Breaking the Yield Barrier:
The Yield Enhancement Network

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ADAS UK ... Cambridge
@drkindred @adasYEN #YEN2016

Baltic Agro Yield conference, Estonia, 28 Nov 2016

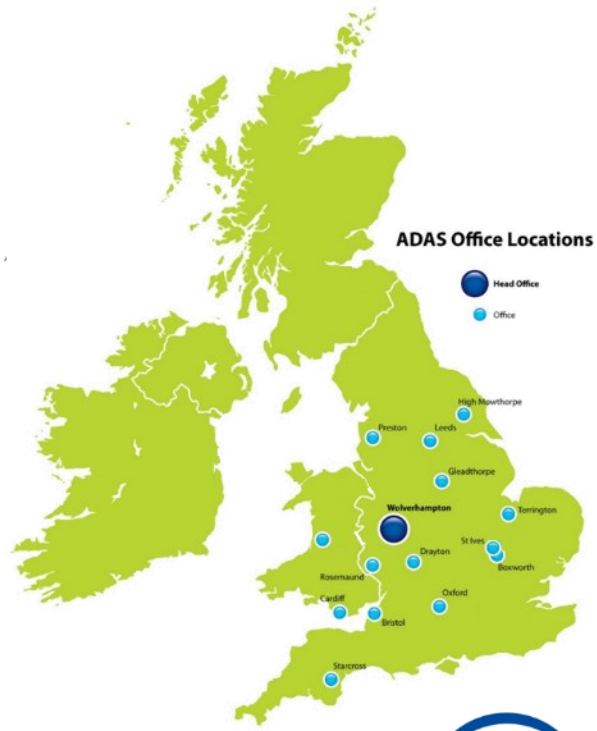
Plan

- UK Agriculture & Arable farming
  - History, trends, structure, future
- Global arable farming
  - Food security, trends
- YEN
  - UK
  - Estonian resources
  - N fert type
  - (cover crops)
- Global wheat yield competitions

About ADAS

ADAS exists to provide ideas, specialist knowledge & solutions to secure our food & enhance the environment

- UK's largest independent agricultural & environmental consultancy & research
- Private company .... £30 million turnover
  - History from 1946 – Ministry of Agriculture
  - Branded ADAS in 1971
  - Privatised in 1997
- 15 Offices across England & Wales
  - Over 400 staff
  - Over 60 specialisms
- Very broad range of services & clients
  - Crops, horticulture, pathology, entomology, nutrition, physiology, ecology, soils, water, biodiversity, livestock, chemicals, wastes, supply chains, policy, GIS, web, modelling, surveys, renewables, energy, land development



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UK Agriculture

- 69% of UK land area
  - 17 M ha
    - 6 M ha cropped … mostly in East
    - 10M ha permanent grass
    - … mostly in West
- 1.5% UK workforce
  - 450,000 people
  - 200,000 farms
    - 48,000 grow cereals
      - 27,000 with >30ha
    - 56,000 with >30 cattle
      - 21,000 with > 150 cattle
    - 45,000 with >50 sheep
    - 3,200 with >50 pigs

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UK Farming history and trends

- Deforestation when?
- Enclosure Act 1700s…
- Estates with many individual farms
  - Each Mixed …
- Increasing specialisation
  - Arable
  - Veg
  - Potato
  - Dairy (very few small dairy farms left in East)
  - Pig
  - Poultry

UK Soils

Wide range of soils:

- Massive clays formed in lakebeds
- ‘Boulder clay’ and ‘drift’ from melting of glaciers
- Mixed ‘glacio-fluvial’ deposits from outwash of glacial lakes
- Sands -sedentary and windblown
- Chalks formed in old seas
- River and marine deposits
- Peats formed under bog conditions

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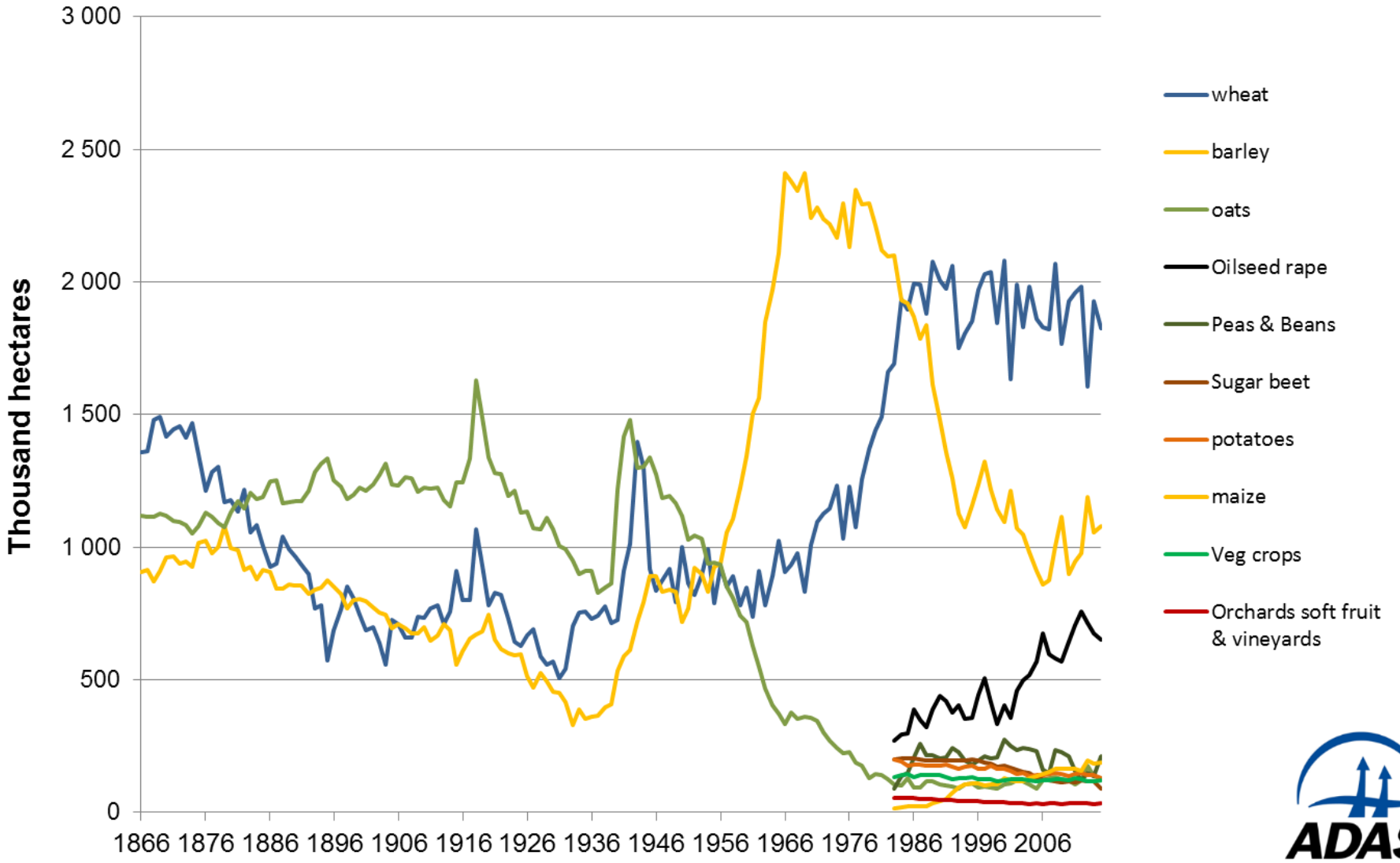
UK arable farming

- 80% of arable area farmed by 20,000 farmers
  - Typical farm size ~200 ha
    - many farms >500ha
    - Increasing numbers >1000ha
  - Typical british landscapes – mosaic of fields
  - Typical rotation:
    - Wheat – barley – OSR- wheat – wheat - Beans

UK crops - areas



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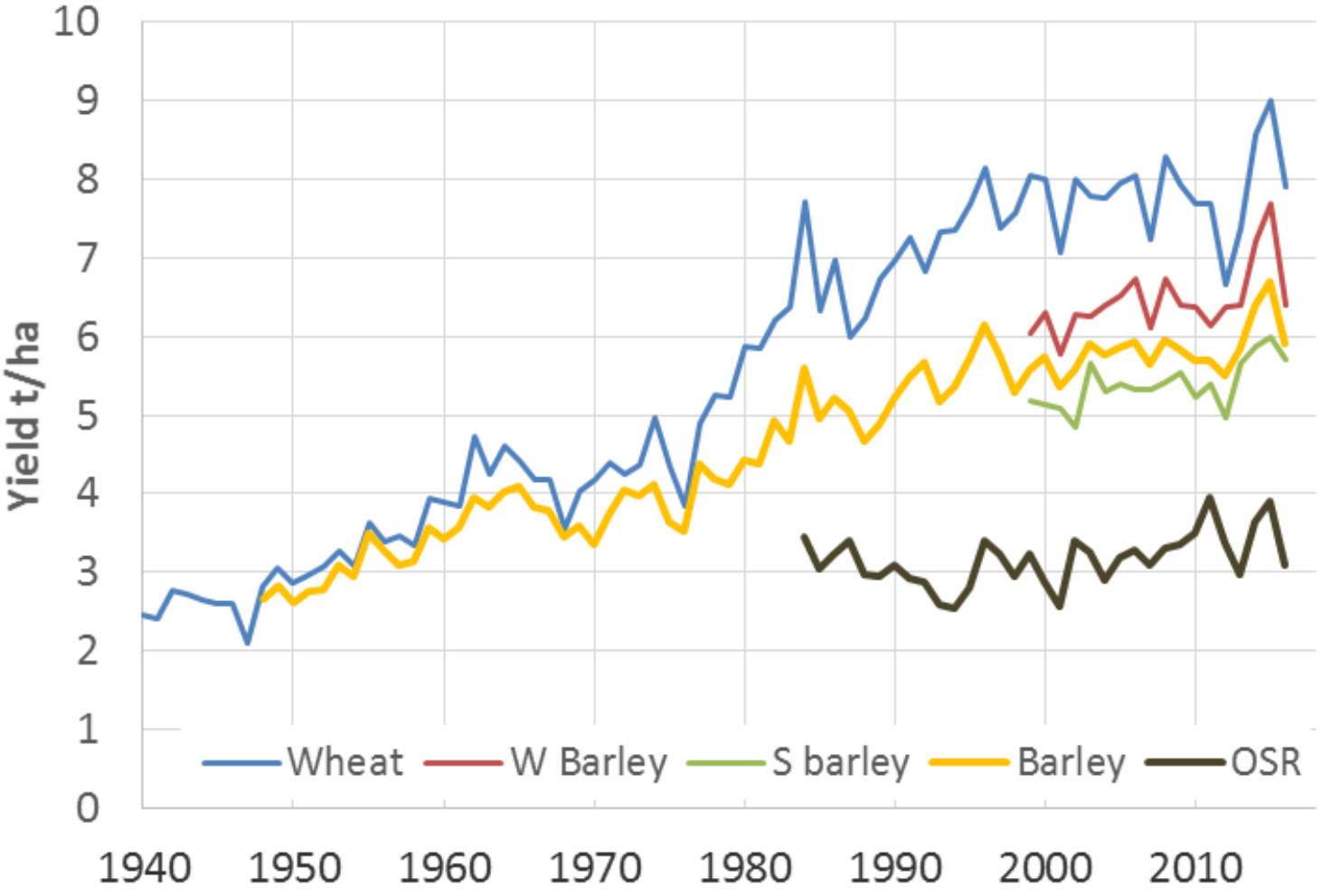
UK crop yields



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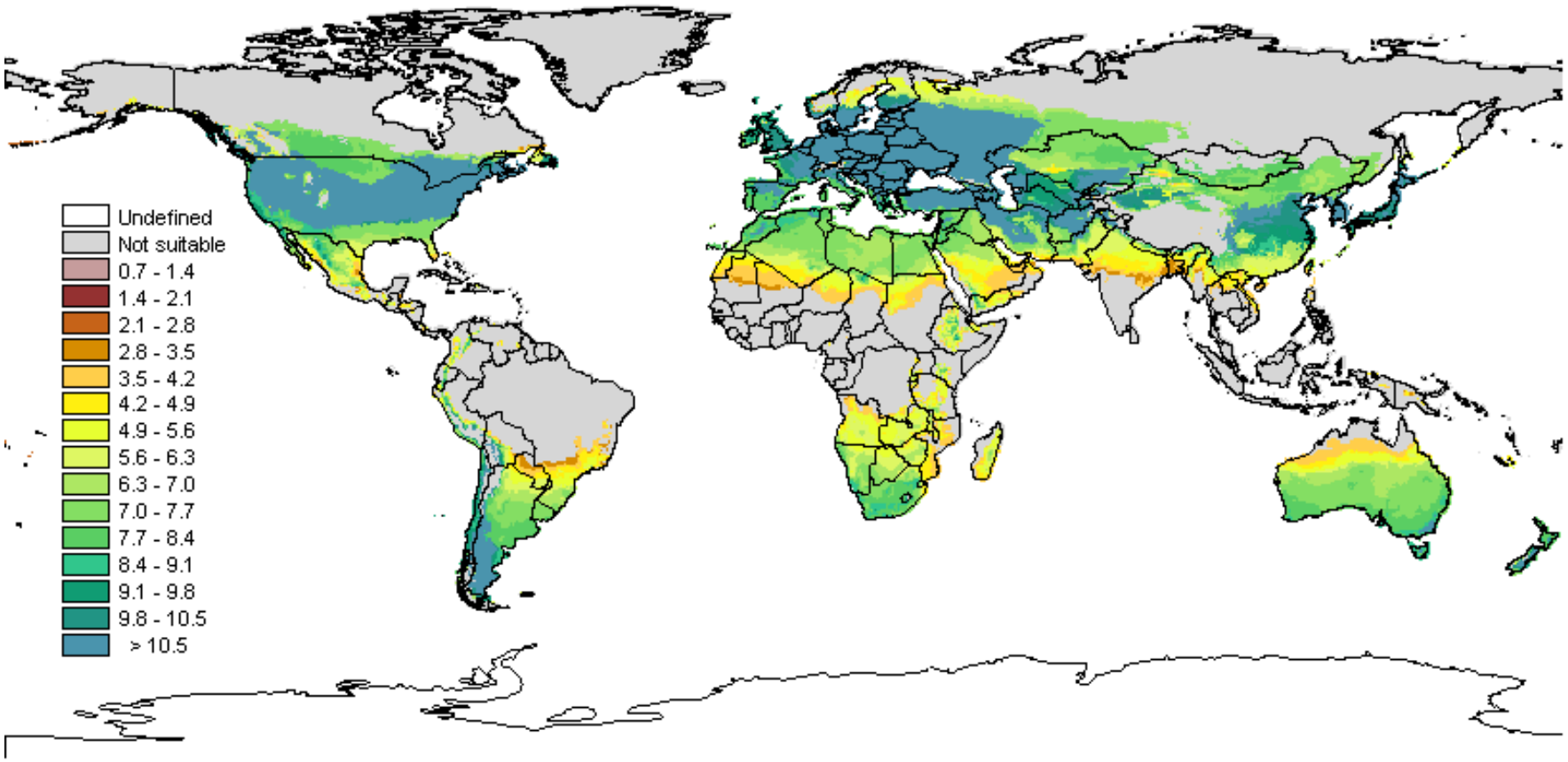
Global food security

- Price spikes in 2007
- Global yields plateauing
  - Some exceptions
- Projected demand to 2050
- UN reports etc

- What action?

GAEZ potential wheat yields



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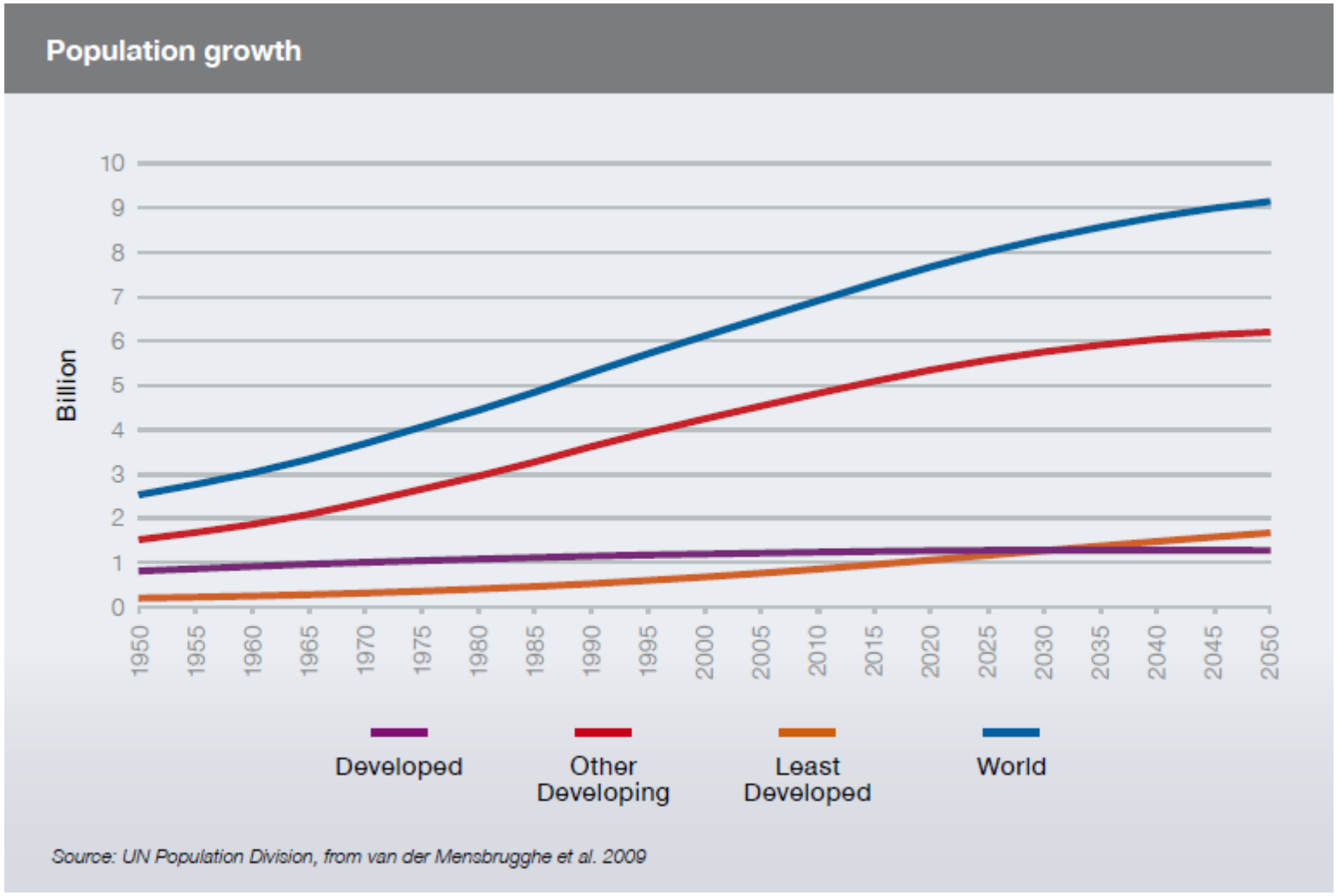
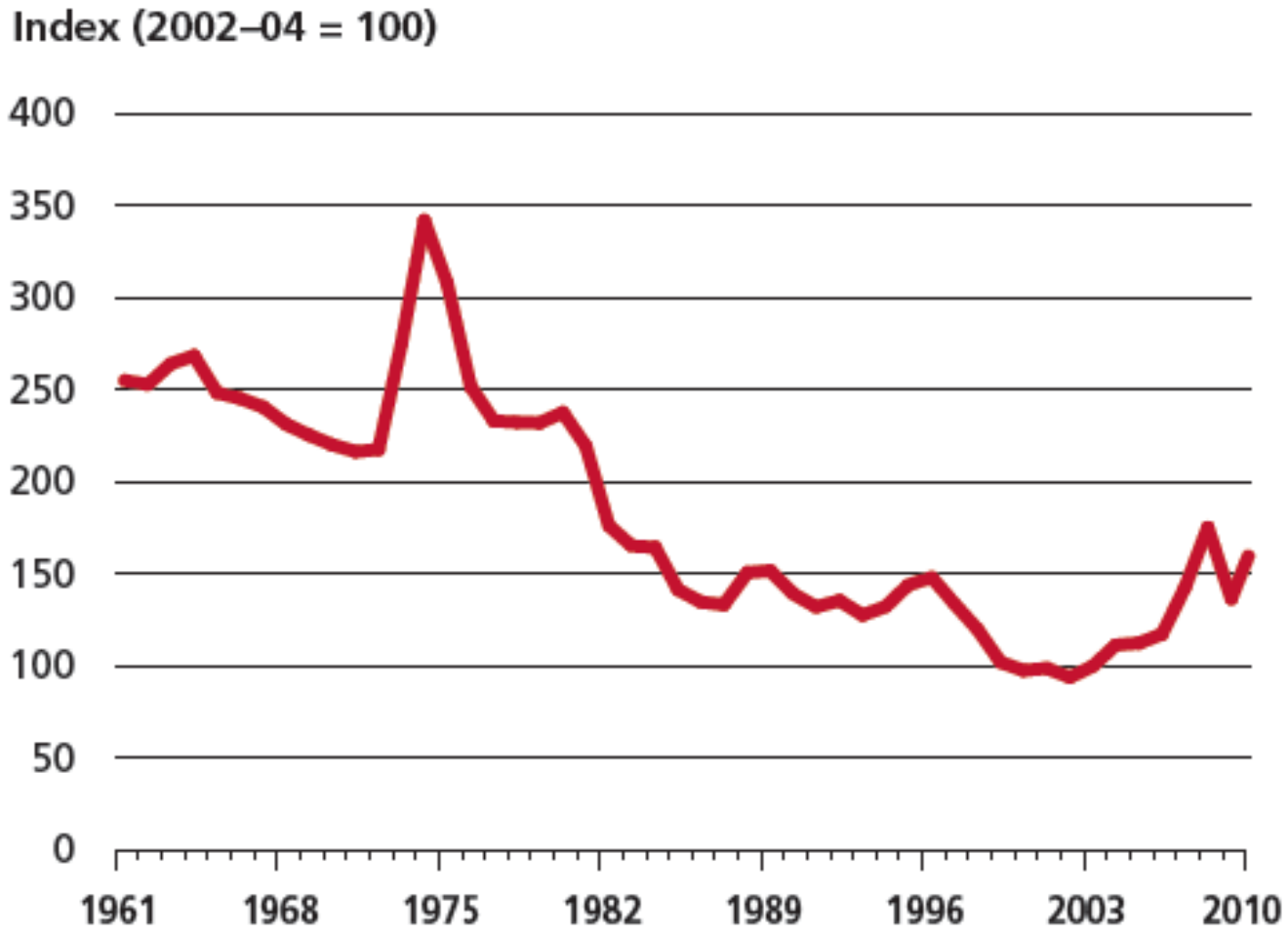
Need to feed 9 billion people by 2050



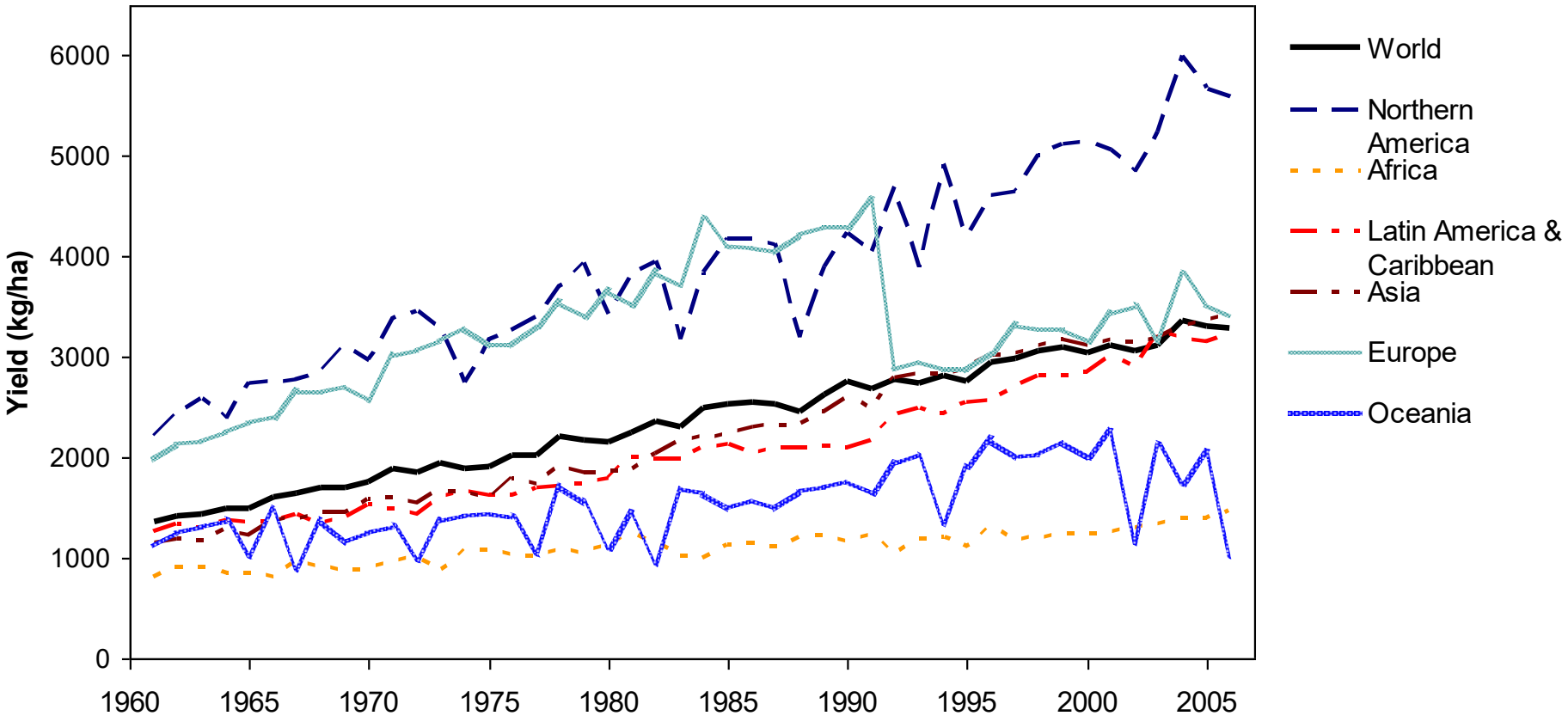
Food prices


Index (2002–04 = 100)
400
350
300
250
200
150
100
50
0
1961
1968
1975
1982
1989
1996
2003
2010

FAO World Food & Agriculture Review 2009

- Increasing population
- Increasing wealth in developing countries
  - Trends to eat more meat
- World cereal demand projected to increase from 2.1 billion tonnes to 3 billion tonnes by 2050
- Need to raise world food production by 70%
  - 90% of increase needs to come from increased yields
  - Minimal opportunities for more land conversion
    - Big Greenhouse Gas costs from land use change
- Biofuels add to demand

World Cereal Yields



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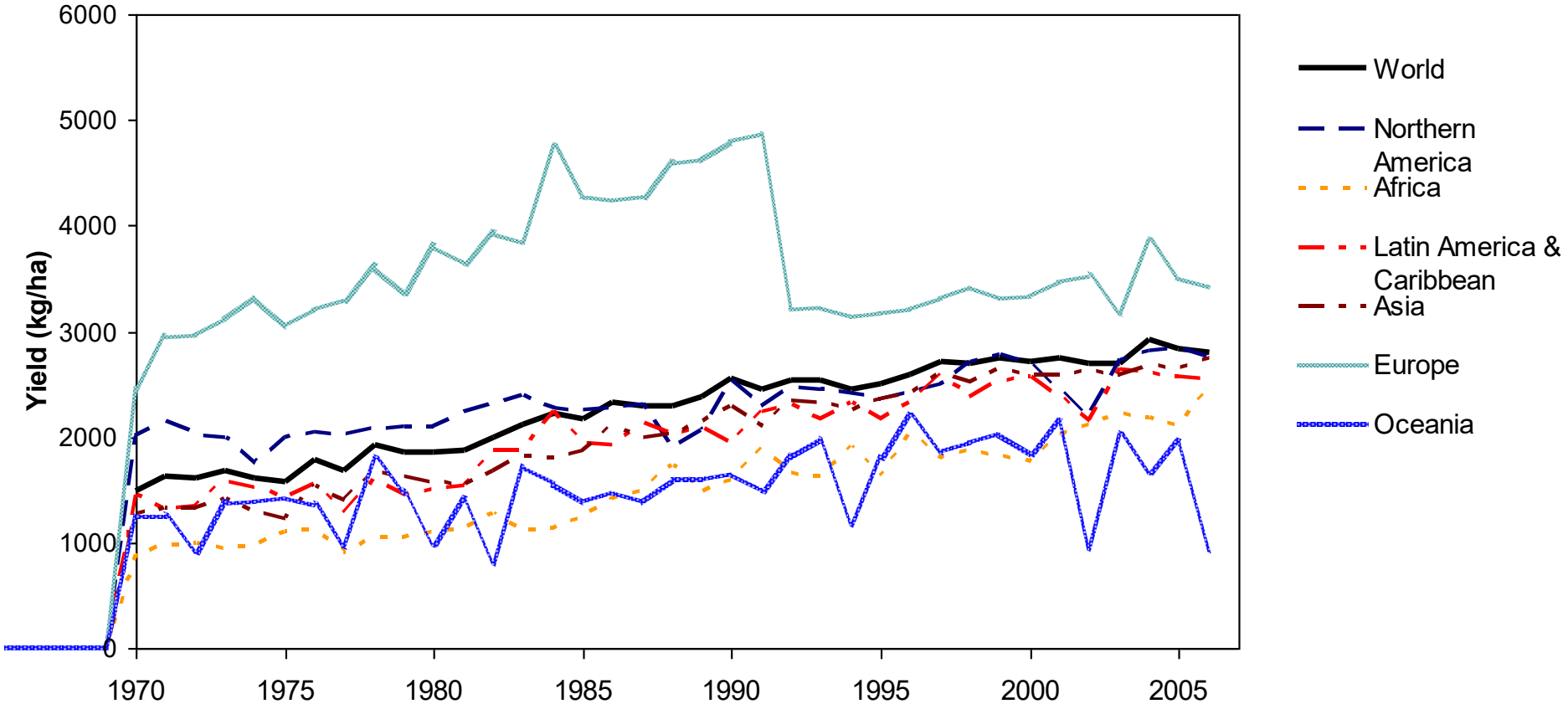
World wheat yields



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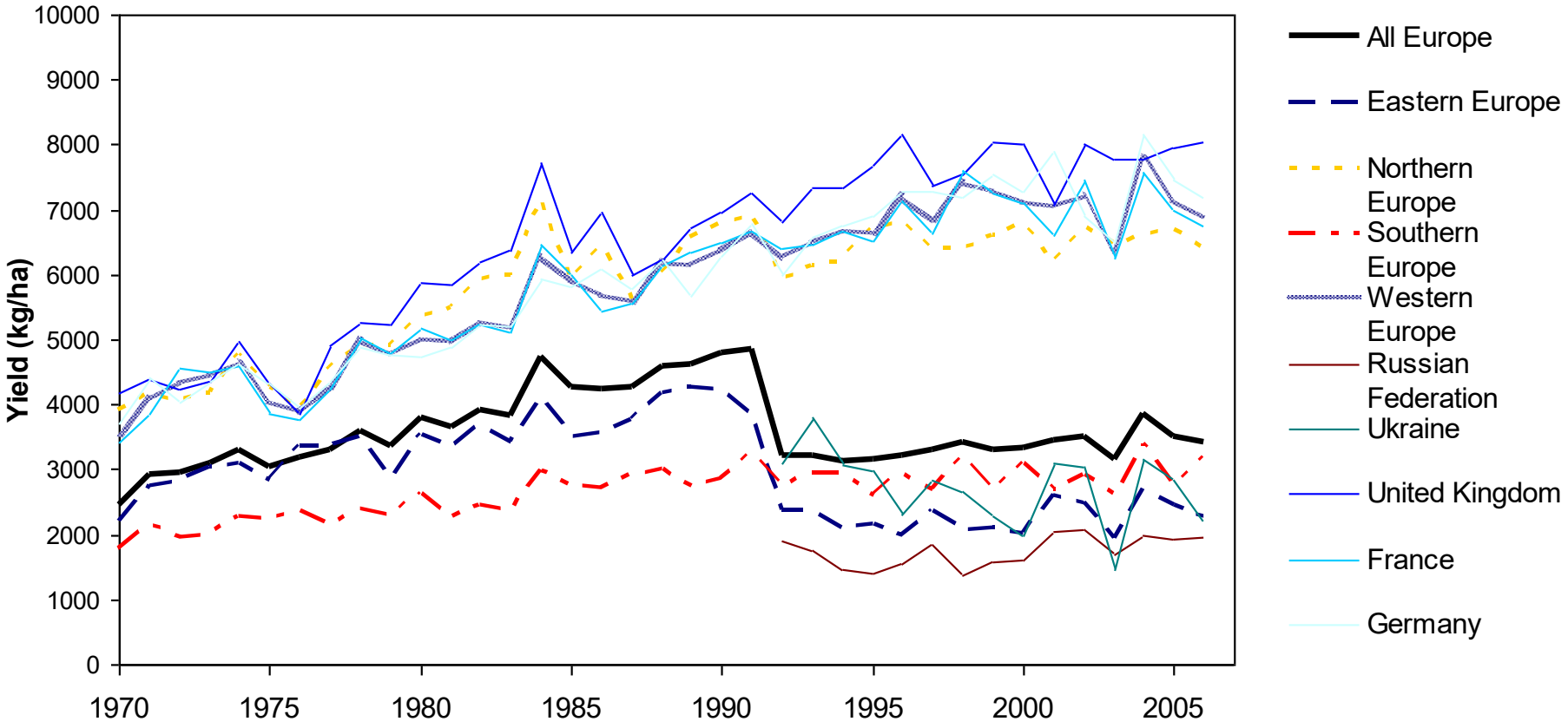
Wheat yields in Europe



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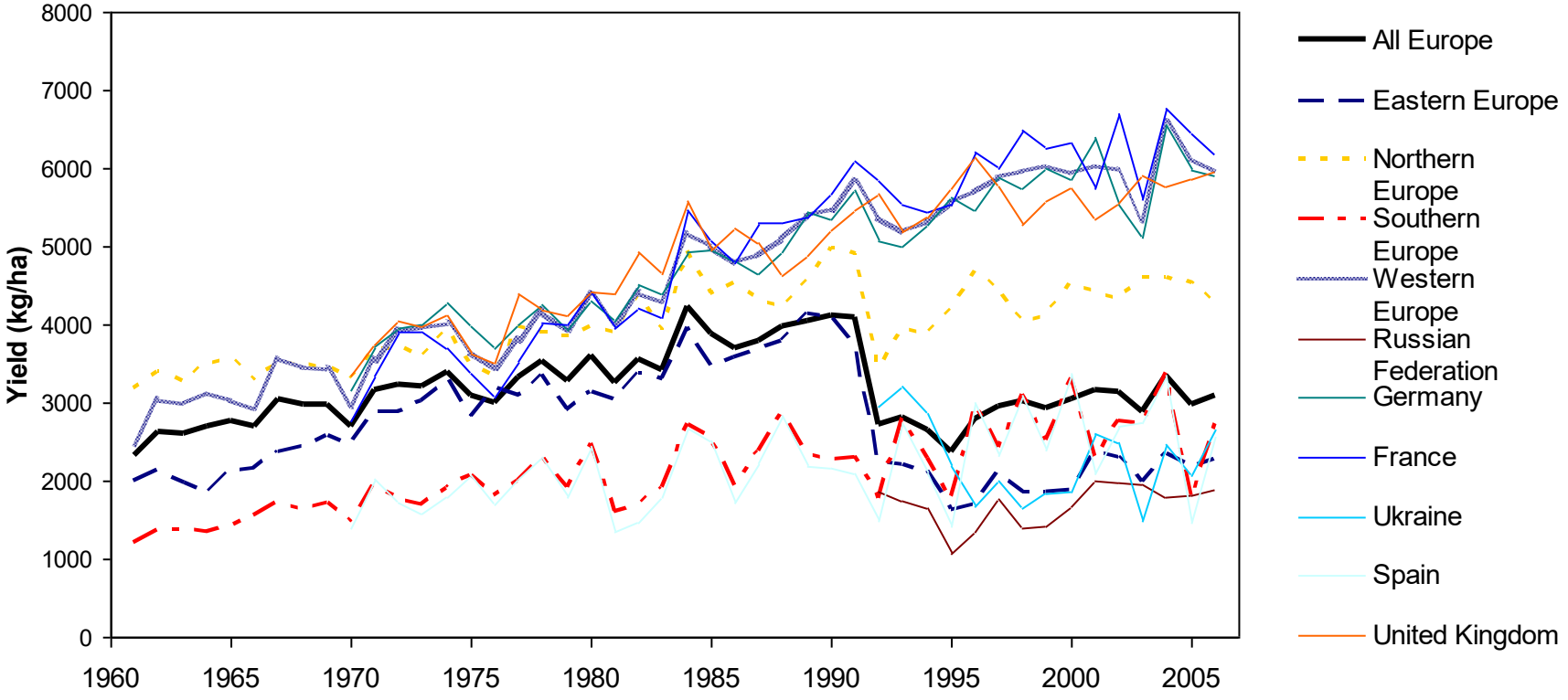
Wheat yields in Estonia

Barley yields in Europe



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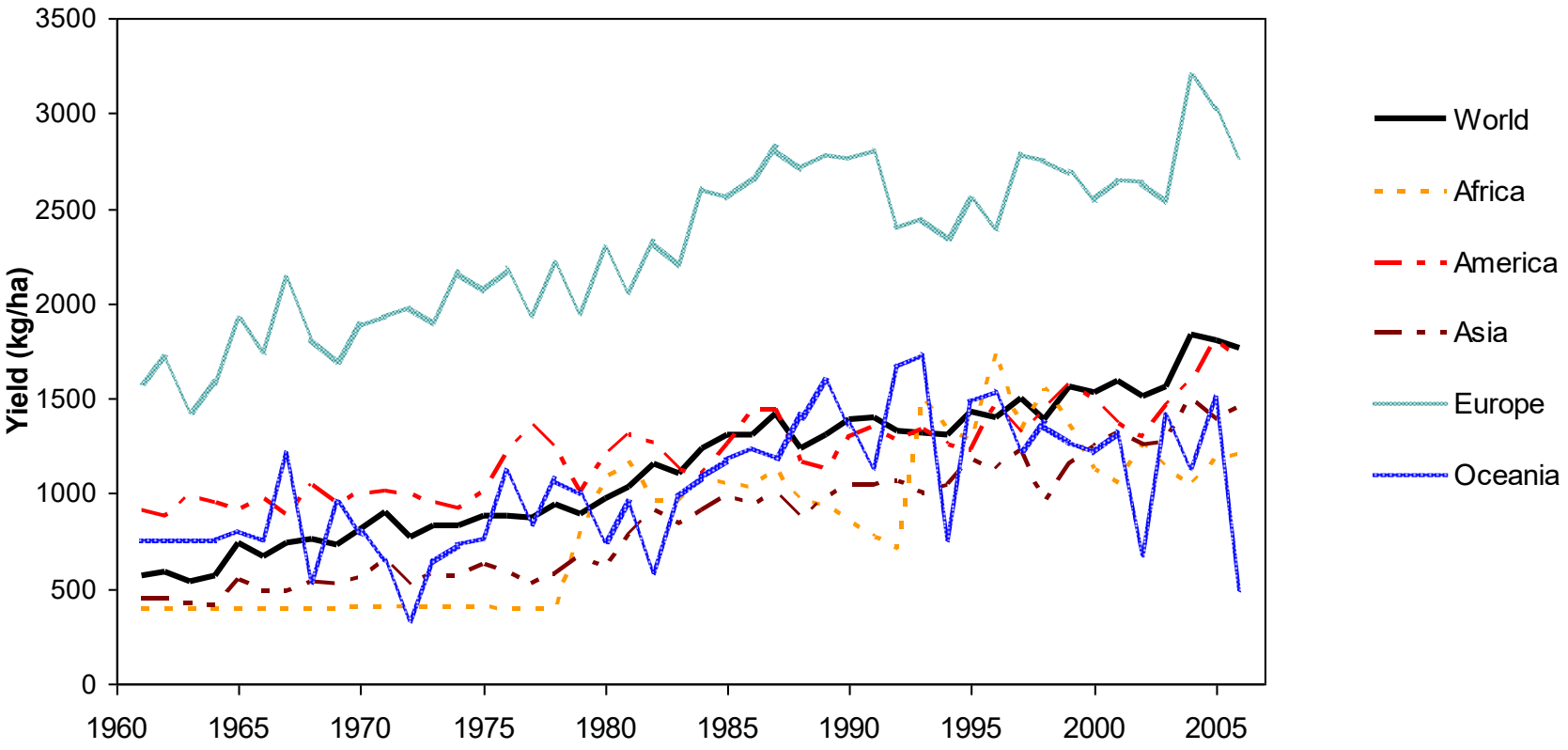
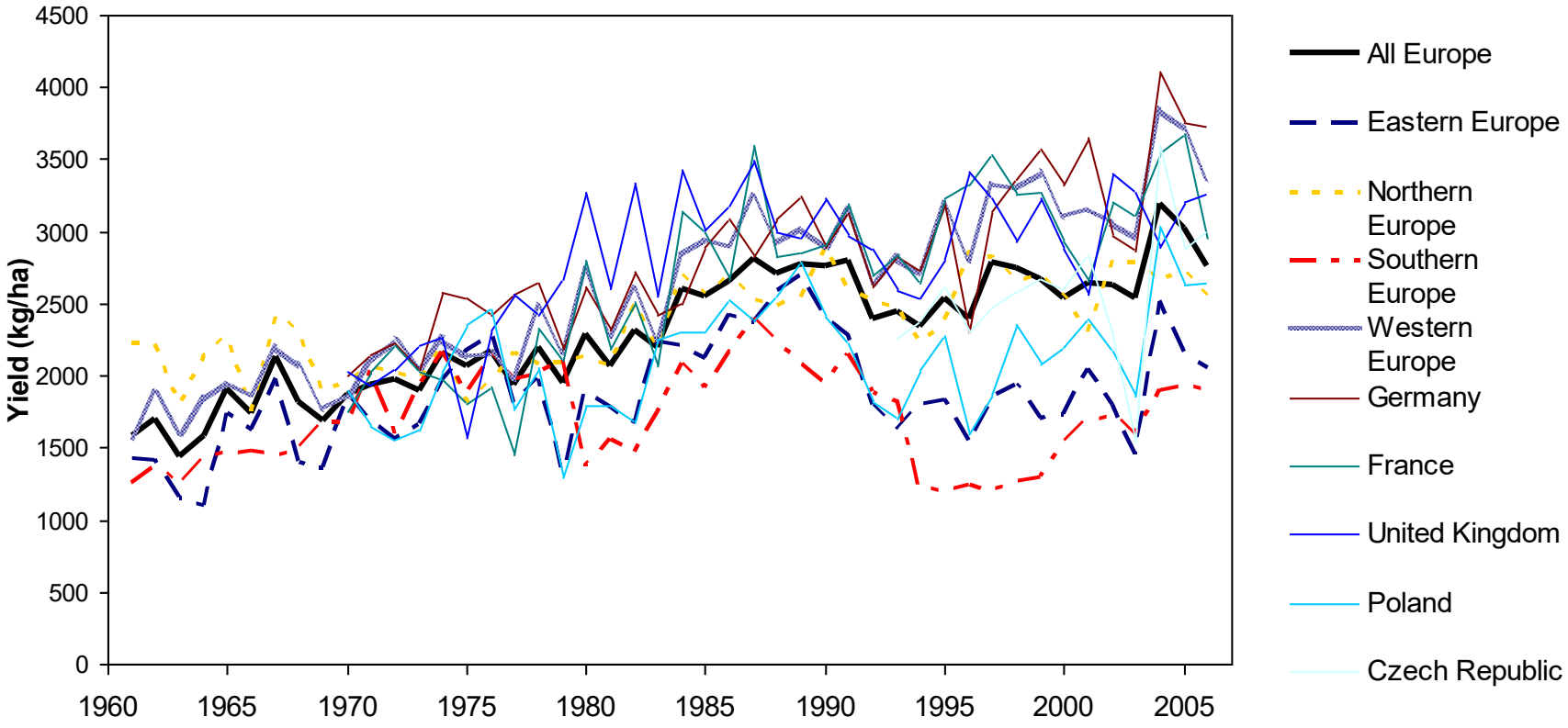
World Oilseed rape yields



OSR Yields in Europe



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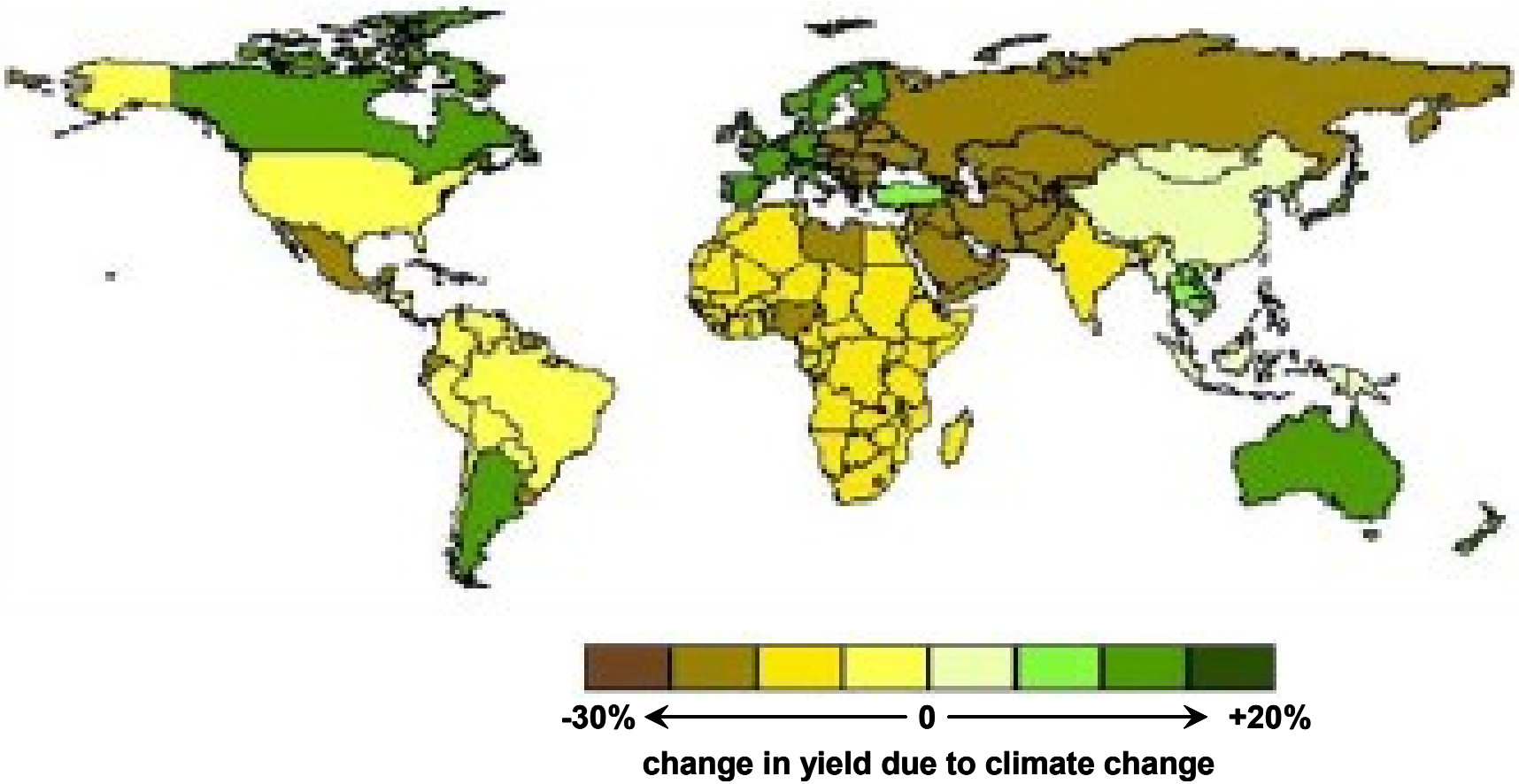
Impacts of Climate change



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Summary

- Demand Increasing
  - Population growth
  - Wealth
  - Bioenergy
- Rate of yield increase slowed in past 20 years
- Very limited opportunity to expand arable area
- Climate change likely to constrain yields in many areas …
- Need to increase yields in North Europe

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syngenta


BASF
We create chemistry


AG Space


BAYER


ROTHAMSTED
RESEARCH


NIAB TAG


Yield Enhancement Network
YEN
www.yen.adas.co.uk


AHDB
CEREALS & OILSEEDS


ADAMA


ADAS


Limagrain
United Kingdom

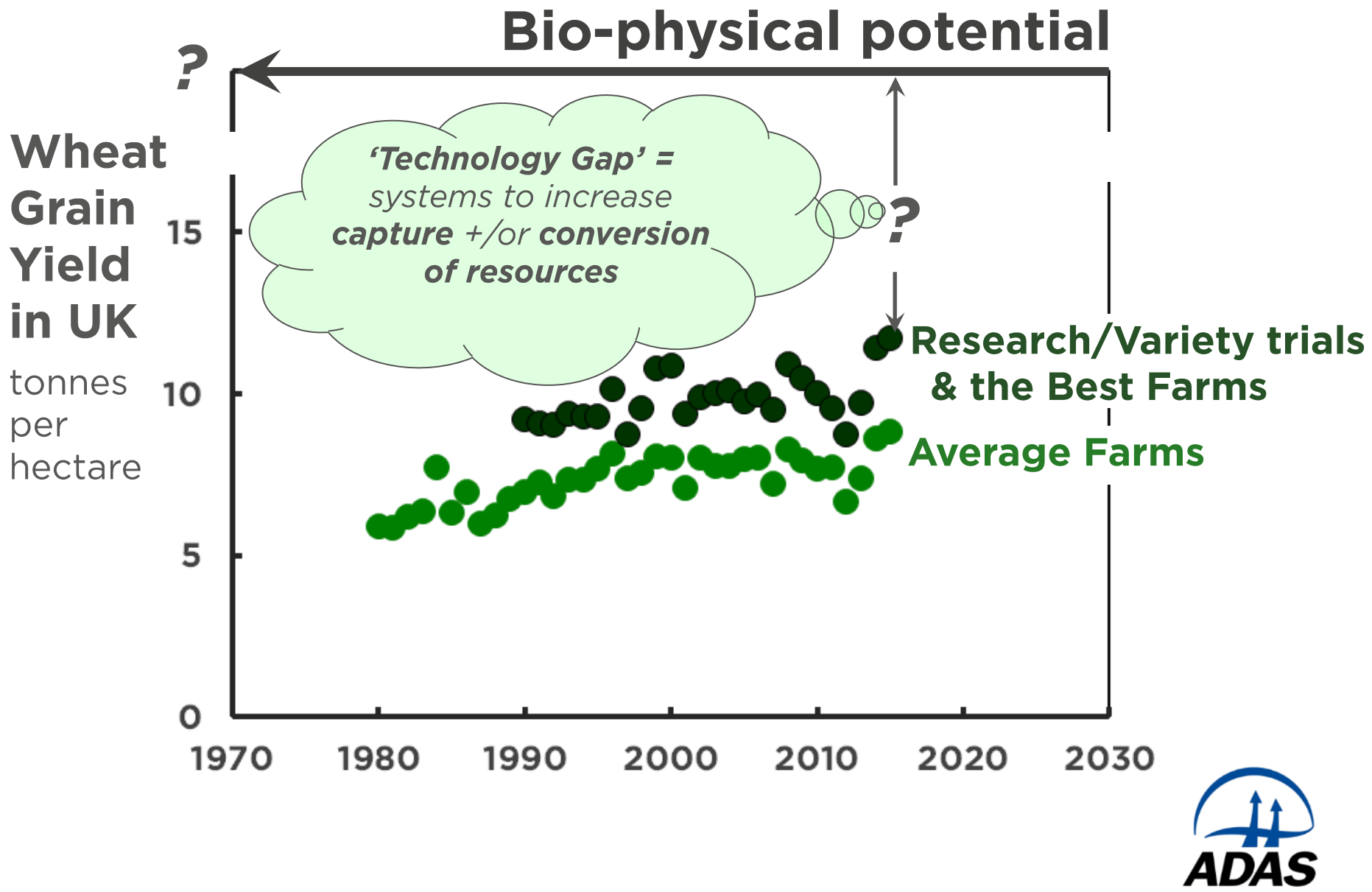
DE SANGOSSE


YARA


nrm
laboratories


NFU


HUTCHINSONS
Crop Production Specialists


Bio-physical potential
?
Wheat Grain Yield in UK
tonnes per hectare
15
10
5
0
1970
1980
1990
2000
2010
2020
2030
'Technology Gap' = systems to increase capture +/or conversion of resources
?
Research/Variety trials & the Best Farms
Average Farms

Aims:

- To identify arable innovators
  and
- Support their innovating

Activities:

1. Competition *… open, with robust yields & explanatory data*
2. Analysis *… associations, explanations & ideas*
3. Networking *… sharing & dissemination*

Ambition …

- Platform for industry-science interaction … & synergies

"We harvest energy"

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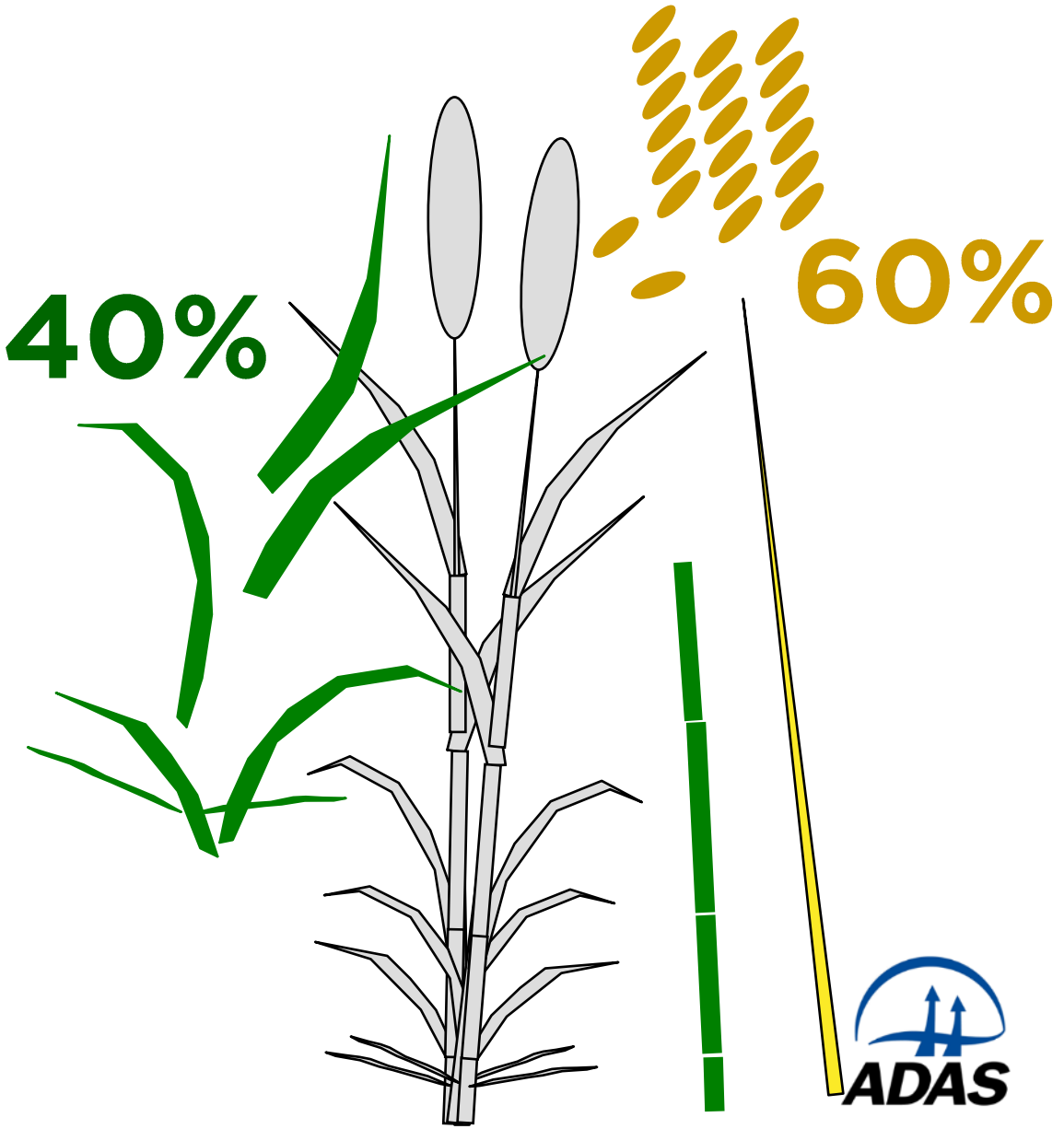
Crop metrics:

Yield =

Solar Energy	Resources	Water
TJ / ha		mm
	x Capture	
%		%
	x Conversion	
tonnes / TJ		t/ha/100mm

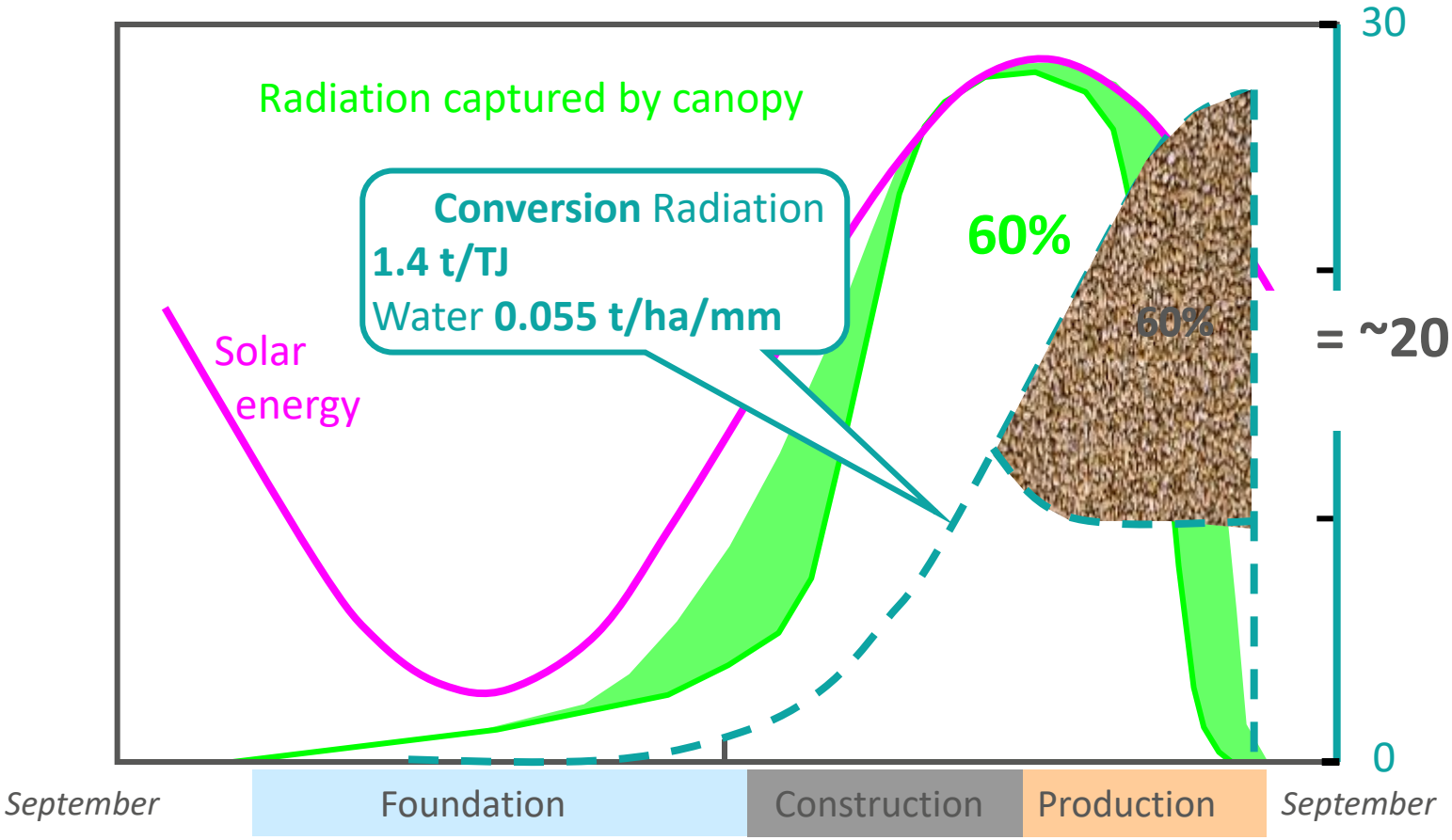
Crop metrics:

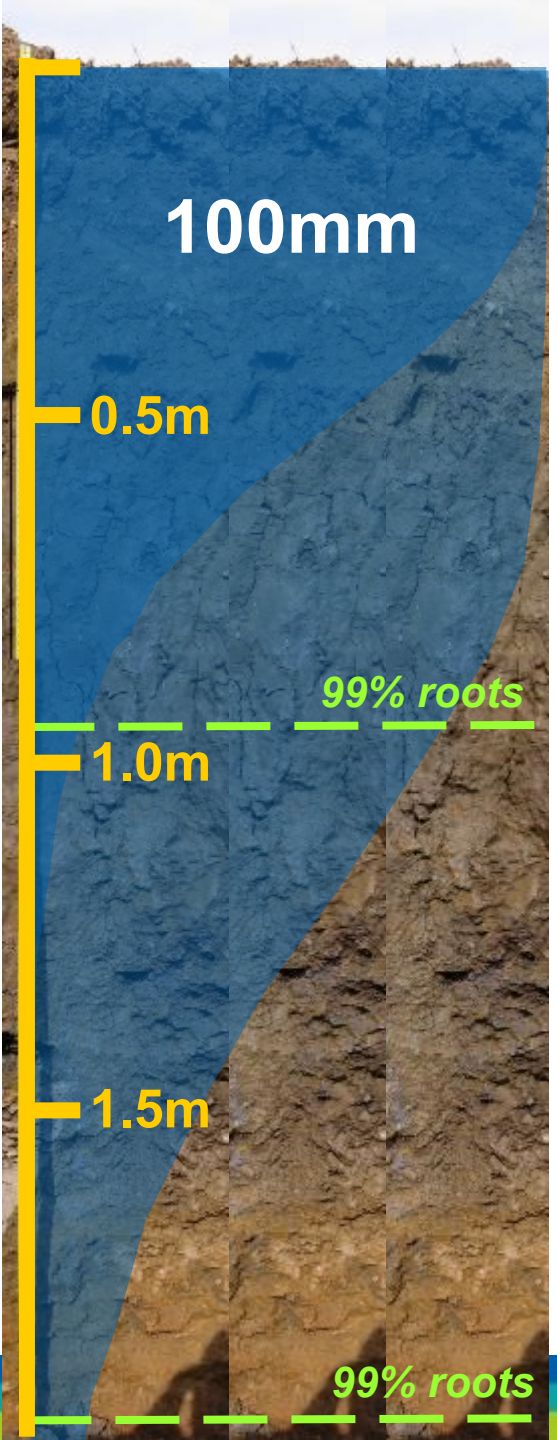
Biomass x Harvest Index



Estimating *bio-physical potential* cereal yields

… based on *Yields of Farmed Species* (2005) Chapter 11: 'Wheat'





Soil Water Capture

- Available water contents of soils:
  - 12% (sand)- 23% (silt loam) in topsoil
  - 5% (sand) - 17% (silt loam) in subsoil.
- Available water if roots fully explore 1m:
  - 71mm (sand)
  - 188mm (silt loam)
- Feasible to achieve rooting depth to 1.5m?
  - (or 75% exploration of maximum 2m depth)
  - 96mm (sand)
  - 273mm (silt loam)

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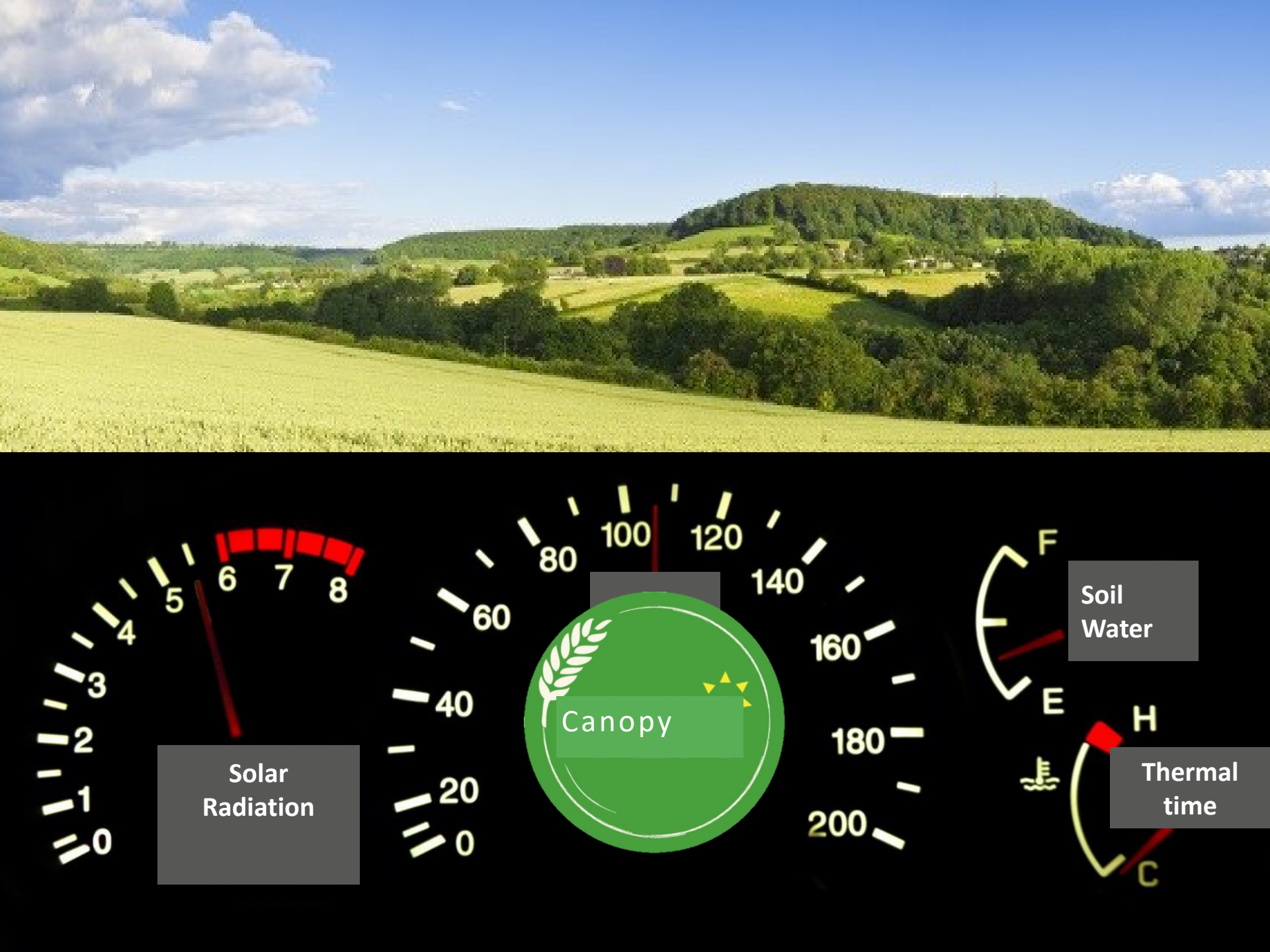
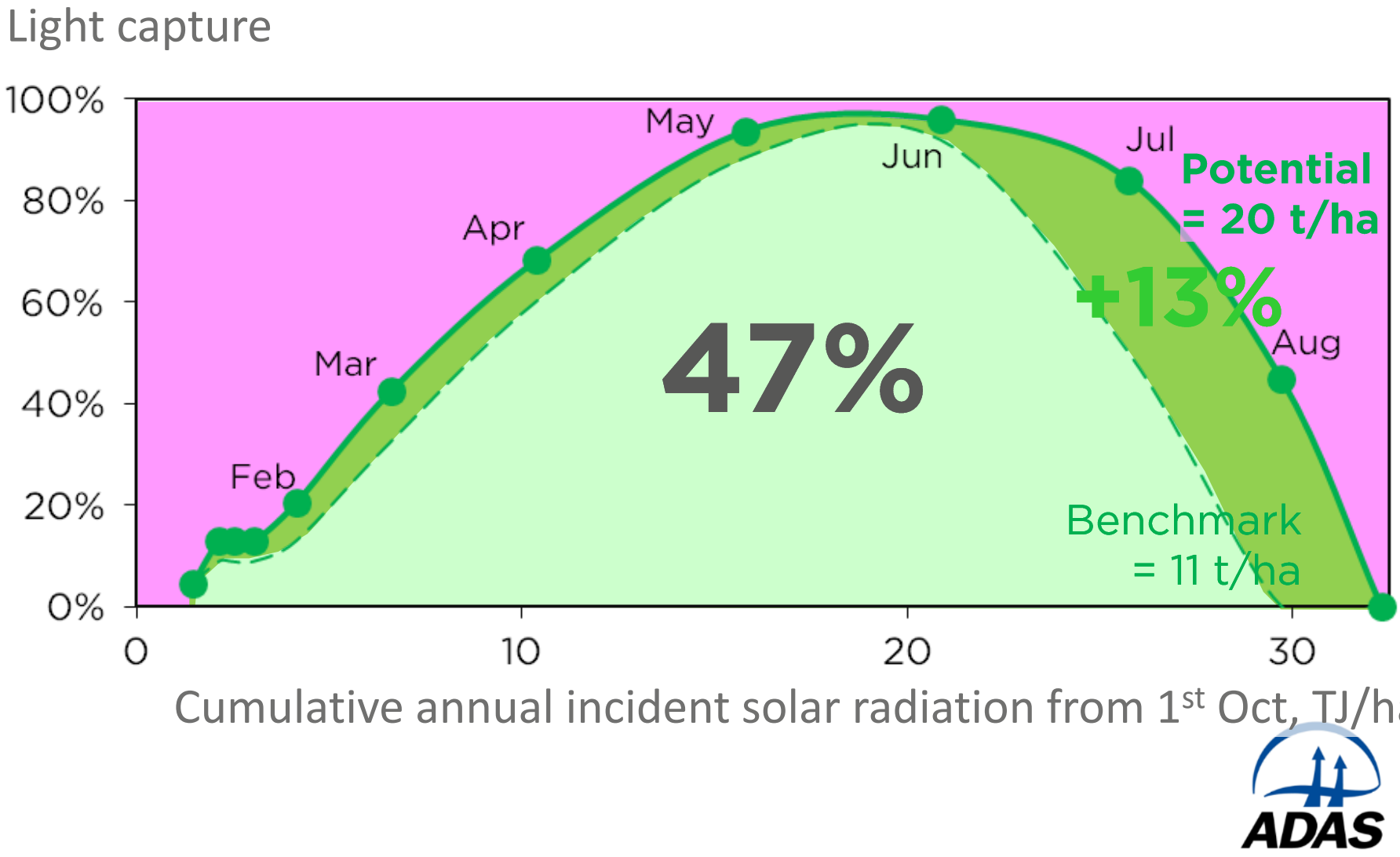
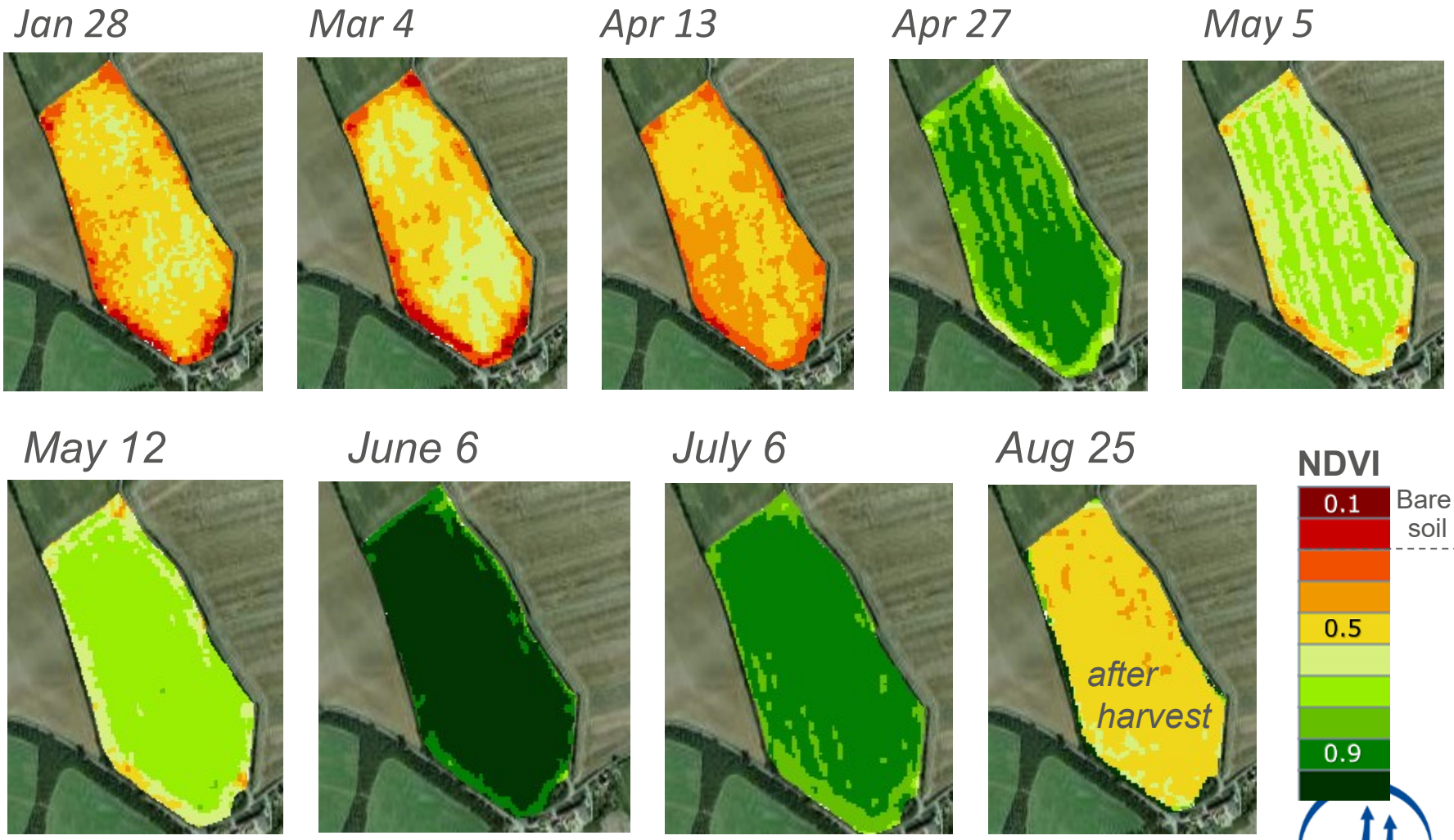

0
1
2
3
4
5
6
7
8
Solar Radiation
0
20
40
60
80
100
120
140
160
180
200
Canopy
F
E
Soil Water
H
C
Thermal time

YEN aim: a ‘Canopy Curve’ for each crop



Canopy Progress by Satellite from AG Space

IPF ....SimplyPrecise



Stackyard Field, 2016, AHDB Monitor Farm, Colchester (Tom Bradshaw): KWS Lili

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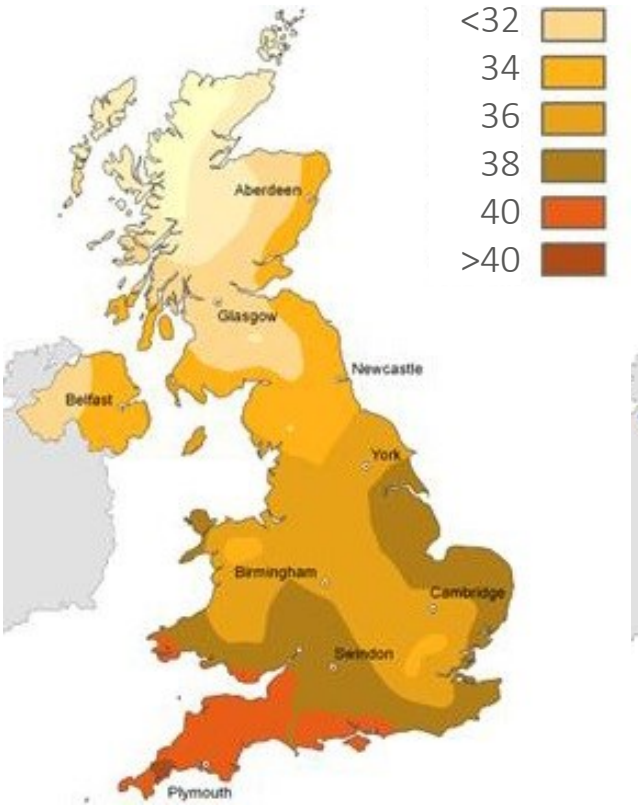
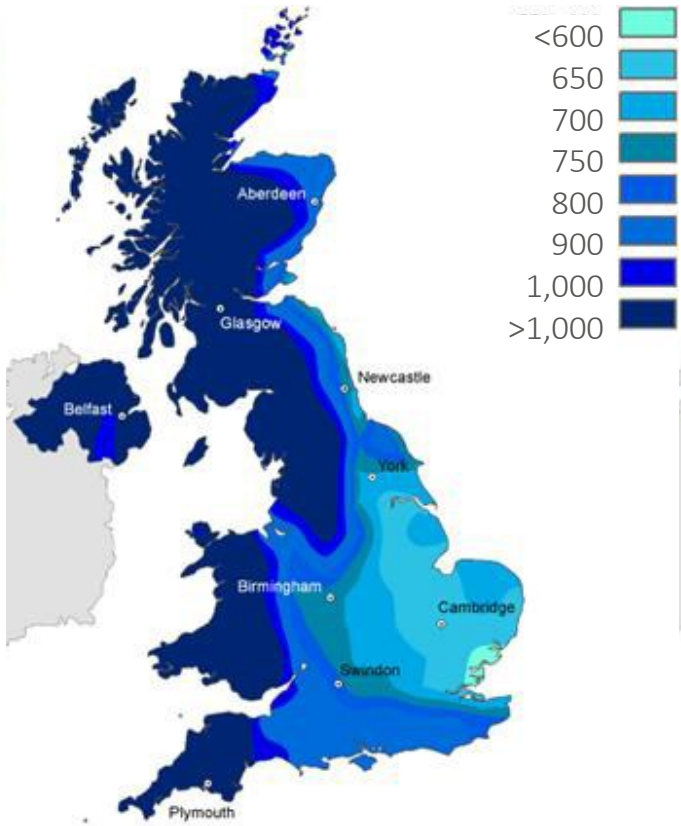
Resources and potential yields in UK

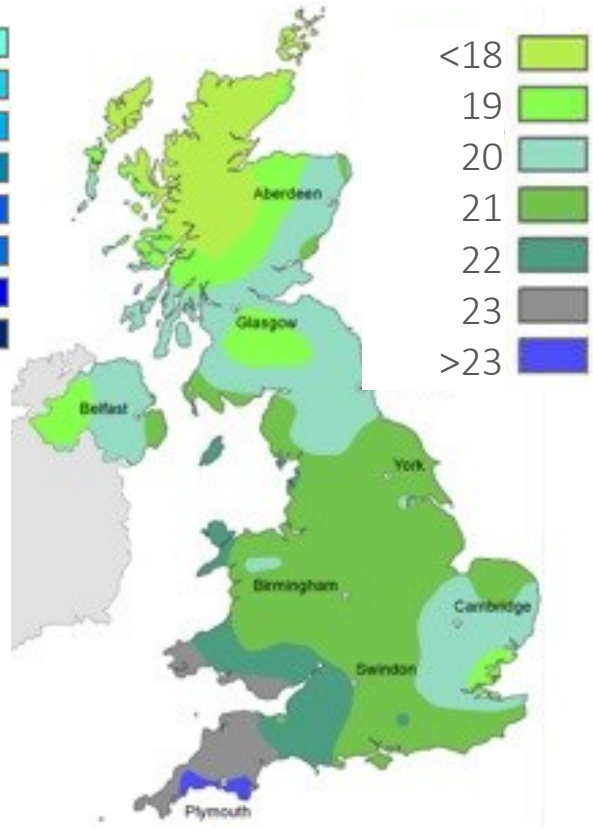
Total Solar Radiation,
TJ ha^{-1} year^{-1}



Rainfall,
mm year^{-1}



Potential grain yield,
t ha^{-1} year^{-1}



Medium soil AWC = 200 mm

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Potential yields on medium soils

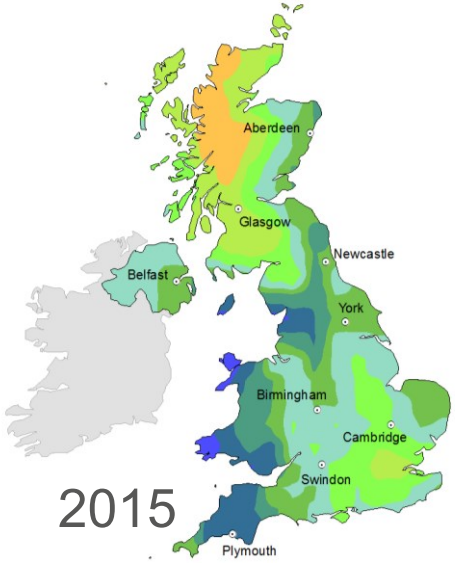
(holding 210 mm water)

LTA
1981-2010

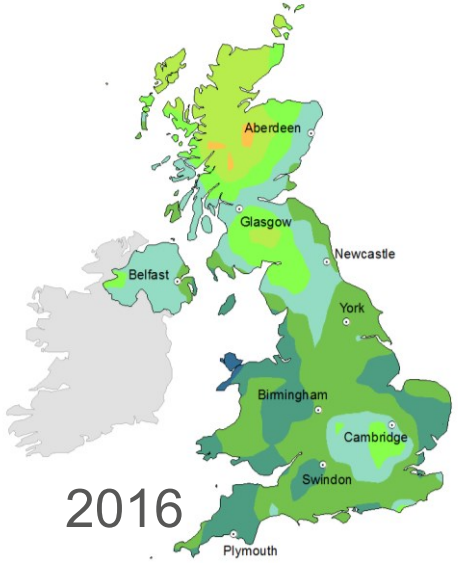
Potential yield
t/ha

<13
14
15
16
17
18
19
20
21
22
23
24
>24

2012



2015



2016

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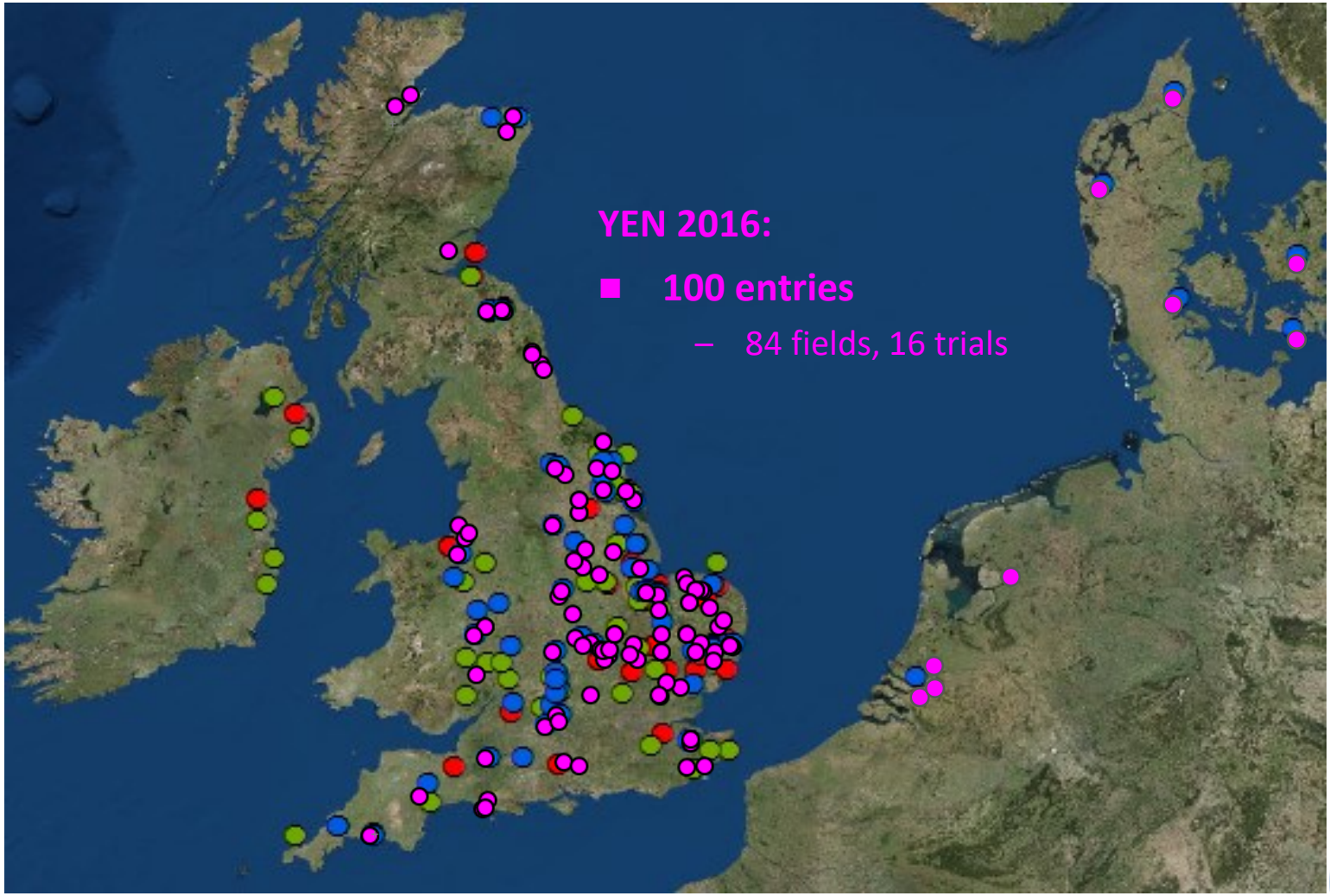
YEN entrants 2013, 2014, 2015 & 2016



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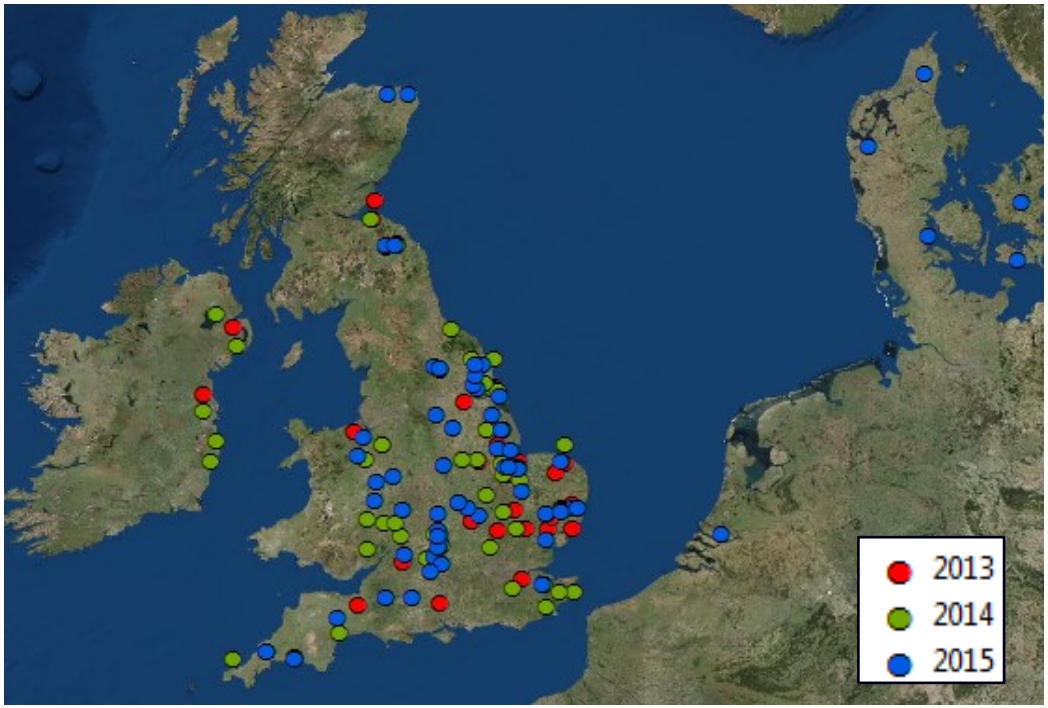
YEN entrants



- **Open to anyone**
- **Calculate potential yield for each site**
  - For LTA weather
  - & in season
- **Collect crop info**
  - Photos
  - dates of key GS
  - Agronomy
- **Verified yields**
- **Grain sample**
  - Protein & specific wt
- **Grab sample**
  - Yield components
  - Harvest Index, Biomass
  - N uptake

- **Results & Awards conference in Nov**
- **Individual reports & recommendations for each site**

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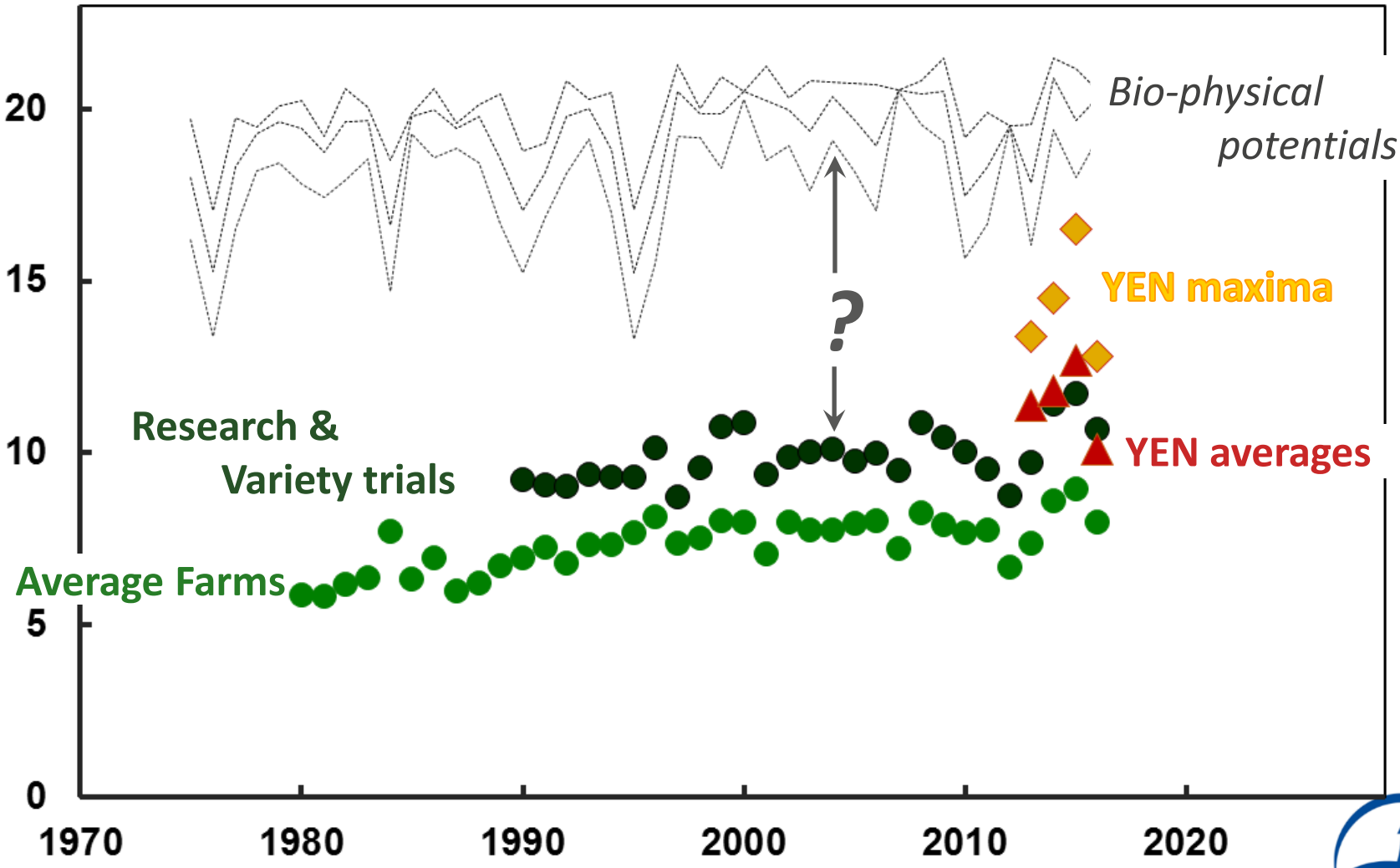
Wheat Grain Yields in the UK, tonnes per hectare



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NEW World Record Yields, 2015

- **Grain cv. Reflection** — **16.5 t/ha**
  - @ 15% MC & 11.5% protein
- **Incident Solar Radiation:** — **36 TJ/ha**
- **Summer Water Supply:** — **470 mm**
  - 200 mm summer rain
  - 270 mm soil water
- **Fert Nitrogen Supply:** — **330 kg/ha**
  - After OSR so SNS~80 kg/ha
  - Grain N 'offtake' 282 kg/ha …
  - Total N uptake 353 kg/ha
  - Fertiliser recovery 71%
- **ESTIMATED POTENTIAL** — **21.0 t/ha**

Yield achieved : ***79% of potential***

Tim Lamyman, Worlaby, near Louth, Lincs, UK

* Claimed by Rod Smith, Northumberland accepted by the Guinness Book of Records with 16.52 t/ha

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Tim Lamyman, Louth, Lincs.

Sponsored by Hutchinsons

	Bench-mark	Entry
Ears / m^2	*460*	**711**
Grains / ear	*48*	**49**
TGW @ 15% MC	*50*	**47**
Sp Wt, kg/hl	*NA*	**81**
Grain protein %	*11.6*	**11.5**
Biomass, t/ha	*18.4*	**26.2**
Harvest Index	*51%*	**54%**
N 'offtake', kg/ha	*209*	**282**
Yield, t/ha (rank)	*11.0*	**16.5 (1st)**
Yield % Potential		**79% (2nd)**

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2016

- Highest yields in Denmark
  - 13 t/ha

- Highest UK yield = 12.8 t/ha

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Shaun Watson, near Newcastle upon Tyne *Sponsored by Bayer*

YEN294: Reflection

	Benchmark	*Entry*
TJ/ha SR (% capture)	36 (47%)	**35 (45%)**
mm H_2O (% capture)	444 (83%)	**459 (80%)**
Ears / m^2	*460*	**498**
Grains / ear	*48*	**56**
TGW @ 15% MC	*50*	**46**
Sp Wt, kg/hl	*NA*	**77**
Grain protein %	*11.6*	**11.6**
Biomass, t/ha	*18.4*	**18.3**
Harvest Index	*51%*	**59%**
N 'offtake', kg/ha	*189*	**221**
Yield, t/ha (rank)	*11.0*	**12.8 (1st)**
Yield % Potential		**64% (1st)**

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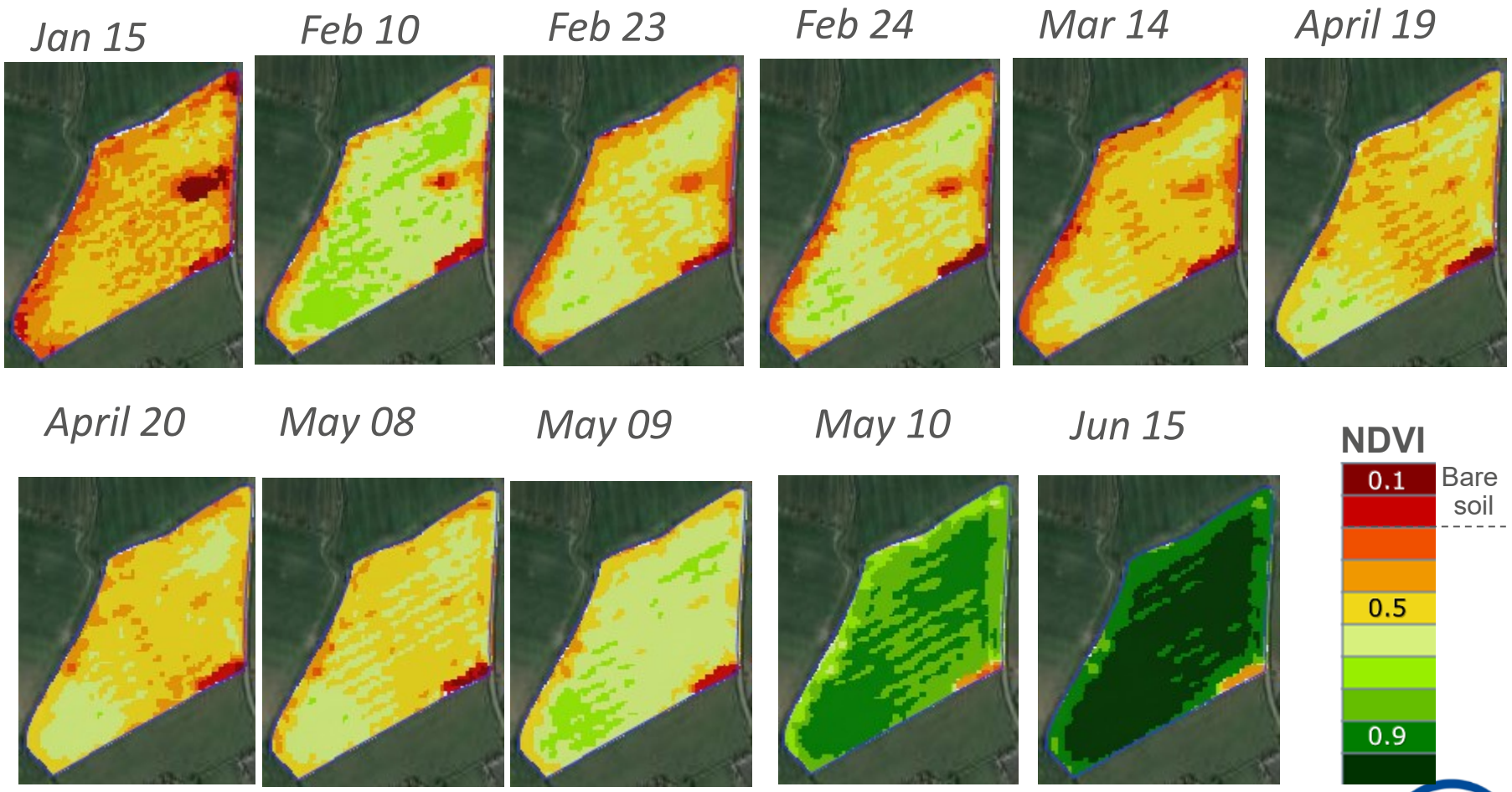
Shaun Watson – Canopy progress by satellite



AG Space

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Jes Hasselbalch *with SEGES at Hejsager, Denmark*

	Benchmark	Entry
TJ/ha SR (% capture)	36 (47%)	**37 (39%)**
mm H_2O (% capture)	444 (83%)	**460 (78%)**
Ears / m^2	*460*	**442**
Grains / ear	*48*	**68**
TGW @ 15% MC	*50*	**43**
Sp Wt, kg/hl	*NA*	**73**
Grain protein %	*11.6*	**11.7**
Biomass, t/ha	*18.4*	**18.1**
Harvest Index	*51%*	**61%**
N 'uptake', kg/ha	*189*	**228**
Yield, t/ha (rank)	*11.0*	**13.0 (1st)**
Yield % Potential		**61.5% (1st)**

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Peter Karlsen *with SEGES* at Ringsted, Denmark

	Benchmark	*Entry*
TJ/ha SR (% capture)	36 (47%)	**37 (42%)**
mm H_2O (% capture)	444 (83%)	**499 (77%)**
Ears / m^2	*460*	**575**
Grains / ear	*48*	**50**
TGW @ 15% MC	*50*	**44**
Sp Wt, kg/hl	*NA*	**74**
Grain protein %	*11.6*	**14.3**
Biomass, t/ha	*18.4*	**19.1**
Harvest Index	*51%*	**57%**
N 'offtake', kg/ha	*189*	**271**
Yield, t/ha (rank)	*11.0*	**12.7 (2nd)**
Yield % Potential		**57% (5th)**

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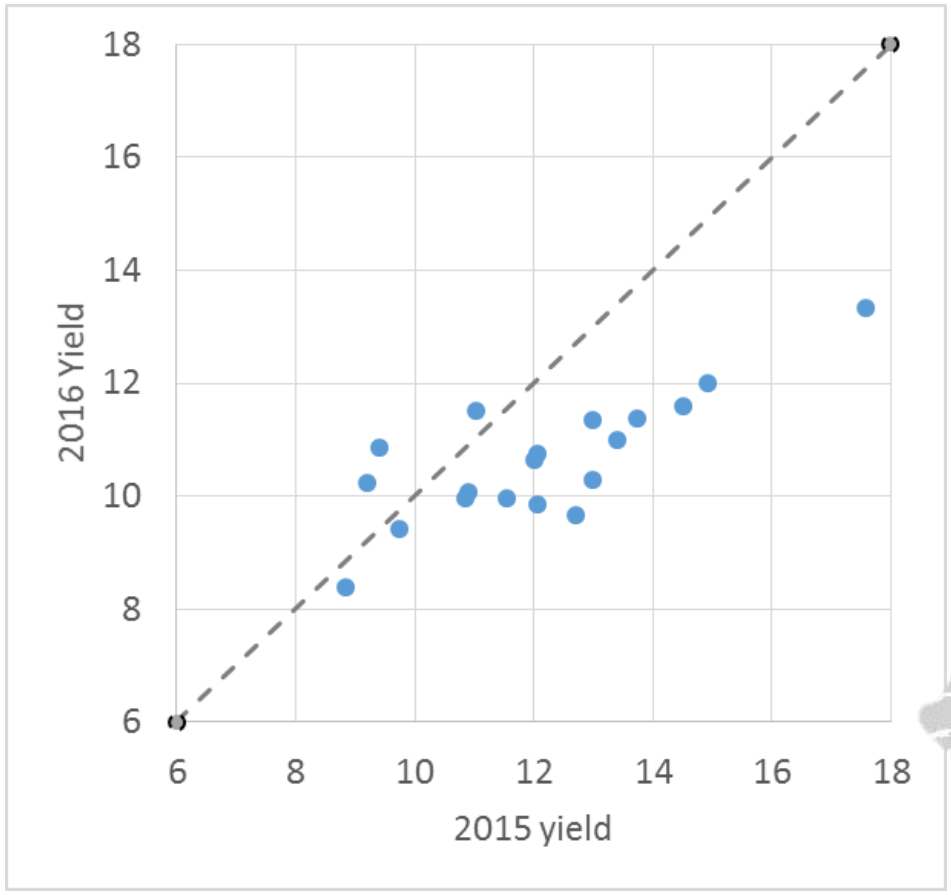
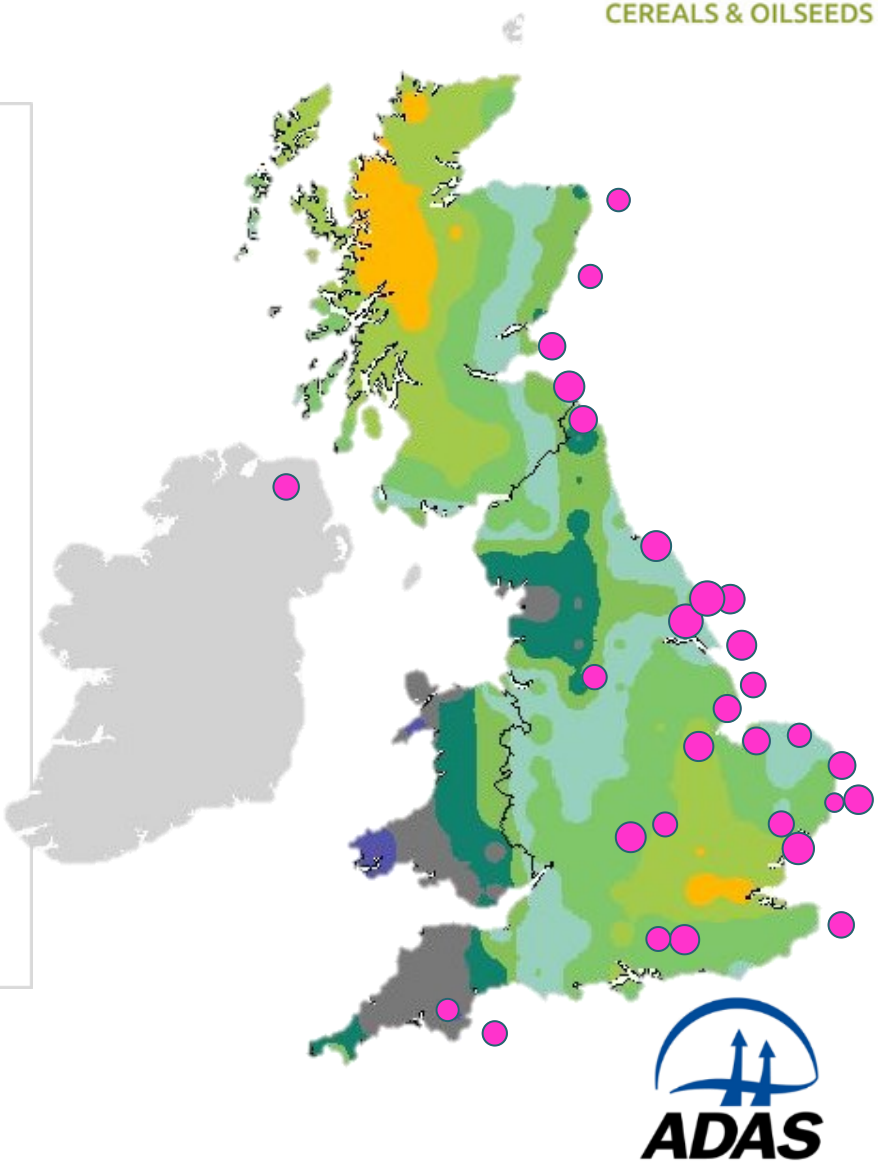
RL yields 2016



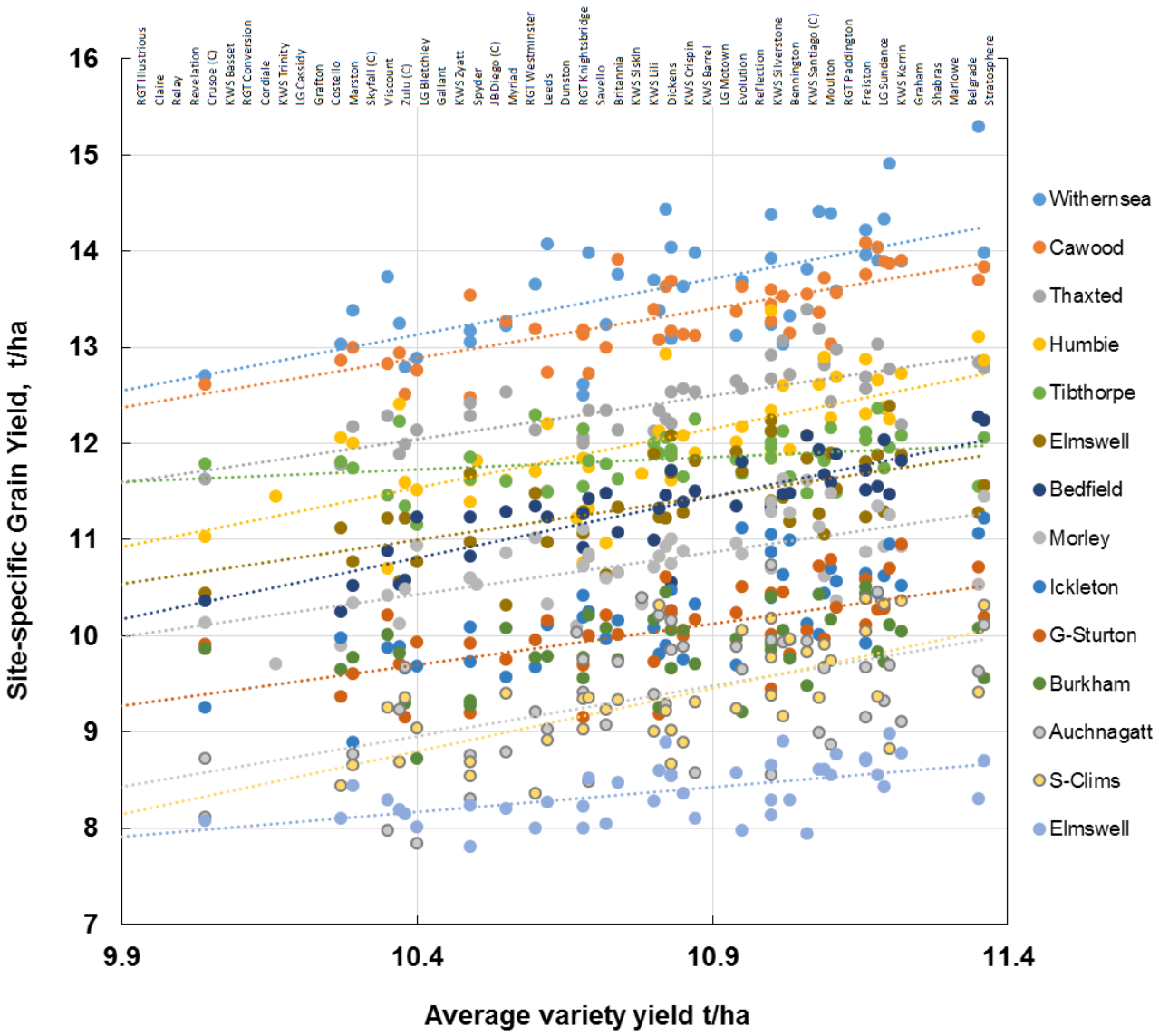


RL yields 10.7 t/ha down from 11.6 t/ha in 2015

13 of 30 trials exceeded 12 t/ha in 2015

… only 4 trials >12 t/ha in 2016

Variety & Site variation : RL 2016 … 14 out of 29 sites



- Site effects exceed genetic effects
  - Variety range 1.3 t ha^{-1}
  - Site range 5.2 t ha^{-1}
    - include soil, weather, rotation, husbandry, etc.
- Slopes are all +ve
  - Slope range 0.3 to 1.4
  - R^2 range 0.1 to 0.7

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YEN Database analysis 2013 – 2015

Explanatory power, R^2

- Ears / m^2 0.15
- Grains / ear 0.01
- Grains / m^2 0.32
- TGW, g 0.12
- Harvest Index 0.00
- Grain N, %DM 0.01
- Biomass, t/ha 0.81
  - Straw DM, t/ha 0.48

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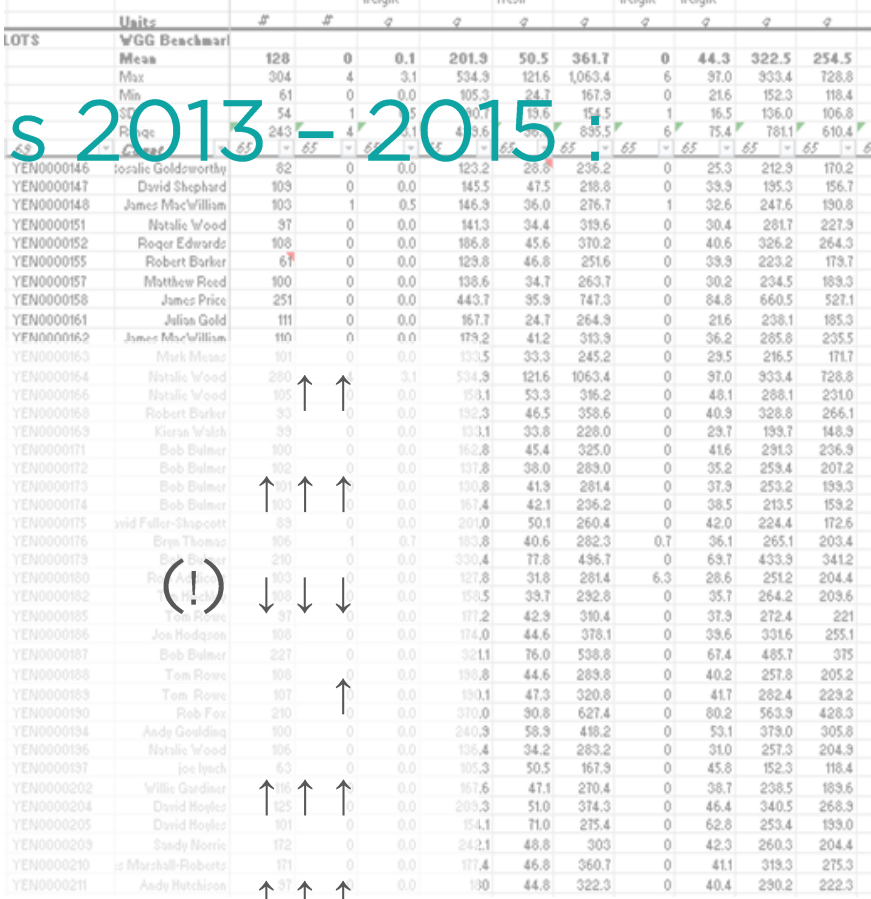
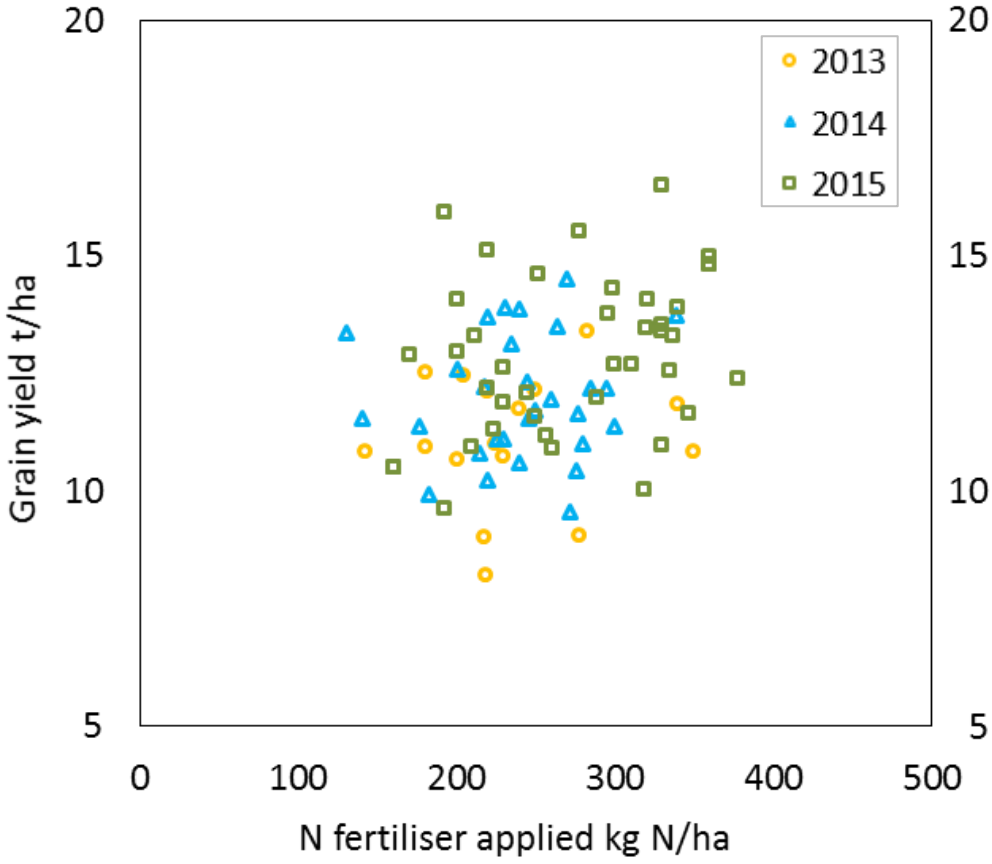
New Database analysis 2013 – 2015 : crop traits

- Height
- Ears / m^2
- Spikelets
- Chaff DM per ear
- Grains / ear
- TGW
- Specific weight
- Harvest Index
- Grain N%

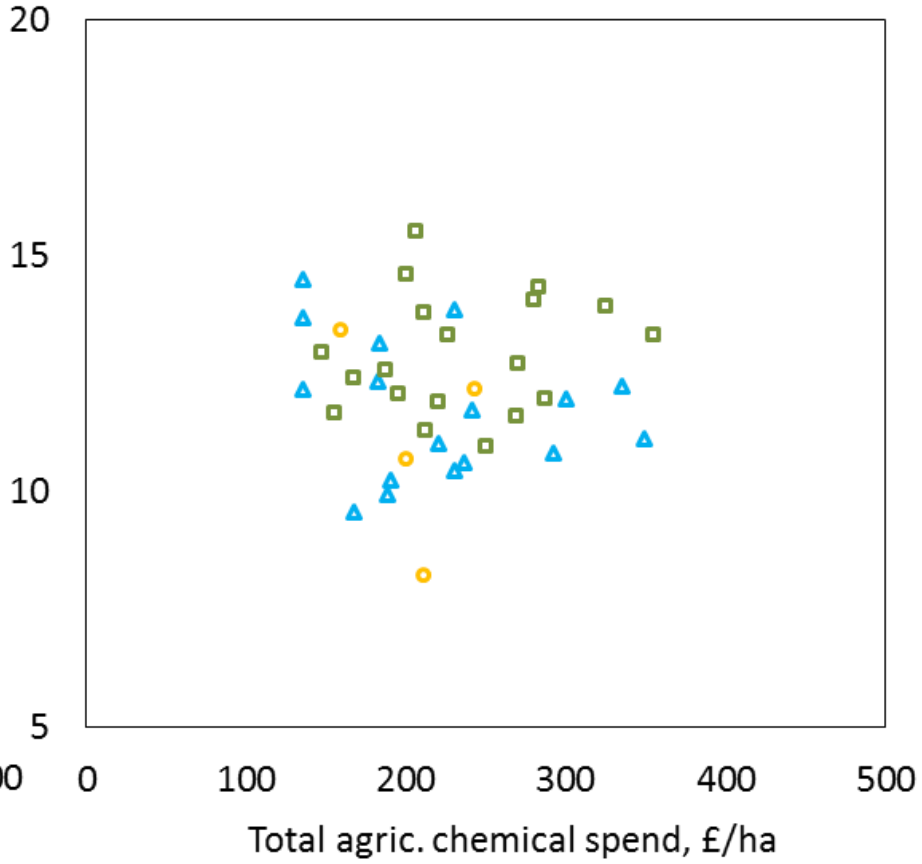


New YEN database analysis 2013 – 2015 : Agronomy

How important is Nitrogen?



.. or Pesticides?



… high yielding crops tend to use resources more efficiently, and increase margins

… BUT they <u>do not</u> relate to boughten inputs

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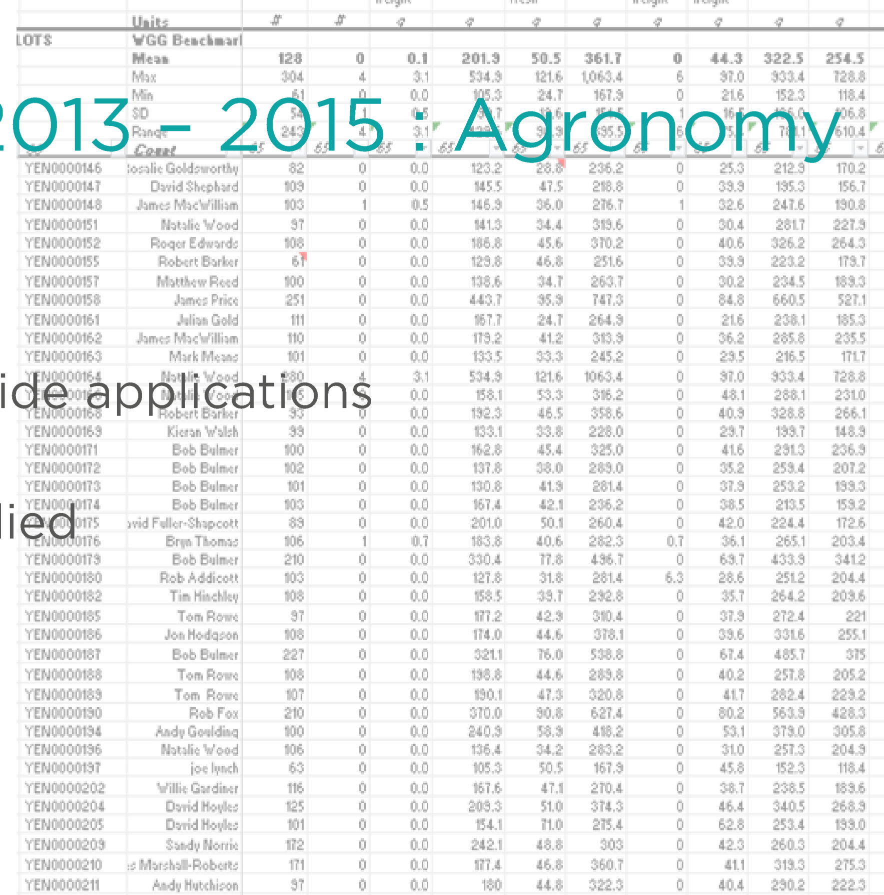
New Database analysis 2013 – 2015 : Agronomy



LOTS	Units	#	#	g	g	g	g	g	g	g	g
	WGG Benchmark										
	Mean	128	0	0.1	201.9	50.5	361.7	0	44.3	322.5	254.5
	Max	304	4	3.1	534.9	121.6	1,063.4	6	97.0	933.4	728.8
	Min	61	0	0.0	105.3	24.7	167.9	0	21.6	152.3	118.4
	SD	54	1	0.5	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	106.8
	Range	243	4	3.1	[illegible]	[illegible]	[illegible]	6	[illegible]	[illegible]	610.4
	Count										
YEN0000146	Rosalie Goldsworthy	82	0	0.0	123.2	28.8	236.2	0	25.3	212.9	170.2
YEN0000147	David Shephard	109	0	0.0	145.5	47.5	218.8	0	39.9	195.3	156.7
YEN0000148	James MacWilliam	103	1	0.5	146.9	36.0	276.7	1	32.6	247.6	190.8
YEN0000151	Natalie Wood	97	0	0.0	141.3	34.4	319.6	0	30.4	281.7	227.9
YEN0000152	Roger Edwards	108	0	0.0	186.8	45.6	370.2	0	40.6	326.2	264.3
YEN0000155	Robert Barker	61	0	0.0	129.8	46.8	251.6	0	39.9	223.2	179.7
YEN0000157	Matthew Reed	100	0	0.0	138.6	34.7	263.7	0	30.2	234.5	189.3
YEN0000158	James Price	251	0	0.0	443.7	95.9	747.3	0	84.8	660.5	527.1
YEN0000161	Julian Gold	111	0	0.0	167.7	24.7	264.9	0	21.6	238.1	185.3
YEN0000162	James MacWilliam	110	0	0.0	179.2	41.2	313.9	0	36.2	285.8	235.5
YEN0000163	Mark Means	101	0	0.0	133.5	33.3	245.2	0	23.5	216.5	171.7
YEN0000164	Natalie Wood	280	4	3.1	534.9	121.6	1063.4	0	97.0	933.4	728.8
[illegible]	Natalie Wood	[illegible]	[illegible]	0.0	158.1	53.3	316.2	0	48.1	288.1	231.0
YEN0000168	Robert Barker	93	0	0.0	192.3	46.5	358.6	0	40.9	328.8	266.1
YEN0000169	Kieran Walsh	99	0	0.0	133.1	33.8	228.0	0	29.7	199.7	148.9
YEN0000171	Bob Bulmer	100	0	0.0	162.8	45.4	325.0	0	41.6	291.3	236.9
YEN0000172	Bob Bulmer	102	0	0.0	137.8	38.0	289.0	0	35.2	259.4	207.2
YEN0000173	Bob Bulmer	101	0	0.0	130.8	41.9	281.4	0	37.9	253.2	199.3
YEN0000174	Bob Bulmer	103	0	0.0	167.4	42.1	236.2	0	38.5	213.5	159.2
YEN0000175	David Fuller-Shapcott	89	0	0.0	201.0	50.1	260.4	0	42.0	224.4	172.6
YEN0000176	Bryn Thomas	106	1	0.7	183.8	40.6	282.3	0.7	36.1	265.1	203.4
YEN0000179	Bob Bulmer	210	0	0.0	330.4	77.8	436.7	0	63.7	433.9	341.2
YEN0000180	Rob Addicott	103	0	0.0	127.8	31.8	281.4	6.3	28.6	251.2	204.4
YEN0000182	Tim Hinchley	108	0	0.0	158.5	39.7	292.8	0	35.7	264.2	209.6
YEN0000185	Tom Rowe	97	0	0.0	177.2	42.9	310.4	0	37.9	272.4	221
YEN0000186	Jon Hodgson	108	0	0.0	174.0	44.6	378.1	0	39.6	331.6	255.1
YEN0000187	Bob Bulmer	227	0	0.0	321.1	76.0	538.8	0	67.4	485.7	375
YEN0000188	Tom Rowe	108	0	0.0	198.8	44.6	289.8	0	40.2	257.8	205.2
YEN0000189	Tom Rowe	107	0	0.0	190.1	47.3	320.8	0	41.7	282.4	229.2
YEN0000190	Rob Fox	210	0	0.0	370.0	90.8	627.4	0	80.2	563.9	428.3
YEN0000194	Andy Goulding	100	0	0.0	240.9	58.9	418.2	0	53.1	379.0	305.8
YEN0000196	Natalie Wood	106	0	0.0	136.4	34.2	283.2	0	31.0	257.3	204.9
YEN0000197	joe lynch	63	0	0.0	105.3	50.5	167.9	0	45.8	152.3	118.4
YEN0000202	Willie Gardiner	116	0	0.0	167.6	47.1	270.4	0	38.7	238.5	189.6
YEN0000204	David Hoyles	125	0	0.0	209.3	51.0	374.3	0	46.4	340.5	268.9
YEN0000205	David Hoyles	101	0	0.0	154.1	71.0	275.4	0	62.8	253.4	199.0
YEN0000209	Sandy Norrie	172	0	0.0	242.1	48.8	303	0	42.3	260.3	204.4
YEN0000210	Marshall-Roberts	171	0	0.0	177.4	46.8	360.7	0	41.1	319.3	275.3
YEN0000211	Andy Hutchison	97	0	0.0	180	44.8	322.3	0	40.4	290.2	222.3

- No effect of:
  - N rate applied
  - Fungicide spend … or no. fungicide applications
  - Sowing date
  - Micronutrients, P K Mg or S applied
  - Cultivation type
  - Manure history
  - Soil type
  - Latitude .. or Longitude.
- Only 2 significant effects found:
  - Grass history
    - higher yields if longer since grass (!)
  - N fertiliser type:
    - Urea -0.2 t/ha UAN -1.5 t/ha

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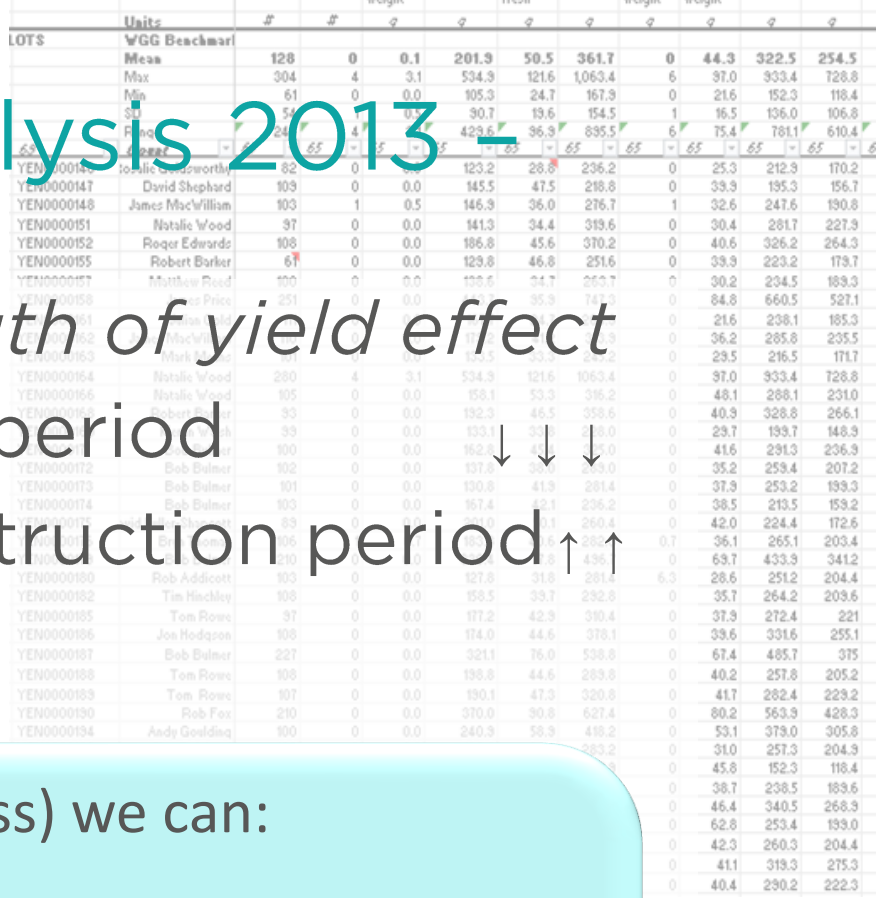
New Database analysis 2013 – 2015 : Weather

FACTOR *Strength of yield effect*

- Rainfall in Foundation period ↓ ↓ ↓
- Solar radiation in Construction period ↑ ↑



From 134 yields (or less) we can:

– prioritise crop traits

– show a few agronomic effects

– find a few weather effects

2016 gave 100 more yields, and …

More yields **More understanding**

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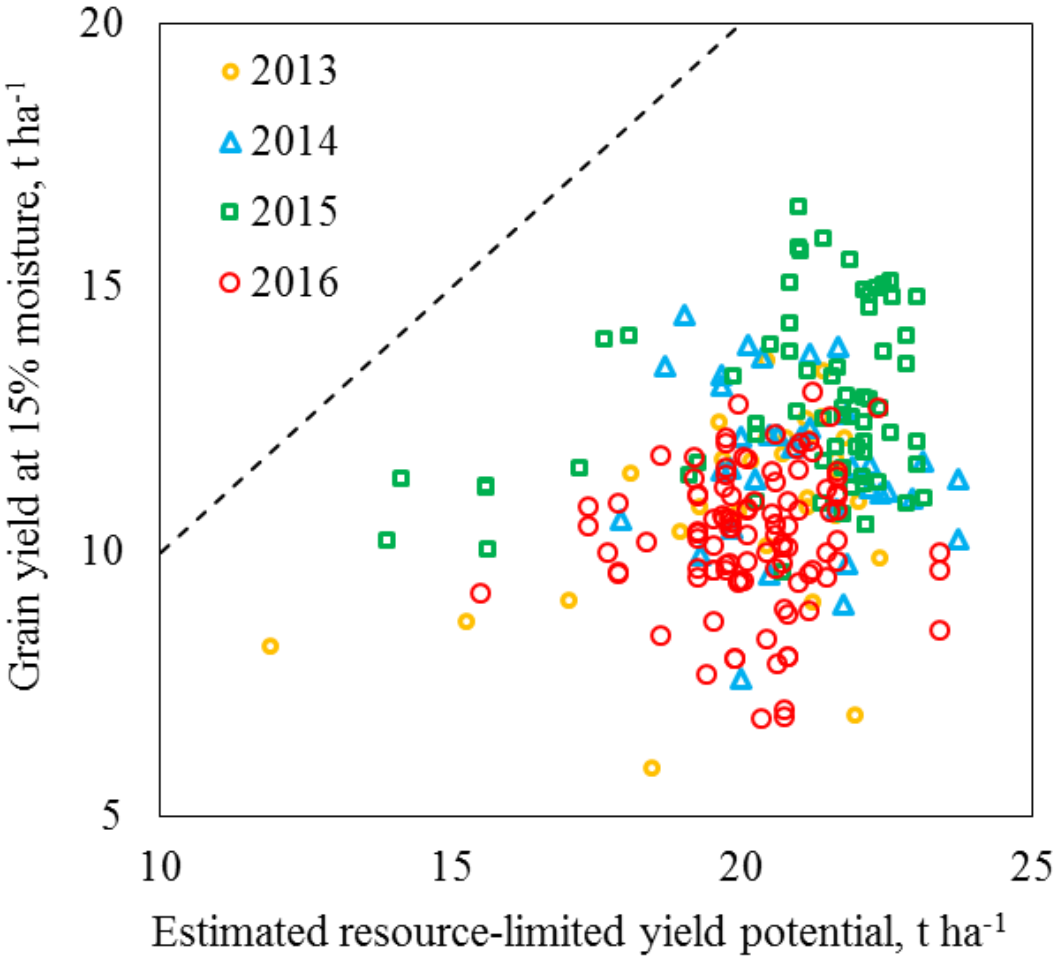
Potential yields vs actual yields



- Bigger gap between potential and achieved in 2016
- Most variation between sites not due to differences in calculated by potentials
- Much still to understand about what is driving differences between fields
  - Temperature & weather
  - Sink impacts
  - Soil differences
  - Farmer Skill

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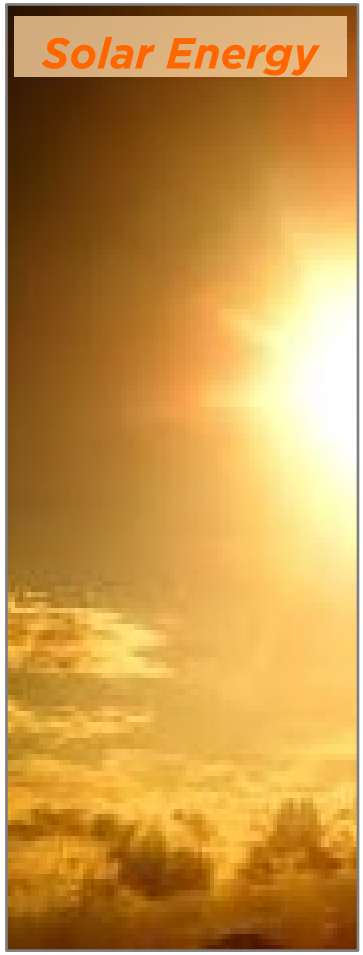
Routes to enhancing yields

- Increase light capture
  - Earlier canopy closure
  - Keep crop & canopies alive for longer
    - Genetics
    - Nutrition
    - Disease control
- Increase water capture
  - Increase available water content of soil
    - Increase SOM
      - … limited direct impact?
  - Encourage deeper rooting
    - Soil management?
    - Rotations with deep rooting crops
      - lucerne
  - Healthy top soil gives greater access to subsoil?
    - increase earthworm channels



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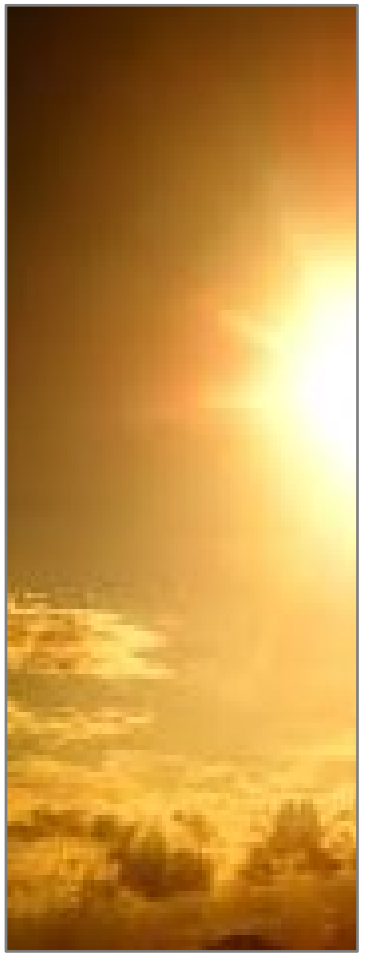
Farm Strategy and Innovation

- Soil & Climate
- Rotation
- Cultivations
- Species
- Variety
- Establishment
- Nutrition
- Protection
- Harvesting

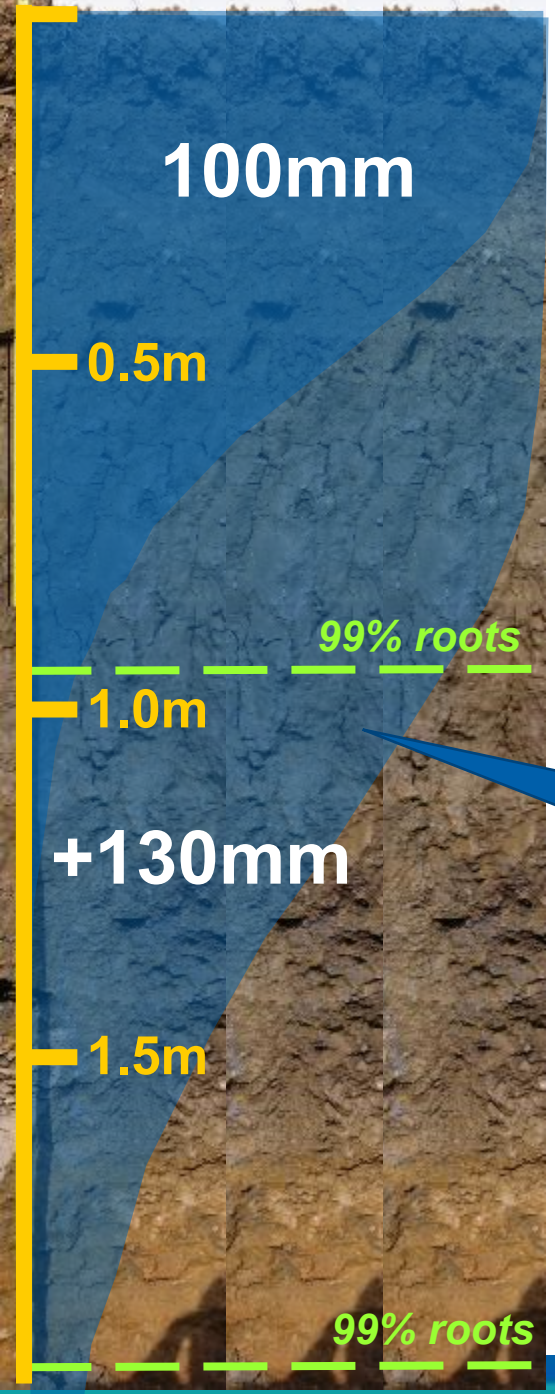
Increasing light capture

- Genetics
- Nutrition
  - Rate
  - Timing
  - N type
    - AN vs Urea vs UAN???
- Disease control



Increasing water capture

- Increase available water content of soil
  - Increase SOM
    - … limited direct impact?
- Encourage deeper rooting
  - Soil management?
  - Cover crops?
  - Rotations with deep rooting crops
    - lucerne
- Healthy top soil gives greater access to subsoil?
  - increase earthworm channels

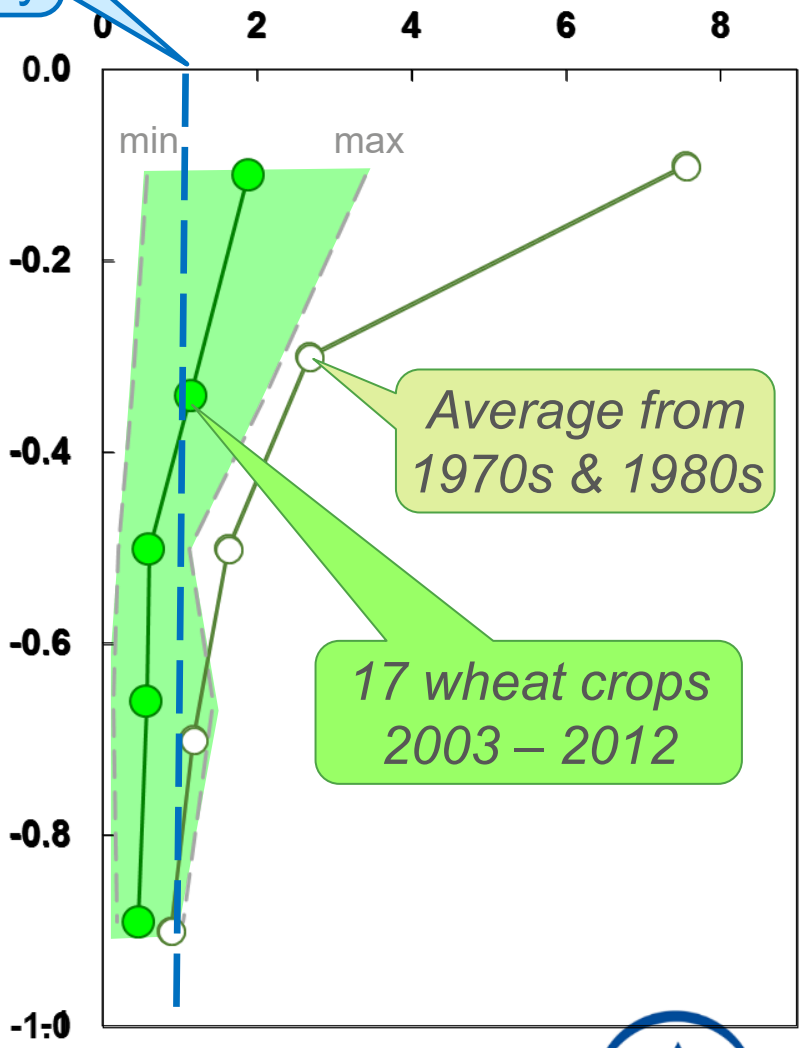


Soil Water Capture

Potential

Critical Root Density

Root density, per cm^2



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Summary – the YEN vision

- Inspiring innovation for better yields, through:
  - Good measurements .. esp. yields
  - Analysis / Understanding
  - Networking

- **Testing Ideas ..**
  - Farm groups, with shared interests
  - Trustworthy yields
  - Verified comparisons

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Conclusions

- Clear scope for further yield enhancement
  - Natural resources are sufficient for 20 t ha^{-1} grain
  - Record yields >16 t ha^{-1} grain
  - Maximising yields depend on increasing capture of light and water
    - Not fundamentally dependent on intensifying bought inputs
- Environmental impacts of yield enhancement
  - Contrasting effects: increase $hectare^{-1}$ versus decrease $tonne^{-1}$
  - Neutral (ha^{-1}) for most manufactured inputs
  - Nutrient impacts depend on better systems & supply-chain requirements
  - Water: mixed effects, site-dependent
- YEN database of validated yields
  - Good, validated data will allow analysis & modelling of actual farm yields
  - Develop hypotheses from data, farmers, agronomists & industry
  - Network of farmers to test hypotheses & engage in research – Agronōmics
  - PLEASE JOIN THE YEN !!

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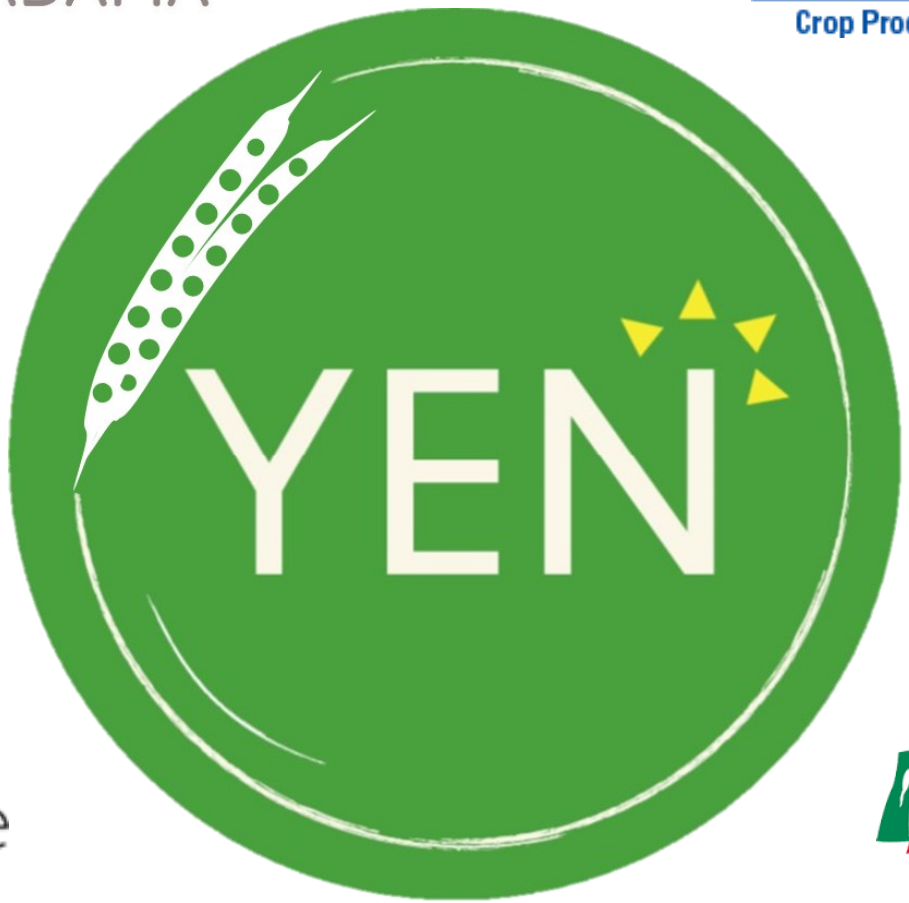
Yield Competitions

New Oilseed YEN 2017

osryen@adas.co.uk



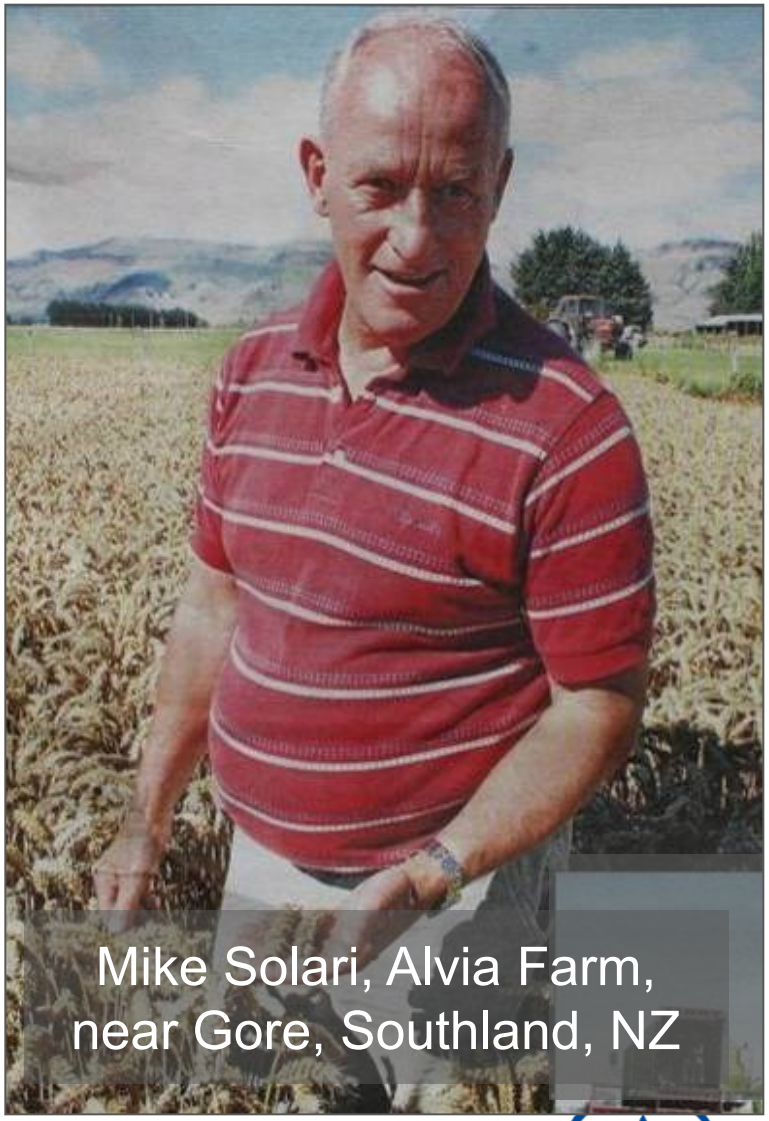
Pea YEN 2016


ADAMA
HUTCHINSONS
Crop Production Specialists
ADAS
CF
YEN
DSV
ADM
nrm
laboratories
AG Space
R·A·G·T
SEEDS
AHDB
CEREALS & OILSEEDS
YARA

World Record Yield .. 2010

- Grain cv. Einstein 15.7 t/ha
  - @ 15% MC & 10.9% protein … ~320 kg/ha crop N
- Incident Solar Radiation: 50 TJ/m^2
  - Mean temp: 11.6 ºC (UK norm: 14.6 ºC)
- Summer Water Supply: 660 mm
  - 394 mm summer rain plus >200 mm soil water
- Nitrogen Supply: 535 kg/ha
  - After peas, 85 kg/ha soil N supply
  - + 450 kg/ha fertiliser N applied.
- ESTIMATED POTENTIAL 25.7 t/ha

Yield achieved : 61% of potential



Mike Solari, Alvia Farm, near Gore, Southland, NZ

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World Record Yield 2015

- Grain cv. Dickens 16.52 t/ha
  - @ 15% MC & 11% protein … ~350 kg/ha crop N
- Incident Solar Radiation: 37.3TJ/m^2
  - Mean temp: 12.4 ºC (UK norm: 14.6 ºC)
- Summer Water Supply: 444 mm
  - 212 mm summer rain plus ~232 mm soil water
- Nitrogen Supply: 395 kg/ha
  - After spring beans, ~85 kg/ha soil N supply
  - + 310 kg/ha fertiliser N applied.
- ESTIMATED POTENTIAL 22.1 t/ha

  Yield achieved : 75% of potential

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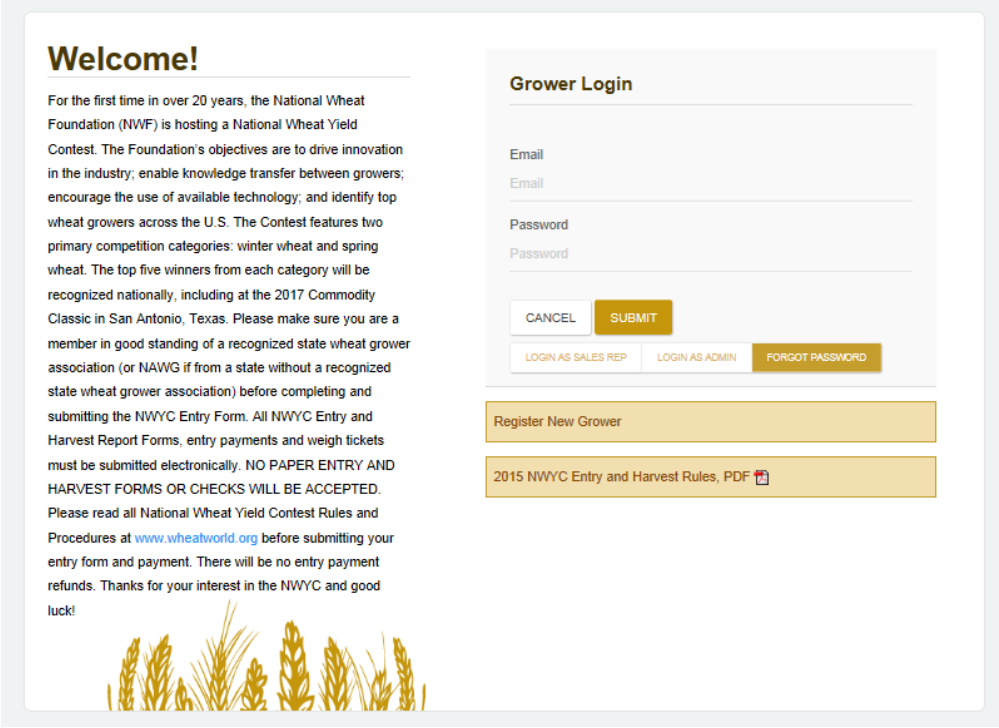
US National wheat Yield contest re-started 2016

- https://yieldcontest.wheatfoundation.org/



JOHN DEERE BASF WINFIELD MONSANTO NATIONAL WHEAT FOUNDATION

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Regional contests in US

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Swedish Yield competition

- http://www.svenskraps.se/rapsmastaren/index.asp

Segrare i tävlingen Rapsmästaren blev Gunnar Henningsson

Vi gratulerar Gunnar till en mycket fin insats! Med sina 6570 kilo frö per hektar toppade han klart övriga 39 deltagare. Gunnars skörd låg drygt 50 % över det lägsta tävlingsresultatet.

Gunnar har lagt ner ett mycket stort engagemang, hjärta och själ i sin raps. Han har tidigare vunnit internationella mästerskap i mest ekonomiska höstrapsodling - nu visar han att han även behärskar maximal skörd.

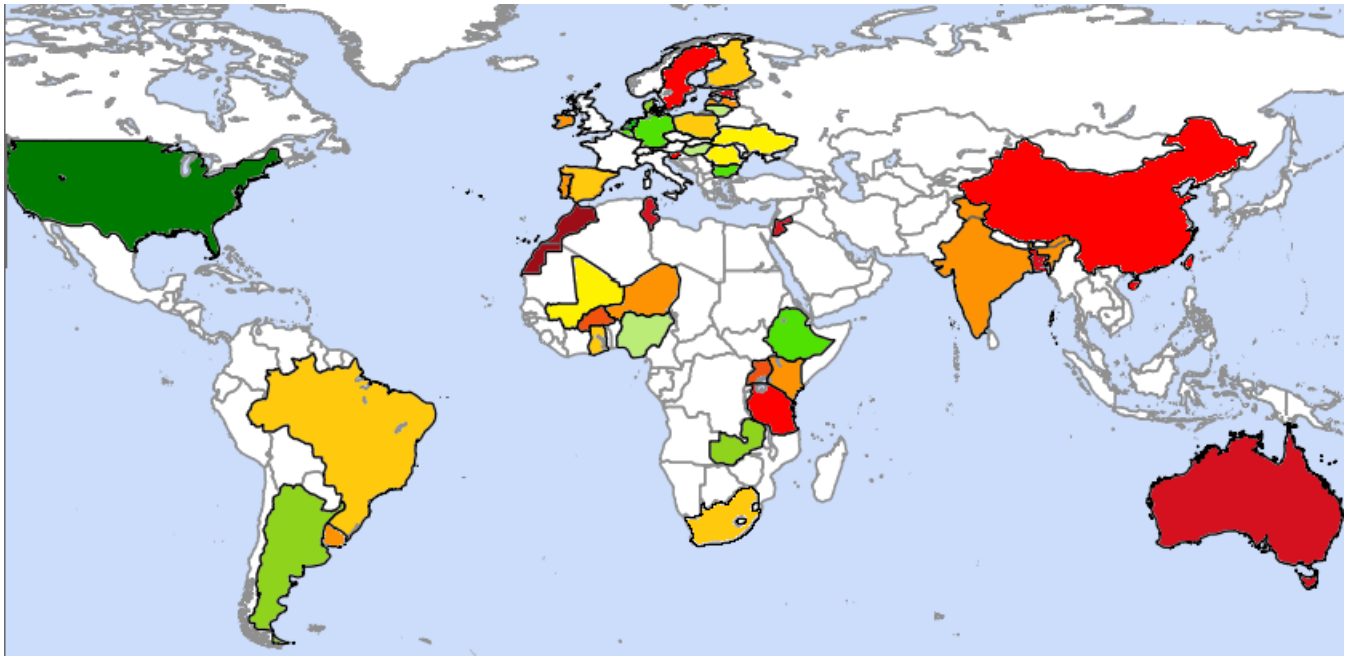
Se filmen där Gunnar helt kort berättar om tävlingen. Artiklar om tävlingen hittar du i Svensk Frötidning och Tidningen Lantmannen. Fler uttömmande filmer där Gunnar redogör i detalj för sina insatser i tävlingen kommer. Här finns mycket att lära!

YEN International?

Global Yield Gap Atlas

WAGENINGEN UNIVERSITY & RESEARCH

University of Nebraska Lincoln



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Thank you

Thank you to our sponsors

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