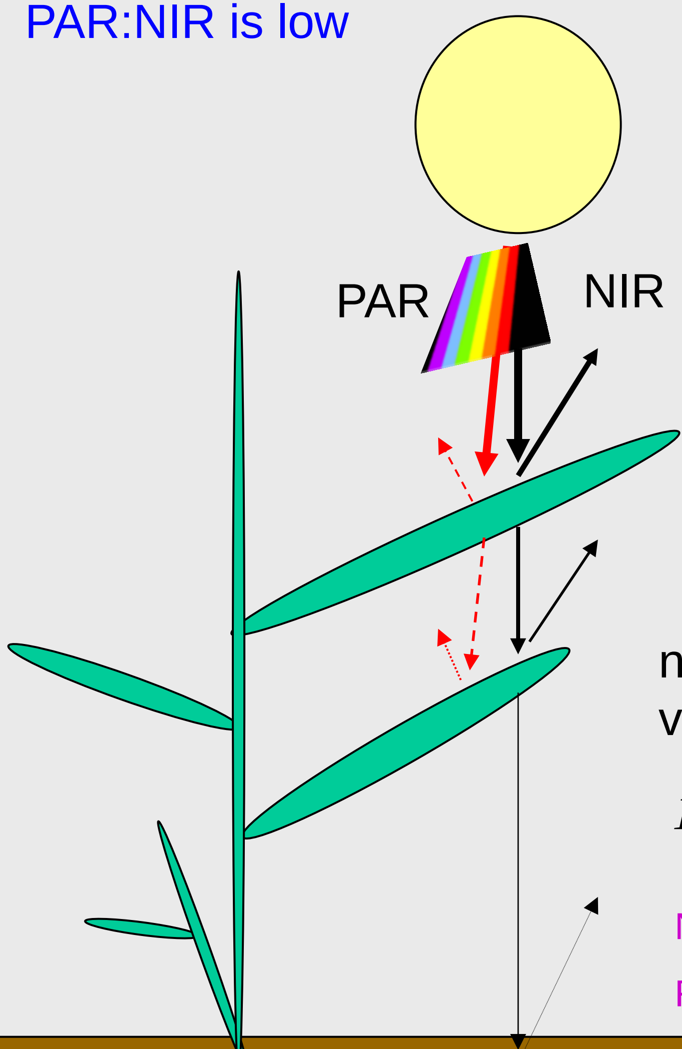
Airborne sampling and optical sensing methods for macro scale mapping

Jon West, Rothamsted Research - abstract page 57

Detecting Diseases by remote sensing

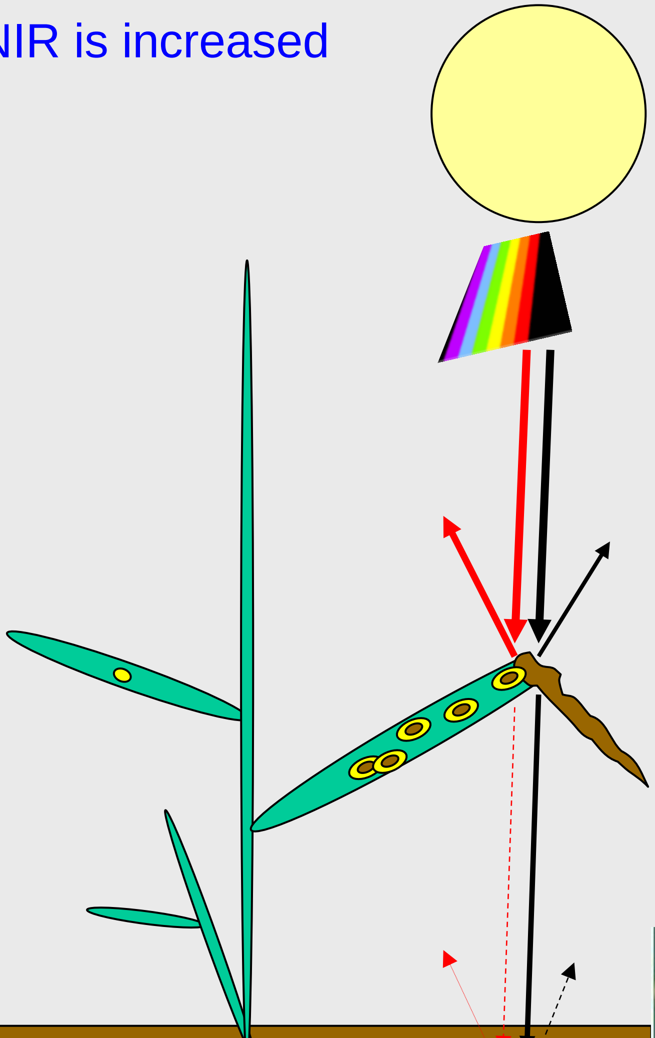
Healthy Canopy

PAR:NIR is low



Diseased / Sparse Canopy

PAR:NIR is increased



normal differential vegetation index

$$NDVI = \frac{NIR - R}{NIR + R}$$

NIR=760-740nm

R=640-620nm

West JS et al. 2010 Chapter In: E-C Oerke et al. (Eds), “Precision Crop Protection – The Challenge and Use of Heterogeneity”, Springer Science, Dordrecht; DOI 10.1007/978-90-481-9277-9_9.

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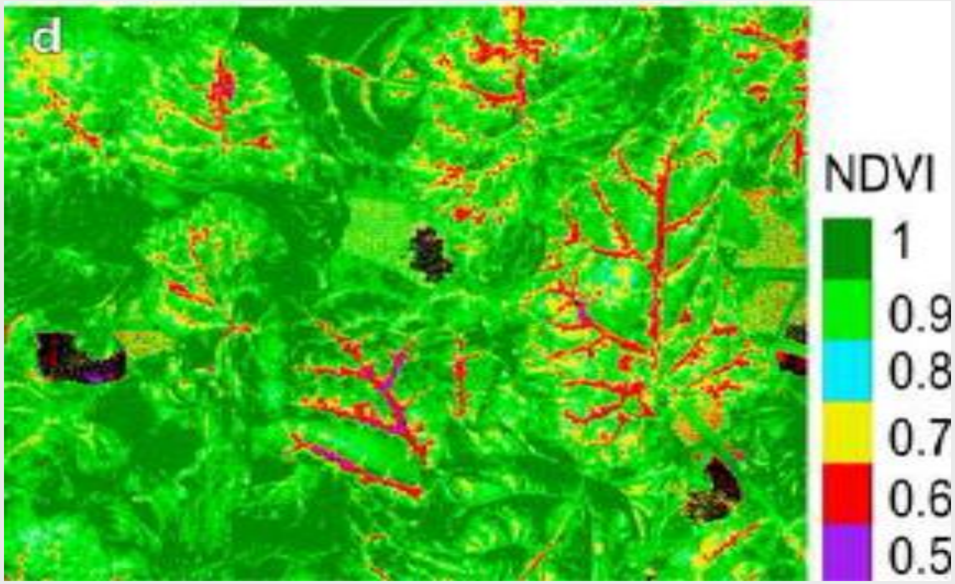
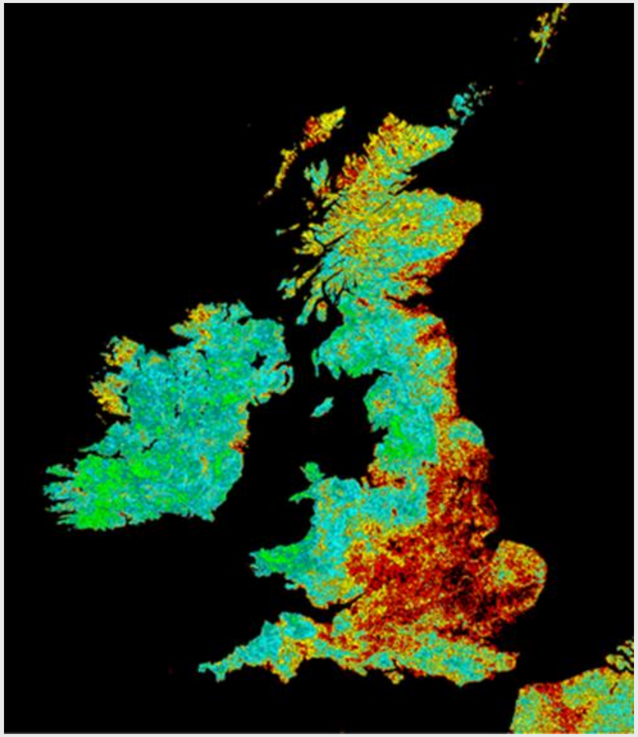
NDVI for powdery mildew-infected beet

Mahlein et al. 2012



Satellite pixel sizes were typically 22m x 22m – now can be <1m^2



UAV pixel sizes now <0.5mm !

Problem of separating nutrient stress effects

from diseases

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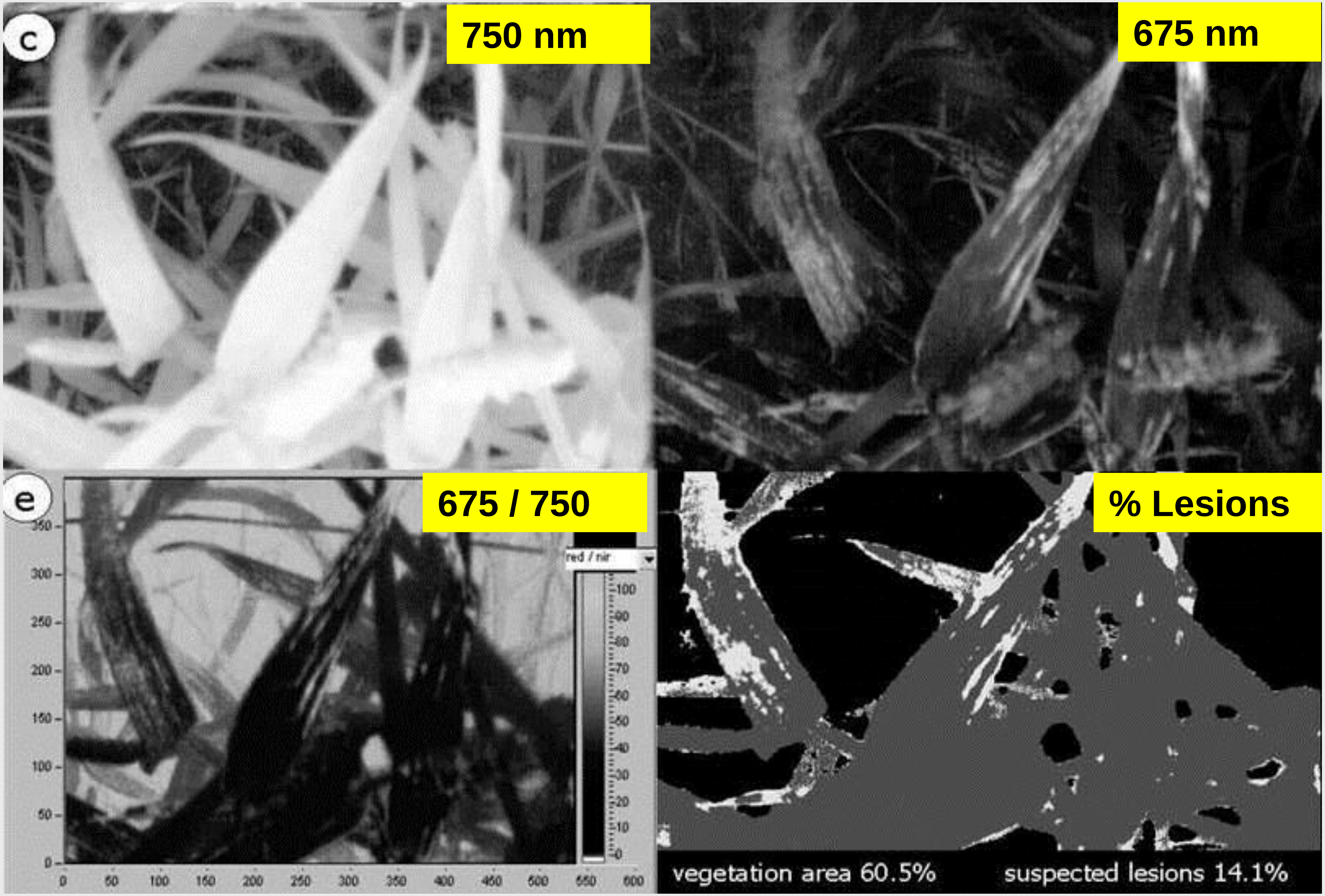
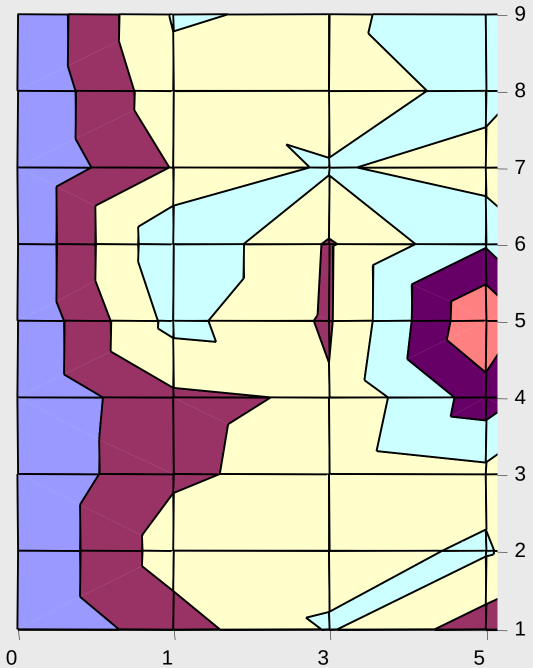
- **Solved by Imaging methods – automatic symptom measurement**



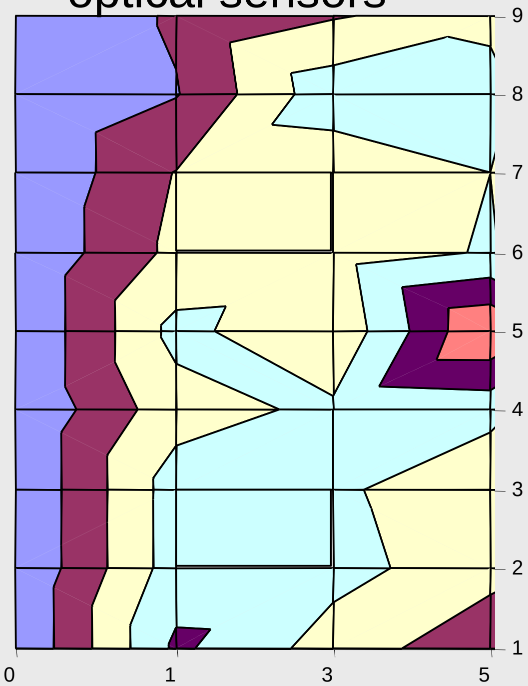
West J.S. et al. 2003 *Annual Review of Phytopathology* **41**: 593-614

Moshou D, et al. 2011. Biosystems Engineering 108: 311 – 321.
Bravo C. et al. 2003. Biosystems Engineering. 84: 137-145.

Disease mapped by manual assessment



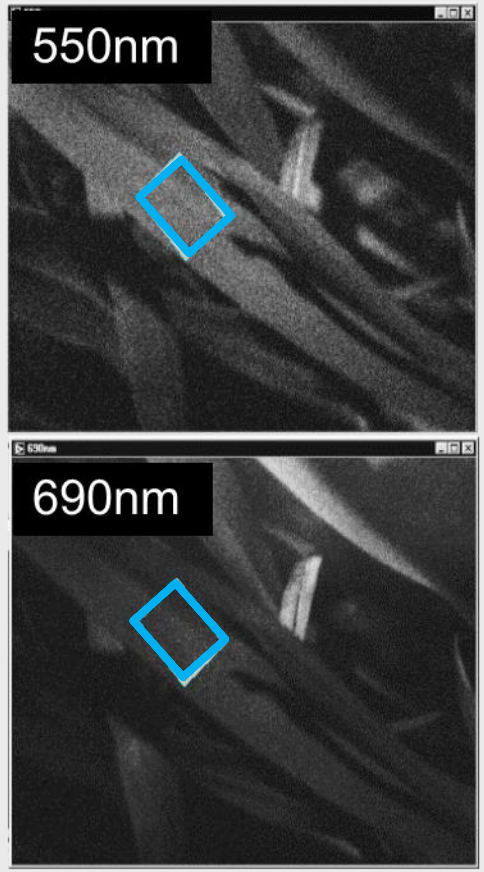
Disease mapped by optical sensors



Fluorescence Imaging

Diseased leaves

Healthy leaves



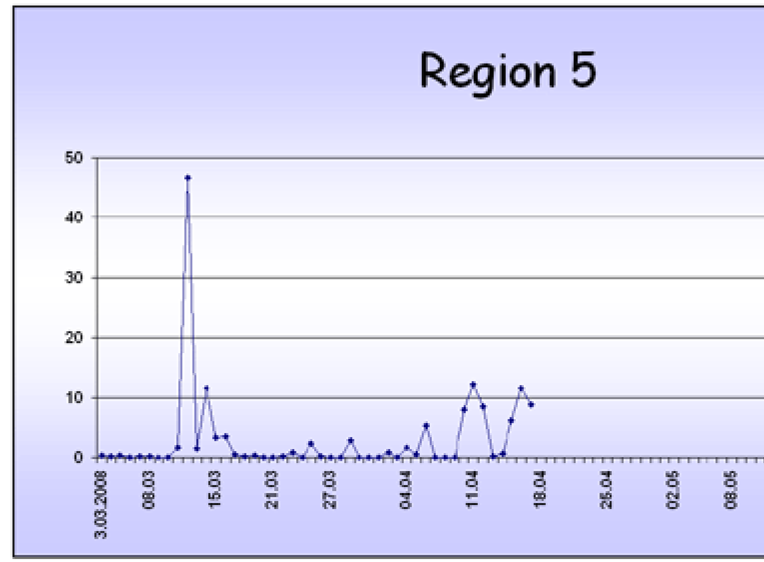
Night-time fluorescence images in the field at 550nm and 690nm.

Infected leaves produced high emission at 550nm and low at 690nm corresponding with lesions (orange frame) and a low emission at 550nm and high at 690nm in the surrounding region (green frame). Healthy regions (blue frame) are characterised by more uniform emission in the two bands.

Moshou D et al. 2005. Real-Time Imaging 11: 75-83.

Network for forecasting disease epidemics in Poland: SPEC

Region selected



L. maculans **spores**

www.spec.edu.pl

Example of an existing airborne spore and weather (infection conditions) – based forecast

syngenta

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Login | Register | Syngenta Global

http://www.syngenta-crop.co.uk/brassica-alert/

Media
- Latest News
- Photo Galleries
- Video Galleries

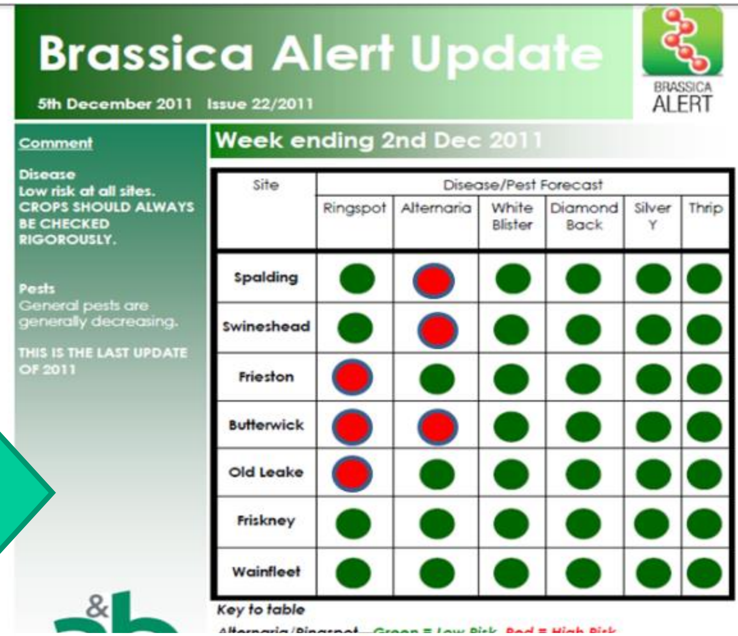
Social Media
- Crop Blog
- Business Blog
- In-Field Focus

Multivial cyclone

Brassica Alert

You can now get early disease risk warnings of the three key brassica diseases before they hit your crops, sent direct to your computer.

Click the map to view or download the latest weekly disease alert



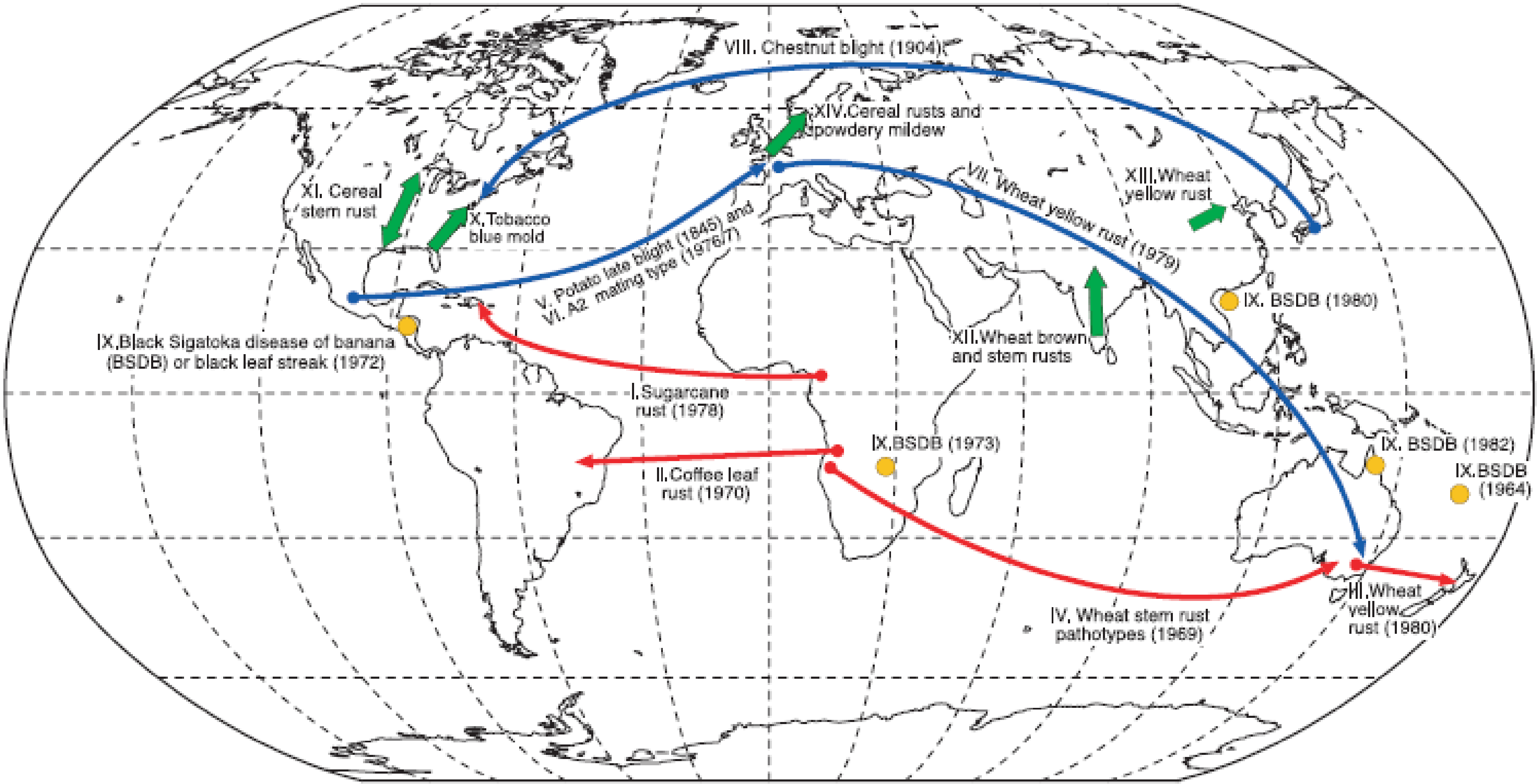
Brassica Alert 05/07/2013
Download (168KB)

* Information supplied by Brassica Alert is provided in good faith. It is neither intended, nor is it implied, to provide specific advice to growers on disease or pest management decisions.

This uses multivial cyclone samplers which sample into tubes and an antibody test is applied only on days when infection conditions are right

Allium & Brassica Agronomy Ltd | University of Worcester | HDC

Disease epidemics caused by introduced inoculum



Airborne spores (regular spore influxes)

Infected plant material then spores locally

Black Sigatoka of banana

Brown & Hovmøller
SCIENCE **297** (2002)

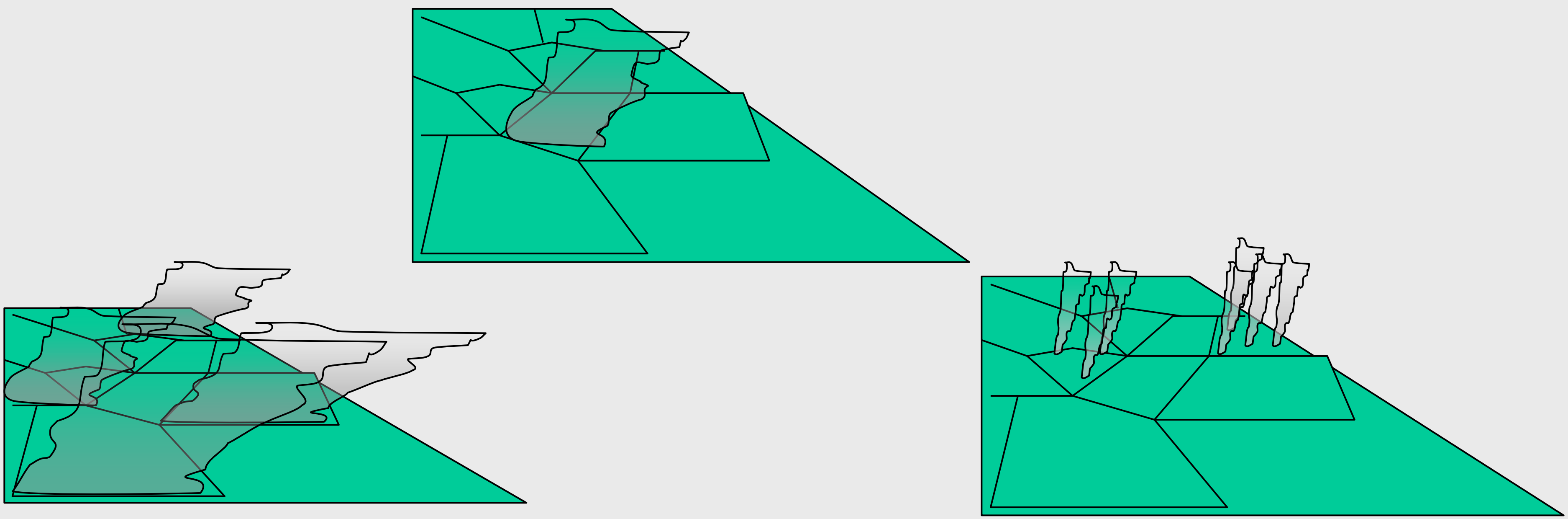
Air dispersal

- Spore release is often synchronised with crop growth-stage and infection conditions but varies spatially depending on spore release mechanism, prevalence of the pathogen, the distribution of the crop it infects and the pathogen’s ability to survive on debris.

- Some pathogens will have patchy spore release at the field and regional scales, while others will be relatively homogeneous at these scales

- Spore trapping helps with understanding epidemics, disease forecasting and monitoring pathogen populations

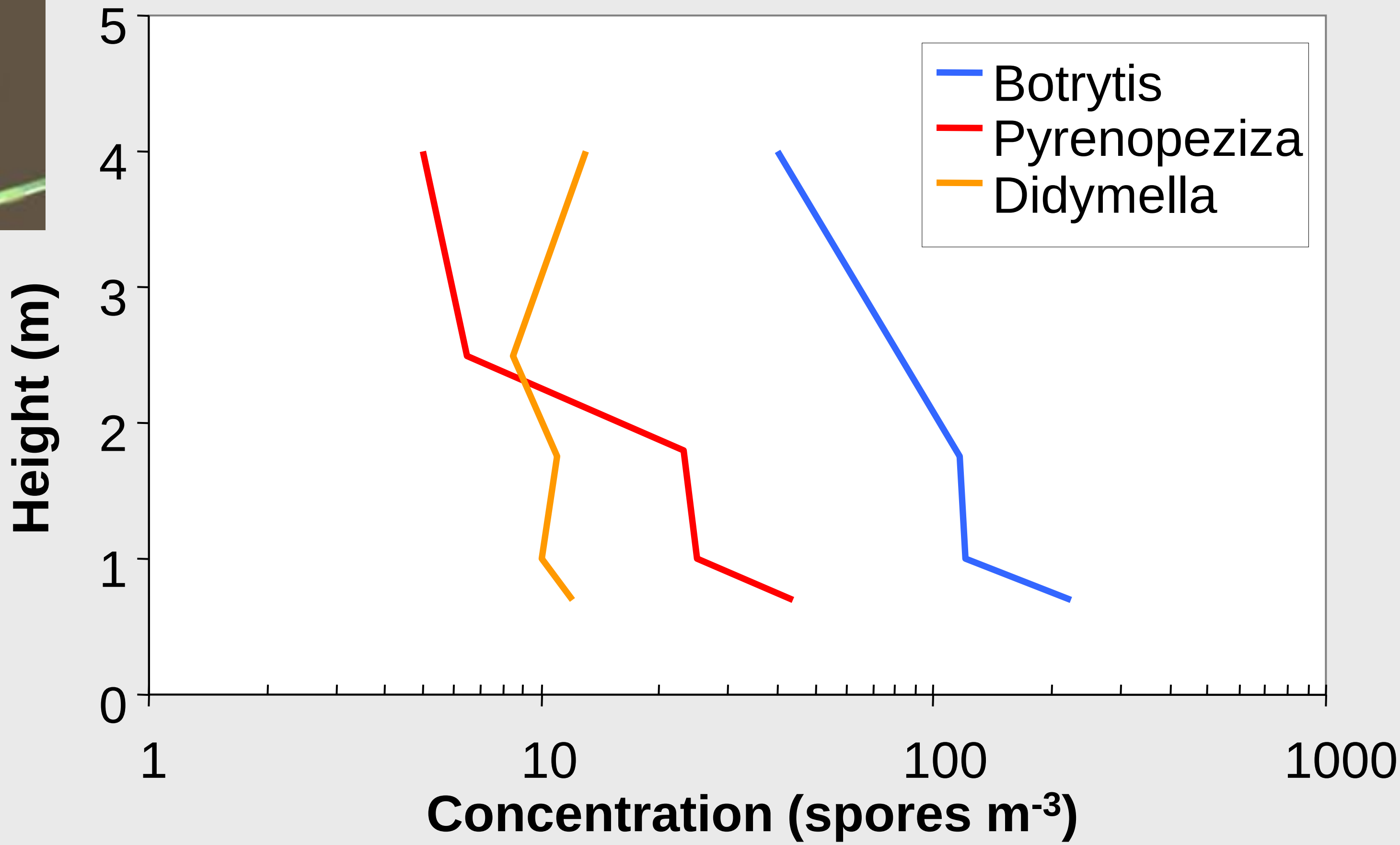
West & Kimber (2015) *Annals of Applied Biology* 166: 4–17



Spore thresholds depend on sampler location!

Change in spore concentration with height above an oilseed rape crop

West et al (2008)



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Spore numbers decline to a regional background level within 200-1000m of the source

‘First, there was a dream, then – Reality’

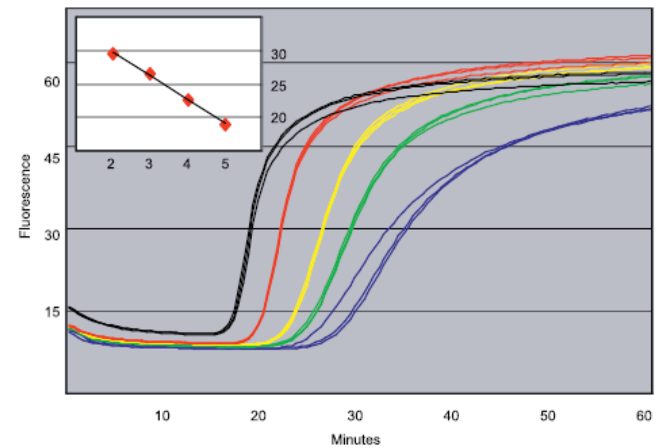
The first fully automated device for the capture, detection and wireless reporting of airborne spores of *Sclerotinia sclerotiorum* – in the world

pure
Innovative crop protection for sustainable agriculture
Technology Strategy Board
Driving Innovation
MANCHESTER 1824
The University of Manchester
syngenta
Burkard
VELCOURT
uniscan instruments
GWENT GROUP
dmc International Imaging
ROTHAMSTED RESEARCH

Future Work:

Automated, rapid detection of DNA from airborne spores

Miniature Virtual Impactor (patent pending), which samples at high flow rate into liquid (incubation media or extraction buffer)



Piepenburg O, et al. (2006) DNA detection using recombination proteins. PLoS Biol 4(7): e204.

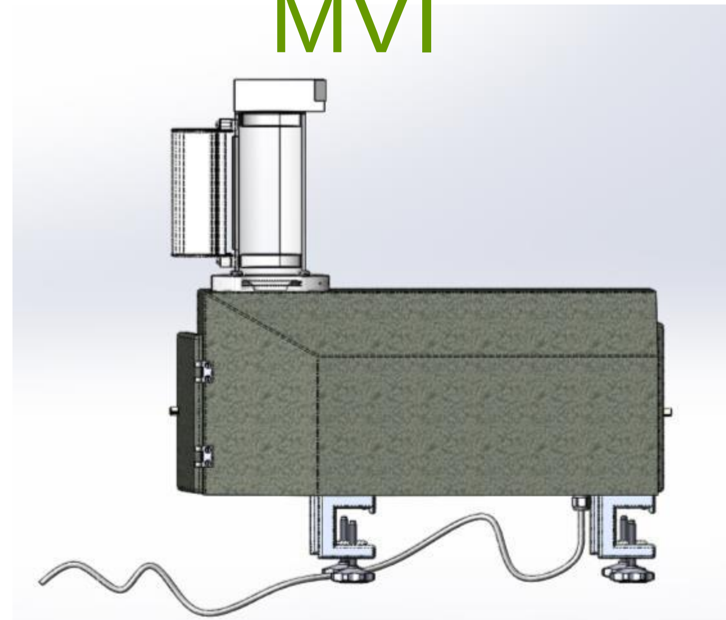
http://www.twistdx.co.uk/

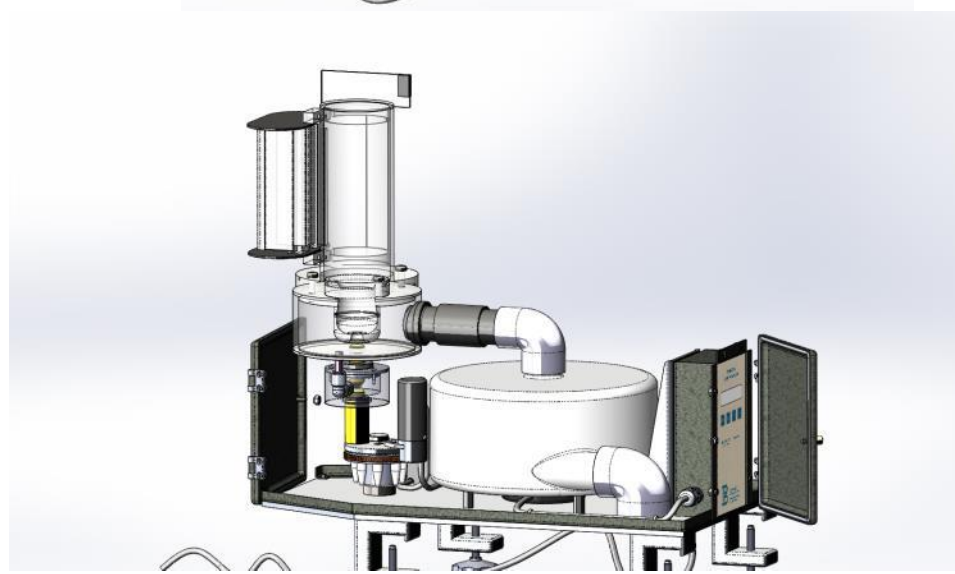
http://www.optigene.co.uk/

Multi Vial MVI

Burkard Manufacturing Co.

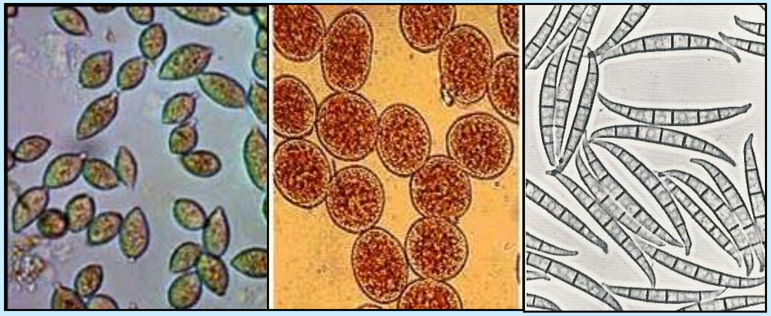
High Through-put MVI





Aim of task 11.2

- Develop platforms for multiplexed molecular detection and quantification of plant pathogens
- Monitoring of plant pathogens in air samples using Next generation sequencing
  - Fungal diversity in air during spring, early summer and autumn
  - Relationship between local disease severity and occurence of airborne spores
  - Early warning or forecasting



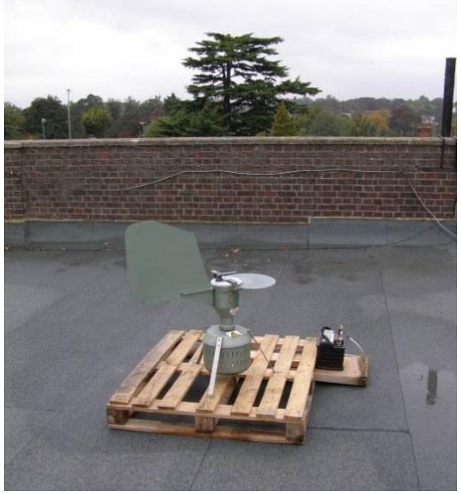
Roof top air sampling

Burkard 7-day recording volumetric spore trap at three locations:

Wageningen (NL),
Rothamsted (UK)
Slagelse (DK)

	2011	2012	2013
spring		17th/18th April-May (4 drums)	23rd April- 14th May (3 drums)
summer		23rd May- 13th June (3 drums)	11th June-25th June (2 drums)
autumn	19th Oct- 2nd Nov (2 drums)	24thOct-14th Nov (3 drums)	16th Oct-13th Nov (4 drums)

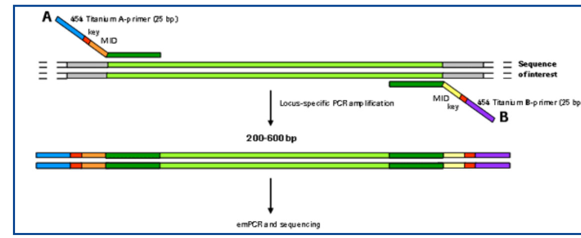
coordinated by Jon West Task11.1

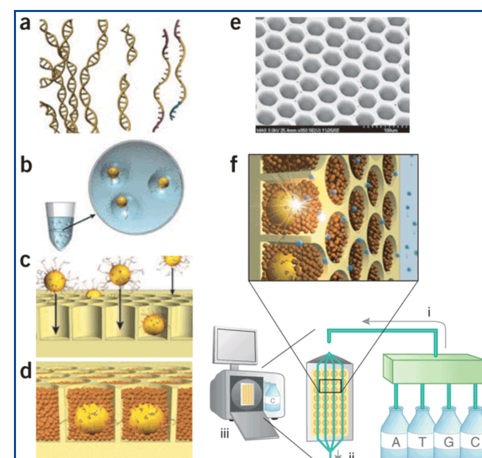


Annemarie F. Justesen

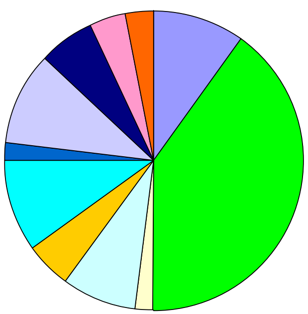
NGS platform (454 amplicon sequencing)

Extraction of total DNA



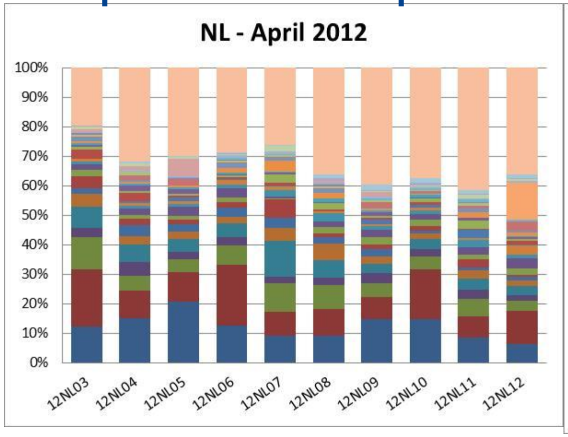


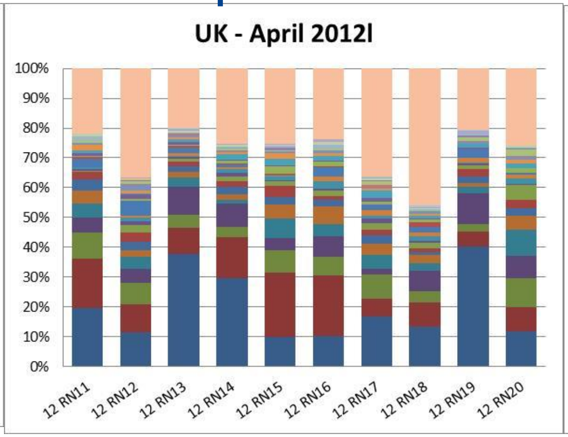
~100.000 reads (GS-FLX junior)
Up to 50 subsamples
~2000 reads ('individuals') per sample

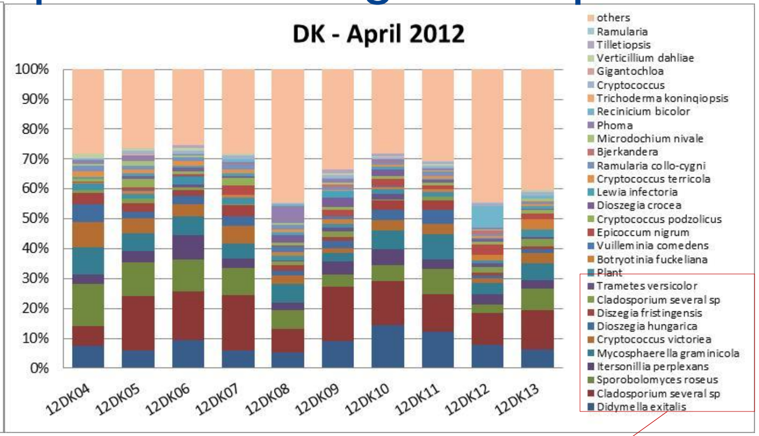


Relative abundance of individual species

Species composition – 30 species make up 70% of fungal air-spora





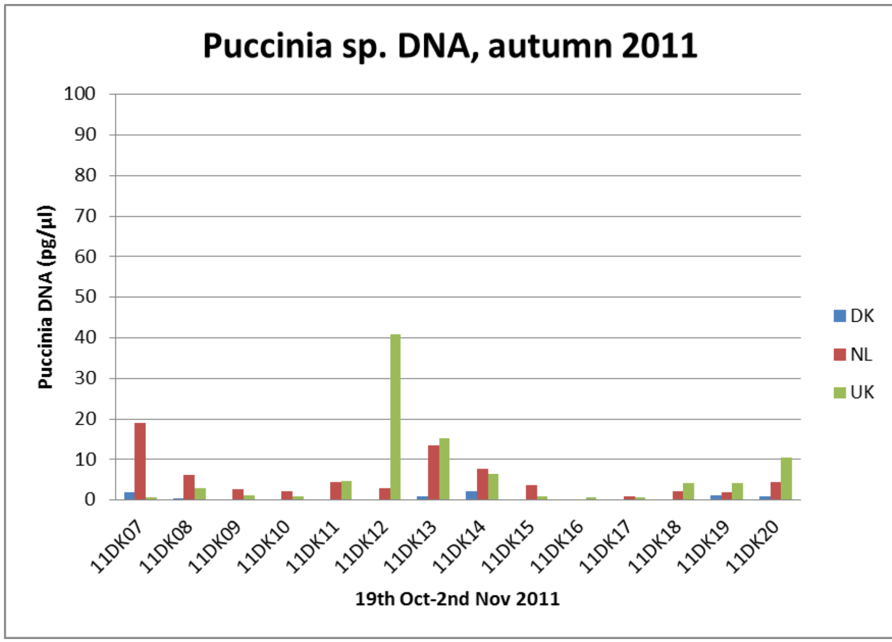


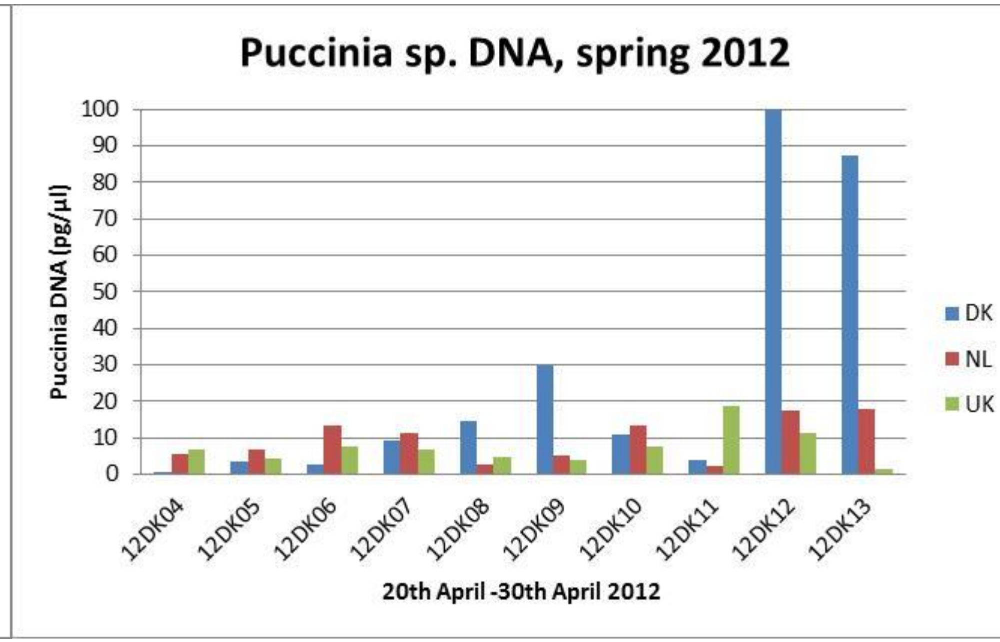
Known Plant Pathogens Detected

- *Didymella exitialis*
- *Mycosphaerella graminicola*
- *Botryotinia fuckeliana*
- *Microdochium nivale*
- *Ramularia collo-cygni*
- *Verticillium dahliae*
- *Blumeria graminis*
- *Fusarium oxysporum*
- *Itersonillia perplexans*
- *Lewia infectoria (Alternaria)*
- *Epicoccum nigrum*

Didymella exitialis
Cladosporium sp.
Sporobolomyces roseus
Itersonillia perplexans
Mycosphaerella graminicola
Cryptococcus victoriea
Dioszegia hungarica
Dioszegia fristingensis
Trametes versicolor

Where are the rusts?





qPCR showed rust spores in air in
autumn as well as spring at al locations

Precision pathology: Summary

• automated, rapid on-site detection is now a prospect using biosensors, rapid isothermal DNA-based methods or immunological tests but thresholds depend on sampler location

• DNA-based methods can also be used to monitor pathogen populations for changes in genetic traits

• Optical sensing, using reflectance, fluorescence or thermal imaging can detect diseases at early stages for mapping to drive control strategies.

• Further research is needed to develop practical systems for precision disease detection as part of integrated pest and disease management

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Airborne sampling and optical sensing methods for macro scale mapping

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Wp11.1

Wp11.2

European Food Safety Authority

Technology Strategy Board
Driving Innovation

collaborative research

Burkard Manufacturing Co Ltd.

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