IPM 2.0
Towards future-proof crop protection in Europe

INRES
Institut für
Nutzpflanzenwissenschaften
und Ressourcenschutz

Hyperspectral imaging –
an innovative tool to detect plant diseases for IPM

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EFPP

CROP.SENSe.net

Network of sensor technology R&D **http://www.cropsense.uni-bonn.de**

Using new and non-destructive sensor technologies ...

... to improve **crop management** and **phenotyping** for plant breeding

Funded by:

Bundesministerium für Bildung und Forschung

EUROPÄISCHE UNION
Investition in unsere Zukunft
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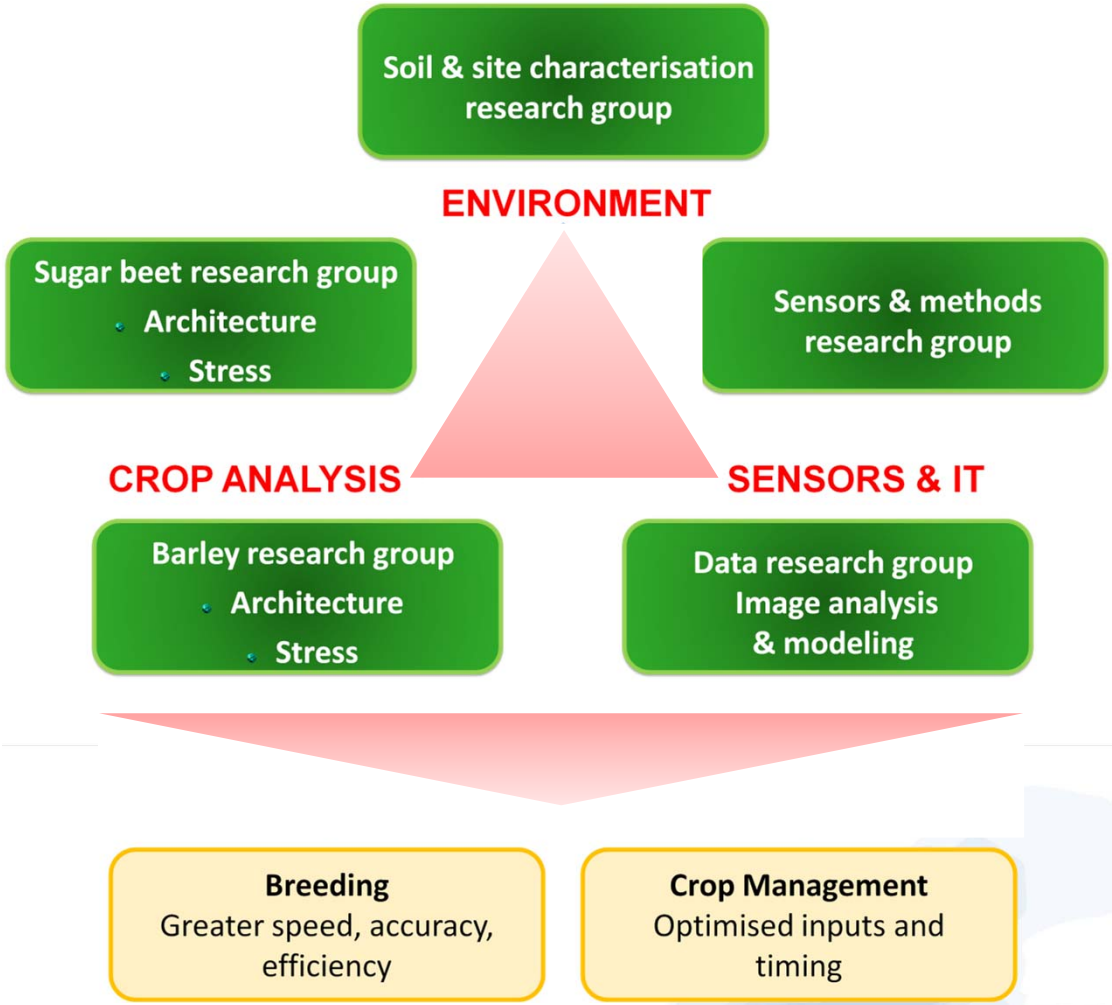


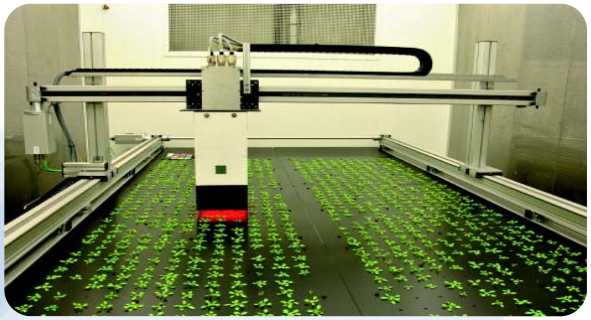
Background

- Detection of plant diseases for IPM, precision crop protection, plant phenotyping or fungicide screening
- Visual assessment of diseases by human individuals is time consuming and often inaccurate
- Phenotyping for disease resistance or fungicide screening requires innovative high-throughput technologies

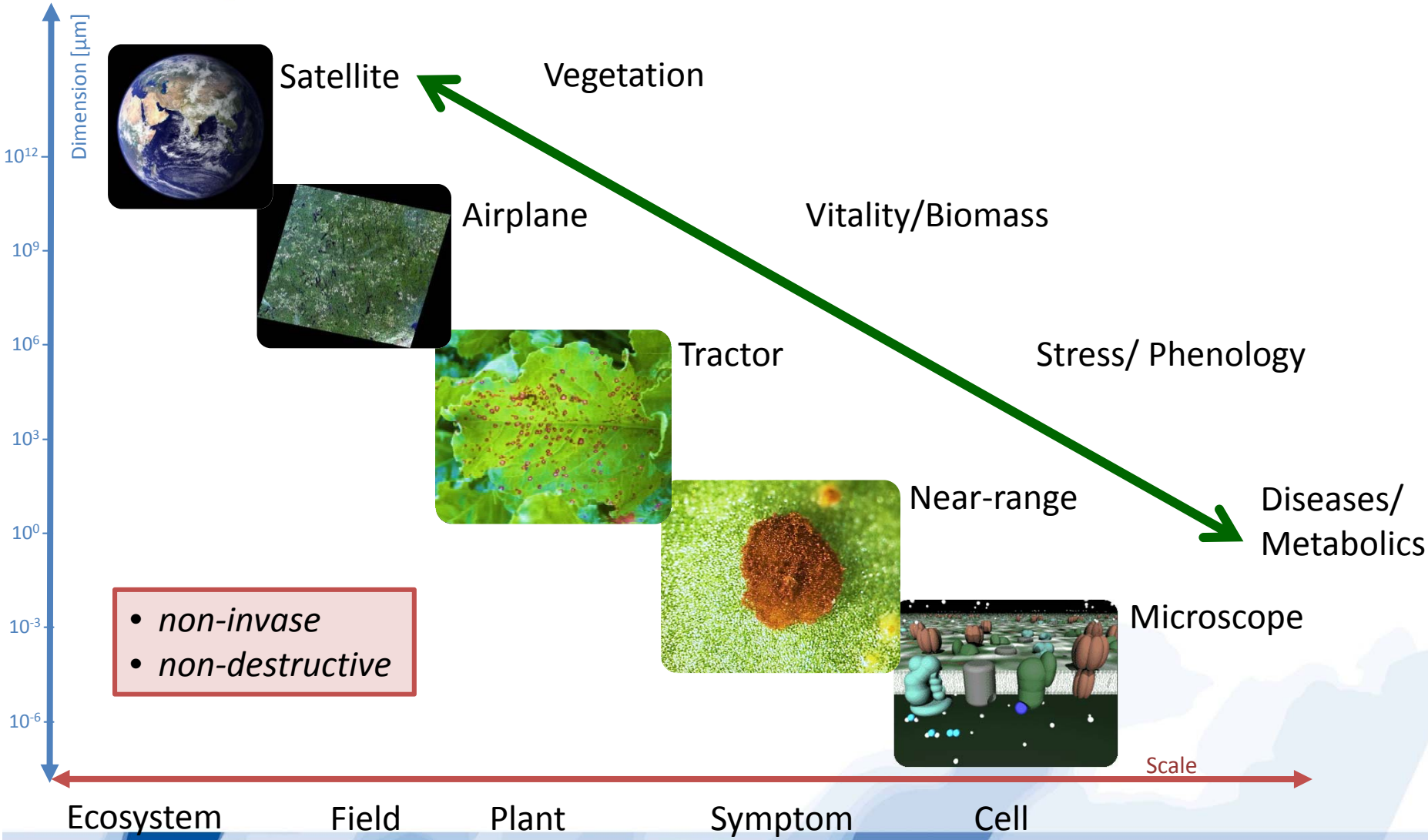
Precision Agriculture

Phenotyping

High-throughput Screening



Sensing plants on different scales

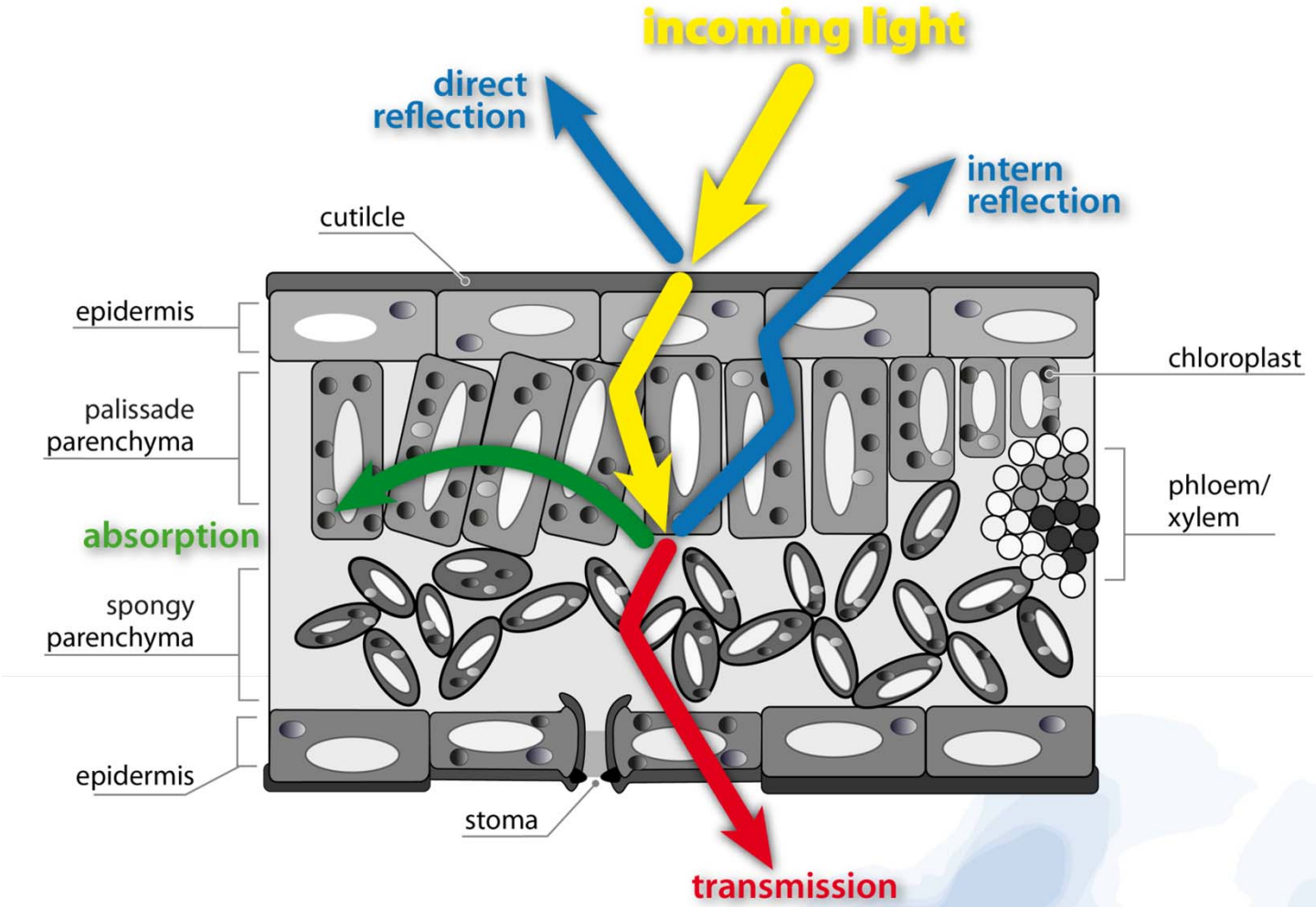


Objectives

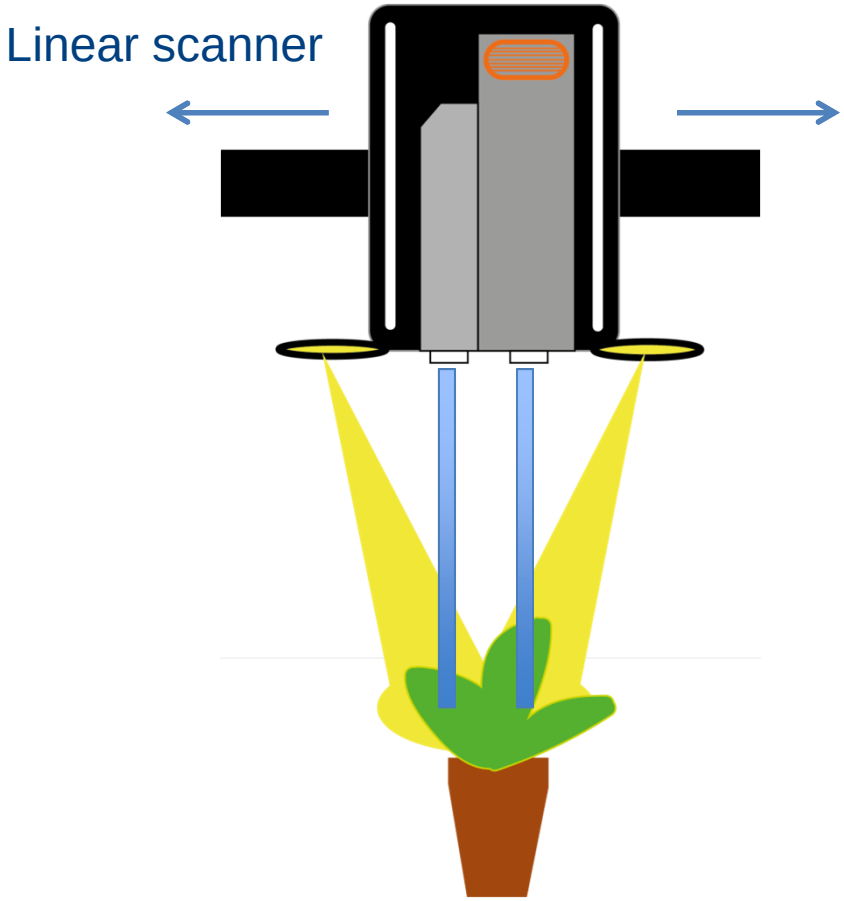
- Reproducible, objective and automatic detection of plant diseases
- Hyperspectral imaging sensors in the visible (VIS), near infrared (NIR) and shortwave infrared (SWIR) 400 – 2500 nm
- Link between reflectance and biophysical/biochemical characteristics

➢ *What is the potential of spectral sensing for disease detection and IPM?*

Leaf reflectance

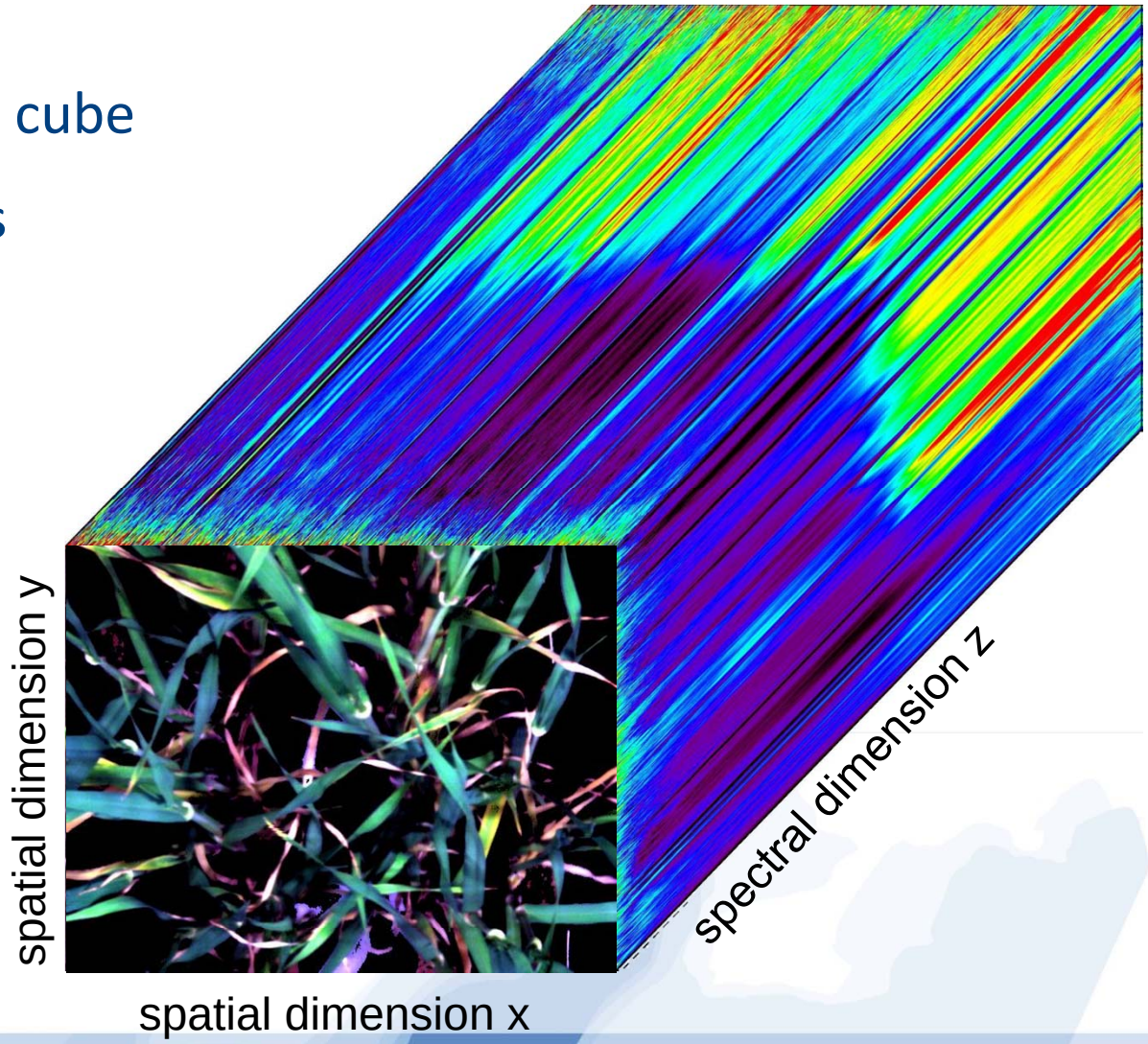


Hyperspectral cameras

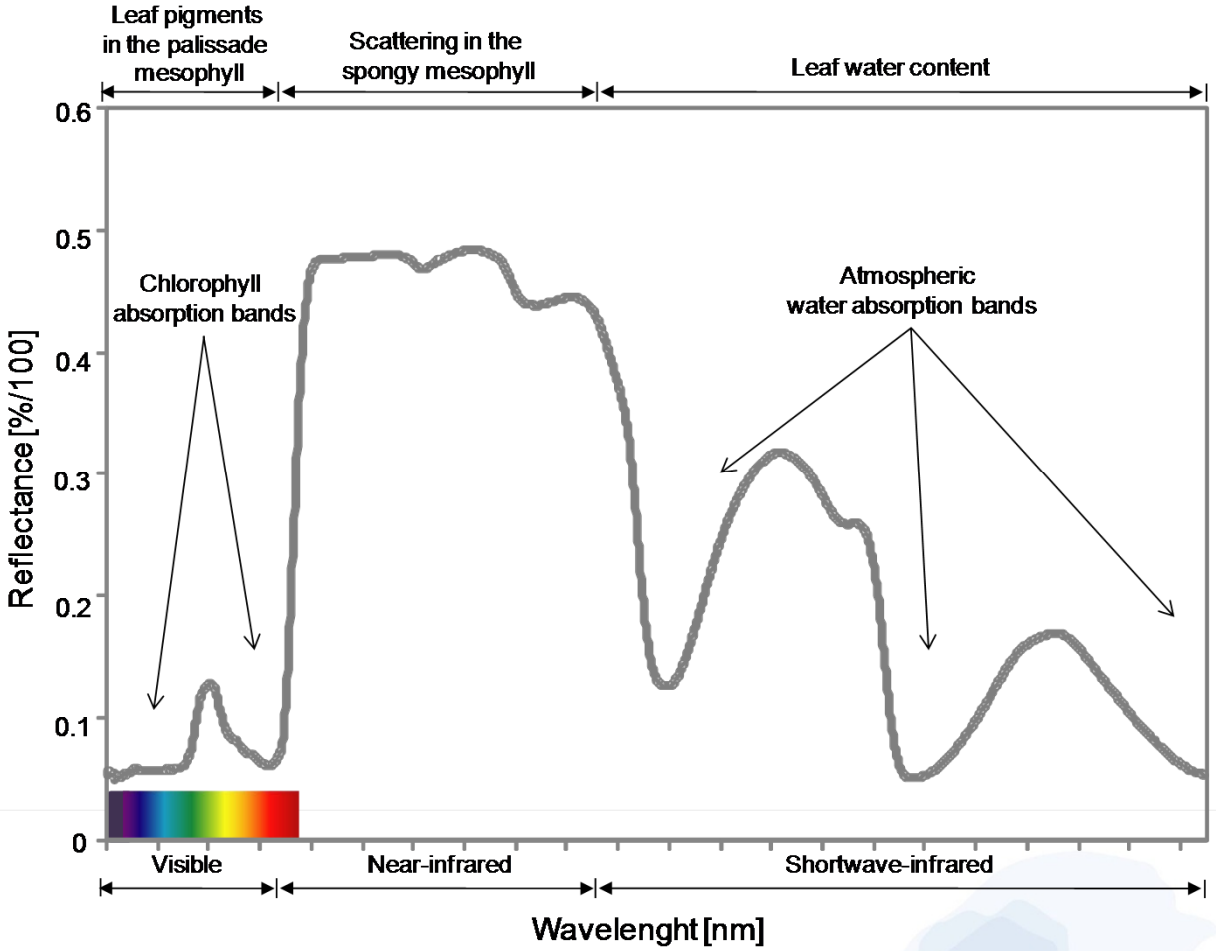


Data dimensionality

- Hyperspectral data cube
- VIS/NIR: 210 bands
  400 – 1000 nm
- SWIR: 256 bands
  1000 – 2500 nm



(Mahlein et al., European Journal Plant Pathology 2012)


Leaf pigments
in the palissade
mesophyll
Scattering in the
spongy mesophyll
Leaf water content
0.6
0.5
0.4
0.3
0.2
0.1
0
Reflectance [%/100]
Chlorophyll
absorption bands
Atmospheric
water absorption bands
Visible
Near-infrared
Shortwave-infrared
Wavelenght [nm]

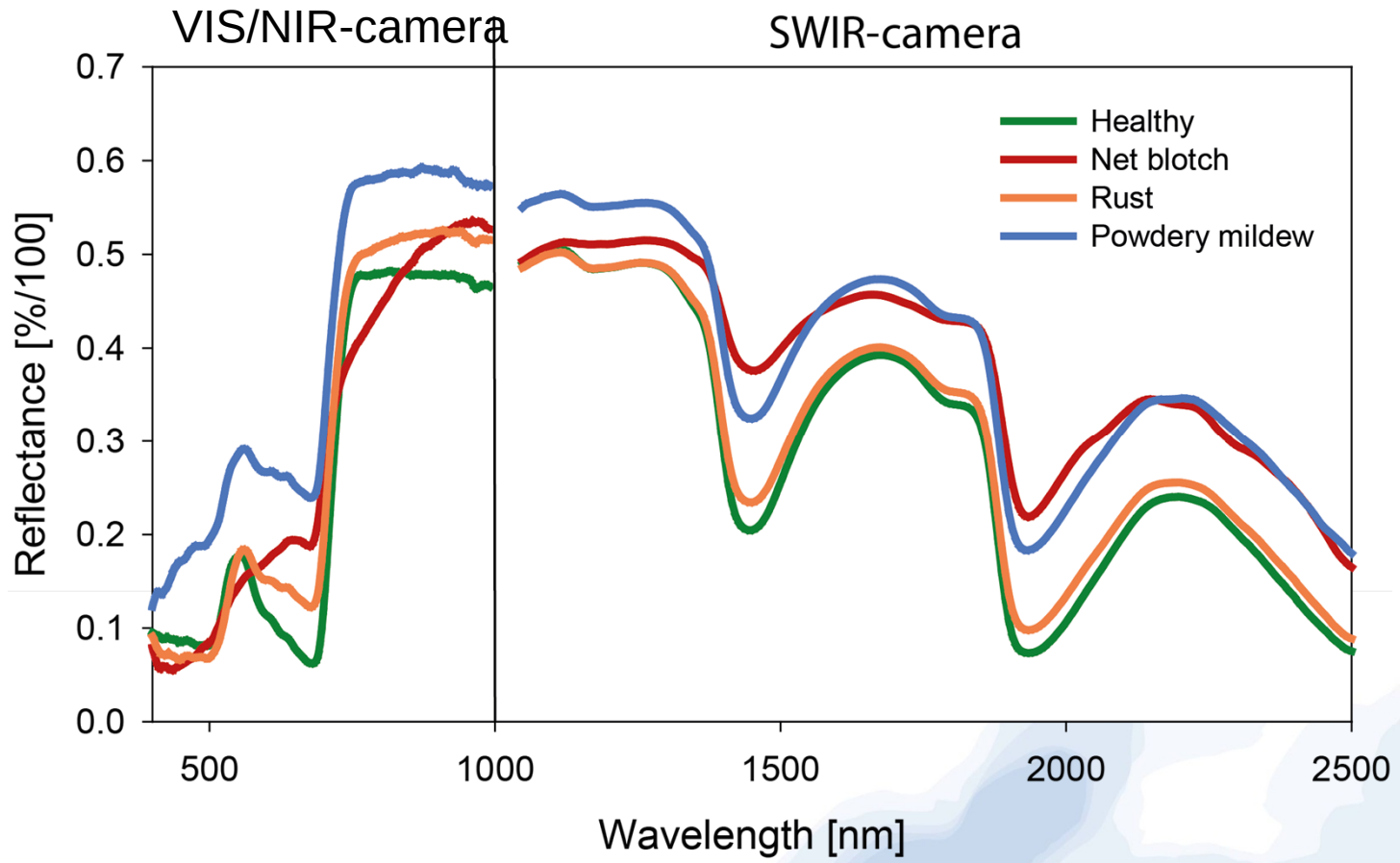
Foliar diseases of barley

Net blotch
(*Pyrenophora teres*)

Brown rust
(*Puccinia hordei*)

Powdery mildew
(*Blumeria graminis hordei*)

Spectral signatures of mature symptoms



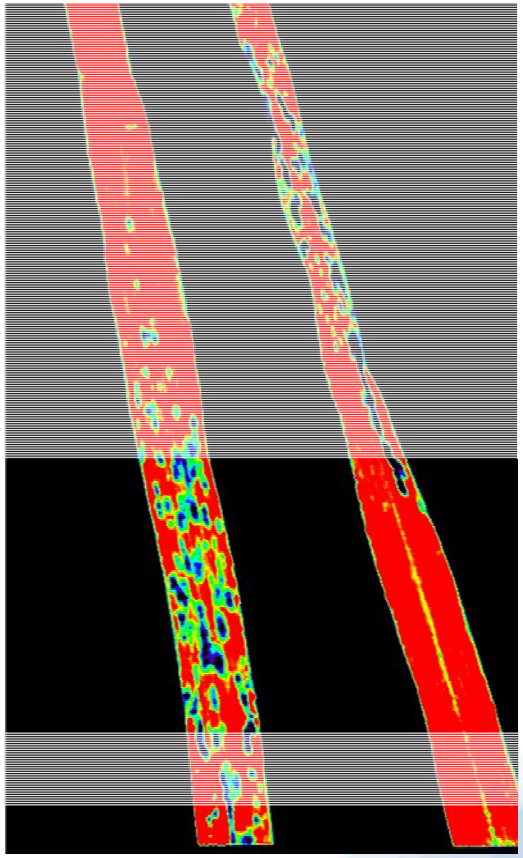
n = 30

Automatic quantification of diseases

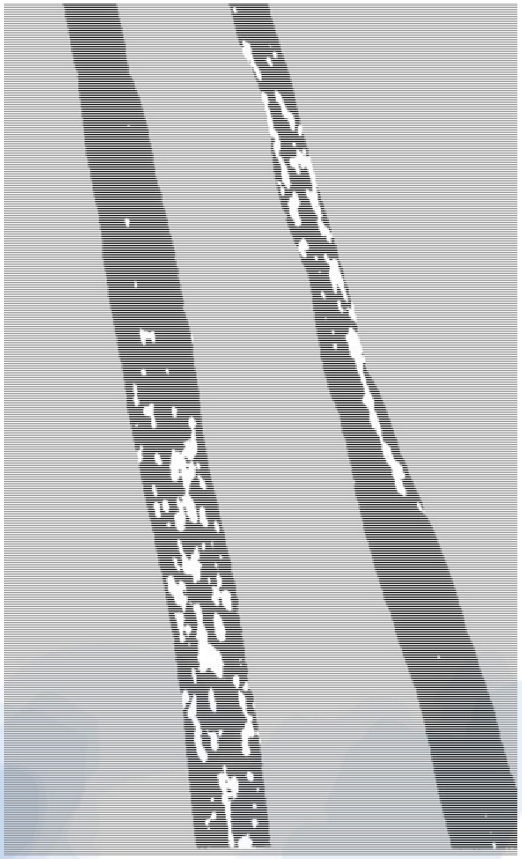
Quantification of powdery mildew of barley

81.4% *healthy leaf area;* ***18.6%*** *diseased leaf area*

RGB-image



SIPI-Vegetation index



Binary disease image

Automatic classification plant diseases

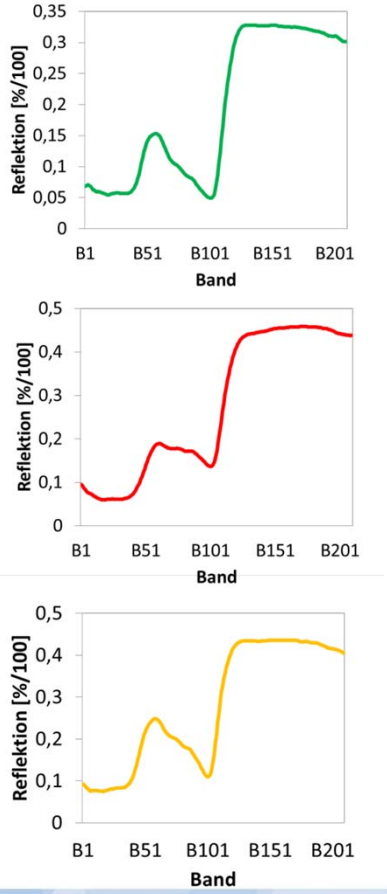
Spectral angle mapper algorithm

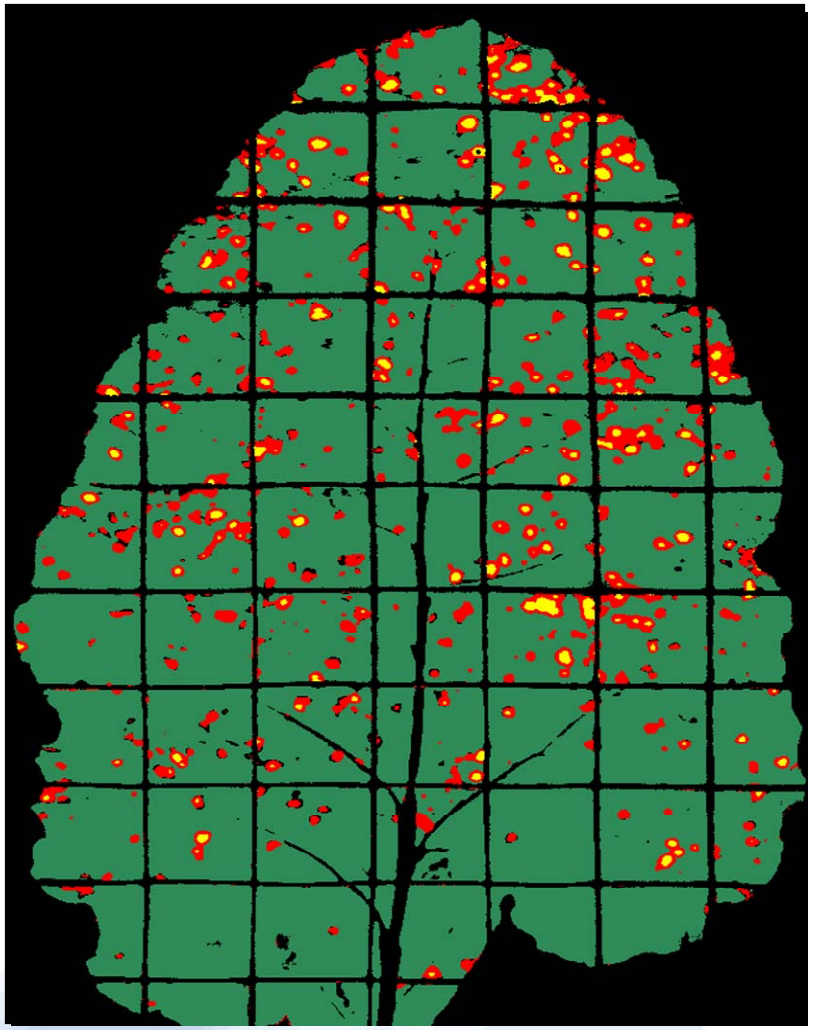
Endmember collection:

I. Healthy Leaf tissue (green)

II. Red border *Cercospora*-leaf spot (red)

III. Necrotic center *Cercospora*-leaf spot (yellow)





(Mahlein et al., Plant Methods 2012)

Early detection of plant diseases

- **Machine vision: S**upport **V**ector **M**achines (SVM)
- Kernel-based classification algorithm in a n-dimensional space
- **Identification** and **early detection** of plant diseases
- Foliar sugar beet diseases
- ~96% classification accuracy

Disease	Accuracy[%]	Specificity[%]	Sensitivity[%]
Cercospora-leaf spot	96.68	97.84	95.45
Sugar beet rust	96.20	97.14	95.14
Powdery mildew	93.18	94.80	91.40

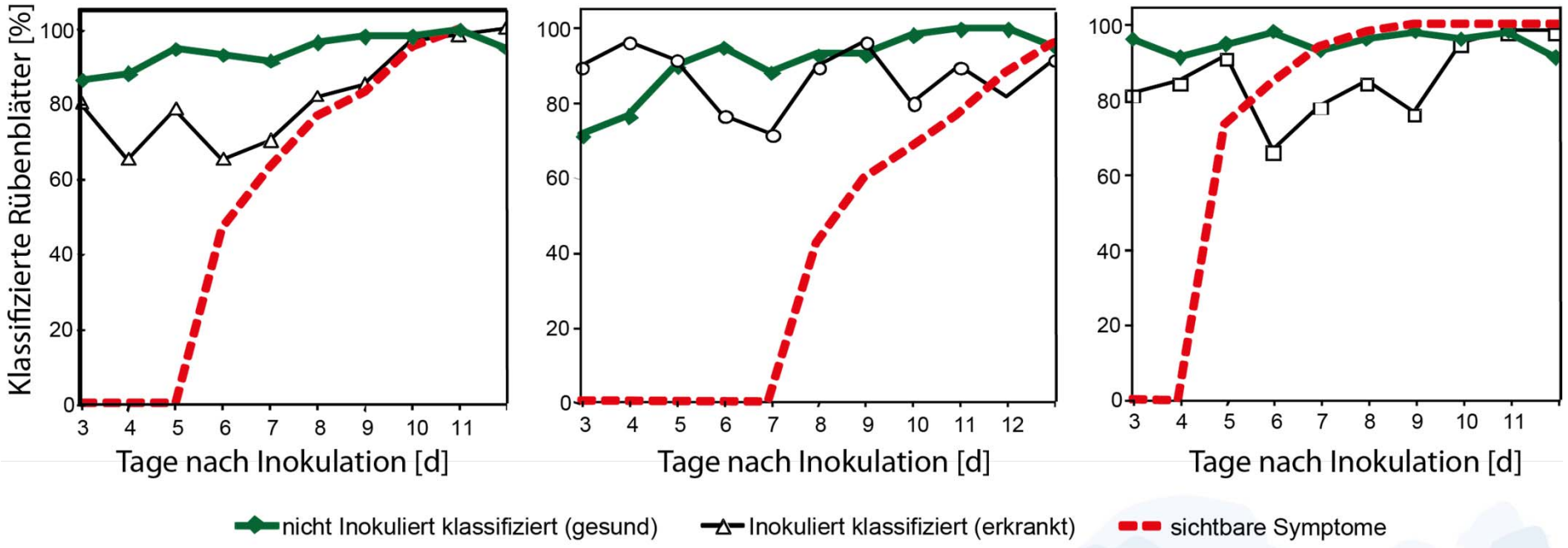
(Rumpf, Mahlein *et al.*, Computers and Electronics in Agriculture 2010)

Early detection before symptoms appear

Cercospora leaf spot
(*Cercospora beticola*)

Sugar beet rust
(*Uromyces betae*)

Powdery mildew
(Erysiphe beticola)



(Rumpf, Mahlein *et al.*, Computers and Electronics in Agriculture 2010)

Conclusion and Outlook

- Reproducible, objective and automatic detection of plant diseases by optical sensors
- Implementation of novel non-destructive techniques and solutions for decision making in order to optimise crop management and accelerate plant breeding
- Interdisciplinary, collaborative research
- But we need disease specific detection algorithm
- Online applications / mobile applications

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Thanks for your attention!

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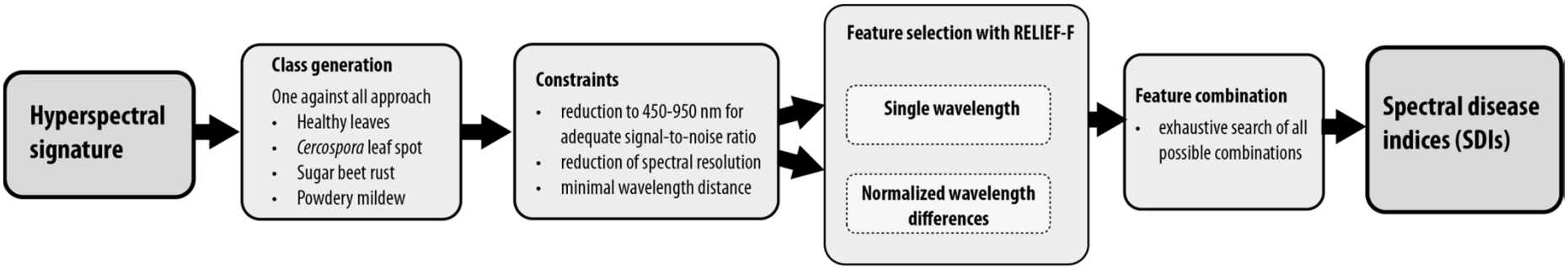
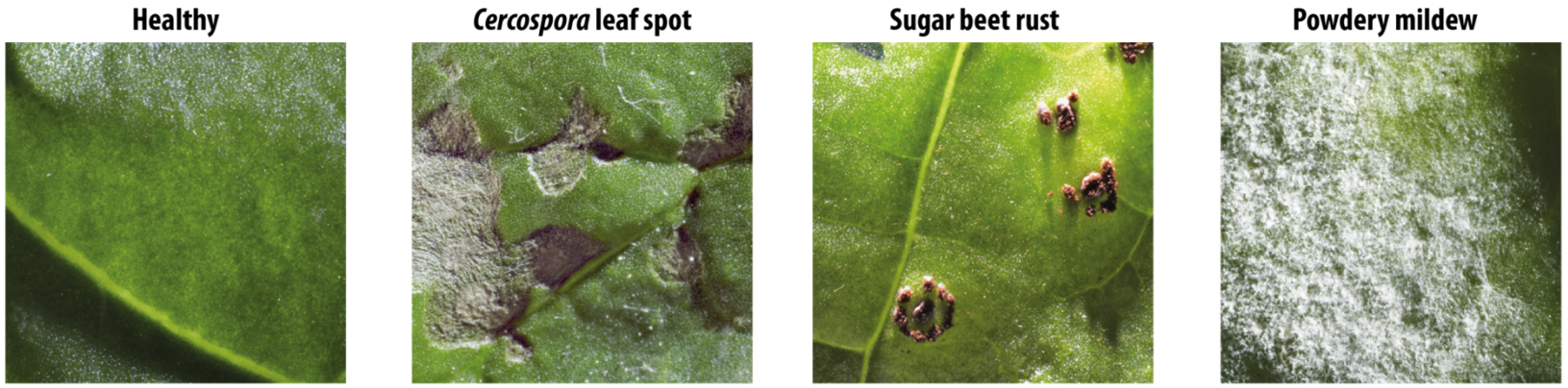
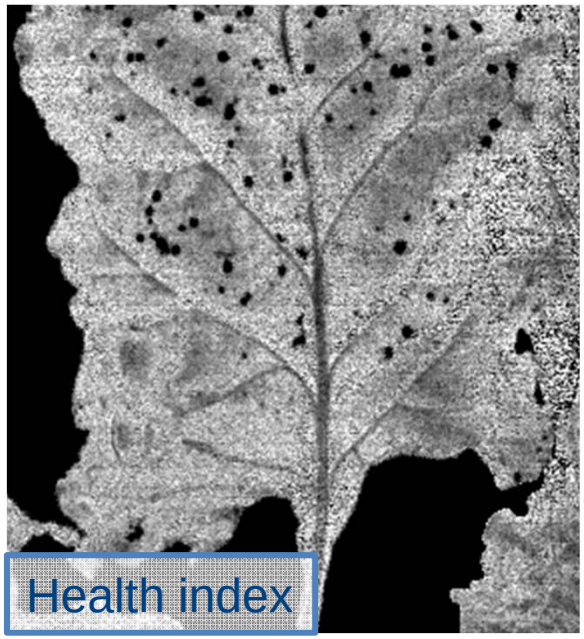
Development of spectral disease indices for sugar beet diseases

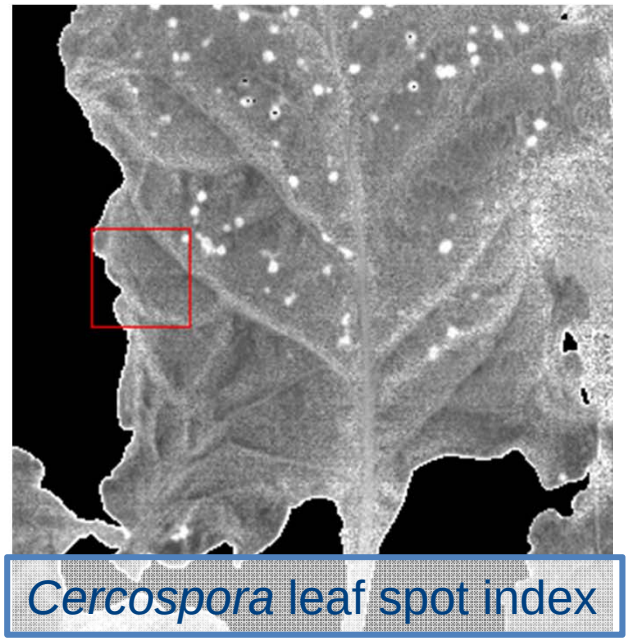
- Detection and discrimination of diseases

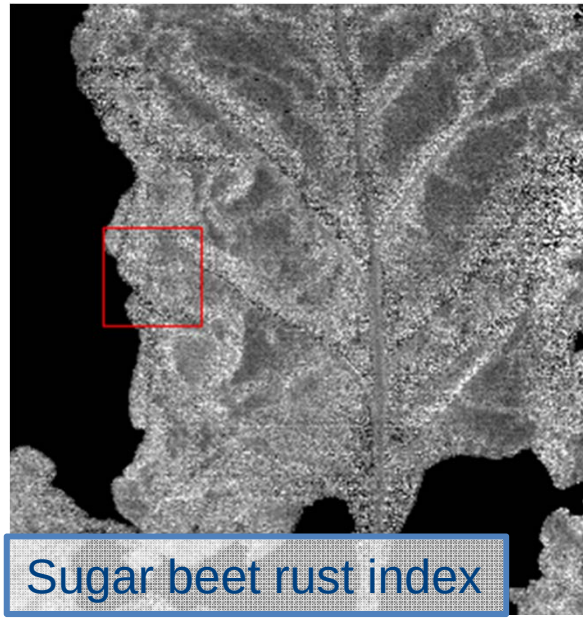


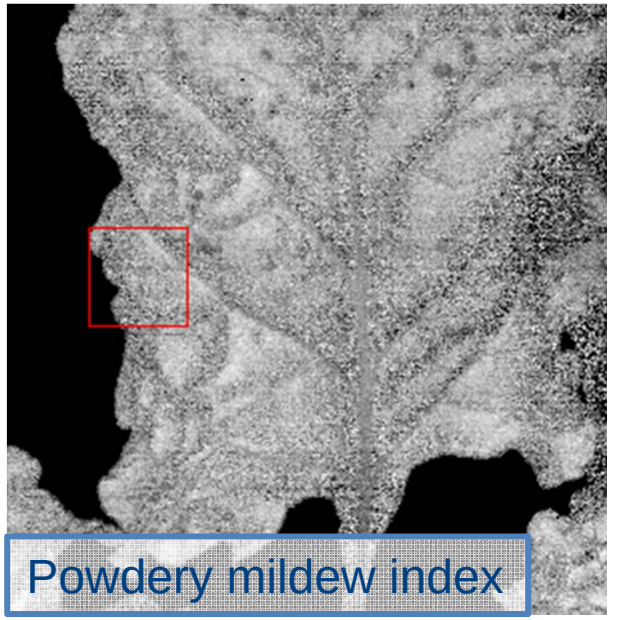



RGB image


Health index


Cercospora leaf spot index


Sugar beet rust index


Powdery mildew index

Dear lecturer, please use this format for your presentation:

- - **keynote** 25 min. and 5 min. discussion max.
- - **standard presentation** 15 min. and 5 min. discussion max.! (- in most cases: 1 slide/minute)

- - *in respect to the subject of IPM: please give attention to the question what your research contributes to the (8) IPM principles of the EU-directive* *(see http://ec.europa.eu/environment/ppps/pdf/final_report_ipm.pdf)*

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