Martin Trtilek
Photon Systems Instruments

Calibration and validation of hyperspectral imagery using a field phenotyping measurement Brno , 2023

State of the Art Technologies
Food quality, Environmental protection, Food security

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Research
&
Development

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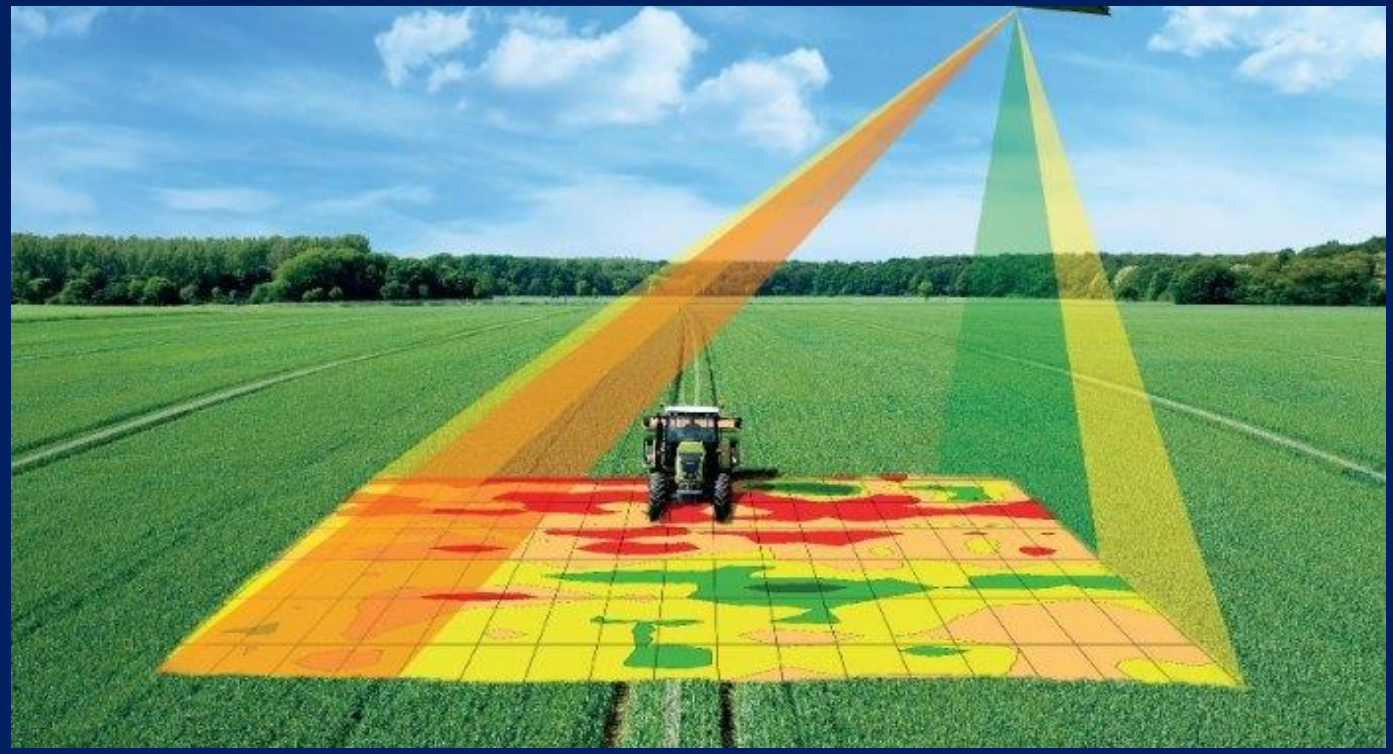
Satellite Imaging

Satellite Imaging

Reference measurement

- Calibrations
- Data interpretation



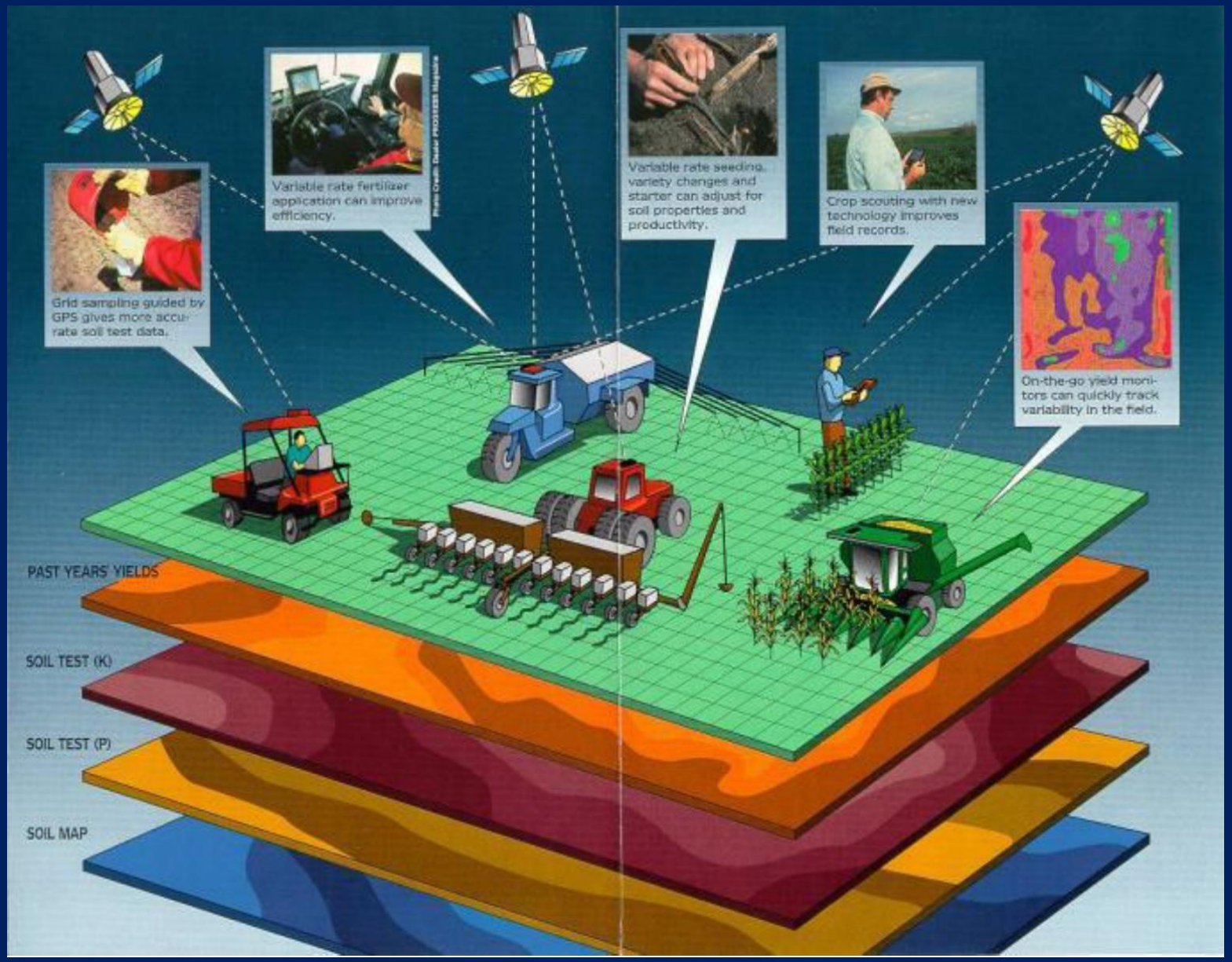
Advantage

- Large area
- Fast
- Daily measured

Disadvantage

- Resolution
- Weather condition (Clouds)
- Interpretation
- Indirect measurement

SCERIN-10 Workshop on Earth System Observations



Precision Agriculture

- *resource use efficiency productivity*
- *Quality*
- *profitability*
- *sustainability of agricultural production*

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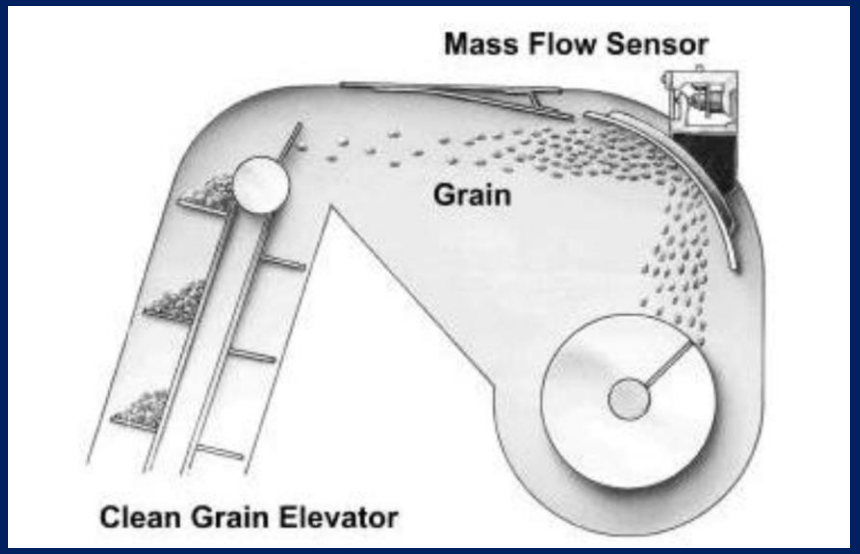
SCERIN-10 Workshop on Earth System Observations

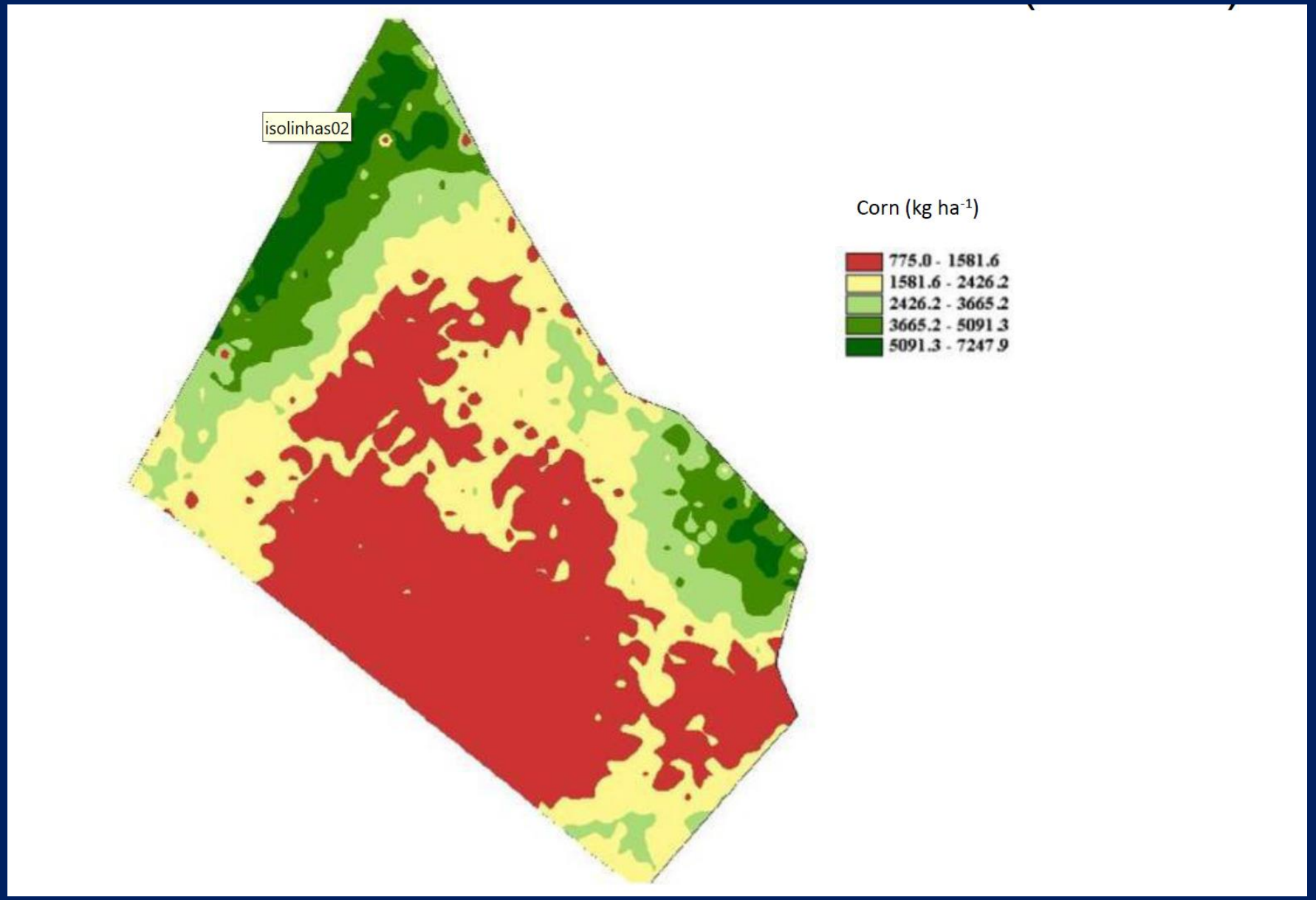
Fertilizing by nitrogen content



Yield monitoring

Spraying with fertilizer

- Ground Based for validation
- Yield optimalization



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Field Phenotyping

Various Approaches

FieldScreen™ Rover

FieldScreen™ Rower2

FieldScreen™ High clearance

FieldScreen™ Crane

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Sensors

3D Imaging

Kinetic chlorophyll fluorescence Imaging

Hyperspectral Imaging

X-RAY

Mass Spectroscopy

Root Imaging

RGB and Morphometric Imaging

Near Infrafed/Thermal Imaging

FieldScreen™ Tractor

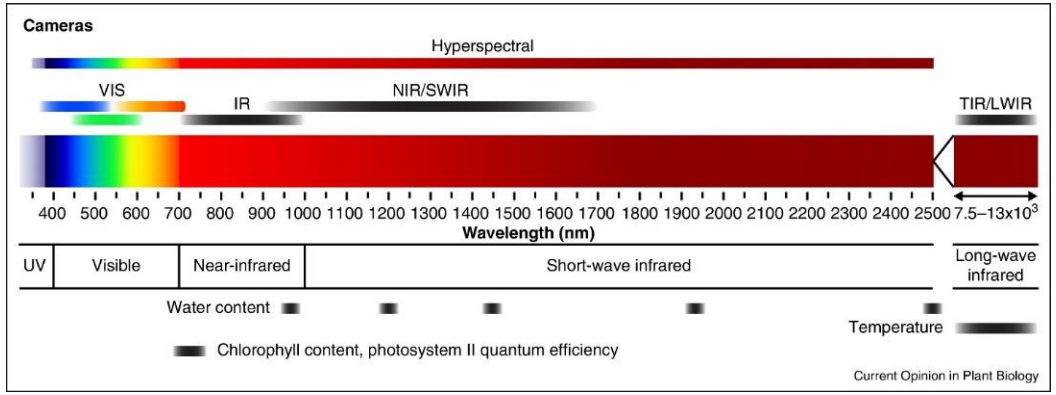
FieldScreen™ Tractor

- Ground Based measurements to create correlation model for satellite imagery

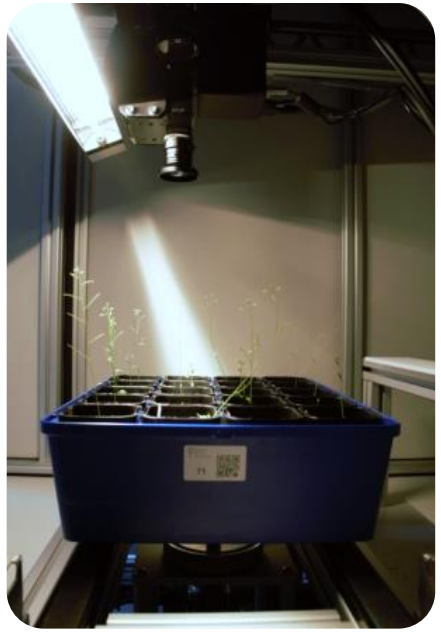
- This is necessary to be able to interpret data from Satellite

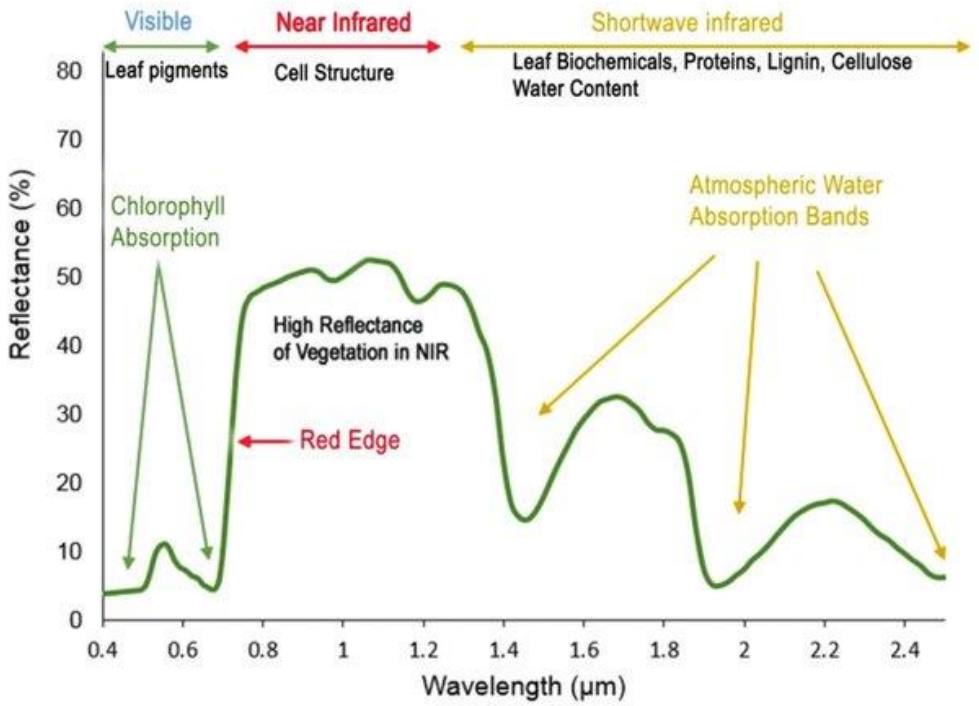
- ❑ Reference measurement to eliminate the artefacts
  - Spectralon reference target in the field of view
- ❑ How to do reference measurement for each image from satellite ?

Hyperspectral imaging



Hyperspectral cameras can measure hundreds of spectral bands between 350 and 2500 nm at nm-level resolution for each image pixel





APPLICATIONS

- **pigments composition (VIS)**
- **biochemical compounds (SWIR)**
- **nitrogen content**
- **leaf water status (SWIR)**

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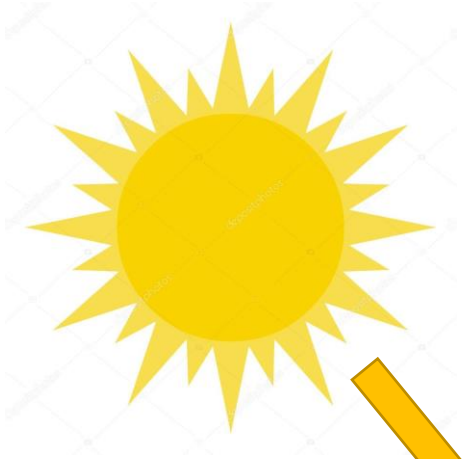
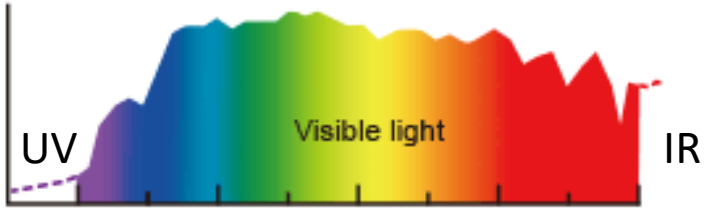
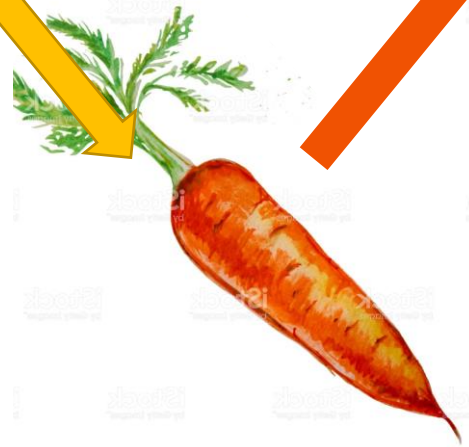
Hyperspectral Imaging – pigment composition

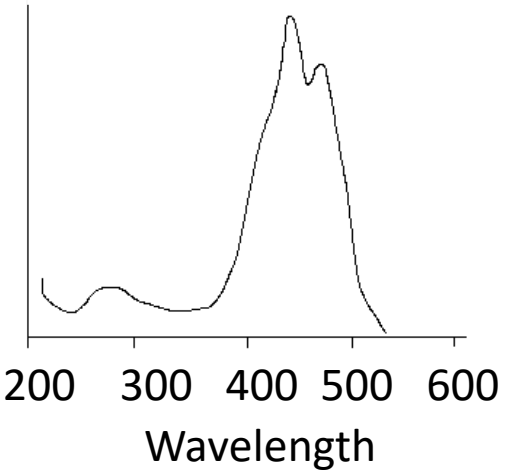


Spectral distibution of sunlight





Spectral distibution of beta-carotene



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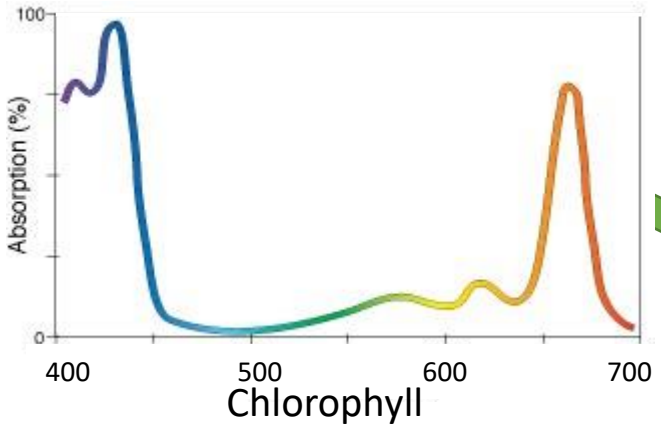
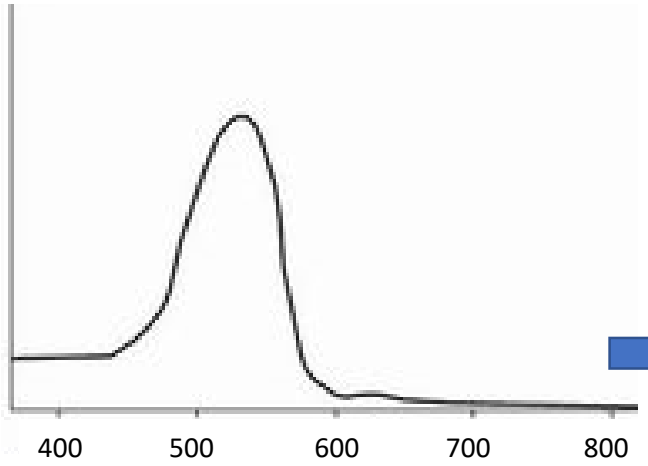
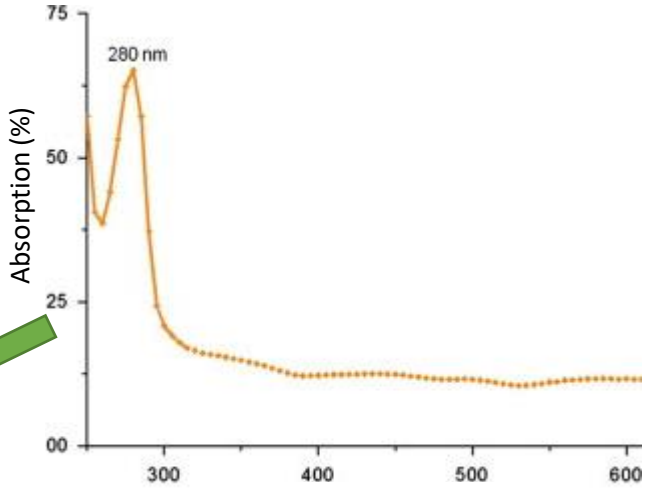
Hyperspectral Imaging



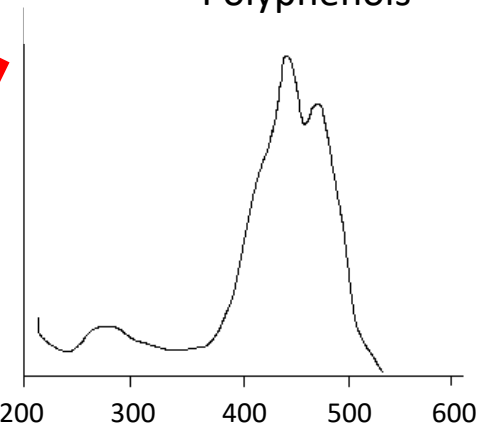
Chlorophyll



Anthocyanin



Polyphenols



Carotenoids

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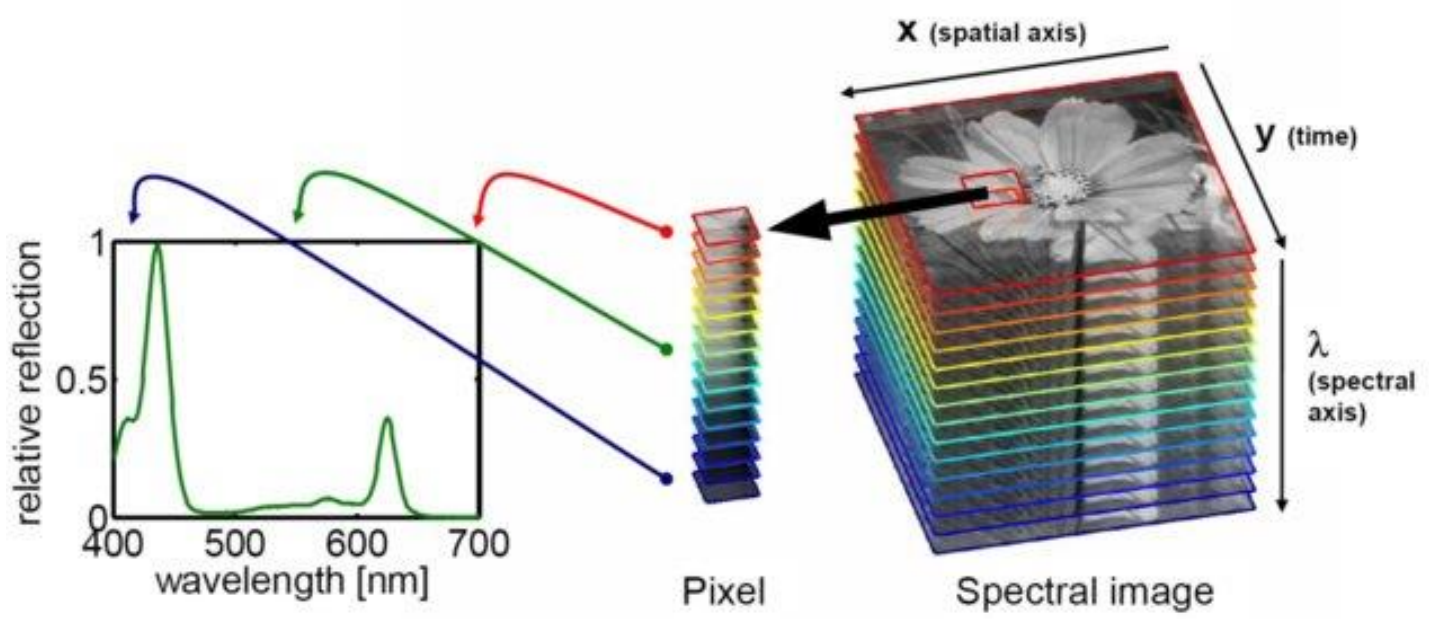
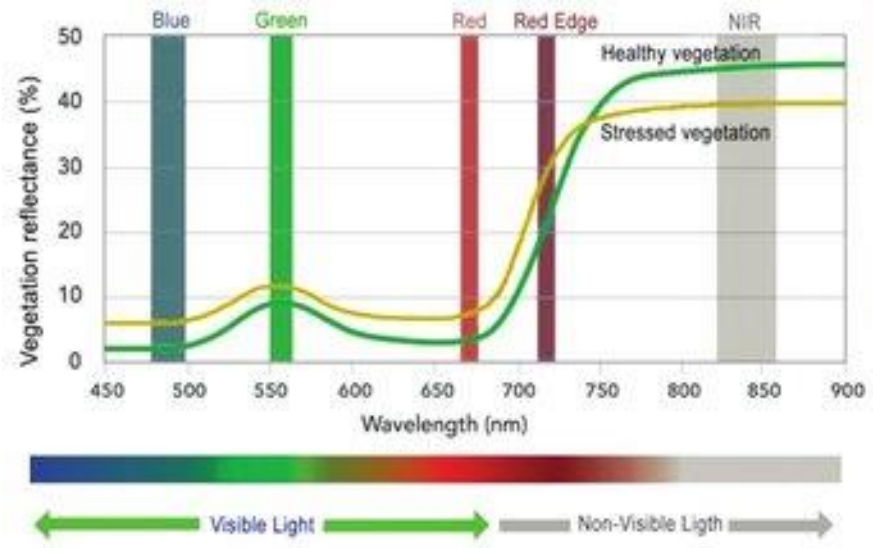
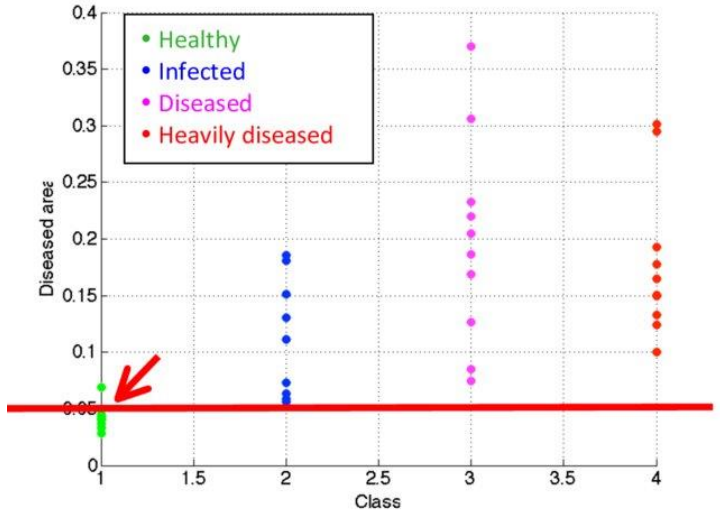
Plant Reflectance Indices

- **Normalized Difference Vegetation Index NDVI** = (RNIR - RRED) / (RNIR + RRED)
- **Simple Ratio Index (SR)** SR = RNIR / RRED
- **Modified Chlorophyll Absorption in Reflectance Index MCARI1** = 1.2 * [2.5 * (R790- R670) - 1.3 * (R790- R550)]
- **Optimized Soil-Adjusted Vegetation OSAVI** = (1 + 0.16) * (R790- R670) / (R790- R670 + 0.16)
- **Greenness Index G** = R554 / R677
- **Modified Chlorophyll Absorption in Reflectance MCARI** = [(R700- R670) - 0.2 * (R700- R550)] * (R700/ R670)
- **Transformed CAR Index TCARI** = 3 * [(R700- R670) - 0.2 * (R700- R550) * (R700/ R670)]
- **Triangular Vegetation Index TVI** = 0.5 * [120 * (R750- R550) - 200 * (R670- R550)]
- **Zarco-Tejada & Miller Index ZMI** = R750 / R710
- **Simple Ratio Pigment Index SRPI** = R430 / R680
- **Normalized Phaeophytinization Index NPQI** = (R415- R435) / (R415+ R435)
- **Photochemical Reflectance Index PRI**= (R531- R570) / (R531+ R570)
- **Normalized Pigment Chlorophyll Index NPCI**= (R680- R430) / (R680+ R430)

Hyperspectral imaging - Stress detection







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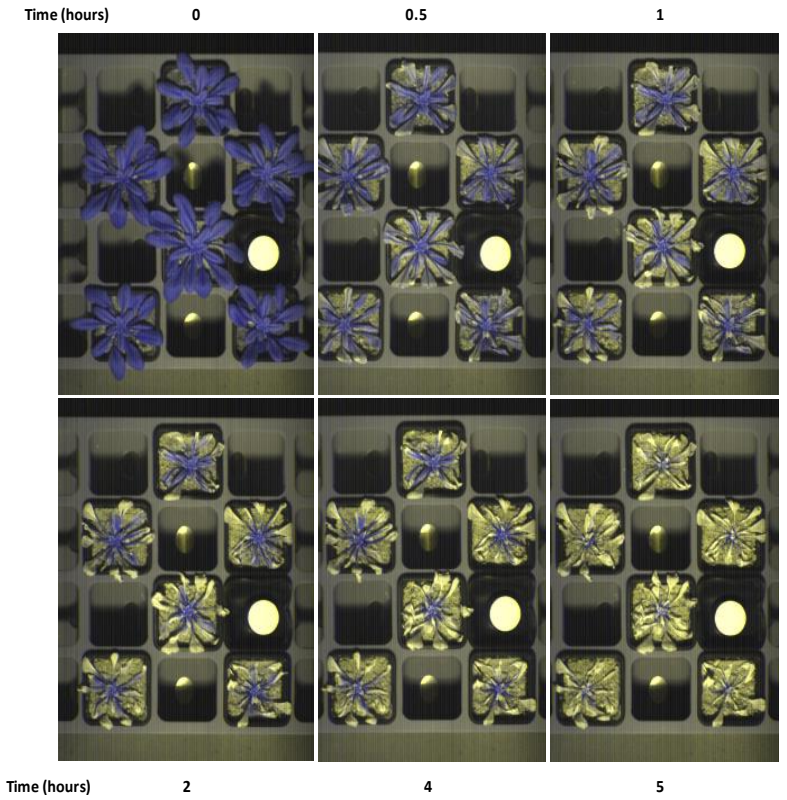
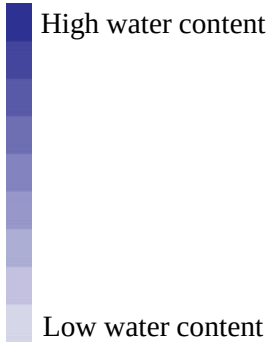
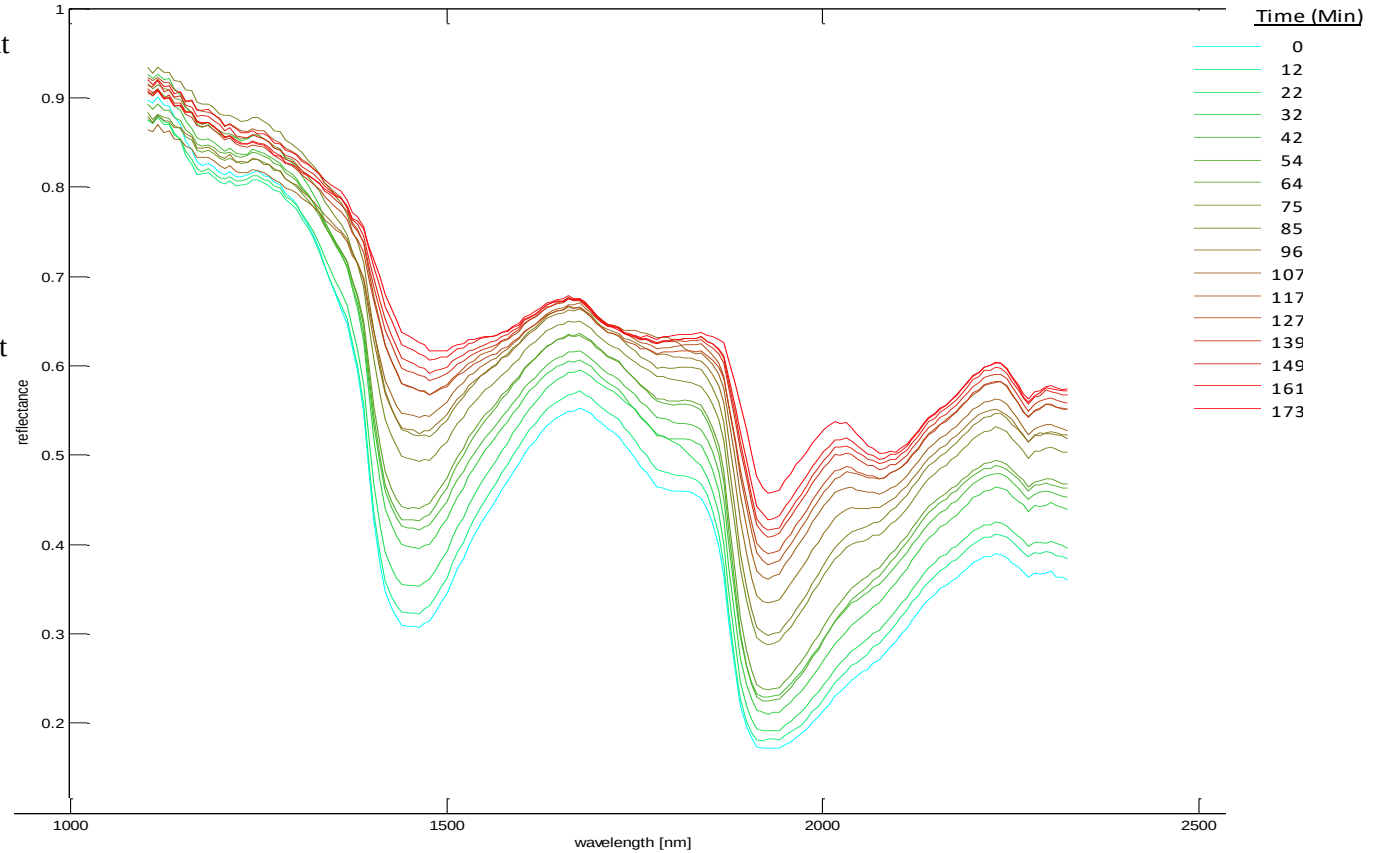
Hyperspectral Imaging

Water content analysis in drought stressed plants



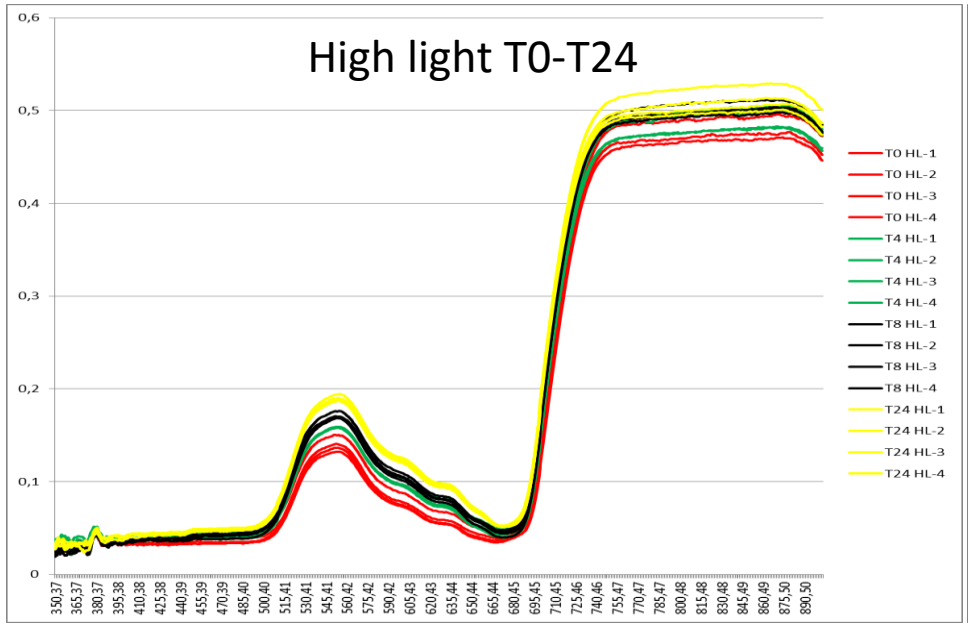


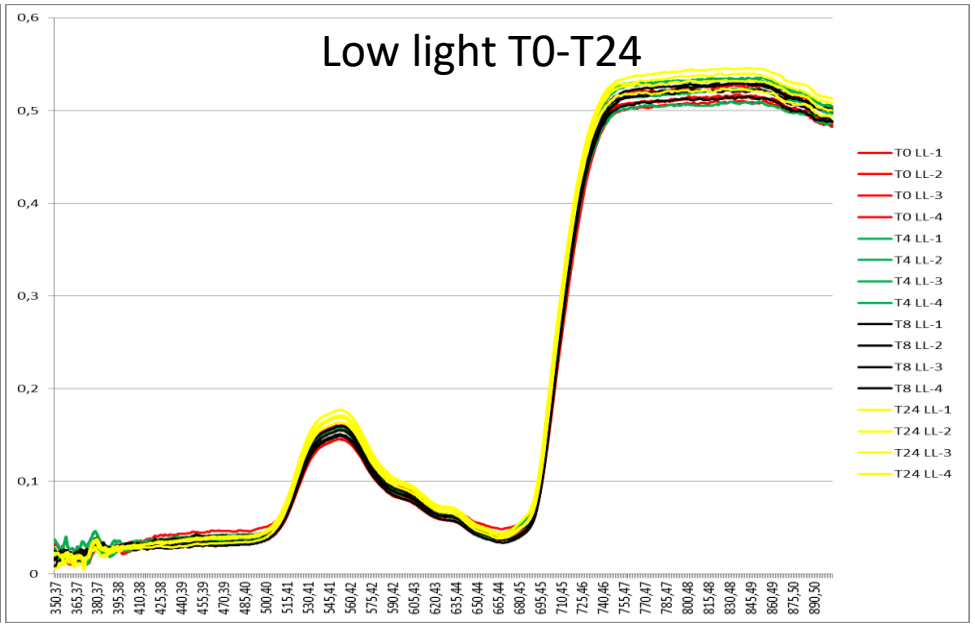


3-w-old *Arabidopsis thaliana* plants were dried for up to 3 in 45°C.

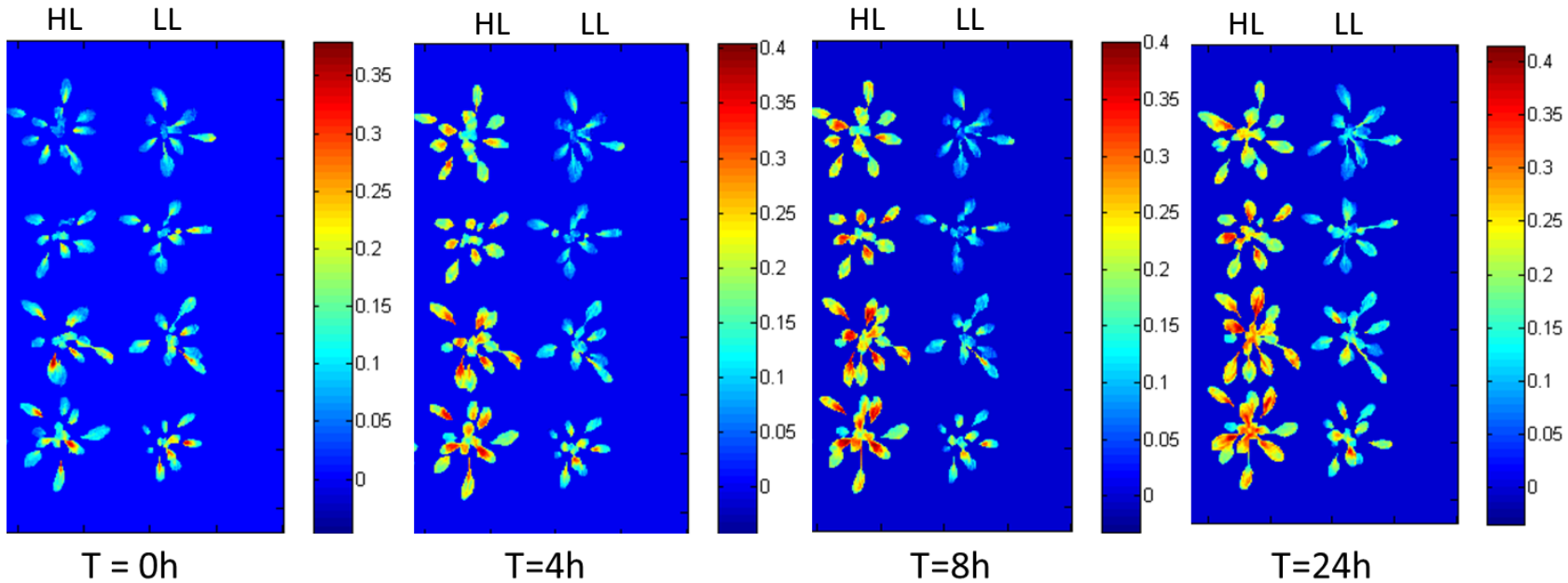
Kinetic analysis of water content reduction in dried plants

Applications - High light stress

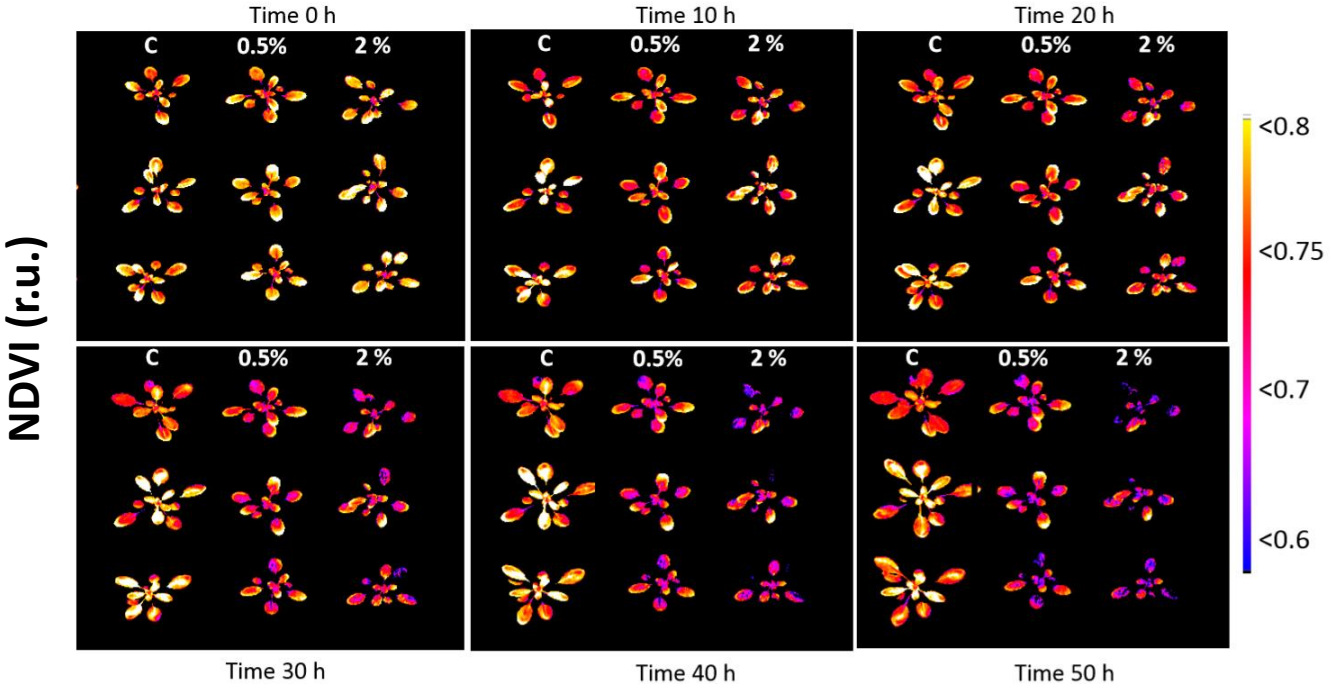




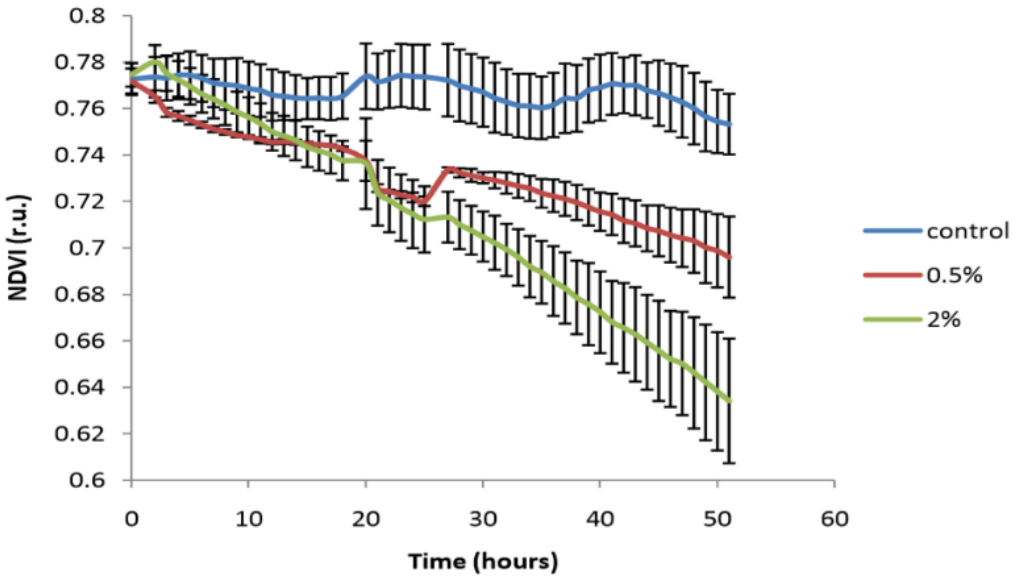
HL stress index



Applications - Glyphosate treatment



Roundup application to 3-w-old *Arabidopsis thaliana* plants.



Roundup application to 3-w-old *Arabidopsis thaliana* plants.

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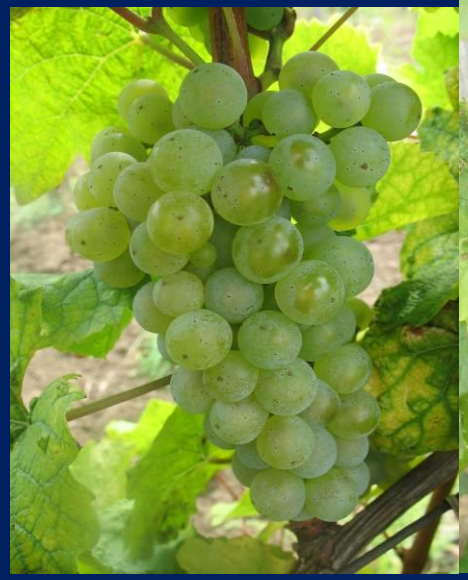
WinePen

Polyphenols in grape

flavan-3-ols: catechin – absorption	280 nm
hydroxycinnamic acids (+ stilbenes)	
caftaric acid (+ resveratrol) - absorption	320 nm
flavonols: quercetin – absorption max.	360 nm
anthocyanins: malvidine – absorption	520 nm



Riesling

Chardonnay

Pinot Noir

Saint Laurent

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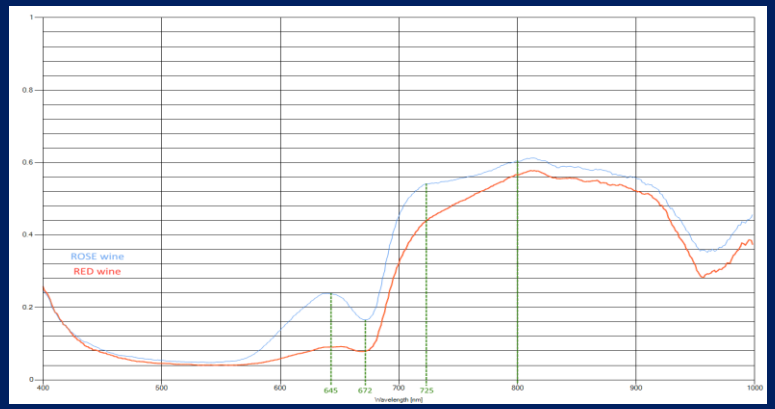
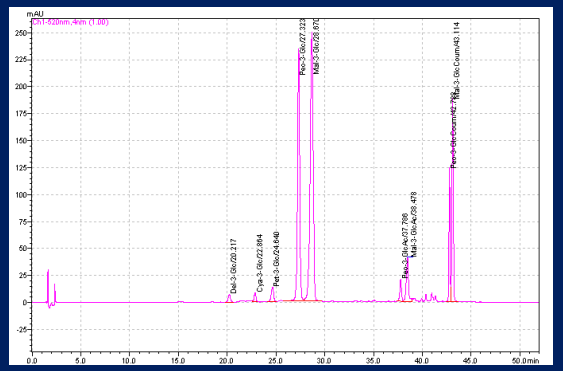
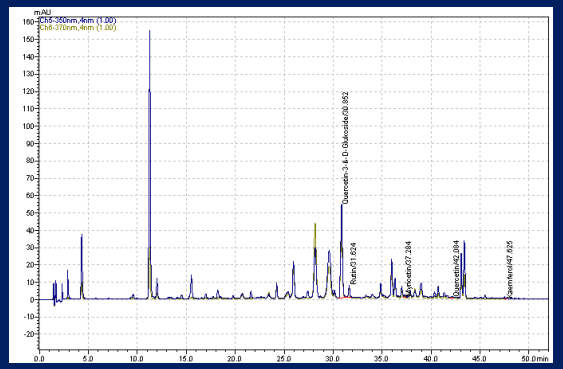
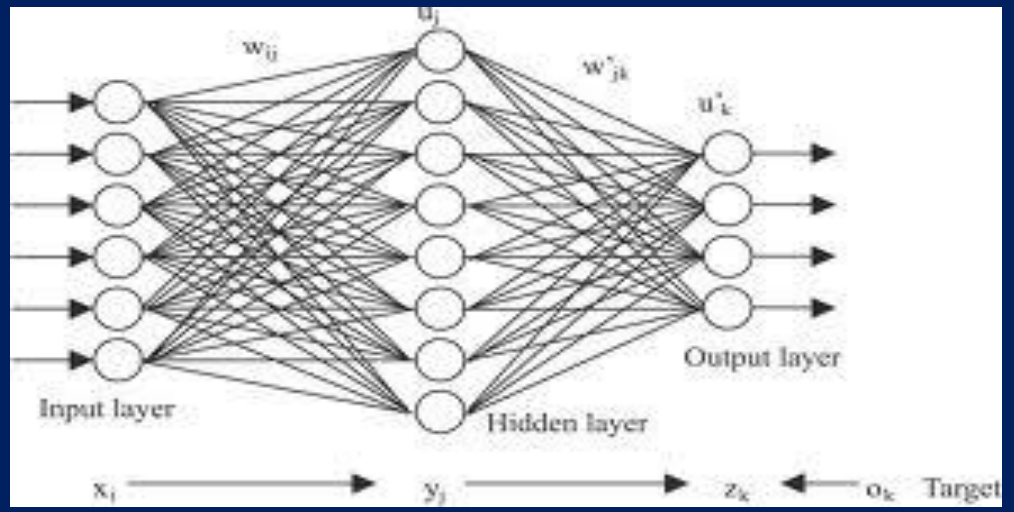
Machine learning – neural network

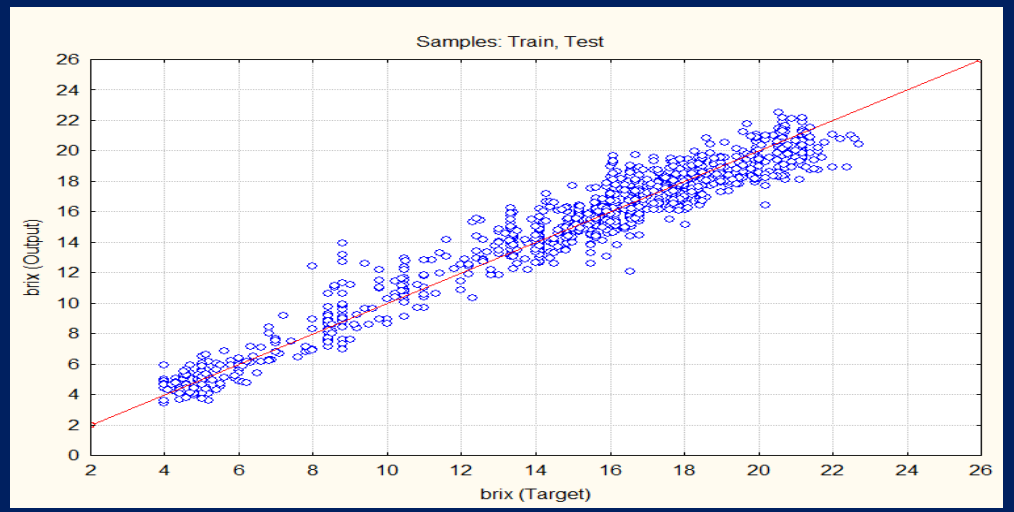






Reflectance spectra from rose and red berries





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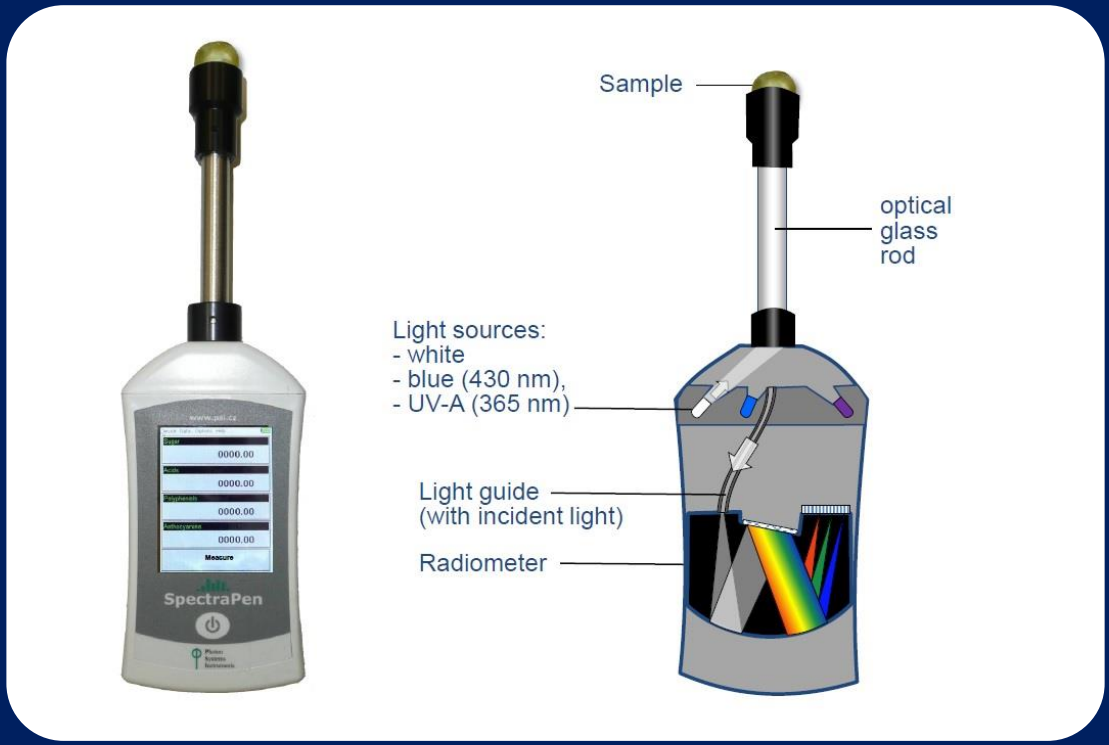
WinePen



Polyphenols in grape

1) flavan-3-ols: catechin – absorption max. 280 nm
2) hydroxycinnamic acids (+ stilbenes)
   caftaric acid (+ resveratrol) - absorption max. 320 nm
3) flavonols: quercetin – absorption max. 360 nm
4) anthocyanins: malvidine – absorption max. 520 nm

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