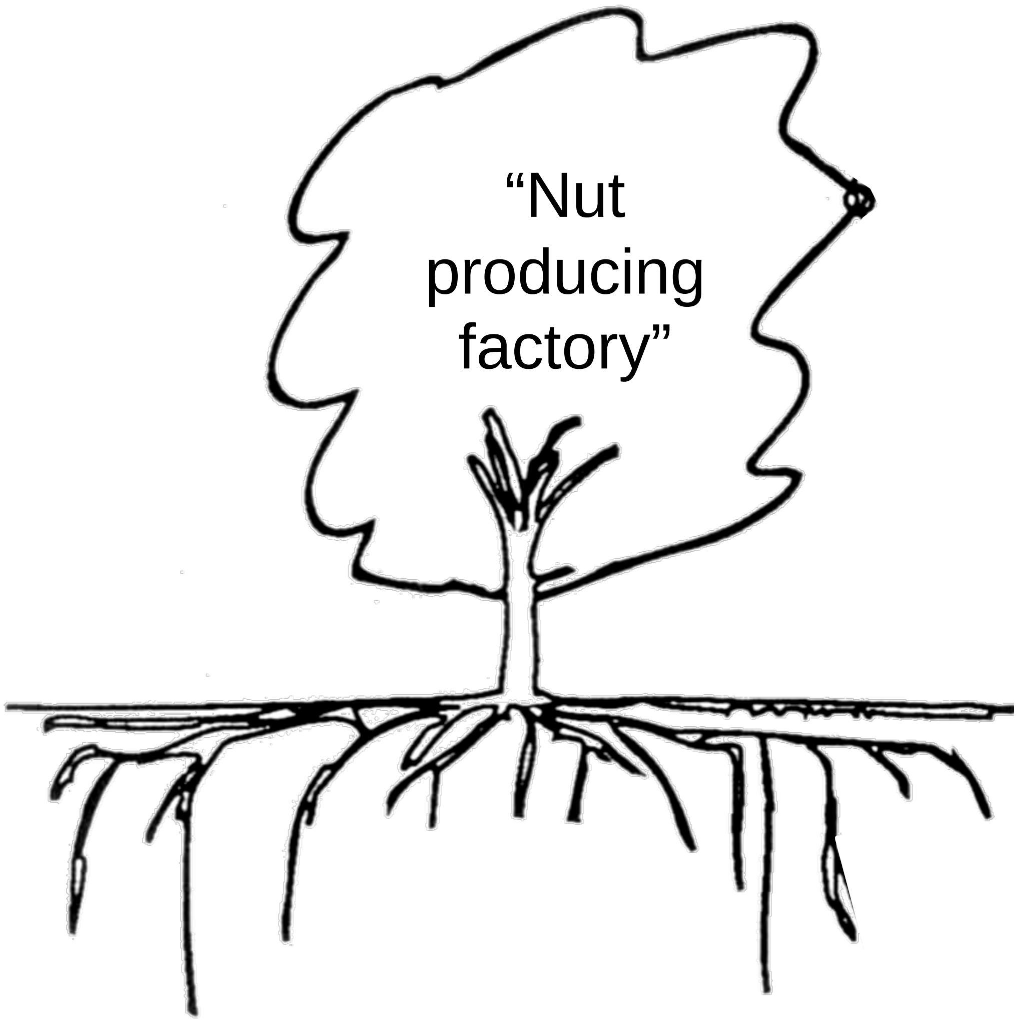
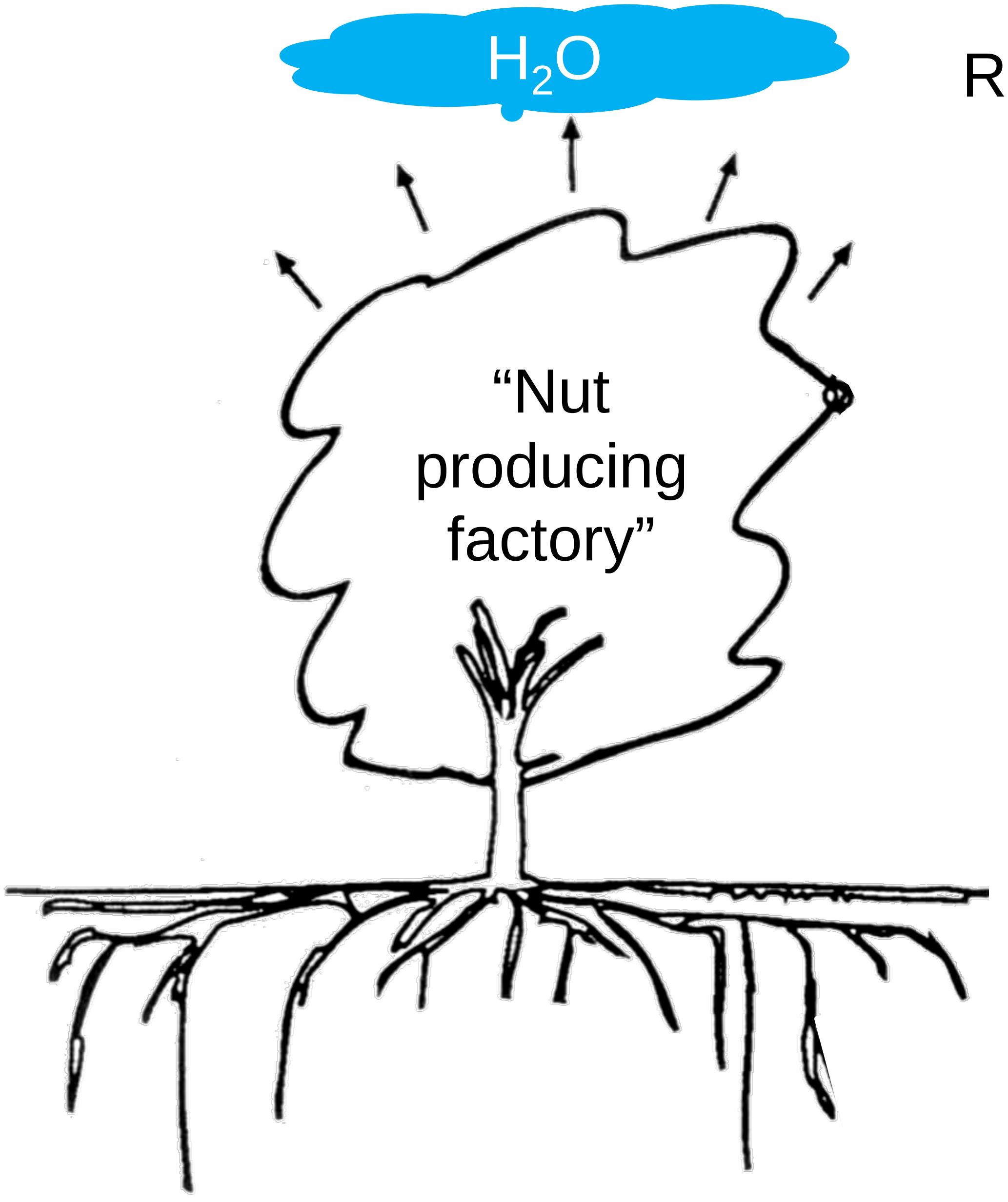
Physiological Aspects of Water Use by Walnuts

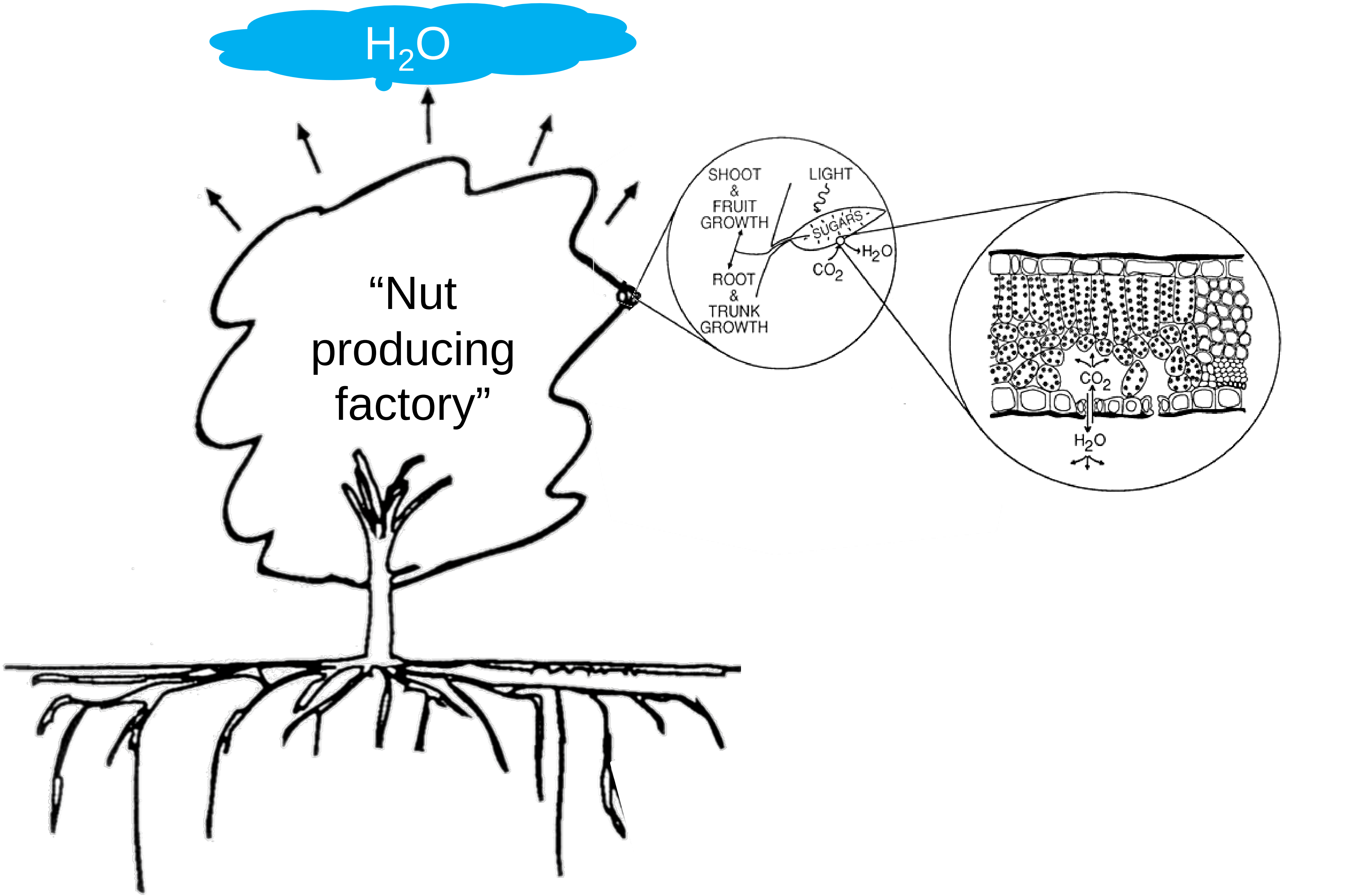


Physiological Aspects of Water Use by Walnuts

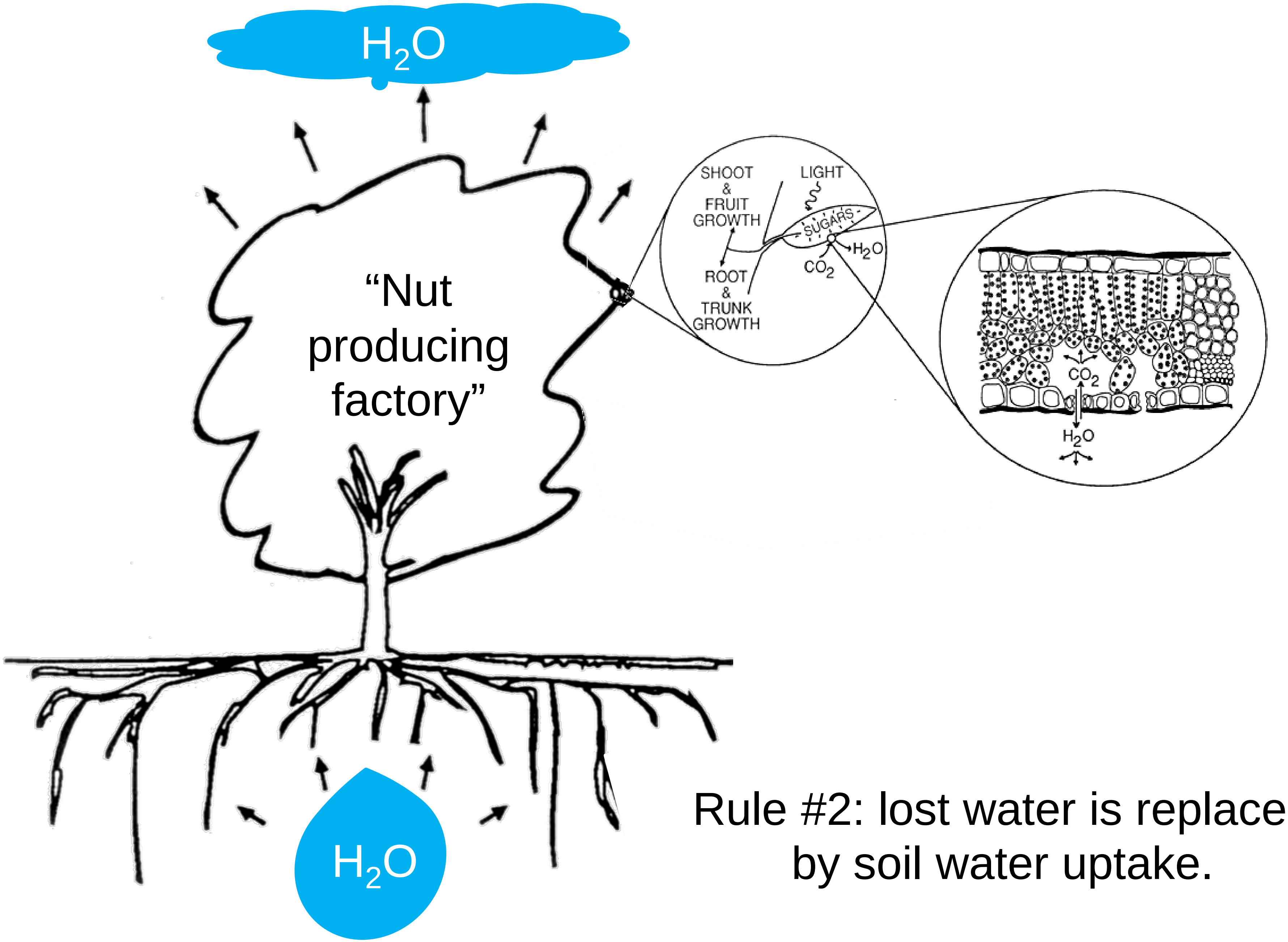


Rule #1: plants lose a lot of water, every day.

Physiological Aspects of Water Use by Walnuts

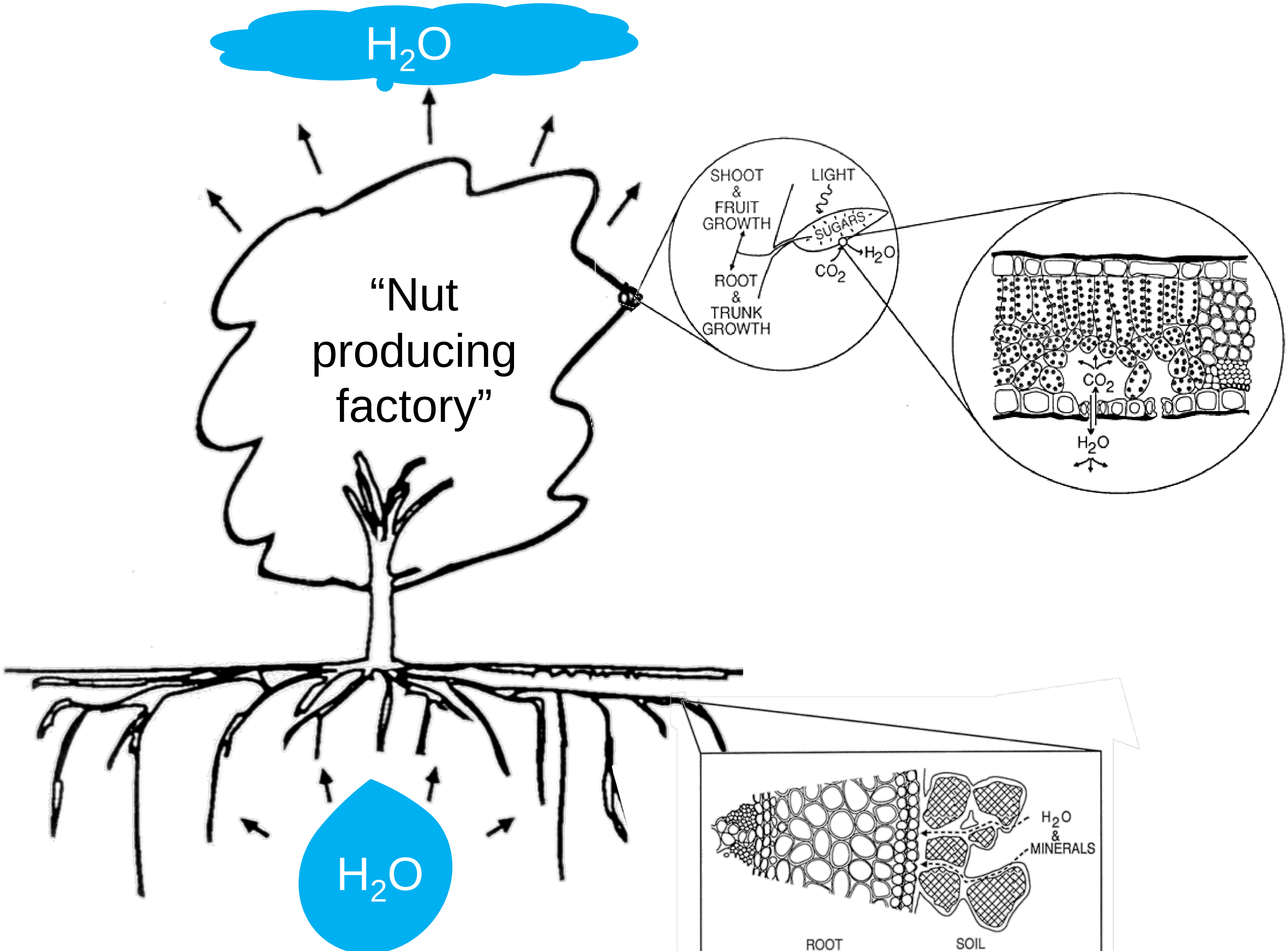


Physiological Aspects of Water Use by Walnuts



Rule #2: lost water is replaced by soil water uptake.

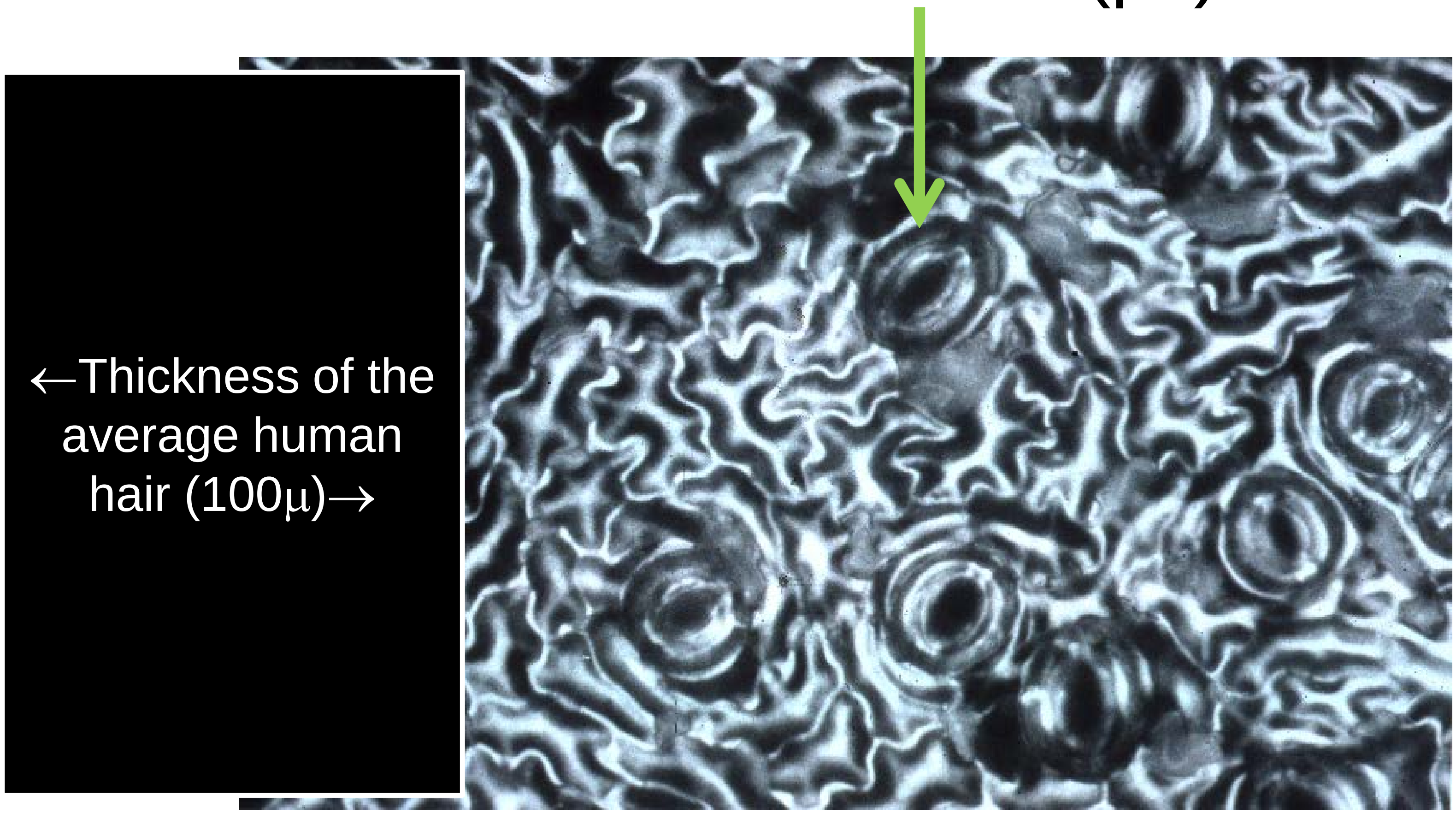
Physiological Aspects of Water Use by Walnuts



Q: Why do leaves lose so much water?

A: Because they have holes in them!

The holes are called ‘stomata’ (pl.)

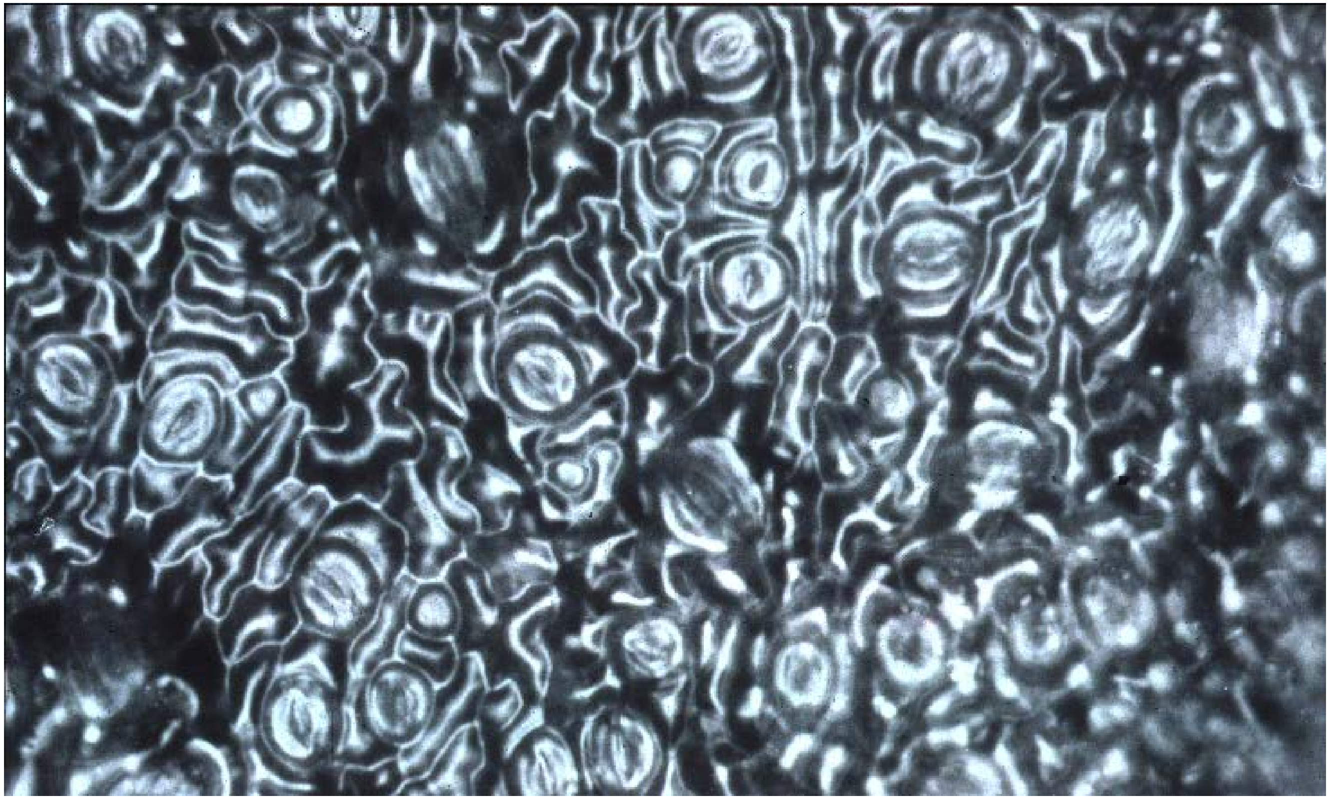


Stomata are the ‘doors’ to the photosynthetic factory of the leaf. They can be open for business

Q: Why do leaves lose so much water?

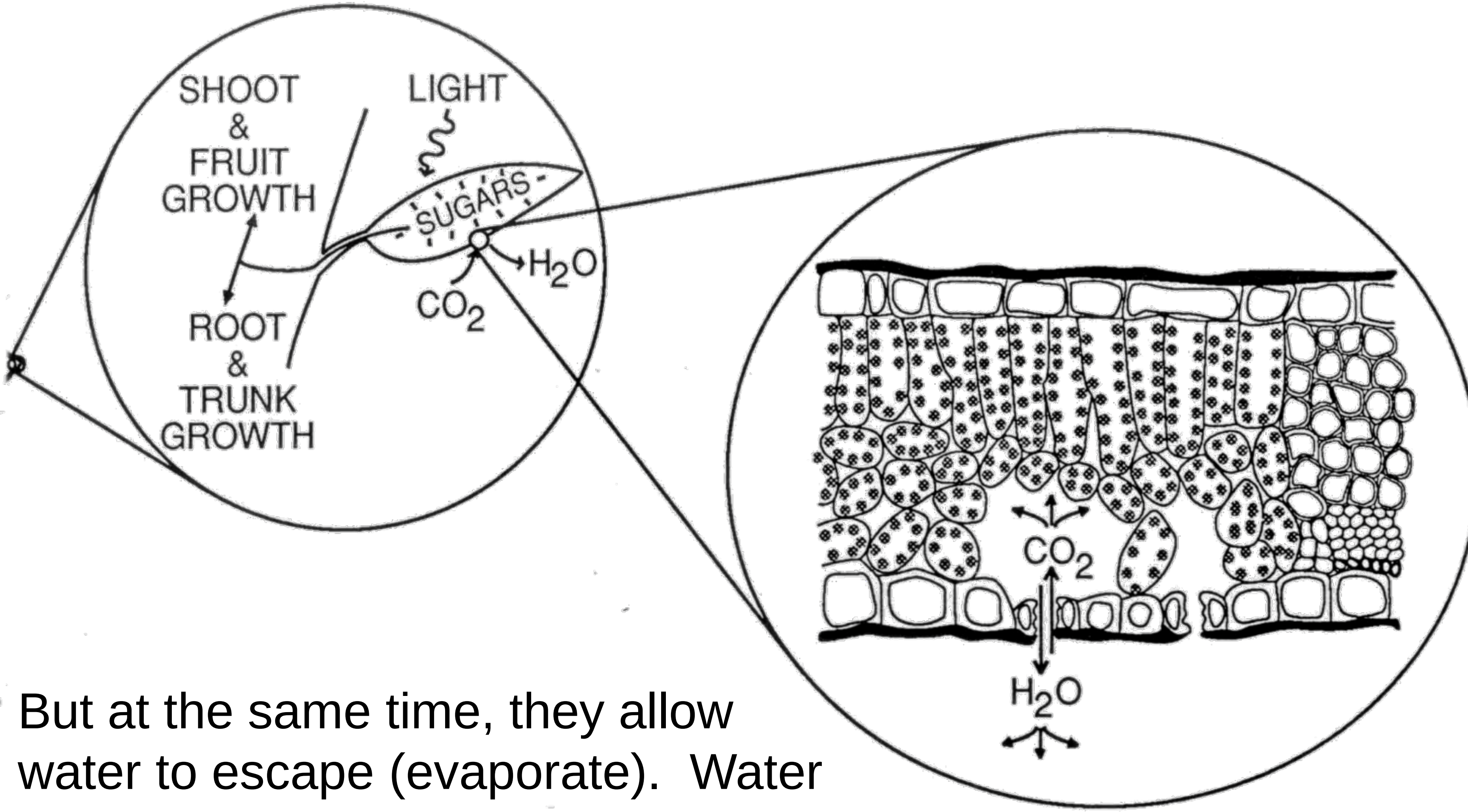
A: Because they have holes in them!

The holes are called ‘stomata’ (pl.)



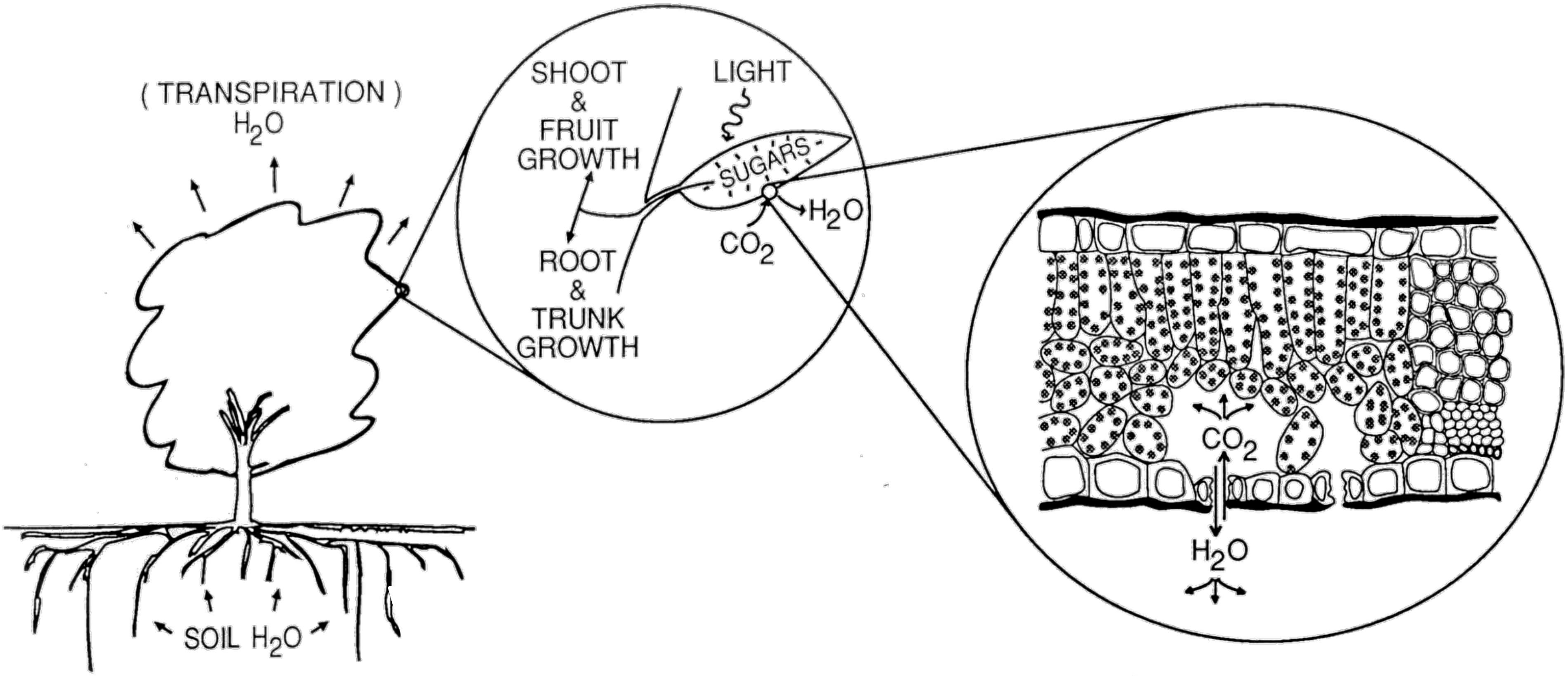
Or they can be closed for the night.

Stomata must remain open to allow CO_2 into the leaf for photosynthesis and sugar production.



But at the same time, they allow water to escape (evaporate). Water loss is the 'economic' cost that the plant factory must pay in order to 'keep the doors open for business' (i.e., be productive).

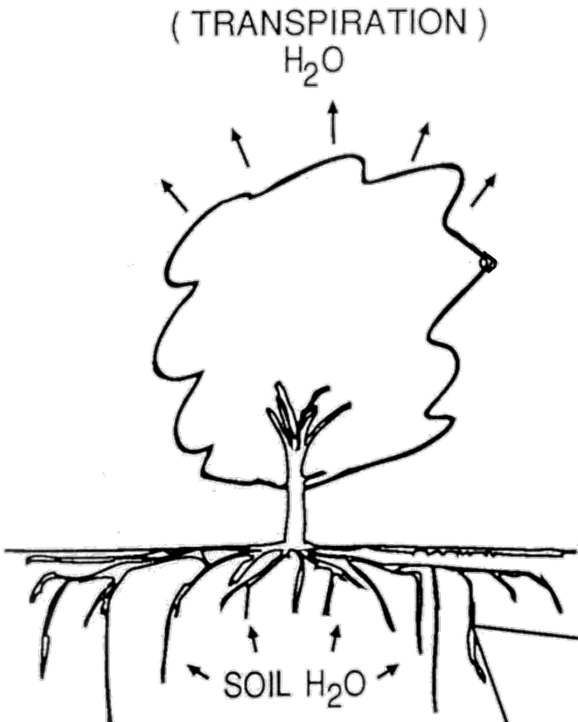
The process of water loss from the tree is called transpiration, and when evaporation from the orchard floor is included, the total is called 'evapotranspiration' or "ET."

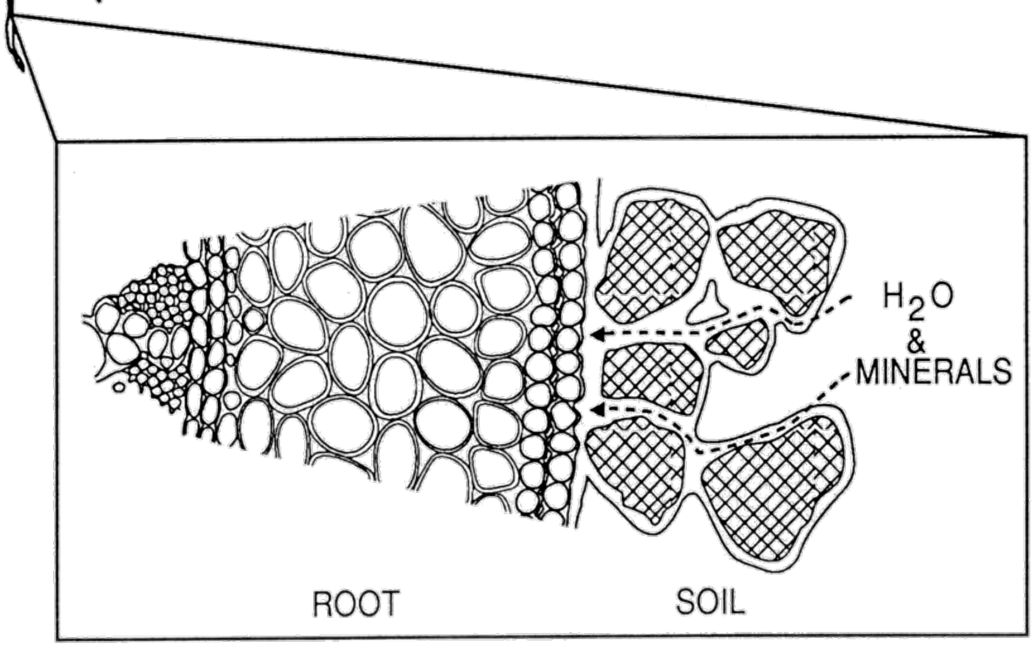


ET must be continually replaced by water uptake from the soil.

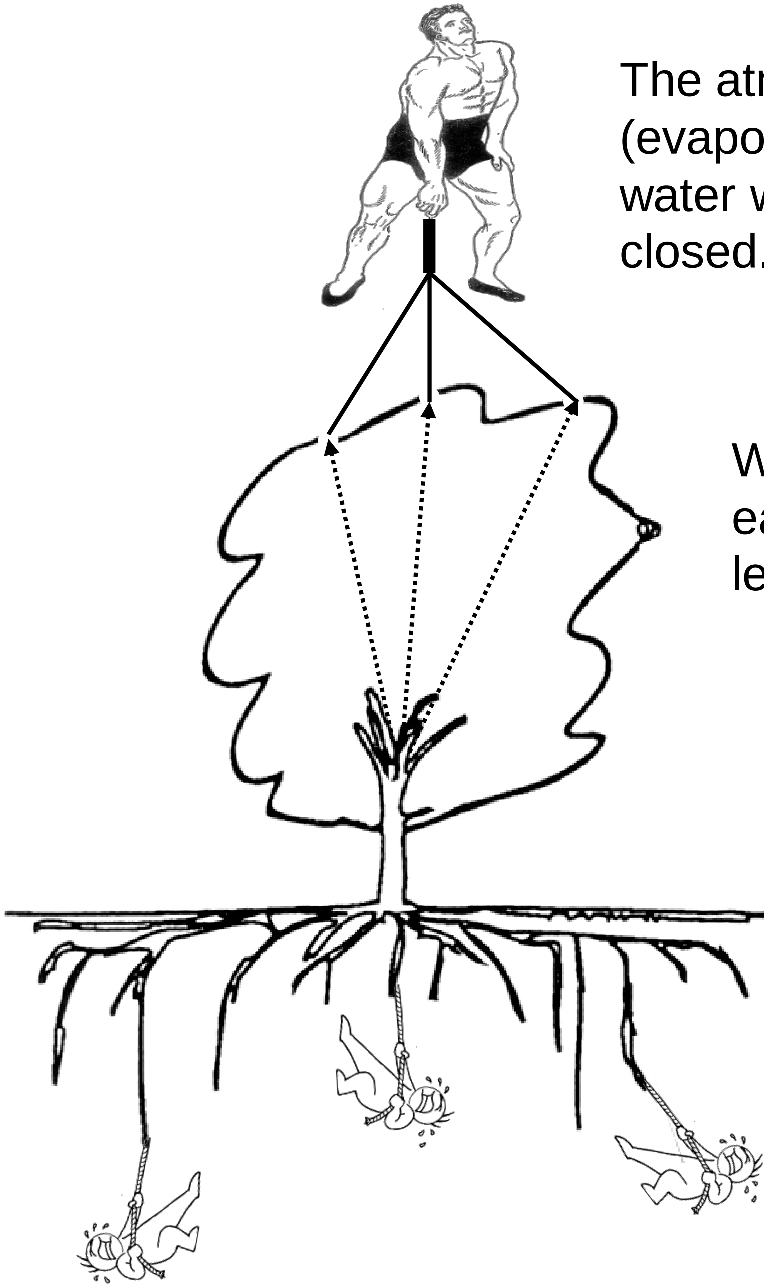
The only way the root can get water out of the soil is to pull (suck) it out.

The level of pull (suction) will increase if the soil dries, or if ET increases.





The tree is in the middle of a ‘tug-of-war’ for water!

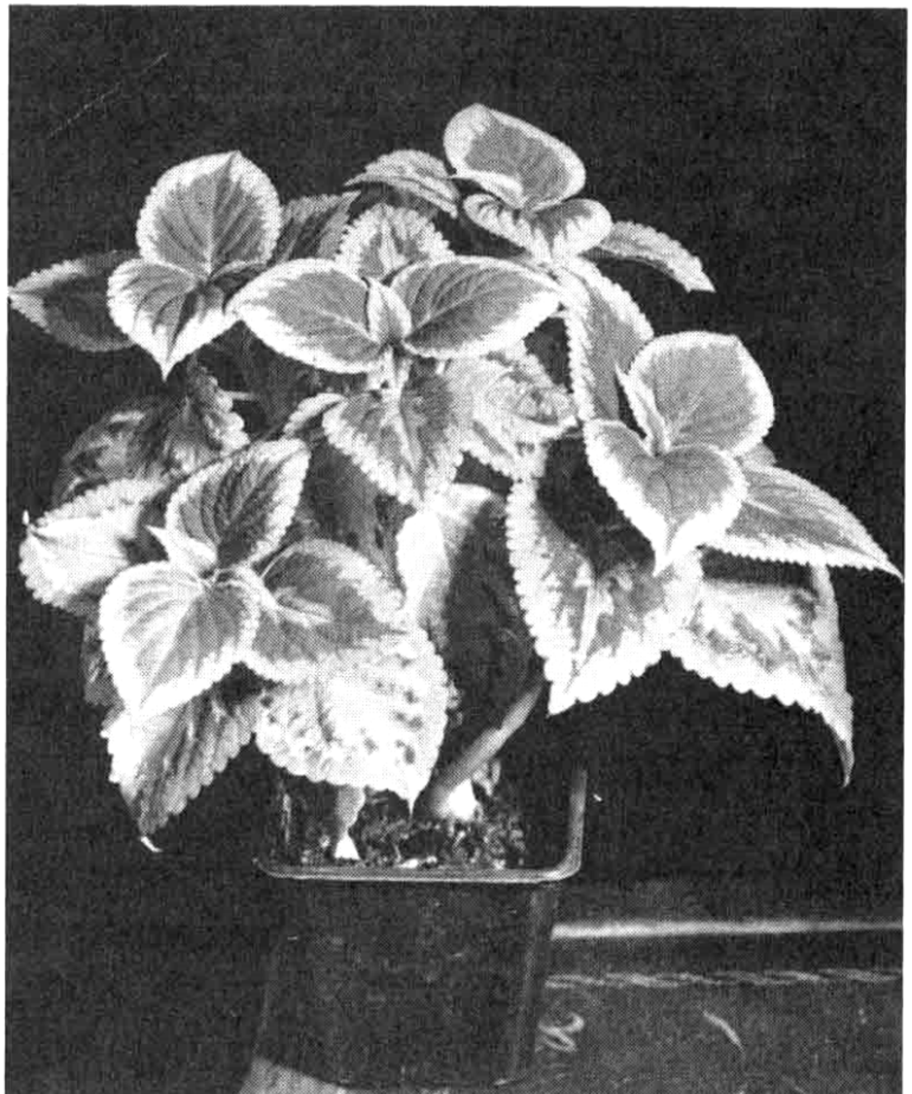


The atmosphere has great power to pull (evaporate) water from the tree, but little to no water will be pulled if the doors (stomata) are closed.

When the doors ‘open for business’ each day, water is pulled from the leaves and branches.

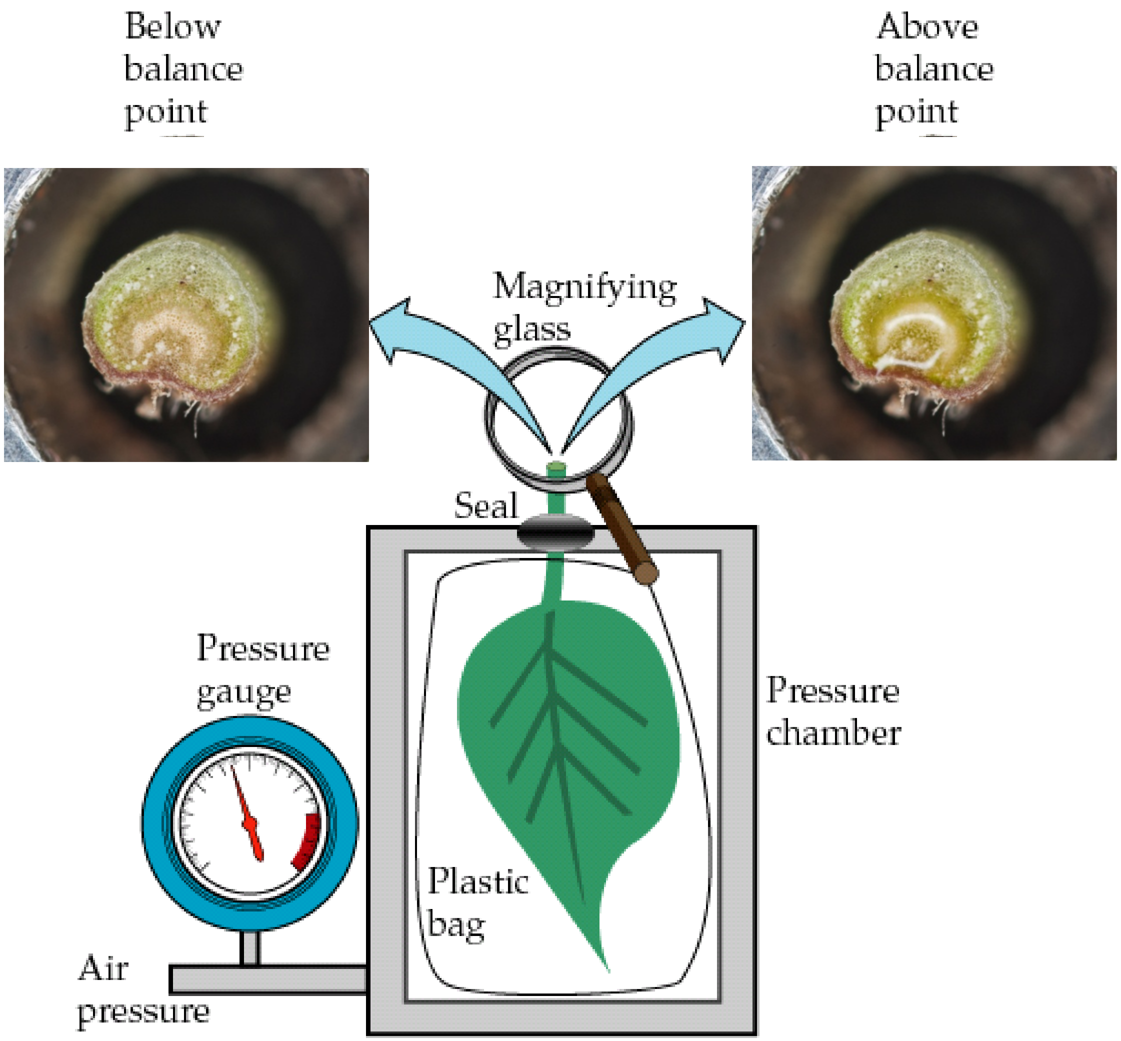
The water in the soil is held more strongly as the soil dries, but even wet soil gives some resistance.

If the level of suction within the plant is high enough, then water will be sucked out of the cells, and non-woody parts of the plant (e.g., leaves) will wilt.

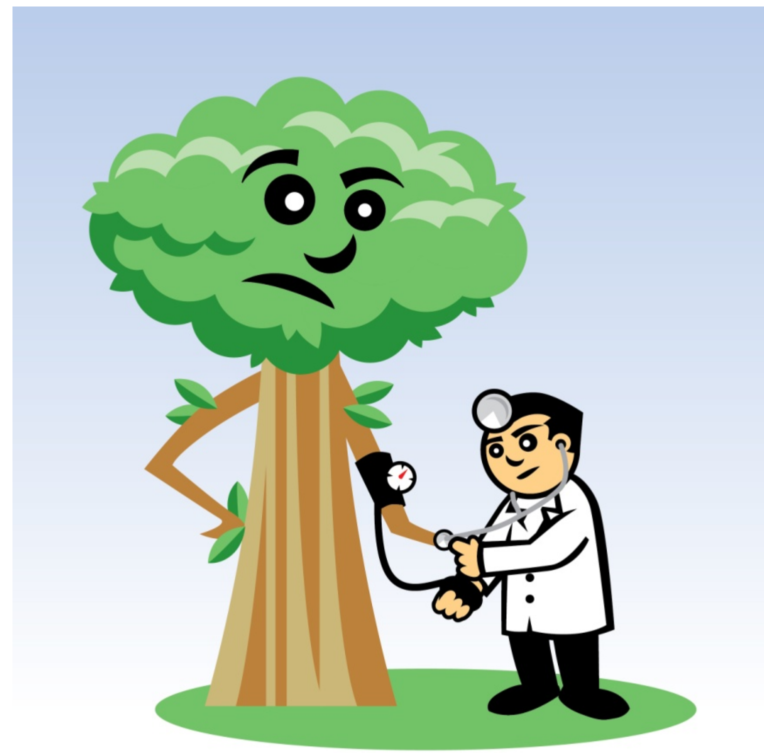


Salisbury & Ross, Plant Physiology (1992)

Pressure chamber method for measuring the level of water suction in the plant: midday stem water potential (SWP)



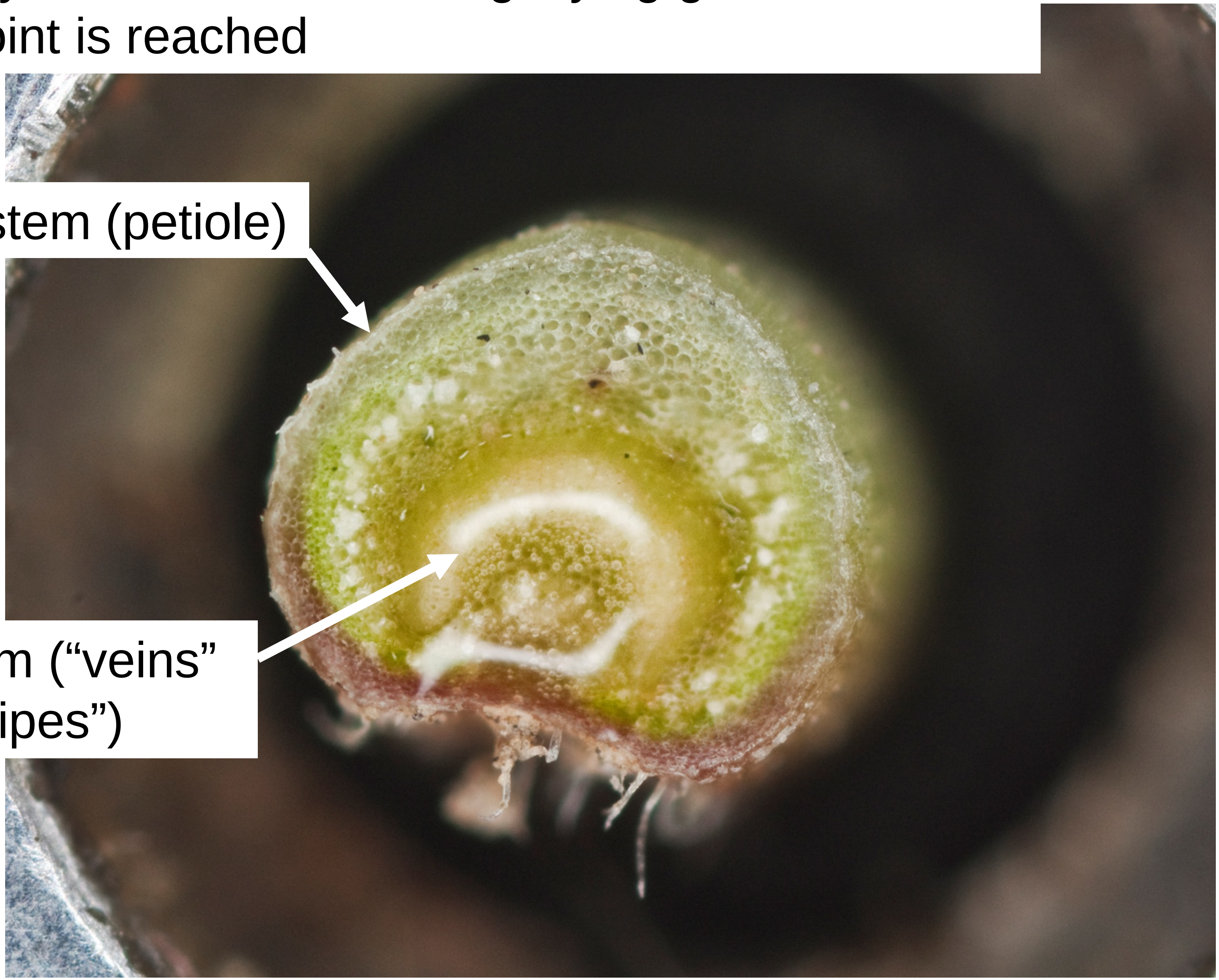
Like measuring the "blood pressure" of the plant




Stem Water Potential
(SWP)

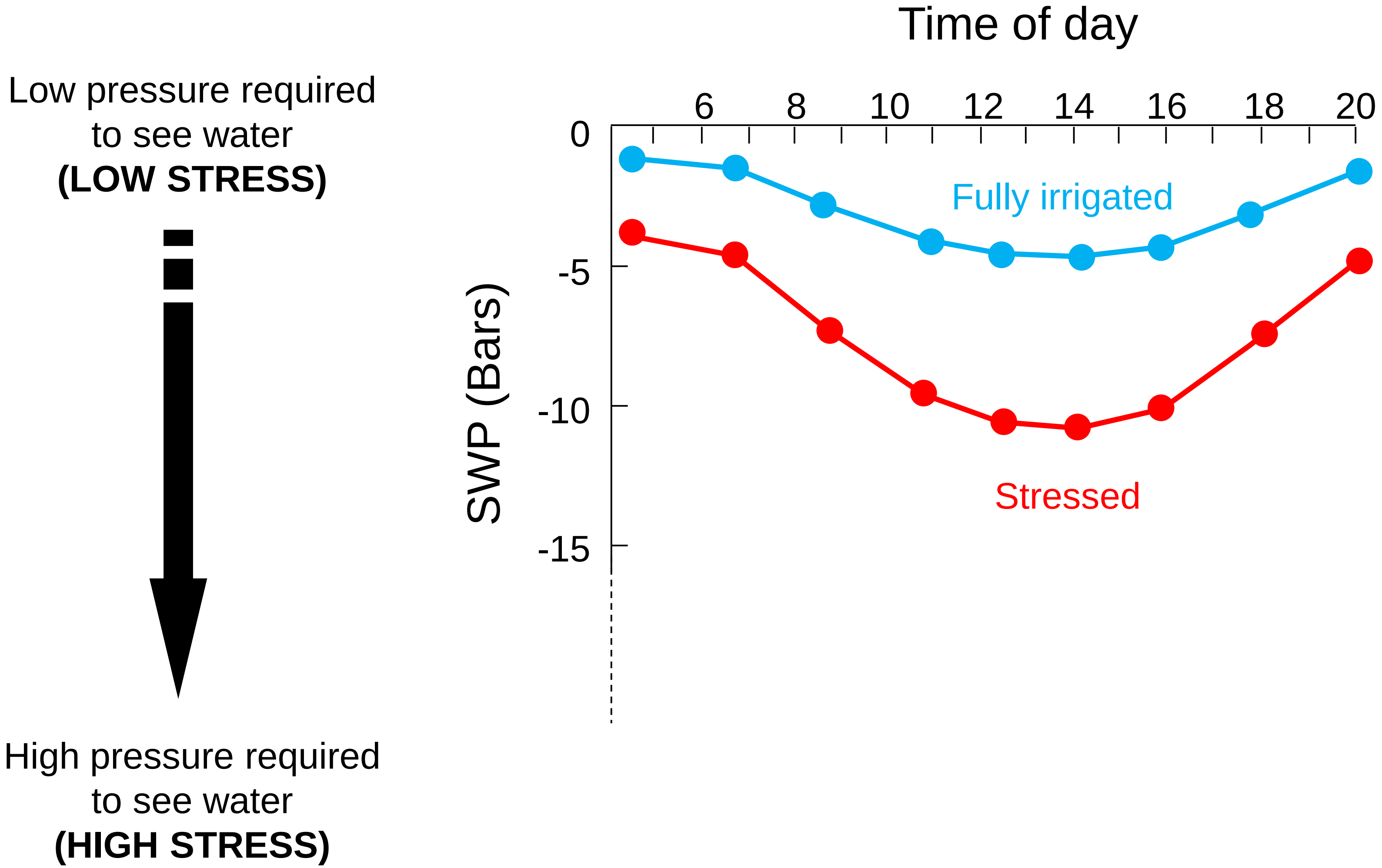
What you see under the magnifying glass **before** the endpoint has been reached

What you see under the magnifying glass **when** the endpoint is reached




S10
CHEVROLET
CORNING
California
E 034608

Typical example of the daily pattern in walnut SWP



Weather effects (Temperature and RH) on midday SWP (Bar) for fully irrigated Walnut

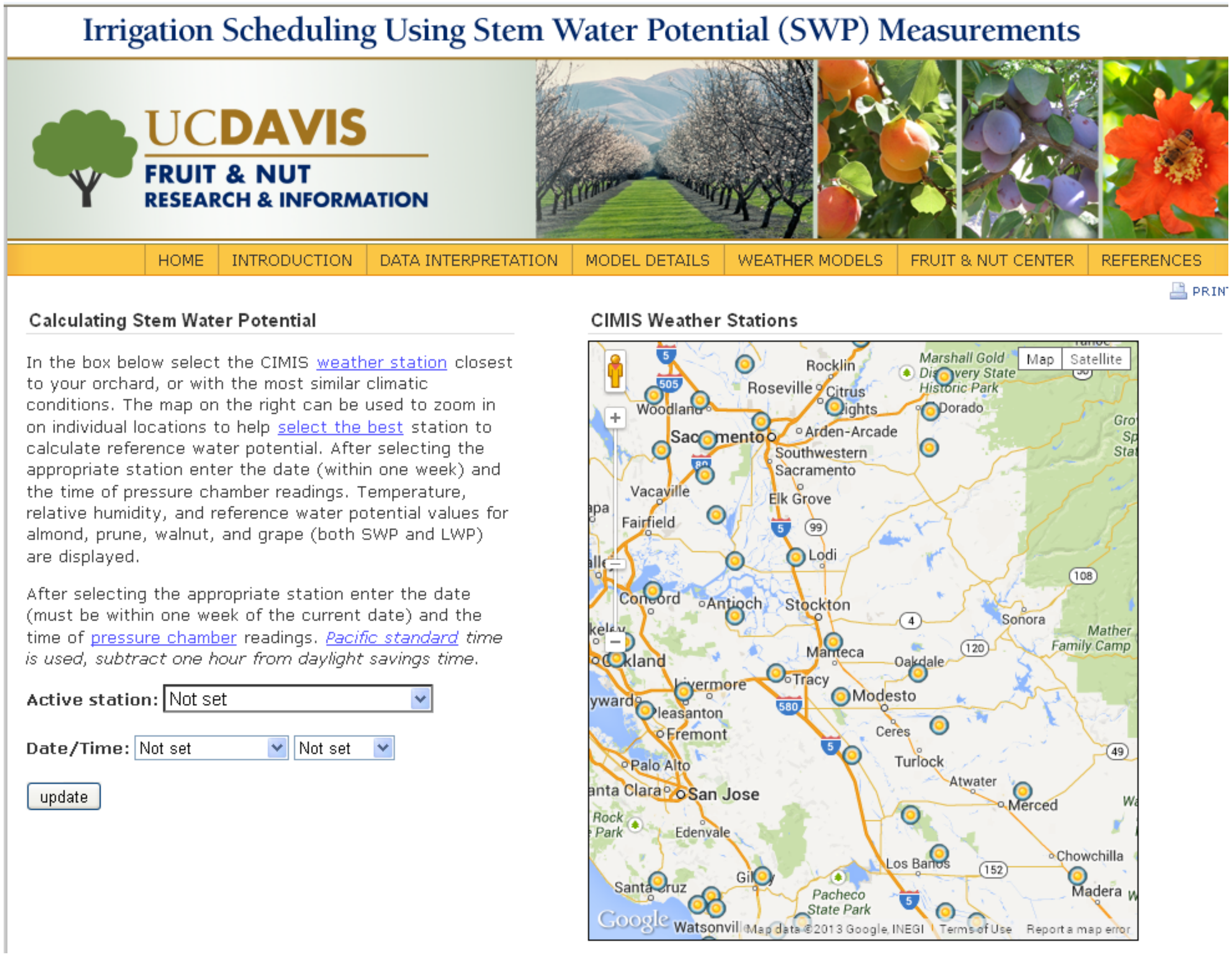
Air Temperature (F)	Air RH (%)		
	20	40	60
60	-3.7	-3.5	-3.2
70	-4.1	-3.7	-3.4
80	-4.6	-4.1	-3.7
90	-5.2	-4.6	-4.0
100	-6.1	-5.3	-4.5
110	-7.3	-6.2	-5.0

These values are called “Baseline” SWP

Resources to help with the pressure chamber

A ‘baseline’ website:

http://informatics.plantsciences.ucdavis.edu/Brooke_Jacobs/index.php



Resources to help with the pressure chamber

A 'baseline' website:

http://informatics.plantsciences.ucdavis.edu/Brooke_Jacobs/index.php

Calculating Stem Water Potential

To find baseline stem water potential (i.e., what water potential to expect under wet soil conditions for your date and time of sampling), select the CIMIS weather station closest to your orchard, or with the most similar climatic conditions. Use the map on the right to help select the most appropriate station, then select the station, date, and approximate time of your pressure chamber readings and press 'update.' Temperature, relative humidity, and baseline water potential values (in bars) for almond, prune, walnut, and grape (both SWP and LWP) will be displayed.

The baseline value provided on this website indicates the expected stem water potential of a tree if soil water had not been limiting. This baseline value should be compared to stem water potential measurements made in your orchard to determine whether irrigation is needed.

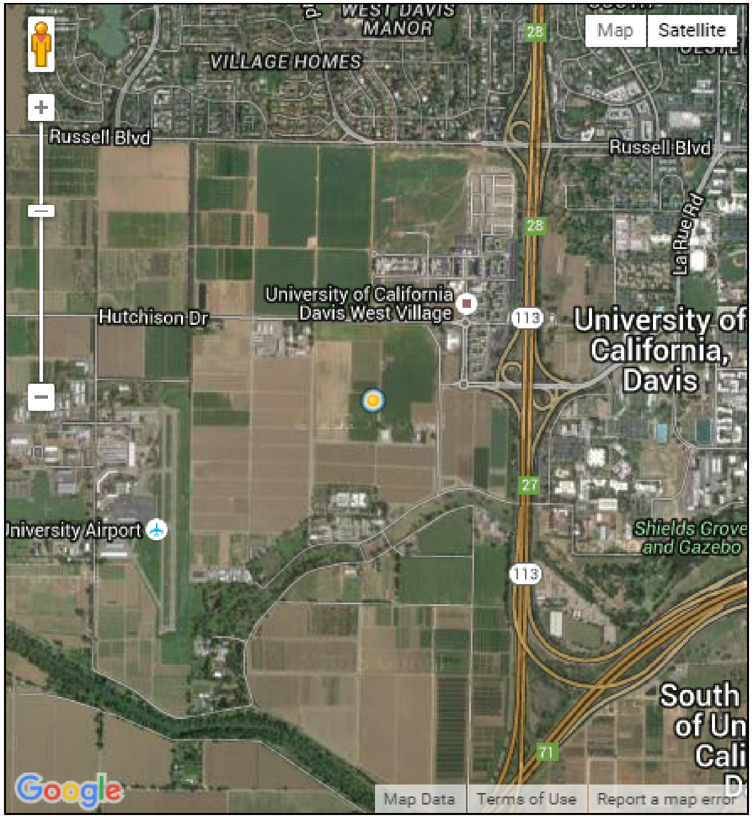
After selecting the appropriate station enter the date (must be within one week of the current date) and the time of pressure chamber readings. *Pacific standard time is used, subtract one hour from daylight savings time.*

Active station: 6 - Davis

Date/Time: Fri, 10-30-2015 | 1:00 PM

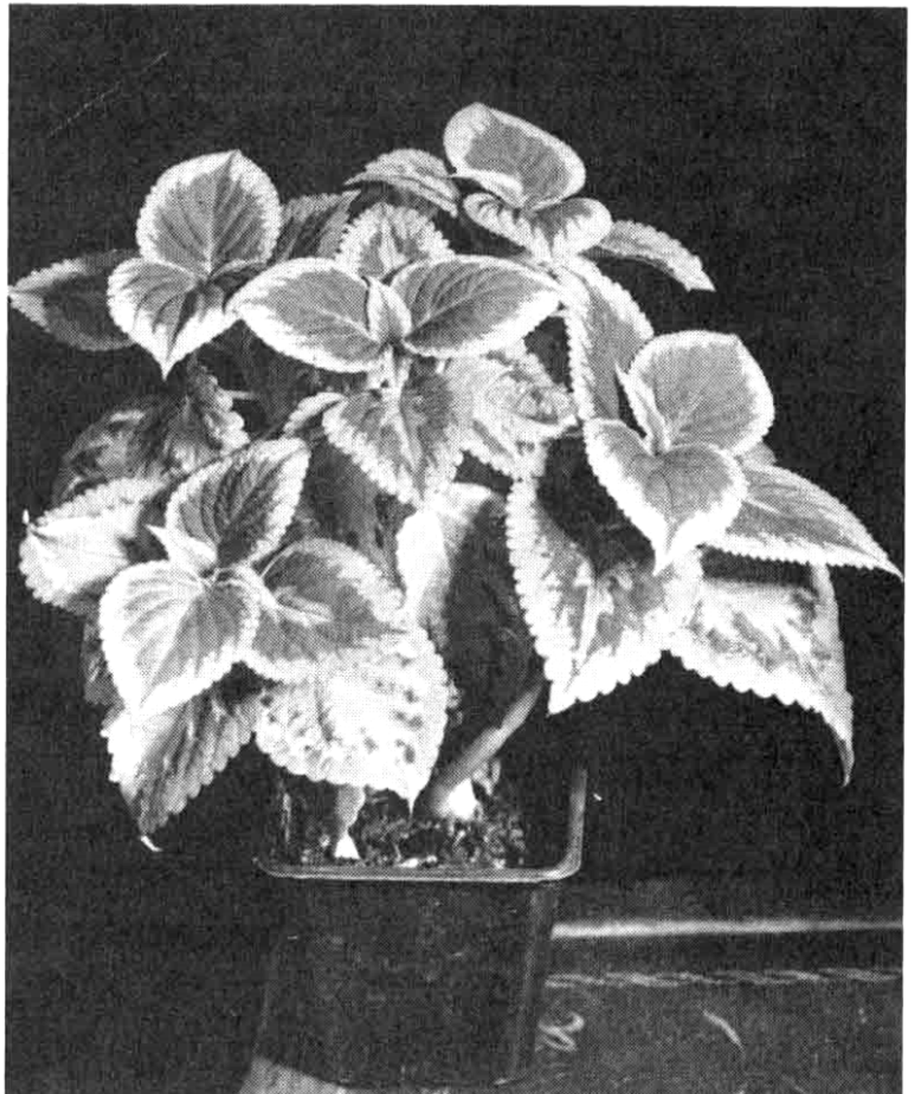
update

CIMIS Weather Stations



Time	Temperature (F)	Relative humidity	Almond/Prune	Walnut	Grape(SWP)	Grape(LWP)
11:00 AM	74.8	29.0	-6.6	-4.1	-3.7	-6.6
12:00 PM	78.1	24.0	-7.1	-4.4	-4.0	-6.9
1:00 PM	80.7	20.0	-7.5	-4.6	-4.2	-7.2
2:00 PM	82.7	18.0	-7.9	-4.8	-4.4	-7.4
3:00 PM	83.9	16.0	-8.1	-4.9	-4.6	-7.5

So, how much stress is too much stress?
Do we wait until we see “obvious signs?”



Salisbury & Ross, Plant Physiology (1992)

Pro's and Con's of 3 typical plant physiological responses to water stress

The Response	The Pro	The Con
Reduce Shoot Growth		
Reduce Stomatal Opening		
Not as much reduction in Root Growth		

Bottom line: most plant responses to water stress are good for plant survival, but at the expense of plant productivity.

The key issue is the PLANT RESPONSE

Forest Gump principle: Stress is as stress does.

If you want to know whether a tree is under stress, then irrigate it. If it gives a beneficial response, then it was under stress.

For young orchards: filling the space quickly has great economic benefits, so growth is a beneficial response.

For mature orchards: the space is already filled, so excessive growth is not a beneficial response.

SWP levels and stress symptoms in Walnut

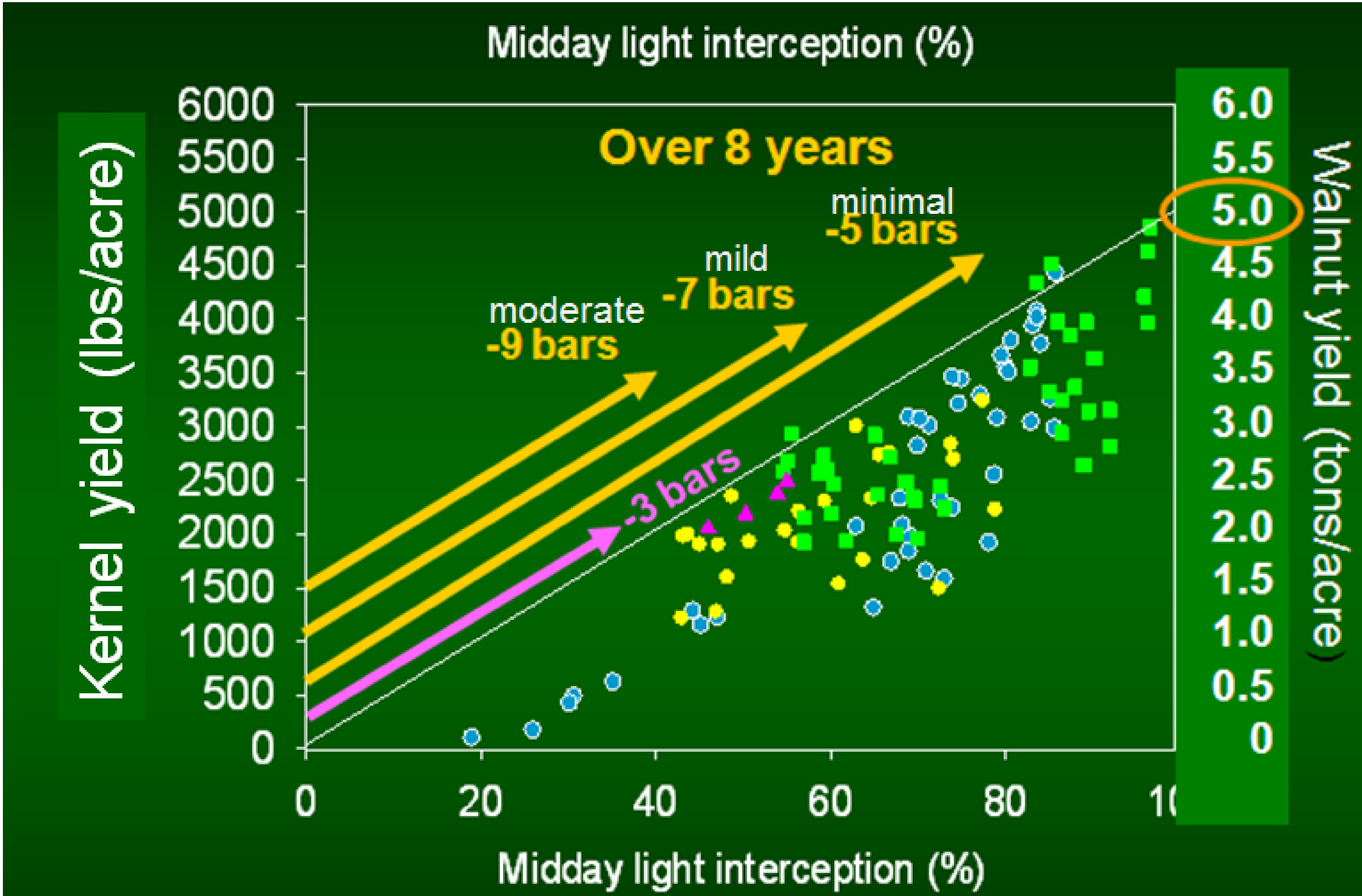
	Pressure Chamber Reading (- bars)	WALNUT
	0 to –2.0	Not commonly observed
(too?) "Wet"	-2.0 to –4.0	Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ETc), long term root and tree health may be a concern, especially on California Black rootstock.
"Medium"	-4.0 to –6.0	Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed.
	-6.0 to –8.0	Mild to moderate stress, shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development.
"Dry"	-8.0 to –10.0	Moderate to high stress, shoot growth in non-bearing trees may stop, nut sizing may be reduced in bearing trees and bud development for next season may be negatively affected.

July/August, 2015, farm call examples

Good growth, SWP varied between baseline and about -7 bars over the irrigation cycle.

Poor growth, SWP around -12 bars when checked. Irrigation was infrequent with too much at once. Trees recovered to around -5 bars and began to grow once irrigation duration was reduced and frequency increased.

Walnut canopy development effects



Walnuts: When to start irrigating?

9 year old Chandler/Paradox orchard about 4 miles SE of Red Bluff, CA.
RCBD, 5 blocks, 5 irrigation treatments:

- Grower practice

Or wait for:

- 1 bar below baseline
- 2 bars below baseline
- 3 bars below baseline
- 4 bars below baseline

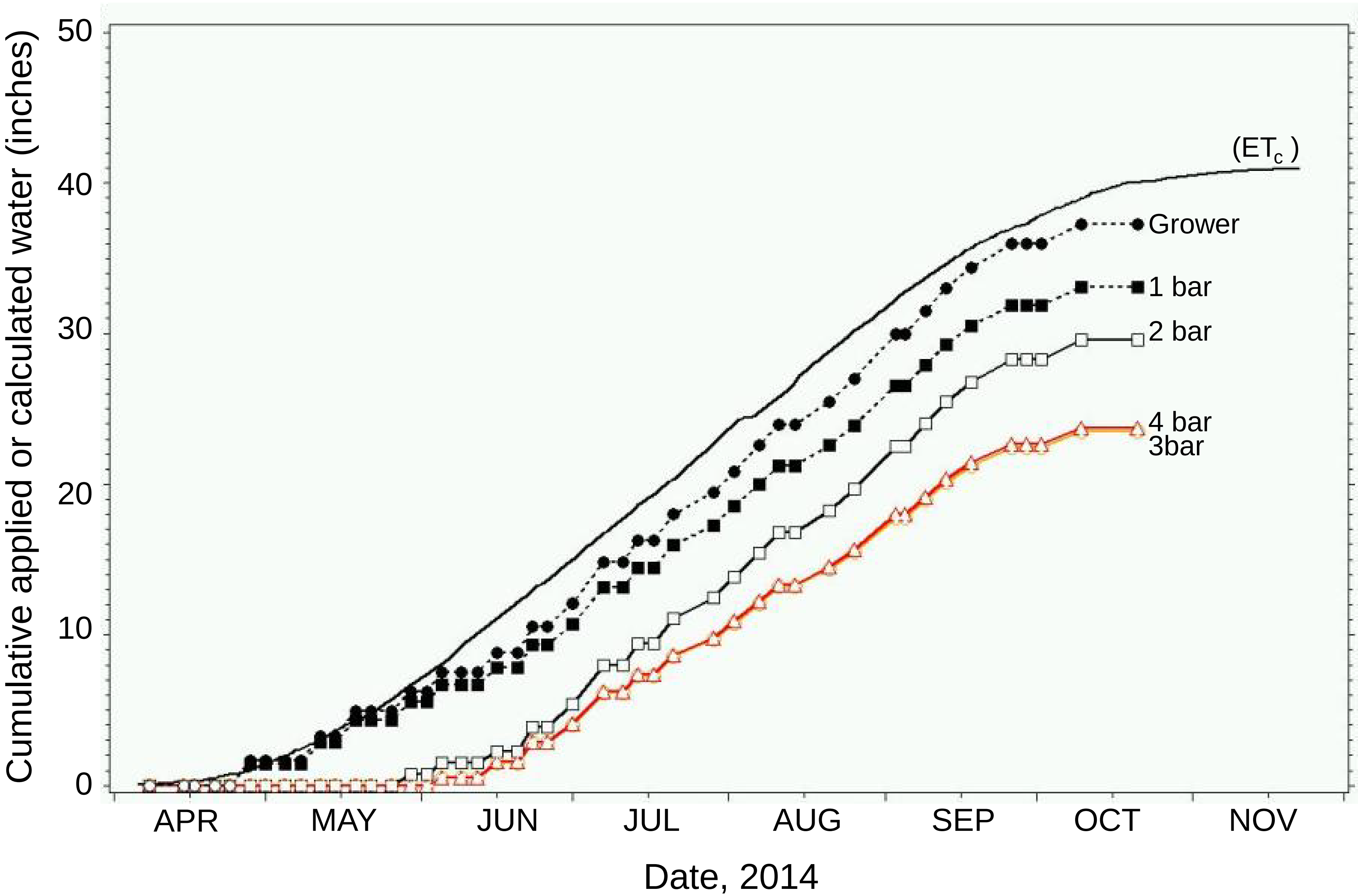
before starting irrigation, then irrigate as Grower.

Questions:

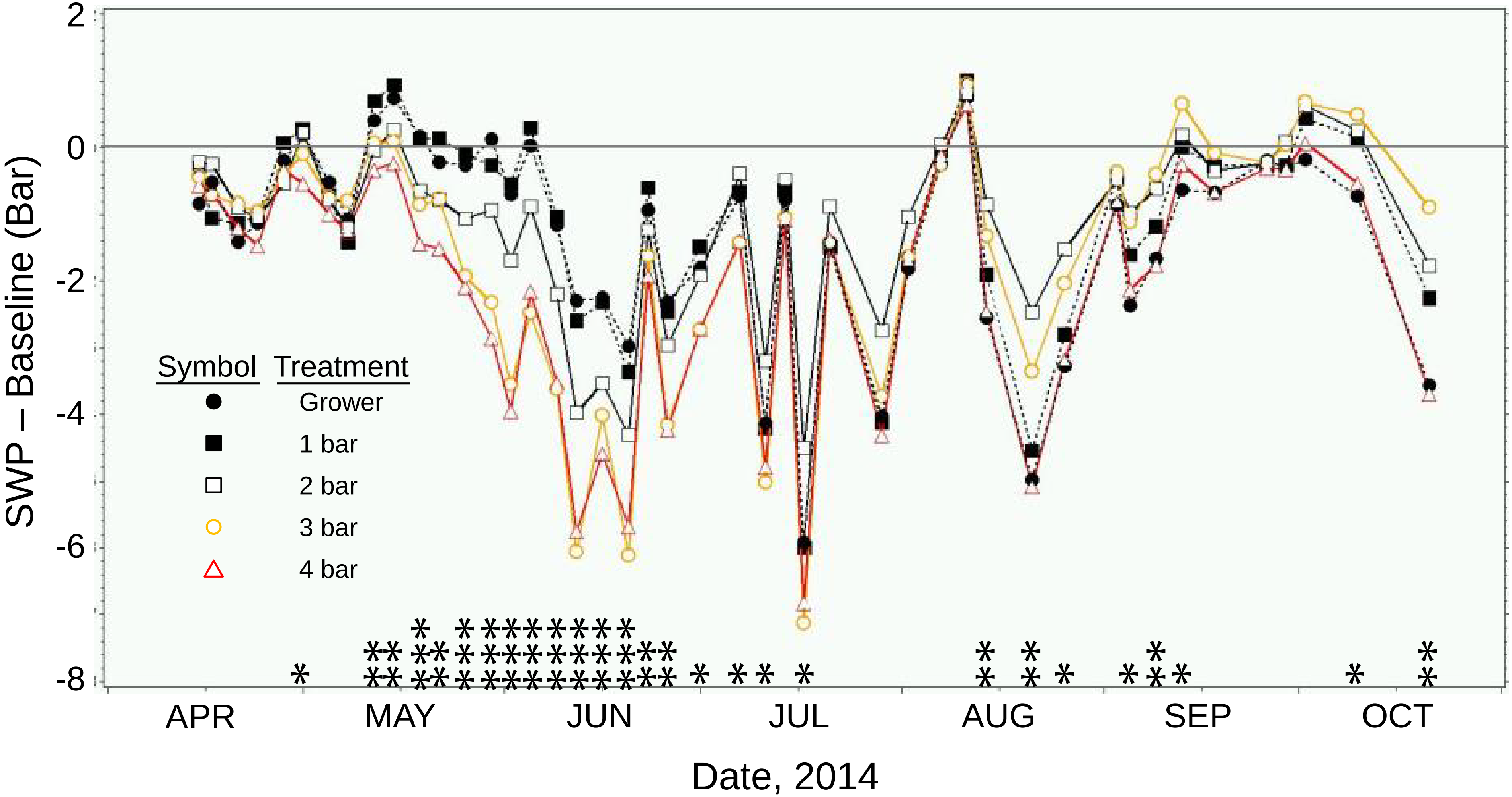
Will a later start date mean that the trees will always be "behind?"

Will this cause excessive stress when irrigation is stopped to allow for harvest? (The 'no bank account' effect).

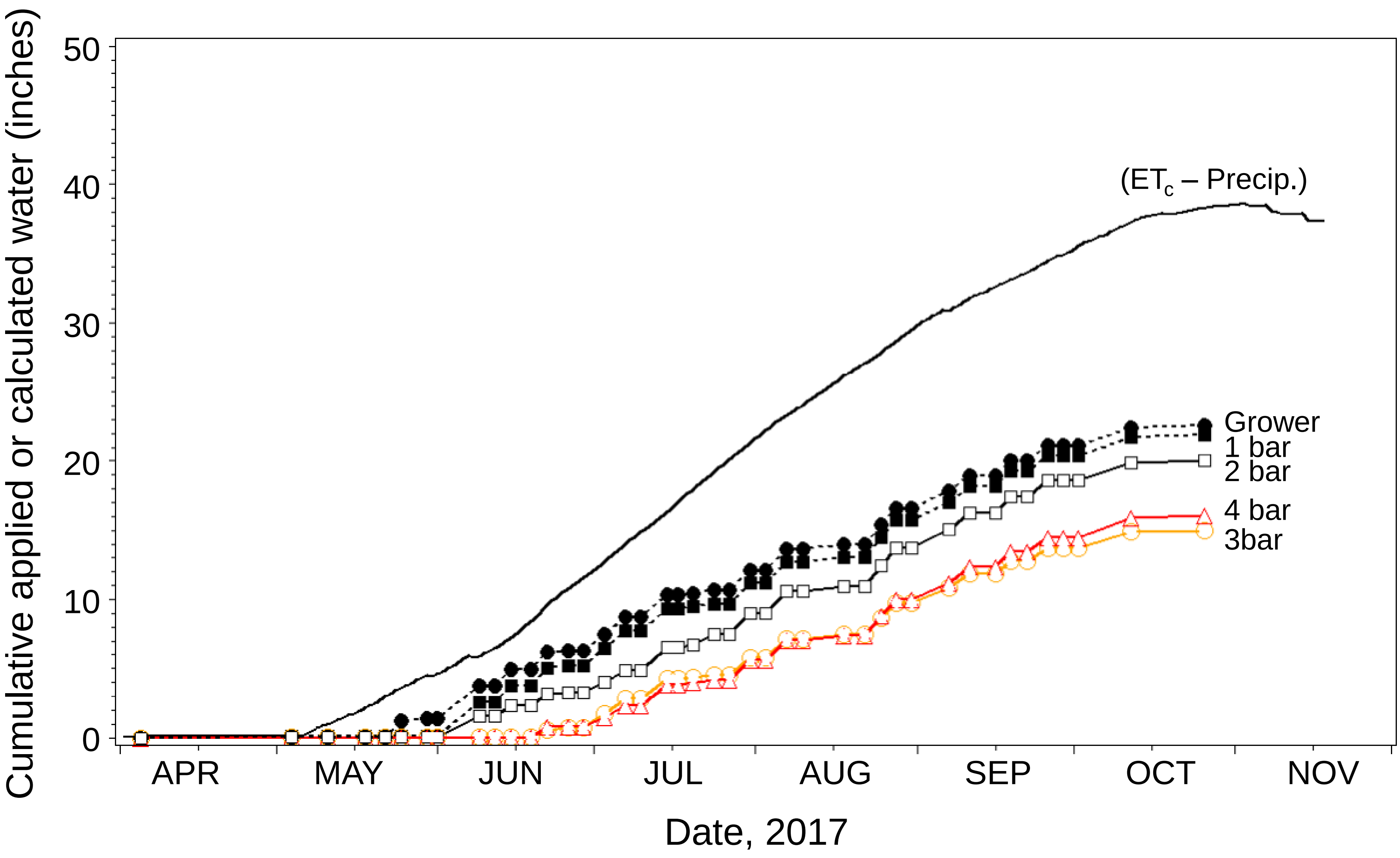
Year 1 results: Cumulative applied irrigation



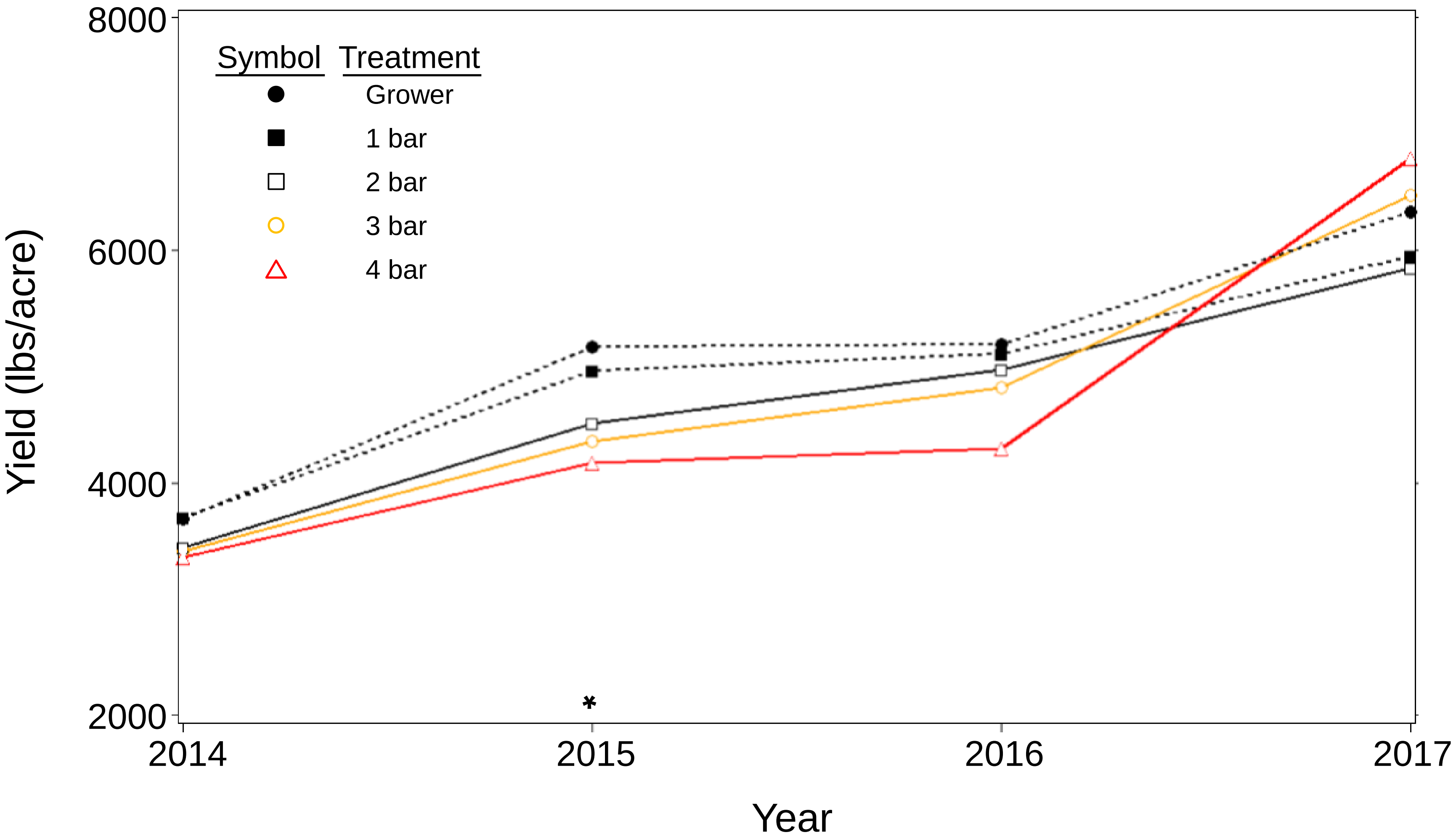
Year 1 results: Seasonal (SWP-Baseline)

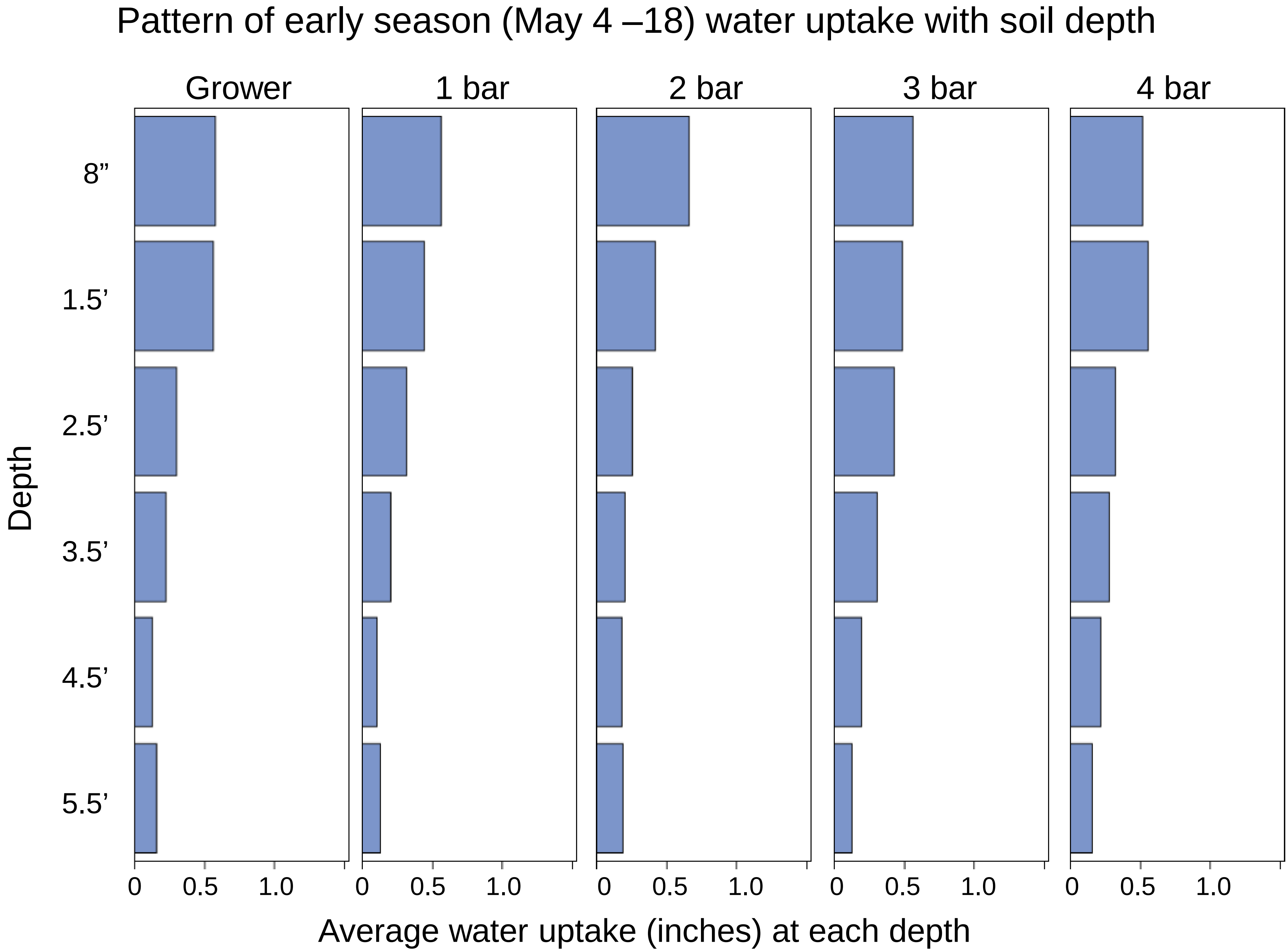


Year 4: Cumulative applied irrigation



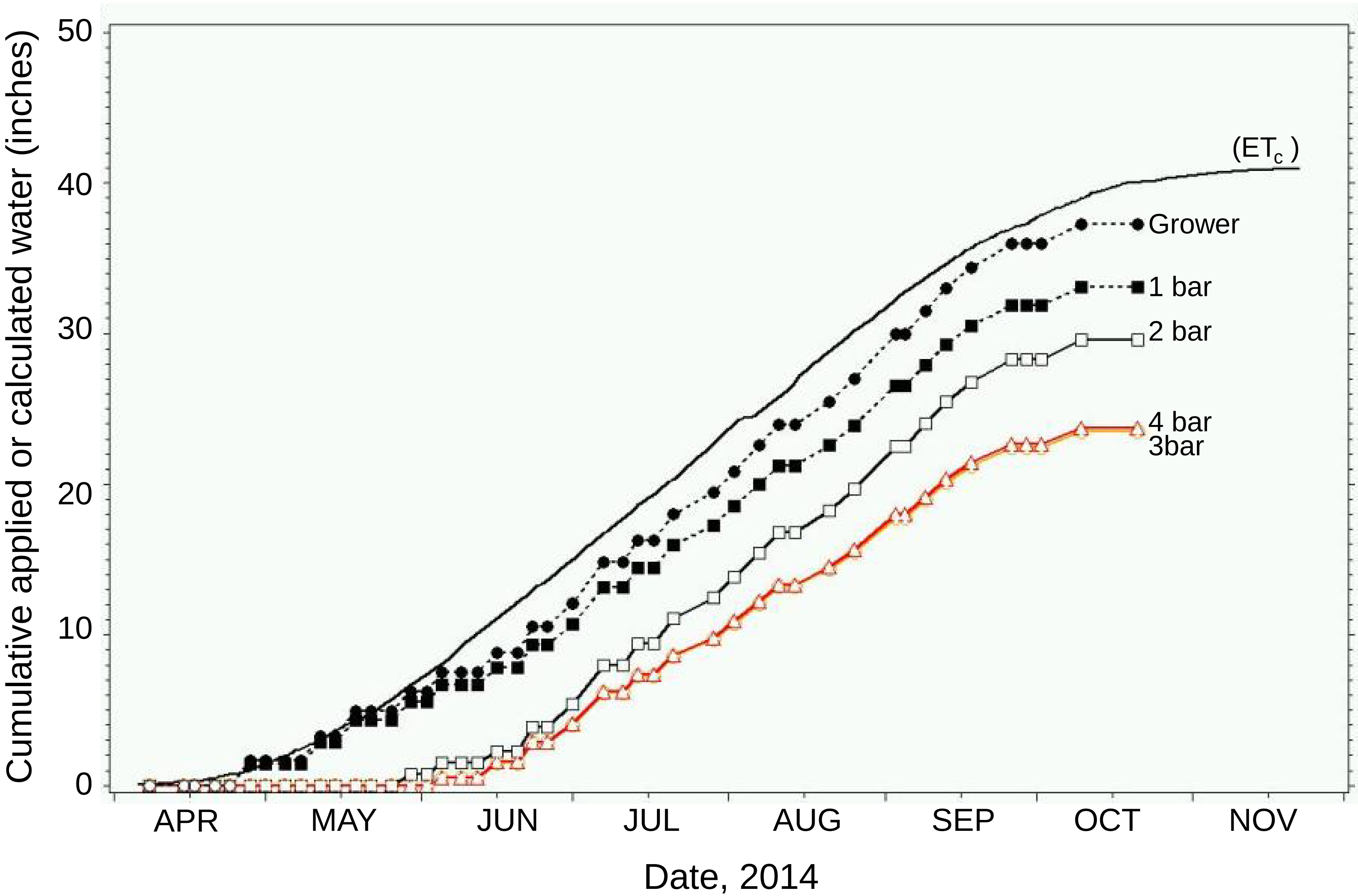
Trend of treatment average yields, 2014-2017





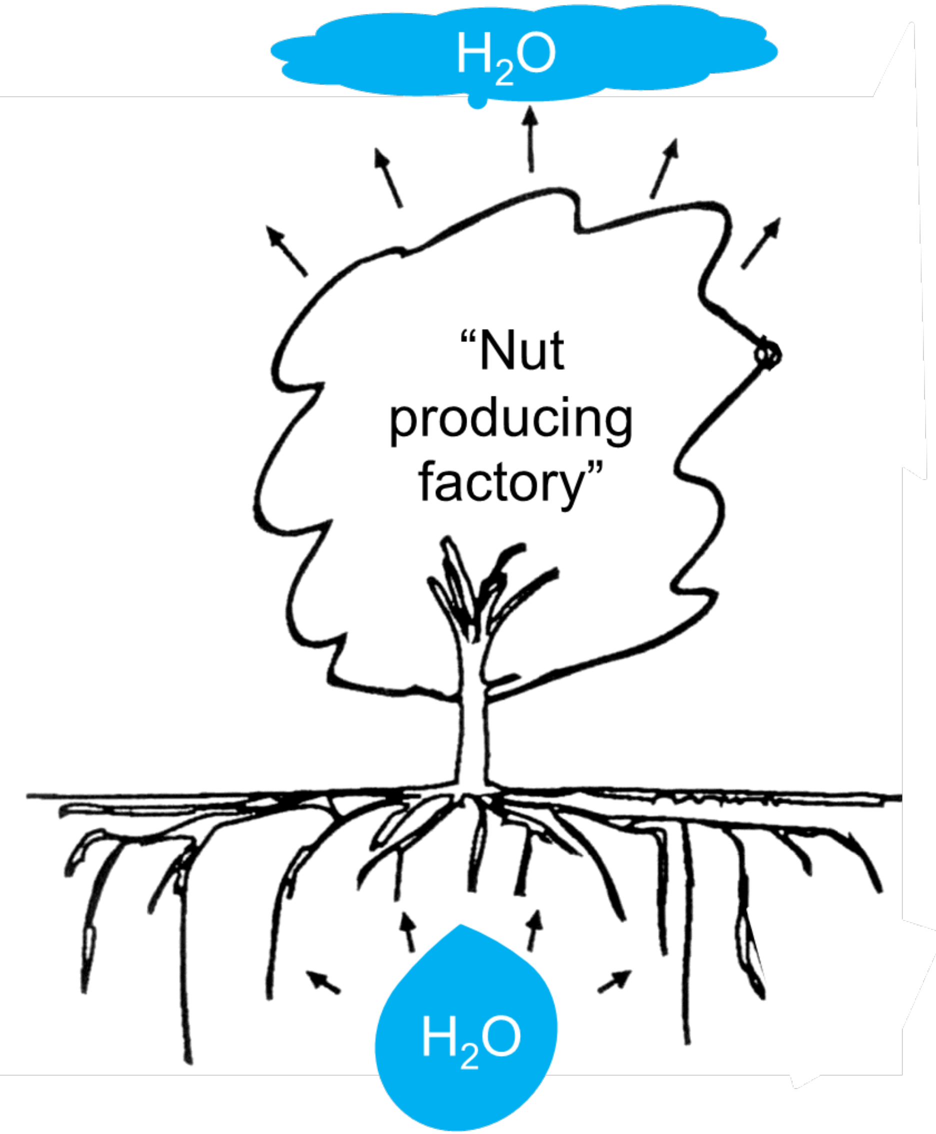
Pattern of early season (May 4 –18) water uptake with soil depth
Grower
1 bar
2 bar
3 bar
4 bar
Depth
8”
1.5’
2.5’
3.5’
4.5’
5.5’
0
0.5
1.0
Average water uptake (inches) at each depth

Walnuts: Perhaps the first case where matching ET is not a ‘safe’ practice



Overall Conclusions

- Walnuts respond to water stress similarly to other plants.
- Most plant physiological responses to water stress improve survival, but lead to lower productivity.
- The level of water stress can be measured with the pressure chamber (SWP) and can help you ‘fine tune’ your irrigation management practices.
- “Unstressed” (near baseline SWP) is generally good, but “completely unstressed” (at or above baseline all the time) may cause physiological (perhaps root related) problems.
- Allowing some stress early in the season (deficit irrigation) may actually reduce, not increase, stress at harvest, and appears to lead to healthier trees. Tree health is a long-term issue however, so stay tuned.
- Automated methods are being commercially developed (or resurrected), and have the advantage of providing daily values. Essentially all automated methods to date do not measure SWP directly, but do show some relation to SWP. Periodic SWP measurements are still needed.



Thanks for your attention

Thanks to my cooperators:

Kari Arnold
Nick Bertagna
Rick Buchner
Jiong Fei
Allan Fulton
Valerie Gamble
Cyndi Gilles
Joe Grant
Wess Hackett
Bruce Lampinen
Chuck Leslie
Cayle Little
Nick Matusomoto
Sam Metcalf
Nick Mills
Bill Olsen
Terry Prichard
Dave Ramos
Dan Rivers
Larry Schwankl

Questions?