Assessment of crop water status by means of crop reflectance

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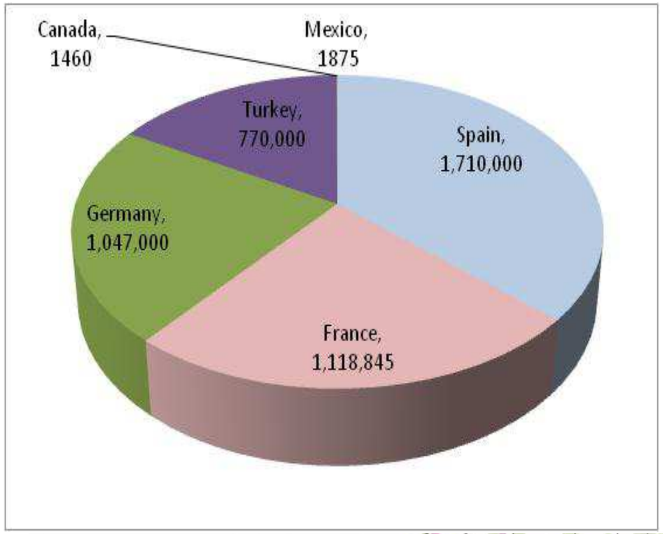
Intelligent crop-based environmental monitoring and control of sustainable greenhouse eco-systems (GreenSense)
Scientific Responsible:
Constantinos Kittas, Nikolaos Katsoulas, Thomas Bartzanas
Certh

COST is supported by the EU Framework Programme Horizon 2020

Organic greenhouse cultivation

❖Alternative method of production

❖The increased concern of consumers about food safety and environmental pollution led to ***an increase of organic greenhouse production***



Spain is an example to follow

Benefits of organic greenhouse cultivation

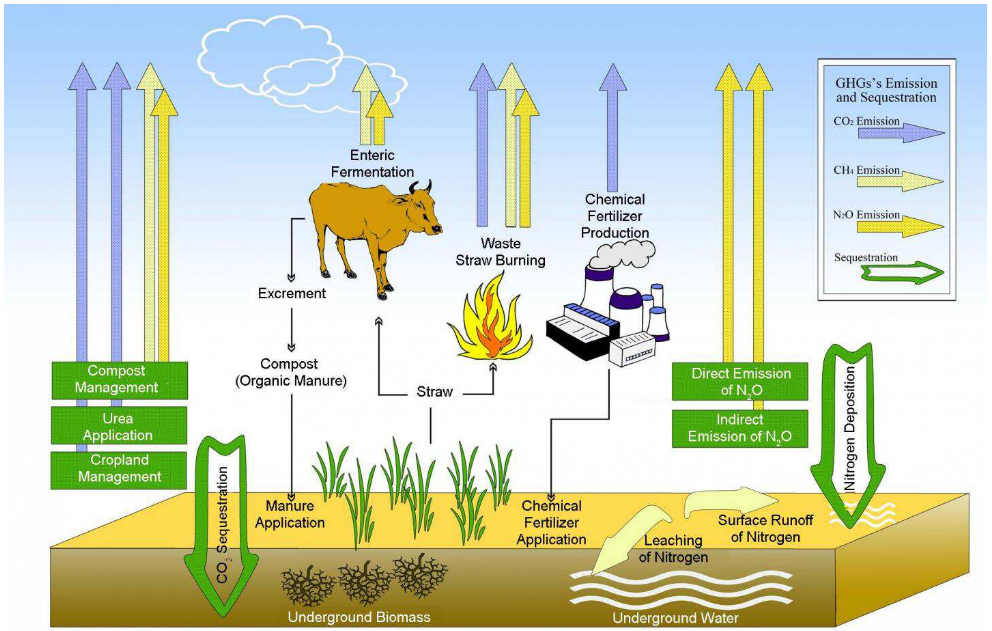
- **Information and technologies**

❖ **Excludes** the use of synthetic fertilizers, pesticides, and growth regulators

❖ Optimize crop yields and quality

❖ Manage production costs,

❖ Minimize the risk of groundwater nitrogen contamination



Strategy research for sustainable organic greenhouse system

- To meet these objectives, organic agriculture farmers need to implement a series of practices that optimize nutrient and water supply

- Improve the management of organic soil, fertilizer amendments and irrigation control

Irrigation & nutrient Mgt.

Up to now are based on time, solar radiation, soil moisture or electric conductivity measurements

Or other indices that require plant contact or destructive sampling

Plant reflectance and temperature evaluation based **on remote sensors** could be used to measure leaf water variation

The method: Non-contact computer vision

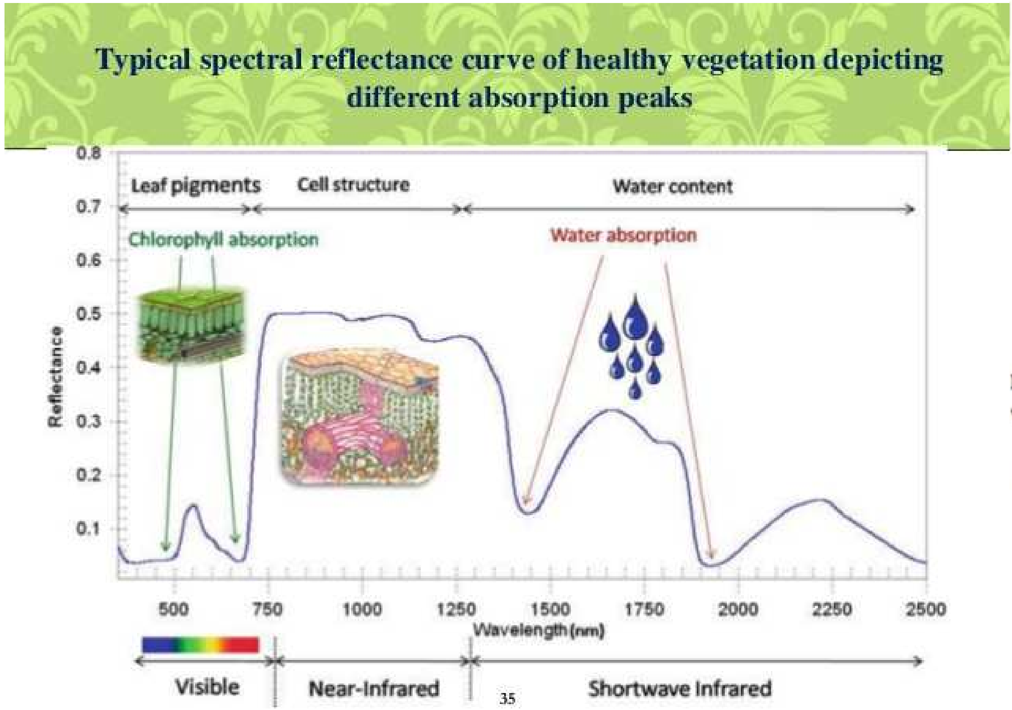
Based on spectral data (colour, temperature, moisture)

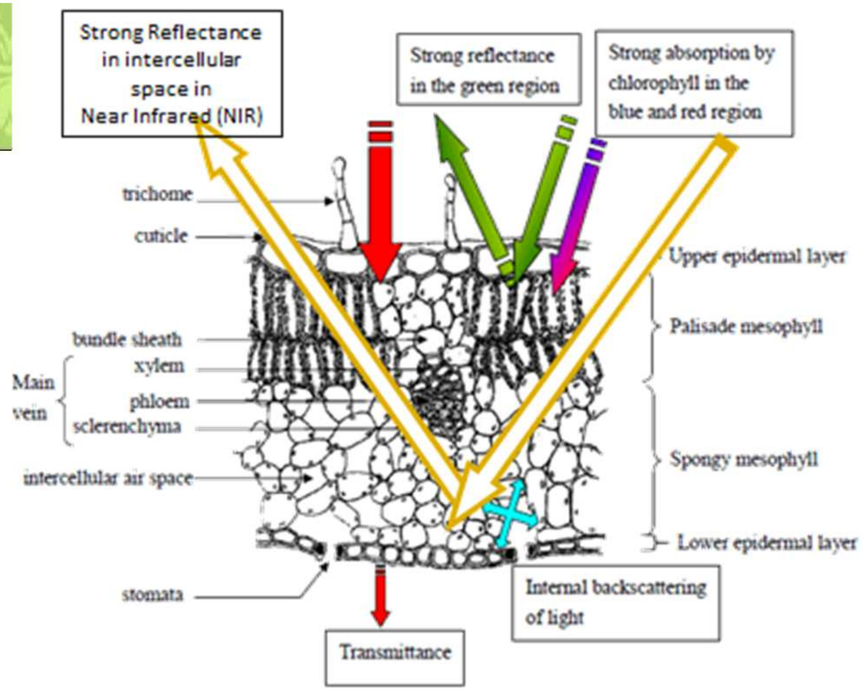
In real time, thus more qualitative & quantitative information

Optimal Resource Management

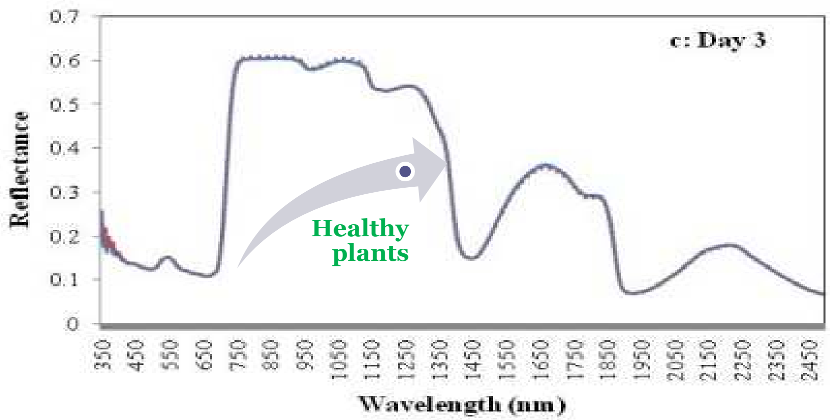
Computer vision use to estimate crop spectrum & its correlation with crop water status & chlorophyll/nitrogen concentration

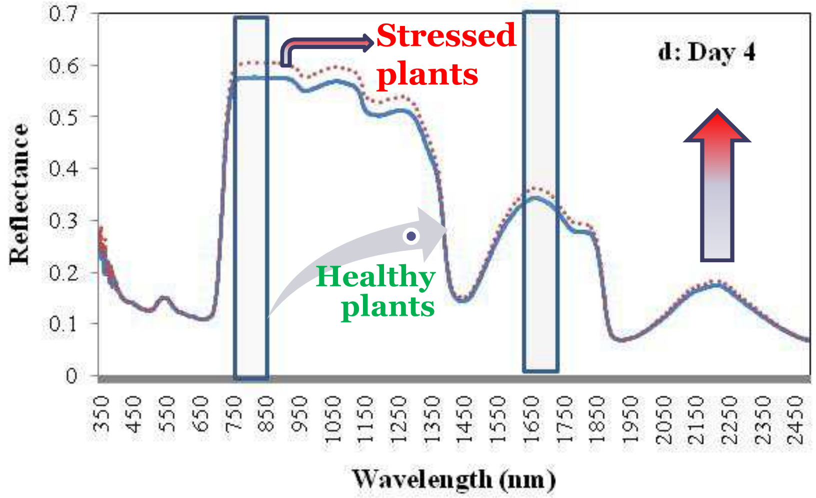
Plant reflectance





Plant reflectance evolution-Index formation





Index	Index's Calculation
PRI	(531-570)/(531+570)
WI	900/970
$NDVI_{(800-680)}$	(800-680)/(800+680)
rNDVI	(750-705)/(750-705)
mrNDVI	(750-705)/(750+705-2*445)
mrSRI	(750-445)/(750+445)
VOGREI	(740/720)
TCARI	3[(R700-R670)-0.2*(R700-R550)*(R700/R670)]

Objectives

- ❖ Detect on real time crop water and nutrient stress using ***plant spectrum reflectance variation based on remote sensing techniques***

- ❖ The investigation of the most effective ***reflectance indices for water and nutrient stress detection***

MATERIALS & METHODS

The growth chamber

Full automatically control chamber ($30m^2$) of temperature, humidity, CO_2 and light intensity

- ❖ High pressure sodium lamps, 600W/each
- ❖ 24 lamps (6 lamps each level)
- ❖ Max radiation 240 w/m^2 (4 levels)
- ❖ The lamps emit radiation at 500 and 570-690nm

Irrigation control

- Close hydroponic system based on perlite substrate

1. Well watered plants: the plants ***were irrigated*** during the days of the experiment (D1-10) according to time irrigation program
2. Water stress plants: the plants remained ***without nutrient solution*** the days of the experiment (D4-8) by removing the drippers from the perlite slabs





Plant reflectance measurements based on hyperspectral cam (1)

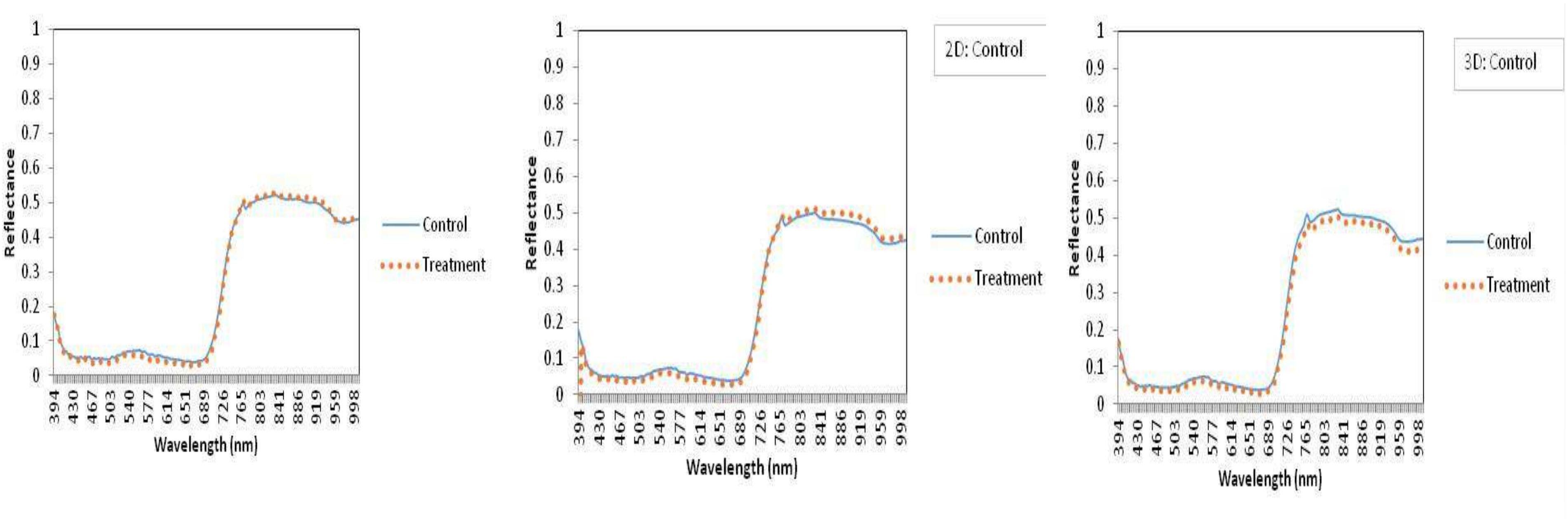
Spectrograph Imspec V10 (Specim Ltd)

- ❖ Spectral range 400 – 1000 nm
- ❖ Pixels in full frame 1312 x 1024
- ❖ Focus length 8 mm

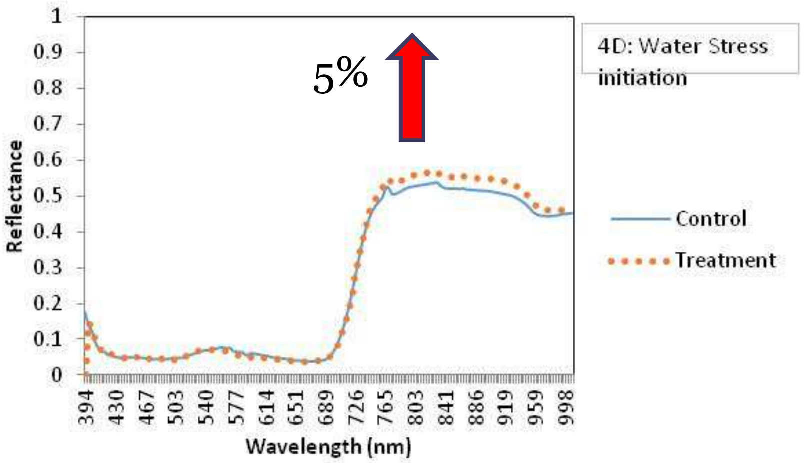
- ❖ Distance from plant to imager: approximately 1m
- ❖ All measurements were taken using additional tungsten halogen light source
- ❖ The imager head was mounted to an upright post on a utility cart, in a side-facing orientation and moved between rows
- ❖ Reflectance measurements were corrected to the avg measurement of a 60x100cm spectralon target

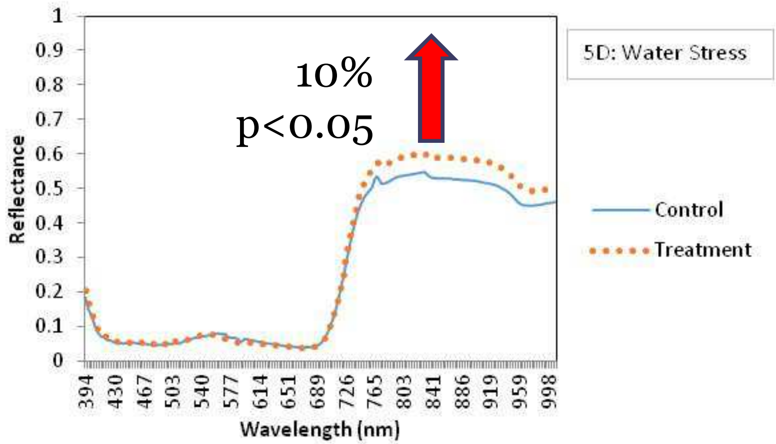

RESULTS

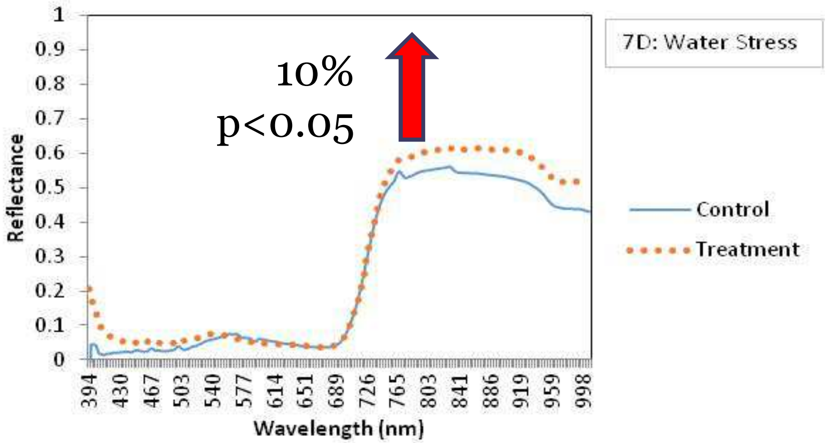
Plant reflectance evolution based on water deficit (1)

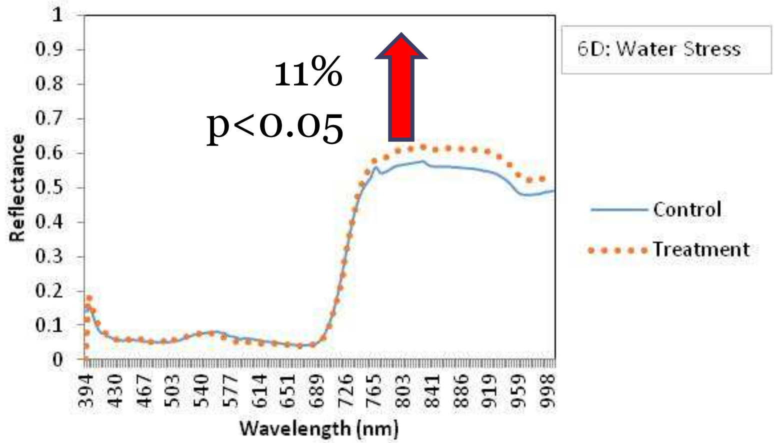


Plant reflectance evolution based on water deficit (2)

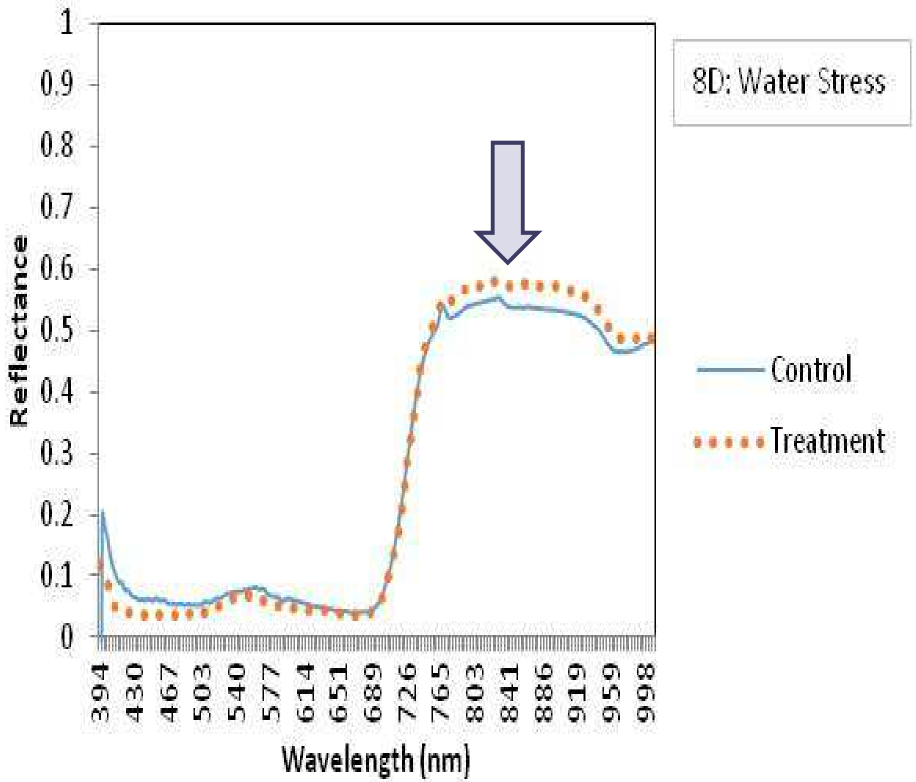


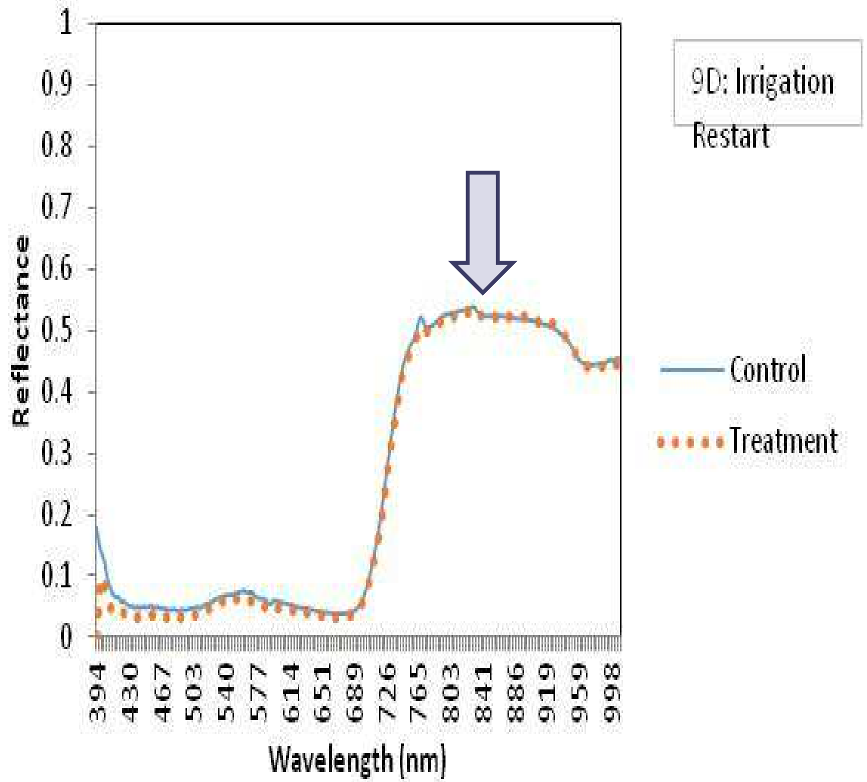




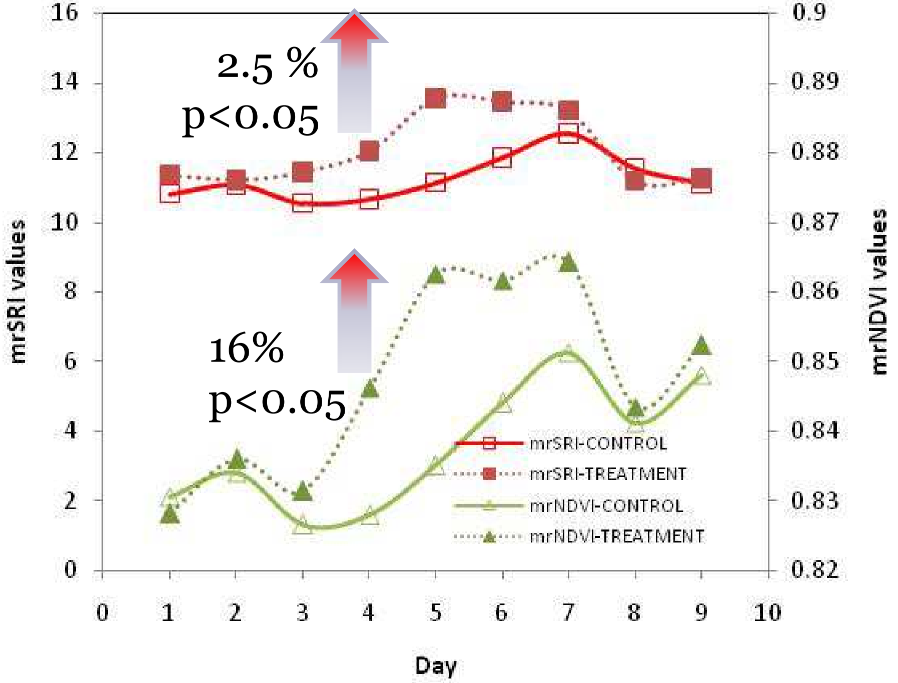


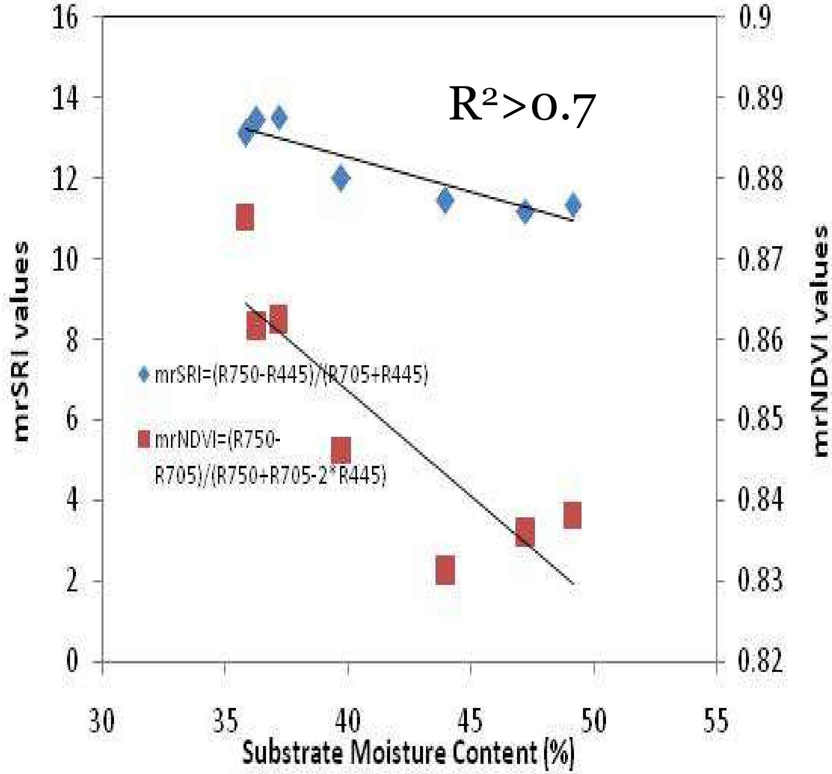
Plant reflectance evolution based on water deficit (3)





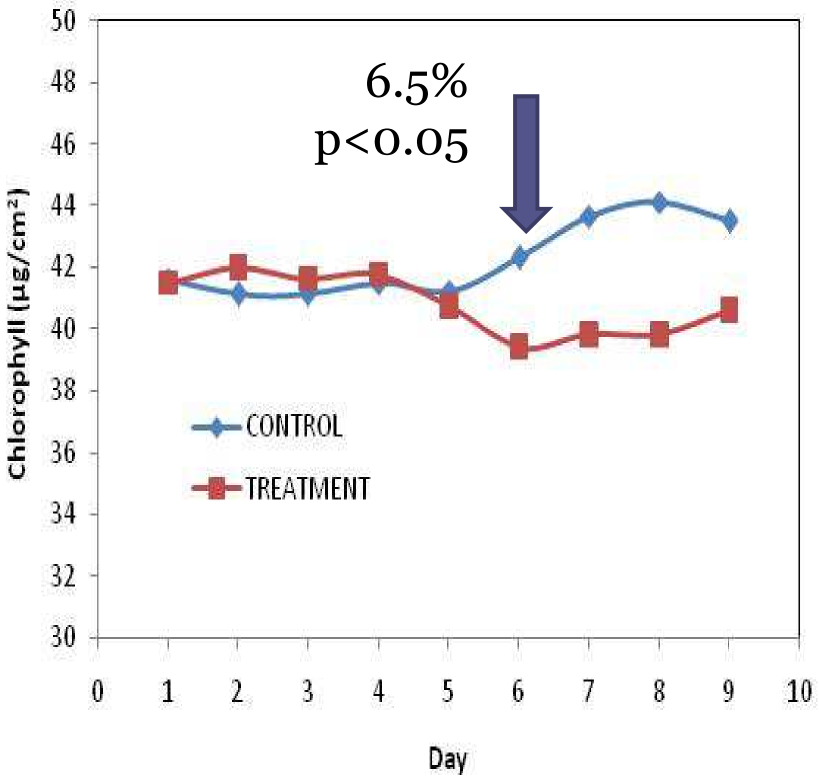
Indices values

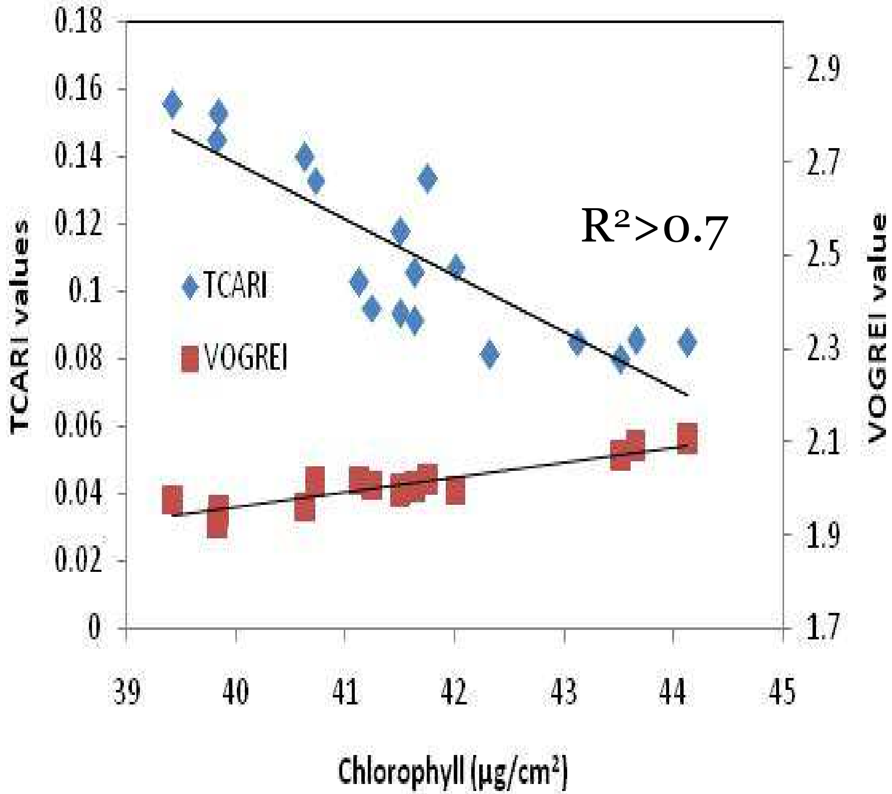




mrNDVI	(750-705)/(750+705-2*445)
mrSRI	(750-445)/(750+445)

Chlorophyll index





VOGREI	(740/720)
TCARI	3[(R700-R670)-0.2*(R700-R550)*(R700/R670)]

- The reflectance indices mrSRI and mrNDVI could be use as an indicator of plant water stress in organic or conventional greenhouse cultivation.

- VOGREI and TCARI were correlated well with changes in chlorophyll and nitrogen content.

- Reflectance measurements might be utilized to provide alarm signals when the water or nitrogen status of a greenhouse crop reaches critical levels for optimal plant growth. This method could be applied in conventional or organic greenhouse conditions.

THANK YOU

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The authors thank the European Commission for the foundation of the Greek GSRT Research Excellence Grant (ΑΡΙΣΤΕΙΑ) project "GreenSense" (9/2013-9/2015) and European Cooperation in Science and Technology for the conference foundation.

Questions