Can genetics mitigate the loss of fungicides against Septoria?

James Brown

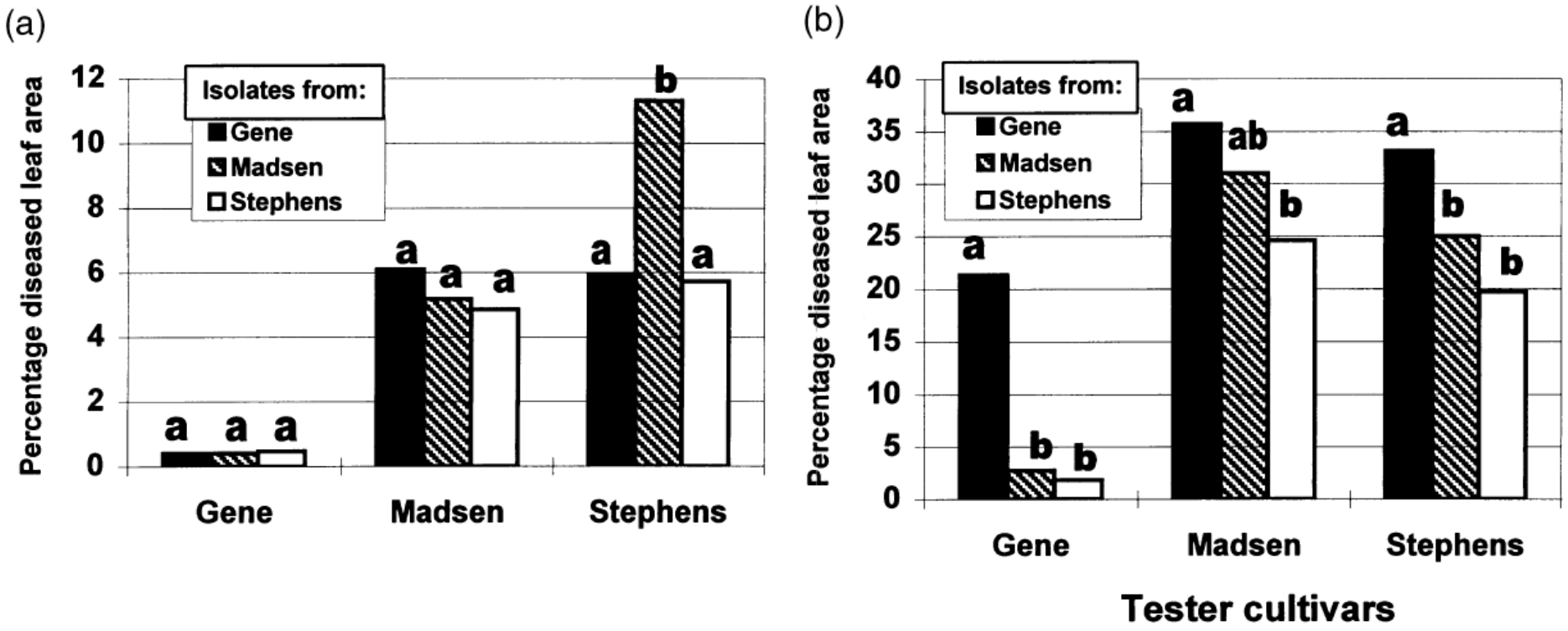
John Innes Centre, Norwich, England

james.brown@jic.ac.uk

Septoria resistance in a nutshell

- Qualitative resistance
  - Major genes effective against fungal genotypes
- Quantitative (partial, horizontal) resistance
  - Minor genes effective against all(?) genotypes
  - Distributed throughout genome
  - Detected genes vary in size of effect
  - Much resistance: minor genes below detection threshold
- As in rusts, mildew, etc
- Reviewed by Brown et al. (2015) Fungal Genetics & Biology

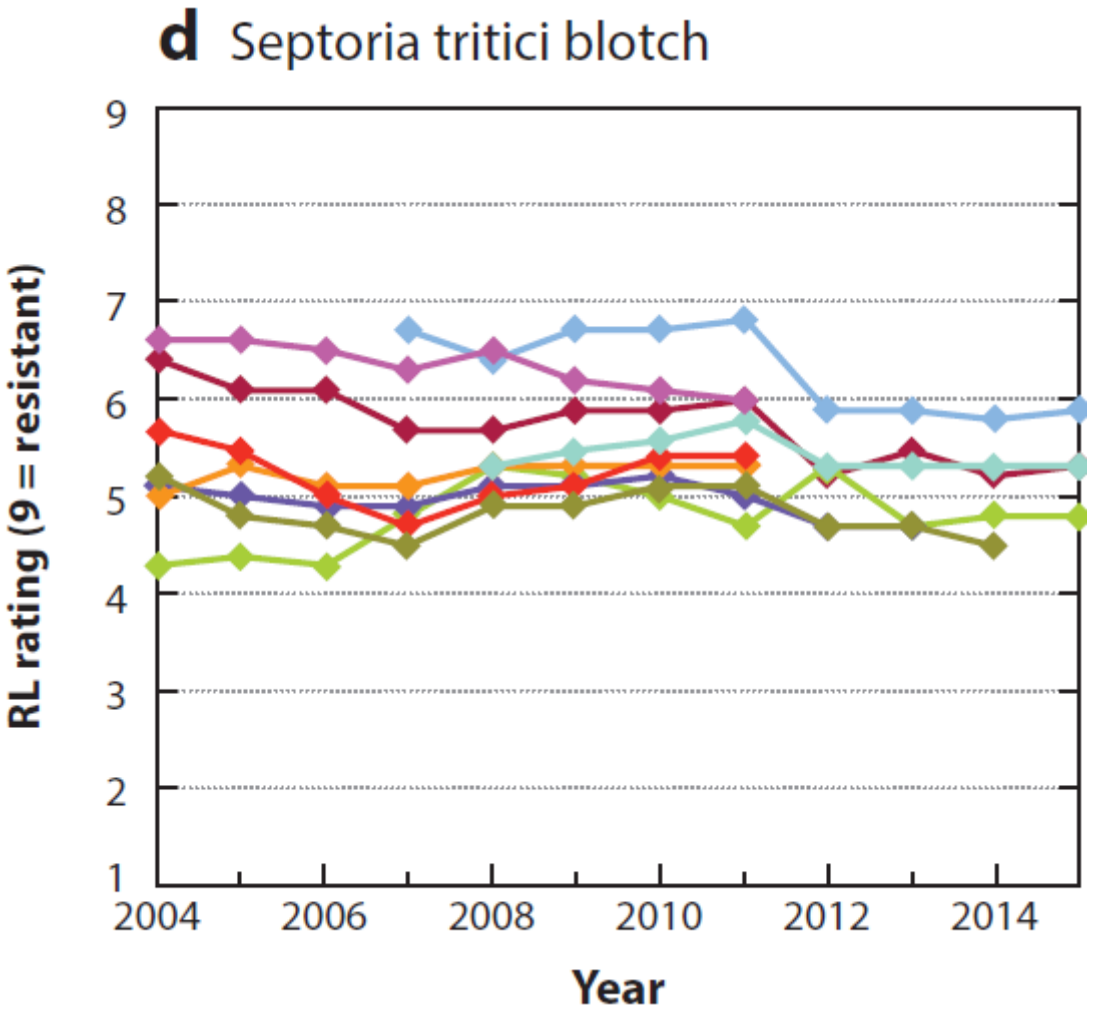
Non-durability of major-gene resistance



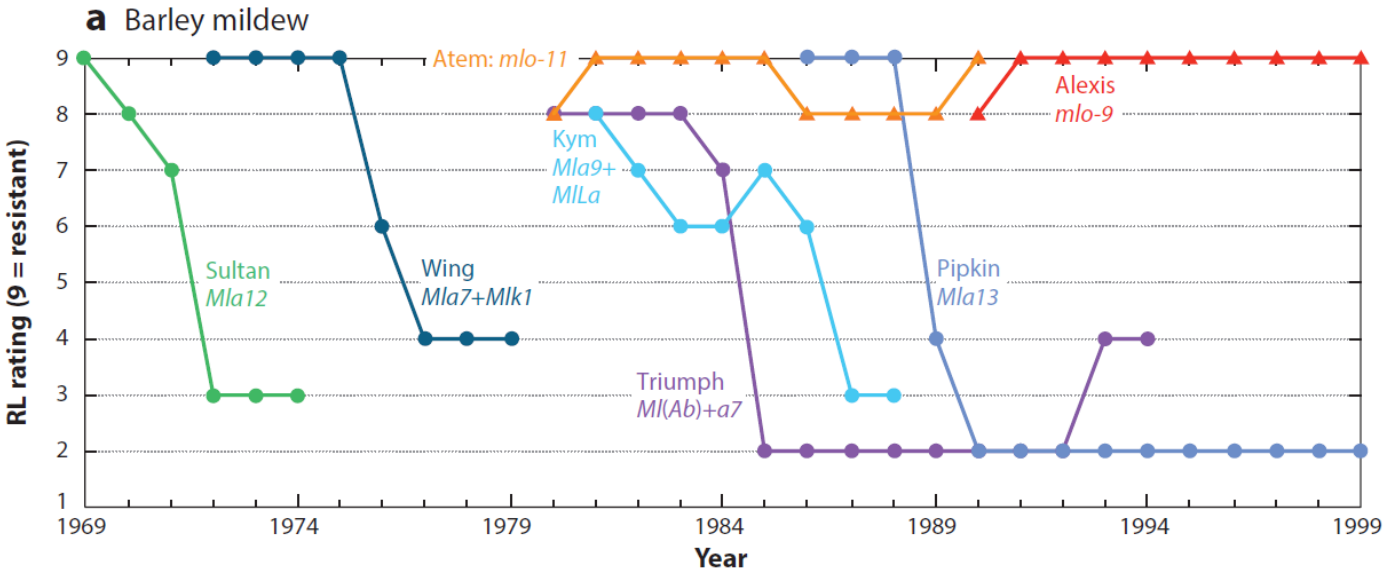
- "Breakdown" of Gene's resistance through evolution of virulent *Zymoseptoria tritici* (Cowger et al. 2000, Plant Pathology)
- Also virulence to Foote (Krenz et al. 2008, Phytopathology)

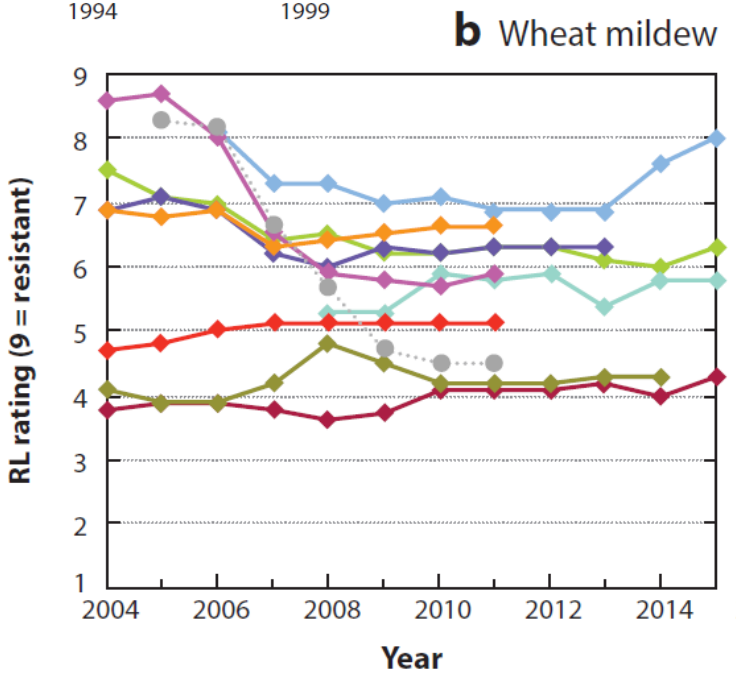
Durability of minor-gene partial resistance

- Little variation in virulence in UK *Z.tritici* population
- RL ratings stable
- Partial resistance has been **durable**
- Effective for a long time over a large area
- Brown (2015) Annual Review of Phytopathology



Strategies of mildew resistance breeding





- Barley – “boom & bust” of major genes: useful varieties lost
- Wheat – consistent selection for minor-gene, partial resistance: mildew now a rather minor disease

“The Vertifolia effect” (Vanderplank, 1963)

‘Horizontal’ (partial) resistance lost if not actively selected

Paragon wheat
UK: mildew common & sometimes severe

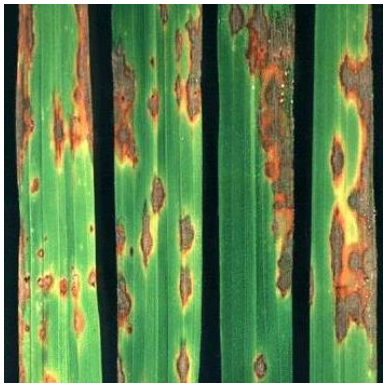
Lal Bahadur
India: mildew rare & unimportant – resistance not selected in wheat breeding

Farmers need adequate resistance to all significant diseases

Trade-offs of *mlo* mildew resistance in barley

mlo gene in barley :
durable resistance in ~50% of European spring barley

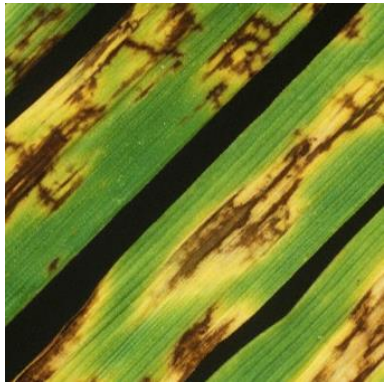
But increased susceptibility to :



Magnaporthe

Cochliobolus

Fusarium

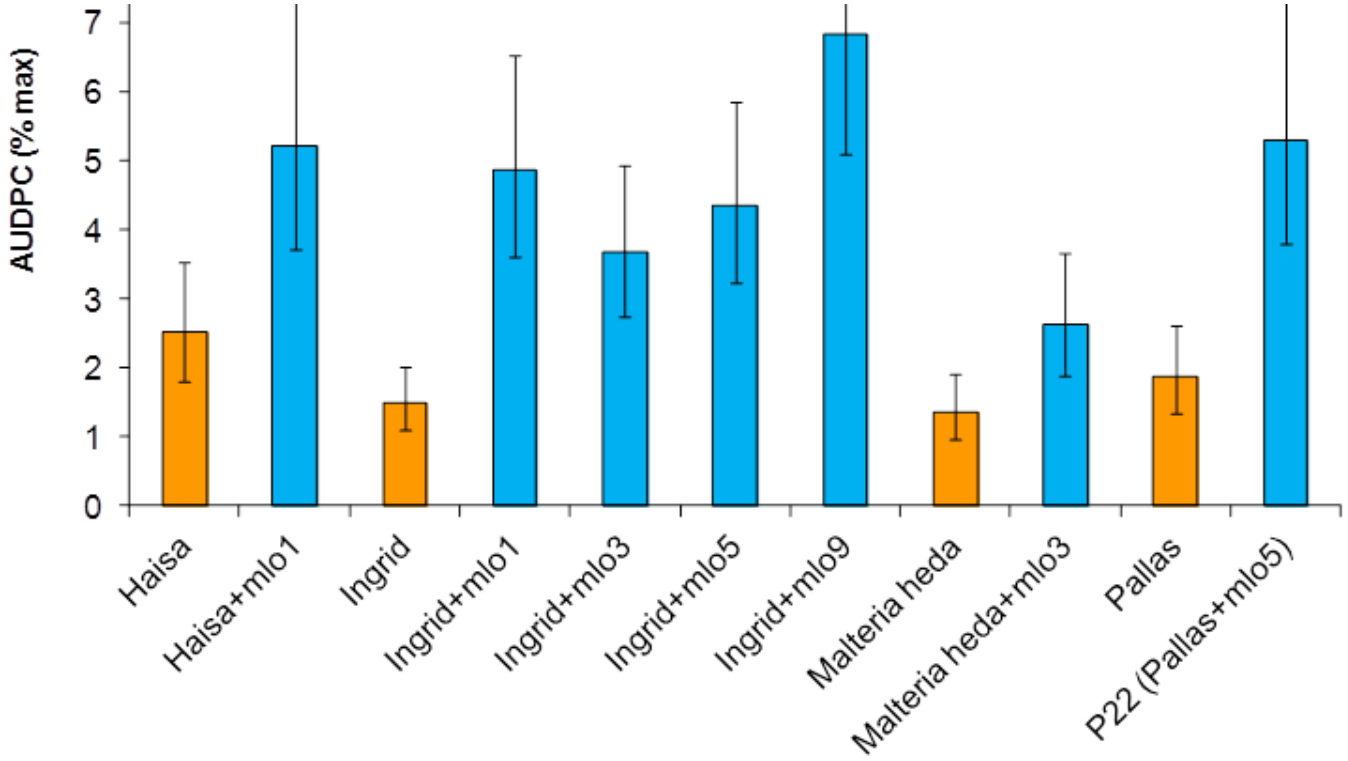


Net blotch

Reviewed by Brown & Rant (2013) Plant Pathology

mlo increases susceptibility to Ramularia

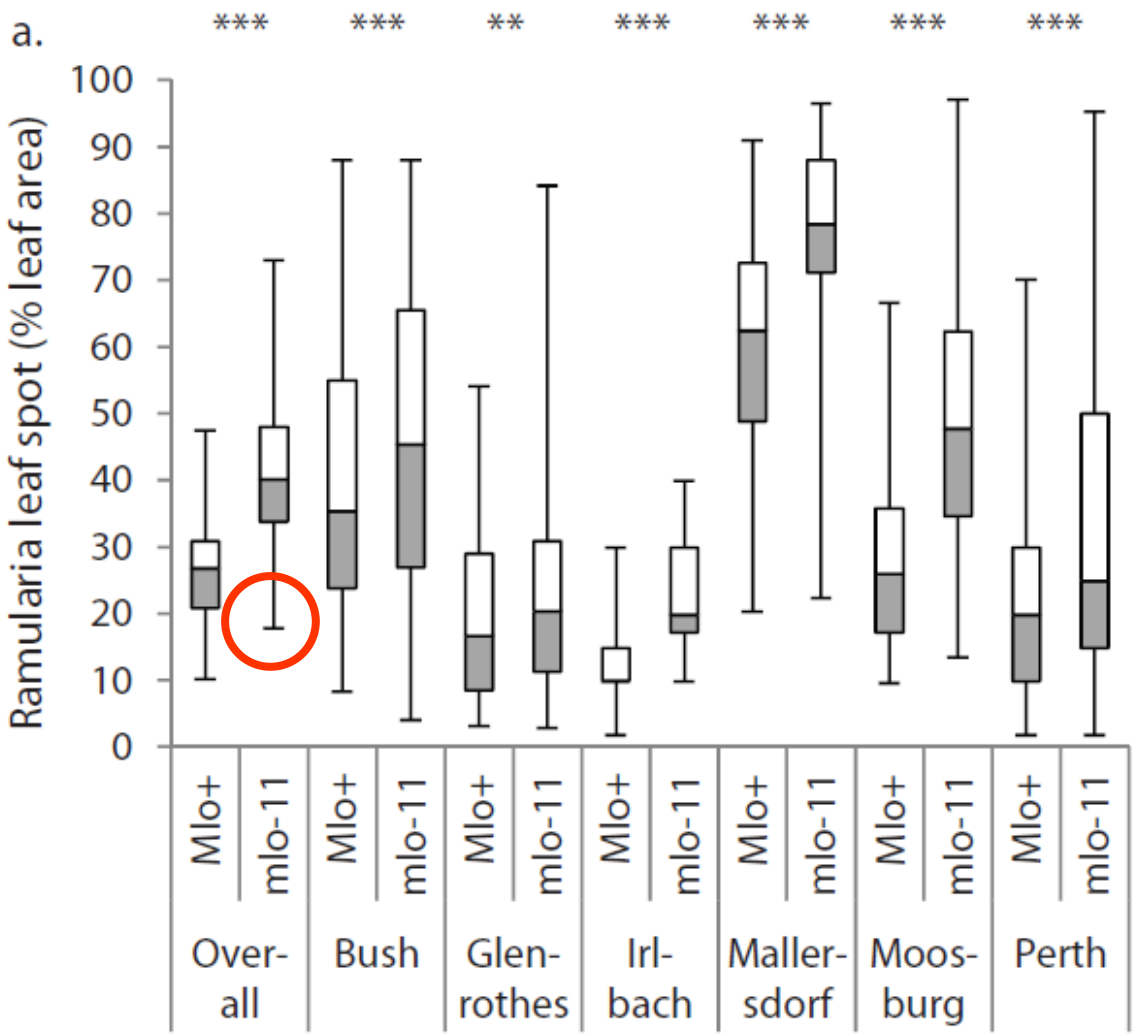
- Important disease of barley since 1998
- Late season disease: losses of grain size and quality
- Early research: all very susceptible varieties had *mlo*



Graham McGrann et al. 2014, Journal of Experimental Botany

Effect of *mlo* on *Ramularia*

- Power (Ramularia-resistant) x Braemar (Ramularia-susceptible, *mlo*)
- 6 trials, Germany & Scotland, 2012
- On average, *mlo* increased Ramularia
- Variation in *Ramularia* in *mlo* lines
- **Can select lines in which cost of *mlo* is mitigated**



Trade-offs of disease resistance

- There are trade-offs between resistances to different types of disease
  - Breeders cannot maximise resistance to all diseases
- & trade-offs between reduced disease and yield
  - Traits which increase disease escape by reducing transmission of spores within the crop are detrimental to plant architecture and physiology
- Need for compromise, balance & judgement
  - To mitigate trade-offs & produce excellent varieties
  - It can be done: apparently no yield penalty of partial resistance to mildew in UK wheat breeding
  - “Silver bullet” genes rarely have long-term benefits

A Darwinian view of plant breeding

High genetic **diversity**

+

Effective **selection**

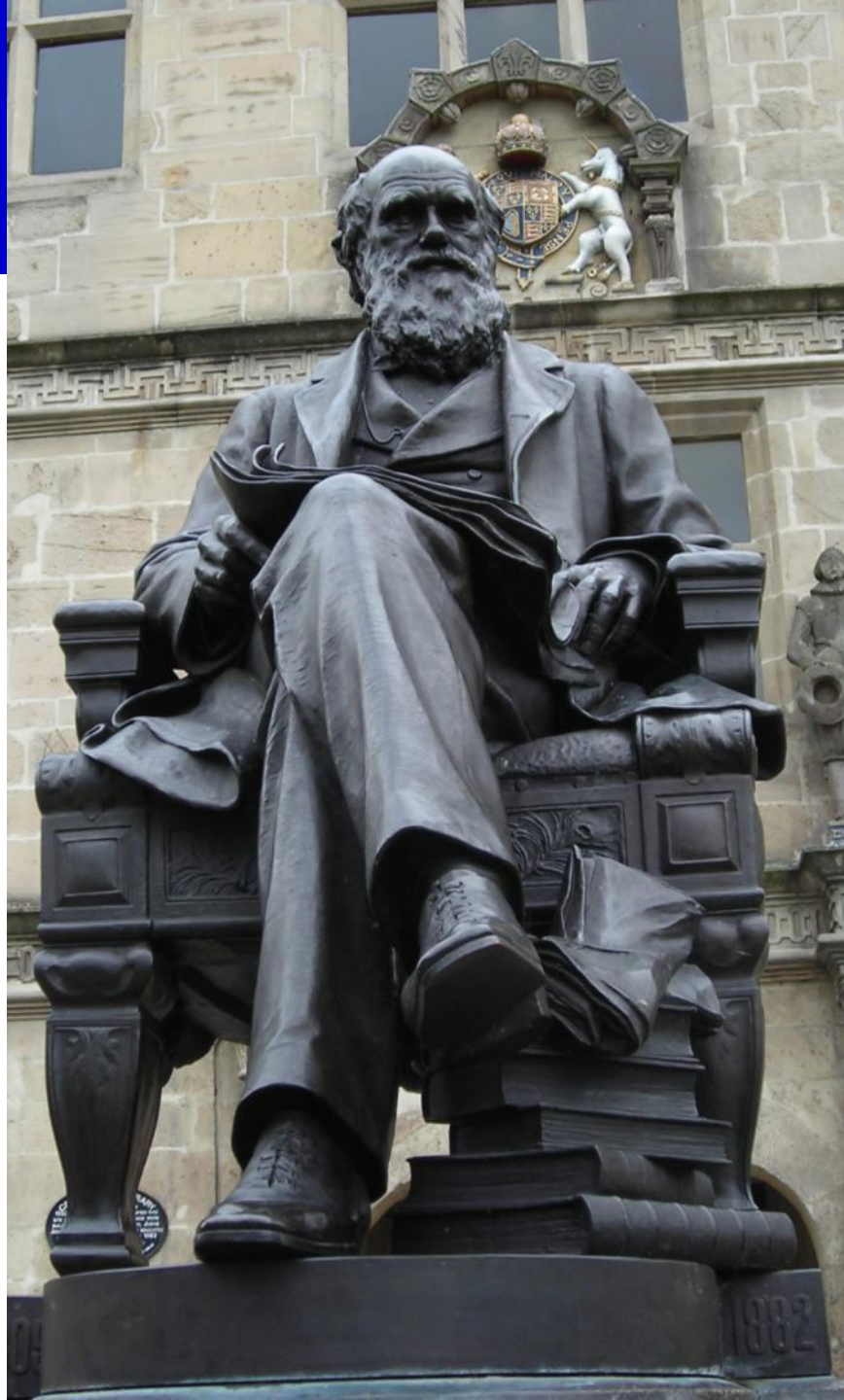
+

Efficient breeding (**inheritance**)

↓

Varieties with optimal balance of traits in a given environment

Require more investment in selection technology as well as genetics



Can genetics mitigate the loss of fungicides against crop diseases? (Including Septoria)

- **Yes** – eventually, if breeders & farmers aim for steady progress rather than 'quick hits'
  - Ensure diversity in breeding germplasm
  - Investment in selection needs to catch up with genetics
  - Select for resistance + yield + quality +… to mitigate trade-offs
- Think of increasing durable resistance in germplasm rather than releasing individual resistant varieties
- Perfect disease resistance may be neither necessary nor beneficial
- *NL and RL ratings should encourage sustainable advances in all-round disease resistance*

Acknowledgements

- ***mlo* / Ramularia**
  Graham McGrann *Now at Scottish Rural Colleges*
  Anna Stavrinides, Joanne Makepeace, Paul Nicholson, Chris Burt, Andy Steed, Laetitia Chartrain
- **Septoria / biotrophs**
  Anuradha Bansal (*Monsanto Beachell-Borlaug International Scholarship*)
  Meluleki Zikhali, Elizabeth Orton, Mags Corbitt
  Morten Lillemo *Norwegian University of Life Sciences*
- **Septoria / yield**
  Chris Judge, Ben Gibson, Lottie Robertson
  John Snape, Cristóbal Uauy, James Simmonds
- Plant breeding companies:
  Agrii, Elsoms, KWS, Lantmännen, Limagrain, LSPB, RAGT, Saaten-Union, Secobra, Sejet, Syngenta