Department for Environment Food & Rural Affairs

ADAS

Integrated Pest Management: Science and Practice
Disease control in cereals

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How can variety choice help?

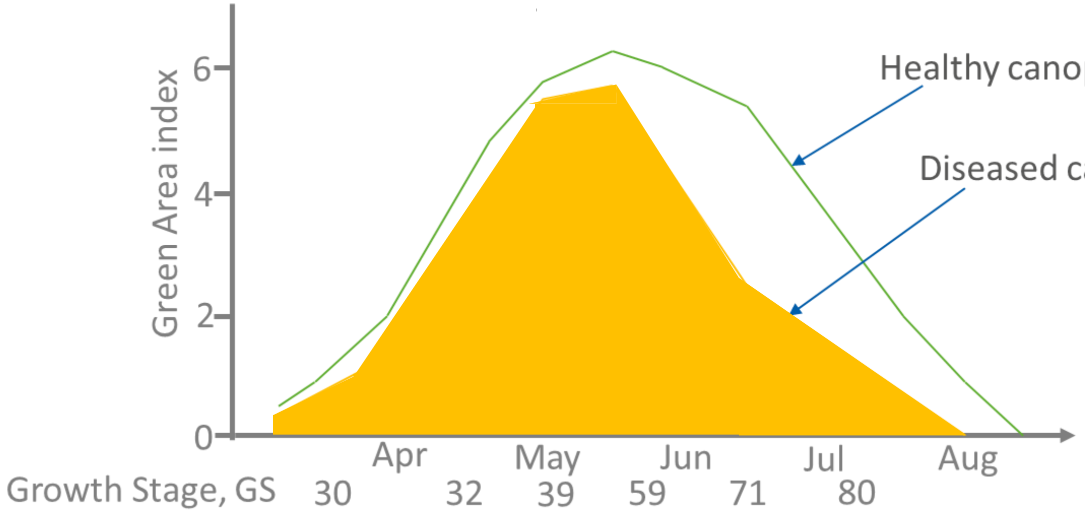
Cereal varieties can reduce disease losses by:

- **Escape:** reduces spores arriving on the upper canopy (Part A)
- **Resistance:** reduces disease severity per amount of spore arrival on upper canopy (Part B)
- **Tolerance:** reduces yield loss per amount of disease severity (Part C, this video)

Why do we need disease tolerant varieties?

- Partial disease resistance of varieties is usually more durable than major gene resistance
- Margin over fungicide cost is maximised with some disease left in the crop
- Very effective disease control drives faster evolution of virulence and fungicide resistance
  “Don’t be too keen to be clean”
- Tolerance likely to be durable and effective against major foliar diseases

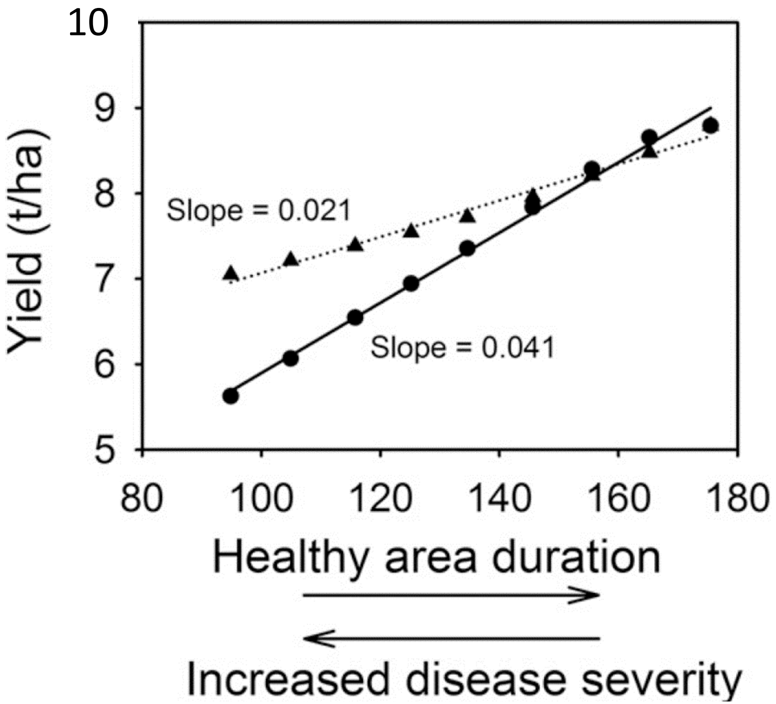
Disease tolerance



GAI integrated over time =
Healthy Area Duration (HAD)

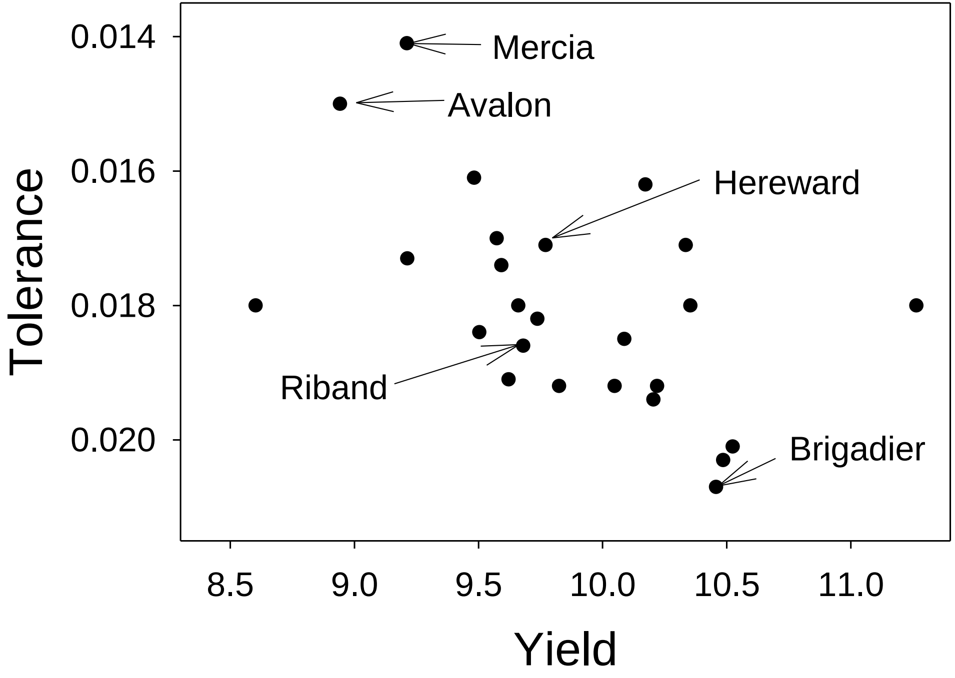
Data source: AHDB wheat and barley disease management guide

Disease tolerance



Shallow slope = high tolerance

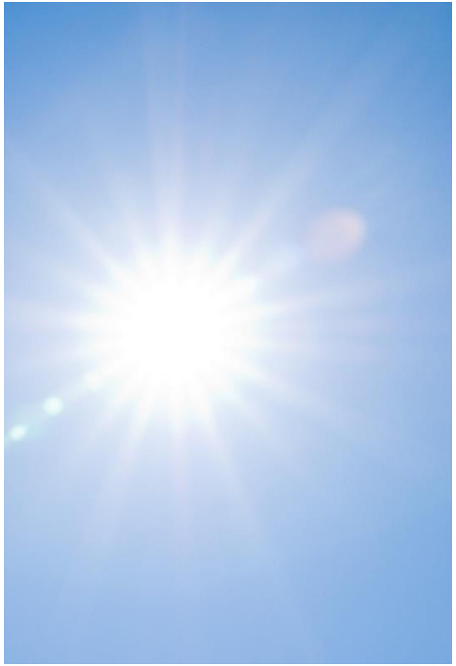
Disease tolerance



Source: Parker et al. (2004) *Plant Pathology*

Dry matter source and sink

Source



+

Sink

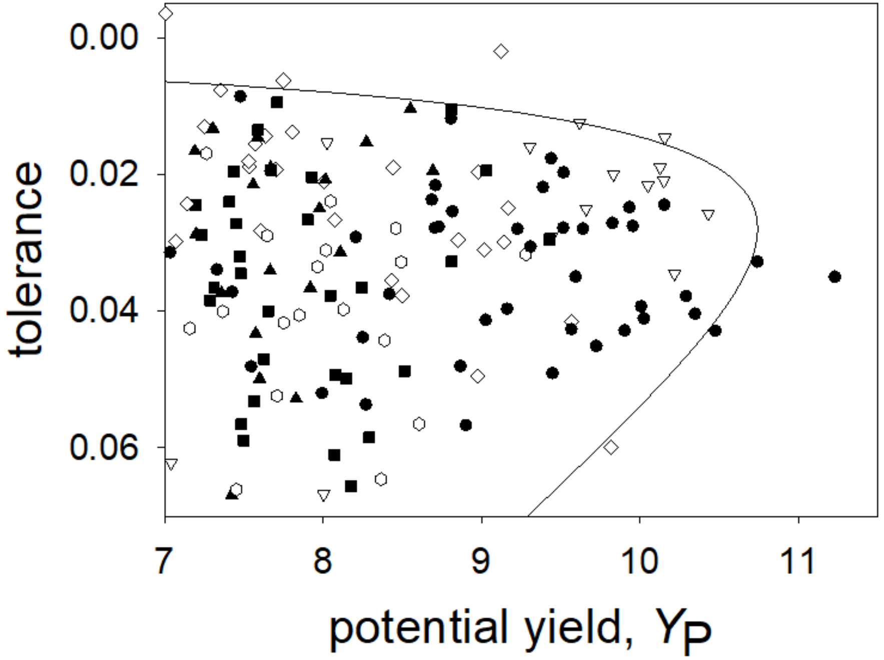
Traits associated with disease tolerance in wheat

- Increased light extinction coefficient
- Increased stem height
- Increased canopy size
- Increased flag leaf area
- Decreased resource use efficiency (grams dry matter per MJ solar radiation)
- Decreased number of grains per ear

HAD per grain is a consistently good predictor of tolerance

Sources: Parker et al (2004); Foulkes et al (2006); van den Berg et al 2017

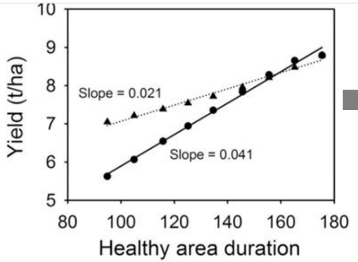
Yield and tolerance



Data for doubled-haploid progeny of crosses between wheat varieties

Source: van den Bosch et al 2021 *Plant Pathology*

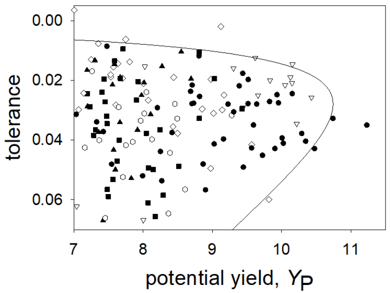
Actual realised yield and tolerance



$$Y_A = Y_P\,(C + \alpha\,HAD)$$

$$Y_A = Y_P\,(1 - \alpha(HAD_P - HAD_A))$$

$$\alpha = \frac{1}{HAD_P - HAD_A}\left(1 - \frac{Y_A}{Y_P}\right)$$



Y_P: Potential yield, fully protected crop

Y_A: Actual realised yield

α: tolerance

HAD_P: HAD of a fully protected crop

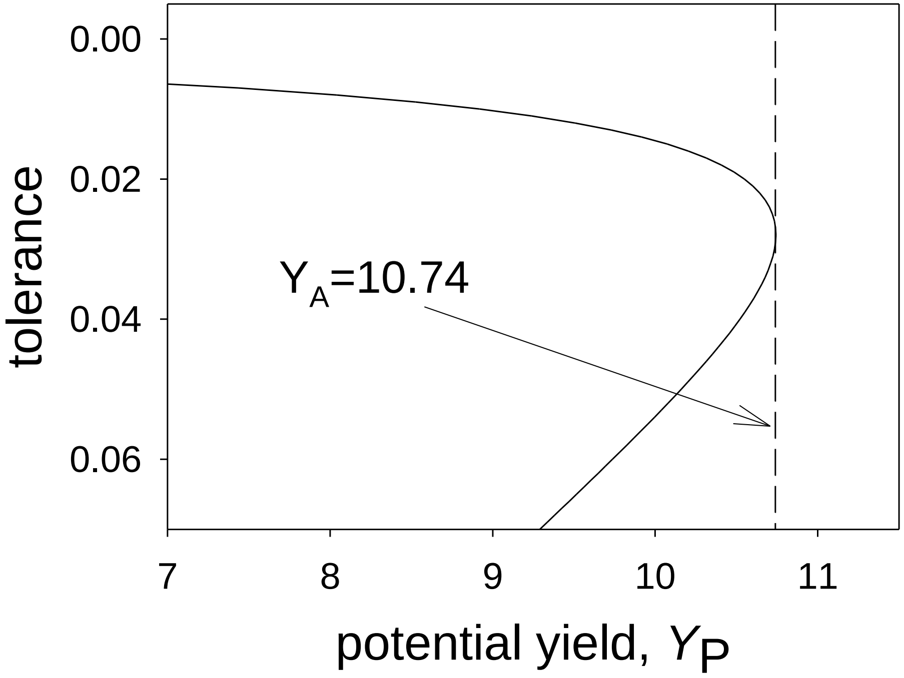
HAD_A: actual realised HAD

$HAD_P - HAD_A$ = HAD loss to disease

C: constant

Source: van den Bosch et al 2021 *Plant Pathology*

Actual realised yield and tolerance

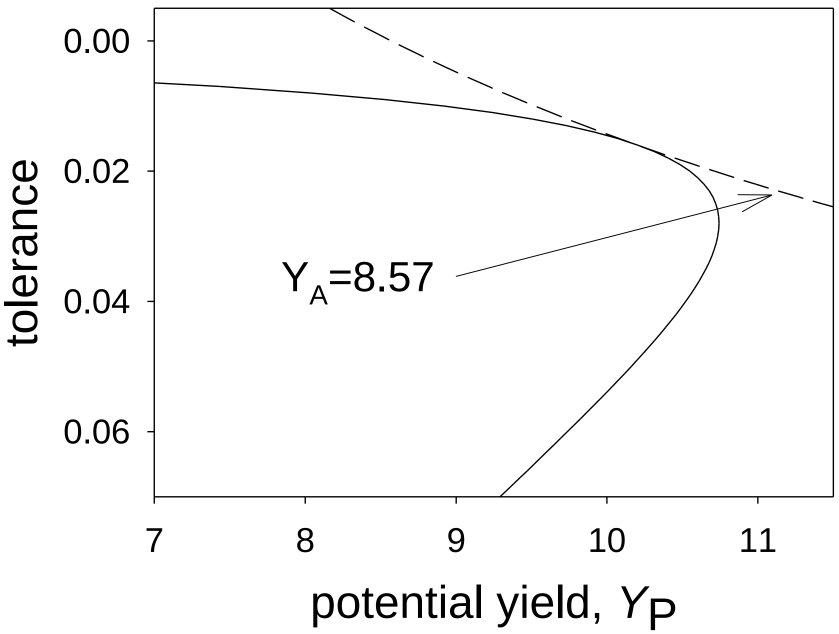


No disease

HAD loss = 0

Source: van den Bosch et al 2021 *Plant Pathology*

Actual realised yield and tolerance



Low/moderate disease

HAD loss = 10

Source: van den Bosch et al 2021 *Plant Pathology*

Winter wheat 2024/25

UKFM Group 1, 2 and 3

AHDB RECOMMENDED

	KWS Zyatt	SY Cheer	Skyfall	Crusoe	RGT Illustrious	KWS Extase	KWS Ultimatum	KWS Palladium	Mayflower	Bamford	RGT Wilkinson	KWS Brium	RGT Rashid	Almara	LG Illuminate	LG Astronomer	Average LSD (5%)
End-use group	UKFM Group 1					UKFM Group 2				UKFM Group 3							
Scope of recommendation	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	E	N	UK	UK	
Variety status		NEW	C			C				NEW		*		NEW	*		
Fungicide-treated grain yield (% treated control)																	
United Kingdom (11.0 t/ha)	99	97	96	95	95	101	101	100	97	106	100	100	99	99	98	98	2.3
East region (10.9 t/ha)	98	97	96	95	95	101	101	99	97	105	101	100	100	98	98	98	2.7
West region (11.2 t/ha)	99	98	96	96	96	102	101	101	97	107	99	99	98	99	99	98	3.0
North region (11.3 t/ha)	97	[98]	95	94	94	99	101	99	96	[105]	99	100	98	[102]	100	97	3.4
Untreated grain yield (% treated control)																	
United Kingdom (11.0 t/ha)	71	84	66	75	82	93	90	90	91	92	83	80	78	87	83	85	4.8
Disease resistance																	
Mildew (1–9)	7	[8]	6	7	6	7	7	8	7	[6]	7	7	3	[6]	5	4	1.5
Yellow rust (1–9)	3	7	3	8	7	7	9	9	9	7	7	9	8	8	7	8	0.6
Yellow rust (young plant)	s	-	s	s	s	s	r	r	r	-	s	s	r	-	r	r	
Brown rust (1–9)	7	6	9	3	5	6	6	5	6	6	5	5	5	6	6	7	0.6
Septoria tritici (1–9)	6.3	6.0	5.8	6.3	5.9	7.4	6.5	7.3	8.9	6.7	5.5	5.7	6.1	6.0	5.6	5.9	0.7
Eyespot (1–9)	6@	4	6@	5	6@	4	6	6	5@	6@	6@	5	5	4	5	5	1.5
Fusarium ear blight (1–9)	6	[7]	7	7	6	6	6	6	6	[5]	6	6	7	[6]	6	6	0.4
Orange wheat blossom midge	-	-	R	-	-	-	-	-	-	-	-	-	R	R	R	R	

Source: AHDB recommended list

How can variety choice help?

- Wheat varieties differ significantly for tolerance
- There is no tolerance information for current UK varieties
- High untreated yields indicate varieties with good disease resistance and tolerance
- There is a trade-off between tolerance and potential (fully protected) yield
- Breeding for a combination of potential yield and tolerance maximises actual realised yield

Further reading

Research papers

Bingham, I.J. & Topp, C.F.E. (2009) Potential contribution of selected canopy traits to the tolerance of foliar disease by spring barley. *Plant Pathology*, 58, 1010-1020.

Collin, F., Bancal, P., Spink, J., Kock-Appelgren, P., Smith, J., Paveley, N.D., Bancal, M.O. & Foulkes MJ. (2018). Wheat lines exhibiting variation in tolerance of septoria tritici blotch differentiated by grain source limitation. *Field Crops Research*, 217, 1-10.

Foulkes, M.J., Paveley, N.D., Worland, A., Welham, S.J., Thomas, J. & Snape, J.W. (2006) Major genetic changes in wheat with potential to affect disease tolerance. *Phytopathology*, 96, 680-688.

Kramer, T., Gildemacher, B.H., van der Ster, M. & Parlevliet, J.E. (1980) Tolerance of spring barley cultivars to leaf rust, *Puccinia hordei*. *Euphythica*, 29, 209-216.

Pagan, I., Garcia-Arenal, F. (2020). Tolerance of plants to pathogens: A unifying view. Annual Review of Phytopathology 58, 77-96.

Parker, S.R., Welham, S., Paveley, N.D., Foulkes, J. & Scott, R.K. (2004) Tolerance of septoria leaf blotch in winter wheat. *Plant pathology,* 53, 1-10.

van den Berg, F., Paveley, N.D., Bingham, I.J. & van den Bosch, F. (2017) Physiological traits determining Yield tolerance of wheat to foliar diseases. *Phytopathology* 107, 1468-1478.

van den Bosch F, Smith J, Wright P, Milne A, van den Berg F, Kock-Appelgren P, Foulkes J, Paveley N (2022). Maximising realised yield by breeding for disease tolerance: A case study for septoria tritici blotch. *Plant Pathology* 71, 535-543.

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