Impact of climate change on diseases of UK winter oilseed rape

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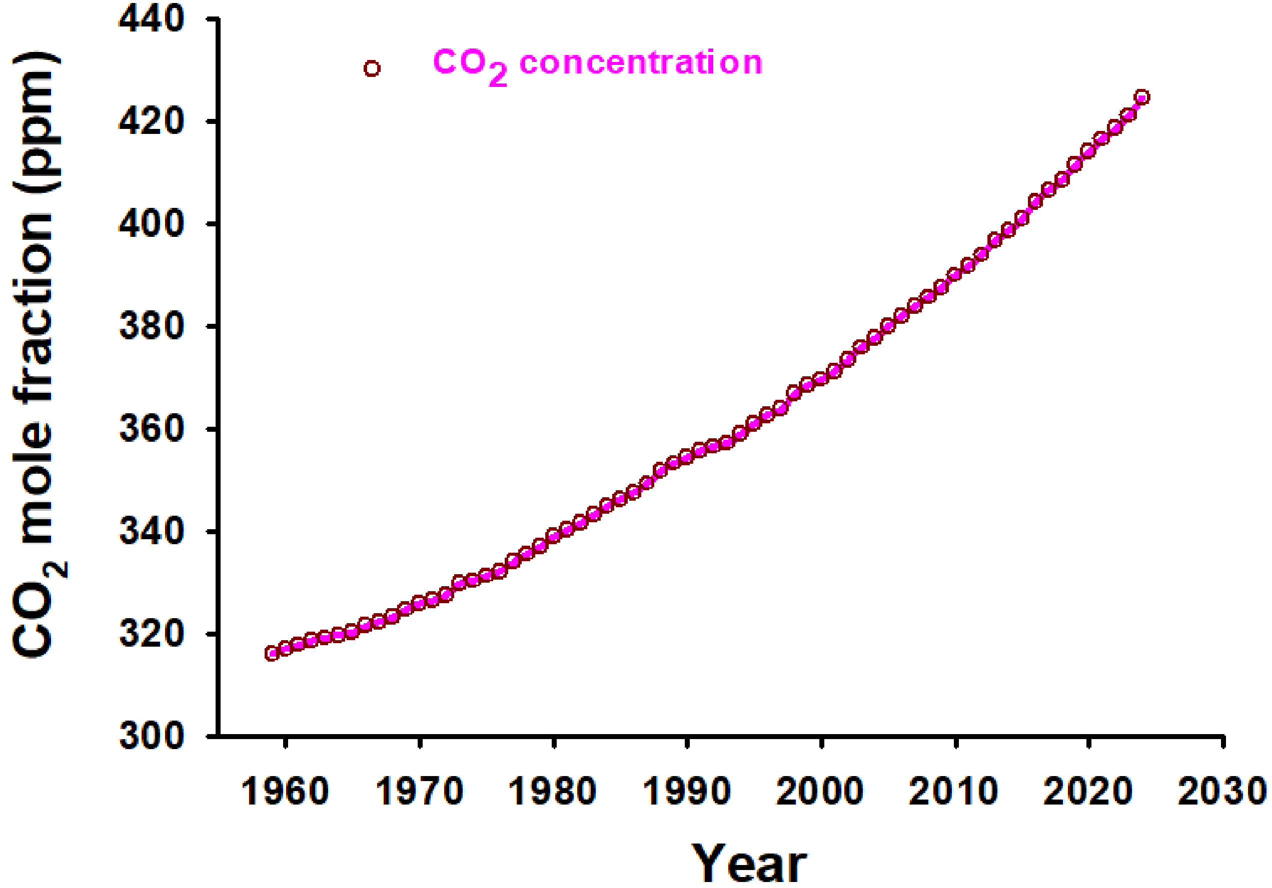
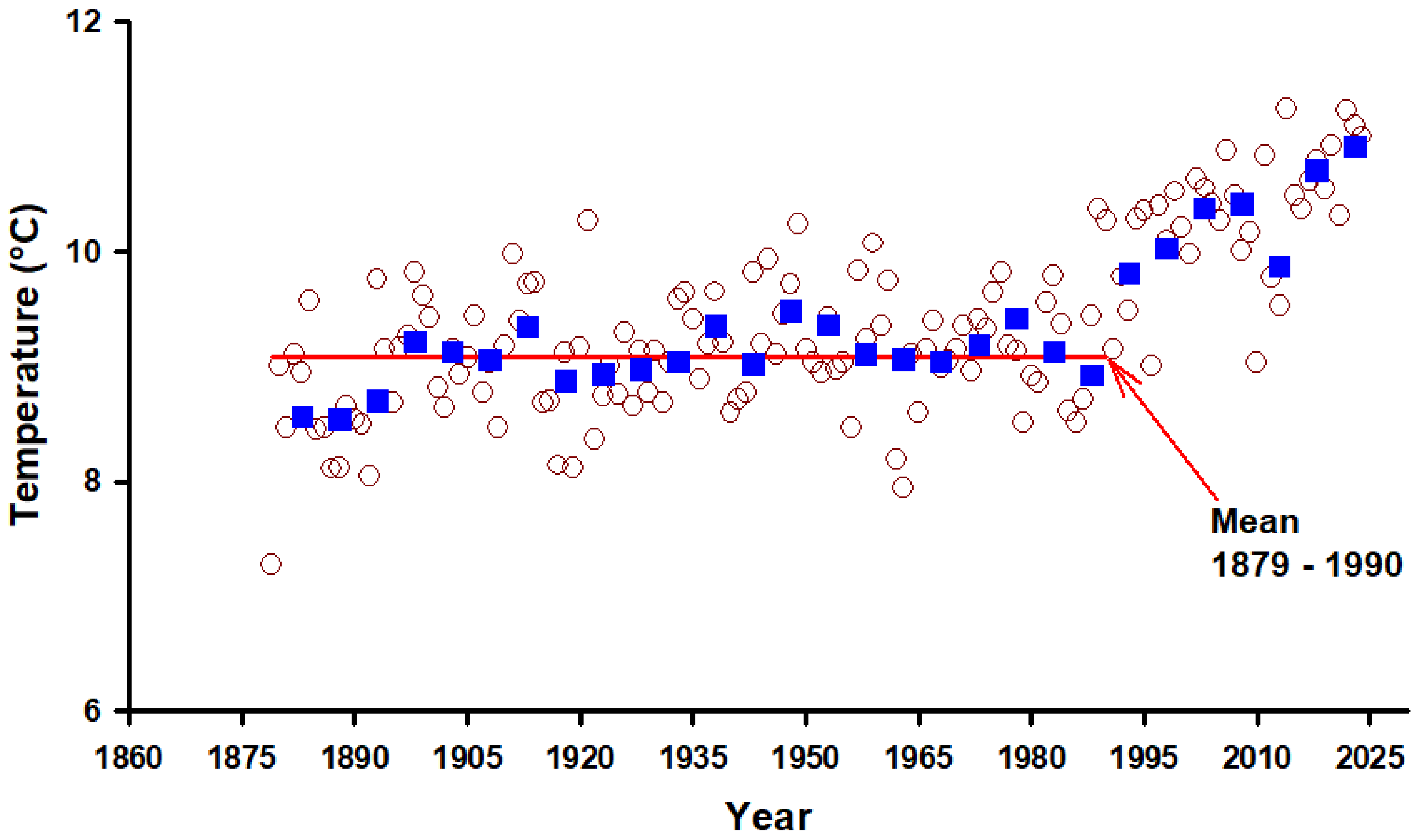
Climate change - Increased CO_2, increased temperature

Annual CO_2 atmospheric concentration (1959 – 2024)
measured at Mauna Loa Observatory, Hawaii, USA

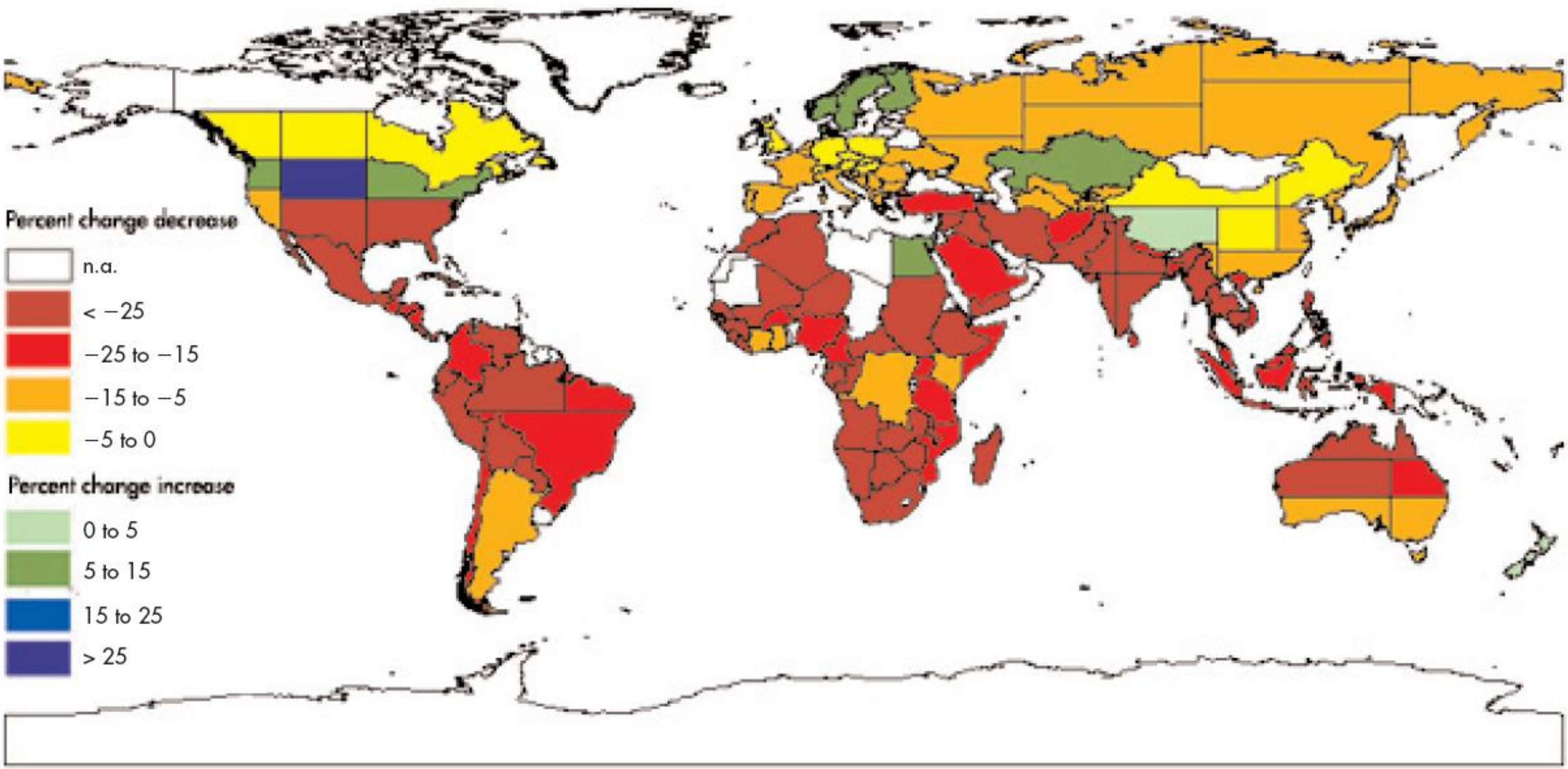


Climate change - Increased CO_2, increased temperature

Annual mean air temperature (1879 – 2024) and five-year moving averages at Rothamsted, Harpenden, UK



Climate change threatens food security



Impacts of climate change on agricultural productivity by 2080s

Cline WR (2007), Global warming & agriculture; impact estimates by country

Crop diseases threaten food security

Crop losses to diseases decrease world food production, despite crop protection

Diseases, pests, weeds etc.	Actual crop losses (with crop protection)		Potential crop losses (without crop protection)	
	Mt	£bn	Mt	£bn
Rice	28	85	58	176
Wheat	21	35	38	62
Maize	36	56	46	72
Potato	15	28	28	53
Soya	26	19	60	44

Richard et al., 2022, Plant Path 71,187-206

Important diseases of oilseed rape

Clubroot

Verticillium

Light leaf spot

Phoma stem canker

Sclerotinia stem rot

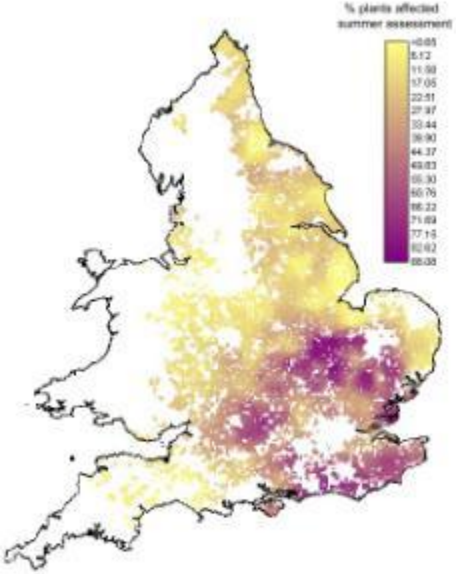
Alternaria leaf
& pod spot

Pathogens that cause these diseases

Plasmodiophora brassicae	Club root	Obligate biotroph	Intracellular
Verticillium longisporum	Verticillium	Hemibiotroph	Extracellular/ Intracellular
Pyrenopeziza brassicae	Light leaf spot	Hemibiotroph	Extracellular
Leptosphaeria maculans	Phoma stem canker	Hemibiotroph	Extracellular
Sclerotinia sclerotiorum	Stem rot	Nectrotroph	Kills cell in advance
Alternaria brassicae	Leaf and pod spot	Nectrotroph	Kills cell in advance

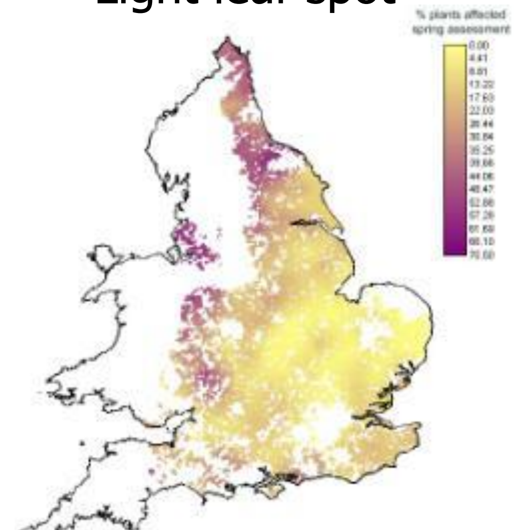
Distribution differs between main UK oilseed rape diseases

Phoma stem canker



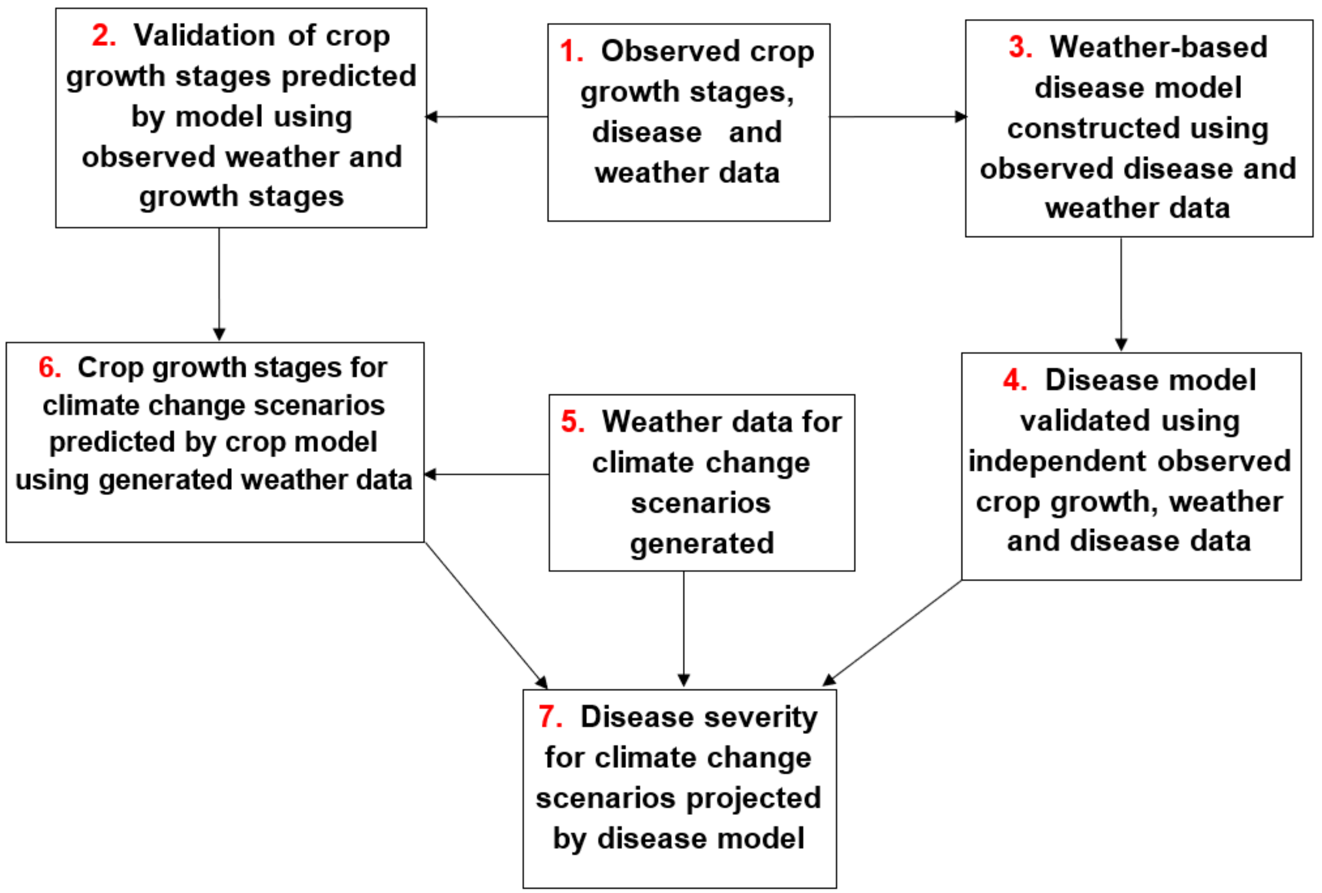
Defra oilseed rape pest and disease survey; ADAS https://www.pestanddiseasesurvey.co.uk

Light leaf spot



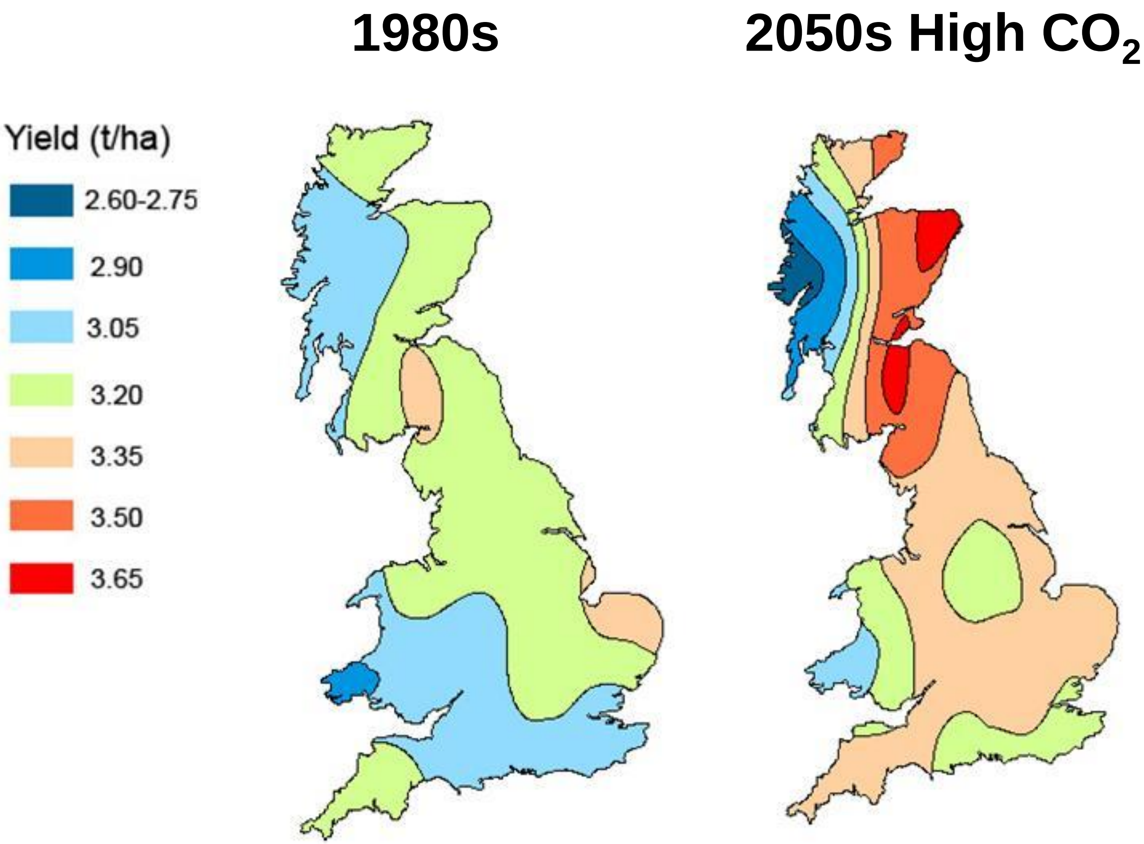
£150M losses annually
Most severe in North

Projecting impacts of climate change on oilseed rape diseases



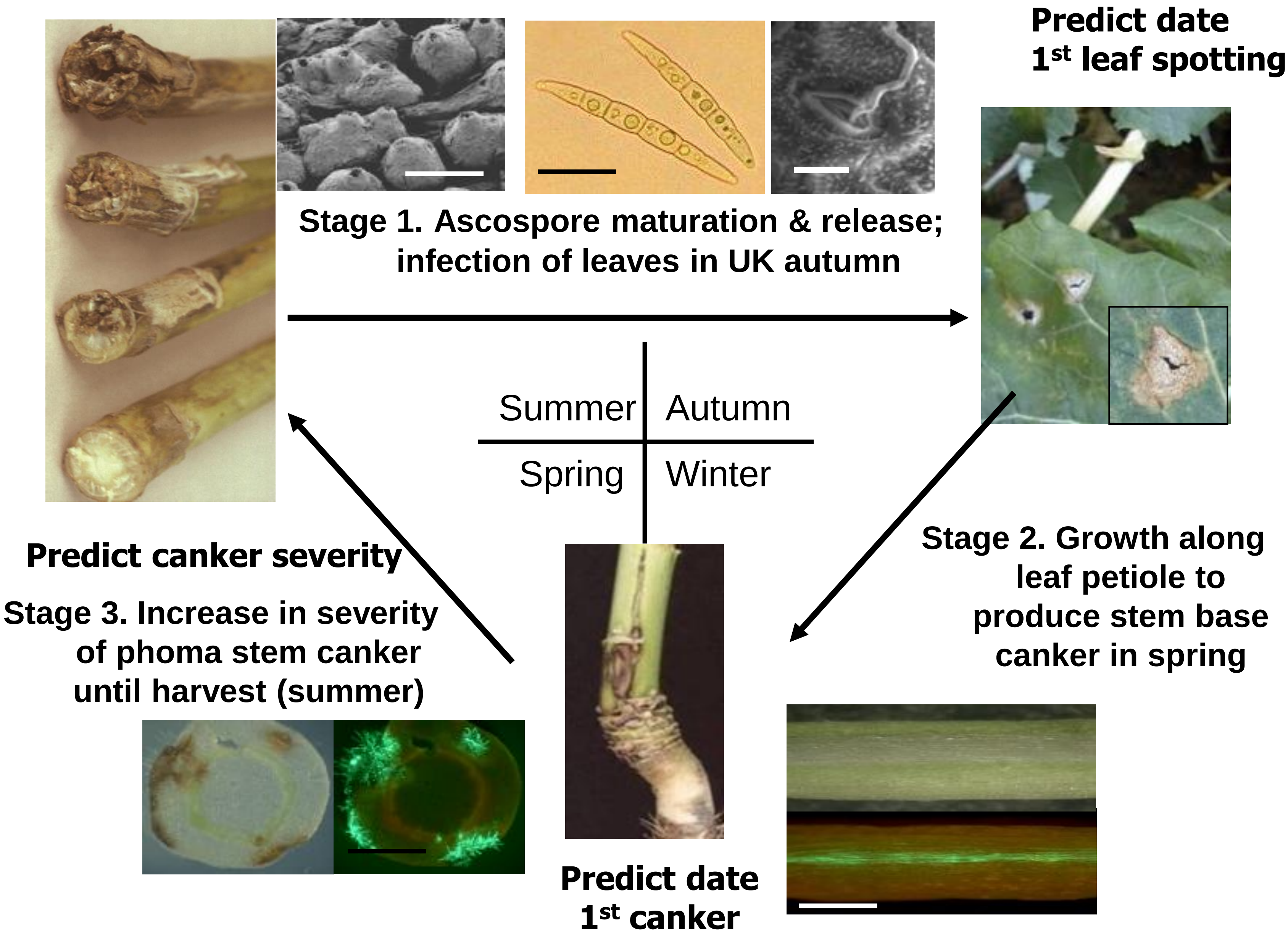
Climate change projected to increase yields of winter oilseed rape (if disease controlled), especially in Scotland

- Combined climate & crop models
- Yields greatest in Scotland



Butterworth *et al*., 2010, J. Roy. Soc Interface 7, 123-130

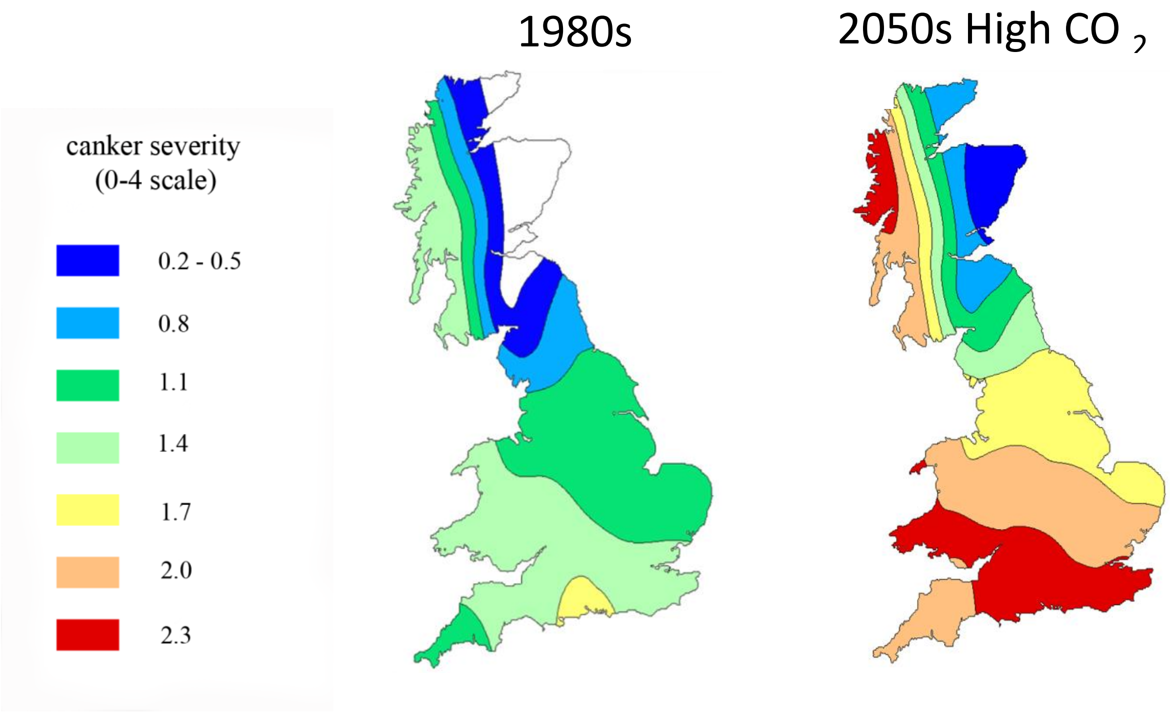
Phoma stem canker (monocyclic disease) 3-stage weather-based model



Evans et al. (2008) J Royal Soc Interface 5, 525–531

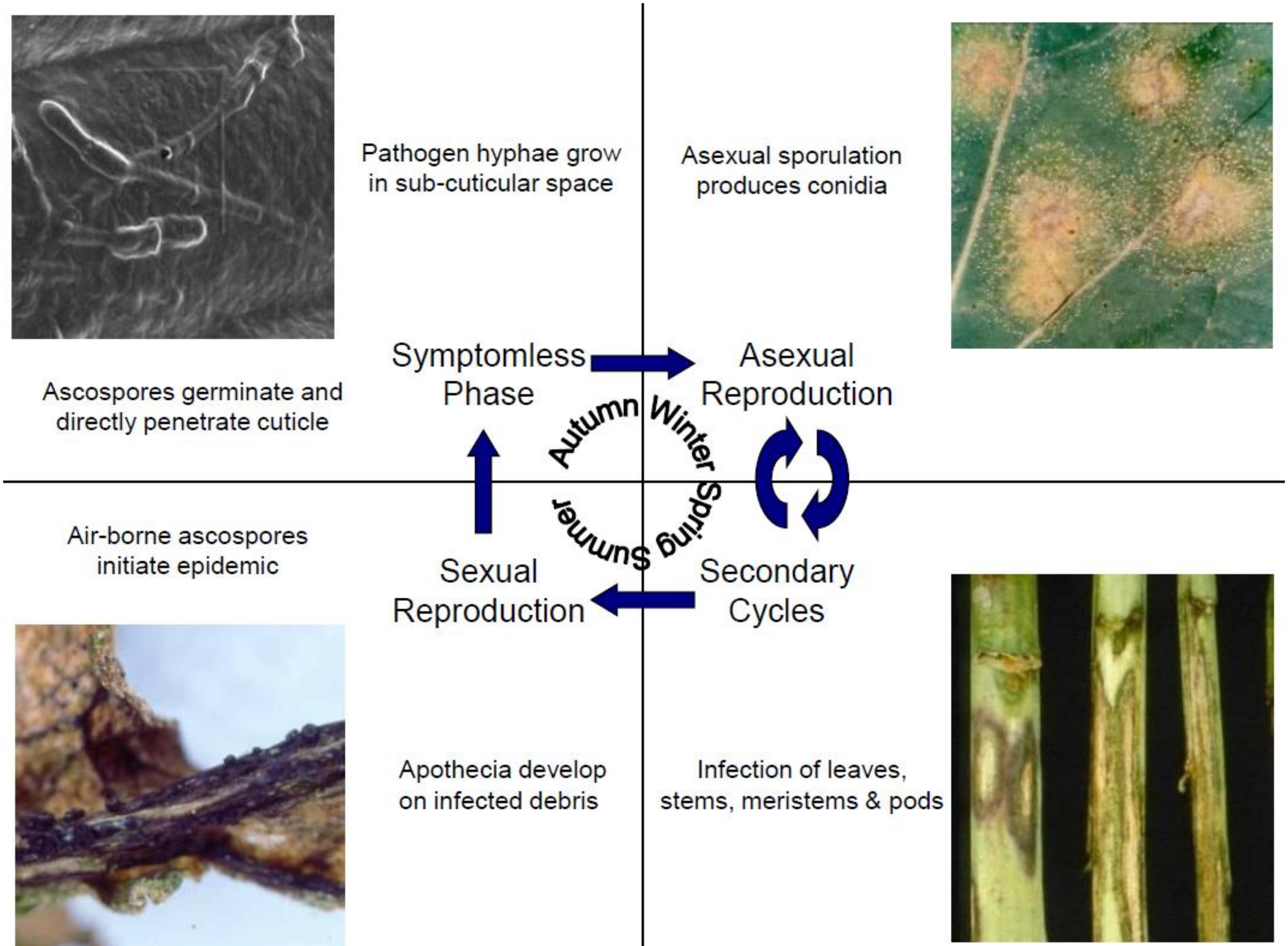
Climate change projected to increase range and severity of phoma stem canker

- Projected weather for climate change scenarios inputted into weather-based phoma stem canker model
- Severity of stem canker for cultivars with average resistance



Evans et al. (2008) J Royal Soc Interface 5, 525–531

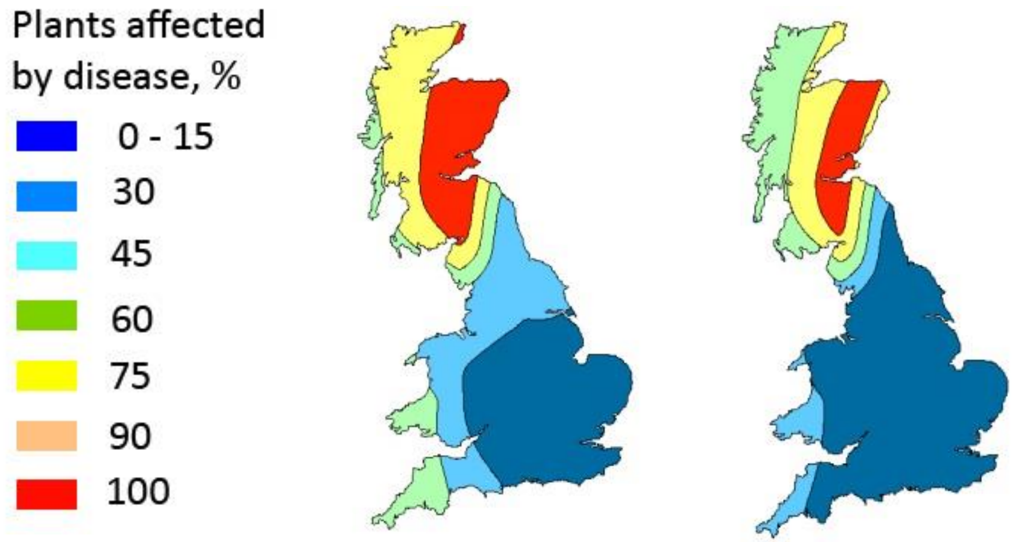
Light leaf spot is a polycyclic disease



Climate change projected to decrease incidence of light leaf spot

- Projected weather for climate change scenarios inputted into weather-based light leaf spot model
- Incidence of light leaf spot for cultivars with average resistance

1980s   2050s High CO_2



Evans et al. (2010) Food Security 2, 143–156

Observations

- Contrasting impacts of climate change on different oilseed rape diseases
- Climate change may affect oilseed rape resistance to pathogens
- Climate may affect competition between pathogens
- Climate change (e.g. increased temperature) may directly affect pathogen growth

Major gene *Rlm6* mediated resistance to *L. maculans* is temperature-sensitive

Cultivar Darmor

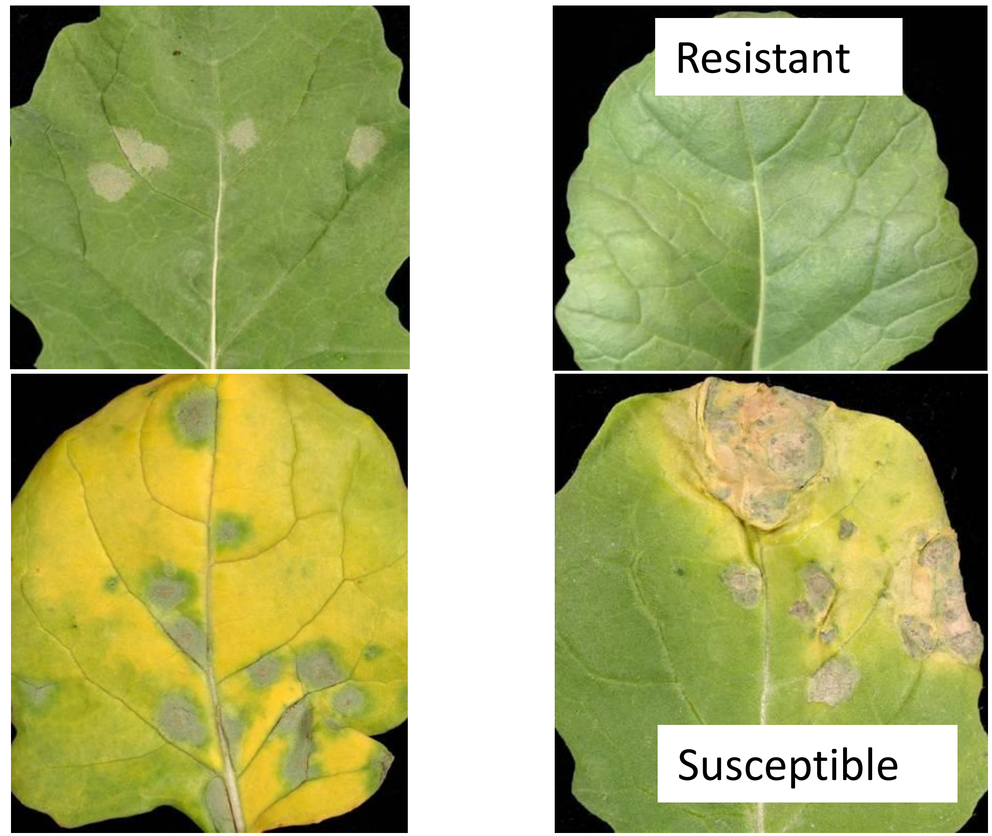
DarmorMX (*Rlm6*)

15°C

16 days

post inoculation

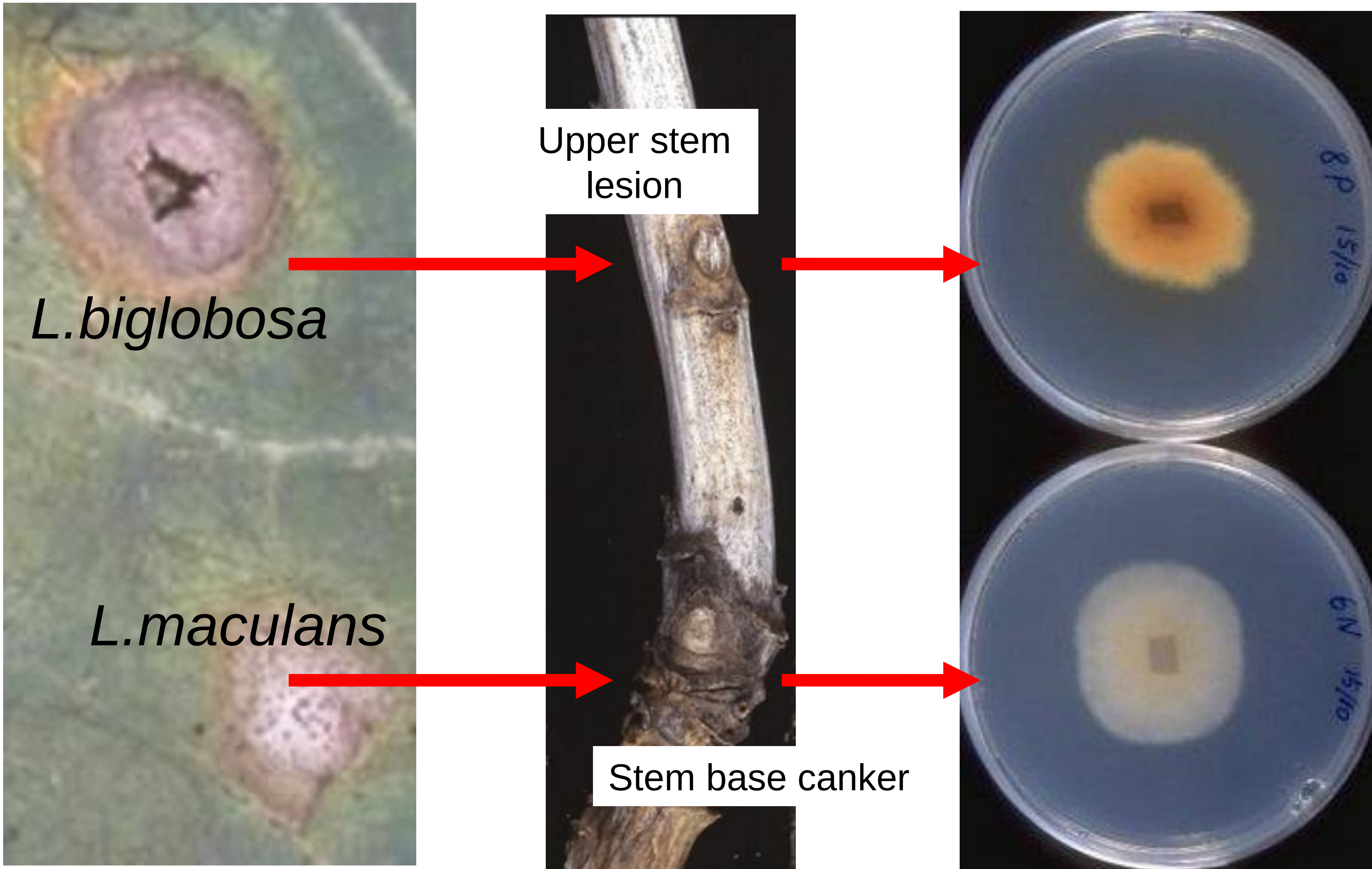
25°C



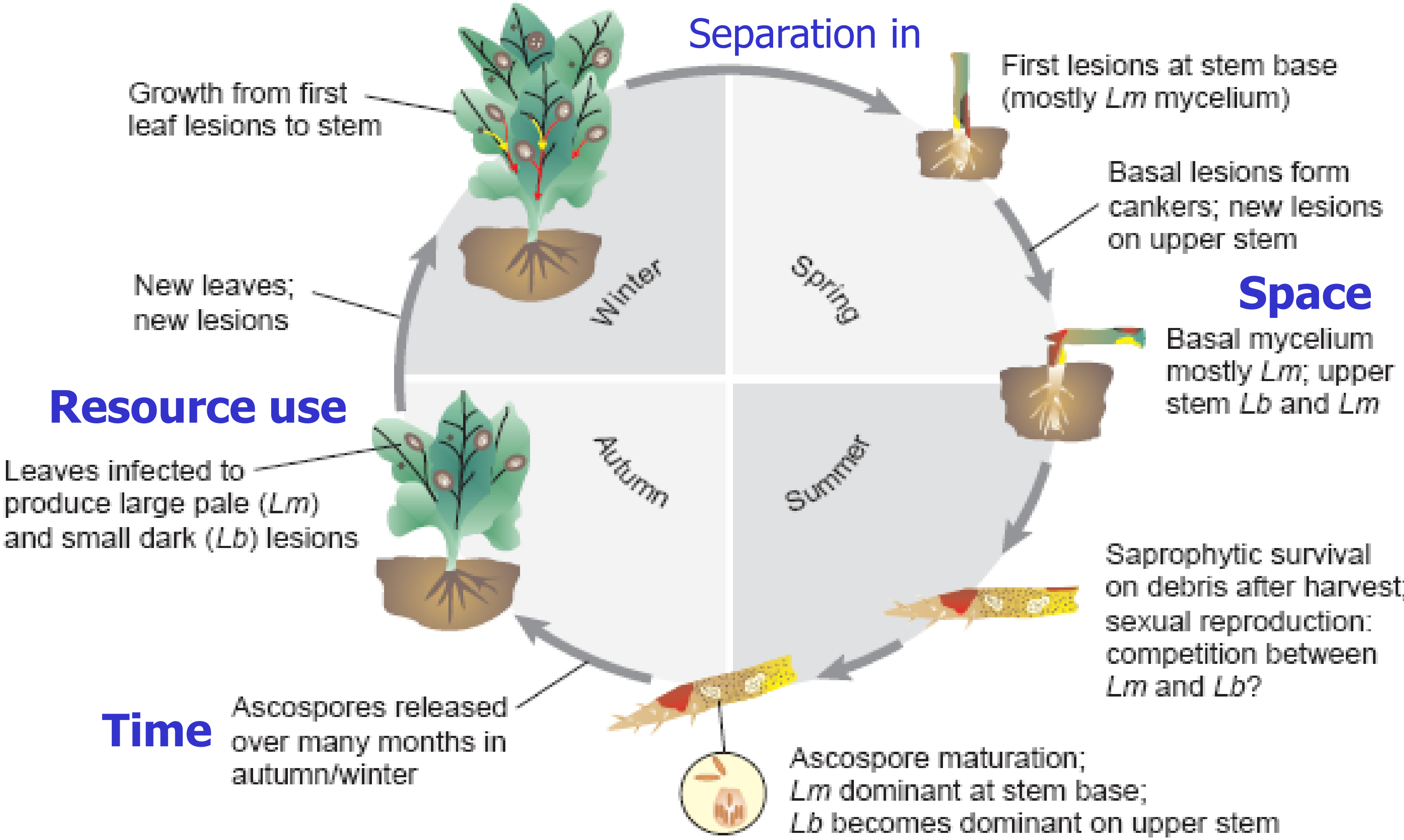
Near-isogenic-lines (INRA Rennes)

Huang et al., 2006, New Phytologist 170, 129-141

Phoma stem canker;
co-existing pathogens in UK oilseed rape crops



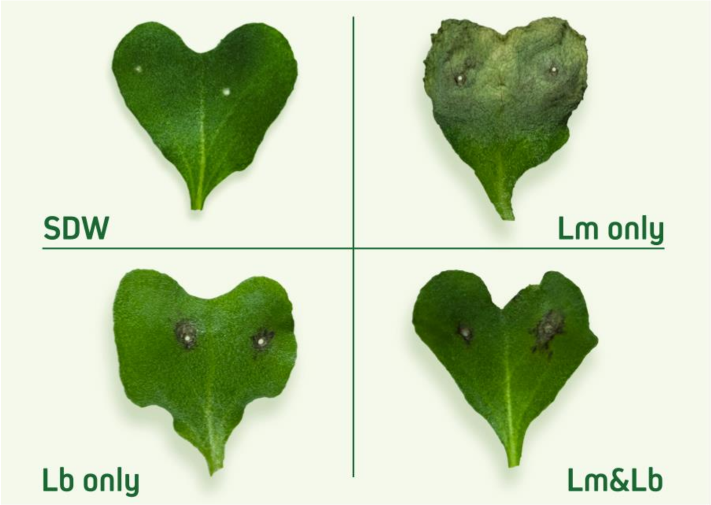
Co-existence of *L. maculans* (Lm) & *L. biglobosa* (Lb)



Fitt et al, 2006, Ann. Rev. Phytopath. 44, 163-82

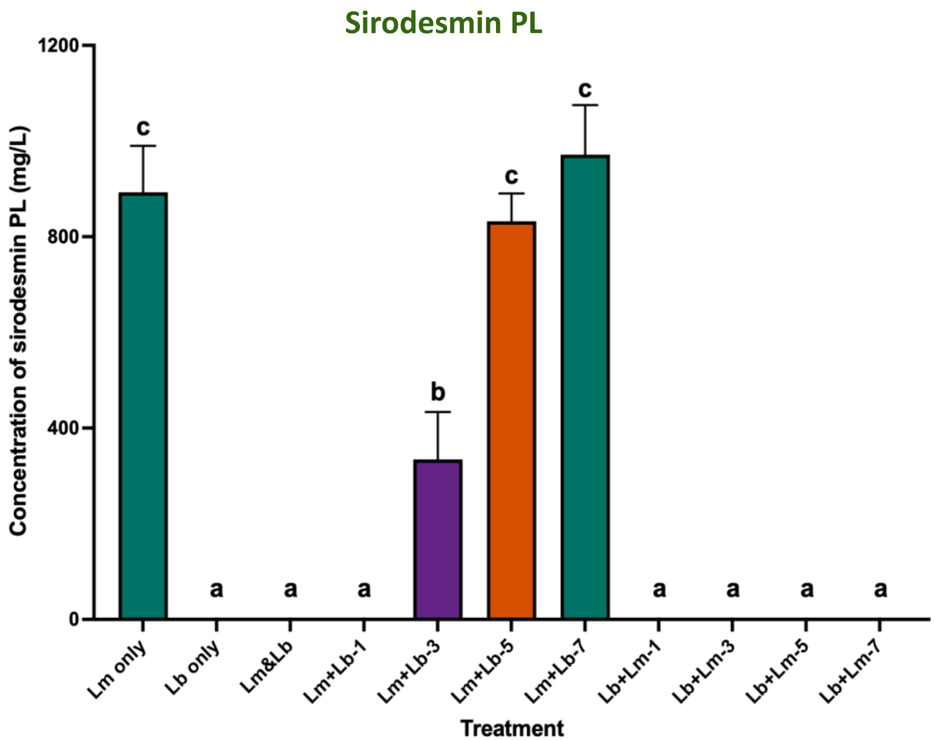
Competition between *L. maculans* (Lm) and *L. biglobosa* (Lb)

- *Lm produces a non-host selective phytotoxin sirodesmin*
- *Lb does not produce sirodesmin*
- *Lb can inhibit production of sirodesmin by Lm when Lm&Lb simultaneously co-inoculated*
- *Lb can inhibit Lm growth when Lm&Lb simultaneously co-inoculated*



Fortune et al. (2024) Pest Management Science 80, 2416-2425;

Production of sirodesmin – sequential inoculation



No production of sirodesmin if Lb is inoculated before or up to 1 day after Lm

Lm&Lb: co-inoculated simultaneously

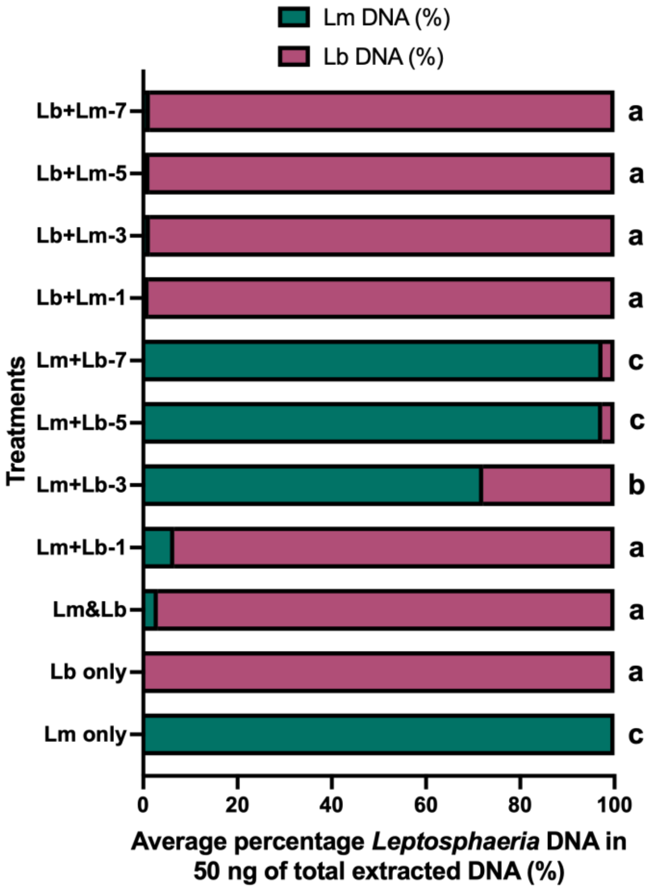
Lm + Lb-1, 3, 5, 7: Lm first, followed Lb at 1, 3, 5, 7 days later

Lb + Lm-1, 3, 5, 7: Lb first, followed Lm at 1, 3, 5, 7 days later

Bingol et al. (2024) Pest Management Science 80, 2443-2452.

Lm and Lb growth– sequential inoculation

- **No Lm growth if Lb is inoculated before Lm**
- **Some Lm growth if Lb is inoculated 3 days after Lm**
- **No/little Lb growth if Lm inoculated 5 or 7 days before Lb**

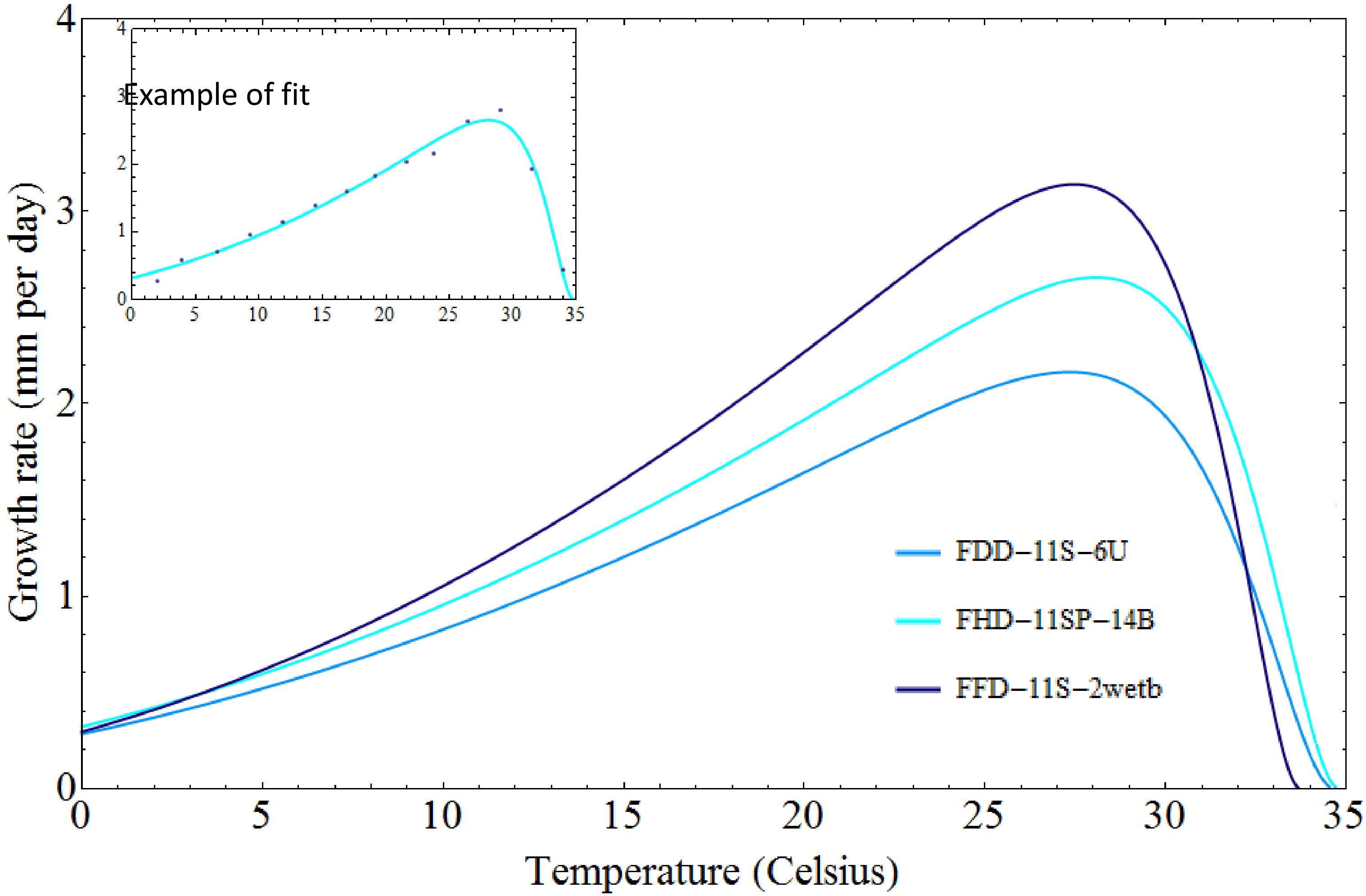


Bingol et al. (2024) Pest Man Sci 80,2443-2452.

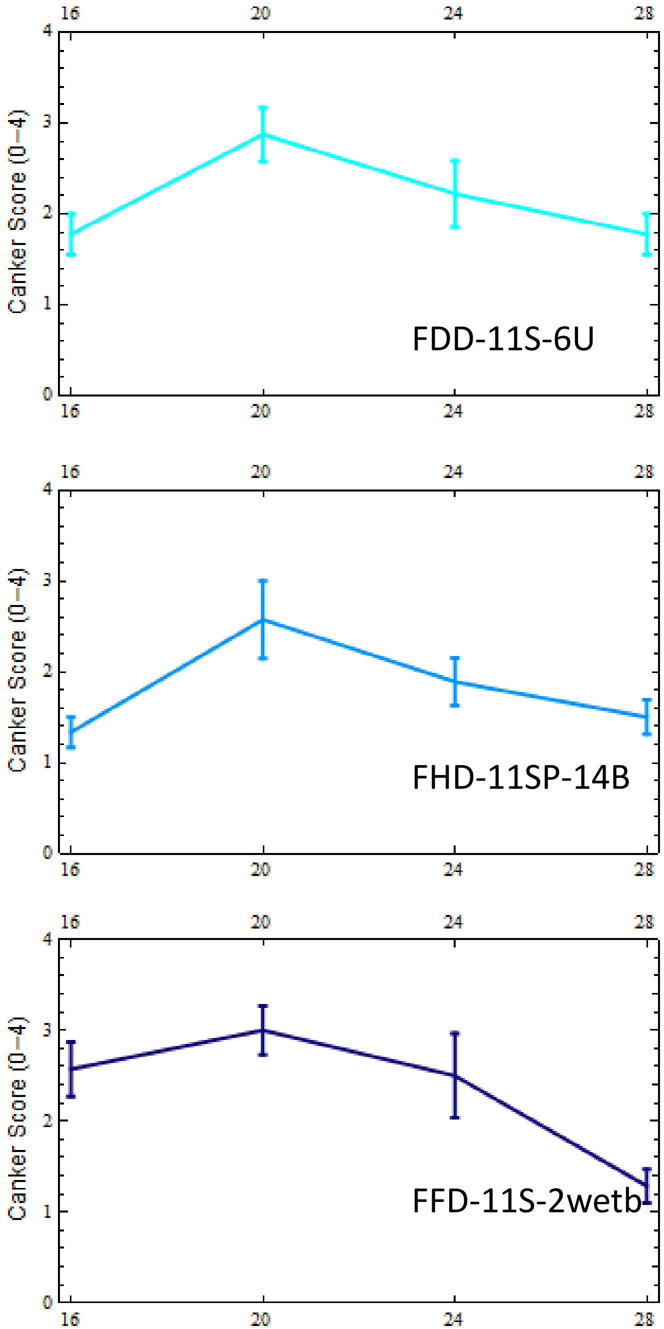
***L. maculans & L. biglobosa* differ in optimal temperatures for growth; climate change may affect competition**

Uncertainty in climate change projections

In vitro Leptosphaeria maculans temperature response (optimum 28°C)



Newbery et al. (2020). Plant Pathology **69,** 1469-1481



In planta phoma stem canker score temperature response (optimum 20°C)

Newbery et al. (2020). Plant Pathology **69,** 1469-1481.

Conclusions

- Climate change projections can provide a basis to guide government and industry planning for adaptation to impacts of climate change on crop diseases to ensure future food security.
- Need to breed new oilseed rape cultivars with temperature-resilient resistance against pathogens

Acknowledgements

- Collaborators

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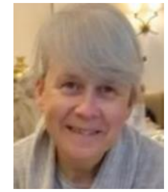


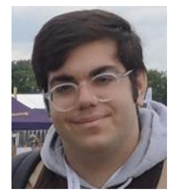



- Funding

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AHDB CEREALS & OILSEEDS
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Perry FOUNDATION
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Elsoms The Seed Specialists