

Midday Stem Water Potential

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Plant and Environmental Sciences

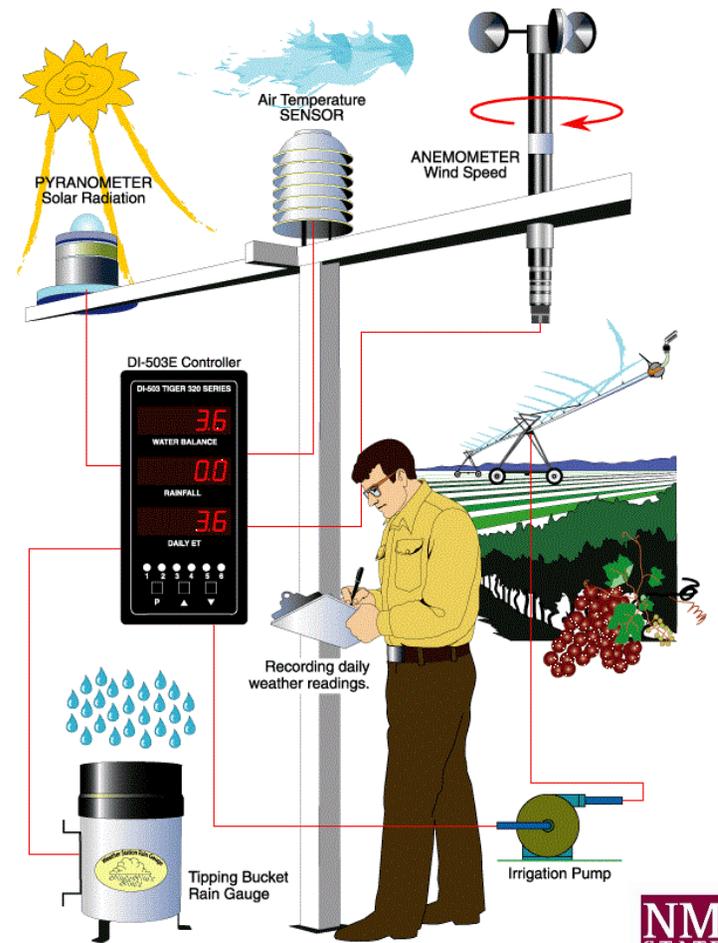
Ways to improve irrigation efficiency in pecans

Irrigation scheduling

When to irrigate

How much to apply

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



<http://www.texmate.com>

Measurements used for detecting water status in pecan orchards

Plant-based



Midday stem water potential (Ψ_{smd})

Soil-based



Soil TDR

Plant-soil-based

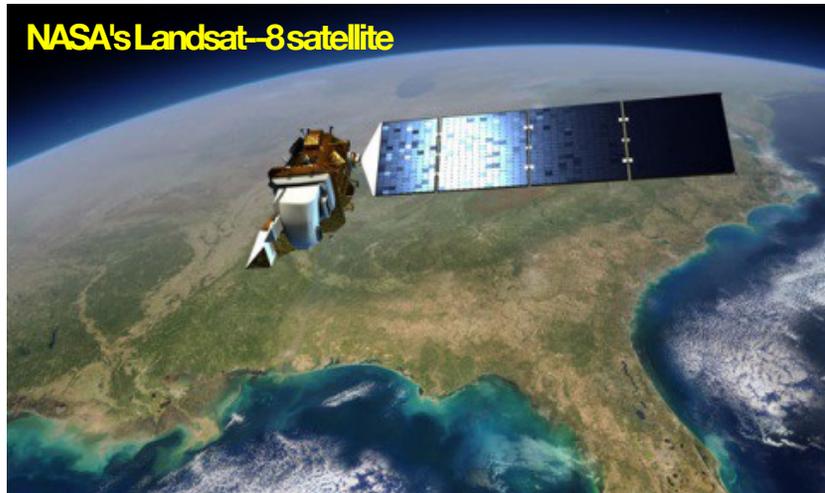


Lysimeters

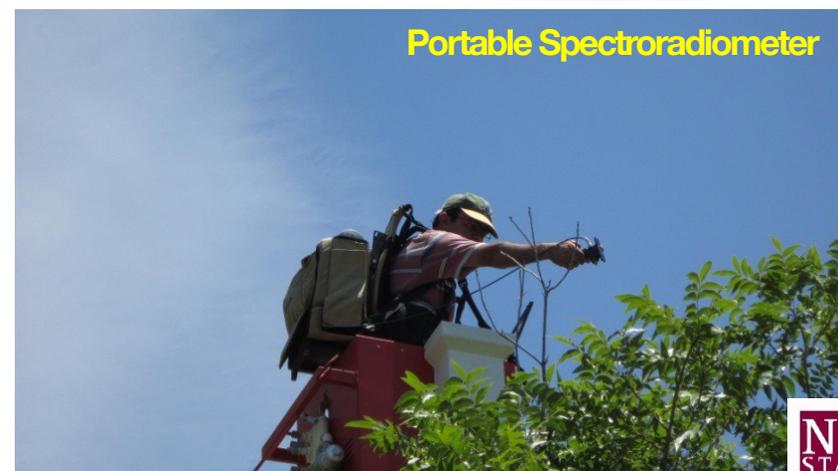
Limitations:

Small area, extraordinary cost, extraction time, leaf destruction

We tried remote sensing to detect moisture status



Handheld portable Spectroradiometer

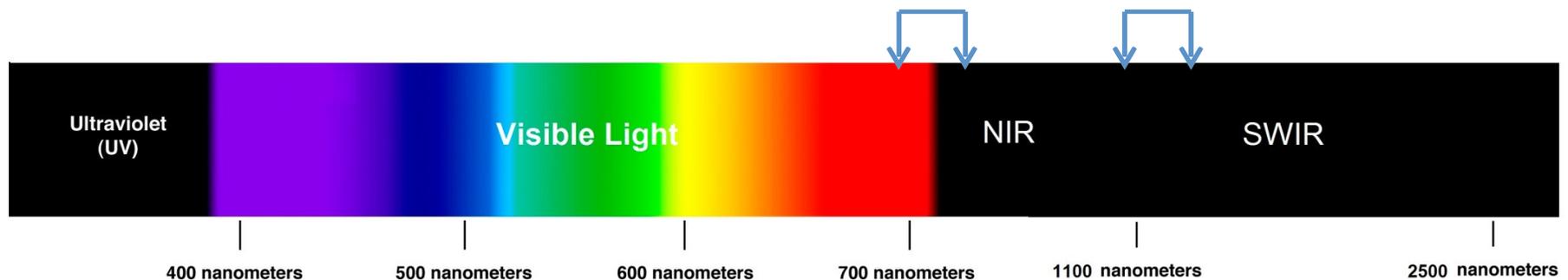
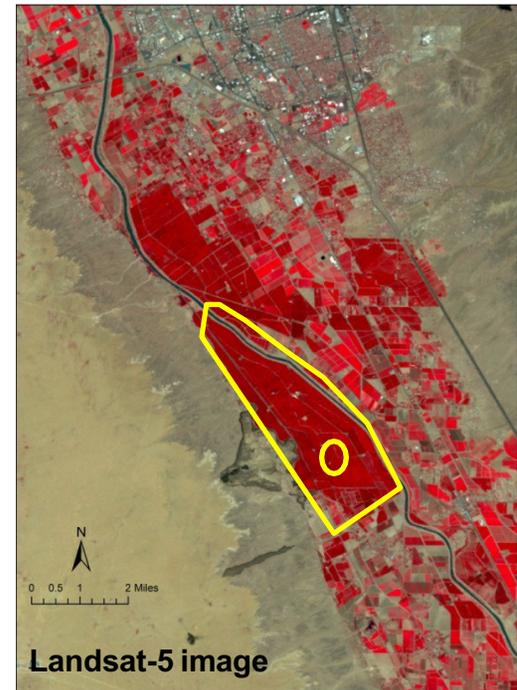


Remote sensing applications

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:

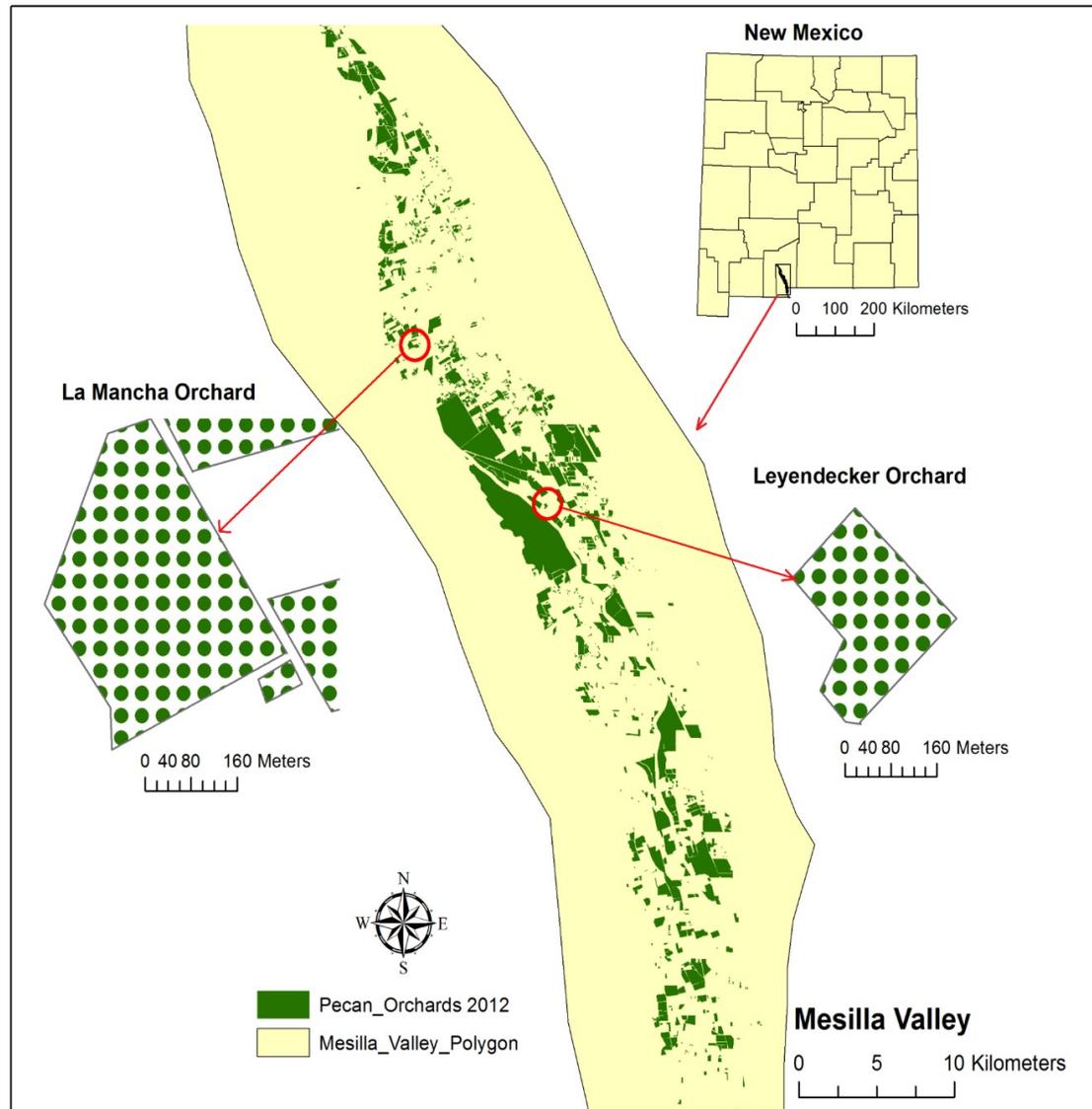
1

2

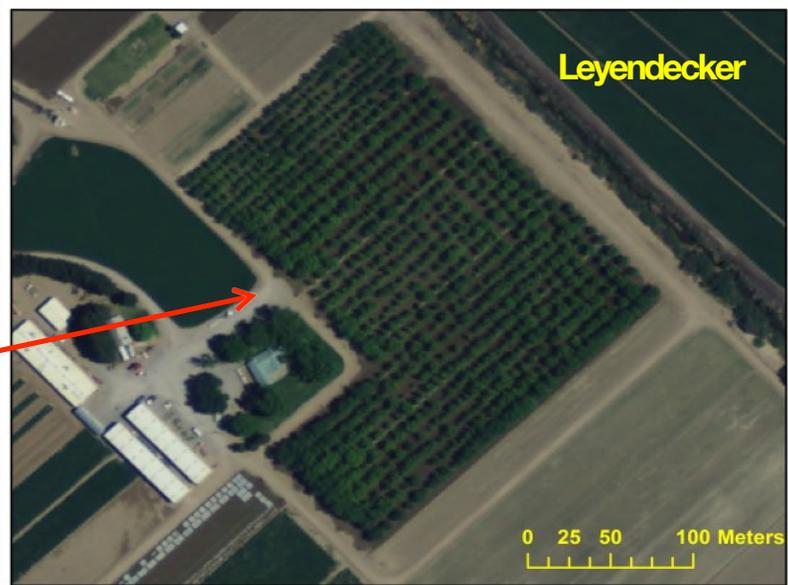
3

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

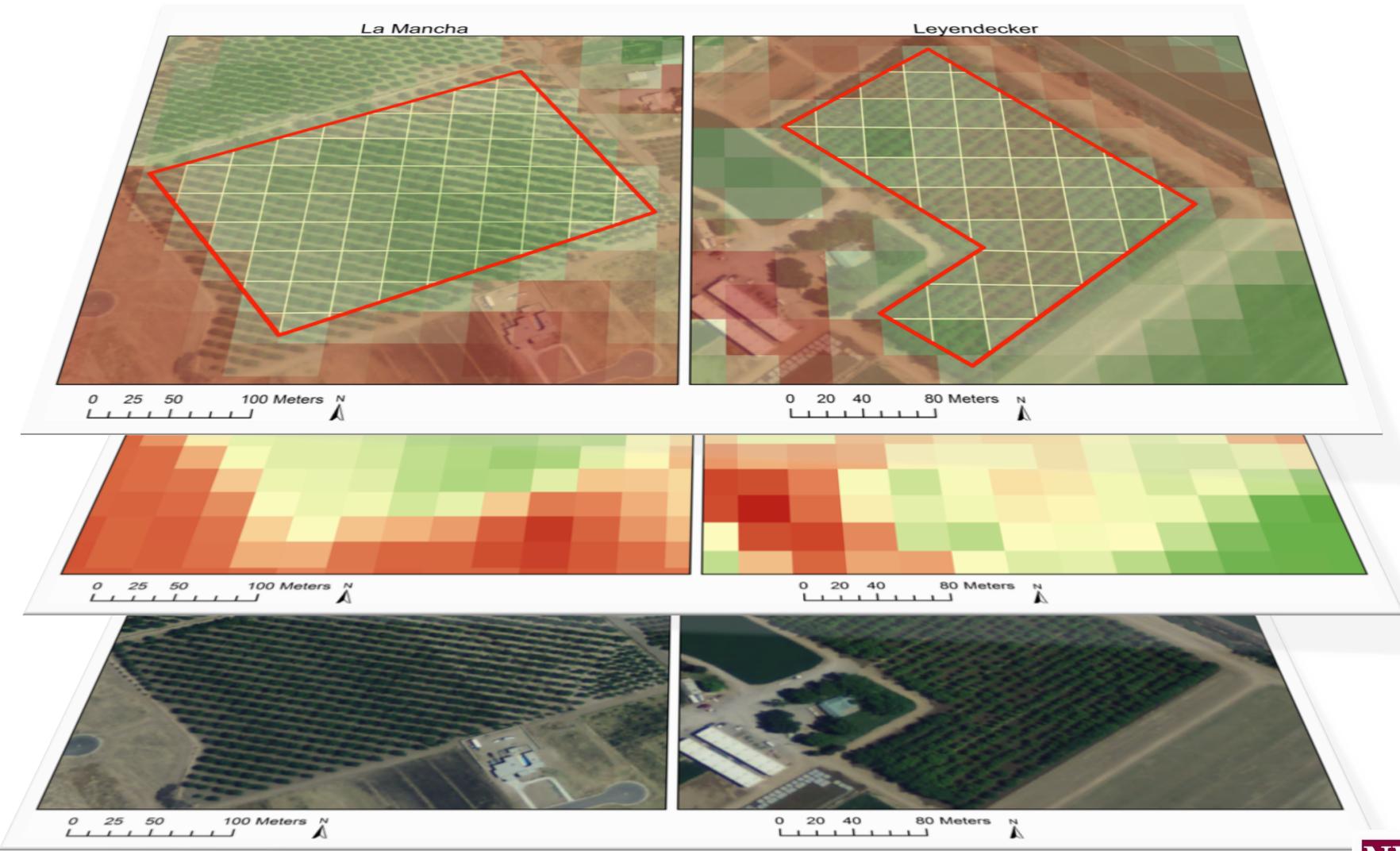
Locations of the studies



Locations of the studies

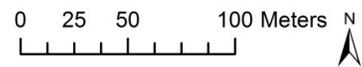
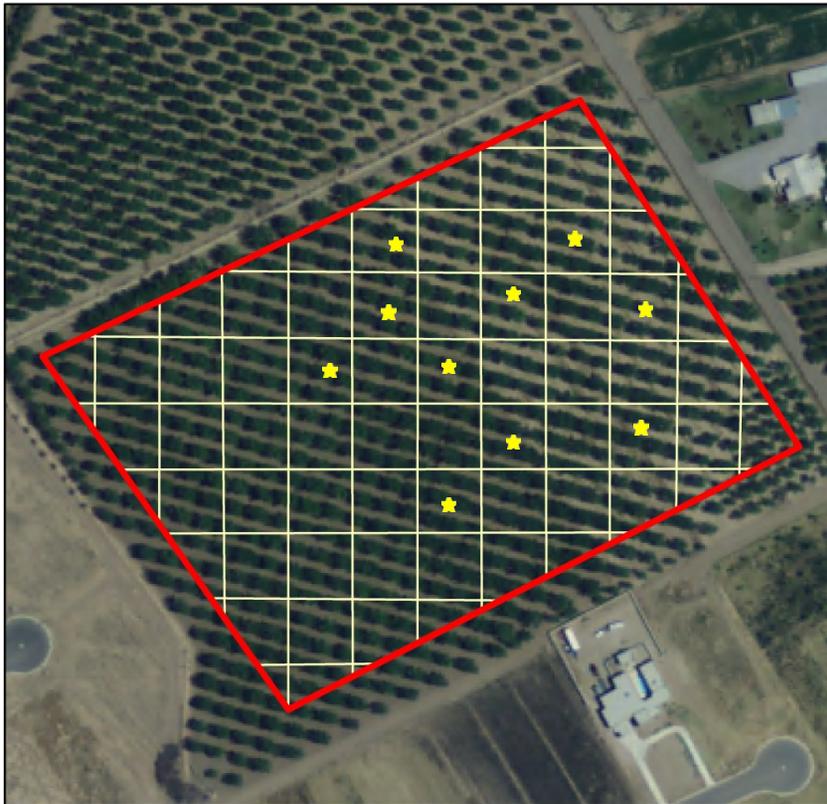


Sampling design

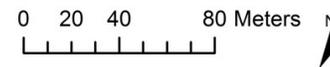


Sampling design

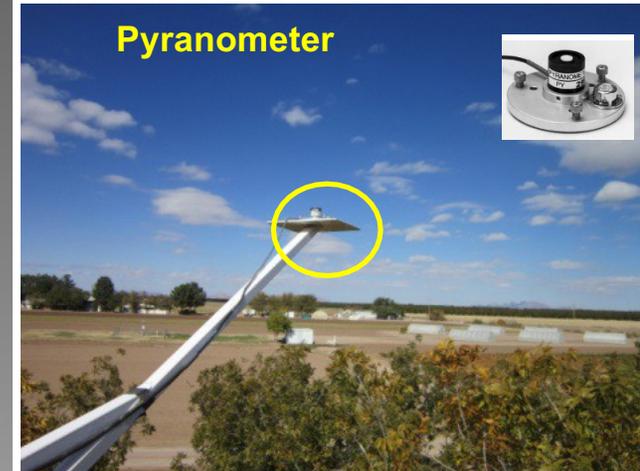
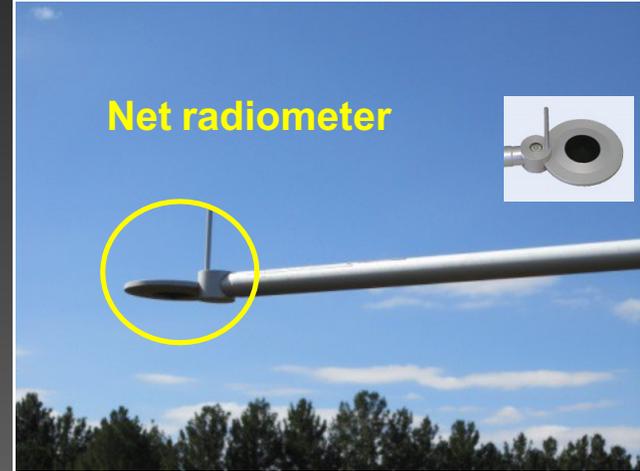
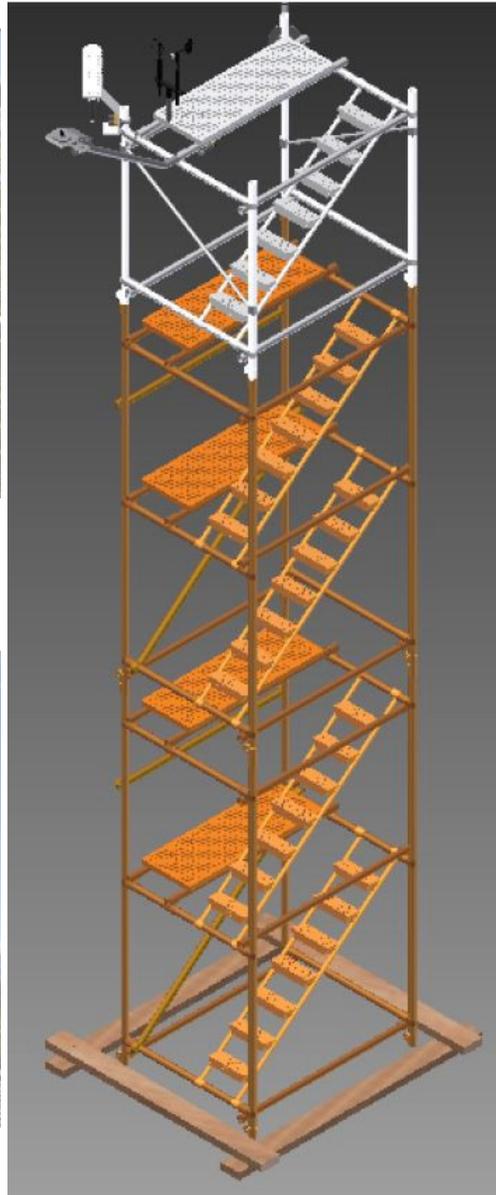
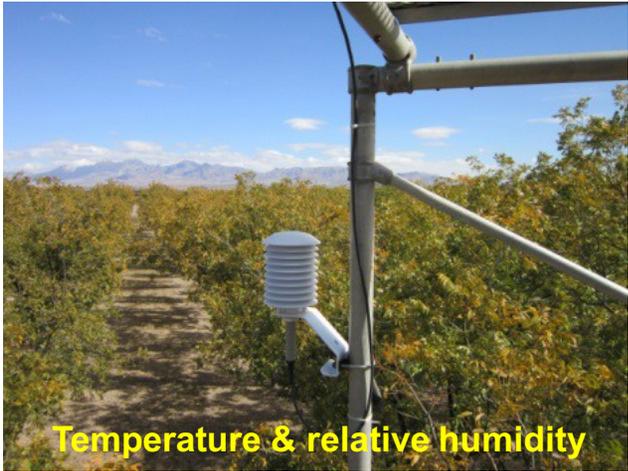
La Mancha



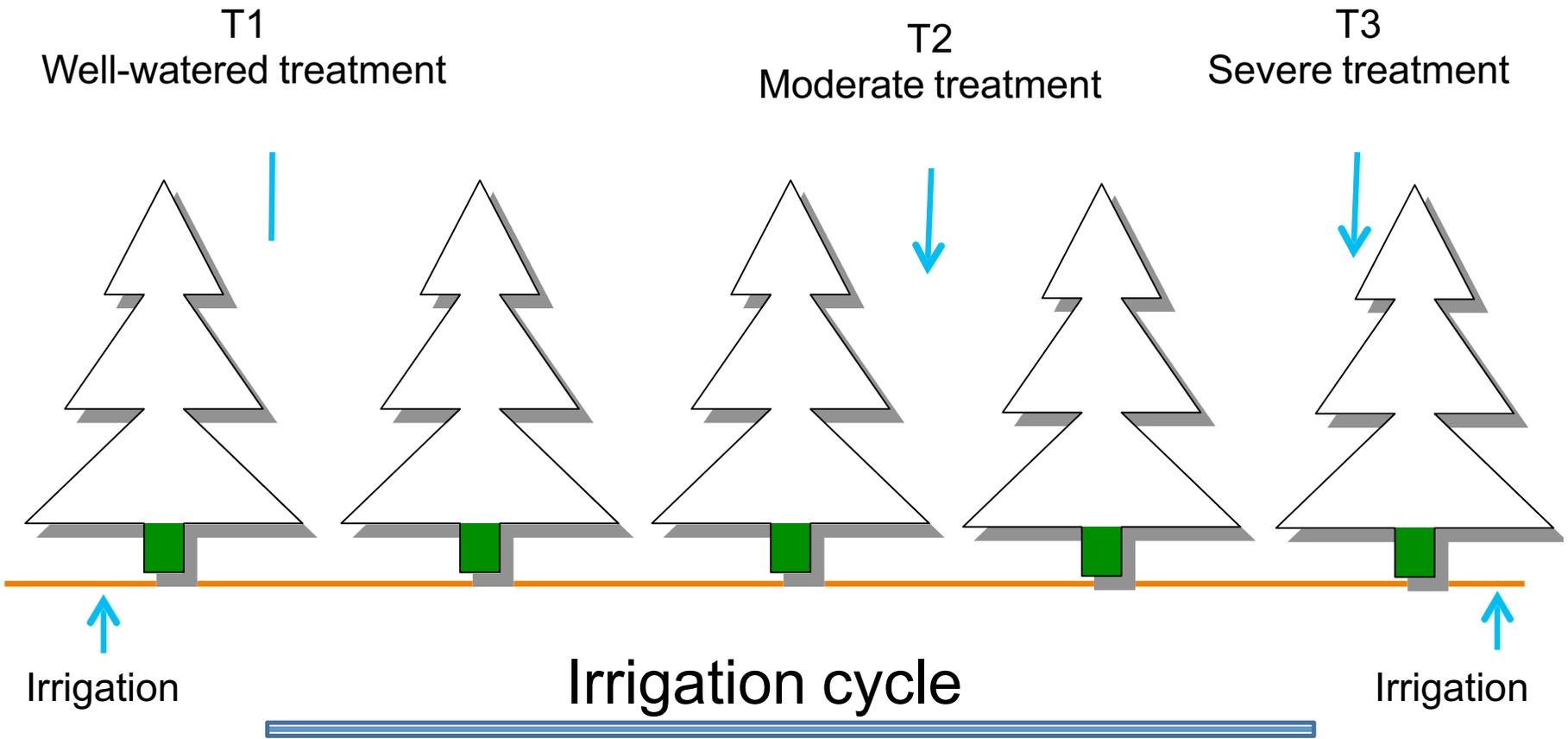
Leyendecker



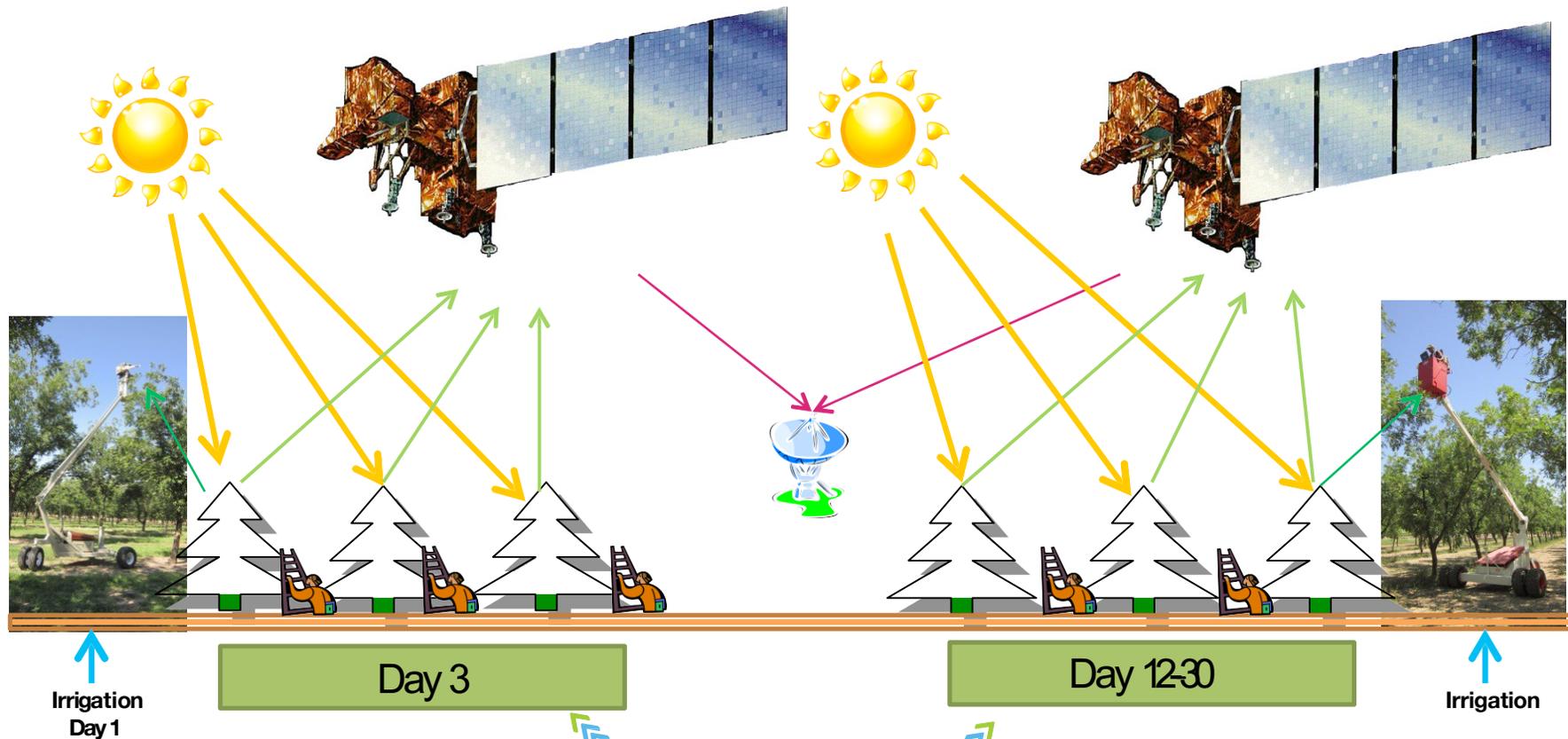
Meteorological instrumentation



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 is visible with the tagline "science for a changing world" and the text "Earth Resources Observation and Science Center (EROS)". Navigation links for "USGS Home", "Contact USGS", and "Search USGS" are present in the top right. 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 scene 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.

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 left of this area. At the bottom left of the interface, there are "Add", "Delete", and "Send to Cart" buttons, along with the USGS logo.

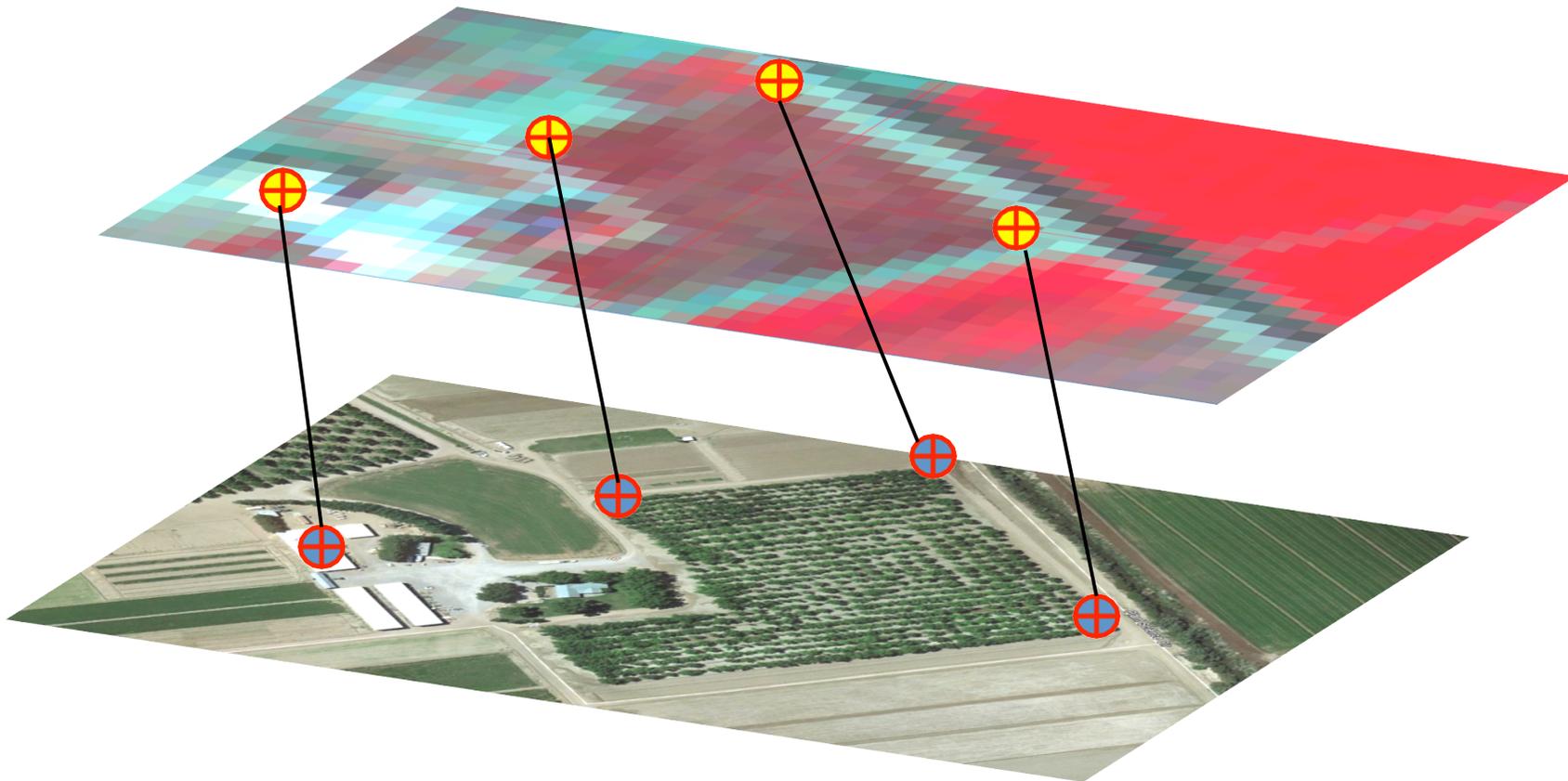
Satellite image processing

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

Vegetation
moisture index
II(VMI-II)

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

Normalized
Difference
Infrared
Index (NDII)

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

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

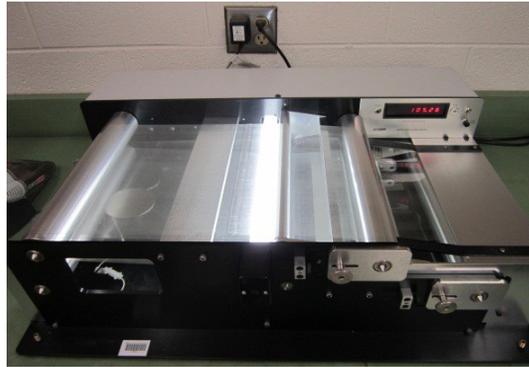
NDVI



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)

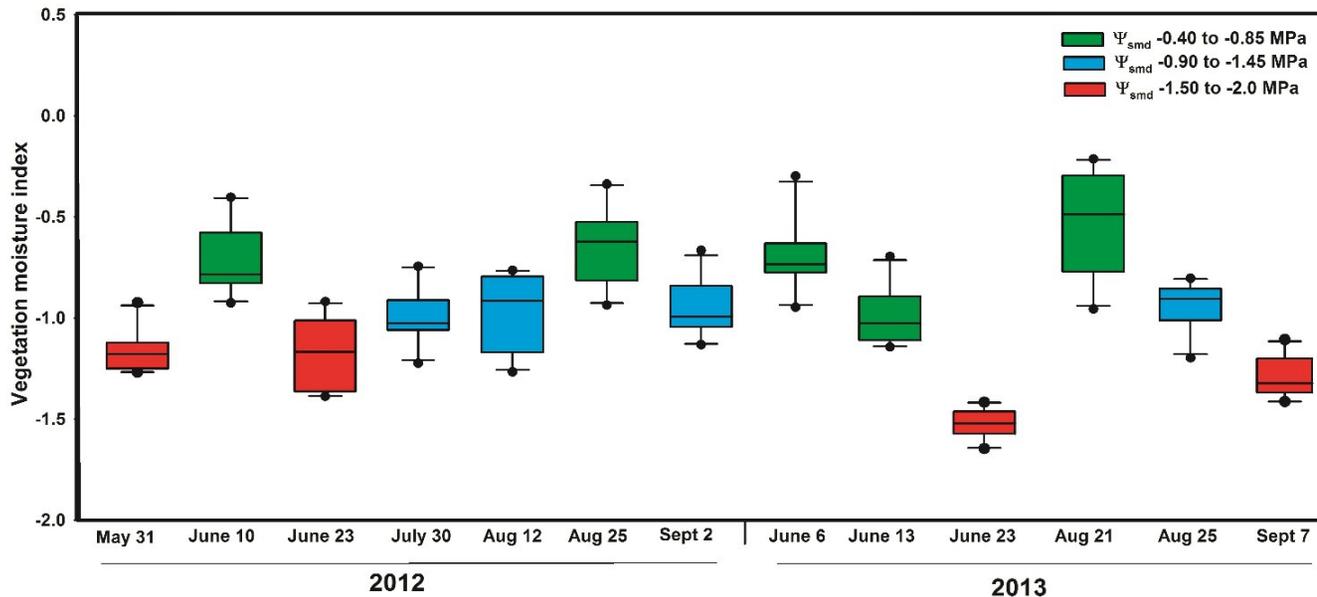
Screen leaf-level physiological variables

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



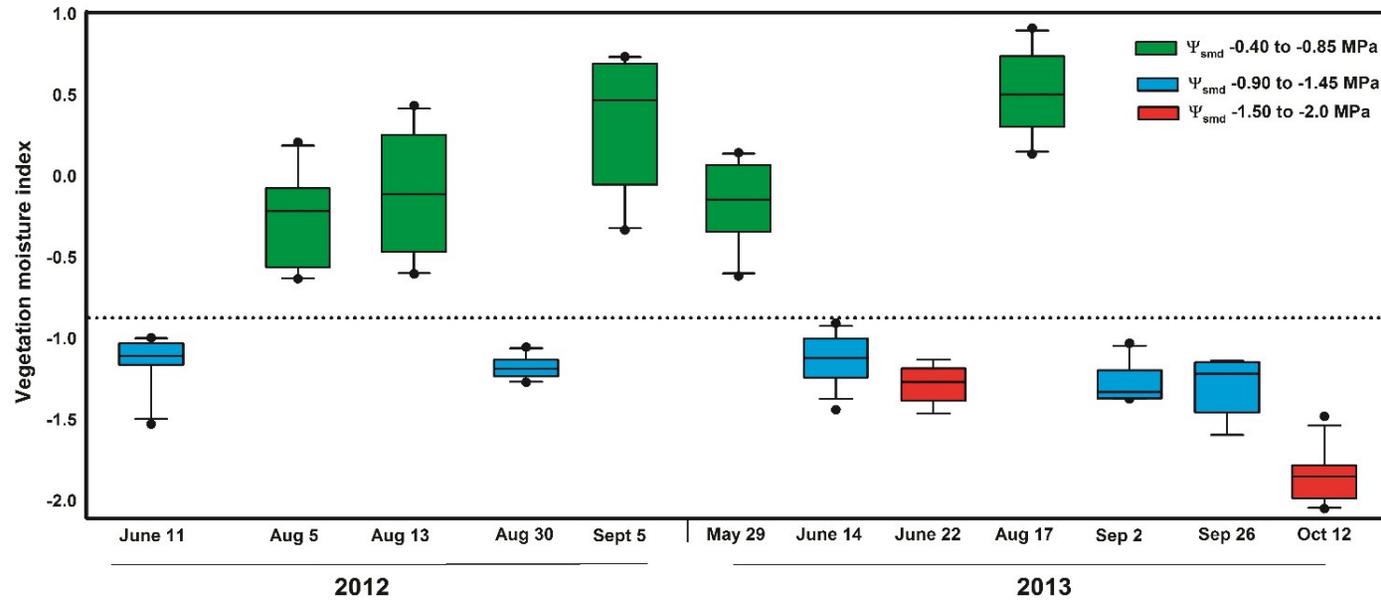
Midday stem water potential (Ψ_{smd})

Remote sensing data



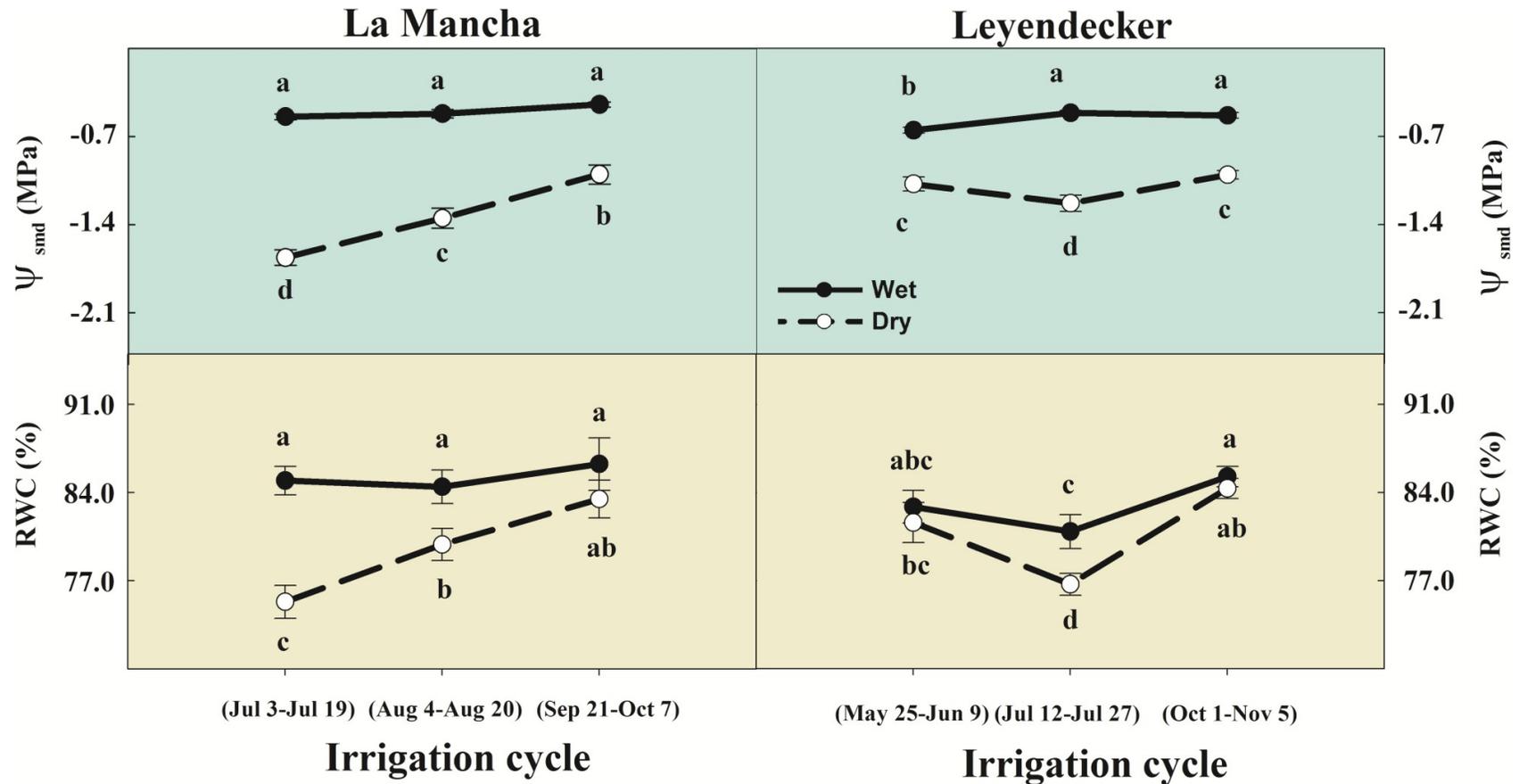
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential (Ψ_{smd}) at the La Mancha pecan orchard measured in 2012 and 2013.

Remote sensing index



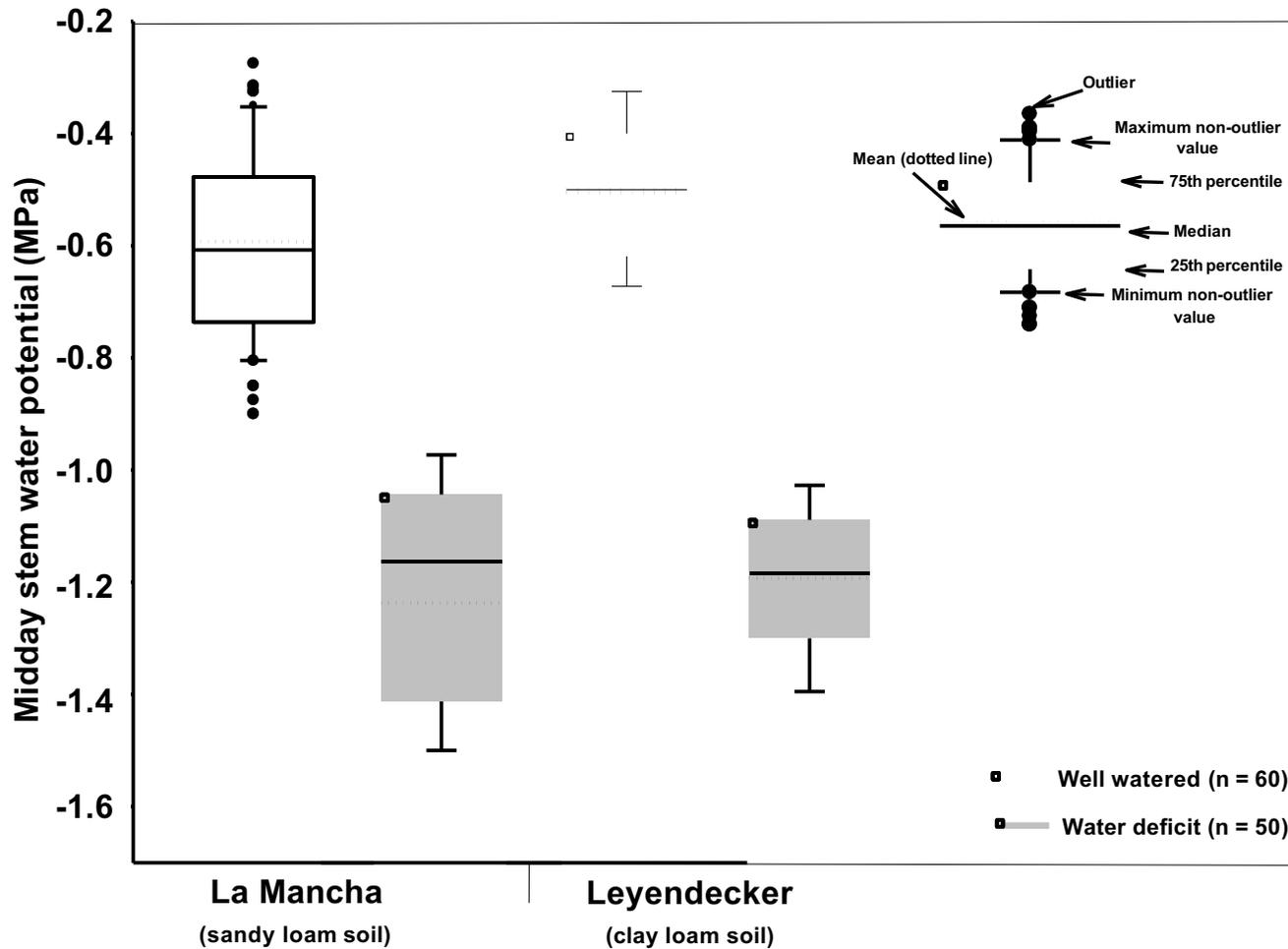
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential (Ψ_{smd}) at the Leyendecker pecan orchard measured in 2012 and 2013.

Screen leaf-level physiological variables

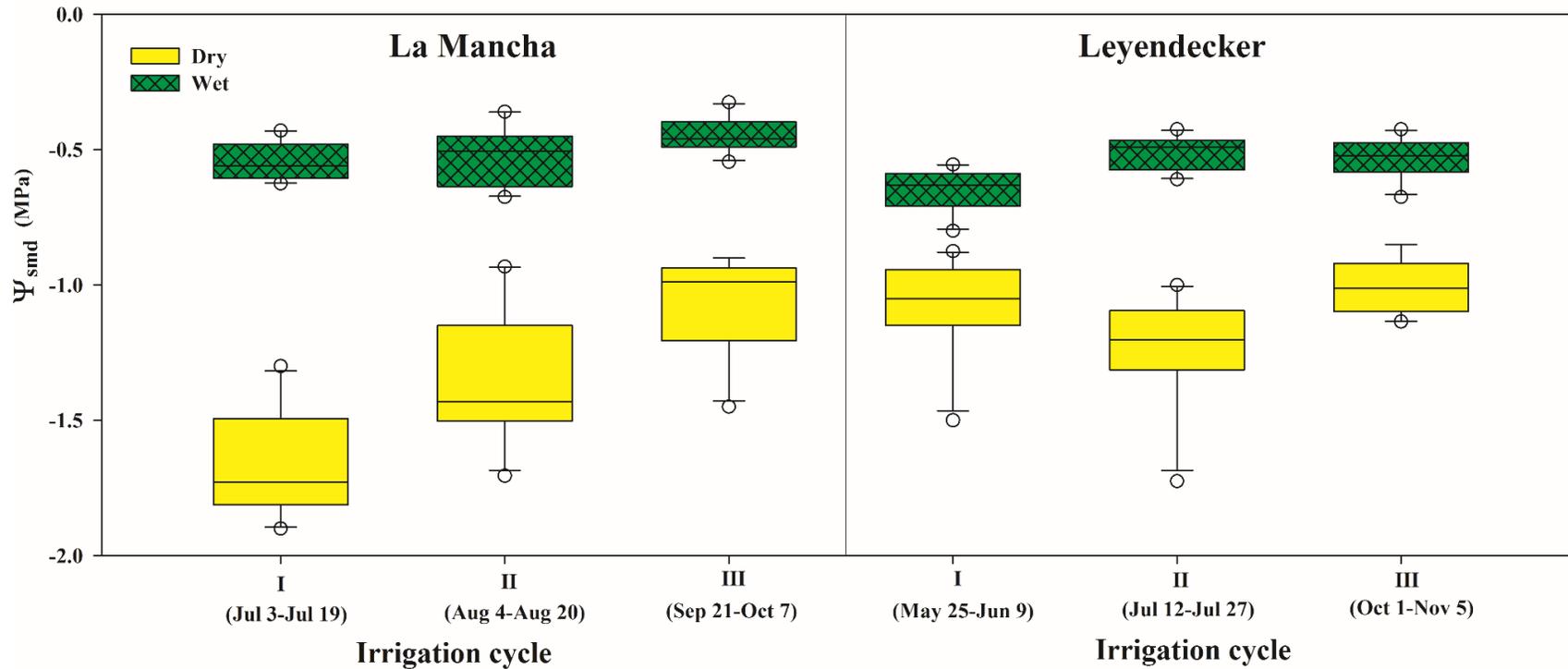


Midday stem water potential (Ψ_{smd}), and relative water content (RWC) of La Mancha and Leyendecker orchards measured in 2011. Different letters indicated a significant difference between irrigation treatments ($P < 0.05$).

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.

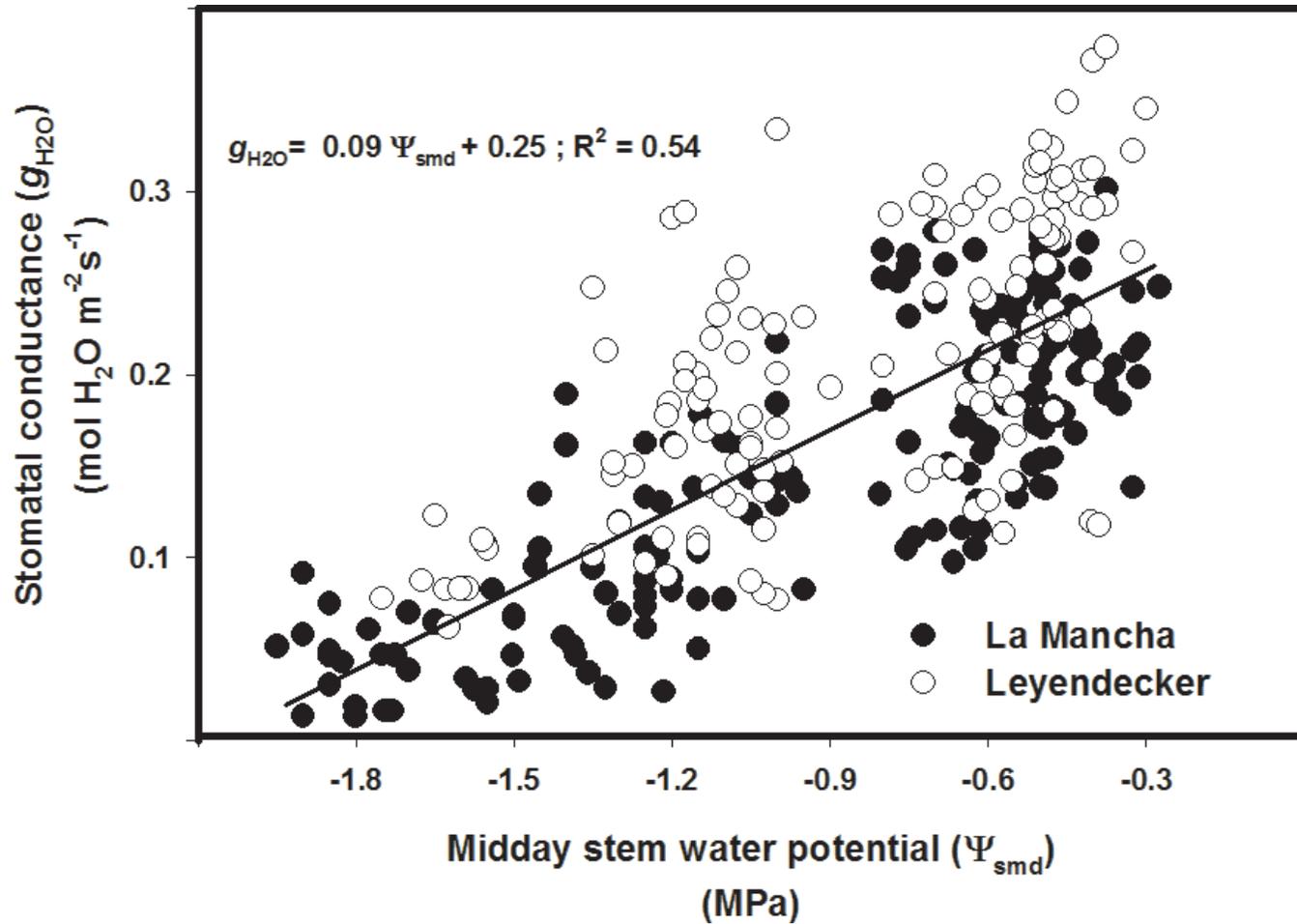


Screen leaf-level physiological variables

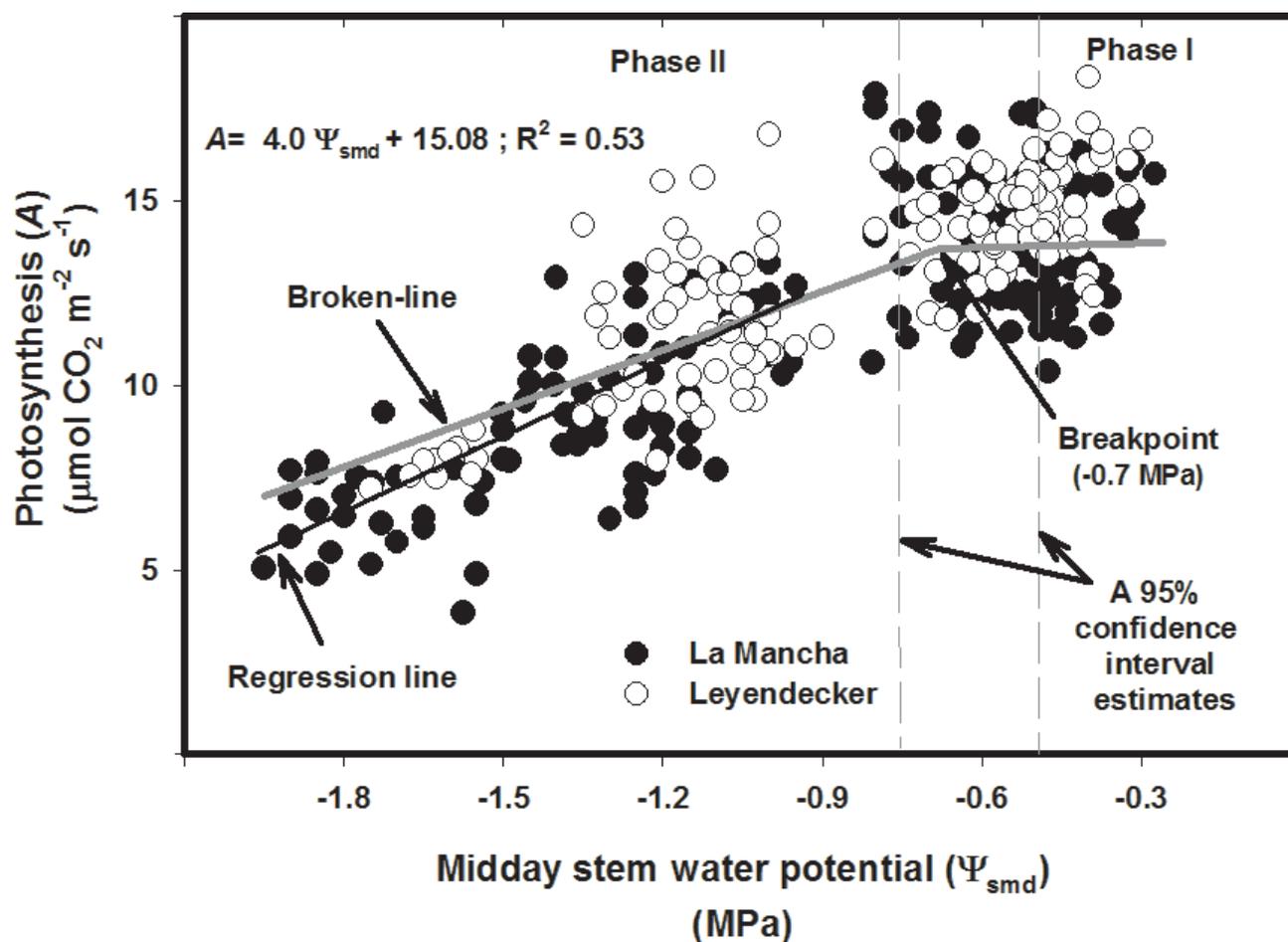


Boxplots of midday stem water potential (Ψ_{smd}) of two southern New Mexico pecan orchards subjected to cyclic flood irrigation (La Mancha and Leyendecker) during the 2011 growing season.

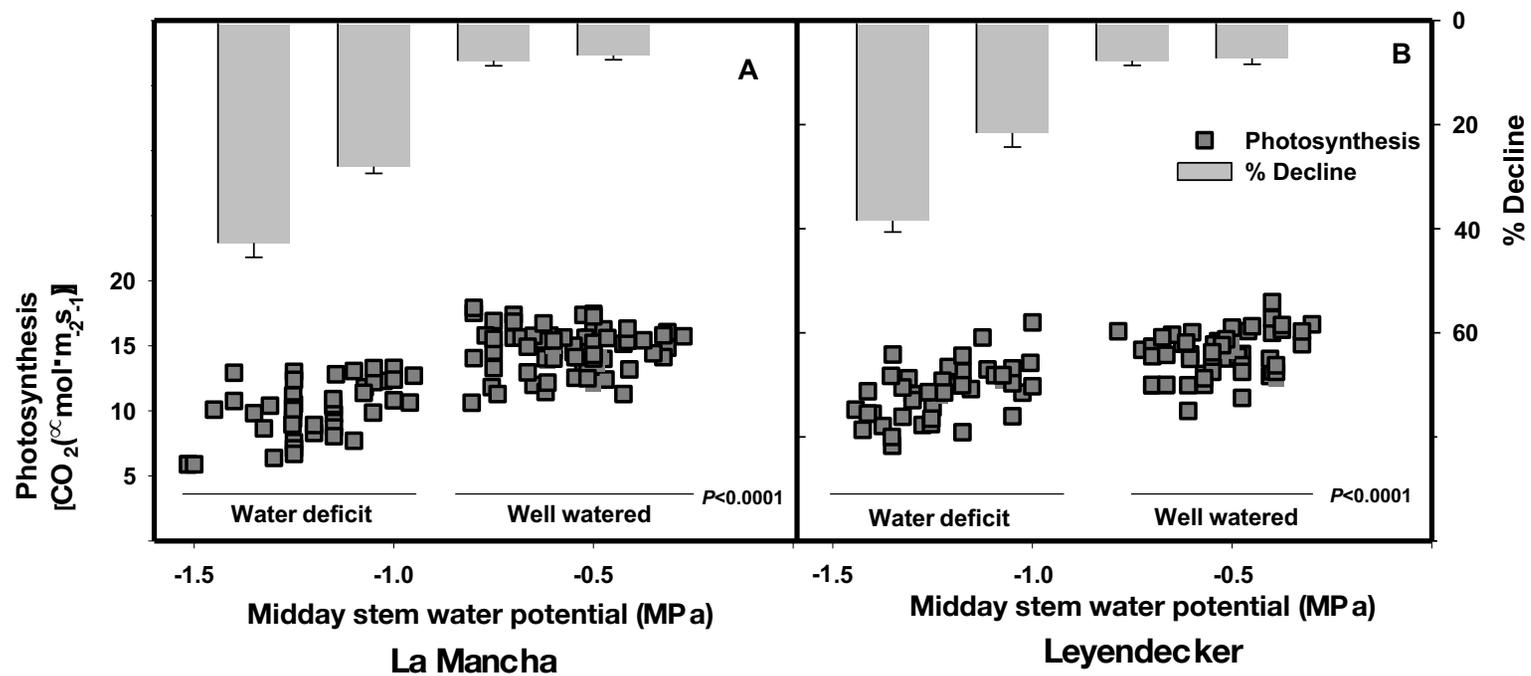
Relationship between stomatal conductance and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards.



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

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 (Ψ_{smd} -0.4 to -0.85 MPa) and moderate water deficit (Ψ_{smd} -0.9 to -1.5 MPa) trees.

Recommendation

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

Personnel

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