Integrated Pest Management strategies for a changing climate – building-in resilience

Adrian C Newton

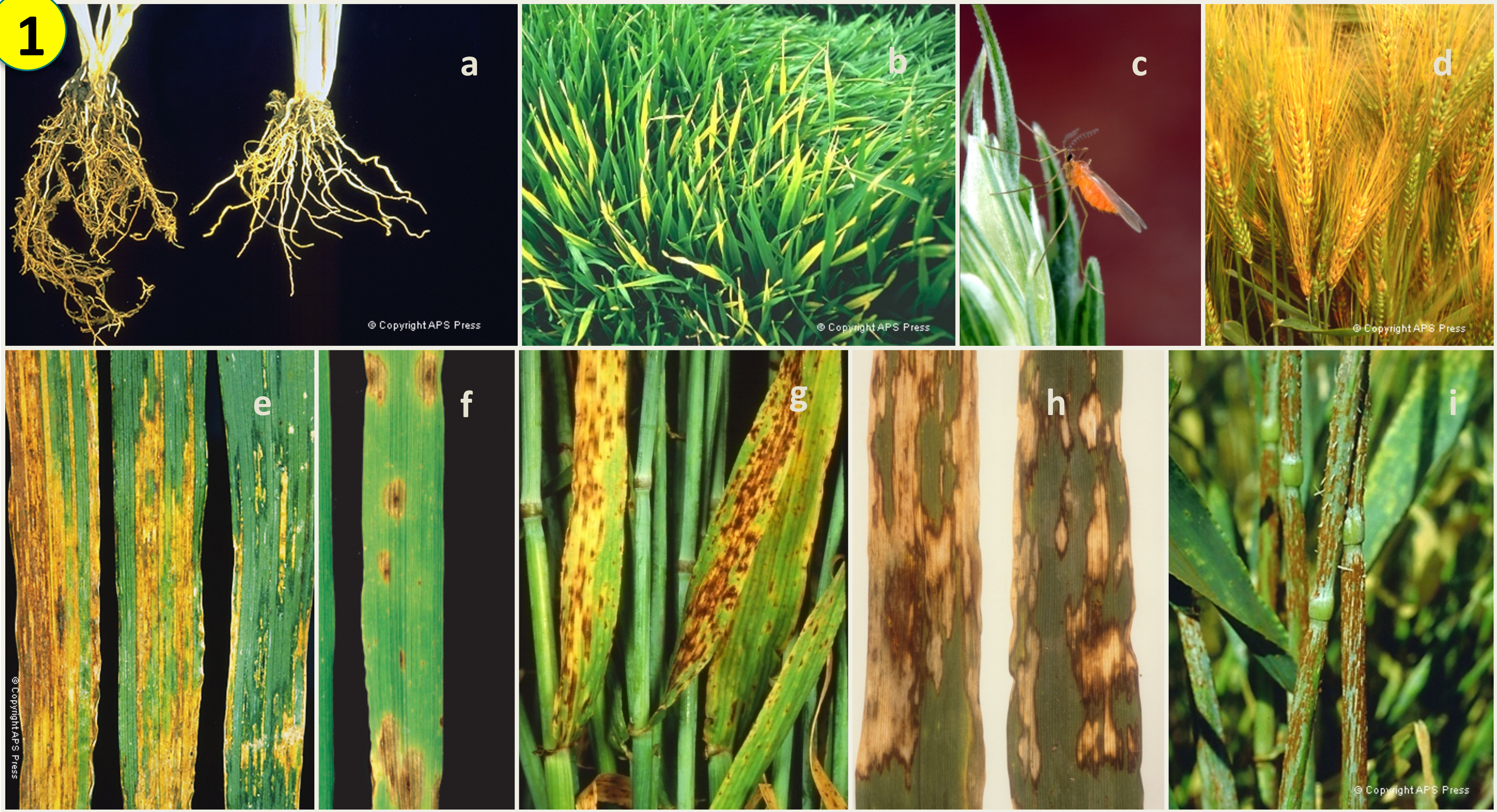
Food System Impacts of Pests & Pathogens in a Changing Climate. 19th – 23rd August 2019, Aspen, Colorado

The James Hutton Institute

Overview

1. Can we predict pathogen changes well enough for targeted IPM?
2. Complexity, connectivity, heterogeneity and diversity: the **parameters of resilience**?
3. Can complexity, connectivity, heterogeneity and diversity be managed PRACTICALLY?
4. SYSTEMS that exploit such resilience…
5. [APPROACHES to resistance breeding and management…]

1



Representative current and emerging pest and disease problems that could threaten barley food security.

a) cereal cyst nematode, b) Barley Yellow Dwarf Virus,
c) orange blossom midge, d) Fusarium head blight,
e) cereal bacterial leaf streak, f) rice blast (on barley),
g) Ramularia Leaf Spot, h) rhynchosporium or scald, i) stem rust (on barley)

Image a courtesy R Cook, b courtesy B Cunfer, d and i courtesy B Steffenson, e courtesy V Peterson, all reproduced by permission from Compendium of Barley Diseases, 2nd Ed., 1997, American Phytopathological Society, St. Paul, MN, USA; image c courtesy and copyright of Rothamsted Research Ltd, Harpenden, UK; image f courtesy of B. Steffenson; image g courtesy of Dr Neil Havis of SAC Edinburgh, UK; image h by permission, from Paulitz, T. C., and Steffenson, B. J. 2011. Biotic Stress in Barley: Disease Problems and Solutions. Pages 307-354 in: Barley: Production, Improvement, and Uses. S.E. Ullrich, Ed. John Wiley & Sons, Inc., Ames, IA.

Barley

Journal: Food Security 3, 141-178

Crops that feed the world 4. Barley: a resilient crop? Strengths and weaknesses in the context of food security.

Adrian C Newton, Andrew J Flavell, Timothy S George, Philip Leat, Barry Mullholland, Luke Ramsay, Cesar Revoredo-Giha, Joanne Russell, Brian Steffenson, J Stuart Swanston, William T B Thomas, Robbie Waugh, Philip J White, Ian J Bingham

DOI 10.1007/s10658-015-0598-7

Future environmental and geographic risks of *Fusarium* head blight of wheat in Scotland

Peter Skelsey · Adrian C. Newton

Accepted: 20 January 2015 / Published online: 7 February 2015

Abstract Methods used to assess climate change risk for crop diseases often assume that both host and pathogen are present. Consequently, model output may misrepresent future growing seasons, due to a failure to reflect likely change at the landscape- and farm-scale and its impact on disease risk. In this study, data defining the spatial coverage of crops in Scotland were combined with spatially coherent, probabilistic climate change data to project the future risk of *Fusarium* head blight (FHB) in wheat. Primary inoculum was initially treated

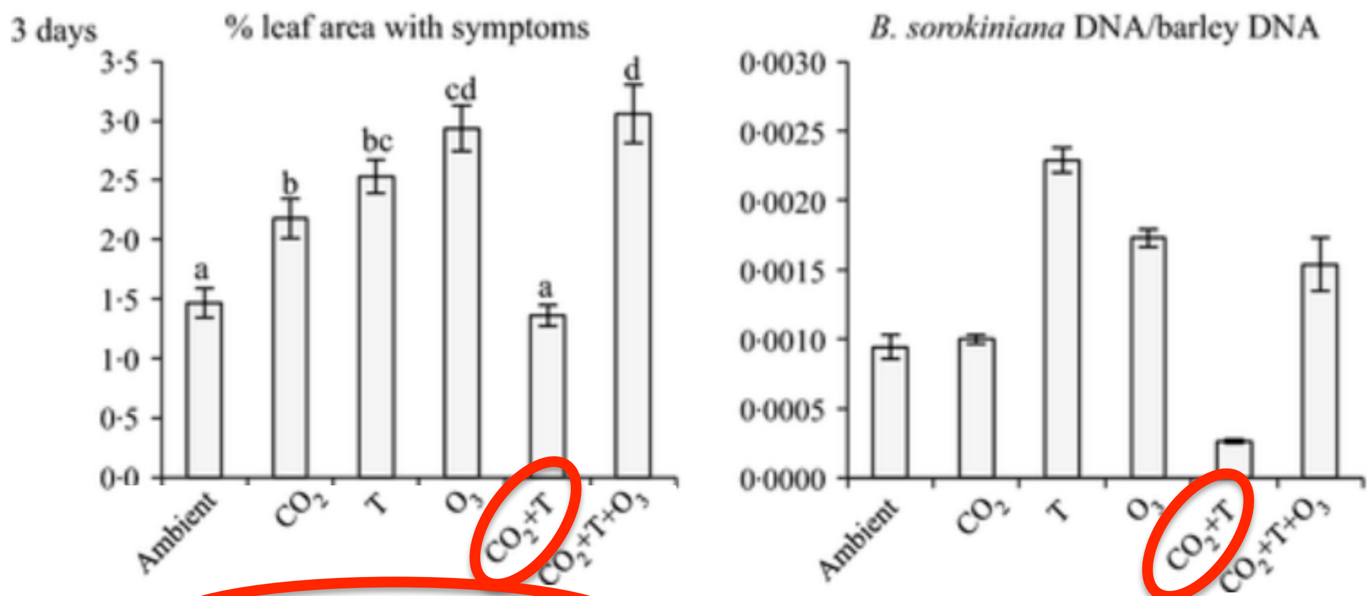
vulnerable to sea-level rise, with little additional risk of FHB. These projections, made by considering the temporal and spatial coincidence of host and pathogen species under various climate change scenarios, suggest that improved control of FHB might not be a high priority for future food security in Scotland.

Keywords *Fusarium* head blight (*Gibberella zeae/Fusarium culmorum*) · Mycotoxins · Climate change · Risk assessment · Inoculum dispersal

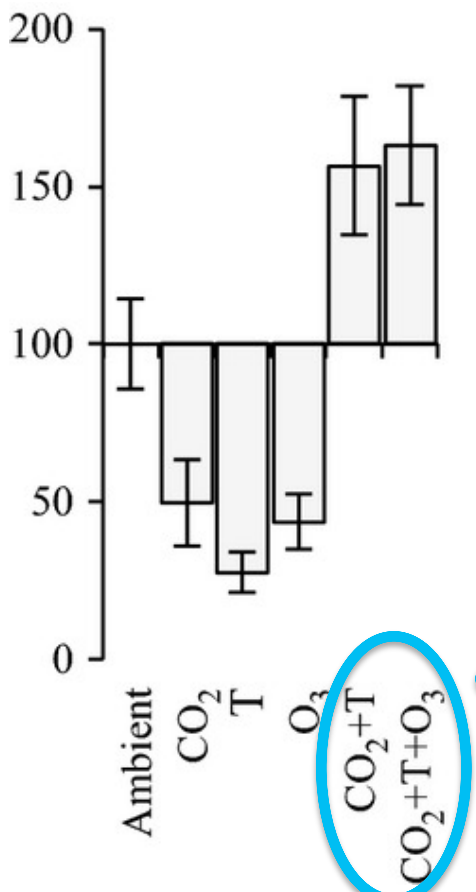
1

The James Hutton Institute

Prediction of pathogen change – possible?



Spot blotch infection Percentage leaf area covered with symptoms and amount DNA/ng barley DNA



Powdery mildew infection. Successful fungal penetration

Complex interplay of future climate levels of CO2, ozone and temperature on susceptibility to fungal diseases in barley

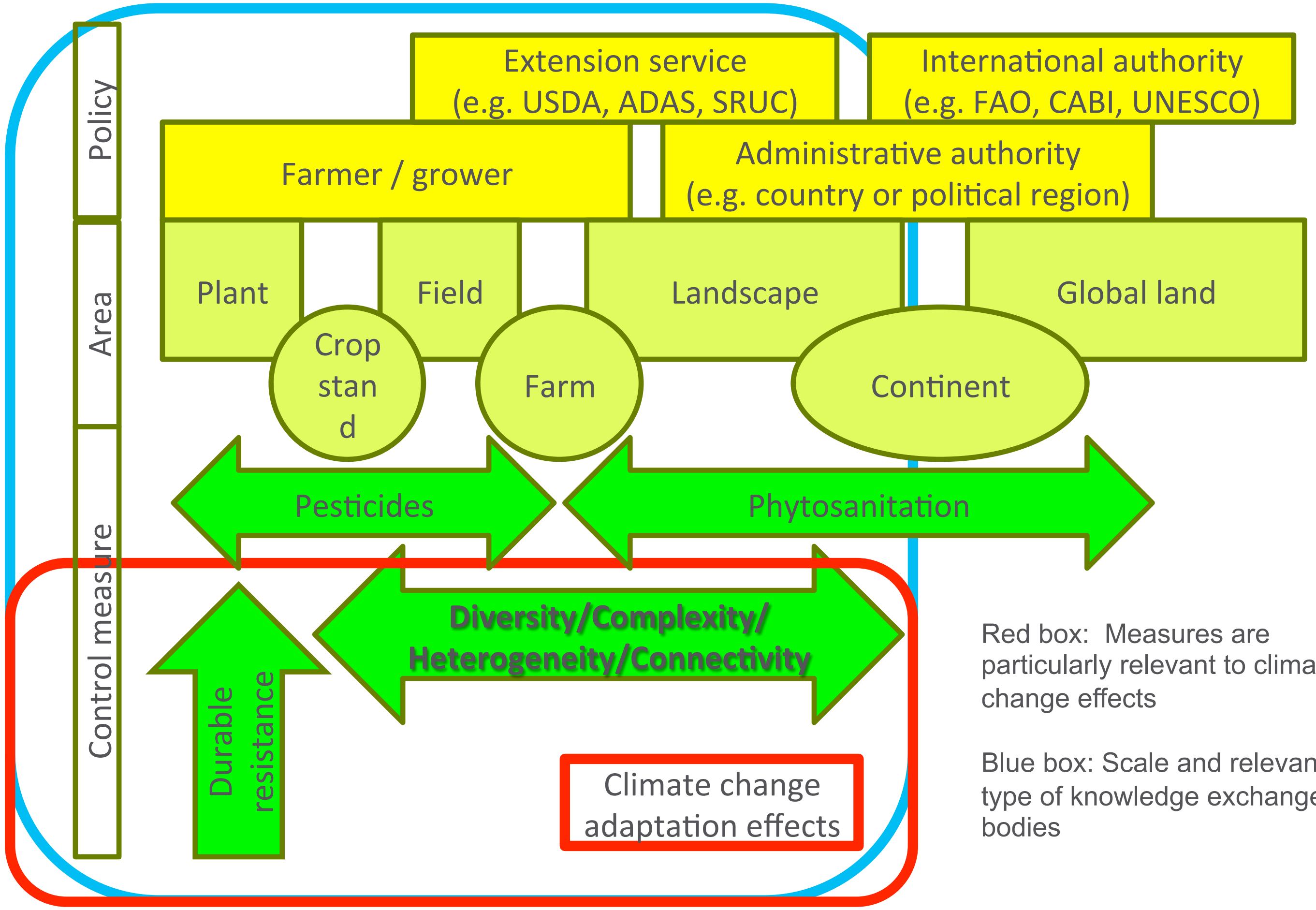
B. L. Mikkelsen, R. B. Jørgensen, M. F. Lyngkjær
Plant Pathology, Volume: 64, Issue: 2, Pages: 319-327,
First published: 08 July 2014, DOI: (10.1111/ppa.12272)

2

Influences on pest and pathogen threat to food security

The James Hutton Institute

Where does "diversity" (complexity, connectivity, heterogeneity and diversity) fit in?



Red box: Measures are particularly relevant to climate change effects

Blue box: Scale and relevant type of knowledge exchange bodies

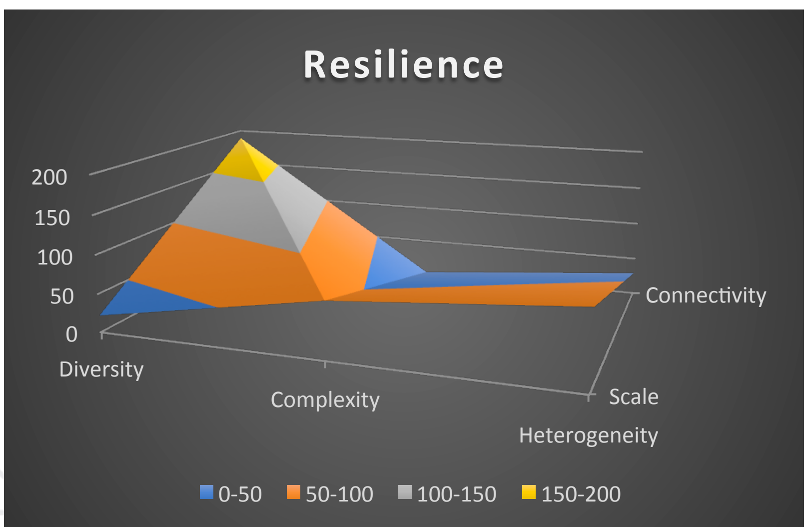
Newton, Johnson & Gregory, 2011. Euphytica 179, 3-18

2

The James Hutton Institute

Resilience index?

			Resilience/sustainability index calculation	
Complexity	Heterogeneity	Connectivity	Diversity high (8)	Diversity low (2)
[Total number]	[uniform / patchy distribution]	Complexity/ heterogeneity	How different	How different
8 high	2 low	4 high	512	128
8 high	8 high	1 medium	512	128
2 low	2 high	1 medium	32	8
2 low	8 low	0.25 low	8	8



- ❑ Crop genotypes / traits
- ❑ Agronomy
- ❑ Spatial deployment ← **Spatial**
- ❑ Temporal deployment

- ➢ Policy drivers
- ➢ Supply chain implications

Structured resistance gene deployment

a) Monoculture b) Homogeneous c) Structured

Selection for: a) Simple b) Complex c) Simple and Complex <u>and Groups</u>

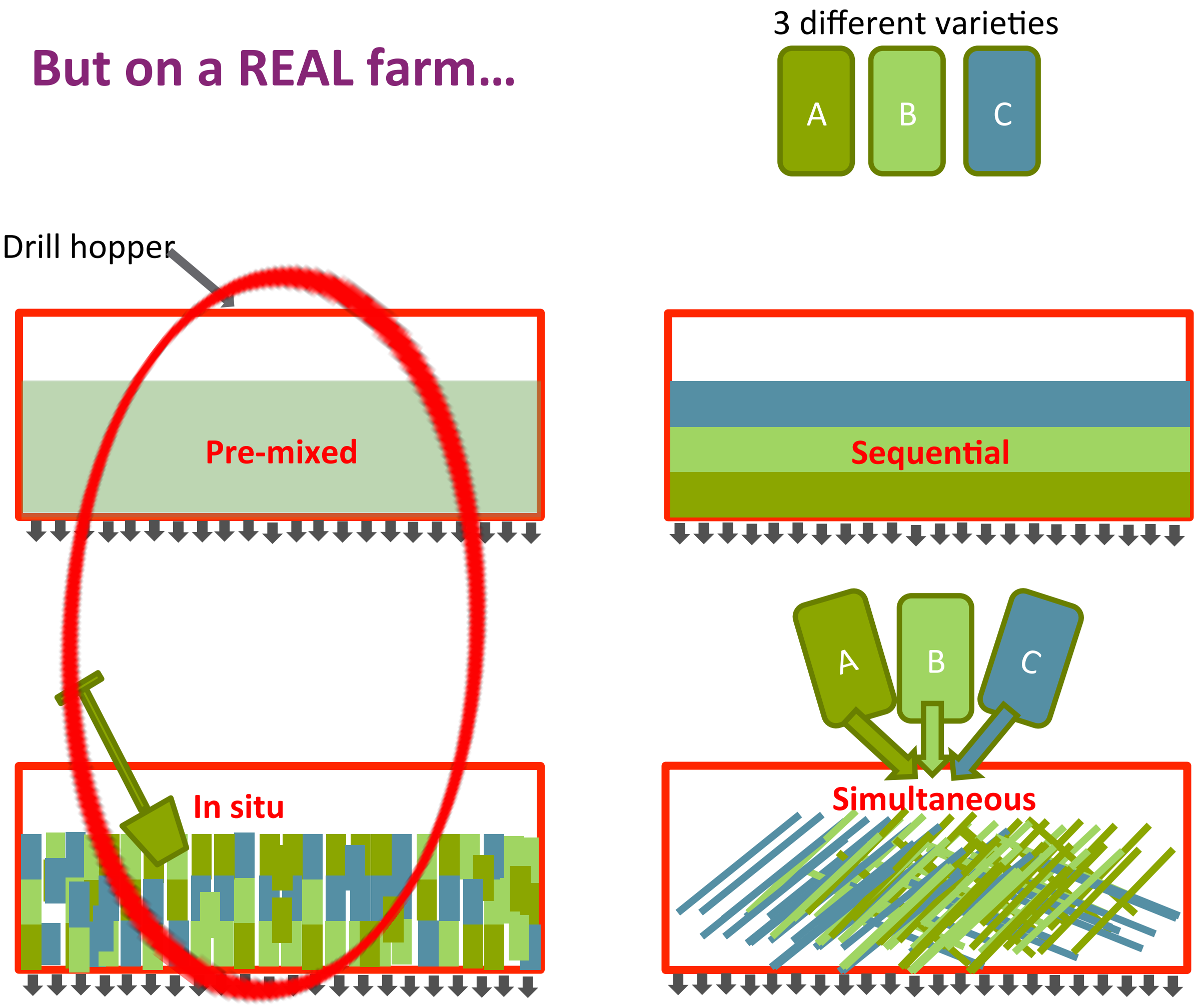
<u>**Mildew[1]**</u> 4.09[a] 4.69[a] **2.61[b]**

LSD 1.06

[1] Percentage whole plant infection.

3

But on a REAL farm…

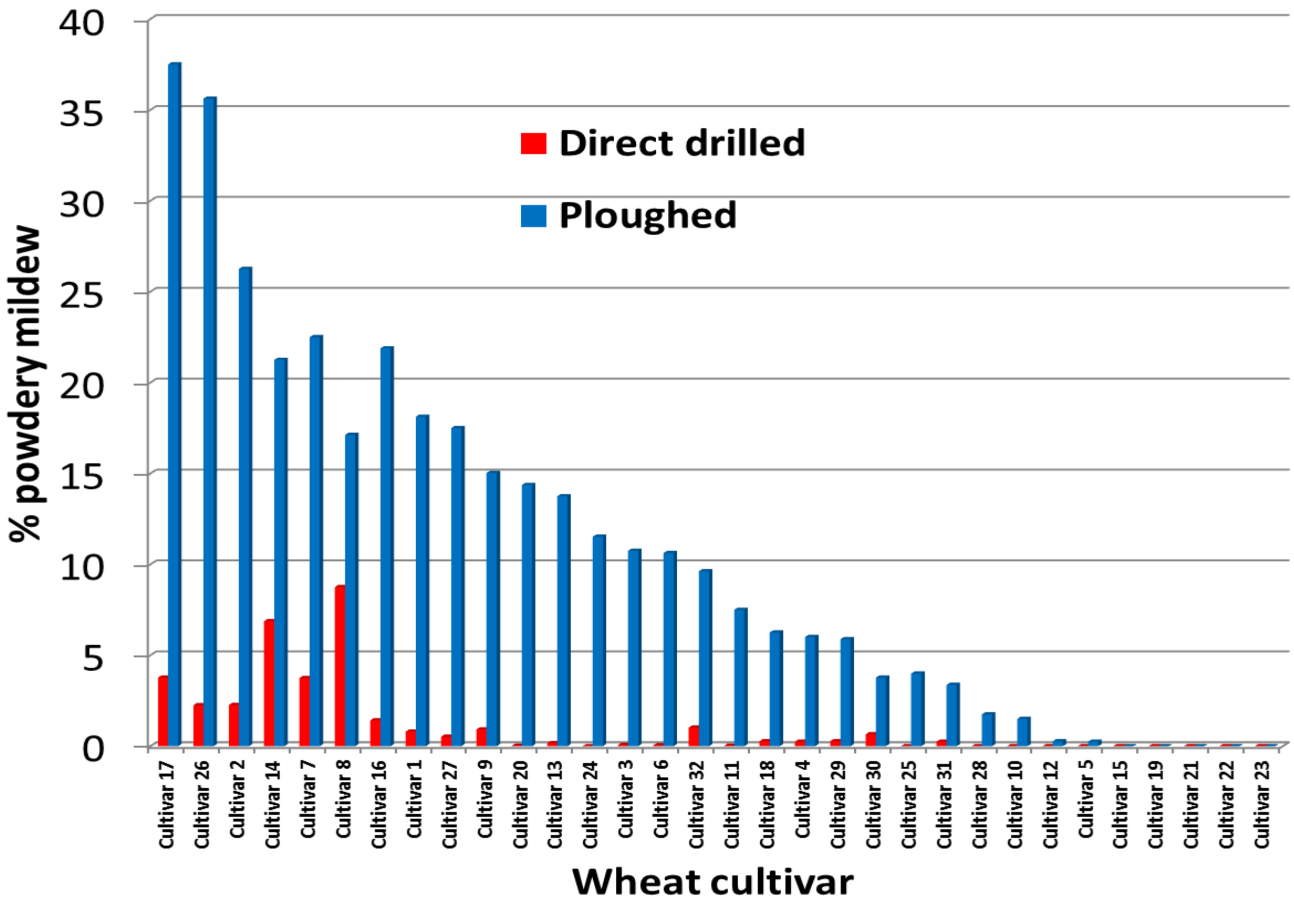


The James Hutton Institute

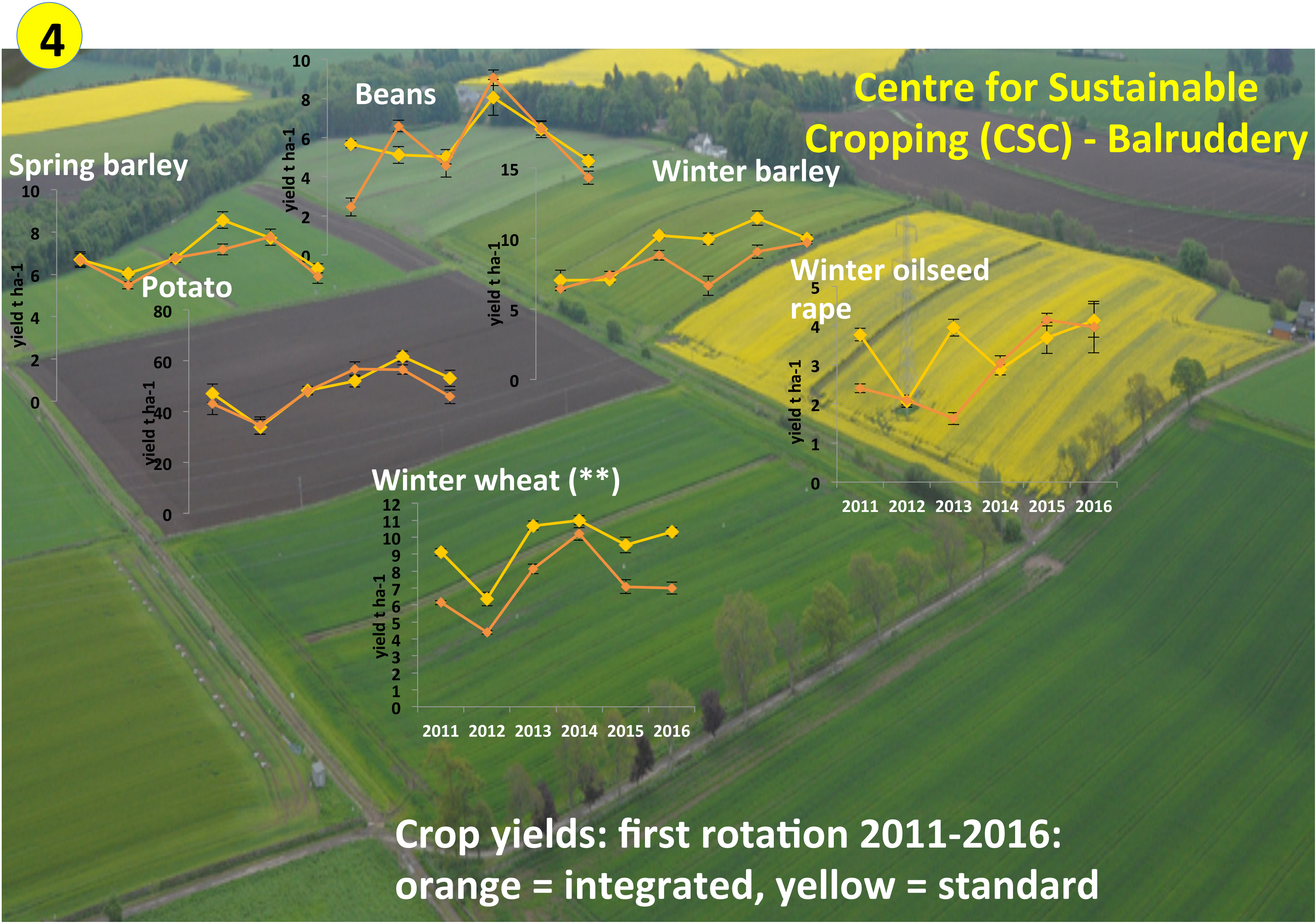
		In situ	Pre-mix
Yield		**In situ**	**Pre-mix**
Mixtures cf. mono mean:	2005	+13%***	-4%
	2006	+17%***	+10%
Rhynchosporium		**In situ**	**Pre-mix**
Mixtures cf. mono mean:	2005	-34%***	+10%
	2007	-58%***	-35%

Intercrops = bigger trait interaction potential = bigger responses

4



Mature direct drilled wheat compared with inversion tillage (plough & harrow) showing effect of disrupting soil microbe – crop on disease resistance expression in the field (UK, 2018)


4
Centre for Sustainable Cropping (CSC) - Balruddery
Beans
Spring barley
Winter barley
Potato
Winter oilseed rape
Winter wheat (**)
yield t ha-1
2011 2012 2013 2014 2015 2016
Crop yields: first rotation 2011-2016:
orange = integrated, yellow = standard

Thanks to:

Scottish Government (RESAS)

EU & other funders

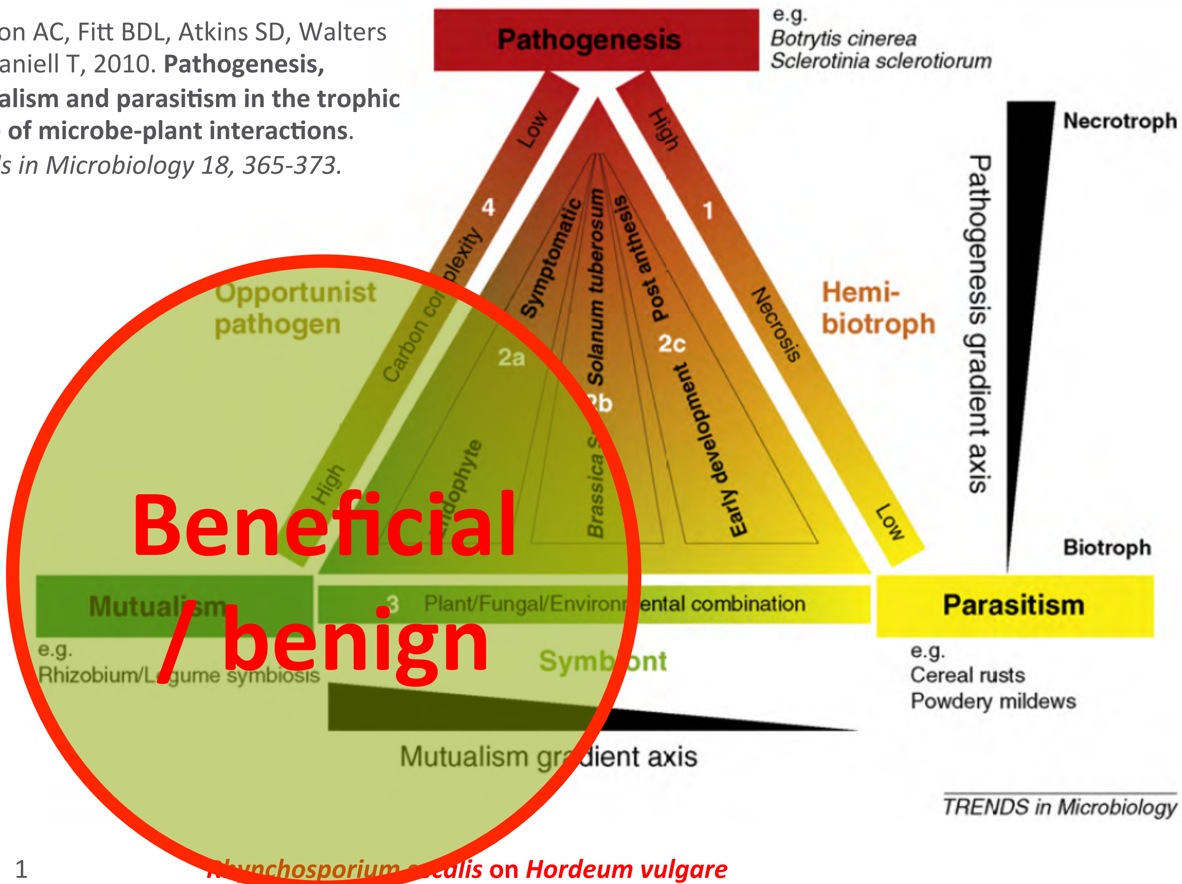
Doug Christie (Durie)

Hutton Farm staff and Dave Guy

Thank you!

5

Newton AC, Fitt BDL, Atkins SD, Walters DR, Daniell T, 2010. **Pathogenesis, mutualism and parasitism in the trophic space of microbe-plant interactions**. *Trends in Microbiology 18, 365-373.*



1 *Rhynchosporium secalis* on *Hordeum vulgare*

2a *Ramularia collo-cygni* on *Hordeum vulgare*

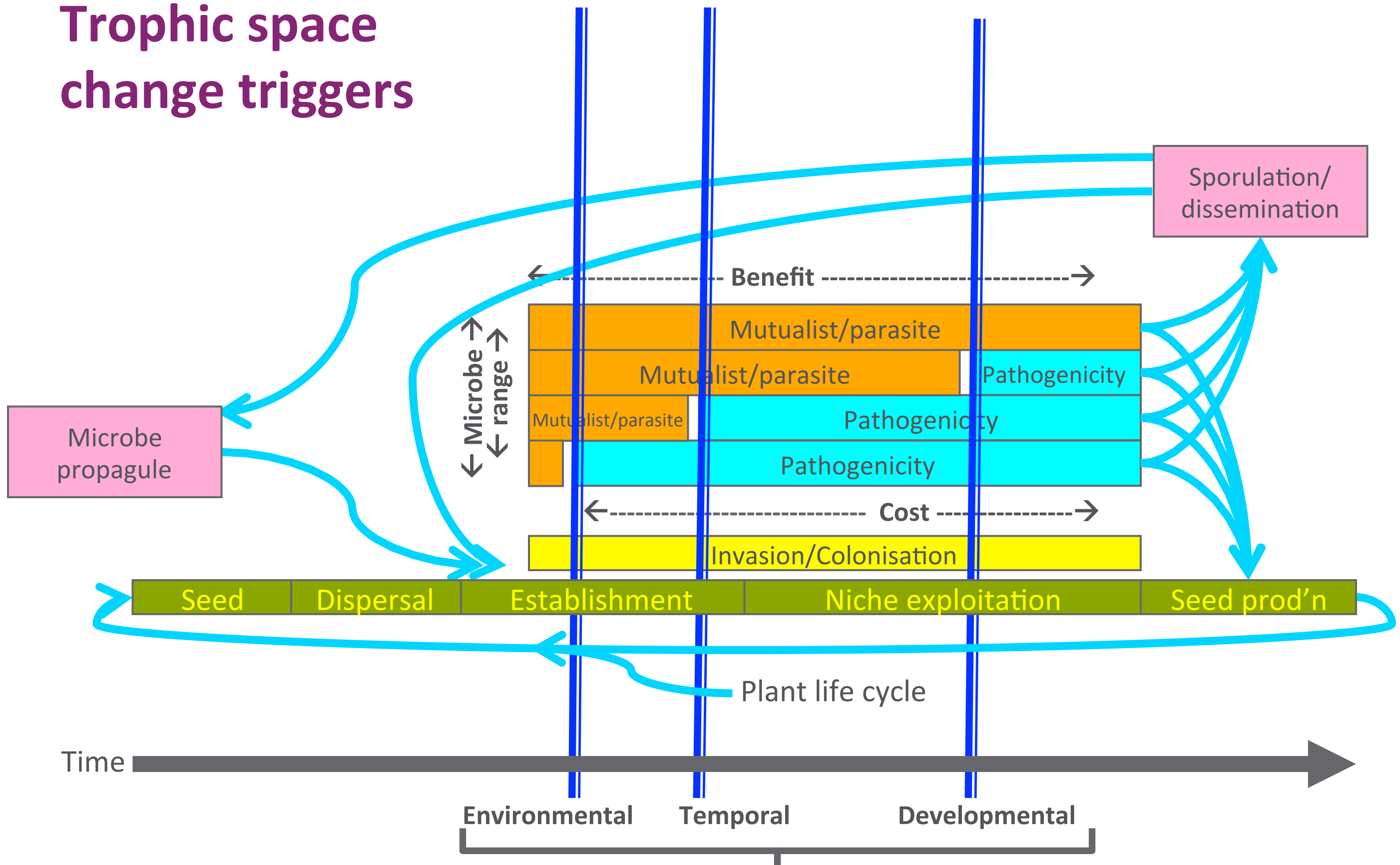
2b *Pectobacterium atrosecticum* on *Brassicae* and *Solanum tuberosum*

2c *Leptosphaeria maculans* on *Brassica napus*

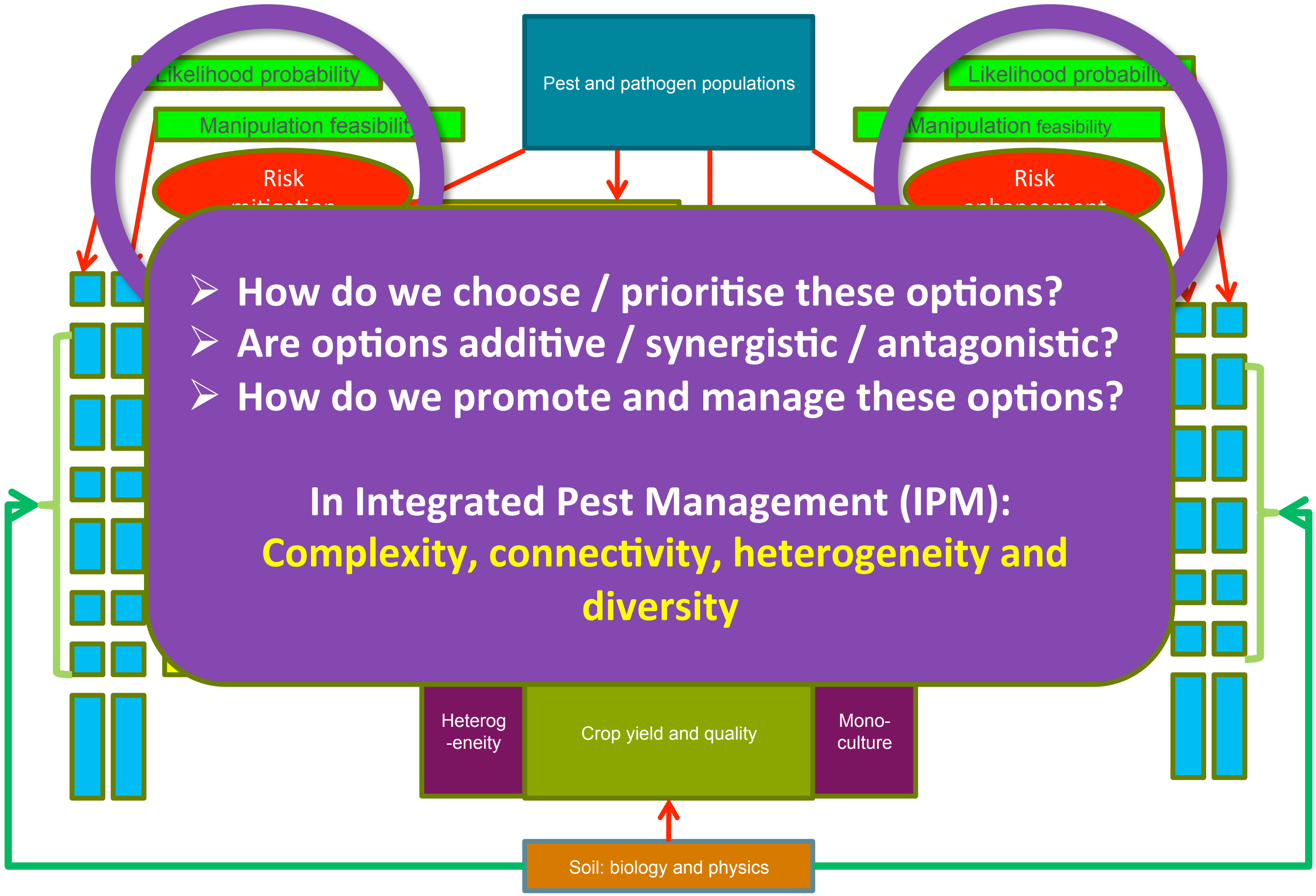
3 Arbuscular mycorrhizal symbioses

4 *Ceratobasidium cornigerum* on *Goodyera repens*

Trophic space change triggers

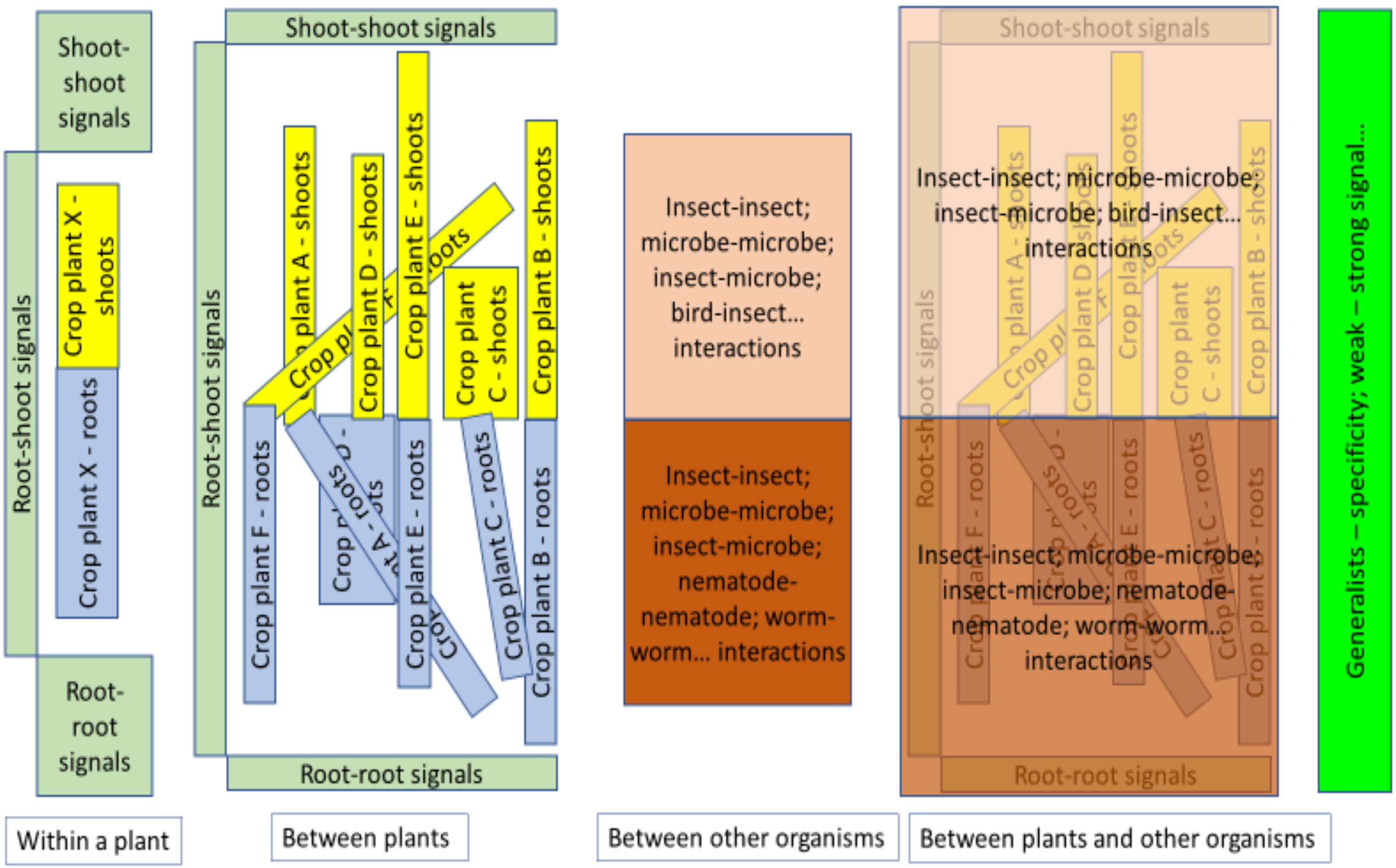


All these are affected by climate change



Chakraborty & Newton, 2011. Plant Pathology 60, 2-14 (special issue on climate change)

Figure 2 Influence of climate change on rate-determining processes that are the result of the complex interaction between the 'enhancing' (right) and 'mitigating' (left) influences on plant and pest ⁄ pathogen interactions. Rankings for likelihood probabilities and manipulation feasibility are initial approximations requiring critical review.



Crop system diversity signalling influences.