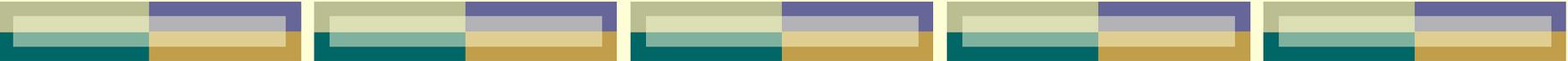




Considerations In Selecting Water Stress Indicators

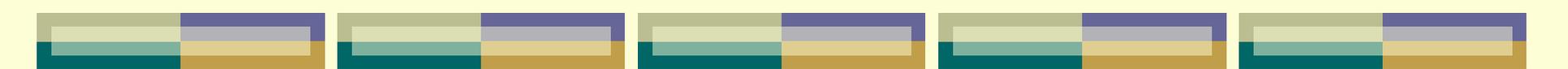
Amos Naor
The Golan Research Institute
and The Northern R&D





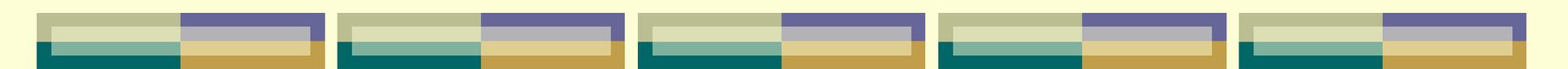
Why should we use water stress indicators even when we have access to ET_0 and K_C data?

- Uncertainty about the accuracy of certain factors:
 - Tree size (% shading/ LAI).
 - Application efficiency (how much water is percolated below root zone).
 - Application uniformity.
 - Crop load effects.
 - Stress coefficients when Regulated Deficit Irrigation is applied.
- 



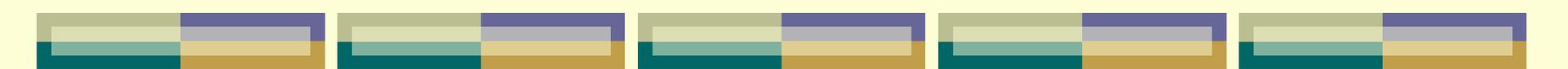
How water stress assessment is integrated in the irrigation scheduling?

- Option 1: Adjust the **irrigation level (directly)** when the water stress indicators reach the threshold.
 - Water stress assessment corrects for both the variable weather and inaccurate irrigation coefficients.
 - Option 2: Use the ET_0 data and adjust the **coefficients** when the water stress indicators reach the threshold.
 - Water stress assessment will be required only to correct for inaccurate irrigation coefficients.
 - It will require less frequent water stress assessment.
 - It will allow permanent change of K_c (final tree size, low and high crop load).
- 



What we expect from a good water stress indicator:

- Correlated with crop yield and quality attributes.
 - Early detection of water stress (before it is too late).
 - Simple threshold setting procedure.
 - Continuous readings is an advantage.
 - Easy to use.
 - Reasonable investment in sensors and operation.
- 



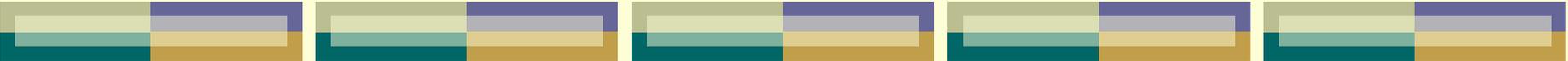
What we expect from a good water stress indicator:

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Topics to be covered:

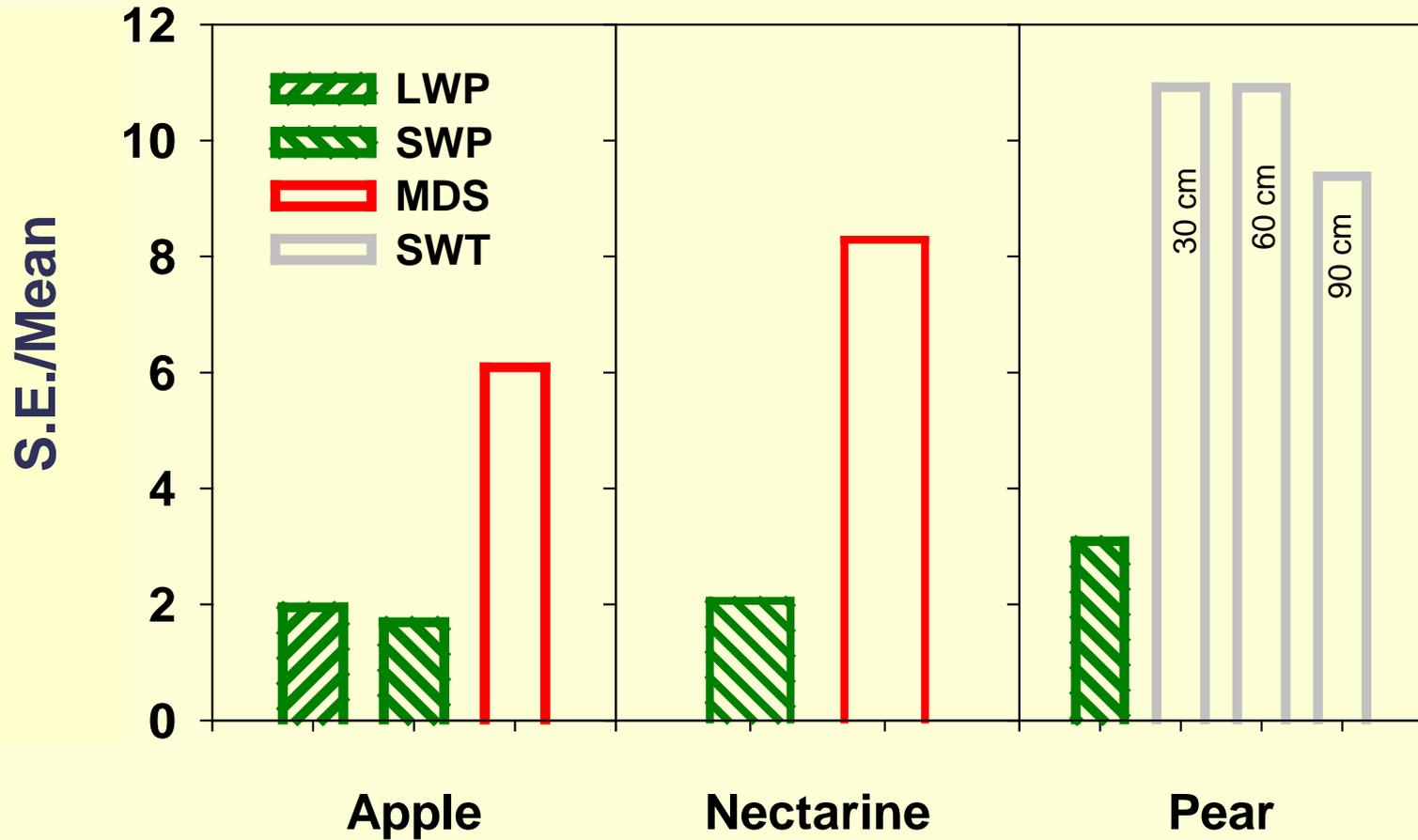
- Soil- versus plant-based water stress indicators
 - Comparison between stem water potential and maximum daily trunk shrinkage
 - Setting thresholds
 - Sample size in commercial plot
 - The unique contribution of thermal imaging.
- 



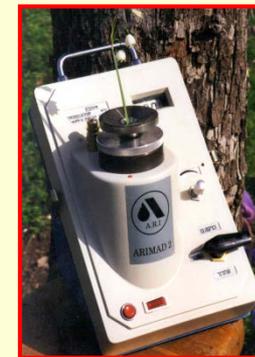
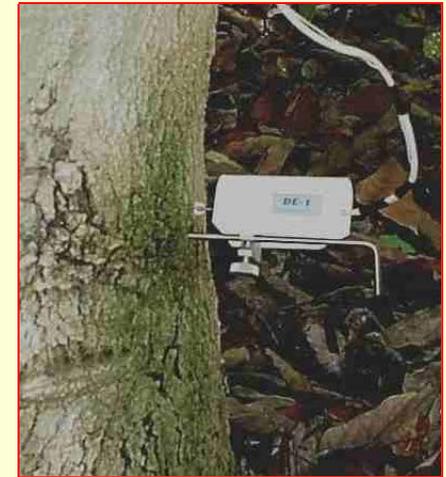
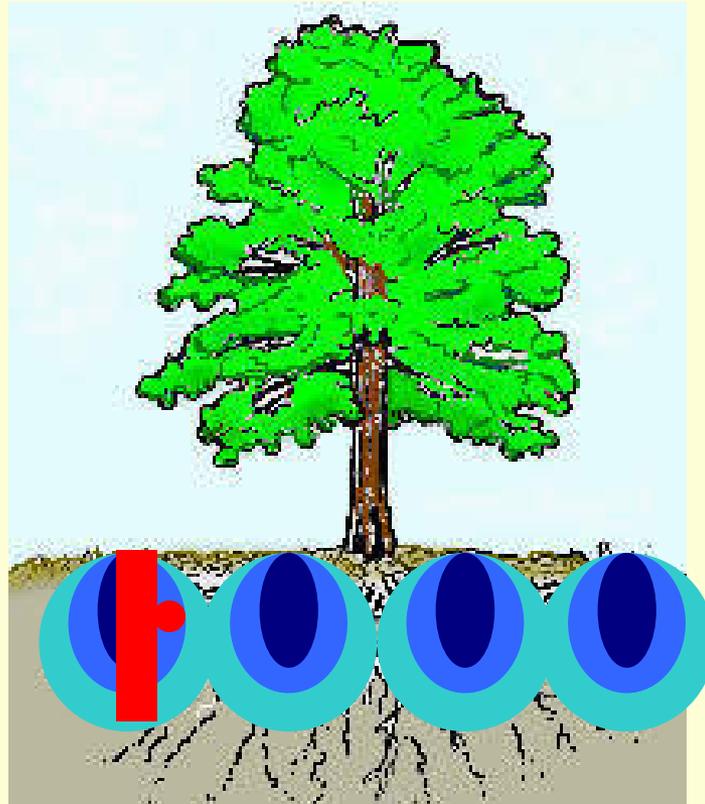
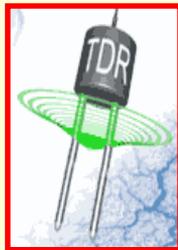
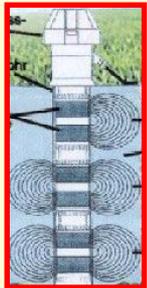
Soil- versus plant-based water stress indicators

- Apple, pear and nectarine were examined
 - 25-30 trees (in close vicinity) were selected
 - Plant water potential, trunk shrinkage and soil water potential were measured.
 - The variability of the sensor readings was compared.
- 

The relative variability of LWP, SWP, MDS and Soil water tension

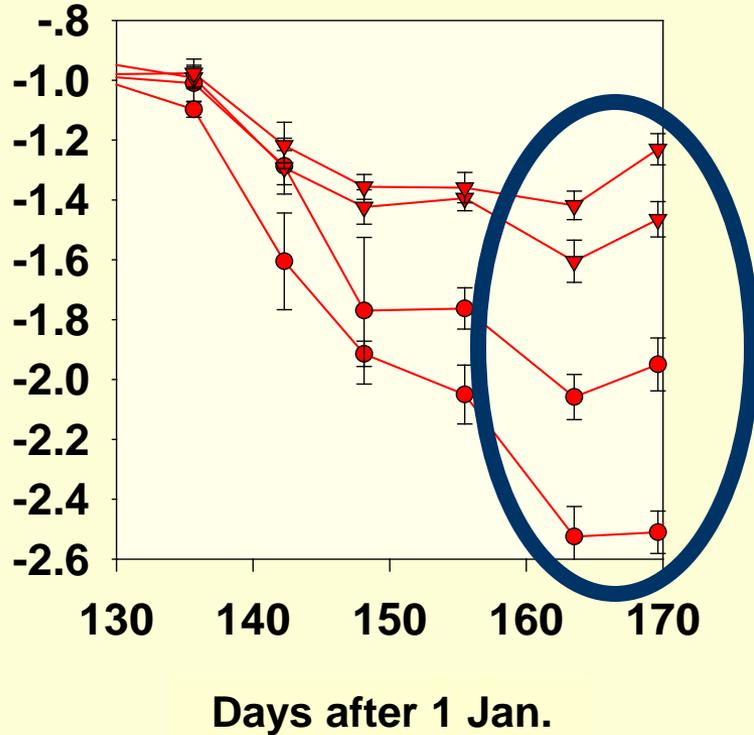


Why soil water stress indicators are more variable than plant water stress indicators?

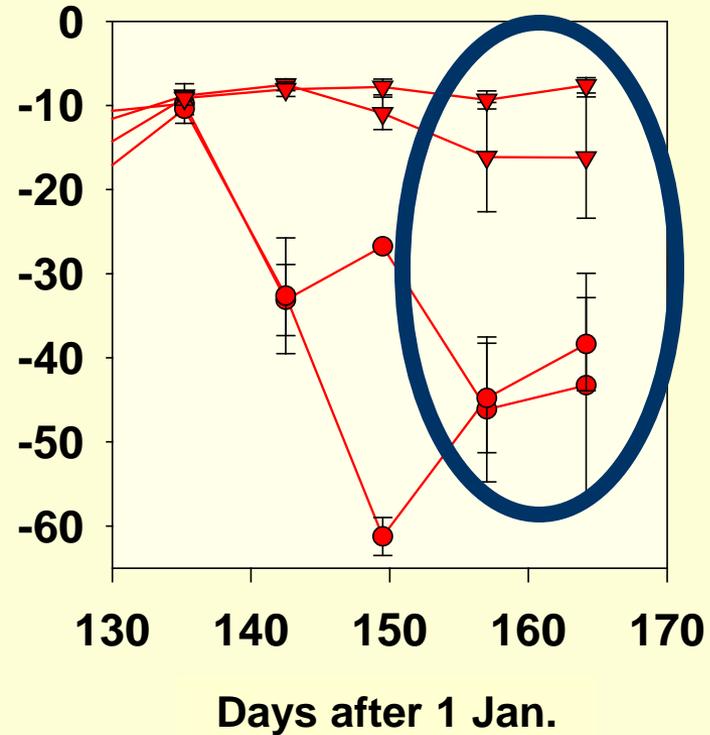


Comparison between tensiometers and stem water potential in plum

Midday SWP

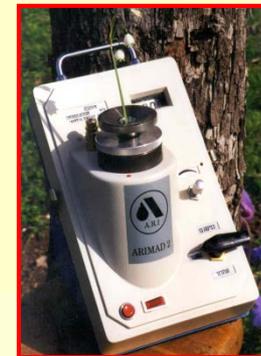


Tensiometers



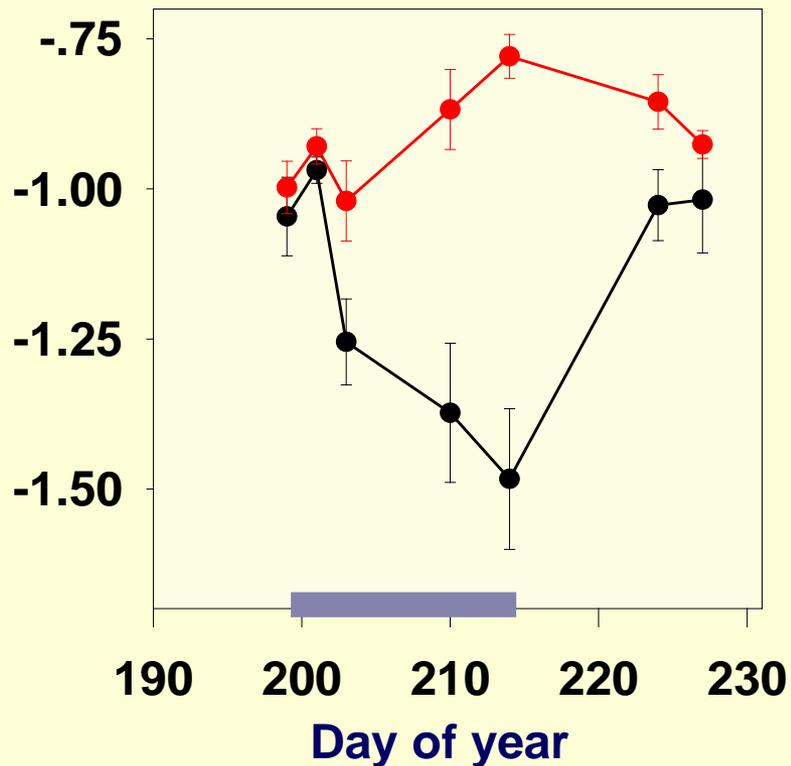
Sensitivity and variability of stem water potential and dendrometer in apple

- Two treatments were applied:
 - Minimum stress control.
 - Stress treatment – irrigation was withheld for 17 days and then resumed.
- Stem water potential and maximum trunk shrinkage were measured on 6 trees.

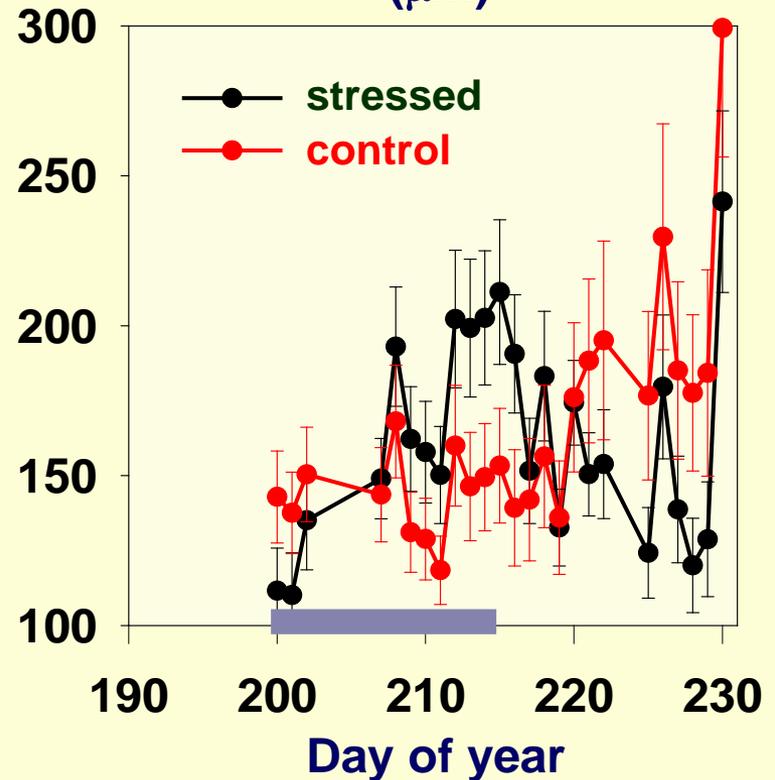


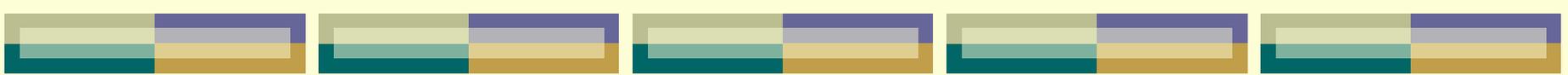
The response of **SWP**, **MDS** to withholding irrigation in apple

Midday stem water potential (MPa)

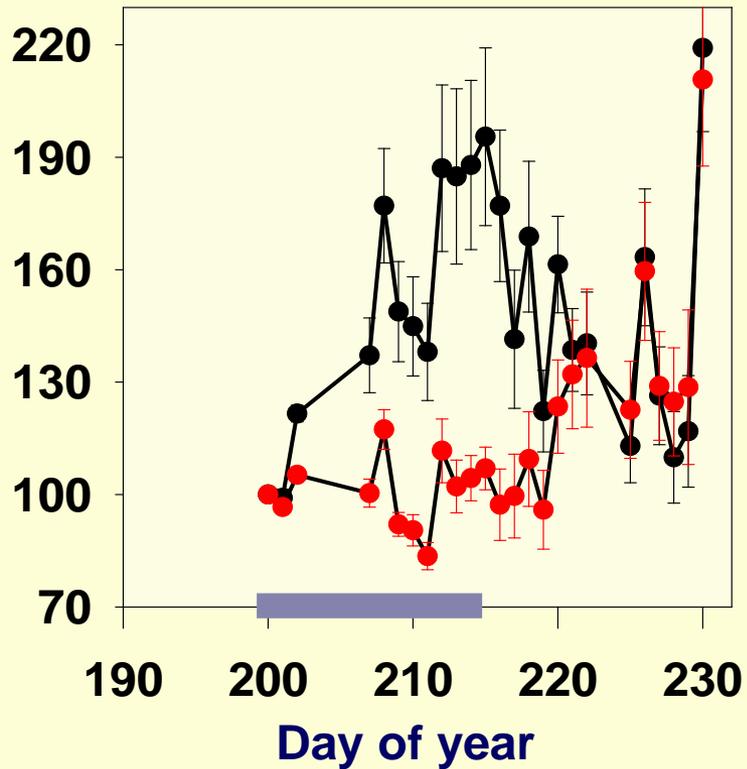


Maximum daily shrinkage (μm)

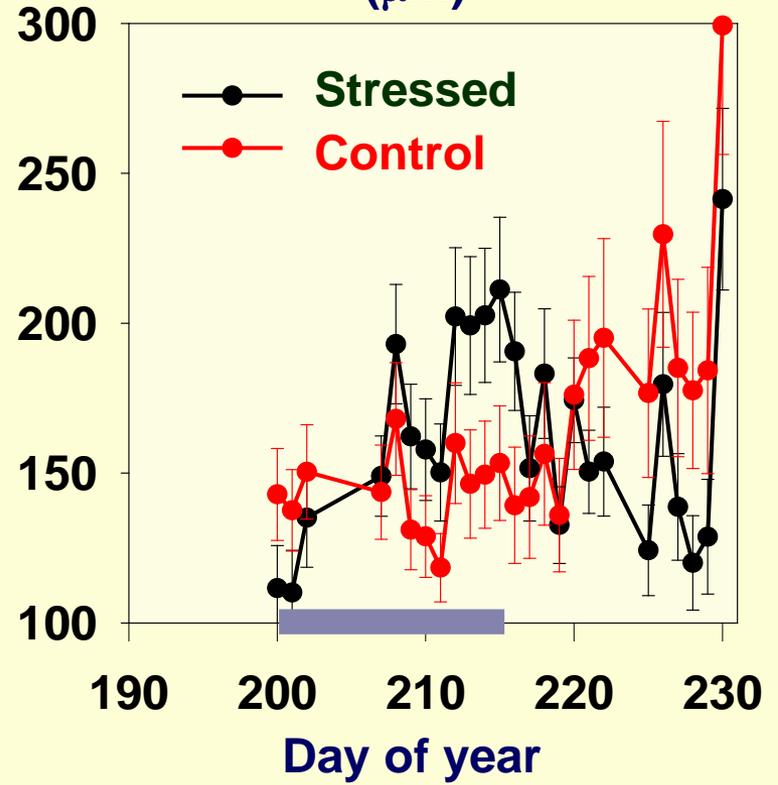




**Maximum daily shrinkage
(relative to initial values)**

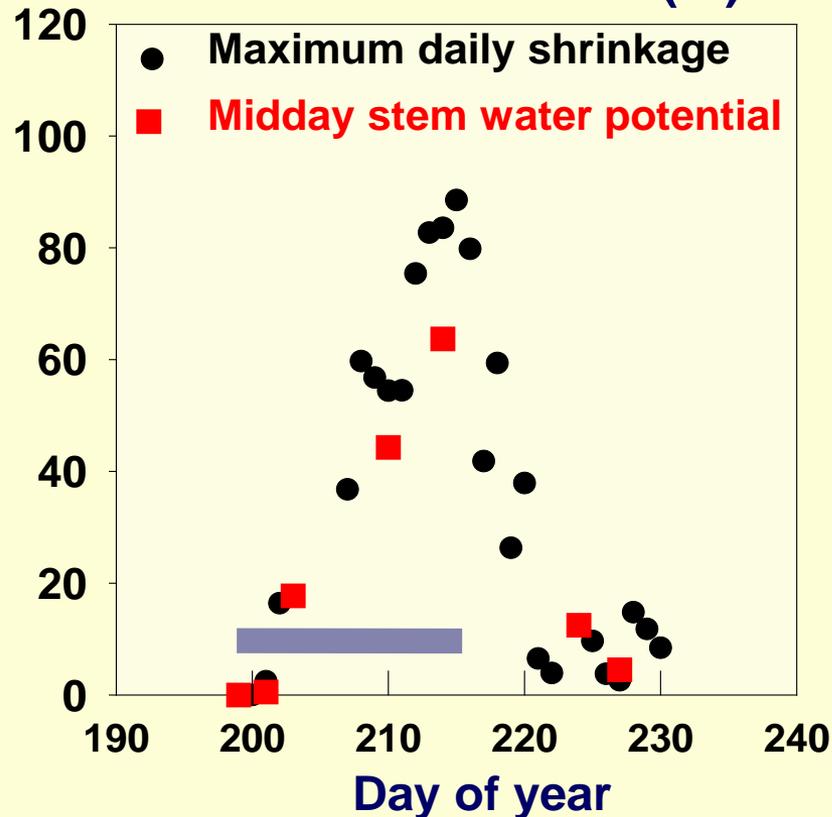


**Maximum daily shrinkage
(μm)**



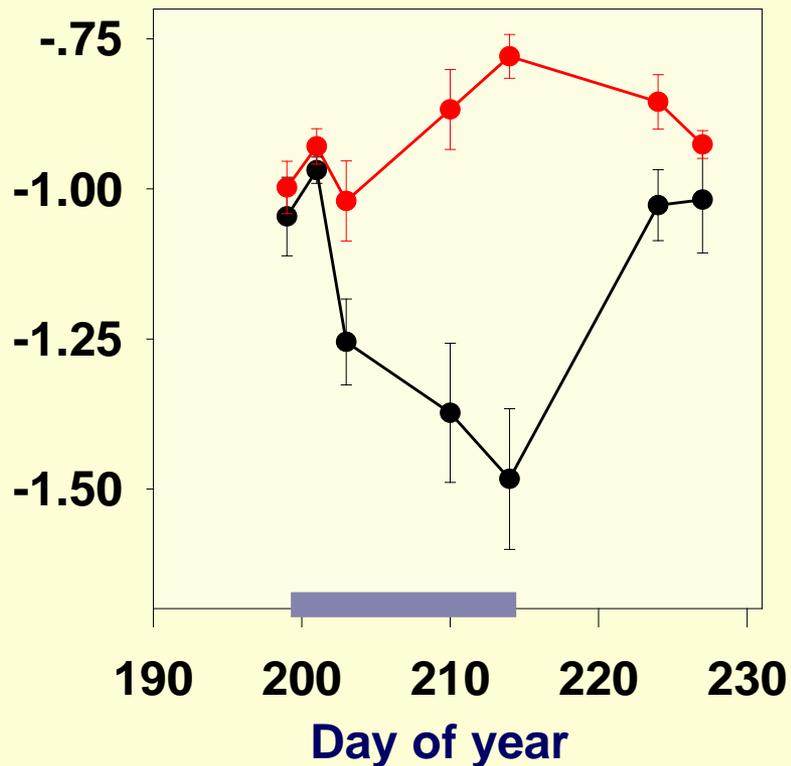
The sensitivity of **SWP**, **MDS** to changes in moisture availability

Differences between the stressed and non-stressed trees (%)

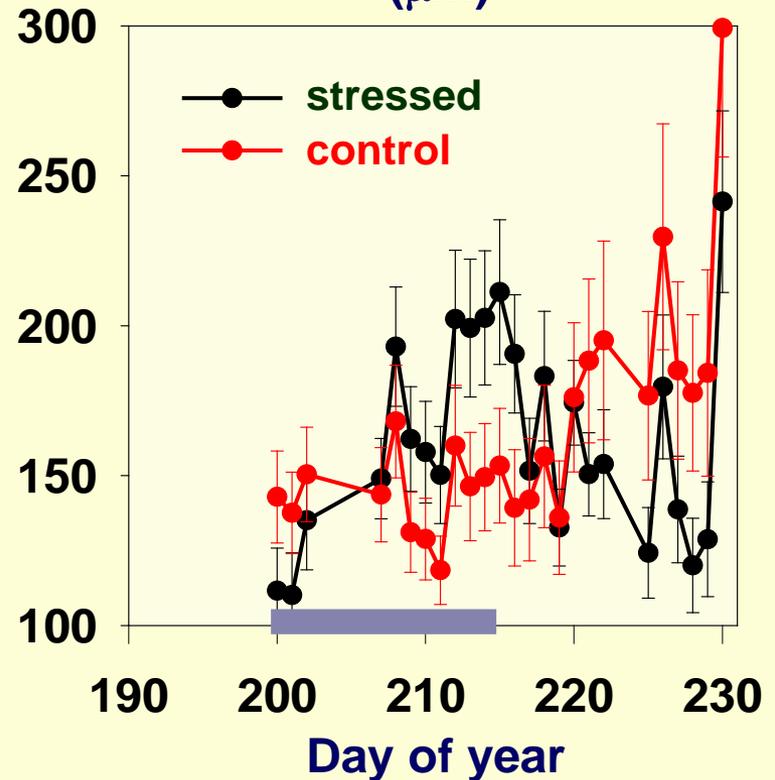


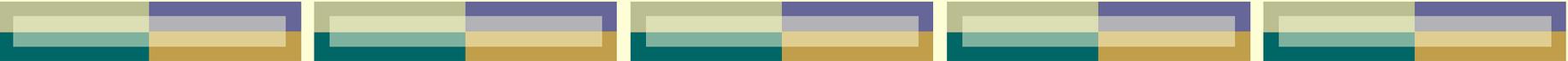
The response of **SWP**, **MDS** to withholding irrigation in apple

Midday stem water potential (MPa)



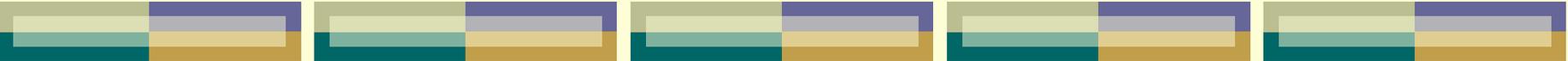
Maximum daily shrinkage (μm)





Variability and sensitivity of water stress indicators

- Soil sensors are more variable than plant sensors and it will be hard to determine the average root-zone soil water status.
 - Dendrometer readings are more variable than SWP
 - Dendrometers are more responsive to water stress than SWP (in many cases).
 - Less SWP measurements will be required to identify changes in plant water status compare with dendrometers (in many cases).
- 

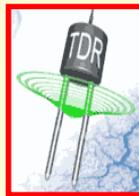
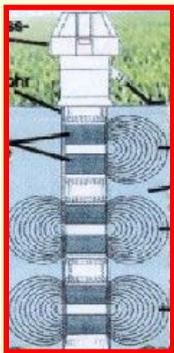


The relevance of plant water stress indicator readings

- Physiological processes respond to water potential rather than directly to length changes.
 - Length changes are only indirectly correlated with physiological processes (affects the ability to get a general threshold).
 - The relationships between SWP and physiological processes are not unique (it may affect the thresholds).
- 

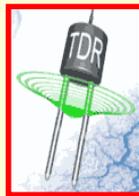
Setting thresholds for irrigation scheduling

- Water stress indicators are **useless** without having thresholds for the grower to make decisions.
- A thresholds can be:
 - A certain sensor reading.
 - An outcome of a complex analysis (but still clear criteria).

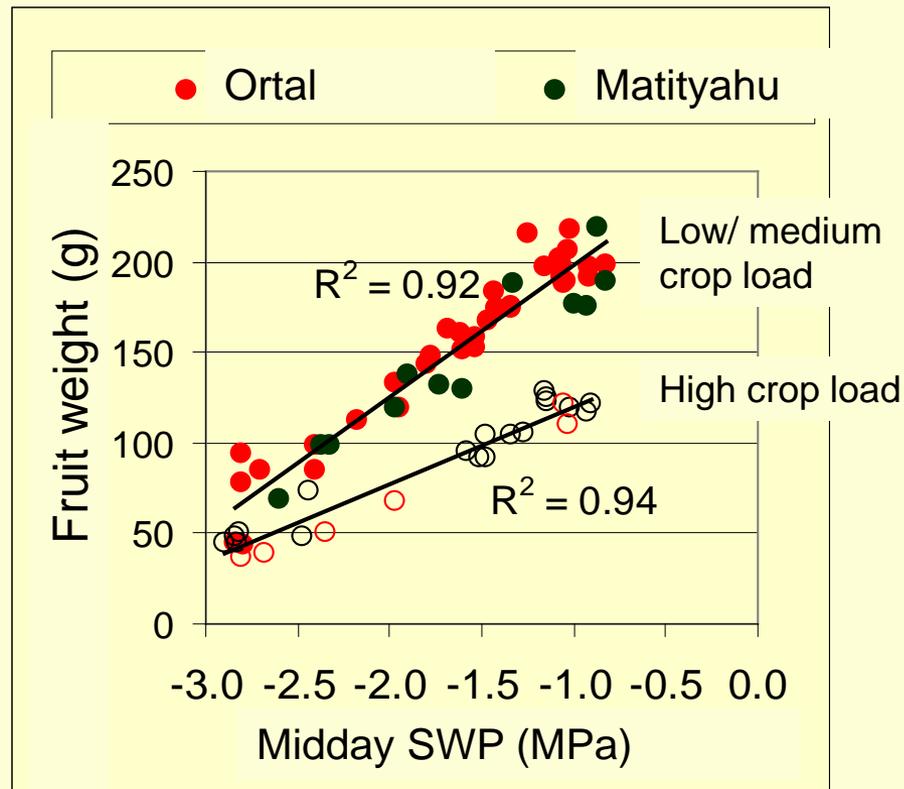


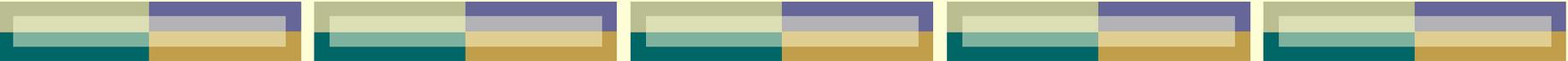
Setting thresholds for irrigation scheduling

- Soil sensors may have different thresholds for each plot because the inability to determine the average soil moisture availability.
- Dendrometers may have different thresholds for each plot because the indirect relations with physiological processes.
- SWP thresholds may apply for an entire region.
- Thresholds may change along the season (applies to all sensors).
- Once a threshold was set properly it is much easier to use soil sensors and dendrometers than SWP.



Effect of stem water potential on apple fruit weight





The SWP sample size required in commercial orchards

- Nine commercial orchards were selected in the Golan Heights and Upper Galilee.
 - 25 trees were randomly selected in each orchard.
 - In each tree stem water potential was measured and S.D. was calculated.
 - The required sample size was calculated based on the S.D. for each plot.
- 

Required sample size for SWP measurements

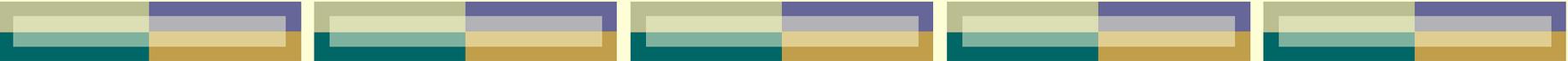
Orchard	0.075MPa	0.1MPa	0.15MPa
EI-1	27	15	7
EI-2	27	15	7
If-1	18	11	5
If-2	15	8	4
Me-1	28	16	7
MG-1	8	5	2
MG2	10	6	3
EZ-1	7	4	2
EZ-2	7	4	2

Larger sample size will be required for soil sensors and dendrometers due to the higher variability

The conflict growers have in selecting a water stress indicator

	Stem water potential	Soil sensors Dendrometers
Advantages	<ul style="list-style-type: none">• <u>Thresholds are transferrable</u>	<ul style="list-style-type: none">• Easy to use• Electronic output
Disadvantages	<ul style="list-style-type: none">• Manual measurement	<ul style="list-style-type: none">• <u>Thresholds should be set for each plot</u>

The importance of having a proper threshold overrides the inconvenience of using a pressure chamber

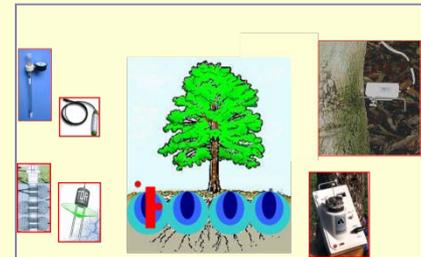
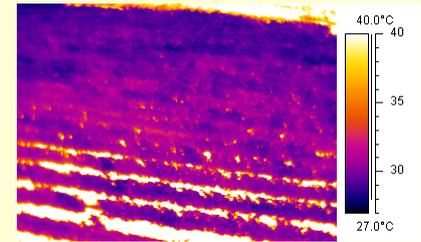


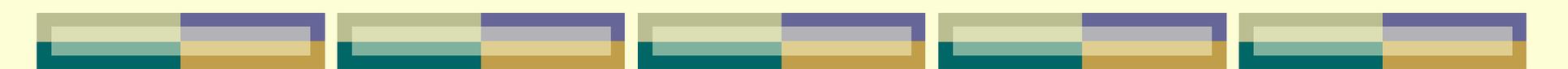
In spite of my conclusion most growers are using soil sensors “successfully”

- The soil sensor thresholds include a safety factor.
 - This safety factor is justified when a grower has access to the extra water.
 - Minimizing the safety factor requires the investment of more efforts in water stress assessment.
 - I would use the pressure chamber (SWP) to calibrate the thresholds of soil water stress indicators.
 - The calibration process should be repeated a few times along the season.
 - I would start by frequent calibration of the soil sensor thresholds in the first season and decrease the frequency upon the cumulative experience.
- 

Point versus area water stress assessment

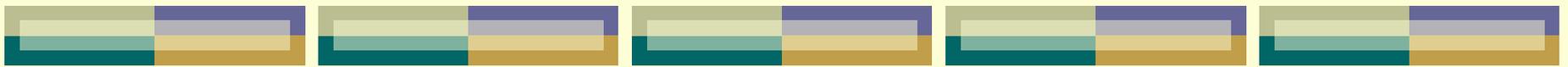
- **Digital thermal imaging may provide us with high resolution maps of tree water status.**
- The future is in thermal imaging but for now it cannot replace the point/tree sensors.
- I would consider (carefully) taking SWP measurements on the same day that thermal images are taken and to use it to calibrate the thermal map.





Take home message

- The weakness of soil sensors is the difficulty to determine the average soil moisture availability.
 - The soil sensor thresholds include a safety factor thus a waist of water.
 - Minimizing the safety factor requires the investment of more efforts in water stress assessment.
 - The pressure chamber (SWP) can be used to calibrate the thresholds of soil water stress indicators.
 - The calibration process should be repeated a few times along the season.
 - The frequency of the calibration of soil sensor thresholds should be determine upon the cumulative experience.
 - I would consider (carefully) taking SWP measurements on the same day that thermal images are taken and to use it to calibrate the thermal map.
- 



Thanks

