

Targeting global food security – meeting the challenges posed by pests and pathogens



EXIST, 2014 Prof Sarah Gurr NORTH WYKE



Outline of Talk

1. The challenges facing global food security

- Crops
- Pests and pathogens fungi

2. Pests and pathogens on the move

- Climate change
- Predictions and global distributions
- Crop saturation

3. Threats / new species/ new variants

- Emergence in agriculture
- Accelerated evolution

4. The way ahead

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Food Security: The Challenges



• Expanding global population

UN 2010 projections and US Census Bureau historical estimates

Food Security: The Challenges



UN 2010 projections and US Census Bureau historical estimates

- Expanding global population
- Food production needs to double within the next 50 years



1. Food Security: The Challenges





- Expanding global population
- Food production needs to double within the next 50 years

Water crisis
 Energy costs
 Land degradation
 Political conditions
 Climate change
 Pests and pathogens

Crops that Feed the World



Source: FAO



Wheat Stem Rust



Rice Blast



The five most devastating crop pathogens

Annual loss due to these pathogens is

sufficient to feed ~ 600 – 4,000 million people

per year

Corn Smut



Soybean Rust

Potato Late Blight

Fisher et al. (2012) *Nature* 484: 185

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Fungi threaten ecosystem resilience



Dutch Elm



- ~ 230-580 megatonnes absorbed CO₂ lost: 0.07% global CO₂
- Sudden oak death has broadened its host range recently







Pine beetle / blue stain

Chestnut blight

Sudden oak death

Fisher et al. (2012) *Nature* 484: 185 Bagchi et al. (2014) *Nature* 012014 DOI2911

Jarrah dieback

Fungi are a major threat to global food security and ecosystem health



Fungal infection of plants and wild creatures outstrips threat posed by all other diseases combined

Meta-analysis following search of 3 databases recording fungal disease alerts (ProMed (1994-2011), Healthmap and Web of Science, in total 87,000 reports) Fisher, Henk, Brownstein, Madoff, McCraw and Gurr (2012) **Nature** 484: 185

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2. Are pests and pathogens on the move in face of climate change?

Global distribution

- CABI database
- Records (26,776 of 612 crop-destroying pests)
- Movement?
- Observational bias

Bebber, Ramotowski & Gurr (2013) *Nature Climate Change*, DOI: 10.1038/nclimate1990) Eyles *et al* (at review)







Pathogens move polewards in a warming world

- Polewards shift for many crop pests
- Increasing number at higher latitudes
- Mean shift is c. 3km per year, since 1960
- *i.* Nearly identical to that expected by temperature change
- *ii.* Faster than in wild species move at 0.6 km per year
- iii. Fungi moving at 7.6 km per year in NHiv.Accelerating



Bebber, Ramotowski and Gurr (2013) Nature Climate Change, DOI: 10.1038/nclimate1990)

What determines the global distribution of pests and pathogens?

- Number of pathogens in a particular country should reflect the volume and diversity of agriculture
- More pests at equator As with wild spp, is there a latitudinal gradient in spp richness?
- Fewer pests on islands Lower immigration rates and higher extinction rates on islands - as predicted by "Island Biogeography"



Bebber, Holmes, Smith and Gurr (2014) New Phytologist 02/2014 DOI12722

What determines the global distribution of pests and pathogens?

Data and Sources

- 2,091 pests in all countries 85,725 records
- 168 crops UN FAO
- GDP per capita
- Investment in R&D
- Trade agricultural exports
- Island, land-locked and coastal

Outcome

- Facts
- Predictions

Bebber, Holmes, Smith and Gurr (2014) New Phytologist 02/2014 DOI12722

FACTS: Pests per unit agricultural production vs GDP per capita



More pests on islands than in land-locked nations....

PREDICTIONS: Expected number of pests per country



 $\forall N \sim log(G) + log(W) + R + C + log(A) + log(P) + D + log(T) + log(V) + I + S$

- Myanmar: coastal, 54% rice, low GDP, low R&D. Reports 371 pests
- USA: GDP & R&D levels *etc* fed into model: **Predicts extra 300 in Myanmar** Bebber, Holmes, Smith and Gurr (2014) *New Phytologist* 02/2014 DOI12722

Can we predict when crops will saturate with pests and pathogens?

Data and Sources

- c. 2000 pests, at national and subnational level (CABI)
- 168 crops UN FAO; matched to host specificity
- Saturation for each pest = <u>no. of countries infected</u> no. of countries potentially infected
- Saturation for each country = <u>no. of pests present</u> no. could occur
- Ordination of countries on presence of pest species by Correspondence Analysis (CA)
- All data normalised.....

Bebber, Holmes, Gurr (2014) Global Ecology & Biogeography Aug. DOI:10.111/geb.12214

Regionalisation of pest assemblages



- CA axis 1: ordination highly correlated with latitude
- CA axis 2: NW from OW
- CA axis 3: OW separated

Assemblages of pests are strongly regionalised

- determined by latitude.....
- suggests that climate change will influence future pest distributions.



Country saturation 1950-2000



- Many important crop producing countries will saturate with pests and pathogens by mid 21st century
- Tropical crops, with restricted latitudinal ranges, are more vulnerable to saturation than are staples with broader latitudinal ranges

Pest category saturation and over time



- Fungi are the most widely dispersed group
- Their dispersal increases with host range

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The emergence of new fungal diseases

- Global changes and trade create new disease challenges
- Modern agriculture forces new variants of old pathogens



Ash die-back

Emergence: The accelerators - Modern agricultural practices

- Trade and transport
- Clonality
- Pathogen –
- Host
- Environmental change





Host

Summary

Main message: Fungi pose a significant threat to food security and ecosystem resilience

- New pathogens/ variants are emerging
- Pathogens are on the move towards poles
- Pathogens are moving in concert with climate change
- Crops will saturate with certain pests mid century
- Fungi are the most "saturated" of all pathogens
- Tropical crops are more saturated than temperate ones
- Pathogens are under-reported in tropics
- Islands are most vulnerable to pests and pathogens

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Pandora's box? : The Spirit of Hope?



4. The way ahead

- Modelling
- Trade and transport routes
- Policy

More fundamental research needed to meet the upcoming challenges

- Greater political & public awareness as to the plight of plants
- More funding for research AgriTech / Horizon 20:20
- More sustainable farming practices
- More monitoring
- Robust detection and legislation practices
- Iterative improvements and not "arbitrary" policy
- More training...
- Exeter's unique position......

McLean, A., Gurr, SJ., (2012) " Prediction for biological hazards: Reducing the impacts of future biohazards through innovation and intervention" *Government/BIS Foresight Programme* (Beddington *report*)

Thanks to:-

- Matt Fisher
- Dan Bebber







NORTH WYKE





