Challenges for increasing crop productivity:
Farmer & scientist solutions

by

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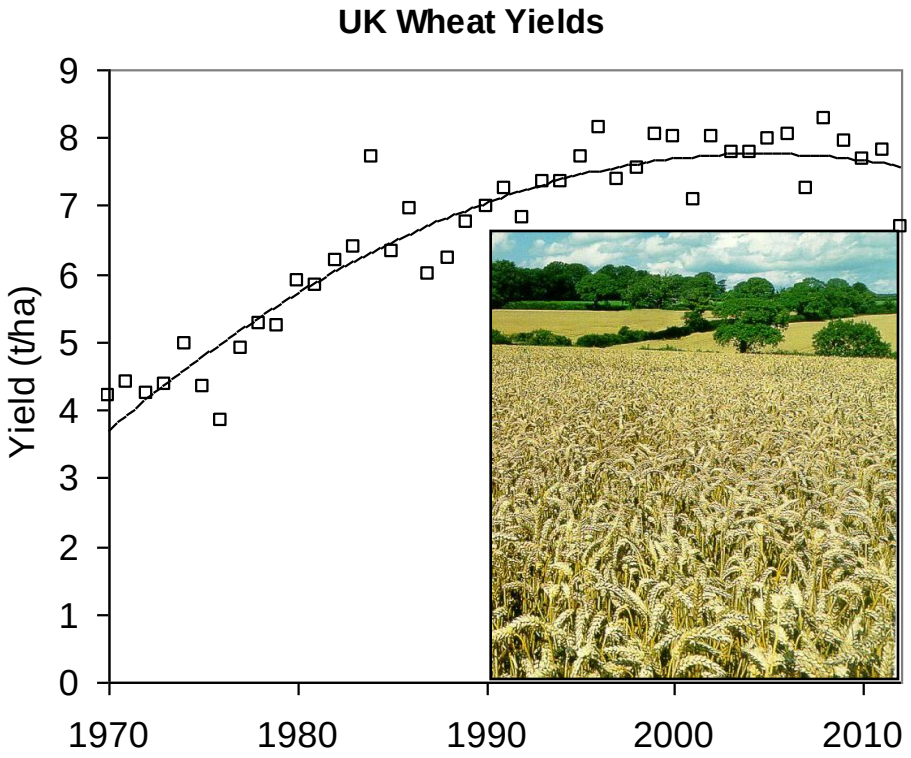
Background

- Increasing demand for food, feed & fuel
- Requirement for smaller environmental impact
- Stagnating crop yields in many countries

Stagnating yields

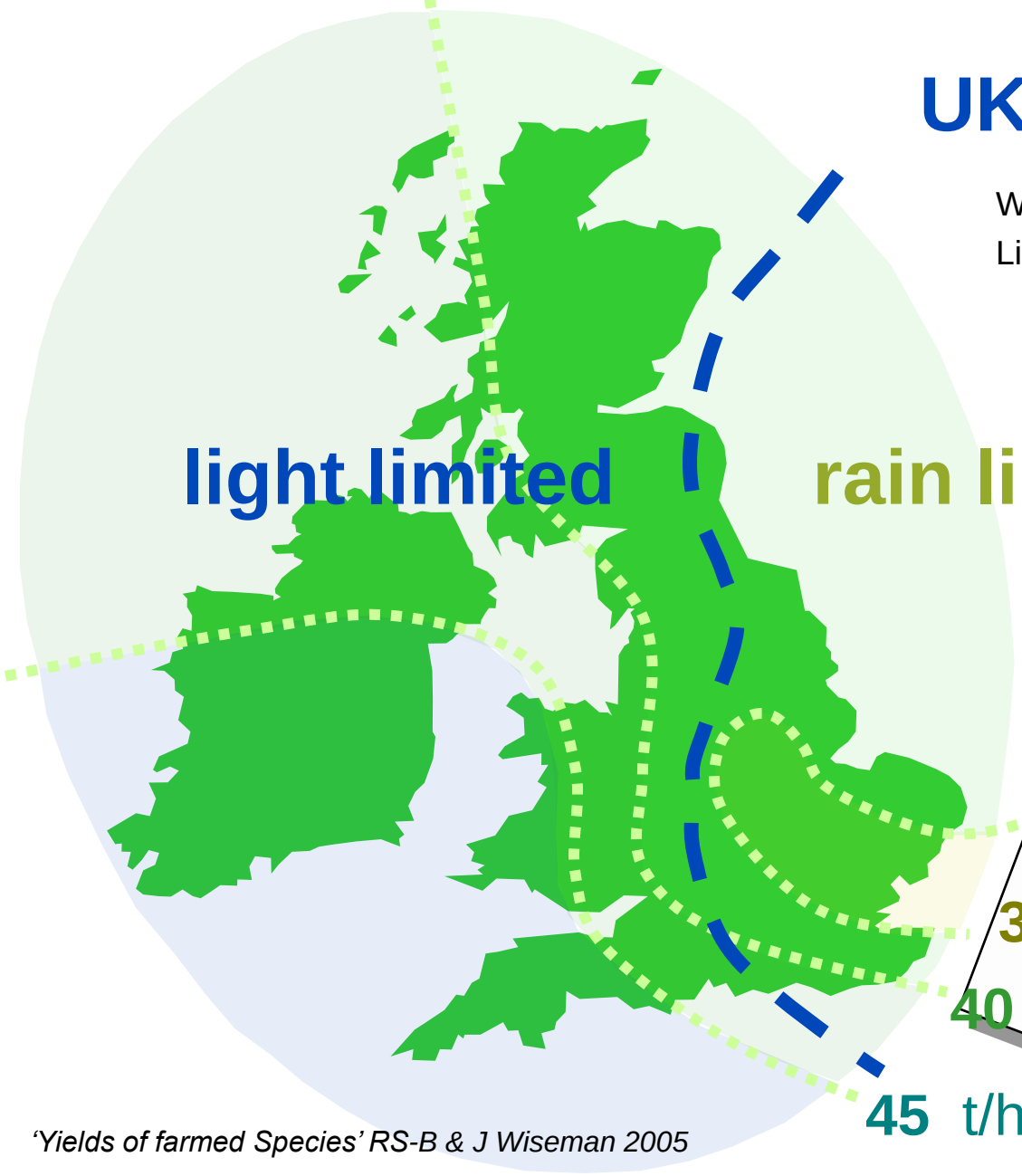
- Wheat yields stagnating in several countries:
- UK: Berry *et al.* 2011
- France; Brisson *et al.* 2010
- Denmark: Peterson *et al.* 2009
- Finland: Peltonen-Sainio *et al.* 2010

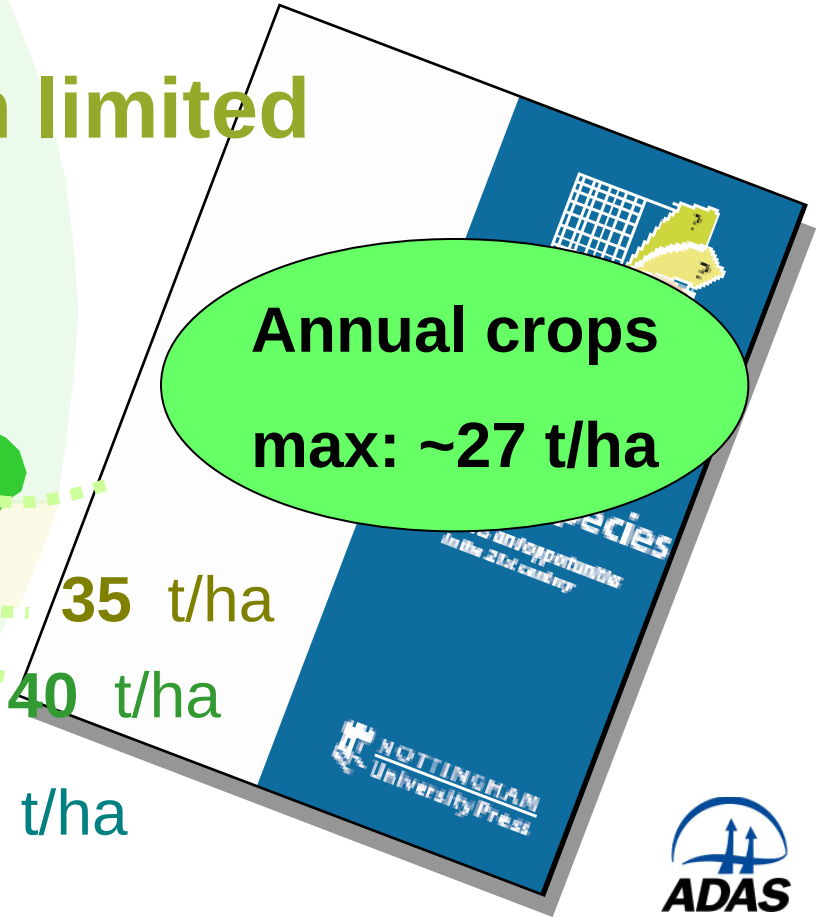


UK potential growth

Water conversion: 5 g DM litre^{-1}

Light conversion (PAR): 2.8 g DM MJ^{-1}





'Yields of farmed Species' RS-B & J Wiseman 2005

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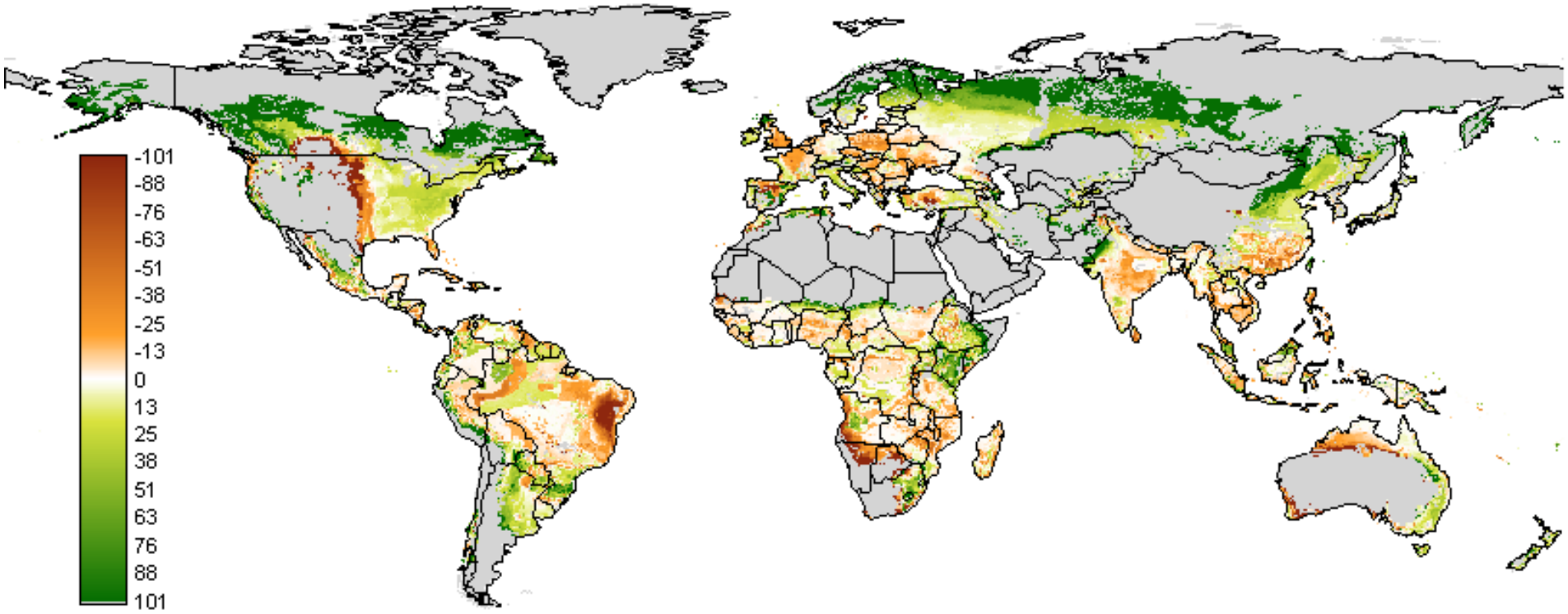
Climate change may constrain yield



Effect of climate change to 2080 on Production Potential of Rain-fed Cereals
http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm

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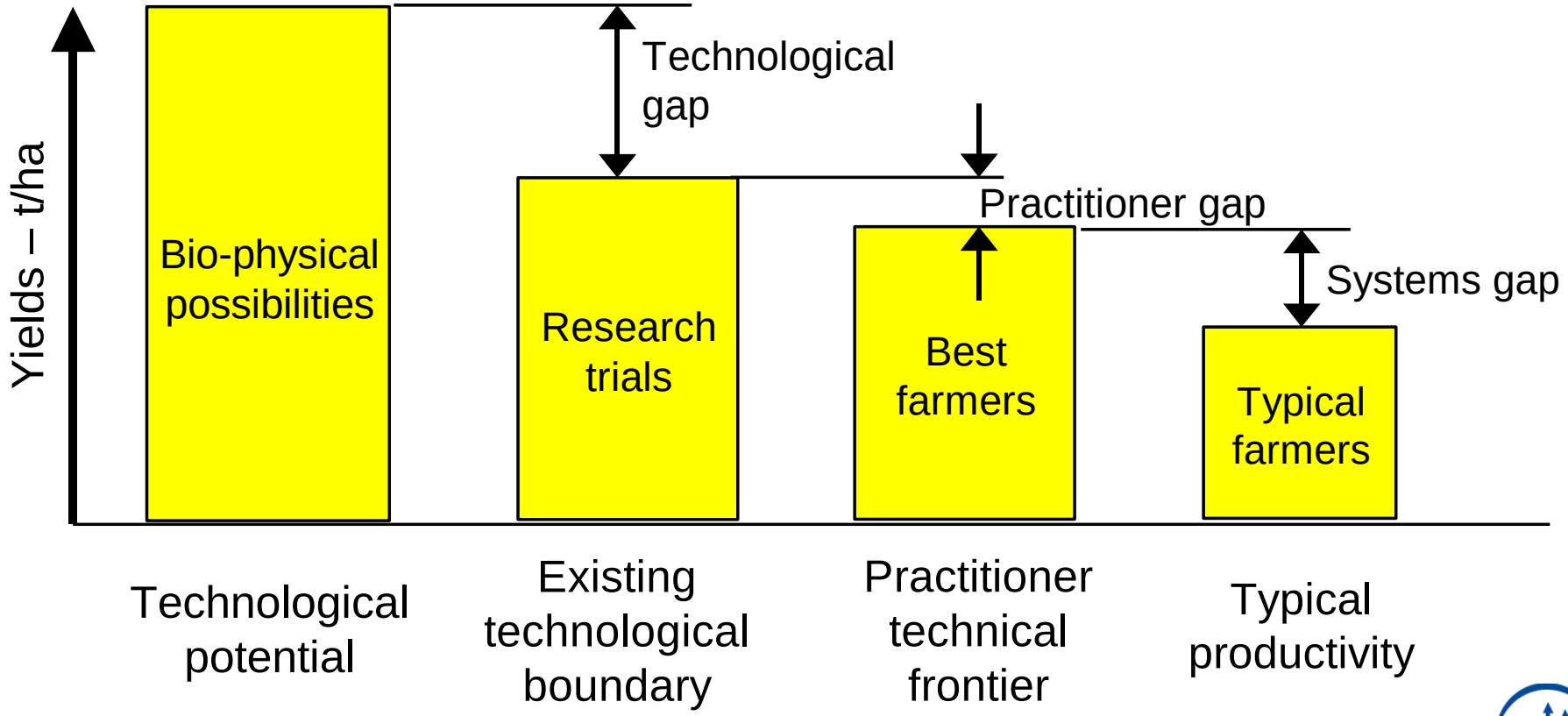
Yield gaps


Yields – t/ha
Bio-physical possibilities
Technological gap
Research trials
Practitioner gap
Best farmers
Systems gap
Typical farmers
Technological potential
Existing technological boundary
Practitioner technical frontier
Typical productivity

Target resources for 15 t/ha wheat

- **Grain yield (15% moisture)** **15 t/ha**
- **Total biomass** **21 t/ha**
  - @ 60% harvest index
- **Water for transpiration** **430 mm**
  @ 5 g DM litre^{-1}
- **Fertiliser N** *current technology* **430 kg/ha**
  - 11.5% grain protein (feed wheat)
  - 60% fertiliser N recovery

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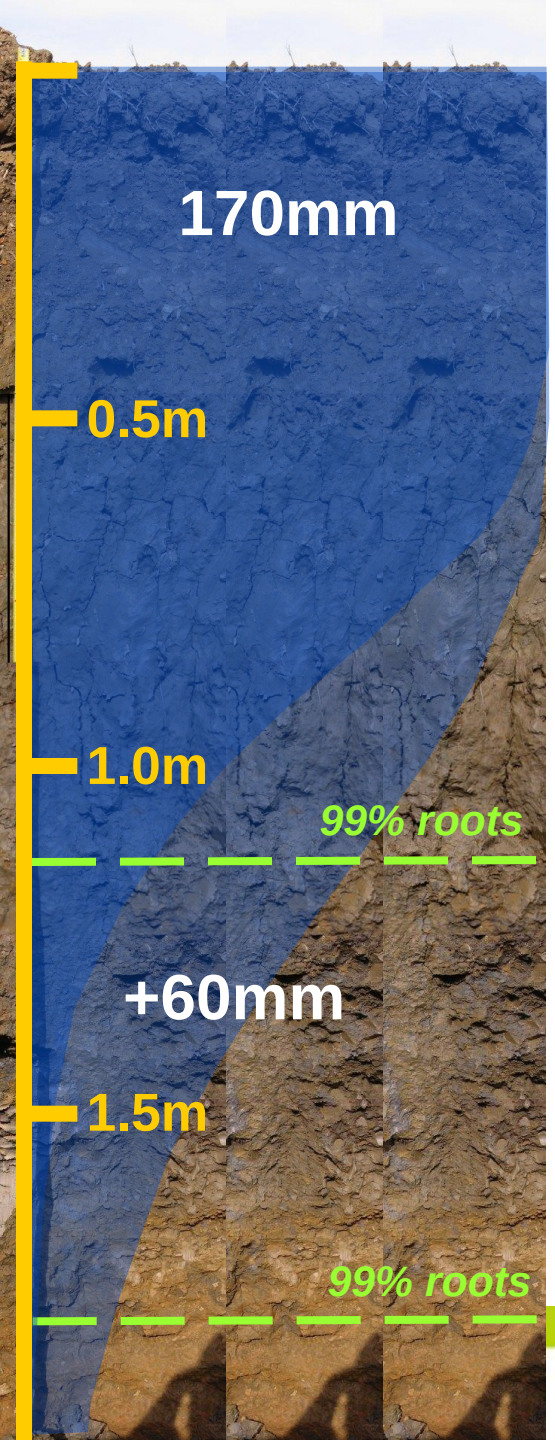

Rooting for 15 t/ha wheat

- **Summer crop water demand**
  - Minimum in summer for 15 t/ha grain 430 mm
  - Losses … soil evaporation 20 mm
- **Summer shortfall**
  - Average rain 220 mm
  - Extra requirement from soil 230 mm
- **Soil water storage**
  - Capacity *per metre* ~180 mm
  - Current water capture norm … *?* 170 mm
    = 99% roots reaching ~1.2 metres
  - New requirement 230 mm
    = 99% roots need to reach 1.8 m ***.. 0.6 m extra***
- **Alternatives:**
  - Irrigation .. or .. GO WEST *!*

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Soil compaction

- Soil compaction from heavier machinery
  - Increasing penetrometer resistance from 1 to 3 MPa reduced growth by 5 t/ha
- Restricted rooting
  - Reduced water uptake
  - Reduced nutrient uptake efficiency
- Water logging
  - 44-58 days water logging overwinter reduced yield by 20-24%

Whaley *et al. 2008*
Dickin & Wright, 2008

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High yields need large nutrient supplies

- **Wheat Nitrogen requirements**
  - Crop N demand 23 kg/tonne grain
  - Crop N demand @ 15 t/ha grain = 340 kg/ha
  - Normal soil N supply – 80 kg/ha
  - Crop N from fertiliser = 260 kg/ha
  - **Fertiliser N requirement at ~60% N recovery = 430 kg/ha**
  - **Current N fertiliser rate = 190 kg/ha**

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- **Phosphorus requirements** — ***as P_2O_5***
  - Crop P demand .. grain — 7.8 kg/tonne grain
  - Chaff, straw & stubble P — 1.3 kg/tonne grain
  - Crop P demand when yielding 15 t/ha grain — = 137 kg/ha
  - **Fertiliser P_2O_5 to maintain soil P** (straw incorp.) — **= 117 kg/ha**
  - **Current P_2O_5 fertiliser rate — = 60 kg/ha**

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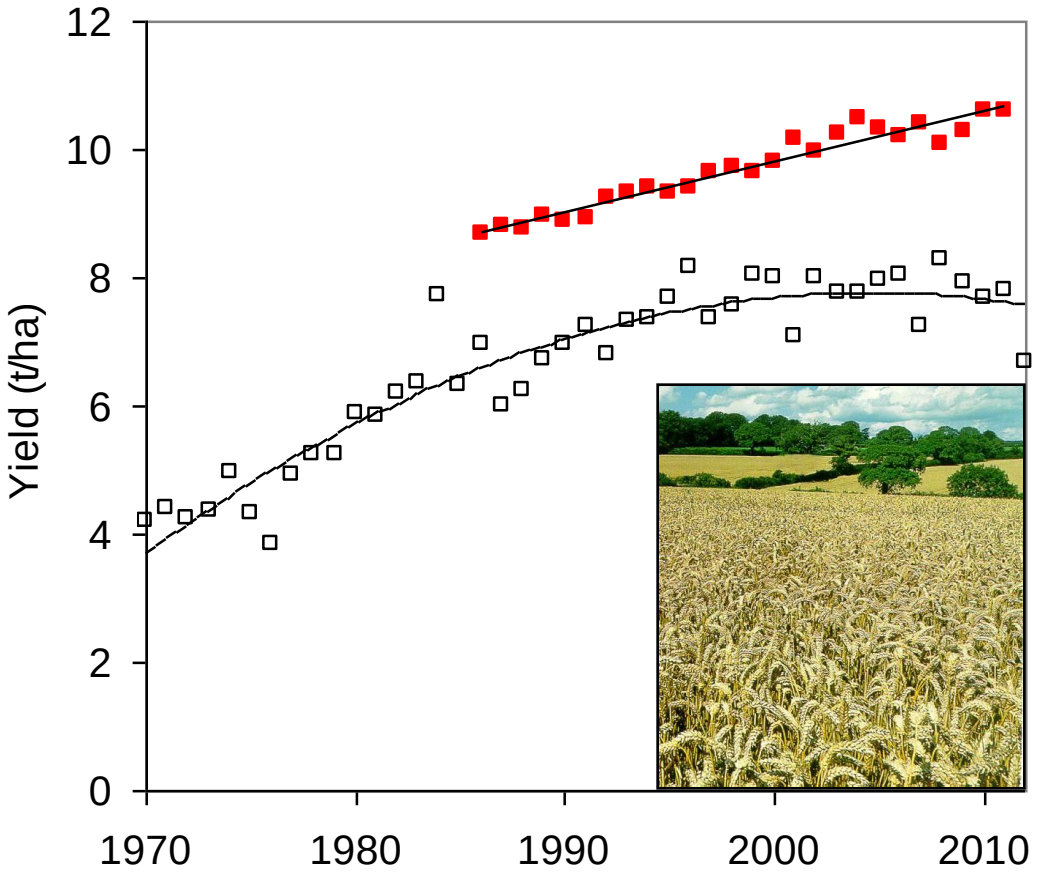
Weeds, disease & pests

- All
  - Pesticide insensitivity
  - Loss of active substances
- Weeds
  - Predict weed dynamics through rotation & effect of cultural controls
- Diseases
  - Durable genetic resistance
  - Take-all, eyespot, light leaf spot
- Pests
  - Sources of genetic resistance/tolerance

Priority challenges

- Prolong yield forming period
- Increase photosynthetic efficiency
- Improve water capture & use efficiency
- Improve nutrient use efficiency
- Protect against weeds, disease, pests

Solutions: Genetics?



Variety trial yields

Farm yields

Berry *et al.*, 2011
Mackey *et al*., 2011

Solutions for increasing yield

	Biotechnology & plant breeding	Chemistry	Engineering & IT	Farm systems & management

Solutions for increasing yield

	Biotechnology & plant breeding	**Chemistry**	**Engineering & IT**	**Farm systems & management**
Prolong seed fill Adapt to warming	**Modify day length & temp. responses** **Frost tolerance**	Growth hormones to delay maturity Prolonged nutrition	Machinery for early sowing	Logistics for early sowing
Greater photosynthesis	**Enhance rubisco**	Prolonged nutrition		

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Water capture	Greater rooting at depth	More roots using growth stimulators	**Soil management and irrigation**	Rain harvesting & water storage
Water conversion	**Greater harvest index** **High photosynthesis**	**Fungicides** Anti-transpirants		Wind breaks

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Nutrient conversion	**Reduce nutrient storage in crops**			**End-use quality requirement**

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Control of pest, weeds, disease	**Resistance to & tolerance of pest**	**Durable pesticides**	Monitoring & forecasting	Rotations, crop choice

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Farmer / scientist partnerships

- Farmer/Scientist interaction required to identify constraints & solutions
- Much innovation occurs on farms
  - E.g. engineering & farm systems
- Initiatives required to stimulate **interaction**, **innovation** and **knowledge exchange**

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Yield Enhancement Network

Yield Enhancement Network

Aims:

- **To identify Arable Innovators**

  and

- **Support their innovating**

First year, 2013:

- **Cereal Yield Contest … open to anyone**
  - Highest Grain Yield
  - Highest % of Potential Yield

Ultimately …

- **A platform for industry-research synergy**

Summary

- **Climate change** may make high yields harder to achieve

- **Key challenges**
  - Prolong yield forming period & rate of photosynthesis
  - Water: capture more & use efficiently
  - Nutrient use efficiency
  - Protect against weeds, disease, pests

- **Solutions**
  - Genetics, chemistry, engineering, systems
  - Farmers & scientists must interact

- **High yields require innovation**
  - Investment & Risk
  - Foster a more *experimental* culture

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Thank you