Department for Environment Food & Rural Affairs

ADAS





Integrated Pest Management: Science and Practice
Disease control in cereals

Neil Paveley and Frank van den Bosch

A video series funded by Defra and produced by ADAS

www.adas.co.uk

Is disease control good or bad for the environment?

Challenges for agriculture:

- Increased food production for a growing global population (despite climate change)
- Reduced environmental impact of production

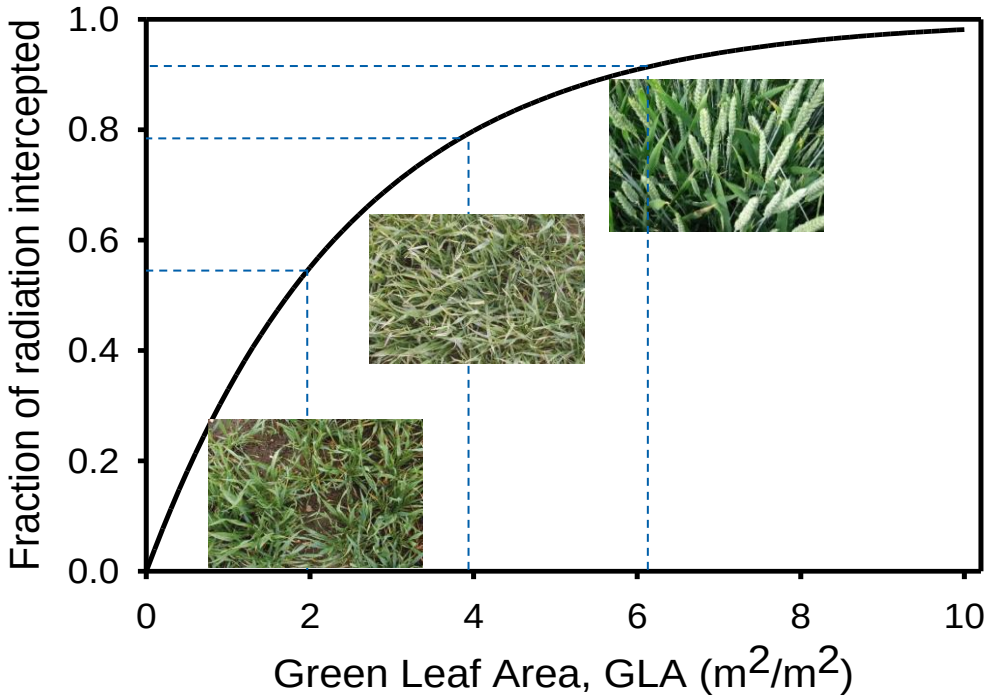
Effect of disease control on environmental impact?

- Impacts of fungicides on non-target species
- Greenhouse gas emissions
- Land use
- Water use

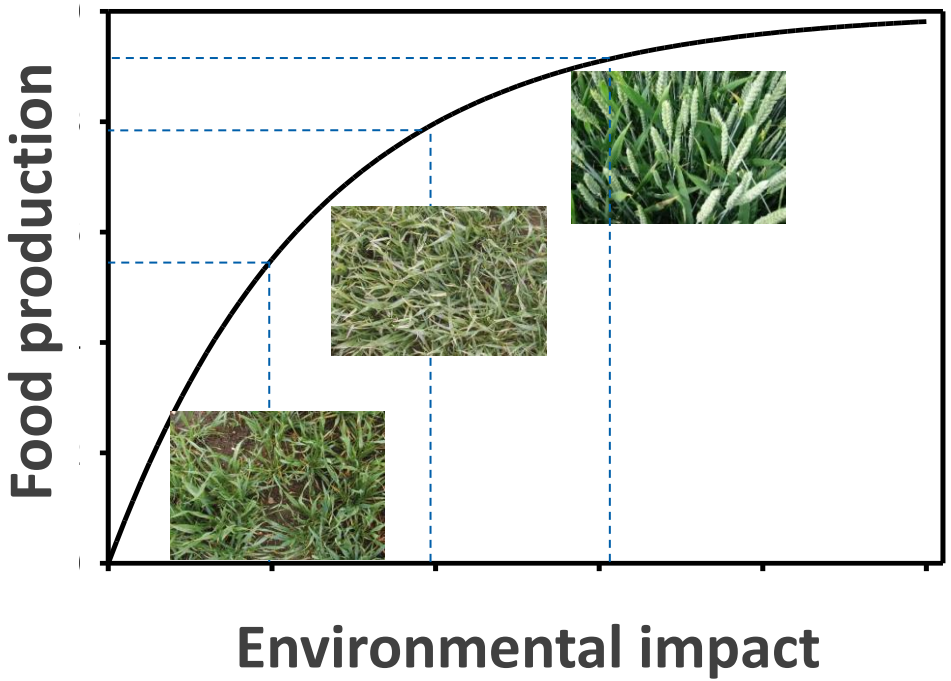
Effects of fungicides on non-target species

Source: https://www.eea.europa.eu/publications/how-pesticides-impact-human-health

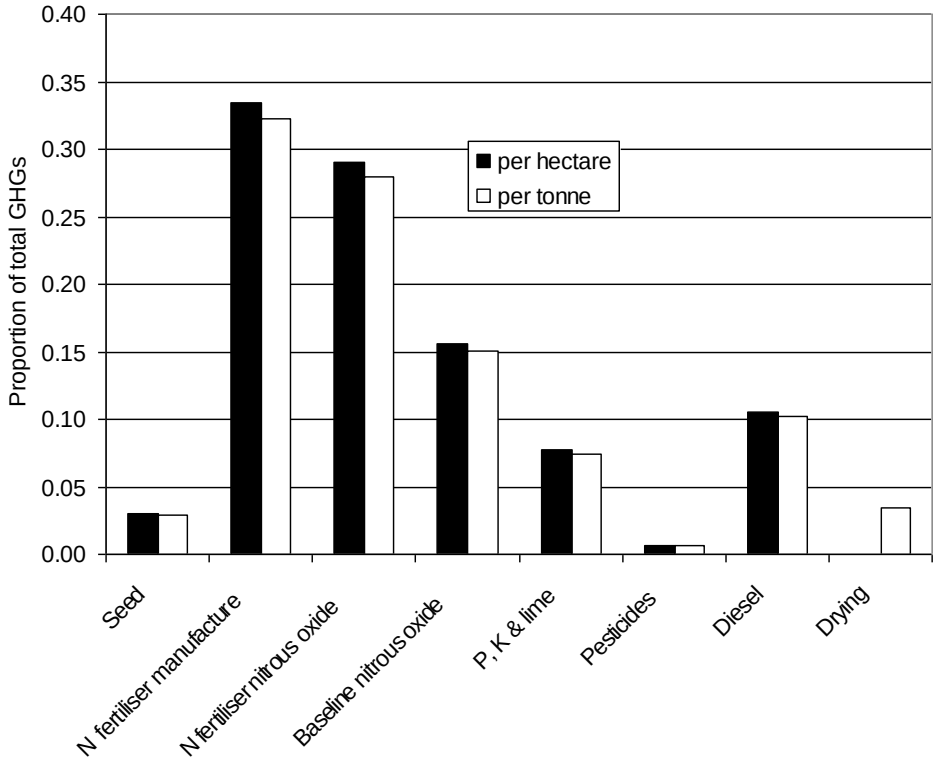
Is disease control good or bad for the environment?



Is disease control good or bad for the environment?

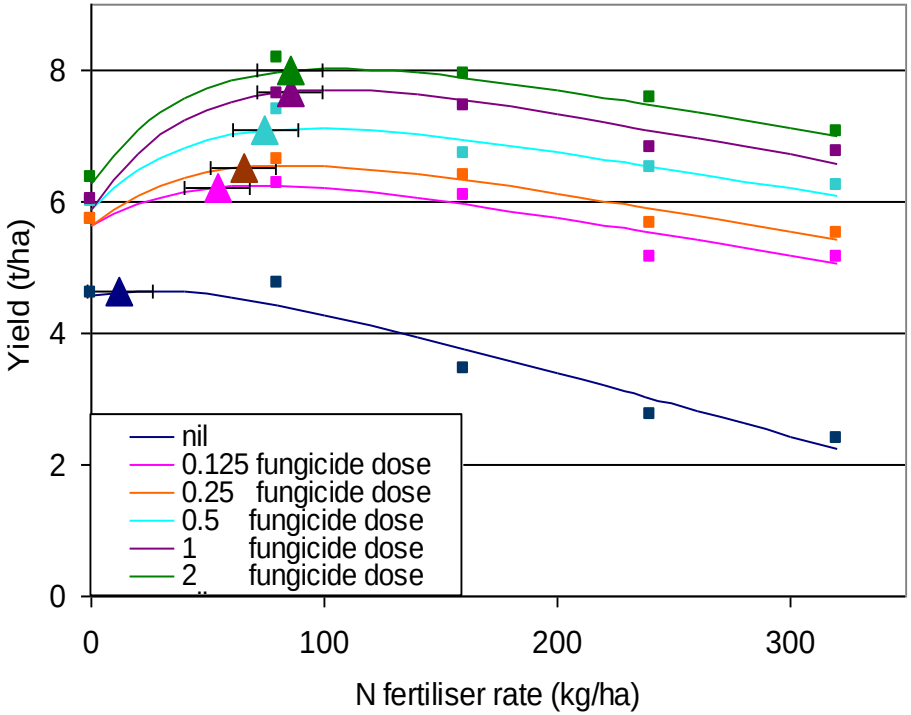


Greenhouse gases associated with crop production



Source: Berry et al. (2008) *Plant Pathology*

Disease control and nitrogen interaction



Source: Berry et al. (2010) Plant Pathology

Land use to meet UK wheat consumption (15M tonnes)

Berry et al. 2008

- Difference in yield (fungicide treated vs. untreated) = 21%
- Difference in land area to produce 15Mt (treated vs. untreated) ≈ 0.5M ha

Source: Berry et al. (2008) Plant Pathology

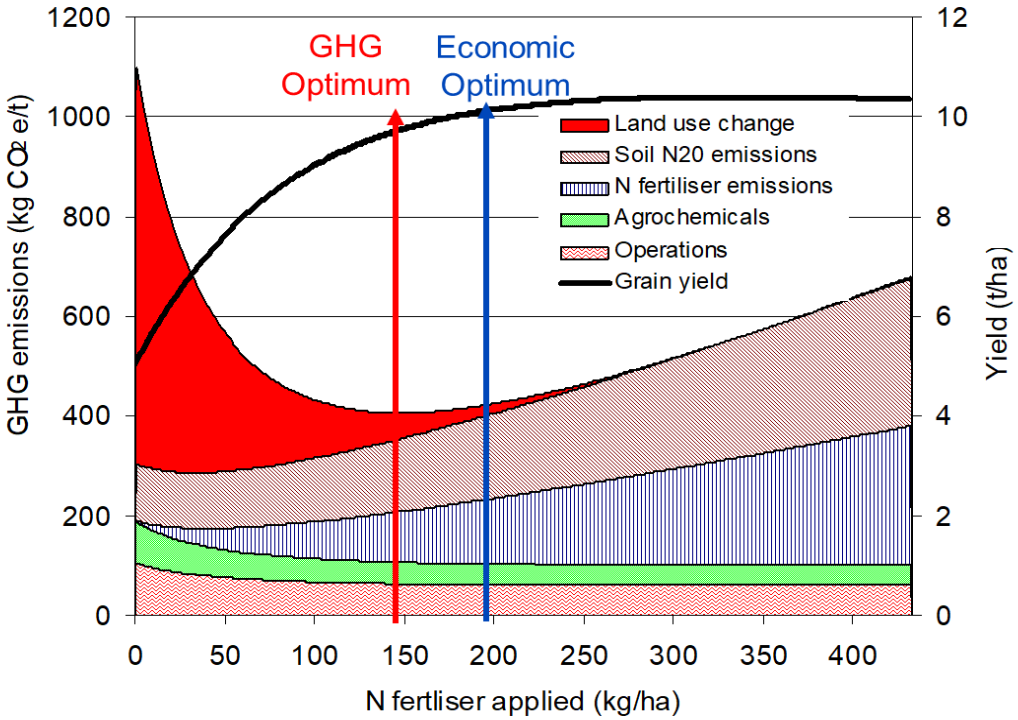
Land use change and greenhouse gases

- Convert grass to arable: 6 t CO_2equivalent per ha per year
- Convert forest to arable: 20 t CO_2equivalent per ha per year

- 1.2 t CO_2equivalent sequestered per ha per year of idle land

Source: Searchinger et al. (2008) Science Express

Land use change and greenhouse gases



Source: Kindred et al. (2008) Aspects of Applied Biology

Greenhouse gas emissions without fungicide treatment

Assumptions:

- Optimum N rate
- Additional 0.48 Mha to produce 15 M tonnes
- Additional land from converting temperate grassland

Results:

- Emissions would rise from 503 to 713 kg CO_2equivalent per tonne of grain
- Additional 3.2 M tonnes CO_2equivalent per year to produce 15 Mt grain

Source: Berry et al. (2010) Plant Pathology

Yield difference fungicide treated vs. untreated

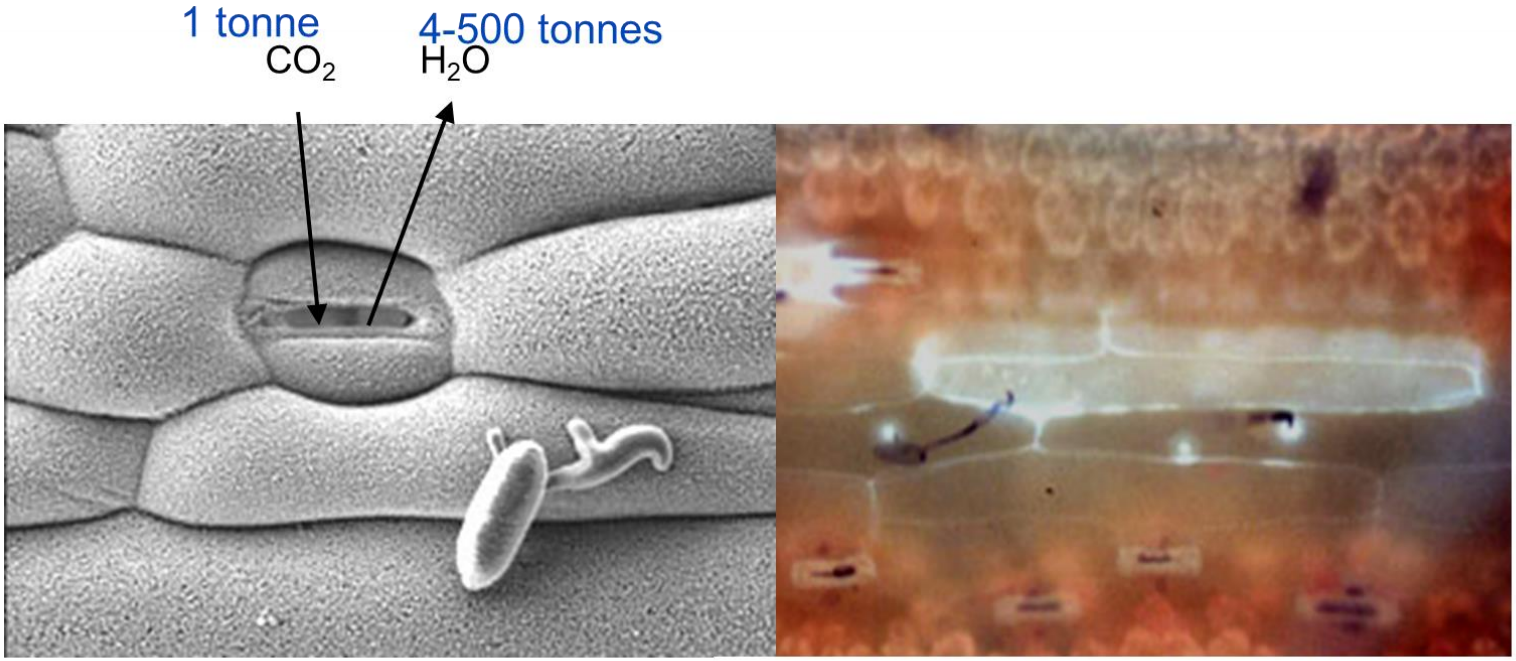
AHDB RECOMMENDEDLISTS

Winter wheat 2024/25

AHDB RECOMMENDED

	KWS Zyatt	SY Cheer	Skyfall	Crusoe	RGT Illustrious	KWS Extase	KWS Ultimatum	KWS Palladium	Mayflower
End-use group	UKFM Group 1					UKFM Group 2			
Scope of recommendation	UK	UK	UK	UK	UK	UK	UK	UK	UK
Variety status		NEW	C			C			
Fungicide-treated grain yield (% treated control)									
United Kingdom (11.0 t/ha)	99	97	96	95	95	101	101	100	97
East region (10.9 t/ha)	98	97	96	95	95	101	101	99	97
West region (11.2 t/ha)	99	98	96	96	96	102	101	101	97
North region (11.3 t/ha)	97	[98]	95	94	94	99	101	99	96
Untreated grain yield (% treated control)									
United Kingdom (11.0 t/ha)	71	84	66	75	82	93	90	90	91
Disease resistance									
Mildew (1–9)	7	[8]	6	7	6	7	7	8	7
Yellow rust (1–9)	3	7	3	8	7	7	9	9	9
Yellow rust (young plant)	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Water use efficiency for wheat production



15M tonnes wheat x 400 tonnes water = 6 billion tonnes of water transpired

Source: Images courtesy of Luis Mur and Tim Carver, Aberystwyth University

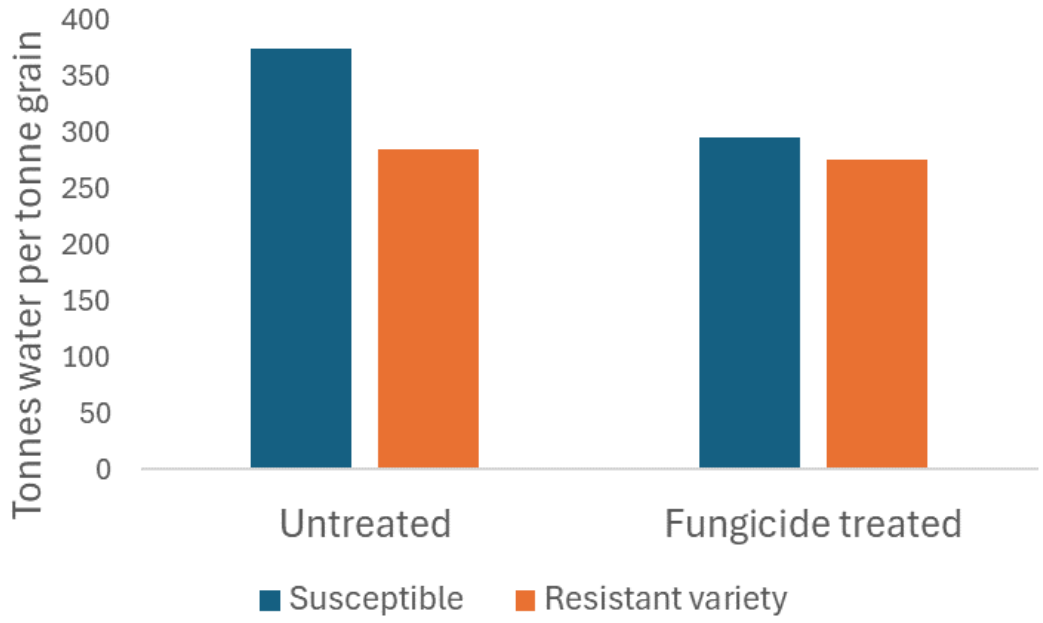
Pathogens affect water use efficiency

- Disease resistance responses associated with stomatal dysfunction, including lock-open in dark (e.g. powdery mildew)
- Impair stomatal opening in light (most diseases)
- Impair stomatal closure in dark (e.g. *Rhyncosporium secalis*)
- Rupture of epidermis when pathogens sporulate (rusts)

Image: AHDB Encyclopaedia of cereal diseases

Source: Grimmer *et al.* (2012) Journal Experimental Botany; Prats et al. (2010) Phytopathology

Water use efficiency and yellow rust control



Source: Berry et al. (2013) Reinhardsbrunn symposium proceedings

Is disease control good or bad for the environment?

- Most environmental impact of cereal production is related to cultivation and nutrients to establish and grow crop canopy
- Allowing diseases to destroy crop canopy is inefficient
- Effective disease control:
  - Reduces the land area required to meet UK demand for food and feed
  - Increases nitrogen uptake and utilisation efficiency
  - Reduces greenhouse gas emissions per tonne of grain
  - Increases water use efficiency
- Control can be obtained by a combination of IPM methods, including disease resistant varieties and treatment with fungicide (according to need)
- Environmental impacts of fungicides should be balanced against environmental benefits

Further reading

For references related to environmental impacts of pesticides: How pesticides impact human health and ecosystems in Europe.
https://www.eea.europa.eu/publications/how-pesticides-impact-human-health
This video was based on a presentation by Dr Pete Berry (ADAS) to the Reinhardsbrunn International Symposium. Details of the research are given in the papers below.

Research papers, mainly by the authors, on the theme of this video

Berry, P, Kindred, D, Olesen, J, Jorgensen, L, Paveley, N (2010) Quantifying the effect of interaction between disease control, nitrogen supply and land use change on the greenhouse gas
emissions associated with wheat production. *Plant Pathology*, *59*, 753–763.

Berry, P, Kindred, D, Paveley, N (2008) Quantifying the effects of fungicides and disease resistance on greenhouse gas emissions associated with wheat production. *Plant Pathology*, *57*, 1000–1008.

Berry, P, Grimmer, M, Smith J, Kindred D, Paveley N (2013). Ecological benefits of fungicides. In: Dehn, HW et al. (Eds), "Modern Fungicides and Antifungal Compounds", Vol VII, pp. 23-24.

Grimmer, M, Foulkes, MJ, Paveley, N (2012). Foliar pathogenesis and plant water relations – a review. Journal of Experimental Botany 63, 4321-4331.

Kindred, D, Berry, P, Burch, O, Sylvester-Bradley, R (2008). Effects of nitrogen fertiliser use on green house gas emissions and land use change. *Aspects of Applied Biology* **89** *Effects of Climate Change on Plants: Implications for Agriculture*. 53-56

Prats, E, Gay, A, Roberts, P, Thomas, B, Sanderson, R, Paveley, N, Lyngkjær, M, Carver, T, Mur, L (2010). *Blumeria graminis* interactions with barley conditioned by different single R genes demonstrate a temporal and spatial relationship between cell death and stomatal dysfunction. Phytopathology 100 (1), 21-32

Searchinger TD et al. (2008) Use of US cropland for biofuels increases greenhouse gases through emissions from land-use change. Science 319: 1238-1240.

Bryson R (2022) Evaluating the contribution of synthetic fungicides to cereal plant health and CO2 reduction targets against the backdrop of the increasingly complex regulatory environment in Europe. Plant Pathology 71:170–186.

Many excellent papers by other authors are cited in the papers above.
If a research paper is not open-access you can request a copy by contacting authors through www.researchgate.net