

# Midday Stem Water Potential

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Plant and Environmental Sciences

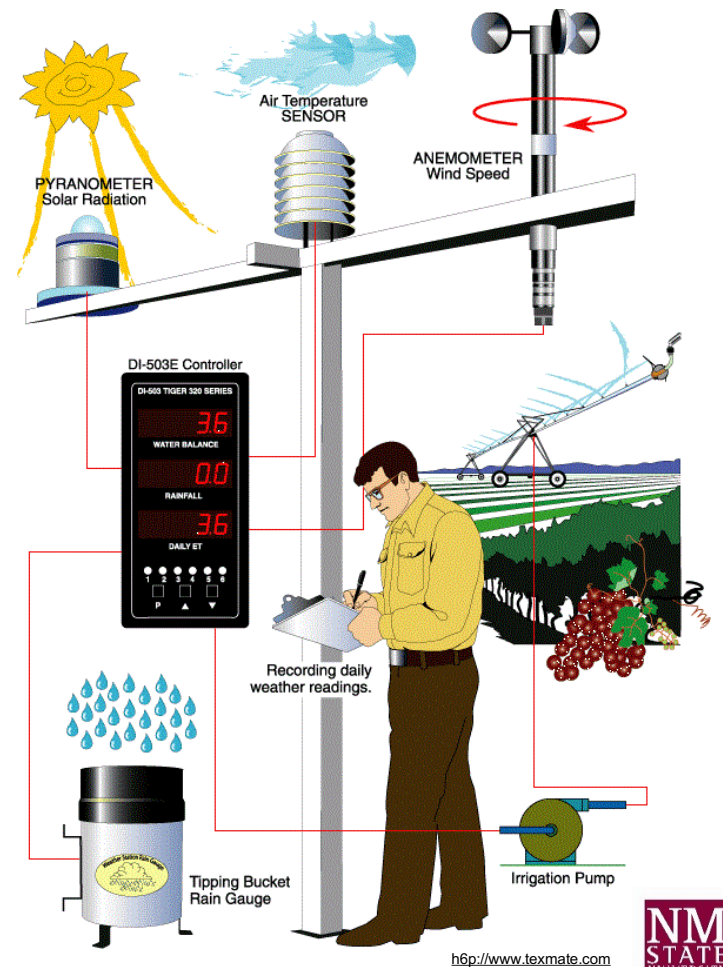
# Ways to improve irrigation efficiency in pecans

## Irrigation scheduling

When to irrigate

How much to apply

Irrigation scheduling depends on the sensitivity of field measurements to water deficit.



## Measurements used for detecting water status in pecan orchards

### Plant-based



Midday stem water potential ( $\Psi_{smd}$ )

### Soil-based



Soil TDR

### Plant-soil-based



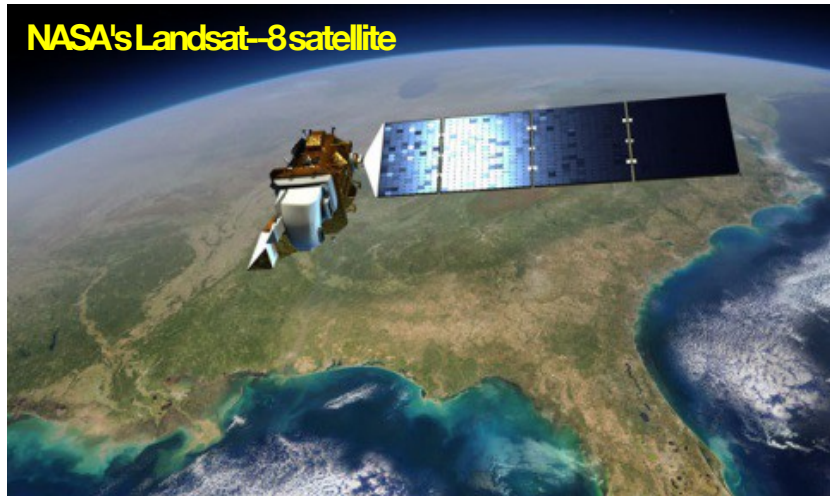
Lysimeters

### Limitations:

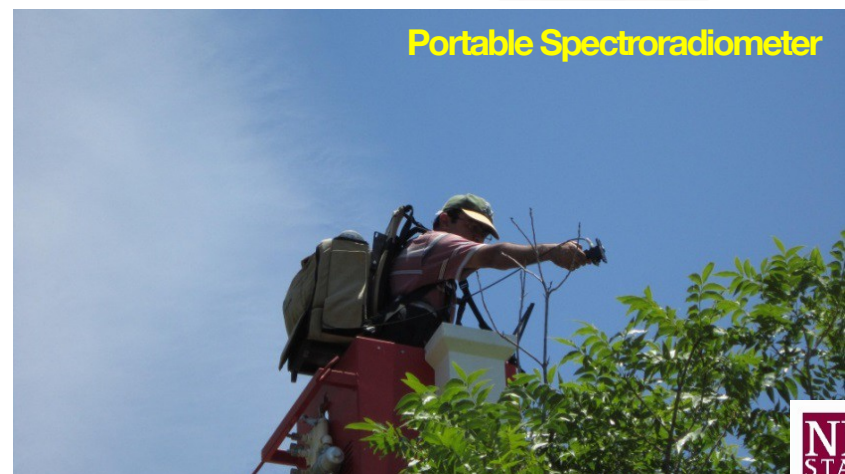
Small area, extraordinary cost, extraction time, leaf destruction

# We tried remote sensing to detect moisture status

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Handheld portable Spectroradiometer

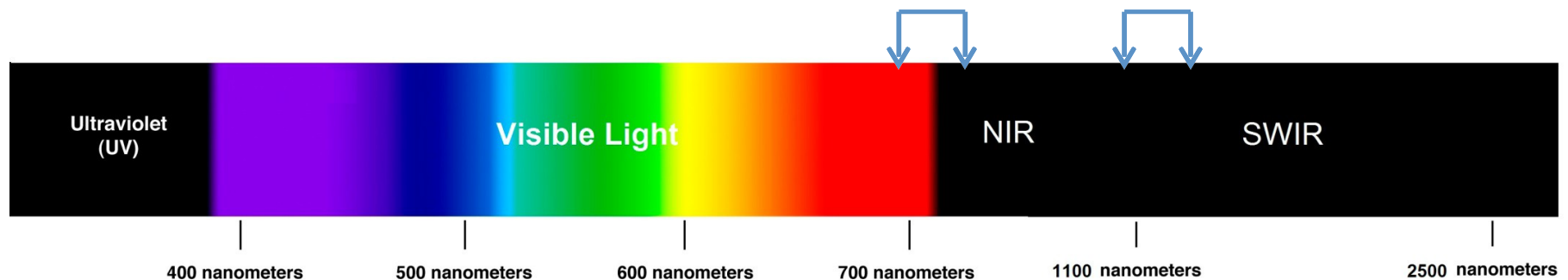
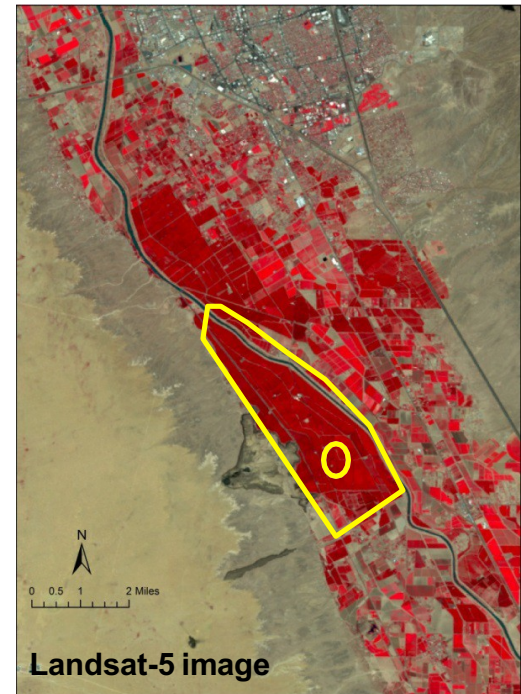


# Remote sensing applications

Scale up leaf-level physiological responses to large areas

Detect pigment concentration

Spectral regions from 680-750 nm and 1275-1640 nm were correlated with pecan water deficit (Johnson 2004).



Electromagnetic spectrum

# Objectives

The overall goal of this research was to develop an advanced sensing and management technologies to optimize water resources and drought monitoring of pecan orchards.

Initial research objectives:

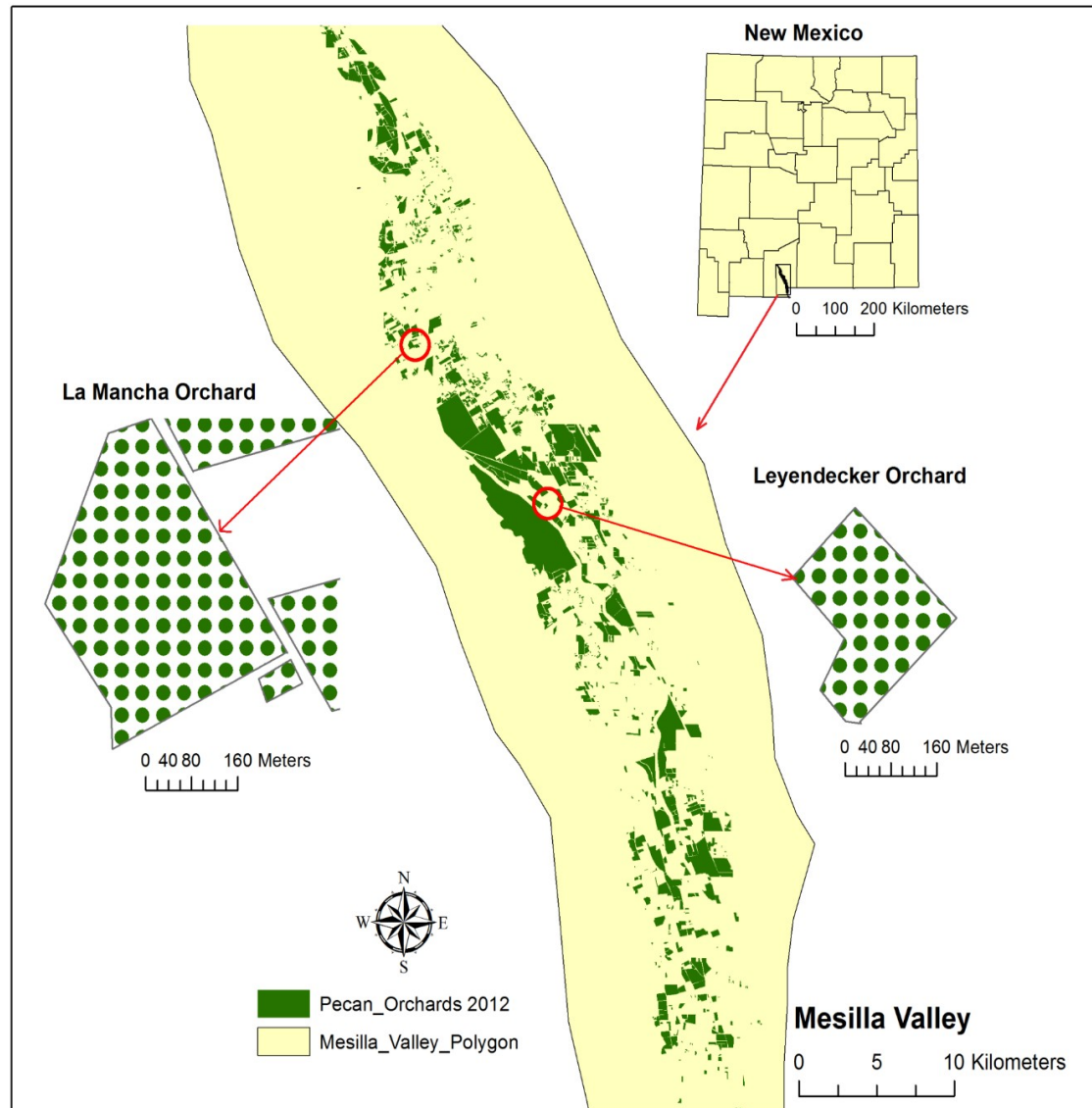
1

2

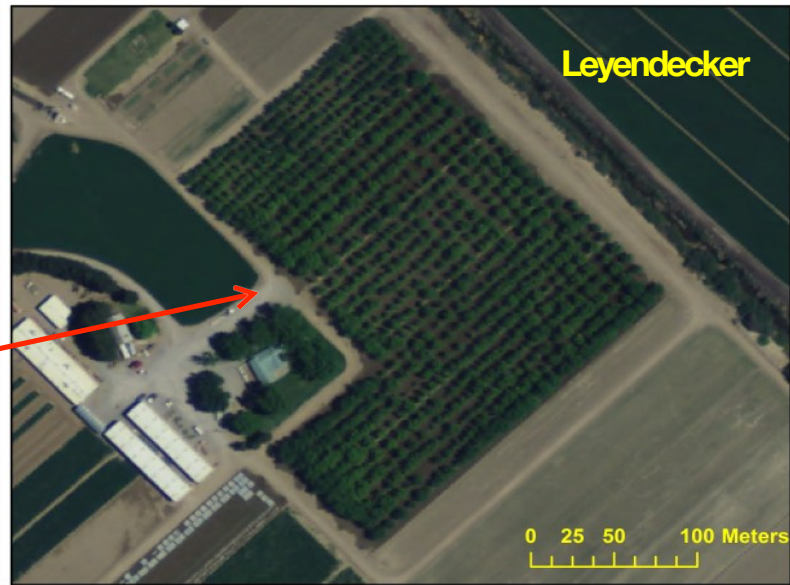
3

Establish preliminary values of midday stem water potential where photosynthesis and gas exchange of pecans are affected.

# Locations of the studies

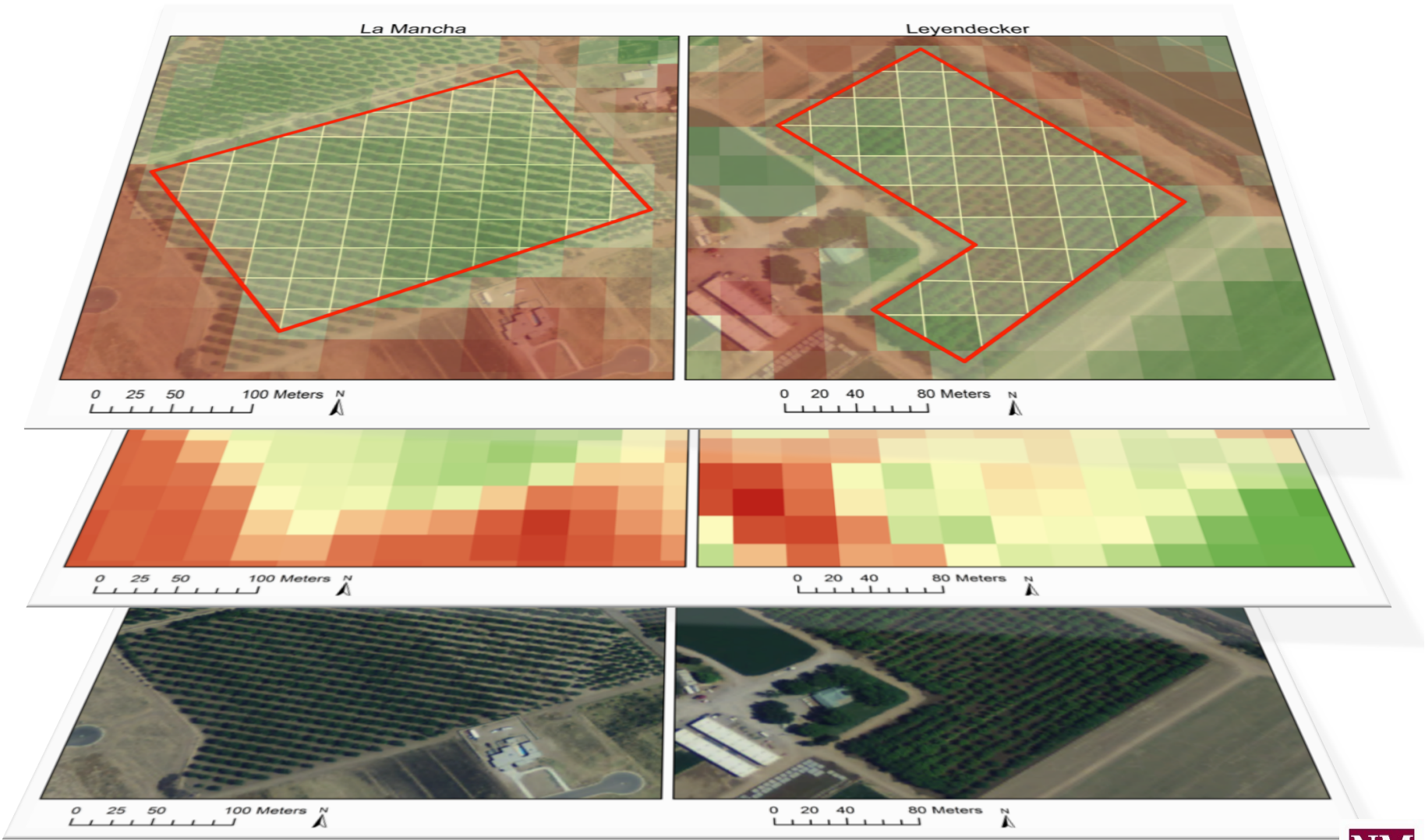


# Locations of the studies



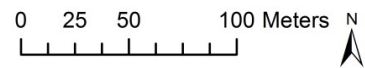


# Sampling design

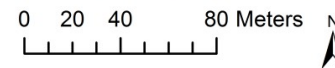


# Sampling design

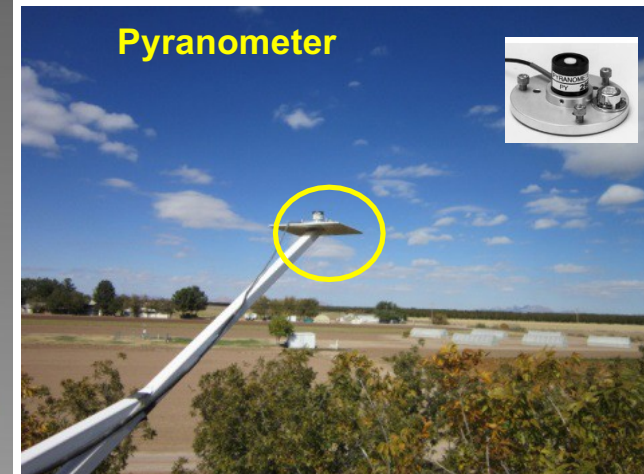
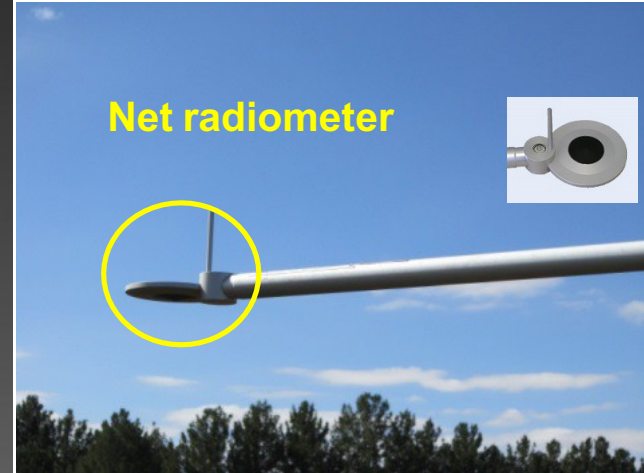
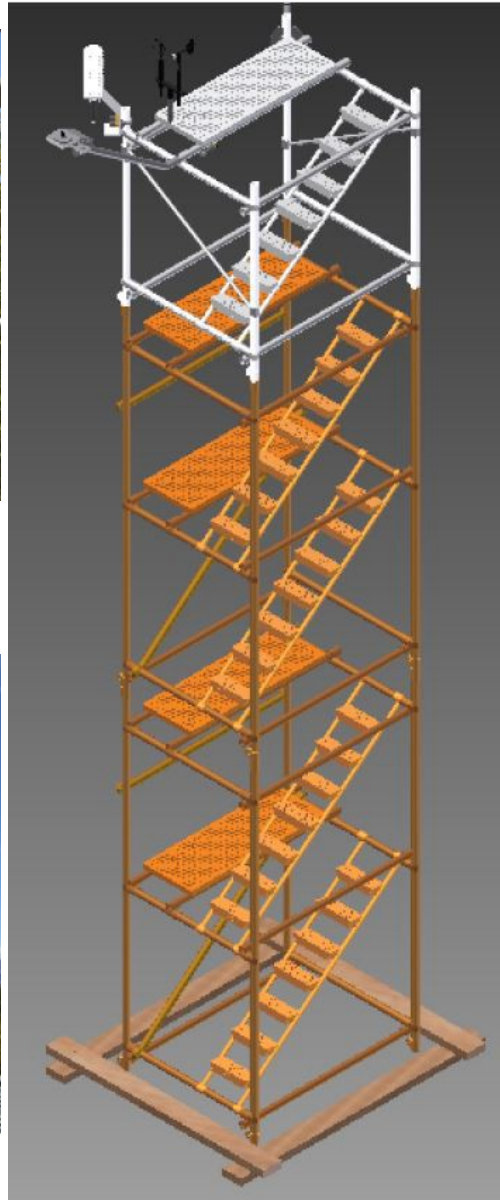
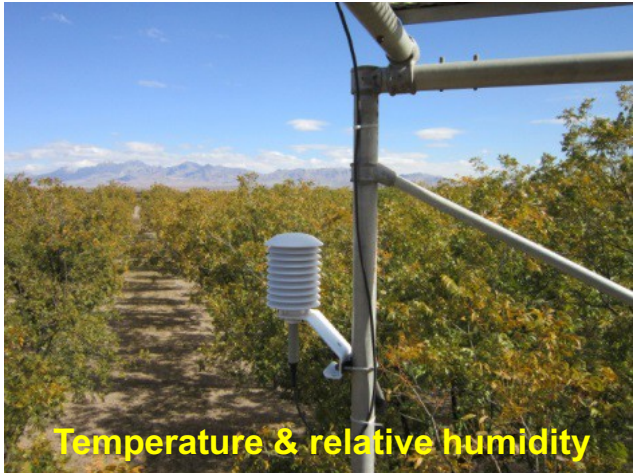
La Mancha



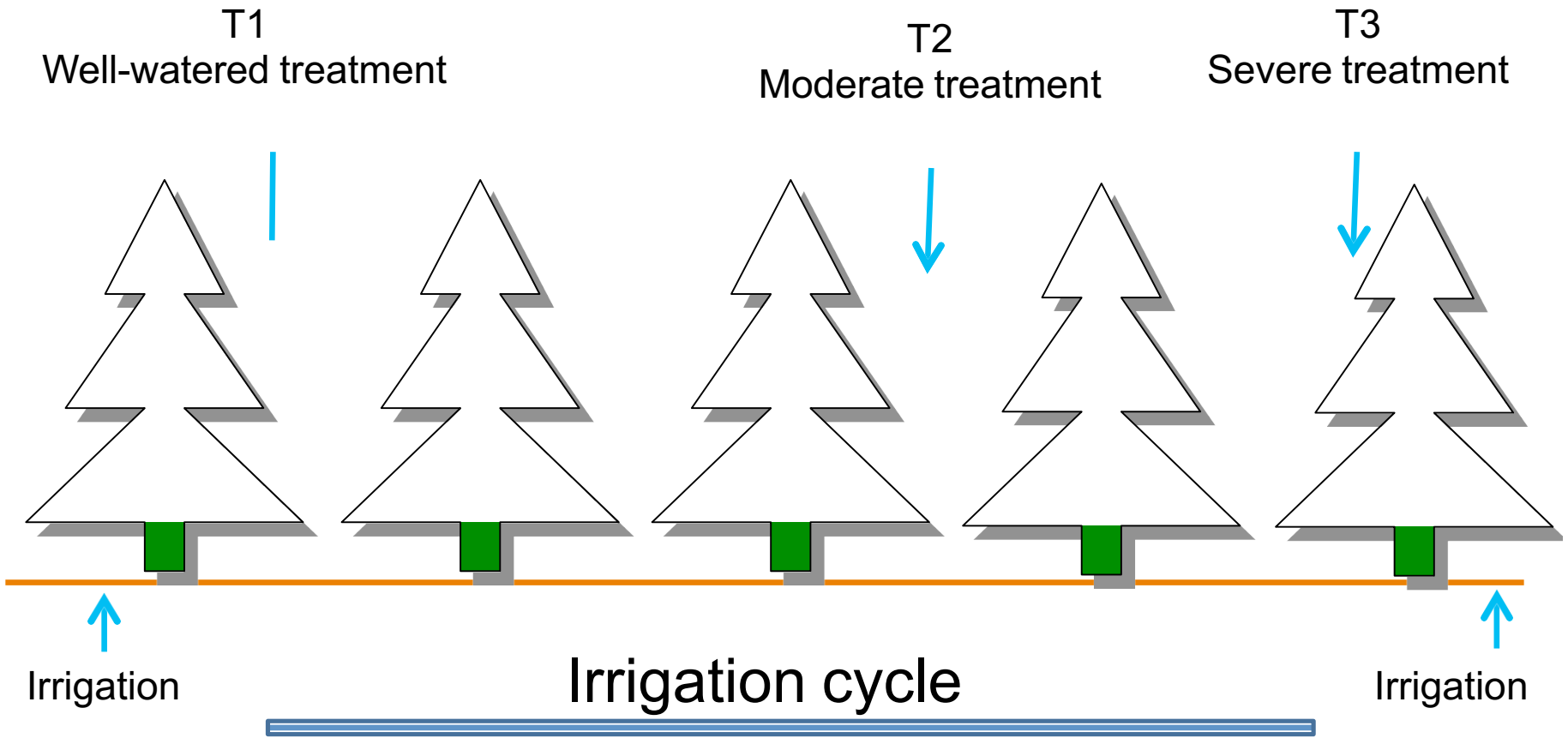
Leyendecker



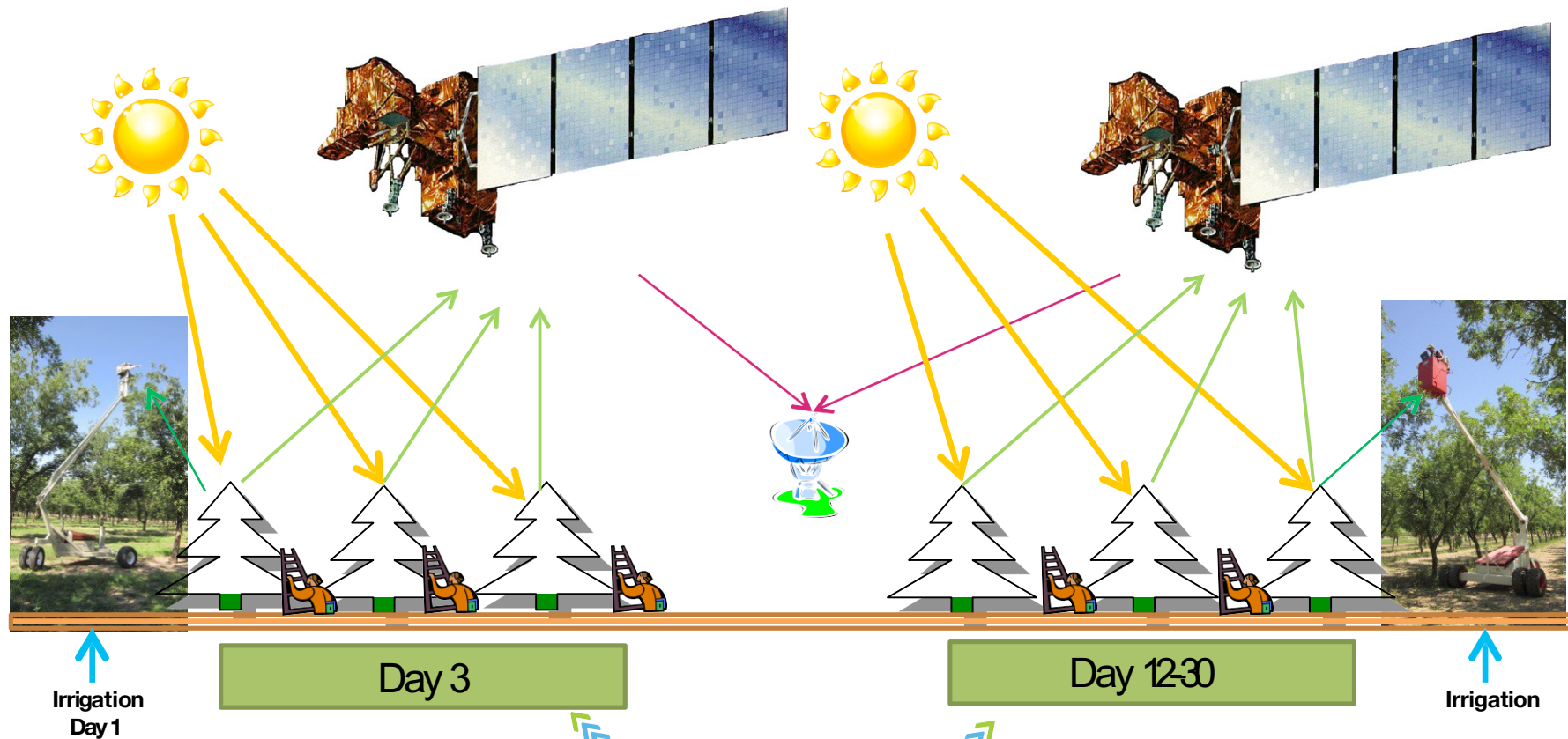
# Meteorological instrumentation



# Treatment



# Spectral and physiological measurements



- Measurements**
- a) Midday stem water potential
  - b) Remotely sensed surface reflectance data

# Satellite image processing

1) Satellite images were downloaded from United States Geological Survey Global Visualization Viewer

The screenshot displays the USGS Global Visualization Viewer interface. At the top, the USGS logo and tagline "science for a changing world" are visible, along with navigation links for "USGS Home", "Contact USGS", and "Search USGS". Below this, the "Earth Resources Observation and Science Center (EROS)" is identified. The main interface includes a "System Notices (1) (New)" button and a menu bar with options: "Collection", "Resolution", "Map Layers", "Tools", "File", and "Help".

The central part of the interface features a map of the United States with a red dot indicating the current location. Below the map, there are input fields for "WRS-2 Path / Row:" (32, 37) and "Lat/ Long:" (33.2, -104.8), each with a "Go" button. A "Max Cloud:" dropdown is set to "100%". The "Scene Information:" section displays: "ID: LC80320372013310LGN00", "CC: 0% Date: 2013/11/6", and "Qty: 9 Product: OLI\_TIRS\_L1T". A "Nov 2013" dropdown and "Go" button are also present. Below this, there are "Prev Scene" and "Next Scene" buttons, and a "Landsat 8 OLI Scene List" table. At the bottom, there are "Add", "Delete", and "Send to Cart" buttons.

The main visualization area shows a satellite image of a landscape with a yellow rectangular box highlighting a specific region. A "Downloadable" label is visible in the top right corner of the image area. The USGS logo is also present in the bottom left corner of the interface.

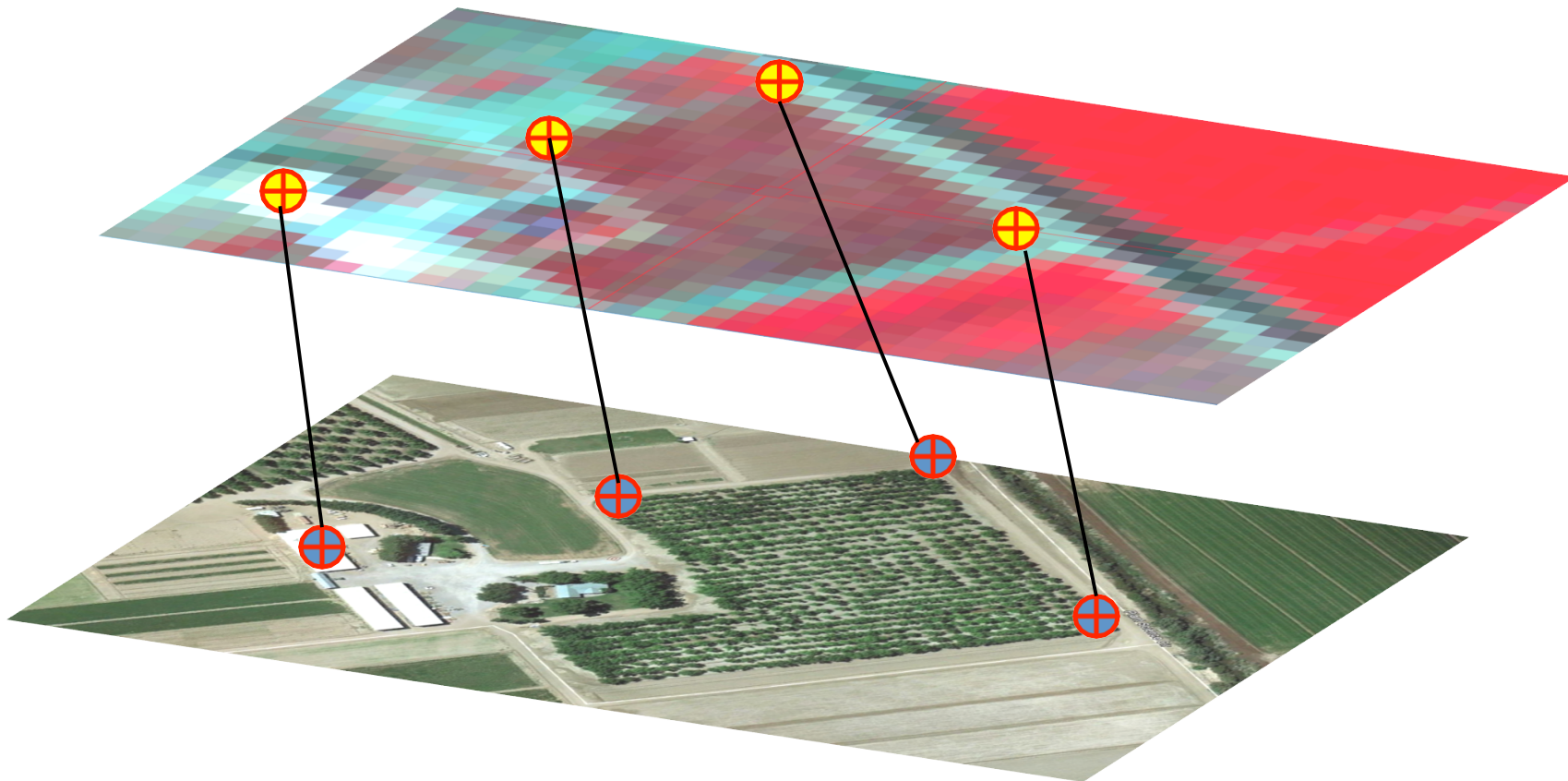
# Satellite image processing

## 2) Radiometric correction

Improve the accuracy of surface spectral reflectance

## 3) Geometric correction

Place data in their proper position.



# Vegetation indices

Band ratio  
B5/B7

TM Band	Wavelength (um)		
6	10.4 - 12.5		Thermal Infrared
7	2.08 - 2.35		Shortwave Infrared
5	1.55 - 1.75		Shortwave Infrared
4	0.76 - 0.90		Near Infrared
3	0.63 - 0.69		Red
2	0.52 - 0.60		Green
1	0.45 - 0.52		Blue

Normalized  
Difference  
Infrared  
Index (NDII)

$$\frac{(\rho_{NIR} - \rho_{SWIR(5)})}{(\rho_{NIR} + \rho_{SWIR(5)})}$$

$$\frac{(\rho_{NIR} - \rho_R)}{(\rho_{NIR} + \rho_R)}$$

NDVI

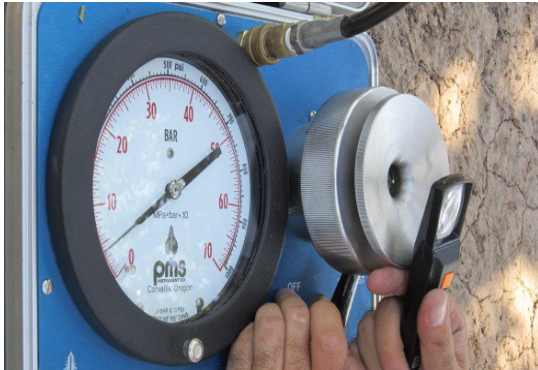
Vegetation  
moisture index  
II(VMI-II)

$$(-0.002 \times \rho_B) + (0.002 \times \rho_G) - (0.001 \times \rho_{SWIR(2)})$$

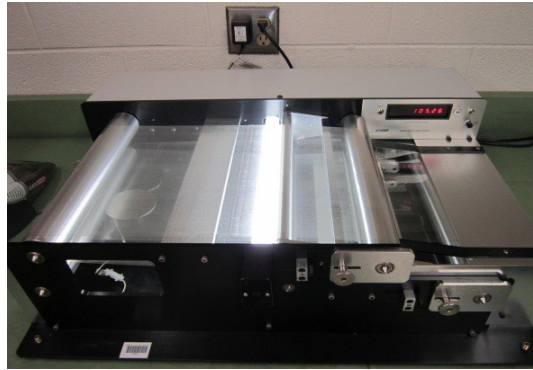




# Physiological measurements



Midday stem water potential



Leaf area ratio



Relative water content (%)



Leaf temperature, transpiration  
Photosynthesis, stomatal conductance,  
vapor pressure deficit.



Chlorophyll fluorescence ( $F_v/F_m$ )



Chlorophyll content (SPAD)

## Screen leaf-level physiological variables

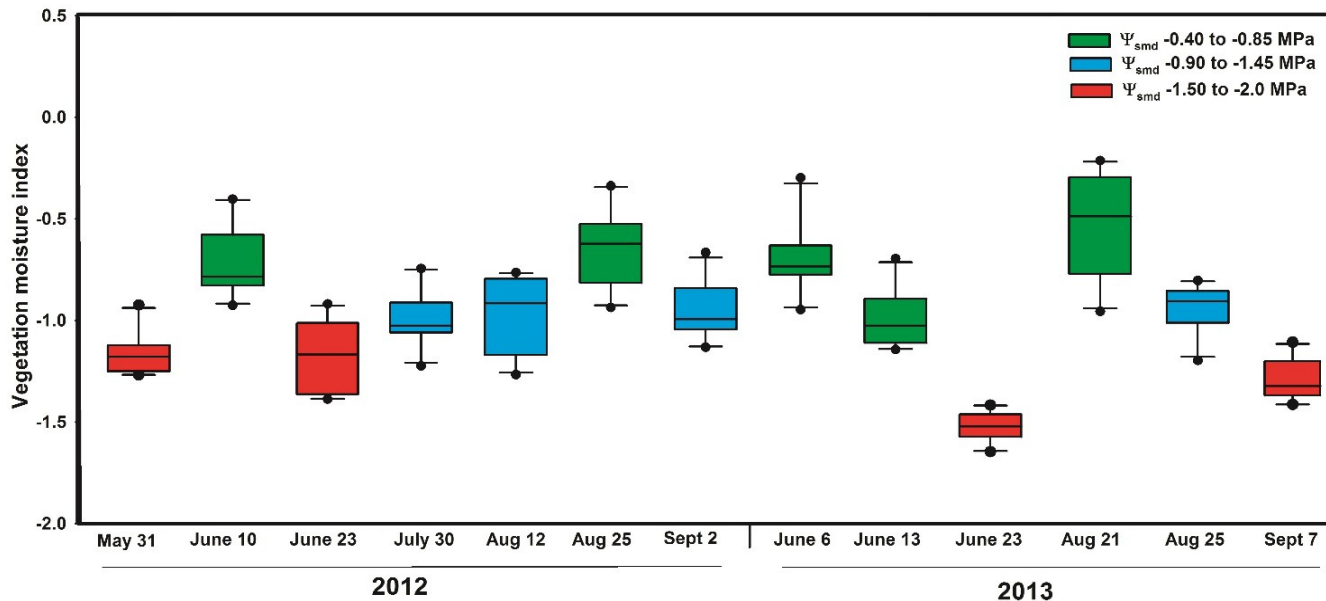
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Midday stem water potential  
Relative water content  
Leaf temperature  
Leaf area ratio  
Transpiration  
Photosynthesis  
Stomatal conductance  
Vapor pressure deficit  
Chlorophyll fluorescence  
Chlorophyll content (SPAD)



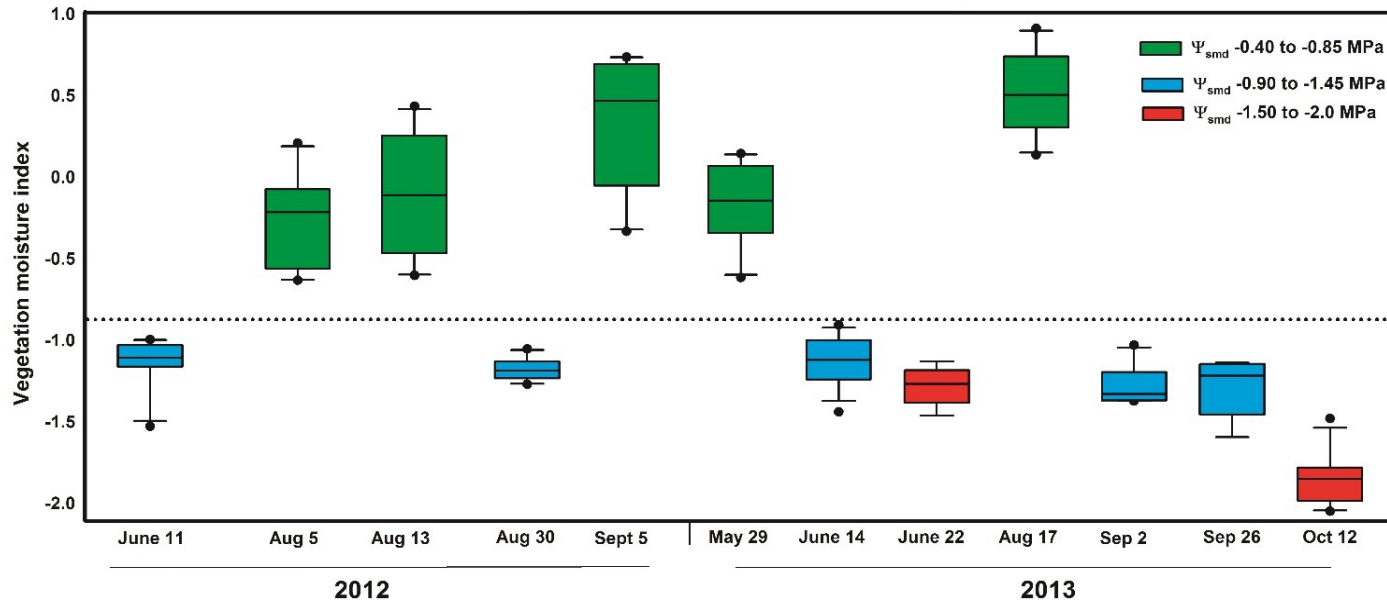
Midday stem water potential ( $\Psi_{smd}$ )

# Remote sensing data



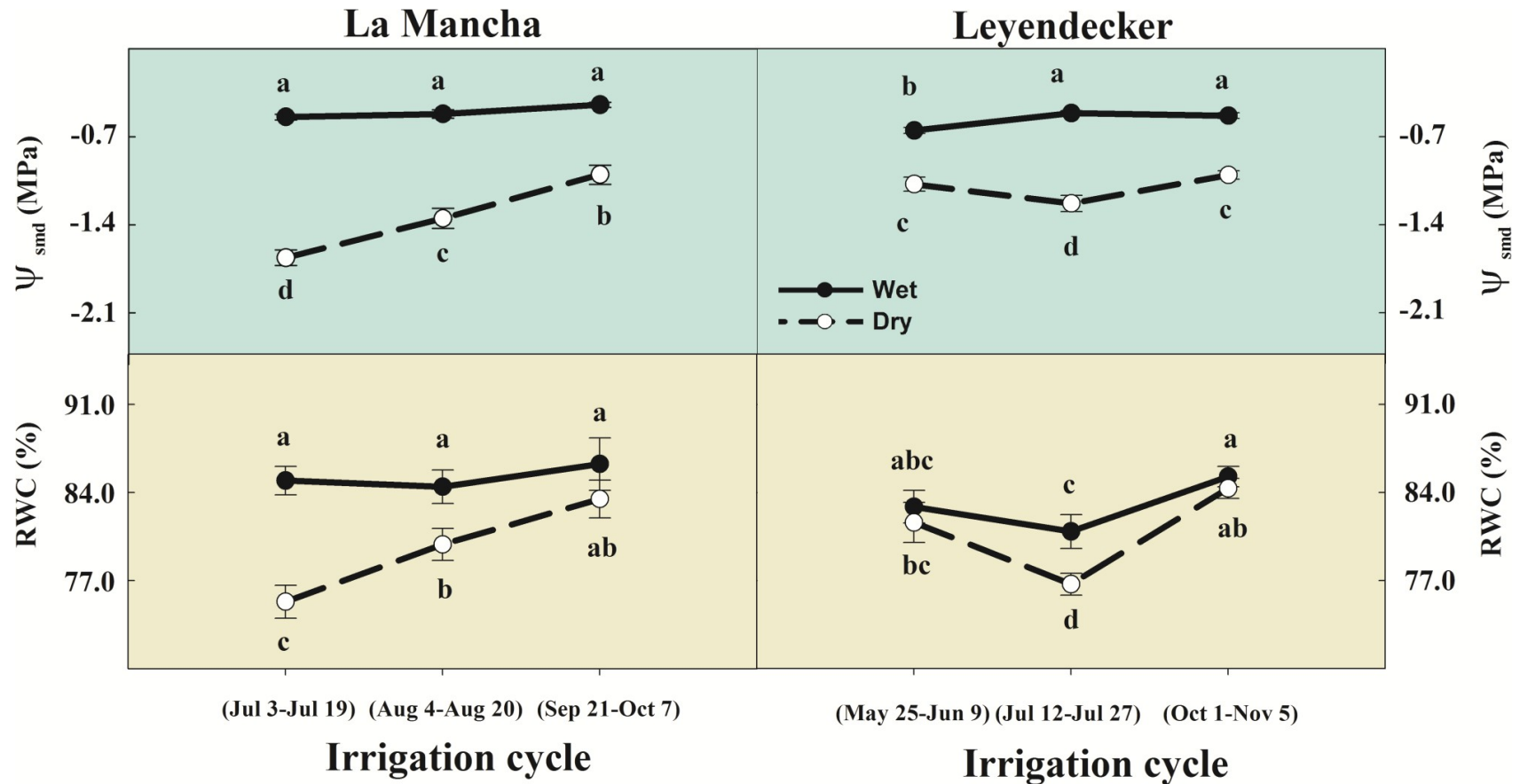
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential ( $\Psi_{smd}$ ) at the La Mancha pecan orchard measured in 2012 and 2013.

# Remote sensing index



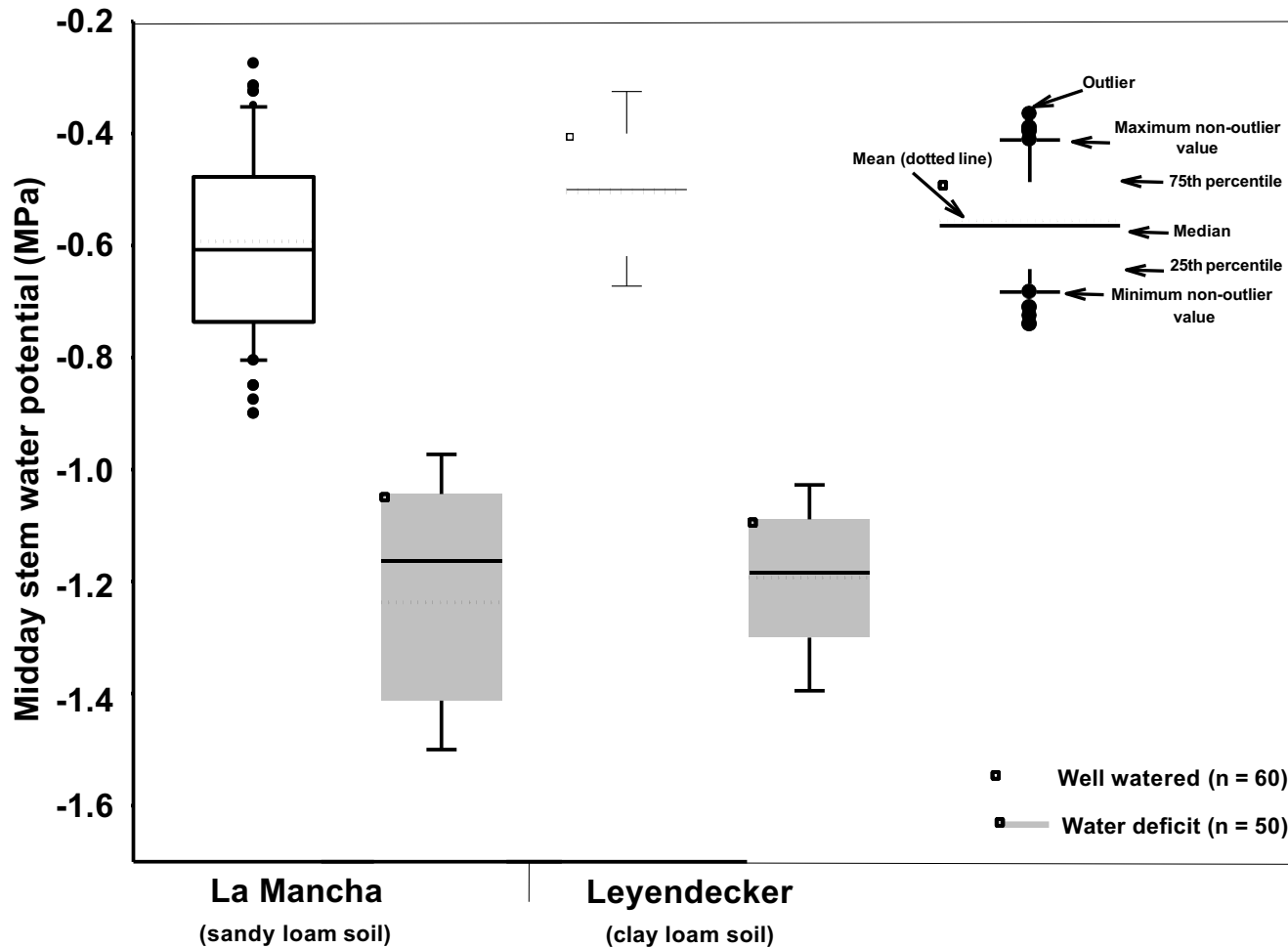
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential ( $\Psi_{smd}$ ) at the Leyendecker pecan orchard measured in 2012 and 2013.

# Screen leaf-level physiological variables

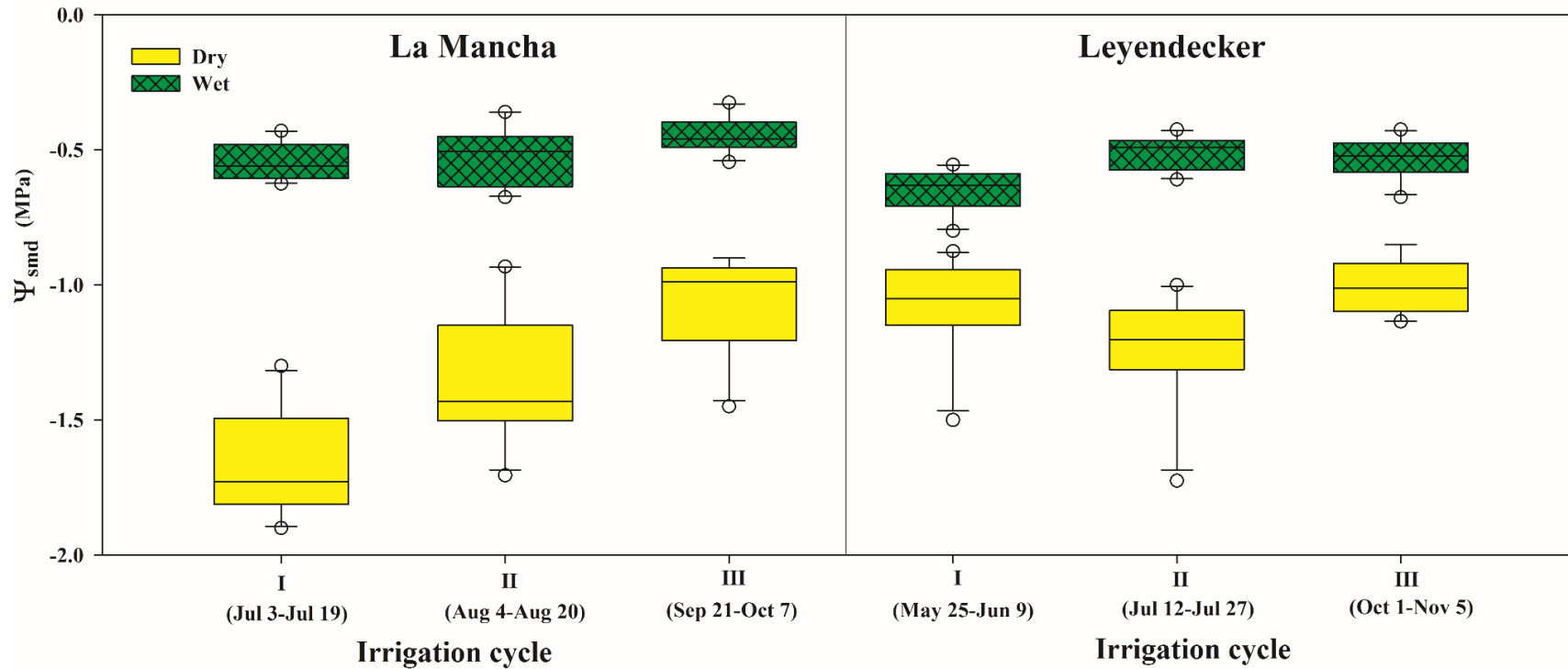


Midday stem water potential ( $\Psi_{smd}$ ), and relative water content (RWC) of La Mancha and Leyendecker orchards measured in 2011. Different letters indicated a significant difference between irrigation treatments ( $P < 0.05$ ).

Midday stem water potential boxplots of La Mancha and Leyendecker pecan orchards (Mesilla Valley, New Mexico) measured in 2012 and 2013. Rectangles represent the 25%, 50% (median), and 75% percentile of the data.

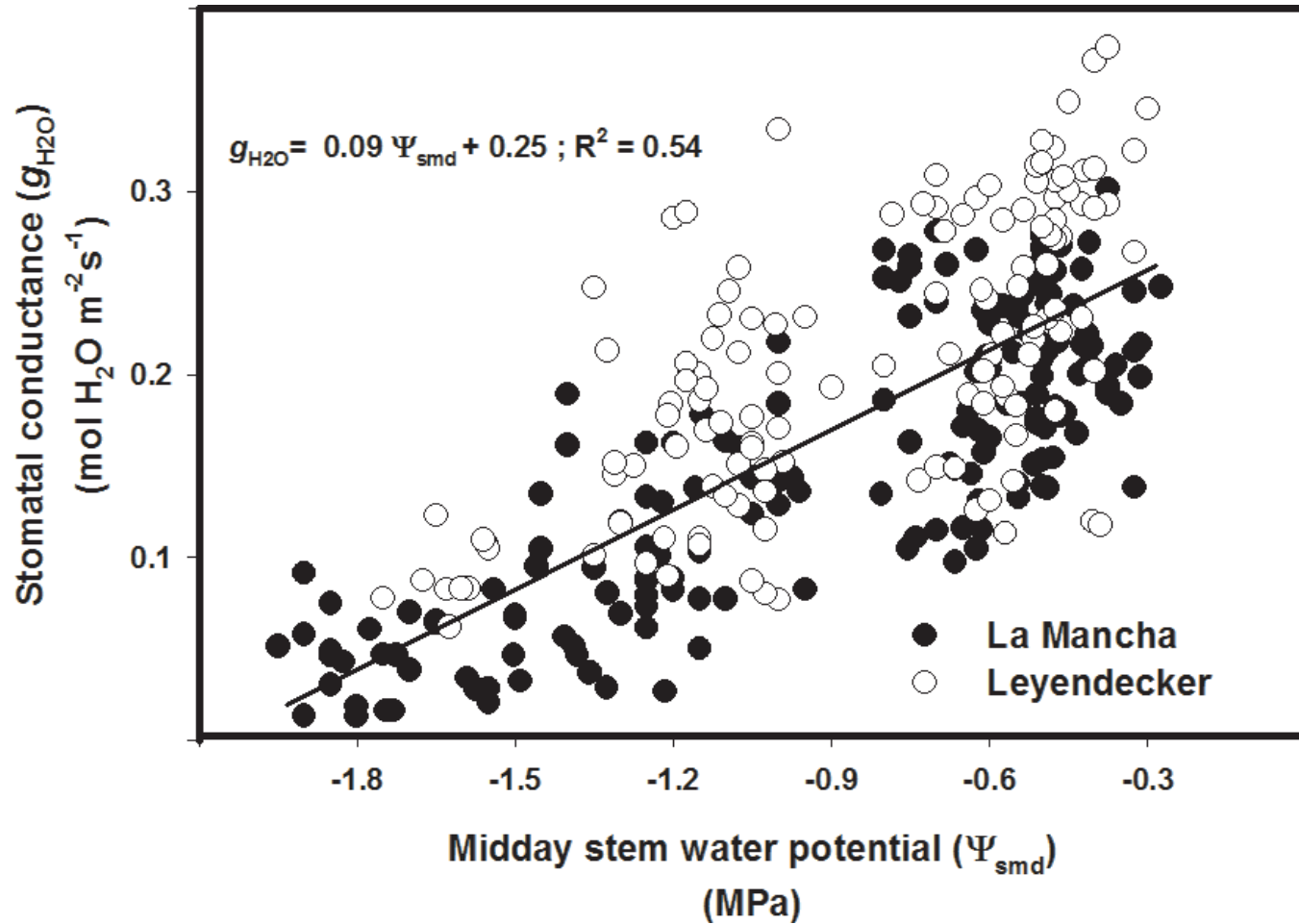


# Screen leaf-level physiological variables



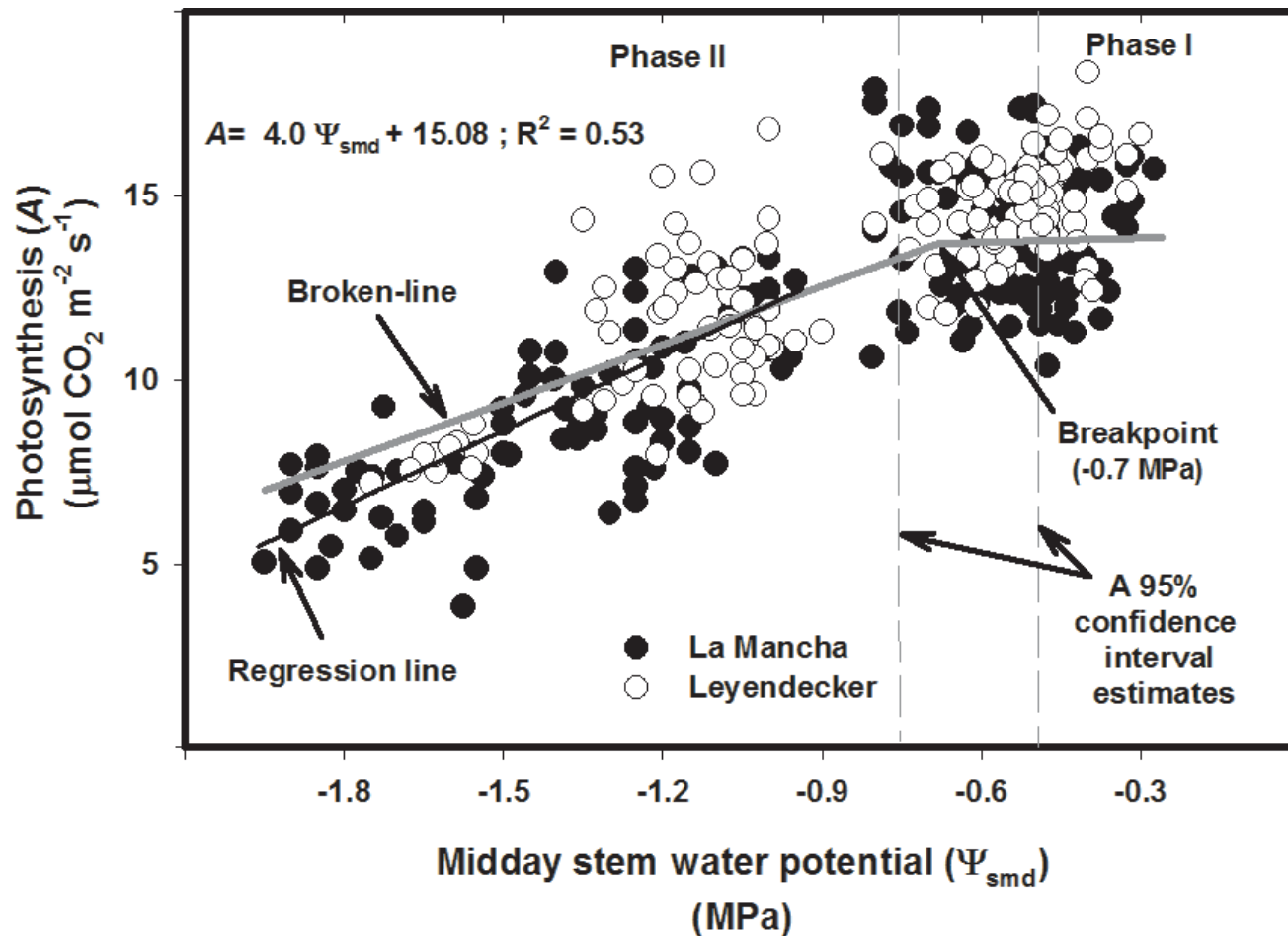
Boxplots of midday stem water potential ( $\Psi_{smd}$ ) of two southern New Mexico pecan orchards subjected to cyclic flood irrigation (La Mancha and Leyendecker) during the 2011 growing season.

Relationship between stomatal conductance and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards.

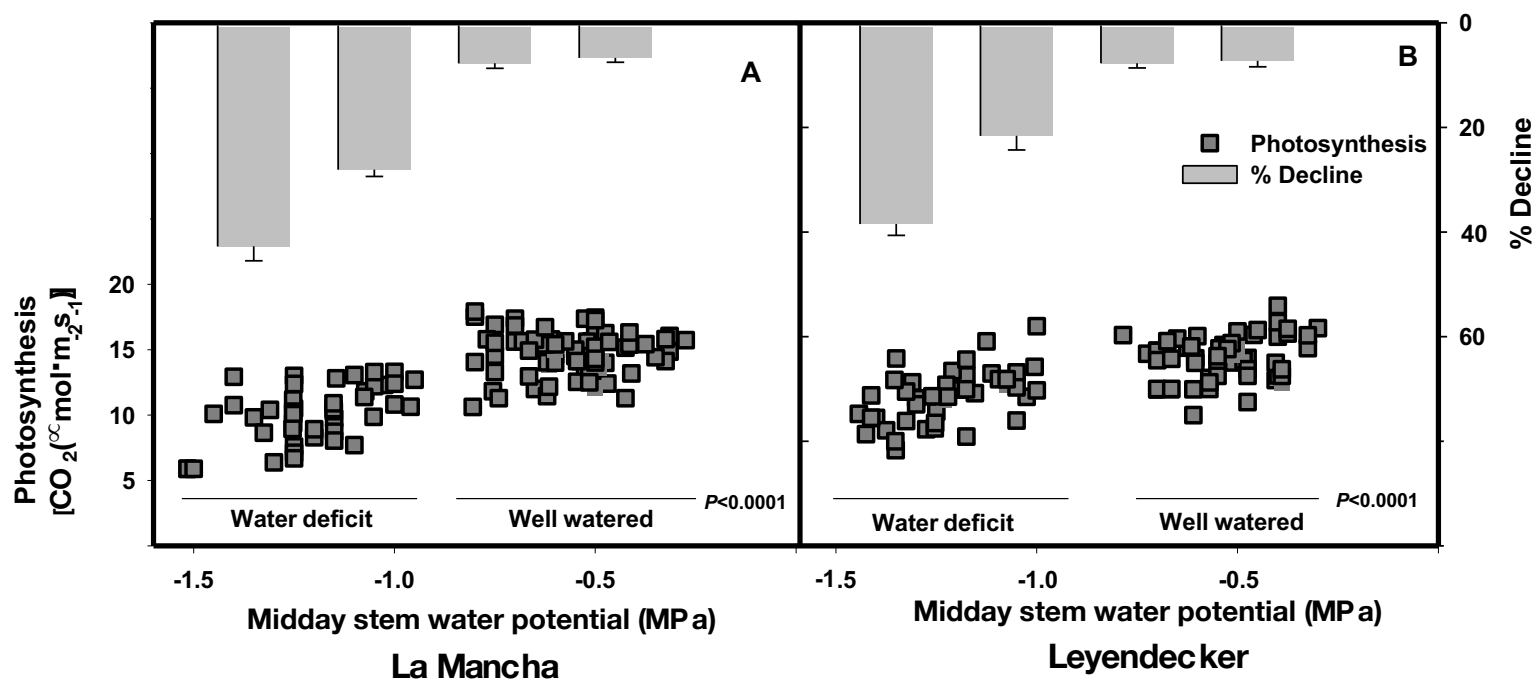




Relationship between photosynthesis and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards. We used data set within the range -0.9 to -2.0 MPa to derive the mixed model equation.



Relationship between photosynthesis (decline) and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards.



# Conclusions

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Midday stem water potential was the best performing leaf-level physiological response variable for detecting moisture status in pecans.

A marked decline in photosynthesis was noticed when midday stem water potential dropped below -0.9 MPa.

A 50% reduction in photosynthesis and gas exchange only occurred when midday stem water potential exceeded -1.5 MPa.

Data from a handheld spectroradiometer could be used to differentiate between well watered ( $\Psi_{\text{smd}}$  -0.4 to -0.85 MPa) and moderate water deficit ( $\Psi_{\text{smd}}$  -0.9 to -1.5 MPa) trees.

# Recommendation

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Maintain pecan orchards at midday stem water potentials that range between -0.80 to -0.90 MPa to prevent significant reductions in carbon assimilation and gas exchange.

# Acknowledgements

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## Personnel

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