Grass-weeds: lost battles and war-winning tactics

Stephen Moss Consulting
Currently (2 February 2018)

- 254 different species (148 dicots/106 monocots).
- 163 different herbicides.
- In 70 countries.
Herbicide-resistant weeds in the UK

The most important herbicide-resistant weed in western Europe

No resistant Bromes - yet
Cambridge field trial on ALS TSR resistant poppies July 2013

Metsulfuron = sulfonyurea ALS inhibitor

Flufenacet + Pendimethalin = other MOA

‘Ally’

‘Crystal’
Black-grass
Counties (37) with herbicide-resistant black-grass (by 2016)

First detected in 1982

- 20,000 farms have black-grass
- 20,000 farms have resistance

Resistance is present on virtually every farm where herbicides are used regularly for its control

- Resistance to ACCase herbicides (fops/dims/dens) widespread
- Resistance to ALS herbicides (e.g. ‘Atlantis’) increasing fast
- Pre-emergence herbicides now the main means of chemical control

Enhanced metabolism at least as important as ACCase and ALS target site resistance. Multiple resistance common.
Black-grass (& most other grass-weeds) emergence

Q. What happens if you sow here?

A. Most black-grass (& brome & rye-grass) emerges in the crop

>80% emergence occurs in early autumn
% of winter wheat crop in England sown in September (1970 – 2016 harvest years)

Source: Defra winter wheat survey
Herbicides with activity against black-grass introduced since 1956
Total = 41; only 23 still available (in **bold**)

Orange fill = resistance demonstrated
Green fill = no resistance (or not tested)

<table>
<thead>
<tr>
<th>Year</th>
<th>Herbicide</th>
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<tbody>
<tr>
<td>1956</td>
<td>simazine</td>
<td>1971</td>
<td>chlorotoluron</td>
<td>1982</td>
<td>metazachlor</td>
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<td>1958</td>
<td>atrazine</td>
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<td>propyzamide</td>
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<td>chlorosulfuron*</td>
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<tr>
<td>1962</td>
<td>paraquat</td>
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<td>carbetamide</td>
<td>1984</td>
<td>quizalofop-ethyl</td>
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<td>1964</td>
<td>tri-allate</td>
<td>1974</td>
<td>glyphosate</td>
<td>1986</td>
<td>imazamethabenz</td>
</tr>
<tr>
<td>1965</td>
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<td>1975</td>
<td>isoproturon</td>
<td>1990</td>
<td>fenoxaprop</td>
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<tr>
<td>1968</td>
<td>terbutryn</td>
<td>1976</td>
<td>diclofop</td>
<td>1993</td>
<td>tralkoxydim</td>
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</tbody>
</table>
No new herbicide modes of action for > 30 years
Oh black-grass, thou shalt stop germinating on my fields

Neighbours, sniggering

Sea of black-grass
TO BEAT BLACK-GRASS
5 control strategies for 5 years

Stephen Moss &
Tom Allen-Stevens
Potential reduction of black-grass by >99% over 5 years IF seed return can be prevented

- Black-grass won’t be eliminated in 5 years, but infestations can be dramatically reduced
- This is why strategies need to be adopted for several years – 1 or 2 years are not enough
5 for 5 to beat black-grass

- Opportunistic (rotational) ploughing
- Post-harvest stubble cultivations
- Min till/direct drilling/strip tillage
- Min till prior to spring crops
- Inter-row hoeing/harrow

- Delay autumn drilling
- More spring sown crops
- Fallow – ideally >2 years
- Grass ley ley breaks (>2 years)
- Crop rotation

- Patch spraying
- Roguing
- Crop destruct (AD?)
- Minimise seed spread (in crop seed, straw, equipment & manure)
- Novel methods (e.g. seed capture)

- Crops (e.g. barley)
- Competitive varieties
- High seed rates
- Narrow rows
- Drainage
- Cover crops

- Use glyphosate pre-sowing to kill weeds effectively
- Rational pre-emergence herbicide use
- Less dependence on high resistance risk post-em herbicides
- Reassess value of older actives (e.g. clodinafop in mixtures)
- Use alternative modes of action in non-cereal crops
- Monitor impact of herbicide resistance

Stephen Moss Consulting
1. Stop weed seed shedding

How easy is it to use GPS to enable repeated, annual spraying of same patches, small or large?
The optimum strategy for freshly shed weed seeds is not to cultivate soon after harvest for most weeds (except sterile brome & volunteer cereals)


Should post-harvest cultivations be delayed to encourage seed predation and ‘natural loss’?
Field at Peldon, Essex – > 50 years in wheat
Highly resistant black-grass
BUT this = 3rd spring-sown wheat
No black-grass visible – 1st time in >30 years

How many successive spring crops are you willing to contemplate?
### 4. Increase crop competition

<table>
<thead>
<tr>
<th>450 wheat seeds sown/m²</th>
<th>150 wheat seeds sown/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 black-grass heads/plant</td>
<td>5.3 black-grass heads/plant</td>
</tr>
<tr>
<td>170 seeds/plant</td>
<td>419 seeds/plant</td>
</tr>
</tbody>
</table>

59% less seed return

How high a seed rate is acceptable?
5. Herbicides

Pre-emergence herbicides are potentially affected by:

- **Resistance** (all pre-ems vulnerable)
- **Amount of soil organic matter** (and other soil properties)
- **Enhanced degradation within soil** (by microorganisms)

Are you willing to experiment to find the best pre-ems for your own farm and to determine exactly what post-ems are delivering?
Also essential are the three ‘R’s: Recording, Reviewing & Revising plan.
Dieting
Needs discipline and commitment – and not easy

Eat & drink less

Ditto for black-grass but need years, not months
One day, son, all this will be yours
Italian rye-grass

1. It is twice as competitive as black-grass
2. It produces 10 x as much seed per plant
3. Populations can build up faster?
Managing herbicide-resistant rye-grass

• Take action as soon as rye-grass is noticed – hand rogue low populations or spray off patches

• Use cultural control measures (delayed autumn sowing and spring cropping may be more effective than against black-grass?)


• Avoid over-reliance on fops/dims/dens & ALS

• Be aware of the risk of glyphosate resistance – it occurs in rye-grass in 13 countries
Brome
### New brome project (started 2017)
(led by ADAS Boxworth – Laura Davies)

58 seed samples for ID and herbicide testing

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterile brome</td>
<td>20</td>
</tr>
<tr>
<td>Great brome</td>
<td>8</td>
</tr>
<tr>
<td>Sterile &amp; Great mix</td>
<td>1</td>
</tr>
<tr>
<td>Meadow brome</td>
<td>8</td>
</tr>
<tr>
<td>Rye brome</td>
<td>15</td>
</tr>
<tr>
<td>Soft brome</td>
<td>1</td>
</tr>
<tr>
<td>Mix Bromus</td>
<td>3</td>
</tr>
<tr>
<td>Unknown (Field brome?)</td>
<td>2</td>
</tr>
</tbody>
</table>

- **38% wrongly identified** by farmers/agrononomists
- 8 samples of rye brome wrongly identified as soft or meadow
- 5 great brome wrongly identified as sterile
Which brome is that?

A new 2 page identification leaflet

Available from:

http://croprotect.com

This new leaflet is as shorter version of the 4 page version produced last year.
Glyphosate-resistant sterile brome?

Susceptible

Resistant?

Untreated

540 g glyphosate/ha applied at 1 – 2 tiller stage: 30 days post spraying
Wild-oats

*Avena* spp.

Common wild-oats
*Avena fatua*

Winter wild-oats
*Avena sterilis* ssp. *ludoviciana*
Somewhere in Essex 2014
Questions/Discussion

• How easy is it to use GPS to enable repeated, annual spraying of the same patches, small or large?

• Rotational ploughing. How effective?

• Could post-harvest cultivations be delayed to encourage seed predation and ‘natural’ loss?

• How many successive spring crops are you willing to contemplate?

• How high a seed rate is ‘safe’ and acceptable?

• Are you willing to experiment to find the best pre-emss for your own farm and what post-emss are delivering?

• ‘Centurion Max’. How useful is it in non-cereal crops?
‘Inspiring our farmers, growers and industry to succeed in a rapidly changing world’
Soil health – what do we know, what can we do?

Elizabeth Stockdale
Head of Farming Systems, NIAB
All land is unique

May have similar constraints

But not the same field by field or even within a field

Soil type sets inherent limits to physical properties

Management modifies properties
Soil Biology and Soil Health Partnership
What will the partnership do?

• Five years to deliver linked knowledge exchange and research on soil biology and soil health

• Improve on-farm understanding of soil health by sharing current academic and industry knowledge in usable formats

• Developing and validating indicators of soil biology and soil health in research trials and on-farm

• Building on work already carried out
Valuing and working with farmer innovation developing locally adapted practices
Existing knowledge
CLIMATE
Temperature, rainfall, evaporation
Where impact is mediated by both amount and seasonality

NUTRIENT INPUTS
Fertiliser, manure, deposition etc
where availability is mediated by many of the same factors

Plant
- Development of root hairs
- Root density
- Root uptake efficiency
- Nodule formation
- Root infection with mycorrhizal fungi

Biological
- Action and activity of soil fauna
- Soil enzymes
- Mineralisation-immobilisation
- N fixation
- Activity of decomposing micro-organisms
- Nodule formation

Chemical
- CEC
- Buffer capacity
- pH
- Redox potential
- Organic ligands
- Presence of potentially toxic elements

Physical
- Soil water balance
- Temperature
- Aeration
- Pore size distribution
- Compaction
- Bulk density
- Textures
- Chemical mineralogy

Soil function
- e.g. nutrient supply

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Fertiliser, manure, deposition etc
where availability is mediated by many of the same factors

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Physical
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- Textures
- Chemical mineralogy
So what does science know?

At scale of farming systems, the scientists’ understanding of impacts of management on soil health is incomplete and, where it does exist, fairly sketchy.

But increasing evidence that increased OM inputs (diversity) and reduced tillage act together to promote increased biological activity.

There is some indication that resilience to extreme events may be increased as a result.

Increasing OM inputs to maintain good baseline activity increases resilience to tillage disturbance (even potatoes).
Know your textures and understand limits to workability, trafficability

• Optimise water balance through drainage if necessary
• Improve soil structure – effective continuous pore space

Physical

KNOW YOUR SOILS; principles to improve soil health

Chemical

• Maintain optimum pH
• Provide plant nutrients – right amounts in the right place at the right time
• Know your textures and minerals – buffering capacity, free supply!

Biological

• Feed the soil regularly through plants and OM inputs
• Move soil only when you have to
• Diversify plants in space and time

Physical

Know your textures and understand limits to workability, trafficability

• Optimise water balance through drainage if necessary
• Improve soil structure – effective continuous pore space
Soil biology
Decomposition – transforming the sun’s energy a joint venture for the food web

Earthworms

Plant residues

Soil organic matter

Bacteria

Protozoa

Bacterial feeding nematodes

Collembola

Enchytraeids

Fungal feeding nematodes

Fungal feeding mites

Predatory nematodes

Predatory mites

comminution

Fungi
SOIL STRUCTURE

**Roots**
- Polysaccharides, glycoproteins
  - Microaggregates – clay domains, silt, sand and OM bound together

**Enmeshment**
- Faecal pellets

**Aggregates**
- Soil organic matter
- Mineral particles
- OM bound together

**Decomposition**
- Plant residues
- Soil organic matter

**Earthworms**
- Comminution
- Bacterial feeding
- Fungal feeding

**Enchytraeids**
- Predatory nematodes
- Predatory mites
- Fungal feeding

**Collembola**
- Bacterial feeding
- Fungal feeding

**Mites**
- Fungal feeding
- Predatory mites

**Bacteria**
- Fungal feeding

**Fungi**
- Fungal feeding

**Protozoa**
- Bacterial feeding
- Fungal feeding

**Predatory nematodes**

**Earthworms**
- Creating transmission pores
  - Mixing OM and mineral particles

**Enchytraeids**
- Comminution
- Mixing OM and mineral particles

**Collembola**
- Bacterial feeding

**Mites**
- Fungal feeding

**Bacterial feeding nematodes**

**Fungal feeding nematodes**

**Predatory nematodes**

**Predatory mites**

**SOIL STRUCTURE**
- Modify pore size and continuity
  - Mixing OM and mineral particles
With greater microbial biomass, generally, there is more soil nutrient supply.

Data from Western Australian Wheatbelt, Prof. Dan Murphy
So how can I help the soil life help me?

System-oriented approaches

- Increase OM inputs
- Increase plant diversity
- Reduce tillage intensity
More detail …
Natural England Commissioned Report 100

Available online
Natural England Commissioned Reports, Number 100.
Why measure soil quality/health?

Think of it in terms of:
An MOT for your soil OR a check up at the doctors

• Working towards
  (i) rolling out soil quality testing
  (ii) ‘what if’ model for knowledge exchange
Components of soil quality

Physics  ↔  Chemistry  ↔  Biology

Current soil reports
pH
Routine nutrients
Components of soil quality

Physics  Chemistry  Biology

- Current soil reports
- pH
- Routine nutrients

Putting it all together will need a different approach to sample collection – linking physical observation and soil samples sent for testing.
Testing and developing measures of soil quality

Existing indicators included
- pH
- Routine nutrients
- Bulk Density
- Penetrometer resistance

Less common indicators evaluated and framework for interpretation developed
- Visual assessment of soil structure (VESS)
- Soil organic matter / loss on ignition (LOI)
- Respiration and Solvita test (NRM)
- Earthworms

New indicators developed and tested
- Total N
- Microbial biomass carbon (MBC)
- Potentially mineralisable nitrogen (PMN)
- DNA measures of pathogens and soil health
- Nematodes
- Microarthropods
Rolling out soil quality testing
Scorecard threshold values

Based on proposals for soilquality.org.uk (based on the Australian model - http://www.soilquality.org.au/) to enable utilisation of a wider database for benchmarking and ultimately advice.

The traffic light system represents:

<table>
<thead>
<tr>
<th>Colour</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>RED</td>
<td>(High risk, need to investigate urgently)</td>
</tr>
<tr>
<td>AMBER</td>
<td>(Moderate risk, need to investigate further)</td>
</tr>
<tr>
<td>GREEN</td>
<td>(Low risk, continue to monitor)</td>
</tr>
</tbody>
</table>
What might a scorecard look like ...

ACME SOIL ANALYSIS COMPANY
Report for Mr A. Farmer
(who has a grassland field that needs some lime, has had a fair bit of P added and is compacted)

Would be followed with links to or hard copy of background information on the parameters measured, especially if red or amber.
### Scotland – Extractable P (Modified Morgan’s)

<table>
<thead>
<tr>
<th>Bar chart classes</th>
<th>Traffic light colour</th>
<th>Description of this class (e.g. toxic)</th>
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<tbody>
<tr>
<td>0-1.7</td>
<td>Red</td>
<td>VL – risk to production</td>
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<tr>
<td>1.8-4.4</td>
<td>Yellow</td>
<td>L – potential risk to production</td>
</tr>
<tr>
<td>4.5-9.4</td>
<td>Green</td>
<td>M-</td>
</tr>
<tr>
<td>9.5-13.4</td>
<td>Green</td>
<td>M+</td>
</tr>
<tr>
<td>13.5-30.0</td>
<td>Yellow</td>
<td>H – potential risk to environment</td>
</tr>
<tr>
<td>&gt; 30.0</td>
<td>Red</td>
<td>VH – risk to environment</td>
</tr>
</tbody>
</table>
‘Inspiring our farmers, growers and industry to succeed in a rapidly changing world’
Fungicide performance update for wheat and barley
UK annual wheat yield response to fungicide treatment – AHDB variety trials

Average benefit from fungicides = 2.2 t/ha
ADAS Rosemaund Rainfall

<table>
<thead>
<tr>
<th>Month</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
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<tbody>
<tr>
<td>Total Rainfall (mm)</td>
<td>7.4</td>
<td>55.4</td>
<td>24.7</td>
<td>50.9</td>
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<tr>
<td>30 Year Mean (mm)</td>
<td>47.3</td>
<td>49.7</td>
<td>52.1</td>
<td>46.7</td>
</tr>
</tbody>
</table>
Yield response by Variety 2017,
AHDB variety trial Coates, Gloucestershire
Trial methods

- Each trial is sprayed just once
- 4 rates of application tested
  - (25%, 50%, 100%, & 200% of full label rate) per fungicide + untreated

Activity observed on each leaf layer and categorised as:

- Eradicant,
  - if a leaf emerged before fungicides were applied
- Protectant
  - if a leaf has just emerged or is still emerging, when fungicides were applied
Septoria protection 2017 (n=6)
Septoria curative activity 2017 (n-3)

- Elatus Era
- AscraXpro
- Librax

- Proline
- Ignite
- Vertisan
- Imtrex

Percentage of full label rate vs. % disease
Septoria trial yields 2017 (n-5)

- Elatus Era
- AscraXpro
- Librax
- Bravo
- Proline
- Ignite
- Vertisan
- Imtrex

Yield (t/ha) vs. Percentage of full Label rate
Rusts 2017

June conditions
- Checked yellow rust development
- Promoted brown rust

75% of AHDB RL current varieties are 6 or less for Yellow or Brown rust.

Most susceptible:
- Yellow rust – Reflection, Cordiale, Gallant, JB Diego, Grafton and Skyfall.
- Brown rust – Crusoe, Zulu Savello, Shabaras
Yellow rust efficacy - 3 year mean (2015 - 17)
Azole - septoria activity (full dose)

Protectant

Curative

% Variance accounted for = 65.6

% Variance accounted for = 65.7

Mean value for all sites in FP trials in each year for % control from 2001 to 2017
SDHI’s - Imtrex
Septoria tritici control 2013 – 2017 (protectant situations)

Bold lines show the mean response in each year, dotted lines the highest and lowest % control achieved
SDHI’s - Vertisan
Septoria tritici control 2013 – 2017 (protectant situations)

Bold lines show the mean response in each year, dotted lines the highest and lowest % control achieved.
Effect of fungicide programs on selection

Mutant strain frequency (%)

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<tr>
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<th>T1</th>
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<th>SDHI</th>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>MS</td>
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<td>MS</td>
<td>-</td>
<td>MS</td>
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Wheat summary

- Septoria tritici
  - SDHIs highly active, but some evidence of decline in efficacy
  - Use azoles and multisites to slow resistance development

- On rusts
  - Epoxiconazole highly effective in curative situations
  - Elatus Era, highly effective on yellow and brown rust

- Fusarium
  - Prothioconazole leads, metconazole, tebuconazole, and epoxiconazole close behind.
Fungicide performance - Barley
Rhynchosporium protectant data 2015 - 17

Graph showing the % Disease vs Percentage of full label dose for different protectants:
- Siltra Xpro
- Elatus Era
- Priaxor

Graph showing the % Disease vs Percentage of full label dose for other protectants:
- Proline
- Comet
- Imtrex
- Vertisan

The graphs illustrate the effectiveness of different protectants at various percentages of the full label dose.
Previously on Ramularia....
2011-2015 (n=3)
Ramularia 2017 (single site)

- Left graph: Disease vs. Percentage of full label dose for Siltra Xpro, Elatus Era, and Treoris.
- Right graph: Disease vs. Percentage of full label dose for Proline, Imtrex, Zulu, Vertisan, and Bravo.

Midlothian 2017 (mean of two leaves)
SRUC Ramularia - additional trial (Scotland)

Note: All fitted lines are the same except bravo.
**Ramularia**

- Rectangular
- Ring
- Reddish
- Reversible

**Spot Form Net Blotch**

- Lesions develop as small circular or elliptical dark brown spots
- Chlorotic zone of varying width
- Spots are dark brown in colour.
- The disease does not go right through leaf
Net blotch - changes in protective activity single active products

2014+2015 trials (n=2)

- Proline
- Comet
- Imtrex
- Zulu
- Vertisan

% Disease vs. Percentage of full label dose

2016+2017 trials (n=3)

- Proline
- Comet
- Imtrex
- Zulu
- Vertisan

% Disease vs. Percentage of full label dose
Net blotch - changes in protective activity – mixtures

2014+2015 trials (n=2)

- Siltra Xpro
- Elatus Era
- Priaxor

2016+2017 trials (n=3)

- Siltra Xpro
- Elatus Era
- Priaxor

% Disease vs. Percentage of full label dose
Modes of action and efficacy on the main barley diseases

<table>
<thead>
<tr>
<th></th>
<th>Rhyncho</th>
<th>Net Blotch</th>
<th>Ramularia</th>
<th>Powdery mildew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoles</td>
<td>✓</td>
<td>✓</td>
<td>Insensitive isolates in UK populations</td>
<td>✓</td>
</tr>
<tr>
<td>Strobilurins</td>
<td>Insensitivity?</td>
<td>Partial Insensitivity F129L</td>
<td>Insensitivity (G143A)</td>
<td></td>
</tr>
<tr>
<td>SDHI’s</td>
<td>✓</td>
<td>Insensitive isolates in UK populations</td>
<td>Insensitive isolates in UK populations</td>
<td>✓</td>
</tr>
<tr>
<td>Multisites</td>
<td>✓</td>
<td>-</td>
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<td>✓</td>
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</table>
Thank you

Acknowledgements

Bart Fraaije, Rothamsted
Stephen Kildea, Teagasc
Paul Gosling, AHDB
Neil Paveley ADAS
Fiona Burnett, SRUC
Stuart Knight, NIAB
Simon Edwards Harper-Adams
AHDB, Dept of Agriculture food and the Marine (Rep of Ireland)
Phosphorus: Feed the soil or feed the crop?

Roger Sylvester-Bradley, ADAS
Phosphorus (P) is essential for good crop performance
Best practice with phosphorous = RB209

- Maintain soil P at Index 2
  - or Index 3, if growing potatoes or vegetables

- At Index 2, replace crop offtake
  - At < Index 2, build soil P up
  - At > Index 2 (or 3), run soil P down

- Check the soil P Index of each field every 3 to 5 years
  - Take care with soil P sampling and analysis
    …Keep everything the same each time

- Soils may differ in behaviour
  - especially calcareous soils needing annual P

- i.e. “Feed the soil to feed the crop”
Critical soil P: from grain yield response to soil P e.g. Wheat at Peldon, Essex

\[ \text{Yield} = a - b \cdot r^P \]

<table>
<thead>
<tr>
<th>Year</th>
<th>Fitted maximum yield</th>
<th>Olsen P for 98% max yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t/ha</td>
<td>s.e.</td>
</tr>
<tr>
<td>2011</td>
<td>8.86</td>
<td>0.22</td>
</tr>
<tr>
<td>2012</td>
<td>11.84</td>
<td>0.18</td>
</tr>
<tr>
<td>2013</td>
<td>8.67</td>
<td>0.28</td>
</tr>
<tr>
<td>2014</td>
<td>10.07</td>
<td>0.38</td>
</tr>
<tr>
<td>2015</td>
<td>10.74</td>
<td>0.28</td>
</tr>
<tr>
<td>2016</td>
<td>11.44</td>
<td>0.78</td>
</tr>
</tbody>
</table>


Critical Soil P = mg/kg (in that year) giving 98% of fitted maximum yield
All critical soil P evidence, eastern UK

Variation mainly explained by Crop Establishment
No relationship with site, yield, or N sufficiency.
Possible Future Phosphorus Use Strategies?


Withers, Sylvester-Bradley et al. 2014. Feed the Crop Not the Soil: Rethinking Phosphorus Management ... Environmental Science & Technology 48, 6523-6530.
Soluble P in run-off water from arable land

Drain-flow, soluble reactive P (µg/l)

Soil P (mg/l) Olsen

WFD target

Withers et al., Environmental Research Letters 2017
Can we farm at P Index 1?

Issues:
• 80% of UK arable land now at P Index 2 (or more)
• Benefits of reducing soil P from Index 2:
  – Large savings (£s) in P inputs
  – Helps to achieve P targets set for UK water bodies

Specific research questions:
(i) Can we reduce soil P AND enhance yields?
(ii) Can fertiliser P efficiencies be increased?
  and/or can Crop P Demands be reduced (by breeding)?
(iii) Can crop P sufficiency be monitored more reliably?

AHDB Research Review No. 83, Research Reports No. 451 & 570
Withers, Sylvester-Bradley, et al. (2014). Feed the crop not the soil...
*Environmental Science & Technology* 48, 6523–6530
‘Run-down’ sites, since 2010, each 4 reps x 0.5 ha

(a) Modbury, Devon
(b) Boxworth, S Cambs.
(c) Weobley, Herefordshire
(d) Stetchworth, E Cambs.

Soil P, mg L⁻¹

Maintenance
No P applied
9-year half-life

= 2 x SE

AHDB Research Report No. 5701
Managing soil-available P ... results not always as expected

36 farms, following RB209 policy, data from SOYL

See AHDB Project Report No. 570
Responses to fresh fertiliser P at soil P Index 1?
(broadcast TSP before sowing)
Responses to fresh fertiliser P at soil P Index 1?
(broadcast TSP before sowing)

- Wheat, barley, oilseed rape and potatoes
- All sites at P Index 1
- P applied to seedbeds as TSP
- Nil to 275kg/ha P$_2$O$_5$ applied (120kg/ha P)
- Crop Uptake <70kg/ha P$_2$O$_5$ (<30kg/ha P)
- Soil derived P provided ~80% of crop P requirements (range 42% to >100%)
- Average P recovery from broadcast TSP only 4%

**Crop P concentration (mg/kg)**

**Crop biomass growth (kg/ha)**

4%
average recovery of seedbed TSP by first crop
Improving responses to fresh fertiliser P?
(at soil P Index 1)

- Economic responses to fresh broadcast TSP?
  - Potatoes: YES. Barley: Maybe.
  - Wheat & OSR: NO (2 were negative!)

- Placement
  - No effect on P recovery
  - Increased yield 4 times out of 10
    - with barley and potatoes
    - with wheat and OSR - yields tended to decrease!
  - On-going tramline trials by Frontier

- AVAIL®-treated TSP
  - No consistent benefits

- Struvite (slow release, recycled P)
  - Increased P recovery v TSP:
    - 8/10 times (4 significant)
    - one small, but significant, decrease
  - Only significant effects on yield with potatoes

What about other P forms?
... organic P?
P top-dressings?
Seed / Foliar P?
Can fresh seedbed P fully correct P deficiencies?

- 10 trials, 4 crops, 2011 to 2014
- Critical P contents from literature
  - Barraclough et al. and abroad (esp. Australia)
  - Fresh P did not overcome ‘deficiencies’
  - Site differences in crop P become more obvious by harvest, especially for potatoes
- Good case for monitoring P at harvest

Monitoring for crop P sufficiency
Relationship between grain P content and yield

\[ y = -100.59x^2 + 80.173x - 4.6428 \]
\[ R^2 = 0.8316 \]

\[ y = -70.16x^2 + 56.223x - 1.1426 \]
\[ R^2 = 0.8199 \]

Critical grain P?

- Peldon 2016
- Cholsey 2016

Normal grain P as in RB209

Grain Yield (t/ha)

Grain P Content (%)

Grain P (mg/kg)

NIAB
How common is low grain P? (in YEN 2016 and 2017)

24% less than 'critical'
Only 17% more than 'RB209'
Grain Nutrition Benchmarking
Open to all farms (November 2017 … and harvest 2018)

- Grain Phosphorus P (mg/kg)
- Plus other key nutrients:
  - Nitrogen, N (%)
  - Potassium, K (mg/kg)
  - Calcium, Ca (mg/kg)
  - Magnesium, Mg (mg/kg)
  - Sulphur, S (mg/kg) (N:S)
  - Manganese, Mn (mg/kg)
  - Copper, Cu (mg/kg)
  - Zinc, Zn (mg/kg)
  - Iron, Fe (mg/kg)
  - Boron, B (mg/kg)

Applying for Grain Nutrition Benchmarking
- Any farm can apply
- Email: yen@adas.co.uk
  Subject: ‘GNB’ stating the number of fields
- Compare two fields (or more) for FREE
- Fill in form (labs will then send sample bags)
- 2017 samples: report in spring 2018
- 2018 samples: report in autumn 2018
Targeting P for yield and profit – Conclusions

• Good P nutrition is vital for high yields
• We have large and valuable soil P reserves
• Crop offtakes may be less than in RB209
• Soil P often runs down very slowly
  • Soil P Index 1 may be sufficient for most crops
• Inorganic fertiliser P is recovered poorly
• Need to improve P monitoring
  • More care in soil sampling etc.
  • Better interpretation of spatial effects
  • Crop analysis very useful
    • grain analysis probably best
  • Sign up for FREE grain P analysis!
Thanks, especially to all our collaborators, partners and funders