FAS / AHDB / SRUC Agronomy Workshops 2019

Inspiring, innovating and integrating new approaches to arable farming
Crop diseases and fungicides:
Lessons from 2018, messages for 2019

Fiona Burnett, Head of Knowledge Exchange, SRUC
Neil Havis, Crop Protection Lead, SRUC
New threats: New Tools

🤔 Extremes of weather
🤔 New and challenging variants of established diseases
🤔 Novel and emerging pathogens
🤔 Product losses
🤔 Slides in efficacy
😊 A few new tools
😊 Targeted solutions

*Bipolaris leaf spot blotch in barley*
2017/2018 Season
Low disease risk over winter

Perception….

….but Average Mean Temp up
Extremes: Record breaking summer heat
Drier than average season with north south difference in spring
2018 Wheat
Disease levels low at stem extension
Fungicide performance update for wheat
Septoria protectant 2018 over-trial (n=4)
Septoria protectant over-year 2016-18 (n=17)

Percentage of full label rate vs. % disease for various protectants:
- Elatus Era
- AscraXpro
- Librax
- Proline
- Bassoon
- Vertisan
- Imtrex
- Bravo
Septoria curative over-year 2016-18 (n=9)

% disease vs. Percentage of full label rate

- Elatus Era
- AscraXpro
- Librax

% disease vs. Percentage of full label rate

- Proline
- Bassoon
- Vertisan
- Imtrex
Septoria yield over-year 2016-18 (n=17)
New variant strains of Septoria
azole performance over time
(protectant, full label dose)

% Control Septoria

△ prothioconazole
• epoxiconazole

Septoria: early-season sensitivity monitoring

Rothamsted (updated 2018): azoles

epoxiconazole

prothio-desthio
New variant strains of Septoria: SDHI performance over time

2013 2014 2015 2016 2017 2018

Imtrex (top curve = best control achieved, middle = average, bottom = worst control)

Vertisan (top curve = best control achieved, middle = average, bottom = worst control)
Septoria: early-season sensitivity monitoring

Rothamsted (updated 2018): SDHI

Sdh mutations detected for the first time in 2017
Septoria: monitoring of Sdh mutations

Early season untreated:
2016 2017 2018

Quantitative detection of frequently occurring Sdh mutations in UK field populations of *Zymoseptoria tritici*. No mutations were detected in early 2016 (detection threshold 3-5%)
Yellow rust 2018 (n=1)

Percentage of full label rate vs. % disease for different treatments:
- Elatus Era
- AscraXpro
- Librax
- Priaxor
- Proline275
- Bascon
- Imtrex
- Comet
Yellow rust over-year 2016-18 (n=3)

Percentage of full label rate

Keystone
Elatus Era
AscraXpro
Librax
Priaxor

Proline
Bassoon
Comet
Imtrex

% disease
Yellow rust yield 2018 (n=1)

- Elatus Era
- AscraXpro
- Librax
- Priaxor

- Proline275
- Bassoon
- Imtrex
- Comet

Yield (t/ha) vs. Percentage of full label rate.
Head blight symptoms

2018 (n=1)
Caution: Data is from 1 trial/year only

2016-18 over year (n=3)
Head blight DNA results 2018
Fusarium

Caution: Data is from 1 trial/year only

Microdochium
Fungicide performance for wheat summary

On Septoria:

- SDHIs more effective than azoles, with Imtrex ahead of Vertisan and Proline ahead of Bassoon
- Bravo continues to demonstrate good protectant activity
- SDHI+azole mixtures achieved the highest levels of control
- Further sensitivity shifts in azoles and SDHIs reinforce the importance of multi-site protectants in programmes

- Yellow rust - azoles and Comet retain good activity against the disease, but Elatus Era gave highest yields
- Brown rust - Elatus Era and Librax very effective, giving increased control compared to the azoles alone
- Head Blight - Soleil performed similarly to Proline / Folicur against Fusarium. Unizeb Gold effective on Microdochium
Low disease, low margin fungicide over cost?

£120
Wheat programmes 2018

2196 AHDB WW Agronomy Trial 2018
Septoria on F-1 at GS 83-87 16 July 2018
with Yield T/ha

Benefit of full programme = 0.38 t/ha or £64
(£170/t AHDB SACC Harvest 2018 – ex farm)
In low risk plots there is less of a case for high fungicide inputs...

Yield responses larger in higher risk dense sown

Benefit of full programme in high risk scenario = 1.5 t/ha or £255

(£170/t AHDB SACC Harvest 2018 – ex farm)
Wheat - key messages for 2019

- Septoria resistance position becoming critical
- Scottish isolates appear less sensitive to some azoles and have higher levels of alternative mechanism
- Better varietal ratings help and have been taken up commercially
- New products on the horizon
- Tailor inputs to risk – extra inputs in 2018 were seldom cost effective
- Use multisites to protect other actives and the crop at a cheap price
- Use appropriate rates and numbers of applications for the risk, and always in balanced mixtures
Fungicide performance update for barley
Rhynchosporium over-trial 2018 (n=3)

- **Siltra Xpro**
- **Elatus Era**
- **Proline**
- **Comet**
- **Imtrex**

Graphs showing the percentage of disease (y-axis) against the percentage of full label dose (x-axis) for different treatments.
Rhynchosporium over-year 2016-18 (n=9)

![Graph showing disease percentage against percentage of full label dose for different treatments.]

- Siltra Xpro
- Elatus Era
- Priaxor
- Proline
- Comet
- Imtrex
- Vertisan

% Disease against Percentage of full label dose.
Net blotch 2018 (n=1)

Disease percentage vs. percentage of full label dose for different treatments:
- Siltra Xpro
- Elatus Era
- Proline
- Comet
- Imtrex
- Kayak

Graph shows the relationship between the percentage of the full label dose and the disease percentage, with different treatments plotted on the same graph.
Net blotch over-year 2016-18 (n=4)

Percentage of full label dose vs. % Disease for different treatments:
- Siltra Xpro
- Elatus Era
- Priaxor
- Proline
- Comet
- Imtrex
- Vertisan
Mildew 2018 (n=1)  Caution: data is from 1 trial/year only
Fungicide performance for barley summary

• Rhynchosporium
  • Good control from Proline, Imtrex and the SDHI+azole mixtures (Siltra Xpro and Elatus Era)
  • Comet less effective than previously, but still giving reasonable control

• Net Blotch
  • Proline and the SDHI+azole mixtures were most effective, with highest yields from the mixtures
  • Although partial resistance exists, Comet and Imtrex gave reasonable control. Kayak has a different mode of action

• Proline, and mildewicides Talius and Cyflamid, continue to provide good mildew control
• Occurrence of resistance to azoles, QoIs and SDHIs means that chlorothalonil is vital for control of ramularia
Integrated Crop Management

- Chemical control
- Biological control
- Mechanical, physical, natural control
- Monitoring, forecasting, warning systems
- Agronomic practices such as crop rotation, resistant varieties, undersowing, intercropping, protection and enhancement of beneficials

Agronomic practices
Monitoring
Physical control
Biological control

SRDP Farm Advisory Service
SRUC AHDB
Winter barley IPM trial SRUC 2018
Can elicitors be used to lower the fungicide dose?

Yield benefit full programme = 0.4 t/ha
= £68 feed or £81 malt
(AHDB SACC Harvest 2018 – ex farm)

£75 Full

(Untreated, Fung seed trt, Regalia, Biological 1, vacciplant, Biological 2)
Spring barley IPM trial cv Propino

Yield benefit full programme = 0.4 t/ha
= £68 feed or £81 malt
(AHDB SACC Harvest 2018 – exfarm)
Spring barley IPM trial cv Laureate

Yield benefit full programme = 0.9 t/ha = £153 feed or £181 malt (AHDB SACC Harvest 2018 – ex farm)
New threats

Loose smut (*Ustilgo nuda*) observed more commonly in winter and spring crops in 2018.

Control lacking from azole seed treatments in 2018?

Are other fungicides still controlling the fungus?

(Sedaxane might be possible alternative)
New threats

Tan spot (*Drechshlera tritici-repentis*) still observed in many barley crops in 2018

40 single spore isolates collected from SRUC trial site at Boghall

Monitoring of control still needed in 2019

Is inoculum building up in crop debris?

Movement of spores is being investigated

Partial resistance to QoIs, azoles and SDHIs
New threats

Leaf spot symptoms caused by *Bipolaris sorokinia*

Symptoms seen in barley crops in 2017 and 2018

Disease first reported in Scotland in the 1970’s

Single spore isolates produced from SRUC Boghall site

Yield losses of up to 20% reported in wheat

Links to hot humid weather

Links to trash and weeds
New threats

**Bipolaris**

- **Summer**: Conidia
  - Spore dissemination by wind and rain
- **Fall**: Infection and symptom development of other wheat plants
  - Host senescence
  - Infected seeds and fungal spores overwintering in soil
- **Spring**: Symptom development of mature wheat plant
- **Winter**: Early stage of infection of seedlings
New threats

Short cereal rotations have favoured the build up of *Cephalosporium graminearum*.

Monitor your cereal crops to see if levels are building
Changing threats

July 2016
Rainfall Amount
% of 1981-2010 Average

July 2017
Rainfall Amount
% of 1981-2010 Average
Changing threats – head blights

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>No of samples</th>
<th>M. nivale</th>
<th>F. tricinctum</th>
<th>F. langsethiae</th>
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</thead>
<tbody>
<tr>
<td>2016</td>
<td>Barley</td>
<td>27</td>
<td>7</td>
<td>20</td>
<td>4</td>
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<tr>
<td>2016</td>
<td>Oats</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2016</td>
<td>Wheat</td>
<td>13</td>
<td>7</td>
<td>7</td>
<td>1</td>
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</table>

Samples exceeding maximum threshold

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>No of samples</th>
<th>DON</th>
<th>H2+T2</th>
<th>ZEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Barley</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>Oats</td>
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<td>1</td>
<td>0</td>
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<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Changing threats

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>No of samples</th>
<th>%Microdochium</th>
<th>%Fusarium</th>
</tr>
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<tbody>
<tr>
<td>2017</td>
<td>Barley</td>
<td>26</td>
<td>100%</td>
<td>92%</td>
</tr>
<tr>
<td>2017</td>
<td>Oats</td>
<td>6</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2017</td>
<td>Wheat</td>
<td>14</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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<td>14</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Changing threats

Samples received by SASA in 2018 indicate less Fusarium spp than normal but increased levels of *F. poae* and *F. langsethiae*.
New variants
UK Barley is accumulating resistance issues

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Diseases affected to some degree</th>
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<tbody>
<tr>
<td>Strobilurins</td>
<td>mildew, net blotch, tan spot, ramularia, rhynchosporium, M. nivale</td>
</tr>
<tr>
<td>Azoles</td>
<td>mildews, ramularia, rhynchosporium, loose smut</td>
</tr>
<tr>
<td>MBCs</td>
<td>eyespot, M. nivale, ramularia</td>
</tr>
<tr>
<td>Quinoxyfen</td>
<td>mildew</td>
</tr>
<tr>
<td>SDHI</td>
<td>net blotch, tan spot, ramularia</td>
</tr>
<tr>
<td>Metrafenone</td>
<td>mildew</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>None</td>
</tr>
<tr>
<td>Cyprodinil</td>
<td>None</td>
</tr>
</tbody>
</table>
Ramularia – fungicide field failure 2017

Midlothian 2017 (mean of two leaves)
Ramularia – evolving resistance picture

- QoI resistance since 2002
- MBC resistance (2 forms)
- Emerging issue with SDHIs
- 2014 single isolates with slightly decreased sensitivity were detected from FR and DL.
- 2015 isolates of reduced sensitivity identified in DL with mutations C-H146R or C-H153R. C-N87S low resistance factors in DE, IRL and SI
- 2016 Intimation of shift to SDHI and azoles in trials and assays
- 2017 Further confirmation of loss of efficacy in FP trial data
New threats – lost tools

- Varietal ratings for ramularia withdrawn
- Risk assessment for ramularia is a work in progress
- Connection with wet weather and stress but inconsistent between seasons
- Walk crops and accurately diagnose levels
- Keep notes and build on farm picture of risk
- Use chlorothalonil to manage ramularia risk at T2
Barley – take home messages

- Resistance challenges in strains of most major barley diseases
- Efficacy of solos drifting but mixtures still give good efficacy (ramularia excepted)
- New disease threats relate to climate but also with crop agronomy
- Target inputs to disease pressure, in-season weather, varietal rating, tillage, rotation and sow date
- Disease already present in winter crops
- Use mixes & alternations and use chlorothalonil to manage ramularia
Fungicide performance update for oilseed rape
Light leaf spot

- No disease in 2018 trials
- Little difference between available products in FP trials 2016 and 2017
- New products being tested
Light leaf spot

• Across trials, yield benefits are around 0.4 t/ha from 2 spray programme
• Dose effects are very site and situation specific - depend on varietal rating, crop growth and disease pressure.
• Azole options include prothioconazole and tebucozole.
• SDHI + QoI options like Pictor allow for diversity
• Early detection and treatment in January/February (where conditions allow) is more effective than treating heavily diseased crops at the stem extension stage.

• Filan is another option for Phoma management
2018/2019 risk lower than average
Changing threats - Clubroot

Developing sustainable management methods for clubroot (RD-2140027105) SRUC and ADAS

- Clubroot continues to be a major issue commercially
- Warm autumns / close rotations making issue worse
- Reports of poor control with resistant varieties continue
- Conflict between short term profit and long term sustainability
How widespread are resistance breaking strains?

• ~75 commercial fields sampled
• WOSR varieties Mentor and Tolkin (supplied from LSPB) and a Chinese cabbage control tested in bioassays
  – Soils tested for +/- of Mendel virulence
Mendel resistance breaking strains

17% of infected sites > 30%

Club root severity in resistant as a % severity in susceptible
Tolkin bioassay all years, n = 75.
How diverse is UK clubroot population?
Pathotype determination
Field mapping has potential to target treatments and help with decision making.

A) Aerial photography of Bridgenorth field and its 30 sampling points
B) Clubroot severity distribution at different sampling time
C) Clubroot presence assessed by qPCR. Low risk: below $1 \times 10^3$ spores.g soil$^{-1}$, Medium risk: between $1 \times 10^3$ and $1 \times 10^5$ spores.g soil$^{-1}$, High risk: above $1 \times 10^5$ spores.g soil$^{-1}$
Clubroot – summary

• Clubroot in the UK is extremely variable – this gives potential for rapid adaptation
• Mendel breaking strains are present throughout the UK (only 18% of infected sites had no symptoms on Mendal).
• Deploying a resistant variety should not be the first / only recourse in an identified infected field or it will be eroded rapidly as a tool for that field
• Alternative non-susceptible crops are the most sustainable long term method of control
Clubroot – key messages

• Keep accurate crop records of clubroot occurrence, location and intensity and note where varietal resistance has been deployed in fields to aid long term planning and help prevent spread
• Where resistant varieties are used monitor the crop carefully and assess the levels of clubroot present. If levels of infection start to increase change strategy
• Buying certified seed ensures that susceptible plant numbers are minimised in a resistant variety seed batch. Do not home save resistant varieties.
• Manage volunteers and susceptible weeds within and between oilseed rape crops. Allowing weed growth will allow clubroot populations to bulk up so manage weeds as early as possible in the season
• Be mindful of other susceptible crop choices when planning rotations – spring rape is susceptible and cover crop mixes often contain susceptible species
• Long term planning should be based on the long term profitability of a field and not on a single season’s predicted margin.
New tools needed…and some are coming

Recent product losses
- Chlothianidin
- Raxil Star for spring barley

Pending losses
- Metaldehyde
- Cherokee
- Diquat
- Older azoles

Anticipated restrictions
- Multisites (CTL)
Threat – metaldehyde withdrawal

• Defra has just announced a ban on metaldehyde for outdoor use from spring 2020
• Ferric phosphate broadly equivalent in terms of cost and efficacy so short term the impact in terms of cost of production is pretty neutral.
• Tendency for slug pellets to be used at reduced rates - particularly true of metaldehyde
• Reflects users conforming to the Metaldehyde Stewardship Guidelines that limit the max dose that can be applied and also the total amount in a calendar year (and from Aug-end of the year)
• Metaldehyde leaves visible slug corpses
• Ferric phosphate affects the slugs’ digestive system by disrupting calcium metabolism, quickly causing a cessation of feeding, and slugs bury themselves in the soil where they subsequently die ‘invisibly’
Messages for 2019
Warm autumn and winter to date and disease already present.
Some areas wetter than average
Key messages

• Targeted programmes are fundamental to business efficiency and stewardship (i.e. IPM)
• Fungicide efficacy is threatened by resistance developments and product losses so we are in a dangerous gap period
• New pathogens are changing the landscape – attention to surveillance and accurate ID is necessary
• Many emerging issues are symptoms of less than ideal agronomy (Cephalosporium, tan spot, bipolaris, fusarium all trash borne )
• 2018 season was low in terms of profits from fungicide programmes and illustrates the win:wins of targeted inputs
• Future points to more expensive production but also to premiums for sustainably produced quality crops
Sustainable and local markets – premium products

Kilchoman floor malting Isla
Take home actions

• Complete an IPM plan  
  (Google Scottish IPM plan)
• Scrutinise fungicide programmes
• Keep up to date on new product information and shifts in efficacies and approvals
• Watch for summer open trial events
• New event for Scotland
Thank you
Cereal Varieties for 2019/20

Steve Hoad, SRUC
Developing messages for 2019/20

• Coping with seasonal and climatic challenges

• Promise of better yield in new spring and winter cereals

• Signs of improved crop resilience

• Laureate’s rise, but what will be supporting and competing?

• Plenty of options in winter wheat (for distilling and feed) and winter barley

https://www.sruc.ac.uk/recommendedcereals
Spring barley – *No yield improvement on farm*

(Source: Scottish Government)
Winter wheat – Yield stagnation and variability

(Source: Scottish Government)
Spring barley

• Laureate’s rise
• Role for Concerto?
• Several supporting varieties
• Waiting for progress in new distilling varieties
Laureate – *New market leader*

- Full MBC Approval for B and D
- 12% higher yield than Concerto
- Strong agronomic features
- Short straw
- Low specific weight
Other malting varieties – *Added value*

![Bar chart showing treated yield (%) for different varieties: Concerto, Laureate, KWS Sassy, Sienna, Fairing, LG Diablo, RGT Asteroid. The chart indicates the percentage of treated yield for each variety.](chart.png)
Other malting varieties – *MBC status*

- KWS Sassy – Full Approval for malt distilling
- Sienna – Full Approval for malt distilling
- Fairing – Full Approval for grain distilling
- LG Diablo – Provisional Approval 1 for brewing and malt distilling
- RGT Asteroid – Provisional Approval 1 for brewing, malting distilling and grain distilling
LG Diablo – *Potential for B and D*

- MBC Provisional 1 Approval for B and D
- Brewing and distilling trials ongoing
- 15% higher yield than Concerto
- Later maturity (at +2)
- Good brackling resistance. Short straw
- Weak for *Rhynchosporium*
RGT Asteroid – *Potential for many uses*

- MBC Provisional 1 Approval for B, D and GD
- Malt and grain distilling trials ongoing
- 10% above Concerto yield, 2% below Laureate
- Maturity same as Laureate
- Good brackling resistance
- Weak for *Rhynchosporium*
Other spring cereals – oats and wheat

Spring oats

Elison: *New variety*. Yield improvement over Aspen, Canyon and Firth. Good specific weight and stiff straw.

Delfin: *Year 2 variety*. Very high yield. Low screenings and stiff straw.

Spring wheat

KWS Talisker: *New variety*. High yielding nabim Group 4. Excellent specific weight and good Hagberg.

Hexham: *New variety*. High yielding nabim Group 4. Very good specific weight and Hagberg. Late maturity.
Winter barley

• Plenty of choice in two-two feed and six-row hybrids

• Yield improvements in variety trials

• Signs of progress in agronomic features
Winter barley – Five new entries to list

<table>
<thead>
<tr>
<th>Variety</th>
<th>Treated yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWS Creswell</td>
<td>110</td>
</tr>
<tr>
<td>LG Mountain</td>
<td>105</td>
</tr>
<tr>
<td>Valerie</td>
<td>100</td>
</tr>
<tr>
<td>LG Flynn</td>
<td>95</td>
</tr>
<tr>
<td>Sunningdale</td>
<td>90</td>
</tr>
<tr>
<td>SY Baracooda</td>
<td>85</td>
</tr>
<tr>
<td>SY Kingsbarn</td>
<td>80</td>
</tr>
</tbody>
</table>
Winter barley – New to Scottish List

LG Mountain: Yield advance. Early maturing

Valerie: Modest yield. Excellent quality. Strong agronomy

LG Flynn: Modest yield. Good quality. Moderate agronomy

SY Baracooda: Competitive yield and good specific weight. Good *Rhynchosporium* resistance

SY Kingsbarn: Competitive yield. Excellent specific weight, low screenings. Stiff straw
LG Mountain – *New high yielding two-row feed*

- Very high yield
- Good across all soil types
- Good specific weight and intermediate for screenings
- Early maturity
- Good straw strength
- Weak for disease resistance
Valerie – *New good quality two-row feed*

- Moderate yield
- Excellent specific weight and very low screenings
- Early maturity
- Very stiff straw
- Intermediate disease resistance

![Treated yield graph](image-url)
Winter wheat

• Wide choice in distilling varieties

• Hard feed and milling varieties might add value in crop rotation and management

https://www.sru.ac.uk/recommendedcereals
Winter wheat – *Many distilling options*

![Bar chart showing treated yield (%) for various winter wheat varieties](chart.png)

- Leeds
- Viscount
- Revelation
- LG Sundance
- LG Motown
- KWS Jackal
- Elation
- LG Skyscraper
- LG Spotlight
- Zulu
- Elicit

Treated yield (%)
KWS Jackal and Elation – both in year 2

- KWS Jackal:
  - High yield
  - Good second wheat
  - Medium for distilling
  - Intermediate agronomic features

- Elation:
  - High yield
  - Good second wheat
  - Good for distilling
  - Good specific weight and stiff straw

![Bar chart comparing treated yield (%)]
LG Skyscraper – *New distilling soft feed*

- High yield
- Good second wheat
- Medium for distilling
- Good specific weight
- Tall straw
- Relatively early
LG Spotlight – *New distilling soft feed*

- Yield similar to Leeds
- Moderate as a second wheat
- Excellent specific weight and Hagberg falling number
- Stiff straw (and above average height)
- Intermediate maturity

![Treated yield graph](image)

**SRDP** Farm Advisory Service  
**SRUC**

[Logo]
Summary

• Signs of much needed crop resilience among new varieties

• Check spring barley options – supporting Laureate in 2019 and 2020

• More choices in spring oats. Check against market leaders Firth, Canyon and Conway.

• Take advantage of new winter cereals – wheat and barley

https://www.sruc.ac.uk/recommendedcereals
Thank you
Know your cereal market and requirements

Julian Bell, Senior Consultant, SAC Consulting, SRUC

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Mob: 07795 302 264
UK grain prices reach 5 year high in 2018, feed barley trading close to wheat, rapeseed subdued

Source: AHDB, SAC Consulting
2018: world grain harvest falls behind usage for 1st time in 6 years, S/U lowest in 4 years

Source: USDA, IGC, SAC Consulting
World wheat crop 30mt lower in 2018 – Russia/FSU down 18mt, EU down 14mt

Source: USDA, SAC Consulting
Barley – world output down 3mt to 140.7mt in 2018 - on lower crops in EU, FSU – **lowest** ending stocks in 36 years!

**Barley stocks**

**Barley Production (m t)**

- Australia
- Canada
- EU
- FSU
- Mid East

2014 | 2015 | 2016 | 2017 | 2018
---|---|---|---|---
Australia | | | | |
Canada | | | | |
EU | | | | |
FSU | | | | |
Mid East | | | | |

**World barley stocks (m t)**

Source: USDA, SAC Consulting
Lower stocks = higher prices
- Exclude China to see true picture

### Stocks and prices

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>S/U excl China</td>
<td>14.6%</td>
<td>16.2%</td>
<td>14.6%</td>
</tr>
<tr>
<td>£/t</td>
<td>£195</td>
<td>£169</td>
<td>£171</td>
</tr>
</tbody>
</table>

Source: USDA, SAC Consulting
2018-19: world oilseeds output ahead of demand growth – crop +25mt, demand +19mt, stocks +12mt

Oilseeds outlook
- Record soya crops in Brazil and US
- Chinese soya imports falling on African Swine Fever, greater feed efficiency, 25% tariff on US soyabeans
- Falling crude oil prices $50/b – less biodiesel use
- Lower EU rape area

Source: USDA, SAC Consulting
World plantings set to swing back to cereals in 2019 – weaker; oilseed demand, relative prices, 

Prices favour soyabean plantings

Prices favour maize plantings

Source: AHDB, SAC Consulting
2019 world harvest; higher cereal area, use +46mt

(A) Rising trend yield needed to rebuild stocks
(B) 2018 yield = 12mt fall in stocks
(C) 3yr av. yield = 73mt fall in stocks

Source: USDA, IGC, SAC Consulting
Weak £ adds £20/t to UK grain price since EU ref.
“No Deal” could add another £20/t,
“Soft or No Brexit” could take £20/t away.

Source: AHDB, SAC Consulting
Sterling is not the only currency facing issues in the year ahead -

- **US dollar** - Trump, the economy, 
  China

- **Euro** - 
  Italy spending

- **Euro** - 
  France protests

Source: AHDB, SAC Consulting
Should I sell forward given the heightened currency uncertainty? Well yes, with care.

- The sterling exchange rate is a natural hedge against a “Hard Brexit”; weaker currency = higher grain prices.
- Input costs will also rise but net farm income effect is positive
- On the other hand a favourable Brexit outcome and the £ strengthens = lower grain price.
- Response? – sell forward a proportion of expected yield as usual to cover current costs (seed, fert, fuel) and sterling costs (rent, interest), hold grain unsold to cover future costs

Source: AHDB, SAC Consulting
UK a net wheat importer in 2018 for third year in a row due to small crop – even with loss of ethanol demand

<table>
<thead>
<tr>
<th>UK wheat '000 t</th>
<th>2016/17</th>
<th>2017/18</th>
<th>2018/19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Stocks</td>
<td>2,787</td>
<td>1,755</td>
<td>1,718</td>
</tr>
<tr>
<td>Production</td>
<td>14,383</td>
<td>14,837</td>
<td>13,953</td>
</tr>
<tr>
<td>Imports</td>
<td>1,855</td>
<td>1,793</td>
<td>1,700</td>
</tr>
<tr>
<td>Available</td>
<td>19,025</td>
<td>18,385</td>
<td>17,371</td>
</tr>
<tr>
<td>Human Use</td>
<td>8,110</td>
<td>7,816</td>
<td>7,067</td>
</tr>
<tr>
<td>Animal Feed</td>
<td>7,236</td>
<td>7,515</td>
<td>7,738</td>
</tr>
<tr>
<td>Seed etc</td>
<td>355</td>
<td>352</td>
<td>349</td>
</tr>
<tr>
<td>Domestic Use</td>
<td>15,701</td>
<td>15,683</td>
<td>15,154</td>
</tr>
<tr>
<td>Exports/surplus</td>
<td>1,438</td>
<td>447</td>
<td>517</td>
</tr>
<tr>
<td>End Stocks</td>
<td>1,755</td>
<td>1,718</td>
<td>1,700</td>
</tr>
<tr>
<td>Net trade</td>
<td>-417</td>
<td>-1,346</td>
<td>-1,183</td>
</tr>
</tbody>
</table>

Source: AHDB, SAC Consulting

UK barley crop down 549kt to 6.5mt

UK barley exports down 480kt to 676kt
UK rise in winter cereal area expected in 2019 - AHDB

<table>
<thead>
<tr>
<th>UK</th>
<th>2018 harvest ('000's ha)</th>
<th>2019 harvest ('000's ha)</th>
<th>Change (%)</th>
<th>Change ('000's ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1,797</td>
<td>1,871</td>
<td>4%</td>
<td>74</td>
</tr>
<tr>
<td>Winter barley</td>
<td>394</td>
<td>449</td>
<td>14%</td>
<td>55</td>
</tr>
<tr>
<td>Spring barley</td>
<td>763</td>
<td>737</td>
<td>-3%</td>
<td>-26</td>
</tr>
<tr>
<td>Oats</td>
<td>173</td>
<td>190</td>
<td>10%</td>
<td>17</td>
</tr>
<tr>
<td>Other cereals</td>
<td>51</td>
<td>38</td>
<td>-25%</td>
<td>-13</td>
</tr>
<tr>
<td>OSR</td>
<td>601</td>
<td>585</td>
<td>-3%</td>
<td>-16</td>
</tr>
<tr>
<td>Pulses</td>
<td>198</td>
<td>183</td>
<td>-8%</td>
<td>-15</td>
</tr>
<tr>
<td>Fallow</td>
<td>270</td>
<td>228</td>
<td>-16%</td>
<td>-42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,954</strong></td>
<td><strong>4,967</strong></td>
<td><strong>0%</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

Source: AHDB Early Bird survey and DEFRA
UK to swing back to a net wheat exporter in 2019 – just as we enter a potentially new trading regime post Brexit!

<table>
<thead>
<tr>
<th>UK wheat</th>
<th>'000 t</th>
<th>2016/17</th>
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<tbody>
<tr>
<td>Open Stocks</td>
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</tr>
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<td>7,067</td>
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<td>Net trade</td>
<td></td>
<td>-417</td>
<td>-1,346</td>
<td>-1,183</td>
<td>394</td>
</tr>
</tbody>
</table>

Source: AHDB, SAC Consulting
Smallest Scottish cereal harvest in six years - expected 347kt down

<table>
<thead>
<tr>
<th>Scotland</th>
<th>Area (ha)</th>
<th>Yield (t/ha)</th>
<th>Prod'n (t)</th>
<th>Change (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHEAT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>109,489</td>
<td>8.12</td>
<td>889,308</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>99,778</td>
<td>6.83</td>
<td>681,000</td>
<td>-208,308</td>
</tr>
<tr>
<td><strong>W. BARLEY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>47,509</td>
<td>7.41</td>
<td>352,108</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>37,542</td>
<td>7.14</td>
<td>268,000</td>
<td>-84,108</td>
</tr>
<tr>
<td><strong>S. BARLEY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>243,838</td>
<td>5.88</td>
<td>1,432,815</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>250,476</td>
<td>5.54</td>
<td>1,388,000</td>
<td>-44,815</td>
</tr>
<tr>
<td><strong>OATS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>32,625</td>
<td>5.66</td>
<td>184,813</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>32,101</td>
<td>5.48</td>
<td>176,000</td>
<td>-8,813</td>
</tr>
<tr>
<td><strong>TOT.CEREALS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>433,460</td>
<td>6.60</td>
<td>2,859,045</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>419,897</td>
<td>5.98</td>
<td>2,512,000</td>
<td>-347,045</td>
</tr>
<tr>
<td><strong>OSR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>31,000</td>
<td>3.30</td>
<td>102,000</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>34,187</td>
<td>4.21</td>
<td>144,038</td>
<td>42,038</td>
</tr>
</tbody>
</table>

Source: Scottish Government
Scotland expected to see swing back to winter cereals from spring barley & fallow in 2019 - AHDB

<table>
<thead>
<tr>
<th></th>
<th>2017 harvest ('000's ha)</th>
<th>2018 harvest ('000's ha)</th>
<th>Change (%)</th>
<th>Change ('000's ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>100</td>
<td>116</td>
<td>16%</td>
<td>16</td>
</tr>
<tr>
<td>Winter barley</td>
<td>38</td>
<td>46</td>
<td>21%</td>
<td>8</td>
</tr>
<tr>
<td>Spring barley</td>
<td>250</td>
<td>238</td>
<td>-5%</td>
<td>-12</td>
</tr>
<tr>
<td>OSR</td>
<td>33</td>
<td>32</td>
<td>-3%</td>
<td>-1</td>
</tr>
</tbody>
</table>

Note – treat with caution due to
- Small sample size - <5% of cropped area

Source: AHDB Early Bird survey and DEFRA
Malting barley use in Scotland – demand and capacity set to rise in 2019

<table>
<thead>
<tr>
<th>Year</th>
<th>Scottish / Berwick malting Spring barley purchases ('000's t)</th>
<th>Scottish Spring Barley Crop ('000's t)</th>
<th>Est. Malting varieties (%)</th>
<th>Est. Malting varieties ('000's t)</th>
<th>Scottish malting purchases as % of malting varieties</th>
<th>Malting premium over feed £/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>775</td>
<td>1,521</td>
<td>76%</td>
<td>1,156</td>
<td>67%</td>
<td>14</td>
</tr>
<tr>
<td>2016</td>
<td>765</td>
<td>1,296</td>
<td>64%</td>
<td>829</td>
<td>92%</td>
<td>28</td>
</tr>
<tr>
<td>2017</td>
<td>775</td>
<td>1,433</td>
<td>57%</td>
<td>815</td>
<td>95%</td>
<td>41</td>
</tr>
<tr>
<td>2018e</td>
<td>810</td>
<td>1,338</td>
<td>72%</td>
<td>963</td>
<td>84%</td>
<td>47</td>
</tr>
<tr>
<td>2019f</td>
<td>840</td>
<td>1,373</td>
<td>72%</td>
<td>989</td>
<td>83%</td>
<td>40</td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: SAC Consulting
MAGB, Scottish Government,
Scottish malting barley – price premium rises to £47/t over feed, £16/t over English malting barley

Malting barley - Scotland
Malting barley - England
Feed barley - UK

£ per tonne ex-farm

£19/t /feed £26/t
£-9/t /Eng £3/t

£44/t £14/t

£47/t £16/t

New malt distilleries coming – 10 in 2019, 40 by 2021

The past 12 months have been relatively quiet in terms of new distillery openings, but as Becky Paskin reveals, 2019 will be an even more exciting year for Scotch whisky.

<table>
<thead>
<tr>
<th>Distillery</th>
<th>2019 Capacity (m LPA)</th>
<th>Malt Use (t malting barley equiv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardnahoe</td>
<td>750,000</td>
<td>2,259</td>
</tr>
<tr>
<td>Ardross</td>
<td>1,000,000</td>
<td>3,012</td>
</tr>
<tr>
<td>Brora</td>
<td>800,000</td>
<td>2,410</td>
</tr>
<tr>
<td>Cabrach</td>
<td>45,000</td>
<td>136</td>
</tr>
<tr>
<td>Falkirk</td>
<td>750,000</td>
<td>2,259</td>
</tr>
<tr>
<td>Holyrood</td>
<td>100,000</td>
<td>301</td>
</tr>
<tr>
<td>Lagg</td>
<td>800,000</td>
<td>2,410</td>
</tr>
<tr>
<td>Port Ellen</td>
<td>800,000</td>
<td>2,410</td>
</tr>
<tr>
<td>Rosebank</td>
<td>800,000</td>
<td>2,410</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,845,000</strong></td>
<td><strong>17,605</strong></td>
</tr>
</tbody>
</table>

Source: scotchwhisky.com, Scotch Whisky Industry Review 2017
Malt whisky drives Scotch upturn in 2018
- malting barley + 33kt in 2018, +110kt by 2023?
- grain (wheat and maize) + 7kt in 2018, +58kt by 2023?

Source: Scotch Whisky Industry Review 2018, SAC Consulting
New maltings planned - will need local barley to replace imported malt
- Bairds +30kt capacity in 2019, + 70kt by 2022 -

Source: Scotch Whisky Industry Review 2017, SAC Consulting
Where will extra 100kt of malting barley come from in 2022? Already use 80%+ of current Scottish supply, could be 90%+ by 2022

<table>
<thead>
<tr>
<th>Year</th>
<th>Scottish / Berwick malting Spring barley purchases ('000's t)</th>
<th>Scottish Spring Barley Crop ('000's t)</th>
<th>Est. Malting varieties (%)</th>
<th>Est. Malting varieties ('000's t)</th>
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<th>Malting premium over feed £/t</th>
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<td>1,521</td>
<td>76%</td>
<td>1,156</td>
<td>67%</td>
<td>14</td>
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<td>2016</td>
<td>765</td>
<td>1,296</td>
<td>64%</td>
<td>829</td>
<td>92%</td>
<td>28</td>
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<td>95%</td>
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<td>72%</td>
<td>989</td>
<td>83%</td>
<td>40</td>
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<td>2022</td>
<td>910</td>
<td>1,373</td>
<td>72%</td>
<td>989</td>
<td>92%</td>
<td></td>
</tr>
</tbody>
</table>

Source: SAC Consulting
MAGB, Scottish Government,
Higher spring barley yields? Some progress in RL trials but none on farm in last 10 yrs

Source: AHDB, Scottish Government
Higher spring barley plantings? Losing out to wheat and EFA fallow (+20ka since 2015) – will EFA fallow go after Brexit?

Source: Scottish Government
Spring barley may have to take land off wheat – can gross margins compete? They didn’t in autumn 2018.

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Yield (t/ha)</th>
<th>Price (£/t)</th>
<th>Straw (£/ha)</th>
<th>Output (£/ha)</th>
<th>VC (£/ha)</th>
<th>GM (£/ha)</th>
<th>Diff. Vs. Wheat (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>8.5</td>
<td>125</td>
<td>168</td>
<td>1,224</td>
<td>437</td>
<td>787</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>8.1</td>
<td>142</td>
<td>252</td>
<td>1,406</td>
<td>438</td>
<td>968</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>6.8</td>
<td>165</td>
<td>390</td>
<td>1,515</td>
<td>438</td>
<td>1,077</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>8.5</td>
<td>165</td>
<td>260</td>
<td>1,663</td>
<td>470</td>
<td>1,193</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S. Barley - malting</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>5.4</td>
<td>129</td>
<td>130</td>
<td>828</td>
<td>285</td>
<td>543</td>
</tr>
<tr>
<td>2017</td>
<td>5.9</td>
<td>160</td>
<td>195</td>
<td>1,136</td>
<td>263</td>
<td>873</td>
</tr>
<tr>
<td>2018</td>
<td>5.5</td>
<td>217</td>
<td>225</td>
<td>1,427</td>
<td>280</td>
<td>1,147</td>
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<tr>
<td>2019</td>
<td>5.8</td>
<td>185</td>
<td>157</td>
<td>1,224</td>
<td>303</td>
<td>921</td>
</tr>
</tbody>
</table>

Source: SAC Consulting
Know your markets – malting barley

- UK malting 1.87mt, Scotland/ Berwick 0.87mt

- Distilling 2018
  Malt - 700kt <1.65%N
  Grain - 70kt >1.85%N

Distilling demand has been robust, overtaking UK brewing use in 2012.
Distilling varieties restricted to non GN traits.

- Scottish brewing (var N%) – small, declining
- Export brewing (<1.85%N) benefits from new varieties – dominates in England, ltd in Scotland.

Brexit – “No deal” risks low, zero tariff on spirits, UK malt and barley supply self contained
English exports redirected to Scotland
Will Scottish wheat retain its price premium in 2019?

No - 16% rise in Scots wheat area would mean 967kt +285kt at trend yield

Yes - Distilling wheat use could rise to replace maize in 2019? 150kt – 200kt potential. If price discount to French wheat rises, if enough soft distilling varieties available.

New crop Scottish wheat at a discount to French maize.

<table>
<thead>
<tr>
<th>Delivery date</th>
<th>Nov’17</th>
<th>Spot - Jan’19</th>
<th>New crop - Nov’19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat - delivered</td>
<td>153.0</td>
<td>188.5</td>
<td>178.5</td>
</tr>
<tr>
<td>Fr. Maize delivered</td>
<td>168.0</td>
<td>187.0</td>
<td>185.0</td>
</tr>
<tr>
<td>Fr. Maize - premium</td>
<td>15.0</td>
<td>-1.5</td>
<td>6.50</td>
</tr>
</tbody>
</table>
Wheat use in Scotland dominated by distilling

Distilling
- UK / Scotland use 500kt to 600kt
- Soft Group 3 & 4 well suited to Scotland
- Specific weight can be an issue in a poor year
- Distilling demand drives the Scottish wheat premium over English market (+ £5 -10/t)
- Main competition is imported maize

Brexit – “No deal” risks low to moderate – zero tariff on spirits, low or zero tariff on maize, but may re-direct more English wheat to Scotland
Wheat for distilling – the best varieties deliver more spirit and encourage distilling use

<table>
<thead>
<tr>
<th>Variety</th>
<th>Good</th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Viscount</td>
<td>Elation</td>
<td>KWS Barrel</td>
</tr>
<tr>
<td>Yield (t/ha)</td>
<td>10.81</td>
<td>11.23</td>
<td>11.45</td>
</tr>
<tr>
<td>Price (£/t)</td>
<td>165</td>
<td>165</td>
<td>165</td>
</tr>
<tr>
<td>Output (£/ha)</td>
<td>2,043</td>
<td>2,113</td>
<td>2,149</td>
</tr>
<tr>
<td>Diff vs best</td>
<td>-106</td>
<td>-36</td>
<td>-</td>
</tr>
<tr>
<td>Variable costs (£/ha)</td>
<td>495</td>
<td>495</td>
<td>470</td>
</tr>
<tr>
<td>Diff vs best</td>
<td>+25</td>
<td>+25</td>
<td>-</td>
</tr>
<tr>
<td>Gross Margin (£/ha)</td>
<td>1,548</td>
<td>1,618</td>
<td>1,679</td>
</tr>
<tr>
<td>Cost difference (£/t)</td>
<td>+£12.11/t</td>
<td>+£5.40</td>
<td></td>
</tr>
</tbody>
</table>

Can be a yield penalty and no premium.

New varieties can close the yield and disease rating gap.

Good distilling varieties will always find a market.
Wheat use – milling - biscuit

Milling wheat
- Use UK 4.8mt, Scotland 300kt, soft 60-80kt 2 mills
- Soft wheats well suited to Scotland
- Bread wheat limited – a few growers south of Forth
- Small premiums for soft wheat £3- £7/t can be a useful bonus over distilling, but easily oversupplied

Specification – soft biscuit
- Preferred varieties – Elicit, Zulu and KWS Barrell
- Wider range of soft wheat varieties is acceptable in blends (no hards!)
- Dry carefully >60°C! To avoid gluten damage
- DON testing

Brexit – “No deal” impact - medium from tariffs on processed products (biscuits)
Oats focused on milling

Oats

- UK use 525kt, Scotland use 120kt – 4 mills+
- Strong premiums available for producer groups (£25/t+ over wheat futures) on limited tonnage
- Spot oats market typically at a £5 to £10/t discount to wheat
- Useful break crop
- Steady growth in demand
- Gluten free a small but growing niche
- But relatively small market, easily oversupplied, don’t grow without a contract

Brexit – “No deal” risk medium to high from heavy tariffs on oats and processed products
Future subsidy support post Brexit
- some clarity to 2022, beyond?

• UK - 2019 to 2020 – as is (cut to LFASS in Scotland)
• Scotland
• - 2021 to 2023 – continue Direct Payments system, some changes,

• England
• - 2020 to 2027 – England phase out Direct Payments
• - >Post 2028 - England move to “public money for public goods”
Nobody knows what’s going to happen
- can you lower risk / increase resilience?

1. Increase financial resilience
   - Move loans from short term to long term
   - Delay investment, hold cash

2. Diversify markets and income
   - Favour dual use varieties, e.g. swop hard feed wheat for good soft distilling, yield penalty but choice of two markets
   - Diversify income – AD crops, off-farm income

3. Minimise Apr – Jun trading exposure
   - Forward buy essential spring inputs before March – seed, fert, agchem, fuel where feasible
   - Consider risks for holding grain unsold after March
Know your cereal market and requirements

1) Are higher cereal prices here to stay?
   2018 - world grain stocks to use lowest in 4 years – prices have risen £20-30/t – Russian exports slowing
   2019 – world cereal harvest to rise? - higher cereal plantings and rising trend yields could rebuild stocks unless major crop problem.

2) Will a weaker pound protect against Brexit?

3) Will Scots barley supply rising whisky production?
   Lower area in 2019. Are premiums high enough? Will fallow area fall post-Brexit?

4) UK back to a net wheat exporter in 2019?
   Brexit risk to UK exports, bigger Scottish wheat crop could reduce premium, need the right soft wheat varieties to maximise distilling

5) In an uncertain world focus on what you can control
   Financial resilience, reduce trading risk spring 2019, keep your market options open, spread your risks
Scottish grain prices - up 20-35% in 2018 – harvest 2019 values £10-30/t lower but up on ‘17

<table>
<thead>
<tr>
<th></th>
<th>Last year</th>
<th>This year</th>
<th>Change</th>
<th>Next year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dec-17</td>
<td>Dec-18</td>
<td>(£/t)</td>
<td>(£/t)</td>
</tr>
<tr>
<td>Wheat (ex-f)</td>
<td>143</td>
<td>171</td>
<td>+£28</td>
<td>+20%</td>
</tr>
<tr>
<td>Feed barley (ex-f)</td>
<td>131</td>
<td>165</td>
<td>+£34</td>
<td>+26%</td>
</tr>
<tr>
<td>Distil. Barley (ex-f) # (Oct)</td>
<td>161</td>
<td>217</td>
<td>+£56</td>
<td>+35%</td>
</tr>
<tr>
<td>Brew. Barley (ex-f)</td>
<td>168</td>
<td>203</td>
<td>+£35</td>
<td>+21%</td>
</tr>
<tr>
<td>OSR (del.)</td>
<td>302</td>
<td>317</td>
<td>+£15</td>
<td>+5%</td>
</tr>
</tbody>
</table>

#last traded values October
Thank you
Demonstrating research outcomes in practice

Fiona Geary – AHDB Arable Knowledge Transfer Officer
Content

• Introduction
• Farm Excellence
• AHDB arable research
• On-farm trials: Strategic Farms
• On-farm trials: Monitor farms
• Guide to on-farm trials
Introduction to the arable team
Farm Excellence

• 22 monitor farms
  Farmer-led, farmer-driven
  Focusing on business, technical and personal development

• 7 strategic farms
  Putting research into practice
  Accelerating innovation and productivity through coordinated R&D and KE
### AHDB Arable Research

**Maxi-Cover Crop:** Maximising the benefits from cover crops through spades selection and crop management (21140009)

**PhD: SOIL CADRE - Soil and Cover Crop Associations Developing Rhizo-biological Efficiency** (21140024)

**Soil biology and soil health (cross-sector project: 21140025)**

**Cereals Rotations Research Partnership** (21140019)

**PhD: Soil-root interactions in potato** (11140035)

**Research Partnership: Management of rotations** (11140023)

**PhD: Precision soil and growth mapping** (11140054)

**Soil biology and soil health** (1114002)

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<thead>
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</thead>
<tbody>
<tr>
<td>Maxi-Cover Crop</td>
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<tr>
<td>Soil biology and soil health</td>
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<td>PhD: Soil-root interactions in potato</td>
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<td>Research Partnership: Management of rotations</td>
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<td>PhD: Precision soil and growth mapping</td>
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</tbody>
</table>
Soil biology and soil health cross sector project

**WP1 Benchmarking and baselining activities**
- Project 1: Translating existing knowledge
- Project 2: Agreeing a soil health scorecard
- Project 3: Scoping molecular approaches for soil health

**WP2 Measuring and optimising long-term impacts of soil management**
- Project 4: Soil health assessment
- Project 5: Routine DNA-based measures for soil-borne disease
- Project 6: Assessing soil health using DNA
- Project 7: Managing soil amendments in horticulture

**WP3 Co-designed knowledge exchange**
- Project 8: Industry benchmarking of priority issues
- Project 9: On-farm monitoring of soil health
- Project 10: Knowledge exchange events for soil health
- Project 11: Innovation fund
Development of soil health scorecard

- **RED**: High risk, need to investigate urgently
- **AMBER**: Moderate risk, need to investigate further
- **GREEN**: Low risk, continue to monitor
## Development of soil health scorecard

<table>
<thead>
<tr>
<th>Physical</th>
<th>A: Relevance to:</th>
<th>B: Applicability to:</th>
<th>C: In practice:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crop production</td>
<td>Environmental impact</td>
<td>Agricultural soils</td>
</tr>
<tr>
<td>texture</td>
<td>1.2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stoniness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vess</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VSA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk density</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penetrometer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>available water capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>shear strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aggregate stability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water retention characteristic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rate of erosion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>depth of soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sealing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>infiltration rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>particle density</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Development of soil health scorecard

**Scotland – Extractable P (Modified Morgan’s) mg/L**

<table>
<thead>
<tr>
<th>Bar chart classes</th>
<th>Traffic light colour</th>
<th>Description of this class (e.g. toxic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1.7</td>
<td>Red</td>
<td>VL – risk to production</td>
</tr>
<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+ Application of organic manures still recommended as a supply of other nutrients but generally no requirement for additional fertiliser P</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>
On-farm trials: Strategic Farms
Strategic Farm Farm East

Harnessing varietal resistance
- 1 field
- 4 varieties of winter wheat
- 3 fungicide programmes
- Disease assessments
- Crop assessments
- Full cost benefit analysis

Cover crops to reduce leaching
- 2 fields
- 4 treatments:
  1. Plough
  2. cover crop into plough
  3. stubble,
  4. cover crop into stubble
- Water, soil and crop assessments
- Full cost benefit analysis
On-farm trials: Monitor Farms
Cover crops

Betamaxx

Grabber

Rigol

Sprinter
Guide to on-farm trials

Strategic Farm East Baselining 2017-2018

Drawing a line in the soil

The first year of the Strategic Farm project, known as the ‘baseline year’, has been a success. The strategy set out at the start of the project is already evident at the end. It’s clear that the initial objectives have been met.

Earthworm survey

The survey has been developed to improve the management of soils throughout the UK. Using the information collected, the survey is likely to help farmers improve the productivity of their soil and increase their overall efficiency.

Scientific basis

Soil phisio, chemistry and biology are key drivers of agricultural systems. These factors can affect the availability of nutrients for crops, which in turn affects the productivity of the farm.

Earthworms

Soil biology is a crucial factor in determining the health and productivity of the farm. Earthworms play a key role in this process.

How to do a visual soil assessment

Posted by AHDB Cereals & Oilseeds

137 Views
Your feedback

I would like AHDB to research....
‘Inspiring our farmers, growers and industry to succeed in a rapidly changing world’
Soil Health – what is it, why should we care and how do we measure it?

Bryan Griffiths, SRUC

Bryan.Griffiths@sruc.ac.uk
SRUC research into soil health is supported by several funding agencies
Soil health – what is it…
A healthy soil:
Looks good
Feels good
Smells good

Easy to work
Supports lot of life
Soils deliver many ecosystem services

**Food & biomass production**

*J. Moulin (CA 36)*

**Habitat, gene pool**

*Infosol (INRA Orléans)*

**Soil ecosystem services**

**Storing, filtering & transformation**

*A. Richer de Forges (CA 45)*

**Physical & cultural environment for mankind**

*J. Moulin (CA 36)*

**Source of raw materials**

*C. Schwartz (LSAL)*

*Courtesy of Antonio Bispo, ADEME*
Ecosystem services

Ecosystem Services Provided by Soil Biota

- Regulation of biogeochemical cycles
- Retention and delivery of nutrients to primary producers
- Maintenance of soil structure and fertility
- Bioremediation of pollutants
- Provision of clean drinking water
- Mitigation of floods and droughts
- Erosion control
- Regulation of atmospheric trace gases
- Pest and pathogen control
- Regulation of plant production via non-nutrient biochemicals
Components of soil health

Physics ↔ Biology

Chemistry
KNOW YOUR SOILS; principles to improve soil health

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

**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!

**Physical**
- Know your textures and understand limits to workability, trafficability
- Optimise water balance through drainage if necessary
- Improve soil structure – effective continuous pore space
Components of soil health

Physics \leftrightarrow Biology

Chemistry

Putting it all together will need a different approach to sample collection – linking physical observation and soil samples sent for testing

Current soil test:
- pH
- Routine nutrients
Soil health – why should we care…
Positive effects of earthworms on crop yield

Meta-analysis by Van Groenigen et al 2014
Positive effects of soil health on crop yield

Fertilised

Grain yield [dt/ha, mean ± 2 SD]

Tillage depth
- Shallow, <20 cm
- Medium, 20-25 cm
- Deep, 25-30 cm
- Very deep, 30-40 cm
- Extremely deep, 40-60 cm

Soil quality score
- Moderate-poor, < 60
- Good, 60-80
- Very good, >80

Meta-analysis by Mueller et al., 2018
AHDB Project Report No. 576
Improvement of soil structure and crop yield by adding organic matter to soil

- Amendments can improve yield, soil structure and organisms.
- Greater resistance to disease in crops growing in soil with amendments.
- At least two consecutive years of application before the increases became significant.
- Benefits continue for at least two and perhaps as many as five years after application. Carbon content is a better guide than total dry matter.
- No evidence for notable effects of amendments on earthworms.
Ecosystem services

You can do all this with tillage, sprays, fertiliser and complex technology

BUT

a healthy soil will do these for you!

<table>
<thead>
<tr>
<th>Ecosystem Services Provided by Soil Biota</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation of biogeochemical cycles</td>
</tr>
<tr>
<td>Retention and delivery of nutrients</td>
</tr>
<tr>
<td>to primary producers</td>
</tr>
<tr>
<td>Maintenance of soil structure and fertility</td>
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</tr>
<tr>
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<tr>
<td>Erosion control</td>
</tr>
<tr>
<td>Regulation of atmospheric trace gases</td>
</tr>
<tr>
<td>Pest and pathogen control</td>
</tr>
<tr>
<td>Regulation of plant production</td>
</tr>
<tr>
<td>via non-nutrient biochemicals</td>
</tr>
</tbody>
</table>
Soil health – how do we measure it…
What is a healthy soil?

What we need is a set of easily understood indicators.
Equivalent to an MOT for your soil
Or
a check up at the doctors
Practical considerations

Selected soil health measurements:

- Routine analysis (P, K, Mg, Ca, pH)
- LOI
- VESS
- Earthworms
- PMN

Why?

Lab set-up
Turn around time
Combines physics, chemistry and biology
Traffic light system for reporting values

The traffic light system represents:

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</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>
Ranges for each band derived from scientific evidence

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Scale ranges for each indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH bands according to Table 2 in new lime requirement TN 656</td>
</tr>
<tr>
<td>Extractable Phosphorus</td>
<td>0-1.7</td>
</tr>
<tr>
<td>Extractable Potassium</td>
<td>0-39</td>
</tr>
<tr>
<td>Extractable Magnesium</td>
<td>0-19</td>
</tr>
<tr>
<td>Extractable Calcium</td>
<td>&lt;1000</td>
</tr>
<tr>
<td>Extractable Sodium</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Ca:Mg</td>
<td>&lt;4.1</td>
</tr>
<tr>
<td>Potentially Mineralisable N</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Organic Matter (LOI)</td>
<td>&lt;5</td>
</tr>
<tr>
<td>mean VESS</td>
<td>1-1.4</td>
</tr>
<tr>
<td>Mean worms</td>
<td>&lt;4</td>
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<td></td>
<td>&lt;15</td>
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</tbody>
</table>
## Soil Health Check - Field Sheet

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<tr>
<th>Field Name:</th>
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<table>
<thead>
<tr>
<th>Field ID:</th>
<th>Area:</th>
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</thead>
<tbody>
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</tbody>
</table>

### History:

### Soil Type:
- Light
- Medium
- Heavy

### Texture Class (if known):

### Does it change within the field? (Are two samples or avoid minority soil type):

### Soil Moisture Level:
- Dry
- Moist
- Wet
- Waterlogged

### Previous Crop:
- If grass, how many years?

### Crop Residue:
- Chopped
- Removed

### Presence of crop residue in soil? What & how long ago?

### Tillage – previous crop establishment:
- Plough
- Min till
- Direct drill
- Power harrow
- Bed tiller
- De-stoner

### Organic Manures:
- Type available:
- When last applied:
- Approx rate:

### Soil Checks:

<table>
<thead>
<tr>
<th>Worm Count</th>
<th>Dig 1</th>
<th>Dig 2</th>
<th>Dig 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>VESS</td>
<td></td>
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</tbody>
</table>

Background information helps the interpretation
Example scorecard...

<table>
<thead>
<tr>
<th></th>
<th>West</th>
<th>Mid</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.6</td>
<td>5.8</td>
<td>6.3</td>
</tr>
<tr>
<td>Extractable Phosphorus</td>
<td>5.13</td>
<td>13.5</td>
<td>27.9</td>
</tr>
<tr>
<td>Extractable Potassium</td>
<td>390</td>
<td>321</td>
<td>305</td>
</tr>
<tr>
<td>Extractable Magnesium</td>
<td>113</td>
<td>118</td>
<td>170</td>
</tr>
<tr>
<td>Extractable Calcium</td>
<td>1500</td>
<td>1400</td>
<td>2000</td>
</tr>
<tr>
<td>Extractable Sodium</td>
<td>14.5</td>
<td>11.6</td>
<td>13.1</td>
</tr>
<tr>
<td>Ca:Mg</td>
<td>13</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Potentially Mineralisable N</td>
<td>30</td>
<td>30</td>
<td>36.4</td>
</tr>
<tr>
<td>Organic Matter (LOI)</td>
<td>5.39</td>
<td>5.38</td>
<td>5.74</td>
</tr>
<tr>
<td>mean VESS</td>
<td>2.7</td>
<td>1.7</td>
<td>2</td>
</tr>
<tr>
<td>Mean worms</td>
<td>2.3</td>
<td>1.7</td>
<td>1</td>
</tr>
</tbody>
</table>

Soil texture = sandy loam

Soil health recommendation
Soil structure (VESS) low in the West field
Adding OM and upping pH should alleviate this
Depending on OM source consider extra N to account for immobilisation

Worm numbers would benefit from OM and reduced tillage
The real power of the SAC soil health test - benchmarking

• Results kept in a confidential database
• As in the current SRUC ‘AGREcalc’ where you can see your carbon footprint in relation to others
• You will be able to see how your soils perform against comparable soils and over time
• Benchmarking will improve the more data is entered
Cradle Coast Compare Your Data

Site Report - Bulk Density - 0 - 10 cm

State
Tasmania
Region
Cradle Coast
Paddock ID
TAS0164

Management Group
Unavailable
Soil Texture
Loam
Land Use
Crop + Pasture
Rainfall
< 800mm

How To Compare Data

The circle on the graph represents your value from soil test results. This sits next to a plot showing the entire spread of that group's data. The line in the centre is the average value of all the data, and the box surrounding represents the middle 50% of the sample sites in this dataset. The upper and lower “tails” reflect the range for the top and bottom 25% of the sample sites in this data set.

Choose a Soil Quality indicator from one of the three tabs below to compare grouped data.

Biological

Chemical

Physical

- Clay Content
- Bulk Density
- Gravel Content

SRDP Farm Advisory Service
SRUC AHDB
Advantages of benchmarking

- Changes over time
- Comparison like for like
Thank You

https://www.sruc.ac.uk/soiltest
soilhealth@sac.co.uk
Visual Evaluation of Soil Structure

Soil structure affects root penetration, water availability to plants and soil aeration. This simple, quick test assesses soil structure based on the appearance and feel of a block of soil dug out with a spade. The scale of the test ranges from $Sq^1$, good structure, to $Sq5$, poor structure.

**Method of assessment:**

<table>
<thead>
<tr>
<th>Step</th>
<th>Option</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Block extraction and examination</td>
<td>Loose soil</td>
<td>Remove a block of soil ~15 cm thick directly to the full depth of the spade and place spade plus soil onto the sheet, tray or the ground.</td>
</tr>
<tr>
<td></td>
<td>Firm soil</td>
<td>Dig out a hole slightly wider and deeper than the spade leaving one side of the hole undisturbed. On the undisturbed side, cut down each side of the block with the spade and remove the block as above.</td>
</tr>
<tr>
<td>2. Examine soil block</td>
<td>Uniform structure</td>
<td>Remove any compacted soil or debris from around the block.</td>
</tr>
<tr>
<td></td>
<td>Two or more horizontal layers of differing structure</td>
<td>Estimate the depth of each layer and prepare to assign scores to each separately.</td>
</tr>
</tbody>
</table>

**Block break-up**

| 3. Break up block (take a photograph - optional) | Measure block length and look for layers. Gently manipulate the block using both hands to reveal any cohesive layers or clumps of aggregates. If possible separate the soil into natural aggregates and man-made clods. Clods are large, hard, cohesive and rounded aggregates. |
| 4. Break up of major aggregates to confirm score | Break larger pieces apart and fragment it until a piece of aggregate of 1.5 - 2.0 cm. Look to their shape, porosity, roots and easily of break up. Clods can be broken into non-porous aggregates with angular corners and are indicative of poor structure and higher score. |

**Soil scoring**

| 5. Assign score | Match the soil to the pictures category by category to determine which fits best. |
| 6. Confirm score from: | Factors increasing score: |
| Block extraction | Difficulty in extracting the soil block |
| Aggregate shape and size | Larger, more angular, less porous, presence of large worm holes |
| Roots | Clustering, thickening and deflections |
| Anaerobism | Pockets or layers of grey soil, smelling of sulphur and presence of ferrous ions |
| Aggregate fragmentation | Break up larger aggregates ~ 1.5 – 2.0 cm of diameter fragments to reveal their type. |

7. Calculate block scores for two or more layers of differing structure

**Scoring:** Scores may fit between $Sq$ categories if they have the properties of both. Scores of 1-3 are usually acceptable whereas scores of 4 or 5 require a change of management.

Bruce Ball, SRUC (Bruce.Ball@sruc.ac.uk).
Rachel Gomes, University of Maringá, Brazil (rachel.gomes@gmail.com).
Tom Bailey, Independent Consultant (03) 9896 3726 (e2m.com) and
Lars Munkholm, University of Aarhus, Denmark (lars.munkholm@aarcl.dk)
<table>
<thead>
<tr>
<th>Structure quality</th>
<th>Size and appearance of aggregates</th>
<th>Visible porosity and Roots</th>
<th>Appearance after break-up: various soils</th>
<th>Appearance after break-up: same soil different tillage</th>
<th>Distinguishing feature</th>
<th>Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sq1 Friable</td>
<td>Mostly &lt; 6 mm after crumbling</td>
<td>Highly porous</td>
<td>Roots throughout the soil</td>
<td>Fine aggregates</td>
<td>The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aggregates readily crumble with fingers</td>
<td></td>
<td>Root throughout the soil</td>
<td>High aggregate porosity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sq2 Intact</td>
<td>A mixture of porous, rounded aggregates from 2mm - 7 cm. No clods present</td>
<td>Most aggregates are porous</td>
<td>Roots throughout the soil</td>
<td>Aggregate fragments are rounded, very fragile, crumble very easily and are highly porous.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aggregates easy to break with one hand</td>
<td></td>
<td>Root throughout the soil</td>
<td>Low aggregate porosity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sq3 Firm</td>
<td>A mixture of porous aggregates from 2mm - 10 cm; less than 30% are &lt; 1 cm. Some angular, non-porous aggregates (clods) may be present</td>
<td>Macropores and cracks present.</td>
<td>Roots throughout the soil</td>
<td>Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most aggregates break with one hand</td>
<td>Porosity and roots both within aggregates.</td>
<td></td>
<td>Low aggregate porosity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sq4 Compact</td>
<td>Mostly large &gt; 10 cm and sub-angular non-porous; horizontal/plate also possible; less than 30% are &lt; 7 cm</td>
<td>Few macropores and cracks</td>
<td>All roots are clustered in macropores and around aggregates</td>
<td>Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Requires considerable effort to break aggregates with one hand</td>
<td></td>
<td></td>
<td>Distinct macropores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sq5 Very compact</td>
<td>Mostly large &gt; 10 cm, very few &lt; 7 cm, angular and non-porous</td>
<td>Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks</td>
<td></td>
<td>Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.</td>
<td>Grey-blue colour</td>
<td></td>
</tr>
</tbody>
</table>
Earthworm types

- Red worms – vertical burrowers and surface living
- Pale (+green) worms – soil feeding
- Stripy worms – compost worms
Key to common British earthworms of amenity grasslands

By David T. Jones and Chris N. Lowe

There are 26 British species of earthworm. This guide covers the seven most common species that occur in grass lawns and playing fields. It does not include the red stripy earthworms that occur in compost heaps, other species that occur in gardens, or woodland species.

Start here

Is it more than 2 cm long, and does it have a clearly developed saddle?

The saddle is usually a different colour to the rest of the body, and slightly wider

NO

Saddle

It is not a mature earthworm - you can’t identify it with this guide. At least 50% of the earthworms you find will be immatures.

NO

Head

Mature earthworm

Upper surface

Under surface

1st segment

Male pore

Saddle

A

Black-headed worm Apamocoides longs

Is the body from the first segment to the saddle partly or entirely pale in colour (whitish, pink, grey or greenish)? It may have some reddish or dark segments

YES

NO

Hint

Often a dark purplish head

Long and thin

Are the male pores visible?

YES

NO

Long and fat

Long and relatively thin or Long and relatively fat?

Are the male pores visible?

YES

NO

B

Lob worm Lumbricus terrestris

Hint

A stout worm, often as thick as a pencil

Sometimes flattens its tail into a wide paddle shape

Redhead worm Lumbricus rubellus

Hint

Line drawings show typical sizes of the adult worm

Sometimes slightly flattens its tail into a paddle shape

Produced for OPAL 2012, www.opalexplornature.org

This may be copied for educational purposes only.
Earthworm types

- Red worms – vertical burrowers and surface living
- Pale (+green) worms – soil feeding
- Stripy worms – compost worms
Thank you
Contribution of Cover Crops/Green Manures to Following Crops

Dr John Baddeley & Dr Robin Walker, SRUC
Green Manures – Should we be interested?

• Broadly defined as crops grown for the benefit of the soil
• Some farmers already use (especially organic)
• CAP Greening Regulations
  – permanent grassland
  – crop diversification (3-crop rule)
  – ecological focus areas (EFAs)

• CAP Ecological Focus Areas:
  – Nitrogen-fixing crops
  – Catch crop
  – Green cover
Green manures – Fertility Building Crops

Advantages to green manures:

- Add organic matter to soil
- Increase biological activity
- Improve soil structure
- Increase soil nutrients
- Reduce leaching losses
- Suppress weeds
- Reduce pest and disease problems

In addition, N-fixing green manures:

- Increase soil N levels
- Decrease the need for bagged fertiliser (cost and pollution savings)
Green manures – Fertility Building Crops

Disadvantages to green manures:

• Cost of seed and extra cultivations
• Lost opportunities for cash cropping
• Extra work at busiest times of year
• Exacerbated pest and disease problems (“green bridge” effect)
• Potential for green manures to become weeds themselves
• Fixed N might not be available when crops need it (may become pollutant)
Drivers for SRUC work on green manures

- CAP reform – greening regulations in place but do they deliver the intended benefits?
- Scottish Government RESAS core programme 2016-2020
- Track record of intercropping/mixtures/organic/biodiversity work
Research Aims

• Assess agronomic, environmental and economic performance of a wide range of cover crop species and mixtures at two sites (Aberdeenshire and Midlothian) in replicated trials over multiple years
• Assessment of multi-functionality
• Practical recommendations
• Inform Scottish Government policy
Why Grow Mixtures?

• Mixtures of crops typically yield 20-40% higher than monocrops
• Built-in redundancy if one crop fails, improving stability and resilience to adverse conditions
• May be better suited for some purposes (e.g. high-protein silage)
• Potential to provide greater biodiversity benefits (e.g. longer flowering period)
• May transfer more N to following crop
N release from residues and crop demand

- Crop demand for N
- N supply from mineralisation

- Excess N - leaching
- N deficiency - fertiliser

N kg / ha / day

MAR | MAY | AUG | NOV
Can we manage legume residues to release more N when it is needed?

Perhaps, by using a mix of faster and slower decaying crop residues
CAP N-fixing Crops Trials – Year 1

• Straights of all on CAP list (except lentil & chickpea)
• Five, 3-way mixtures of above
• Mixtures contrast different growth forms
e.g. Three clover species and clover:beans:vetch
CAP N-fixing Crops Trials – Year 2

- Spring barley sown on all plots
- Each legume plot from Year 1 split into 2
- One half received no inputs, one half received 60 kg/ha N
- Sampled at GS 31, 60 and harvest
N-fixing crops growth Year 1

First Cut Yield (t/ha DM)

Green – single legume species
Red – 3-component mixtures
Purple – ryegrass/clover

+Grain legumes

BM, GC, WC, LU, RC, LN, A, E, CC, BE, B, C, D
Spring Barley Yields Year 2 – Midlothian, Zero N
Spring Barley Yields Year 2 – Aberdeenshire, Zero N
Is there a common pattern between sites?

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>LN</th>
<th>PE</th>
<th>WV</th>
<th>CC</th>
<th>E</th>
<th>C</th>
<th>RC</th>
<th>D</th>
<th>BM</th>
<th>LU</th>
<th>WC</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midlothian</td>
<td>BE</td>
<td>LN</td>
<td>PE</td>
<td>WV</td>
<td>CC</td>
<td>E</td>
<td>C</td>
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<td>BM</td>
<td>LU</td>
<td>WC</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Aberdeenshire</td>
<td>BE</td>
<td>LN</td>
<td>PE</td>
<td>BM</td>
<td>WV</td>
<td>D</td>
<td>E</td>
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<td>A</td>
</tr>
</tbody>
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Is there a common pattern between sites?

<table>
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<tr>
<th></th>
<th>Midlothian</th>
<th>Aberdeenshire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BE</td>
<td>LN</td>
</tr>
<tr>
<td></td>
<td>BE</td>
<td>LN</td>
</tr>
</tbody>
</table>

Increasing Yield

- **Blue** – Grain legumes
- **Green** – Forage legumes
- **Red** – Legume mixtures
Effect of N on Barley Yields After Green Manures

Spring Barley Yields Year 2 – Midlothian
Zero N (pale) and 60 kg/ha N (dark)
Increase in Grain Yield with 60 kg/ha N Fertiliser
Summary

• A wide range of N-fixing crops can be grown successfully on much of Scotland’s arable land

• Leguminous green manures can support good yields in a following cereal crop, and qualify for CAP EFA payments

• Mixtures and forage legumes gave the highest barley yields, grain legumes the lowest

• Supplemental N may only be of benefit following grain legumes
Thank you

SRUC trials teams
Funders: Scottish Government RESAS and Loirston Trust