Crops
Environment
& Land Use
Programme

National Tillage Conference 2018

Teagasc
Agriculture and Food Development Authority

NATIONAL TILLAGE CONFERENCE 2018

Published by

Teagasc

Crops Environment and Land Use Programme

Oak Park Crops Research

Carlow

Wednesday, 31st January 2018

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Programme

09.30	Registration/Tea/Coffee
10.30	Conference Opening **Professor Gerry Boyle, Teagasc Director and** **Mr. Andrew Doyle, T.D., Minister of State for Food, Forestry and Horticulture**
Session 1:	***Chaired by John Spink, Head of Crop Science, Teagasc***
10.45	Winter oat agronomy **John Finnan, Teagasc**
11.10	The use of Irish cereals in novel baked and extruded snack formulations **Eimear Gallagher, Teagasc**
11.35	Disease control with a declining number of effective fungicides **Steven Kildea, Teagasc**
12.00	Research Updates, 5 minute presentations
	Insecticide resistance in the grain aphid, in Irish crops **Lael Walsh, Teagasc**
	VICCI: Improving Irish crop varieties **Petra Kock-Appelgren, Teagasc**
	Do six and two-row winter barleys need to be treated differently? **Rob Beattie, Teagasc**
	Diagnosing soil compaction **Jer Emmet-Booth, Teagasc**
	Assessing weather-based forecasting of Ramularia in spring barley **Joe Mulhare, Teagasc**
12.30	Panel Discussion
13.00	Lunch
Session 2:	***Chaired by Andy Doyle, Irish Farmers Journal***
14.30	Prospects for site-specific management of nitrogen for cereals **Richie Hackett, Teagasc**
14.55	Maximising yield potential through soil and fertiliser management **David Wall, Teagasc**
15.20	Coping with current challenges. Audience survey/panel discussion **Panel will include grower, industry and research/advisory representatives**
16.00	Conference Close **Dr. Frank O'Mara, Director of Research**

Contents

Winter oat agronomy

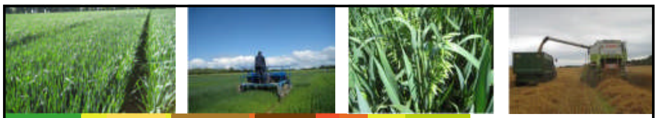
John Finnan
Teagasc, CELUP, Oak Park

SUMMARY

Oats were once grown all over Ireland and covered 670,000 ha. However, compared to other cereals such as wheat and barley, relatively little research has been conducted on oats. It is necessary to understand yield formation in the crop before both yield and quality can be optimised. Like other cereals, oat yields are primarily driven by grain number, but oat yields are more closely related to grain numbers per panicle (head) rather than the number of panicles. This arises because the oat panicle has a very large capacity to set grains compared to barley and wheat and high numbers of panicles are not needed to achieve high grain numbers.

At low plant populations, the panicle on the mainstem can have as many as 200 grains and the plant also develops additional panicles on tillers to compensate for a lower plant population. Grain quality (Hectolitre weight) is constant across a wide range of seed rates. Economic margins tend to be optimised with a plant population in the spring of 250 plants/m^2 although sometimes higher plant populations (270 plants/m^2) are needed to optimise returns. Oat plants tend to compete with each other more so than wheat and barley plants and percentage establishment falls with seeding rate from 90% in the case of a low seeding rate (100 seeds/m^2) to 65% for a high seeding rate (500 seeds/m^2). Consequently, the seeding rate required, in good conditions, to produce a plant population of 250 plants/m^2 in early spring is 350 seeds/m^2. However, in some instances, returns will be optimised at a higher seeding rate of 400 seeds/m^2.

Grain yields increase in response to added nitrogen but typically reach a maximum at 150 kg N/ha for a variety such as Husky grown on Index 1 soils. The principle yield parameter influenced by nitrogen application is the number of grains per panicle. The economic optimum N rate is 120-150kg N/ha but the economic optimum falls off rapidly below 120 kg N/ha. However, hectolitre weight falls with the application of additional nitrogen, typically by 1 kg/hl for each additional 30 kg N/ha. Different strategies for splitting nitrogen between GS30 (March) and GS32 (April) tend to have only small effects on yield but hectolitre weight falls as the proportion of the total amount of nitrogen applied at GS32 increases. A 50:50 strategy for splitting nitrogen between GS30 and GS32 will increase hectolitre weight by 1 kg/hl compared to a 33:66 startegy.



Winter oat agronomy

John Finnan

Teagasc CELUP
Oak Park Crops Research

Background

- Oats were once grown all over Ireland with a peak area of 672,000 ha
- Research on oats is at a low level compared to other cereals
- Management advice is often ‘borrowed’ from other cereals
- What differences exist between oats and other cereals?

Panicle

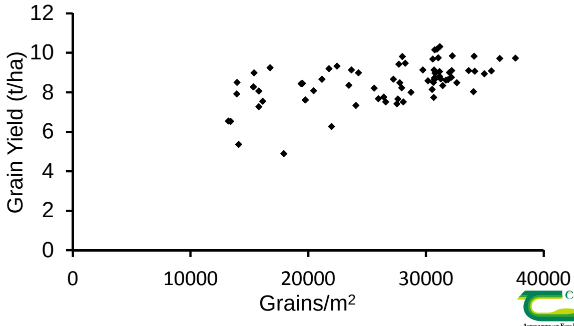
Grain yield in oats

Grain number

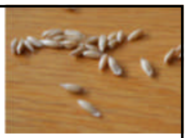
Grain weight

Oat yield components

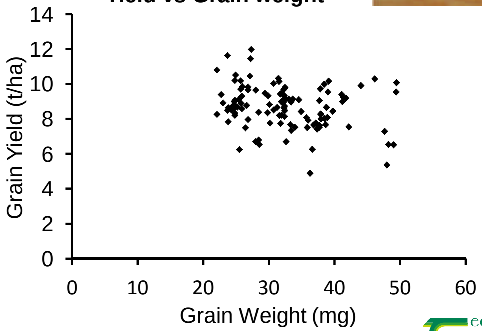
Yield vs Grain number



Oat yield components

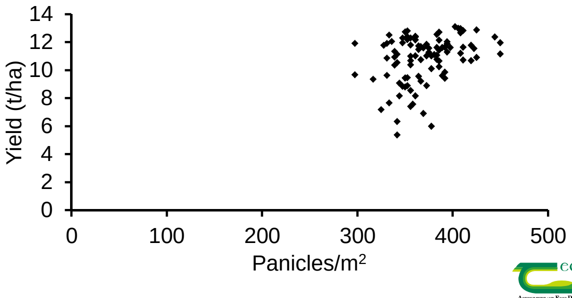


Yield vs Grain weight

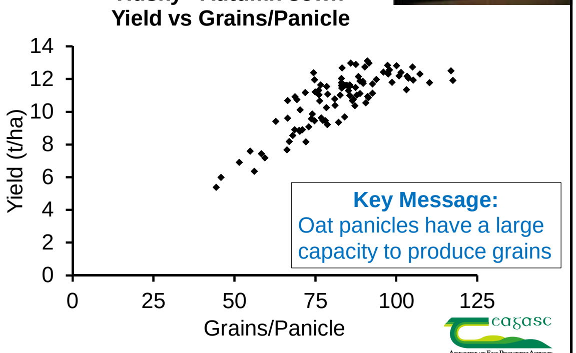


Oat yield components

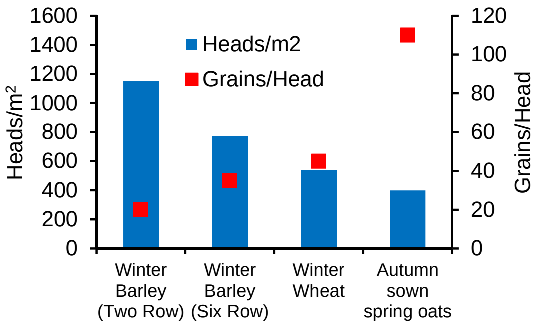
Husky- Autumn sown
Yield vs Panicles/m^2



Oat yield components

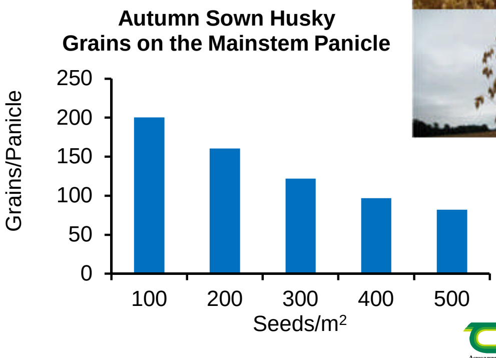


Comparison between cereals

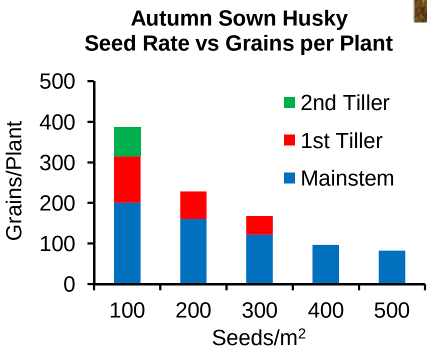


The oat panicle

Grains per panicle

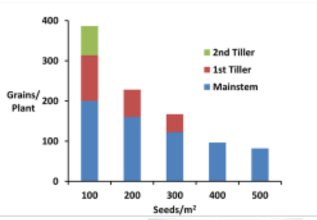


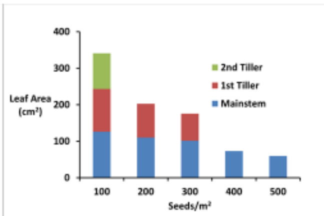
Grains per plant

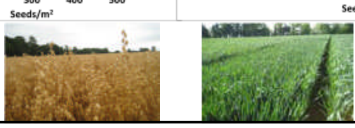


Grains per plant

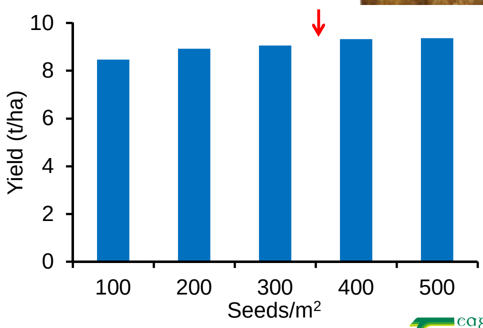
Grains per plant **Leaf area per plant**



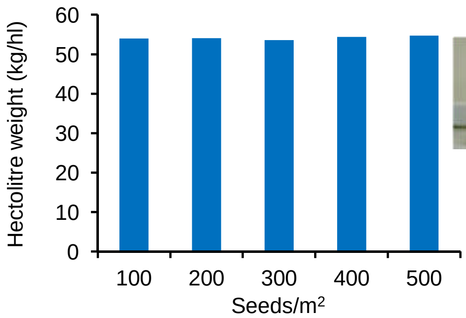




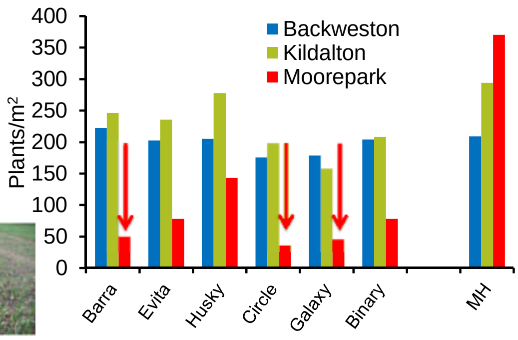
Seed rate vs yield



Seed rate vs hectolitre weight

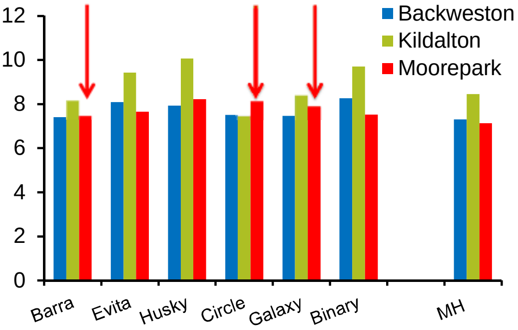


Oat frost damage – winter 2010/2011



Source: DAFM

Oat frost damage - winter 2010/2011



Source: DAFM

When to re-sow?

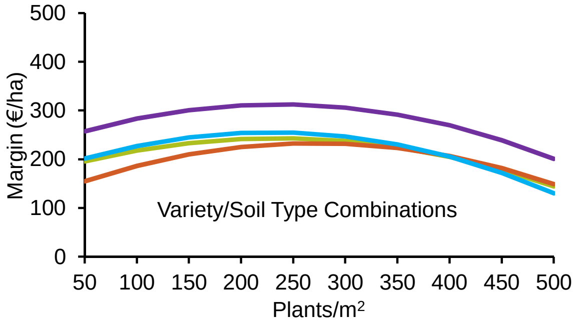
Stick with it?

- Assuming no large patches
- Stick with it: 90 plants/m^2
- Or even if: 40-50 plants/m^2
- Additional spring weed control may be necessary

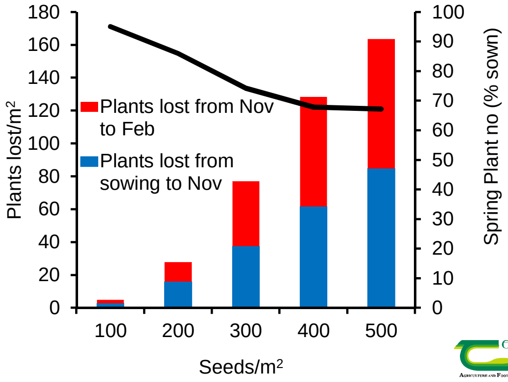
Re-sow?

- Additional cost of planting spring oats
- Lower yield potential of spring oats
- Break even yield for SO (€125/tonne) after the cost of sowing twice = 8.6 t/ha

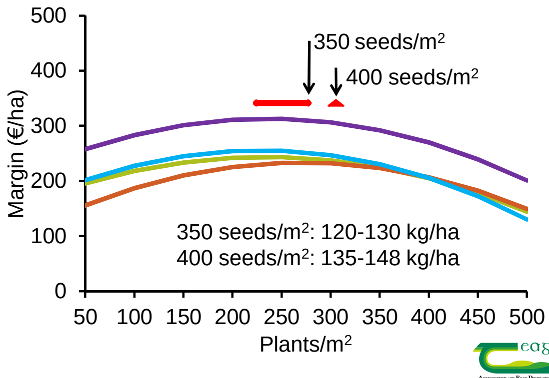
Optimum plant populations



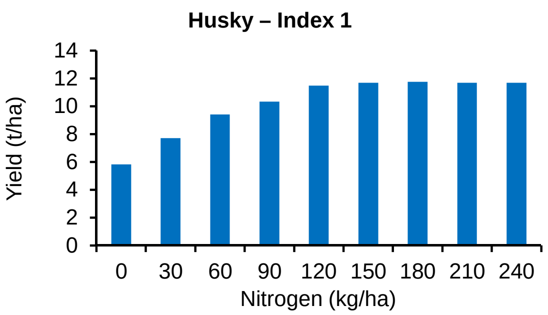
Seeding rates: plant competition



Winter oat seeding rates

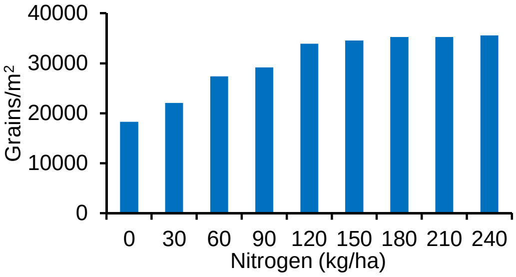


Nitrogen vs yield

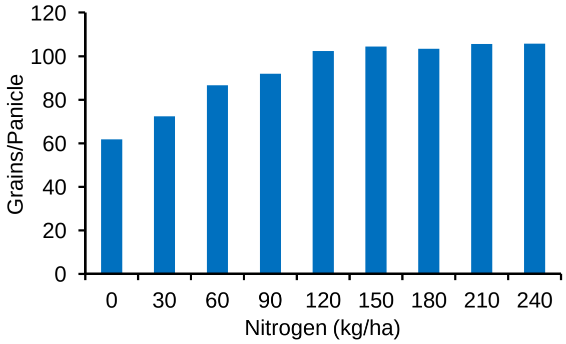


Nitrogen vs grain number

Husky – Index 1

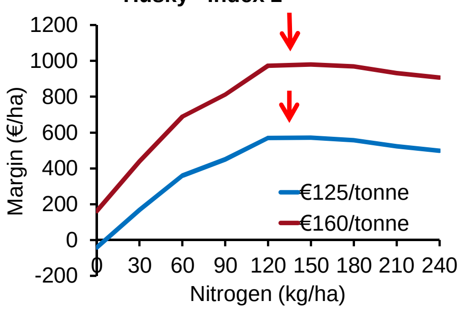


Nitrogen vs grains/panicle

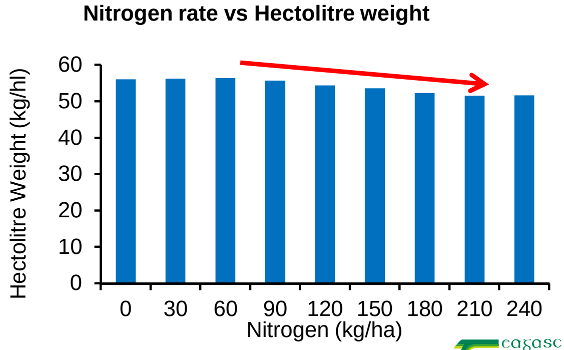


Optimum nitrogen rate

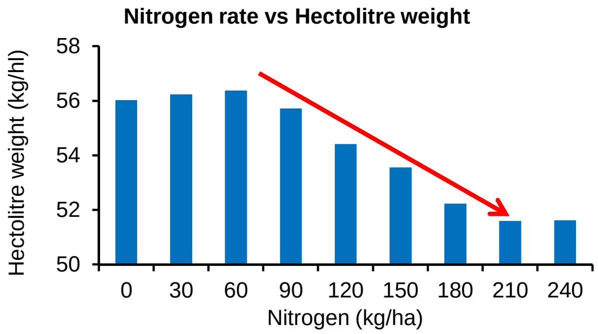
Husky - Index 1



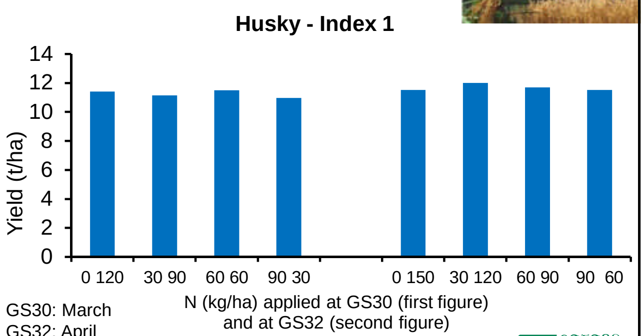
Hectolitre weight



Hectolitre weight

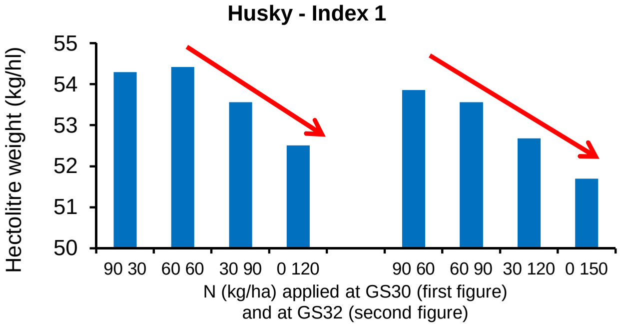


Nitrogen splitting



GS30: March
GS32: April

Nitrogen splitting



Key Message: 50:50 split better than 33:66 split

Conclusions

- Oats can develop a large number of grains in its panicle
- Compensates well for low plant populations
- Optimal seed rates: 350 – 400 seeds/m^2
- Optimal N rate (Index 1): 120-150 kg/ha

But!

- Hectolitre weight will fall as N rate is increased and with delayed application

Acknowledgements

- Liz Hyland, DAFM
- Dr Barry O Reilly, DAFM
- John Spink, Teagasc
- Brendan Burke, Teagasc
- Peter Gaskin, Teagasc

Questions?

The use of Irish cereals in novel baked and extruded snack formulations

Eimear Gallagher,
Teagasc Food Research Centre, Ashtown, Dublin 15.

SUMMARY

This presentation focuses on the research undertaken for a project entitled ‘NutriCerealIreland’, which was funded by the Department of Agriculture, Food and the Marine, under the FIRM initiative. The project focussed on collecting, milling and utilising Irish-grown varieties of oat and barley as ingredients in novel bakery and snack formulations, as the use of these cereals in Ireland is predominantly limited to livestock feed and minor food applications. As well as their potential as ingredients for bakery applications, the levels of nutritive properties, soluble fibre, phenolics and essential amino acids in the cereals were also investigated.

Varieties of barley and oat were studied over three successive harvests. These were cleaned and milled (wholegrain and fractionated). Initially, the technological functionality of these cereals as potential food ingredients was characterised using milling, wet chemistry and rheology tests. Food formulation trials were then undertaken, and ingredient interactions, nutritive value, chemical composition and structural properties of the new products were assessed using the test bakery and cereal analysis facilities at Ashtown. In particular, a bread formulation containing wholegrain barley, a biscuit formulation containing milled oat fractions, a cracker product containing milled barley fractions and an extruded/puffed snack containing a blend of corn and barley were formulated and assessed.

A bread formulation, containing 30% wholegrain barley flour and 70% wheat flour was prepared. To ensure optimal baking properties, natural enzymes (amylase, glucose oxidase and a combination of both) were also studied in the bread formulations. Dough extensibility, stability, optimal development and CO^2 gas release properties were assessed, as were loaf volume, crumb microstructure, texture, shelf-life, aromatic properties and sensory/eating quality. It was concluded from the study that a combination of amylase and xylanase, together with the barley and wheat flours, produced a bread product which had a high loaf volume, an open crumb structure and a soft crumb texture. Barley bran, and a blend of barley endosperm and middlings were studied at different levels of inclusion in a saltine cracker formulation. Products which contained 15% bran, and 35% endosperm/middling fractions produced crispy crackers with good sensory and aromatic profiles. Using a statistical software design tool, a high-quality extruded/puffed product was formulated with 20% barley, 80% corn and polydextrose. The snack that was produced showed comparable expansion/aeration, texture, and eating quality to a corn-based commercial control product.

Through science-based innovation, the researchers involved in this project have shown how new, innovative and healthy cereal-based ingredients and food products, when used in conjunction with appropriate processing aids, may be developed using Irish-grown barley and oats.

The use of Irish cereals in novel baked and extruded snack formulations

Eimear Gallagher
Teagasc Food Research Centre Ashtown

Presentation outline

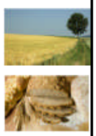
- Cereal/bakery research at Ashtown
- Introduction to the project
- What we did
- What we found
- What can be concluded

Cereal and Bakery Facilities at Teagasc (Ashtown)

- Mill room
- Test Bakery
- Cereal chemistry lab
- Dough rheology lab
- Flavour chemistry/mapping
- Nuclear Magnetic Resonance facility
- National Imaging Centre (microscopy)
- Sensory analysis facility
- Micro and chemical residues lab

Project background

- Project funded by Dept. of Agriculture, Food and the Marine
- To study the suitability of Irish cereals in novel bakery formulations
- Ireland has high yields of oats and barley
  - » Oats: rolled, pinhead, flaked; minor use in sweet baked goods
  - » Barley: animal feed, brewing
- Oats/barley proven to contain soluble fibre, phenolics, essential amino acids
- Their use for food applications is limited
  - opportunity exists to exploit this potential



An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

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Cereals and varieties

- 3 harvests
- 9 barley varieties
- 8 oat varieties

Irina
Mickle
Propino
Paustian
Shada
Cassia
Quench

Barra
Huskey
Mascan
Maestrro
Vodka
Rhapsody
Selwyn
Wholegrain oat flour and oat bran from Flahavans

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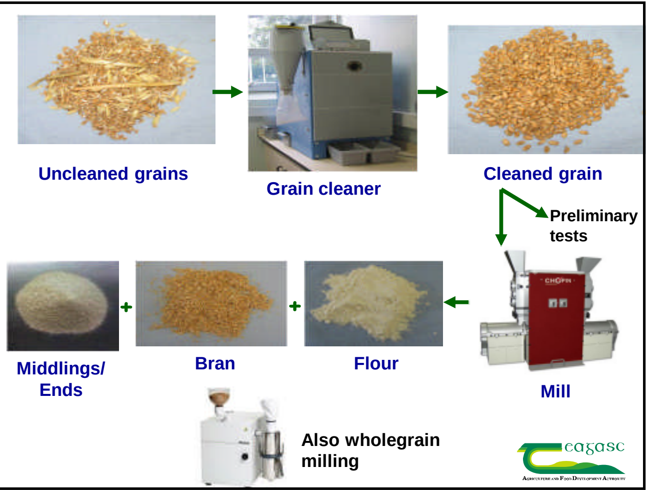
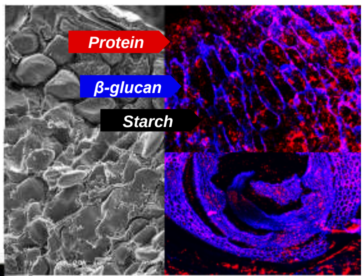


Characterization of the grains and milled fractions

- Hectolitre weight
- 1000 grain weight
- Fat
- Ash
- Water binding capacity
- Total starch
- Protein
- Moisture
- Falling number
- Minerals
- Microstructure
- Soluble, insoluble, total dietary fibre
- Starch pasting properties
- Antioxidant activity
- Beta glucan

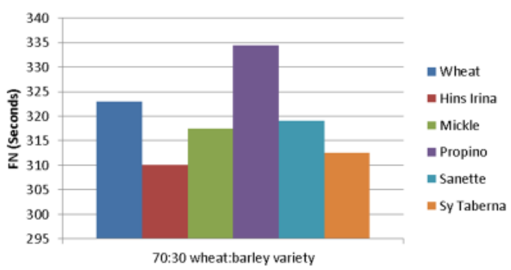
Microstructure of barley grain



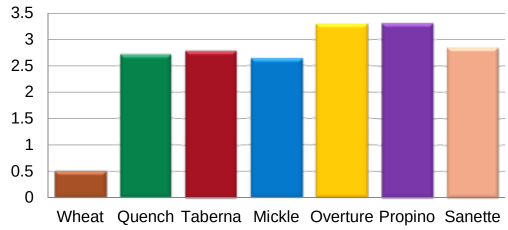
Scanning electron microscopy

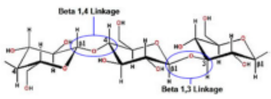
Confocal laser scanning microscopy

Falling number of flour blends

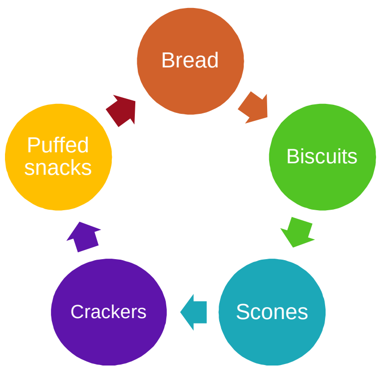


% β-glucan in wheat vs barley





Formulation trials



Bread trials

- Following rheology and preliminary trials, Sanette chosen at 30% replacement of wheat

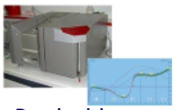
100% wheat **70% wheat: 30% barley**

- Poor volume, closed crumb structure
- Natural enzymes were chosen (amylase, glucose oxidase, xylanase and combinations) to improve the rheology and baking properties

Dough rheology and baking tests

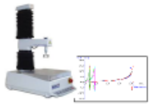
Extensional rheology of doughs

Fermentation properties



Dough mixing rheology

Crumb digital imaging



Crumb texture/ shelf-life

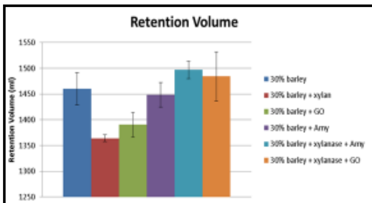
Specific volume

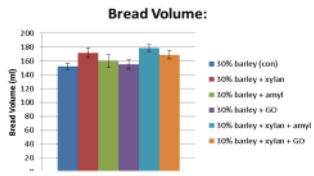
Crumb microscopy

Sensory analysis

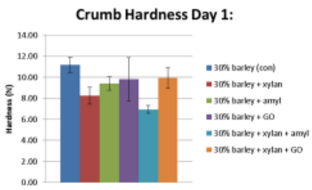
Composition

Some dough and bread results





Sensory analysis on a par with wheat control

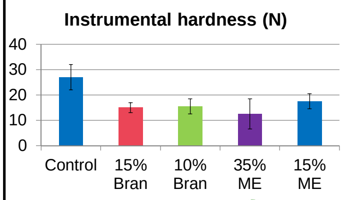


Saltine cracker trials

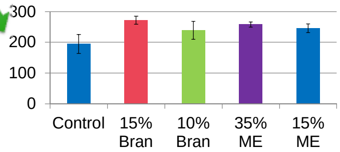
- Long fermentation time, unique flavour
- 2 barley (Mickle) milling fractions: Bran and middlings+endosperm (ME) (by-product, less waste)
- 2 levels of addition to wheat-based formulation

Control (wheat) 15% bran 10% Bran 35% ME 15% ME

Crispiness/eating properties



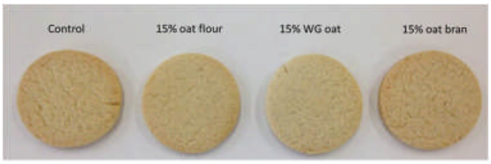
Indicates the barley crackers were crispier



- Mass spectrometry identified 49 FLAVOUR compounds
- SENSORY analysis comparable with control

Biscuit trials

- 3 oat milling fractions: Oat flour (OF), wholegrain oat (WO), Oat Bran (OB)
- Following rheology pre-trials, levels of 10% and 15% substitution of wheat flour. No processing aids required
- Dough rheology, 4-week shelf-life study, sensory analysis, compositional analysis



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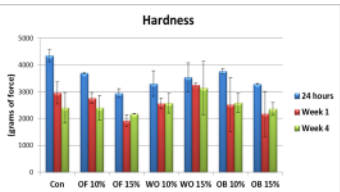
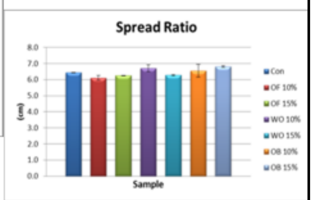
Shelf-life and sensory results





Sensory Ranking	Sample	(%)
1st (favourite)	Oat flour at 15%	53
2nd	Oat bran at 15%	19
3rd	Control biscuit	15
4th	Wholegrain oat at 15%	13

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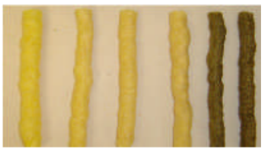
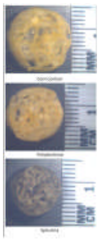
Following baking trials, compositional analysis undertaken

- Focussed particularly on dietary fibre, beta glucan, antioxidant/phenolic properties
- Bread: Total DF ↑ from 2% to >6%
- Crackers: β-glucan ↑ from 0.01% to 1%, phenolic profile (catechins) increased from 0 to 6000μg/100g



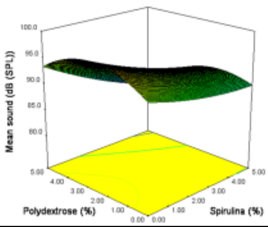
Extrusion trials (puffed snacks)

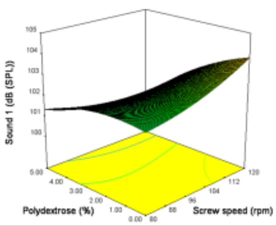
- Shada variety used, blended with corn (20%)
- Extrusion aids also incorporated to improve the expansion characteristics: Spirulina, psyllium husk, polydextrose
- Response surface statistical design used to calculate the best formulations


Some results

- Spirulina and polydextrose ↑ volume
- Polydextrose ↓ hardness, more crispy acoustics, preferred sensory results
- Psyllium husk, greater work of shear
- Significant increase in dietary fibre (from 2.6% to 8.9%)





What can be concluded

- **For barley and oats:**
  - Pre-trials, chemical and rheological characterisation must be carried out
  - Using the appropriate formulations is essential
  - Select processing aids to improve baking performance
  - **With care, it is possible to incorporate Irish cereals in bakery formulations!**

Thank you very much!

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Disease control with a declining number of effective fungicides

Steven Kildea
Teagasc, CELUP, Oak Park

SUMMARY

Under Irish growing conditions, if left unchecked, foliar and ear diseases have the potential to severely restrict the yield potential of cereal crops. To prevent such losses disease control strategies are routinely used. Many cultural control measures are often ineffective on their own and control therefore relies upon varietal resistance and fungicide applications. The availability of varieties with broad spectrum disease resistance and high yield potential is limited and consequently fungicides are depended upon to provide the yield protection required. Changes in how fungicides are registered and the development of fungicide resistance in their target pathogens, are severely undermining the future success of fungicide-dependent disease control strategies. Whilst research is ongoing to provide more integrated disease control approaches, such as matching fungicide programme to variety and disease risk, until such time as varieties with robust levels of resistance and yield become available, fungicides will continue to be relied on even though their efficacy is under threat. To ensure the continued effectiveness of fungicide control programmes it is therefore essential to monitor the fungicide sensitivity of the target pathogen populations, but equally how changes in their sensitivity impact upon the performance of fungicides under field conditions.

Following the detection of strains of *Zymoseptoria tritici* (cause of Septoria of wheat) with varying levels of resistance to the SDHIs in 2015, monitoring has been ongoing to determine their spread through the Irish population. In pre-season sampling varying levels of moderate SDHI resistance were detected, ranging from 15-66%. High levels of variability were also detected in post-treatment sampling, however moderately resistant strains were detected in all crops sampled and in some instances dominated the populations. The Irish *Z. tritici* population also continues to be dominated by strains that exhibit high levels of reduced sensitivity to the azole fungicides. Differences between the main azoles used, epoxiconazole and prothioconazole versus metconazole and tebuconazole, still exist in the population, supporting the continued alternation of azoles from either of these groups at the main leaf 3 and flag leaf fungicide timings.

These reductions in sensitivities observed are impacting upon the performance of these fungicides under field conditions. This is most notable when they are applied as solo products and when applied curatively. It is therefore essential to ensure they are used in mixtures, as protectantly as is possible and in combination with the multisite chlorothalonil. Careful consideration should be given to both the timing of application and rates applied to ensure the weaknesses that now exist do not unduly impact upon control. Where rates or timings are compromised, particularly earlier in the season the application of a multisite such as chlorothalonil when leaf two is fully emerged may be warranted.

Disease control with a declining number of effective fungicides

Steven Kildea
Teagasc CELUP
Oak Park Crops Research

Control dependent on fungicides






Regulations reducing fungicides available

Table 2. Activity of fungicide groups registered for use on winter wheat in the Republic of Ireland and Northern Ireland

Fungicide group	Number of fungicides registered[a]	Septoria tritici blotch	Eyespot	Rusts	Mildew	*Fusarium* spp.
Triazoles	8	Excellent (mixed formulation)[b] Poor – moderate (solo)[b]	Good[c]	Excellent	Limited	Excellent[c]
Imidazole	1	Moderate	Good[d]	Moderate	Poor	Moderate
Succinate dehydrogenase inhibitors (SDHIs)	5	Excellent	Good[c]	Good	Moderate	Poor
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Multisite folpet	1	Good (protection only)	Poor	Poor	Poor	Poor
Multisite mancozeb	1	Moderate	Poor	Poor	Poor	Poor

[a] Number of different active ingredients registered in the Republic of Ireland/Northern Ireland in 2014.
[b] Strains of *Z. tritici* with reduced sensitivity to the most active triazole fungicides are now present in Northern European populations and have impacted upon field efficacy of solo products. Mixtures of the most active triazoles still provide excellent field efficacy when applied at the recommended rates.
[c] Fungicide dependent.
[d] Resistance present but frequency low in population.
[e] Resistance dominant and impacts upon fungicide efficacy.
[f] Includes the fungicides quinoxyfen, proquinazid and metrafenone.
[g] Field resistance to metrafenone present in European populations.

What will be the impact of 2009/1107?

Based on 2014 registrations

Current resistance issues - barley

Ramularia leaf spot (barley)

- QoI – resistance widespread
- Azoles – resistance known, frequency unknown
- SDHI – resistance known, frequency unknown

Net Blotch and Rhynchosporium (barley)

- QoI – varying resistances known, frequency unknown

Good diversity of actives still effective on main barley diseases

– use this diversity!

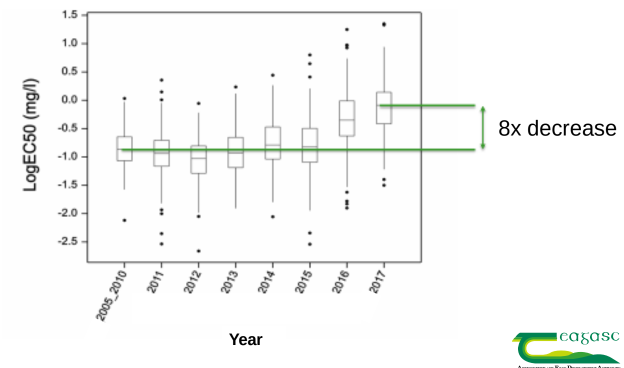
Current resistance issues

Septoria tritici blotch (wheat)

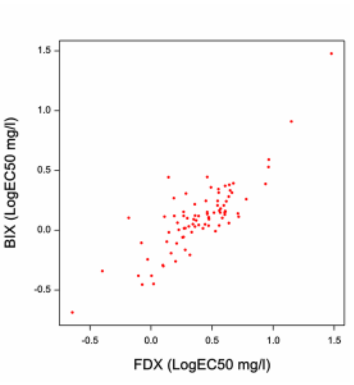
- QoIs – resistance widespread
- Azoles – varying resistances widespread
- SDHI – resistances increasing
- CTL – no resistance but only protective activity

1. **What is the current status of Irish Septoria population?**
2. **Does changing sensitivity impact field control?**
3. **Can we adjust fungicide programmes to counteract potential loss in efficacy?**

Reducing SDHI sensitivity in Septoria

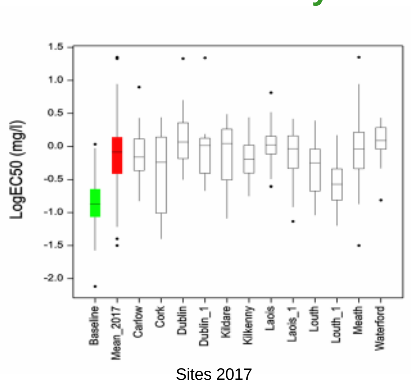


SDHI: Cross-resistance



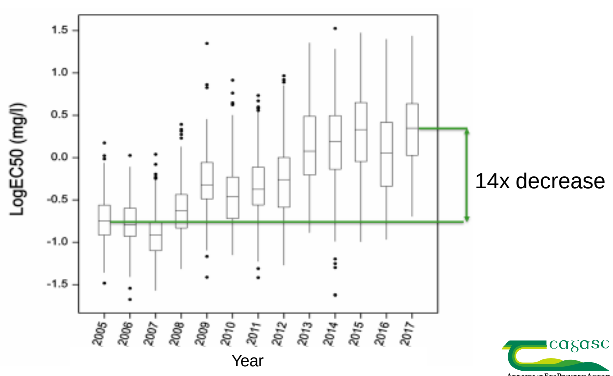
Very strong cross-resistance between SDHIs (R^2 = 0.68-0.88)

SDHI insensitivity widespread

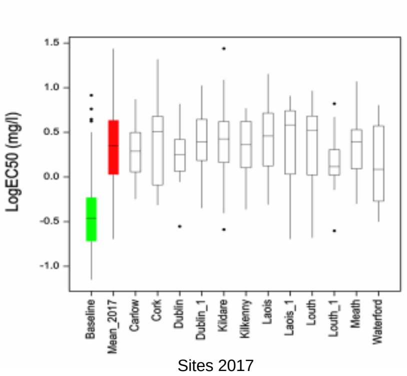


- Wide range of sensitivity in most crops
- Strains with moderate resistance present in all crops
- Strains with high levels of resistance present in all regions

Azole sensitivity reducing in Septoria



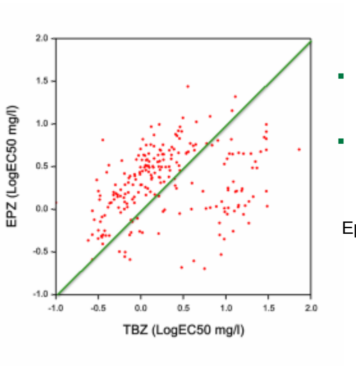
Azole insensitivity widespread



Sites 2017

- Wide range of sensitivity in most crops
- All populations less sensitive than in 2010
- Resistance present in all populations

Azole: Cross resistance



- Differences still exist between azoles
- Still value in alternating azoles in programme

<u>Alternate</u>
Epoxiconazole or Prothioconazole
with
Metconazole or Tebuconazole

Impact on field control

What does a change in sensitivity mean for current STB control strategies?

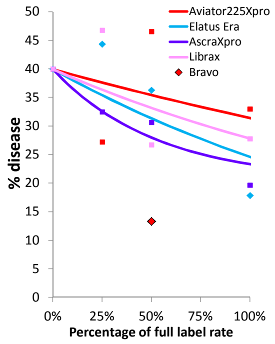
<u>Fungicide Dose Response:</u>

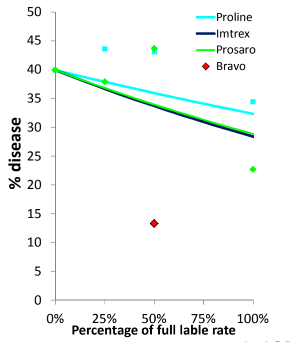
- Oak Park & Knockbeg (reduced trial)
- Single application at 2nd leaf emerged
- Disease and Yield

<u>Developing programmes</u>

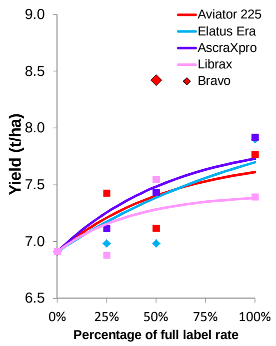
- Knockbeg, Meath & Cork
- 2 applications at GS32 & GS39
- Disease, yield and selection for resistance

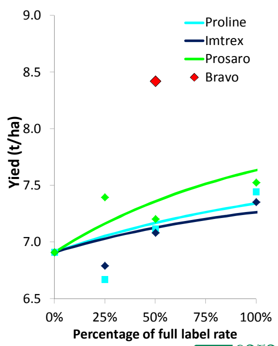
Dose response: Disease L1 & L2



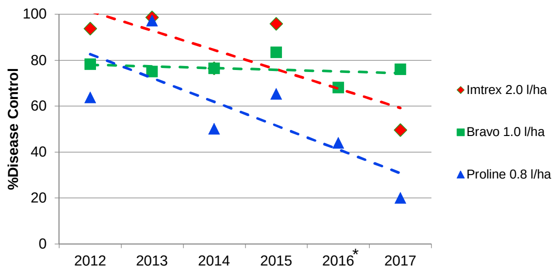


Dose response: Yield



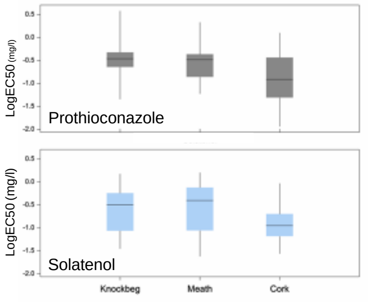


Activity of Azoles and SDHIs declined over recent years



Imtrex not included in 2016

Septoria sensitivity varies between fields

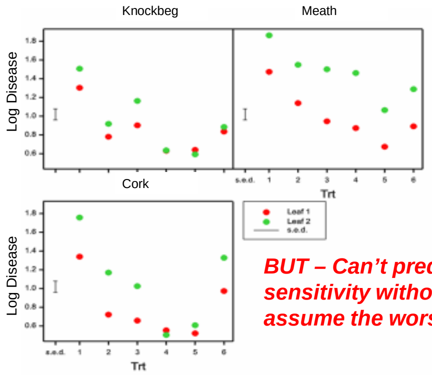


Trial Site 2017

Pre-treatment Sensitivity

- All 1st wheat
- Significant differences between sites in azole & SDHI sensitivity
- SDHI strong cross-resistance (R^2 = 0.83-0.94)
- Differences between azoles (R^2 = 0.03-0.85)

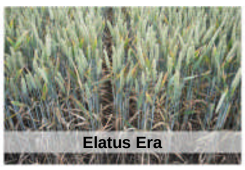
Disease control poorer where septoria less sensitive



Trt	Fungicide	l/ha
1	Untreated	-
2	Proline	0.8
3	Elatus 'alone'	0.75
4	Elatus Era	1.0
5	Elatus Era Bravo	0.8 1.0
6	Bravo	1.0

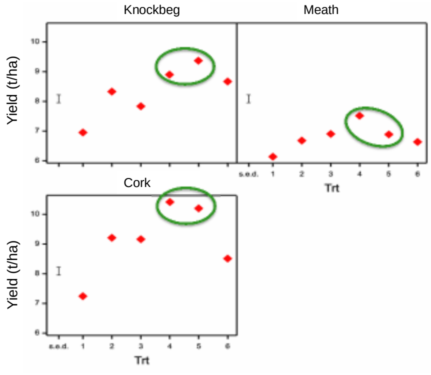
BUT – Can't predict field sensitivity without lab testing – assume the worst!

Building programmes



Knockbeg 7th July 2017

The more actives in the tank the better the yield



Trt	Fungicide	l/ha
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4	Elatus Era	1.0
5	Elatus Era Bravo	0.8 1.0
6	Bravo	1.0

Optimising application timing

Treatment combinations

Trt	Leaf 4	Leaf 3	Leaf 2	Leaf 1	Ear
1	+	+	+	+	+
2	+	+	+	-	+
3	+	+	-	+	+
4	+	+	-	-	+
5	+	-	+	+	+
6	+	-	+	-	+
7	+	-	-	+	+
8	+	-	-	-	+
9	-	+	+	+	+
10	-	+	+	-	+
11	-	+	-	+	+
12	-	+	-	-	+
13	-	-	+	+	+
14	-	-	+	-	+
15	-	-	-	+	+
16	-	-	-	-	+
17	-	-	-	-	-

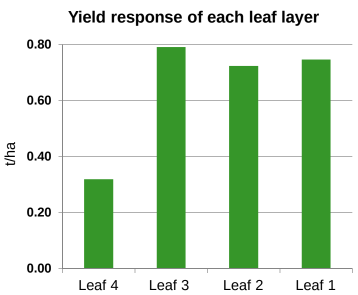
Objective

- What leaf layers important for yield?
- How best to achieve disease control on these leaves?

Methods

- 6 site seasons in 2016 & 2017
- Combinations of leaf applications
- 2016: CTL 1.0 l/ha
- 2017: Elatus Era 0.8 & CTL1.0 l/ha

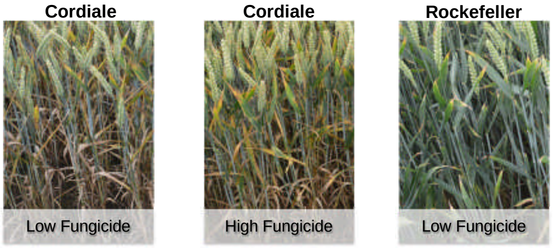
Optimising application timing



- Contribution of L1, 2 & 3 similar when in "programme"
- L4 showed lowest contribution
- Variation between sites due to infection events

Reducing fungicide reliance

Cordiale | Cordiale | Rockefeller



Fungicide	<GS30	GS32	GS39	GS65
Low	CTL	CTL	CTL	Azole Mix
High	CTL	Azole/SDH/CTL	Azole/SDH/CTL	Azole Mix

Recommendations 2018

Winter	<GS30 (T0)	Leaf 3 (T1)	Leaf 1 (T2)	Flowering (T3)
Diseases	• Septoria • (Rust)	• Septoria • Stem Diseases • Rust	• Septoria • Rust	• Fusarium • Septoria
Low Disease Pressure	-----	Azole (Mix) & Multisite	SDHI / Azole & Multisite	Azole (mix) +/- Multisite
High Disease Pressure	(Multisite) (Strob)	(SDHI) / Azole & Multisite	SDHI / Azole & Multisite	Azole (mix) +/- Multisite

Additional application of chlorothalonil only at leaf 2 maybe warranted where earlier application was compromised

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Dr. Hilda Dooley
Dr. Sinead Phelan
Dr. Joseph Mulhare
Farm Staff
Advisory Service

Insecticide resistance in the grain aphid, in Irish crops

Lael Walsh
Teagasc, CELUP, Ashtown & University College Dublin

SUMMARY

There are a number of mechanisms by which insects may become resistant to insecticides, including reduced insecticide penetration, metabolic de-activation and alteration of the insect's target site, all of which reduce susceptibility to the insecticide's mode of action. Over 30 insect species are known to have developed resistance mutations to pyrethroid insecticides, often with more than one mechanism of resistance and/or compensatory mutations that contribute to reduced insecticide efficacy. Target site resistance is implicated in the expression of knock down resistance (kdr) to pyrethroid compounds in the grain aphid Sitobion avenae (Fabricius). This is caused by a mutation (L1014F) on the S. avenae sodium channel gene, which is associated with up to 40-fold resistance. We report bioassay data from grain aphids collected in winter barley fields in Ireland, which show a substantial, up to 5-fold variation in pyrethroid toxicity in field-collected, kdr-resistant aphid populations in Ireland. This stimulated further investigation to determine whether another, specifically metabolic mechanism of pesticide detoxification may underpin our observation of wide variation in pyrethroid toxicity. An additional bioassay incorporating exposure to the synergist piperonyl butoxide (PBO), known to inhibit the enzyme-based detoxification of pyrethroids was undertaken. This assay showed a significantly enhanced toxicity of the pyrethroid compound in some aphid populations using PBO, which strongly suggests that in addition to the known incidence of the kdr mutation (L1014F) in grain aphid populations in both Britain and Ireland, a second enzyme-based pyrethroid detoxification mechanism is present in some Irish field populations.

In the light of this finding, continued over-reliance on pyrethroid insecticides is likely to further exacerbate difficulties in controlling both grain aphid and its transmission of Barley Yellow Dwarf Virus (BYDV), by imposing strong selection pressure for additional pyrethroid resistance mechanisms. In the near absence of alternative pesticide chemistry, it will become essential that non-chemical options are explored as part of a wider Integrated Pest Management (IPM) strategy.

Insecticide resistance in the grain aphid, in Irish crops

Lael Walsh
Teagasc CELUP Ashtown

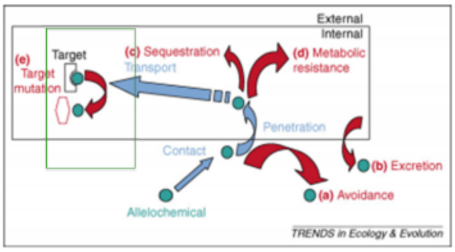
Dr Michael Gaffney
Teagasc CELUP Ashtown

Dr Gordon Purvis
University College Dublin

Dr Louise McNamara
Teagasc CELUP Oakpark

Insecticide resistance mechanisms

Over 30 insect species have developed resistance-associated mutations to pyrethroids (Rinkevich et al., 2013)

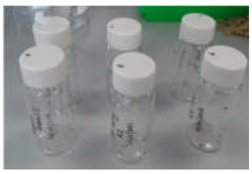


(Despres et al., 2013)

Resistance observed in Irish fields

- **Aphids sampled from Irish Fields for lab tests**
- **Pyrethroid (λ-cyhalothrin) doses from <1% to 200% used in vial tests.**
- **Effectiveness assessed**

ng cm^{-2} (g per ha)	% of field application
0 (0)	0
0.03 (0.003)	0.4
3 (0.3)	4
15 (1.5)	20
75 (7.5)	100
150 (15.0)	200



Resistance in field populations

Experiment 1: Full dose–response bioassay results of *S. avenae* populations against λ-cyhalothrin

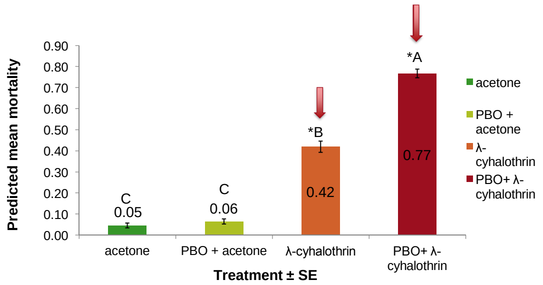
Population	Location	Resistance	LC 50 (g AI/ha)	RF*
1	Wexford	kdr-SR	12.59	2.53
2	Carlow	kdr-SR	7.44	1.49
3	Carlow	kdr-SR	10.53	2.11
4	Cork	kdr-SR	12.07	2.42
5	Carlow	kdr-SR	25.94	5.21
6	Cork	kdr-SR	4.98	1.00
7	Carlow	kdr-SR	24.32	4.88
8	UK	kdr-SR	10.10	2.03

* RF = Resistance Factor (LC50 for test population divided by the lowest LC50)

Variation in LC50 suggests additional resistance mechanism

Pesticide detoxification in the field

Experiment 2: The impact of adding synergist, piperonyl butoxide (PBO), on pyrethroid performance.



Mortality increased significantly with the addition of the synergist (PBO), which blocks enzyme-detoxification

Conclusions

- **Results indicate that in addition to kdr resistance, the grain aphid can also detoxify pyrethroids – an additional resistance mechanism**
- **This increases the challenge for growers with limited alternative chemical control**
- **Growers must adopt cultural control options such as sowing date changes; use of varietal resistance etc. to reduce the pressure on insecticides**

VICCI: Improving Irish crop varieties

Petra Kock-Appelgren, John Spink and Dan Milbourne
Teagasc, CELUP, Oak Park

SUMMARY

In Ireland we have one of the highest yield potentials in the world, particularly for cereal crops. However, these high yields demand high levels of external inputs, and associated costs, for the crop varieties currently on the market to perform. In addition to significant costs for growers, fertilisers can be problematic from an environmental standpoint as they may leech into groundwater and contribute to greenhouse gas emissions. Another of the main challenges facing Irish tillage production is high disease pressure. Crop protection products are the second largest input cost for tillage crop production, which could be reduced with improved resistance in crop varieties. Furthermore, major diseases such as Septoria tritici blotch are rapidly developing resistance to fungicides, which is troubling for future disease control.

Abiotic stresses can also be a limiting factor for growers. In tillage production, winter cereals have a higher yield potential than spring cereals due to a longer growing season; however, actual grain yields can be limited by environmental stresses such as waterlogging, where wet soils over winter and in early spring result in crop damage or failure. Finally, despite our high capacity for crop production, Ireland still imports significant quantities of crop-based products to fill supply gaps. Targeted breeding of field beans (as a replacement protein crop) and potatoes (for the chipping and crisping sectors) could lead to significant import replacement potential.

For this reason the Department of Agriculture, Food and the Marine have funded Teagasc, University College Dublin, NUI Maynooth, NUI Galway and Trinity College Dublin to create the Virtual Irish Centre for Crop Improvement (VICCI). Within VICCI we are able to take advantage of existing Irish expertise in plant science and crop production to target crop breeding specifically for the Irish climate. VICCI has developed its initial research programme around the following areas; nitrogen use efficiency, disease resistance, waterlogging tolerance in cereals, cold tolerance in ryegrass and processing quality in potatoes. The centre has adopted a dual approach; firstly by field testing large numbers of varieties and breeding lines to determine which genetic and phenotypic traits can be used to improve future varieties and secondly, by developing a non-GM biotechnology capacity to allow breeders to incorporate specific traits, that would benefit Irish production, into new varieties.

Thus far highlights include the identification of wheat lines which combine good septoria resistance with high yield potential and wheat varieties which loose relatively little yield when N fertiliser inputs are significantly reduced. The work of the centre can be followed at www.vicci.ie or on twitter @CropImprovement.

Improving Irish crop varieties

Petra Kock-Appelgren
Teagasc CELUP
Oak Park Crops Research Centre
&
the VICCI Consortium

VICCI Virtual Irish Centre for Crop Improvement

Combining existing expertise of Irish research institutions for a common cause

⟶ **Improving Irish crop varieties**

- Teagasc, UCD, NUI Maynooth, NUI Galway and Trinity College
- Wheat, Barley, Oats, Perennial Ryegrass, Potatoes and Beans
  - Fertiliser usage
  - Crop protection
  - Environmental stress
  - Replacing imported crops with Irish-grown alternatives

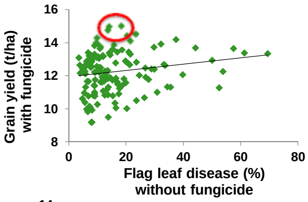
VICCI Research in progress

- **Disease resistance**
  - Wheat
  - Oats
  - Barley
  - Beans
- **Nitrogen use efficiency**
  - Winter wheat
  - Winter barley
  - Spring barley
- **Tolerance to waterlogging**
  - Winter barley
  - Perennial ryegrass
- **Processing quality**
  - Potatoes
- **Testing late generation breeding lines for Irish conditions**
  - Winter oats

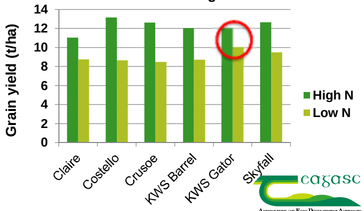
VICCI Research in progress

Example results

- **Septoria**
→There are some quite resistant wheat varieties with high grain yield capacities



- **Nitrogen requirement**
→ Some wheat varieties are able to maintain grain yields with very low nitrogen levels

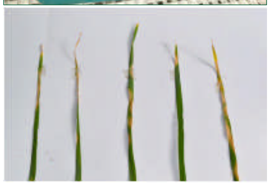


Teagasc

VICCI Research in progress

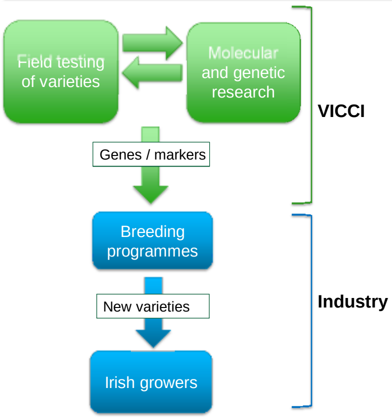
In the laboratories

- Molecular experiments
→ which genes are related to certain crop traits?
- Metabolic experiments
→ what is happening in the plant to make it resistant to a certain stress?
- Glasshouse experiments
→ compliment to field tests and molecular analyses



Teagasc

VICCI Application



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Ronan Sulpice
Charles Spillane
Trinity College
Frank Wellmer

www.vicci.ie
@CropImprovement

Teagasc

Do six and two-row winter barley variety need to be treated differently?

Robert Beattie
Teagasc, CELUP, Oak Park
SRUC, Crops and soils, Edinburgh

SUMMARY

Winter barley has become increasingly popular amongst growers in recent times due to the need to diversify cropping in response to the three crop rule, and improved yield potential as a result of genetic improvement and improved agronomy. An example of genetic improvement has been the introduction of hybrid six-row varieties, which have performed very well in recommended list trials, consistently producing higher yields than conventional two-row varieties. These varieties have dramatically different yield components compared to their conventional two-row counterparts, producing more grains per ear, fewer ears per m^2, which combine to produce more grains per m^2, while the average grain weight is lower. As these varieties are relatively new to the market there has been very little independent research conducted to support current management advice, thus growers are reliant on the information given by the seed suppliers. Currently fungicide application timings are the same for each row type although it could be hypothesised that they might require different approaches due to their different yield components. Additionally, no study has investigated if there is a greater requirement for plant growth regulator (PGR) treatment for six-row varieties as a result of their higher yield and longer straw.

To investigate if the crop protection strategy needs to be altered depending on ear morphology, a field trial to study fungicide application timing in a two (KWS Tower) and six-row (Volume) winter barely variety was carried out for three years (2014/2015, 2015/2016 and 2016/2017) at two sites, SRUC, Edinburgh, Scotland and Teagasc, Oak Park Carlow, Ireland. The fungicide applications were applied as part of programmes, consisting of a control, a single application (growth stage (GS) 31/32), a two spray (GS31/32, GS49), a three spray (GS25-30, GS31/32, GS49) and four spray programme (three spray plus GS65). The products used were; 0.4 L/ha of Proline® plus 0.4 L/ha of Corbel® at the GS25 timing, 1.8 L/ha of Ceriax® at both the GS31/32 and GS49 timing and 0.4 L/ha of Proline® plus 1 L/ha of Bravo® at the GS65 timing. The results showed that, despite the dramatically different yield components of each variety there was no significant interaction between variety and fungicide application (p=0.222) suggesting that disease management does not need to be tailored to ear type.

To investigate if a six-row variety has a greater requirement for PGR treatment compared to a two-row variety, in the same field trial as mentioned above additional treatments of the three and four spray programmes without PGR treatment were investigated. The treatments were independent applications at GS30 and GS37. The products used were; 1L/ha of Ce Ce Ce® 750 plus 0.2kg/ha of Medax Max® at the GS30 timing and 0.4kg/ha of Medax Max® at the GS37 timing. The results indicated that each variety responded differently to PGR treatment (p=0.02), with the six-row variety displaying a significant yield reduction in the absence of PGR, while there was no significant effect on the two-row.

Do a six and two-row winter barley variety need to be treated differently?

Robert Beattie

Teagasc CELUP
Oak Park Crops Research

Supervisors: Ian Bingham (SRUC), John Finnan (Teagasc) and John Spink (Teagasc)

Background

- Hybrid six-rows are becoming popular with growers

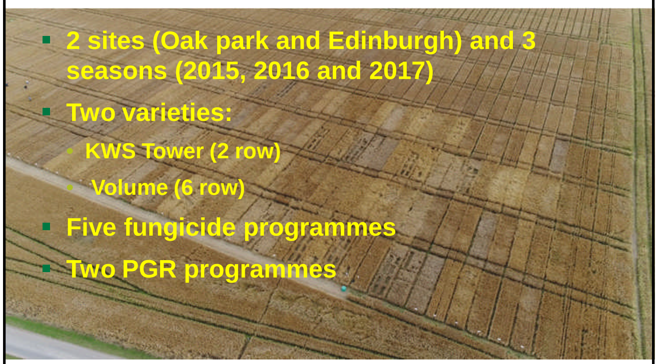
WINTER BARLEY 2018

AGRONOMIC & QUALITY CHARACTERISTICS*	RECOMMENDED						PROVISIONALLY RECOMMENDED
	KWS CASSIA	KWS INFINITY	KWS TOWER	LEIBNIZ	QUADRA	VOLUME	KWS KOSMOS
Relative Yield ♦	97	101	100	103	108	107	107
Varietal Type	2R	2R	2R	6R	6R (H)	6R (H)	6R

Yield components	Two-row	Six-row	Wheat
Ears/m^2	900-1200	650-900	480-600
Grains per ear	17-21	30-40	41-51
grains m^{-2}	15,000-25,000	19,500-36,000	19,700-30,600
TGW (mg)	50-58	40-45	46-56

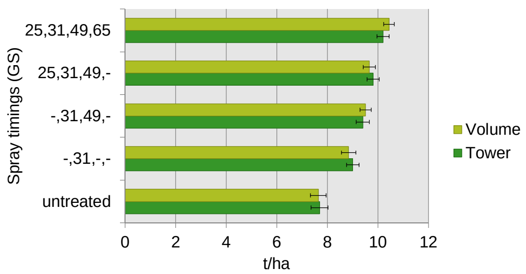
They have different yield components to two-row and wheat

Field trial

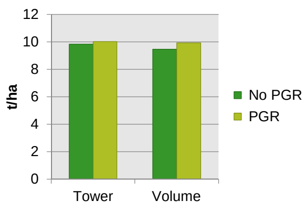


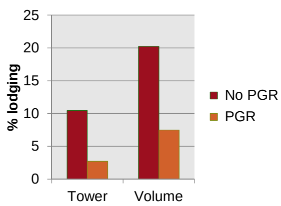
- 2 sites (Oak park and Edinburgh) and 3 seasons (2015, 2016 and 2017)
- Two varieties:
  - KWS Tower (2 row)
  - Volume (6 row)
- Five fungicide programmes
- Two PGR programmes

No difference in response to fungicide timing between varieties



Larger yield response to PGR in volume





- 0.2 t/ha increase in Tower (2 row)
- 0.5 t/ha increase in Volume (6 row)

Conclusions

- Average yield was not significantly different between the two varieties
- There is no evidence to suggest altering fungicide strategy based on row type
- Yield response to PGR application was higher in the six-row compared to the two-row

Diagnosing soil compaction

J. Emmet-Booth[1], D. Forristal[2], O. Fenton[3] and N. Holden[1]
[1]School of Biosystems and Food Engineering, University College Dublin,
[2]Teagasc, Oak Park, [3]Teagasc, Johnstown Castle

SUMMARY

Soil compaction poses a significant threat to soil structural quality globally, affecting crop yields, water infiltration, nutrient cycling, green-house gas emissions, surface runoff and thus pollution. Soil compaction is relatively easily caused and in severe cases, difficult to remedy. Fortunately, soil compaction can be identified by examining soil structure within the field, allowing real-time soil management changes if necessary, before severe damage occurs. The Visual Evaluation of Soil Structure (VESS) method (Guimarães *et al.,* 2011) is a formal procedure for assessing soil structure by means of examining a block of soil extracted by spade, with reference to a score sheet, generating a structural quality (*Sq*) score. *Sq* scores range from 1 (good) to 5 (poor). Despite its simplicity, VESS has been deployed internationally and has been found to correspond with other measurements indicative of soil compaction.

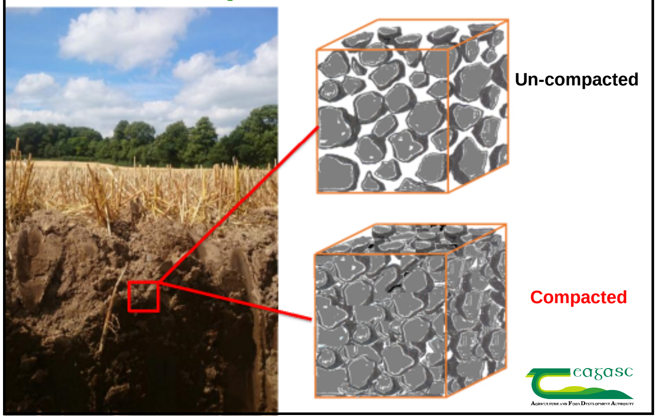
An experiment was established at Teagasc Oak Park in 2015 to explore how well VESS identified varying levels of compaction. Four compaction treatments were imposed on replicated plots of winter barley (*Hordeum vulgare* L.) in a randomised block design at two sites representing light and heavier soil textures. Compaction treatments ranged from no additional traffic prior to sowing, to the ploughed plot being completely covered by wheelings from up to four additional passes of agricultural equipment with axle loads of 6.3 to 7.8 tonnes. Soil measurements including VESS assessments, and bulk density (ρ_b) taken at 5-10 and 15-20 cm depth, were conducted in April 2016. Results indicated that VESS was successful in identifying the different compaction treatments on both soil types. For the heavy soil, mean *Sq* scores ranged from 2.7 to 3.5 (moderate to poor structural quality) with a gradual increase with progressive compaction treatment. For the light soil, *Sq* scores ranged from 1.9 to 2.8 (good to moderate structural quality) though they did not differentiate between the first two levels of compaction. The results corresponded with soil bulk density at 5 to 10cm, which ranged from 1.32 to 1.40 and 0.96 to 1.04 g cm^3 for the heavy and light soils respectively. Bulk density at 10 to 20cm ranged from 1.29 to 1.40 g cm^3 for the heavy soil with a gradual increase with compaction treatment. However at this depth soil density did not reflect compaction treatment on the lighter soil.

It is concluded from these preliminary results that the imposed varying compaction treatments negatively impacted soil structure and that VESS was successful in identifying compaction. This highlights the utility of VESS in diagnosing soil compaction and as a soil management tool.

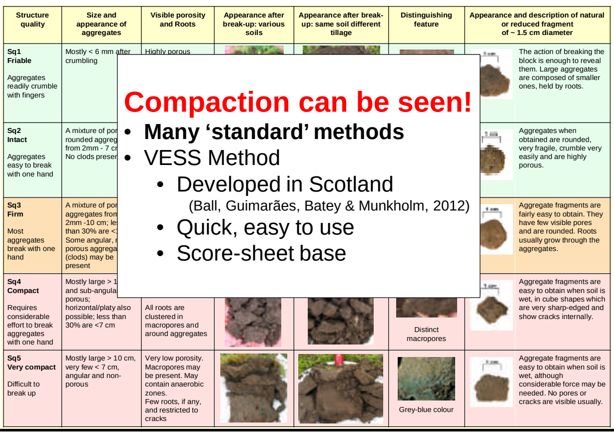
Diagnosing soil compaction

J. Emmet-Booth[1], D. Forristal[2], O. Fenton[3] and N. Holden[1]
([1]UCD, [2]Oak Park Crops Research, [3]Johnstown Castle)

Soil compaction = Bad news !



Visual soil scoring methods



Compaction can be seen!

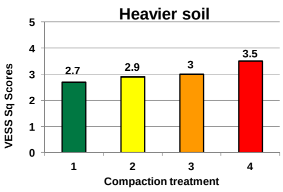
- **Many 'standard' methods**
- VESS Method
  - Developed in Scotland
    (Ball, Guimarães, Batey & Munkholm, 2012)
  - Quick, easy to use
  - Score-sheet base

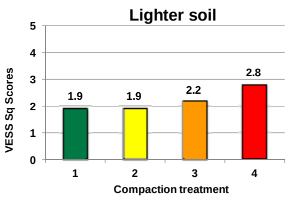
What we did

Aim: Test the sensitivity of Visual Evaluation on Tillage soils

- **Imposed compaction (4 treatments)**
  1. No additional traffic
  2. Complete wheeling cover: 6.5t axle load
  3. As 2 but extra wheeling cover: 7.8t axle load
  4. As 2 but 3 x extra 7.8t wheelings and a high tyre pressure wheeling of 6.3t.
- **Two sites (heavier clay soil & sandy light soil)**

Impact of compaction on VESS Scores





Conclusions

The compaction treatments negatively impacted soil structure

VESS was able to identify the impact of compaction

Compaction can be seen and quickly diagnosed in the field

Assessing weather-based forecasting of Ramularia in spring barley

Joe Mulhare
Teagasc, CELUP, Oak Park

SUMMARY

Ramularia collo-cygni, the causal agent of Ramularia leaf spot, is a seed and wind-borne pathogen known to be widespread throughout Europe. Ramularia has become a significant threat on both winter and spring barley crops throughout Europe over the last two decades as this disease reduces both the quality and quantity of harvested grains. In 2015, harvested grain samples from both winter and spring crops, from four representative regions of Ireland, were analysed for the presence of Ramularia. Ramularia was found in 82% of 229 samples tested, although at low levels. This was in spite of a relatively low Ramularia pressure season. Previous work in Scotland found disease development to be directly related to leaf wetness between GS25 and GS32 (for spring barley), indicating scope to use this as a decision support (DSS) tool for disease forecasting. If the crop is deemed to be at high risk (minutes of leaf surface wetness (LSW) >7,500, which equates to leaves being wet at high relative humidity (>90%) for roughly 1/3 of the total time in this period), fungicide mixtures with known efficacy against the pathogen can be deployed at the GS45 application. This research aims to assess whether the DSS tool is relevant to Irish field conditions.

Field trials were conducted in 2016 and 2017 at Oak Park, Carlow (considered a medium disease pressure environment) and in Kildalton, Co. Kilkenny (a high disease pressure environment), using four different spring varieties from the recommended list (Propino, Irina, Olympus and Planet). Plots received 5 different disease control treatments at GS45; 1) a 'standard' of prothioconazole (Proline) and chlorothalonil (Bravo) applied at 50% of the recommended rate, 2) 'QoI' pyraclostrobin (Modem) to let Ramularia develop but not other major barley pathogens, 3) 'DSS product' of chlorothalonil (Bravo), bixafen and prothioconazole (Siltra Xpro) selected due to high levels of leaf wetness at the start of stem extension, 4) 'DSS rate' with increased rates (75%) of the standard treatment also due to high forecasted risk and 5) an 'untreated' control. At GS75 the percentage of Ramularia and green leaf area (GLA) were visually assessed on leaf two of ten main tillers per plot.

There was significant differences between varieties for both diease control and yield in both years. In 2016, Kildalton was considered as a high risk site while Oak Park as a low risk site according to the DSS tool. While analysis found that both DSS programmes provided the best control, neither was significantly different in either control or yield to the standard programme. In 2017, both sites were considered as high risk and again there was no significant difference between both DSS programmes and the standard programme. This may be due to the superior activity provided by chlorothalonil against Ramularia. It also indicates that in a high risk season, such as 2017, the standard programme provides adequate control while in a low risk season, such as 2016, it can be reduced with confidence while still providing control.

Assessing weather-based forecasting for Ramularia in spring barley

Joe Mulhare and Steven Kildea
Teagasc CELUP
Oak Park Crops Research

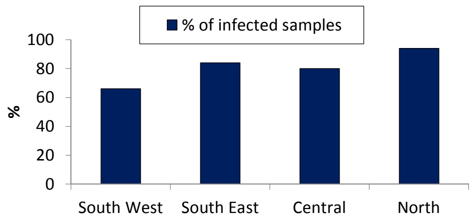
Henry Creissen
SRUC, Edinburgh

Ramularia

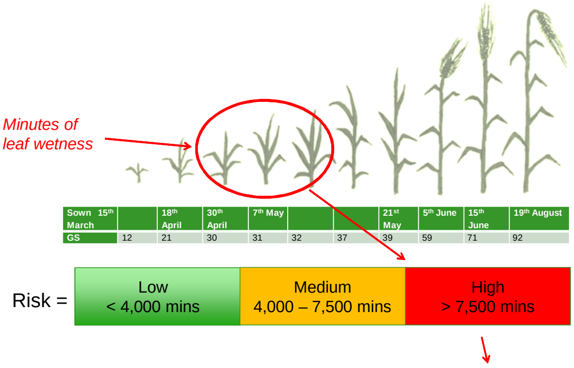
- *Ramularia collo-cygni* (Rcc) affects quality and quantity of grains
- Can cause yield losses up to 0.5t/ha
- Spread by infected seed or airborne spores
- Symptoms only visible post flowering (too late for fungicide application)

Ramularia in barley grain

- Molecular test for Rcc in (229) DNA grain samples from SW, SE, Central and N regions (2015 harvest)
- 82% of samples infected but no samples considered "high" (>5pg of DNA)



Risk prediction (Spring barley)

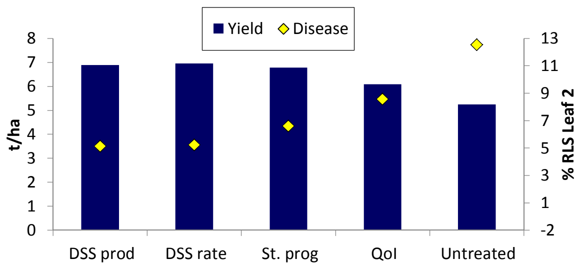


- Stronger programme = 3 actives in mixture @GS45

Field trial

- 2 sites, high and low risk (Kildalton & Oak Park) 2016-2017
- 4 varieties; Propino, Olympus, Irina and Planet
- 5 fungicide programmes @GS45;
  1. Standard (Bravo + Proline) @ 50% rates
  2. QoI (Modem)
  3. DSS product (Bravo +/- Siltra Xpro) (3 actives)
  4. DSS rate (Bravo + Proline) @ 75% rates
  5. Untreated (No fungicide @ GS45)

2017- High risk



- Superior activity provided by chlorothalonil?
- Standard programme adequate for high risk
- Can reduce standard for low risk
- Significant differences between varieties

Prospects for site-specific management of nitrogen for cereals

Richie Hackett
Teagasc, CELUP, Oak Park

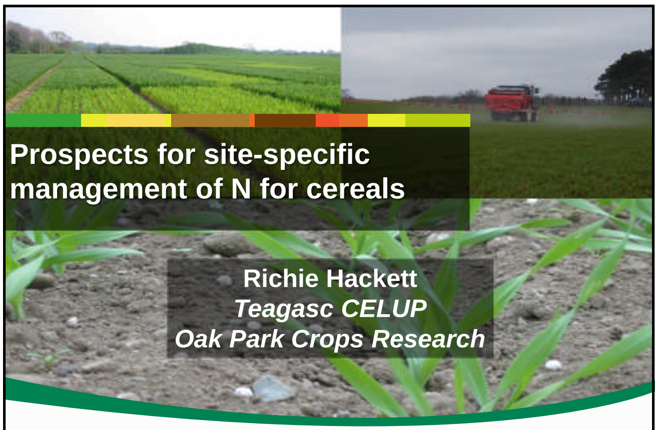
SUMMARY

Current nitrogen fertiliser recommendations are based on data generated from nitrogen response trials. However, results from these trials indicate that there is large variation in the optimum N between sites and seasons. The causes of this variation are not fully understood but differences in yield level and soil N supply between sites and seasons play a significant role. While this system will give, on average, a good indication of fertiliser N requirement averaged over a run of sites and seasons, it takes no account of the actual growth of the crop or many of the characteristics of individual sites on which the crops are being grown. Thus there can be large errors associated with the recommendation for any given site-season. A recommendation system that takes more detailed site-specific information and actual crop growth into account has the potential to reduce the errors that can be associated with the current system and lead to more efficient use of fertiliser N. Given that both soil N supply and the actual yield of a crop, rather than the expected yield, have a significant role to play in determining the optimum fertiliser N rate it would seem appropriate that site-specific information relating to both these factors be included in the decision process.

Soil N supply is currently indicated using the soil N index system which is at best a relatively crude system. Measurements of soil mineral N to 90cm have shown some promise under Irish conditions for indicating soil N supply. However significant further research is required before being recommended for use with confidence.

While actual crop yield will not be known until harvest, monitoring of crop growth can provide indications of what final yield will be. In particular, monitoring of crop N status during the season would indicate if the crop required additional fertiliser N in order to avoid deficiency. The standard method to determine crop N status is to take crop samples and have them analysed in a laboratory but this is not practical at farm level. However reflectance sensors, be they handheld, tractor mounted, on drones or on satellites have shown promise for detecting crop N status and would allow fast and timely assessment of crop N status.

A potential system to achieve more site-specific N management would be to make an initial estimate of fertiliser N requirement at the start of the season using knowledge of the site (e.g. soil mineral N) but retaining a portion of this fertiliser until later in the season, when it could be determined that actual crop growth necessitated its application. This would be determined by monitoring crop N status during the season and only applying additional N where a deficiency or potential deficiency was identified. While initial exploratory work has indicated that such a system has some promise considerable further research is required before it could be recommended for on-farm use.



Prospects for site-specific management of N for cereals

Richie Hackett

Teagasc CELUP

Oak Park Crops Research

Teagasc

Outline

- Current situation
- What is site-specific management?
- What information could be used?
- Outline of potential system
- Some initial findings

Teagasc

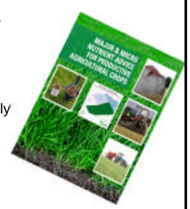
Current situation

- Current N recommendations based on empirical approach
  - Carry out N rate trials and determine optimum N rate
  - Gives good average rate
  - Incorporating indicator of yield and soil N supply (previous cropping) allows some adjustment at farm or field level
  - Farmer or adviser may also adjust based on experience

BUT

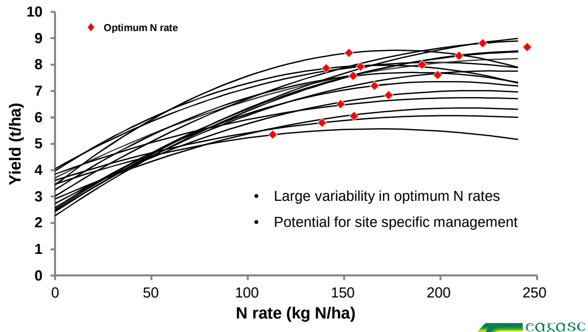
- No account taken of actual crop growth
- No account taken of seasonal differences in soil N supply
- Site differences not fully accounted for
- No account taken of within-field variation

- CAN WE DO BETTER?

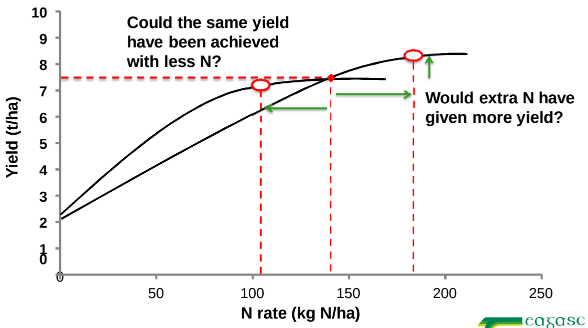


Teagasc

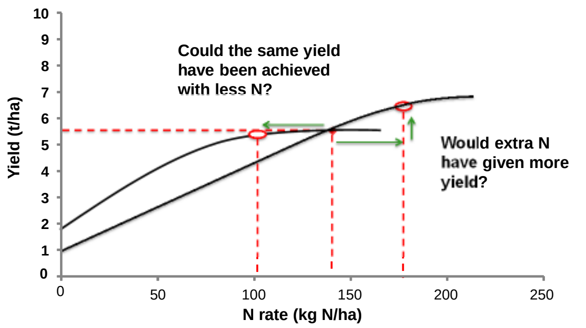
Typical spring barley N response curves



In a field situation you cannot know if the N rate applied was optimum even if yield was high



In a field situation you cannot know if the N rate applied was sub-optimum even if yield was low



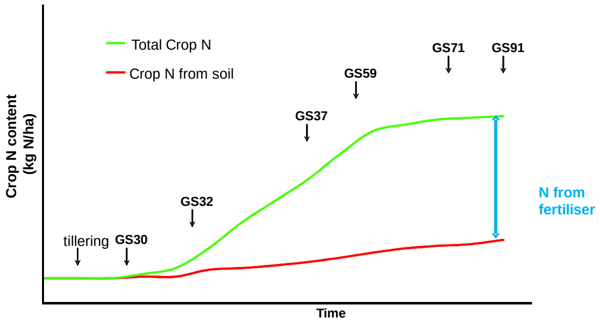
Site-specific management

- Tailoring N inputs to a block of fields, a field or part of a field using site-specific data/information
  - Scale will depend on circumstances
- Apply close to optimum rate rather than redistribution of given amount

Aims

- Reduce fertiliser N inputs and/or Increase yield
- Optimise grain quality (protein)
- Increase profitability/reduce environmental impact
- Approach needs to be adaptable to farm scale

Seasonal pattern of N uptake by a cereal crop



In theory site-specific management is easy!

Fertiliser N requirement (for farm, field or within field) = $\frac{\text{Crop N content at harvest} - \text{Soil N supply}}{\text{fertiliser N recovery}}$

Example

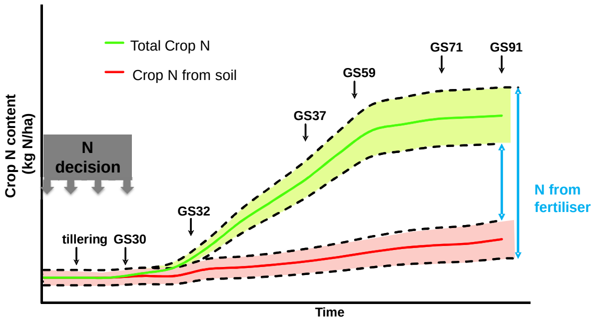
Crop N content at harvest = 200 kg N/ha

Soil N supply = 65 kg N/ha

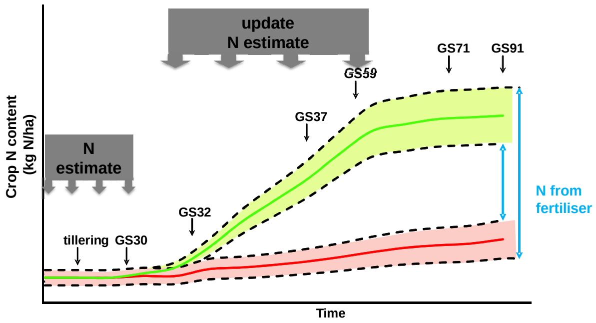
% fertiliser N recovery = 60%

$$\frac{200 - 65}{0.6} = 225 \text{ kg N/ha}$$

In practice unpredictable variability makes site-specific management complicated



Adjust N amount after some of variability has been fixed (i.e. delay final decision)



Site-specific N management

1. **Start of season**
   - Use site data to estimate N requirement
   - Estimate of soil N supply
   - Estimate of N in crop
   - Essentially current system (with improvement?)

Initial estimate of N requirement
Apply less than estimate

2. **During season**
   - Monitor of crop N status
   - Avoidance of large deficiency
   - Final adjustment as late as possible

Apply additional N to maintain adequate crop N status

- All must be achieved
  - Economically
  - Simply
  - In a timely fashion
  - In a fashion suitable for various systems and scales

SOIL N SUPPLY

Soil N supply

- N index system currently used to adjust fertiliser N rates
  - Not a direct measure of soil N supply
  - Based mainly on previous crop
  - Relatively crude indicator
  - Not very site or season specific

Index 1	Index 2	Index 3	Index 4
Previous crop			
Cereals, Maize	Sugar beet, Fodder beet, Potatoes, Mangels, Kale,		
	Oil seed rape		
	Peas, Beans,		
	Leys (1 - 4 years) grazed or cut and grazed.	Swedes grazed in situ.	
	Swedes removed.		
Vegetables receiving less than 200 kg/ha N.	Vegetables receiving more than 200 kg/ha N.		

Can we do better ?

Soil N supply estimation- alternatives

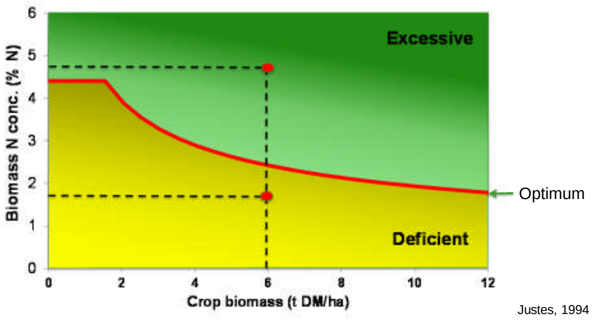
- **Soil mineral N measurements**
  - Laborious (and expensive) to take – do on a regional basis?
  - Might be very useful for seasonal adjustment
  - Would need baseline data and calibration
- **Monitoring crop in unfertilised plots**
  - Tricky to establish unfertilised plots
  - Might only be relevant for late season N applications
- **Soil N tests**
  - None yet proven to work under Irish conditions
- **Use of soil models**
  - Would need a lot of development/calibration
  - Likely to need a lot of input information

CROP N STATUS

Crop N status to fine-tune fertiliser N

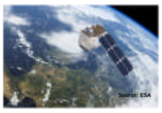
- Crop will indicate its N status
  - Crop colour
- Crop N status not currently taken into account
- Continuously changes through the season
  - When to monitor?
- Crop N status can be determined before anthesis
  - Take quadrat samples and measure N concentration
  - Laboratory work required
  - Only gives instantaneous result
  - No indication of future status
  - No indication of how much N left in soil

Critical nitrogen dilution curve for winter wheat



Justes, 1994

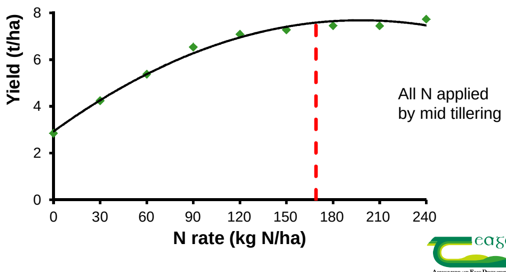
Can we determine crop N status without sampling and lab work?



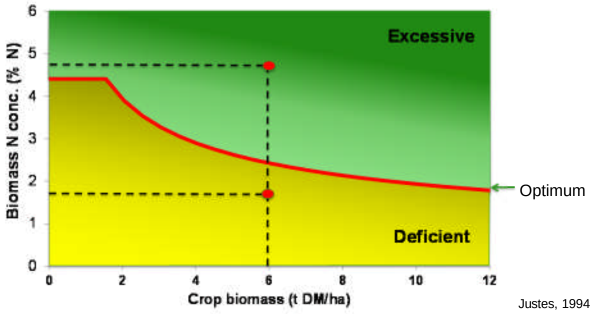
Various sensors could be used to estimate crop N status

THEORY INTO PRACTICE

Spring barley N response trial

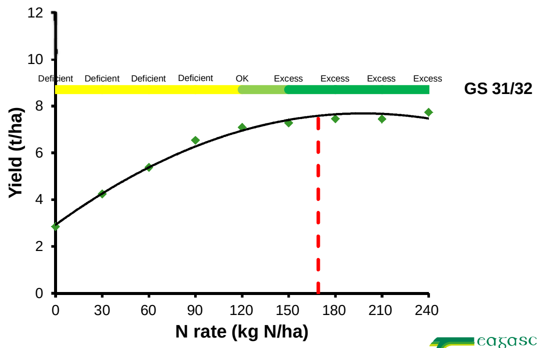


Assessing crop N status

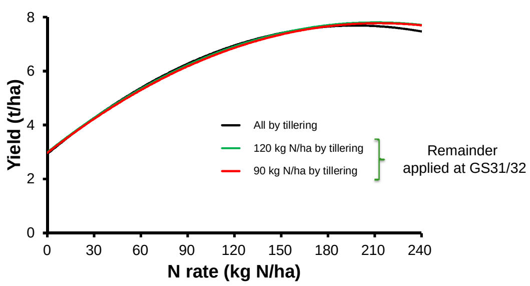


Justes, 1994

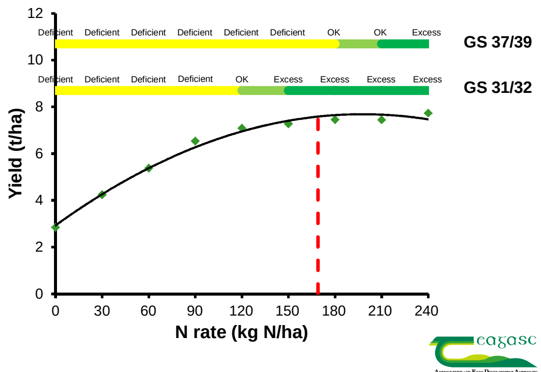
At GS 31/32 crops were becoming deficient at less than 120 kg N/ha



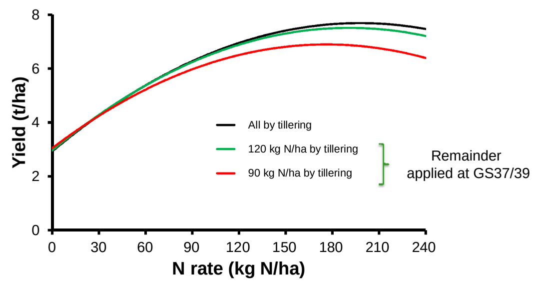
Moderate deficiencies at GS31/32 can be corrected without yield loss



At GS 37/39 crops became deficient below 180 kg N/ha



Large deficiencies at GS 37/39 can incur yield loss



Conclusions

- Crop N status can provide useful information
- Short periods of deficiency early in season not a big problem
  - Avoid large and prolonged deficiencies
  - Potential to delay N application
- How to determine how much to apply?
- If it can work for spring barley…….

Overall conclusions

- Potential to improve on current system
- Site-specific management requires more information/data
  - More work/time
  - Potentially more cost (to acquire data)
  - Potentially more yield and or lower N cost
  - Environmental benefits
- Careful design/calibration required

Maximising yield potential through soil and fertiliser management

David P. Wall
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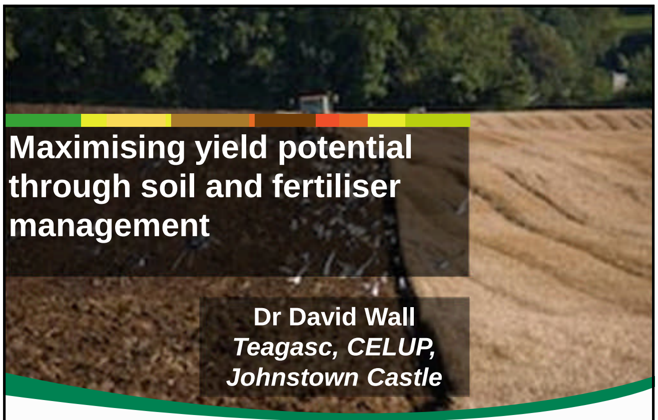
SUMMARY

Crop production and nutrient cycling are two of the key functions that intensively farmed tillage soils must perform. Farmers regularly manage the fertility of the soils on their farms by applying fertilisers and organic manures to build-up or maintain the supply of nutrients required by the different crop types that they produce. However, experienced farmers will know that not all soils (or fields) have the same production potential (or suitability for certain crop types) or respond in terms of their soil fertility status to the nutrients that are applied. This poses a challenge for individual farmers and their advisors when planning nutrient and fertiliser management strategies for their farms. A blanket fertiliser application approach, where all fields receive and "are perceived to respond" to similar nutrient application rates may not be effective for attaining target yields, or be the most efficient in terms of financial return on investment. Overall a very small proportion of soil samples tested achieved good overall soil fertility (approx.12% tillage samples). Soil pH is the first area that needs attention with about 55% of tillage soils requiring lime applications in order to reduce acidity levels. During periods of low fertiliser use, soil fertility may drop more rapidly on tillage farms especially where high crops yields are removed. In times of low farm gate prices there may be a temptation to cut costs by reducing lime P and K fertiliser inputs in particular. However, such a strategy can have negative effects for years into the future. When soil fertility levels slip it usually takes many years to recover, with reductions in crop yields and profits as a consequence.

To this end, soil fertility research is being conducted at Teagasc, to develop more soil and crop specific nutrient advice. The arrival of protected urea provides further options for tillage farmers to meet both agronomic and environmental targets and is currently being investigated in research trials. The benefits of older technologies such as fertiliser placement are also being re-evaluated for their benefits in this new era of regulated fertiliser inputs and for modern cereal varieties. The challenge for tillage farms will be to implement the latest fertiliser technologies into their crop production systems to enhance nutrient use efficienty for increased yield potential, profitability and sustainability of the farming systems. This can only be achieved by linking crop and soil fertility knowledge to different soil types and by training support professional advisors and farmers to manage their soils and cropping systems sustainably.



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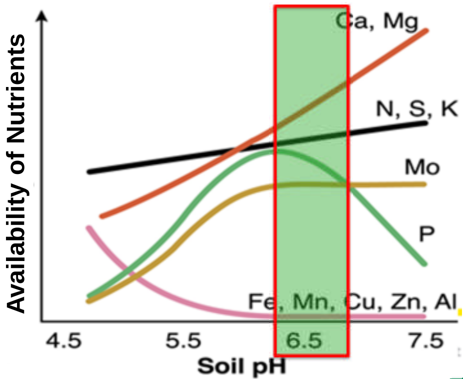
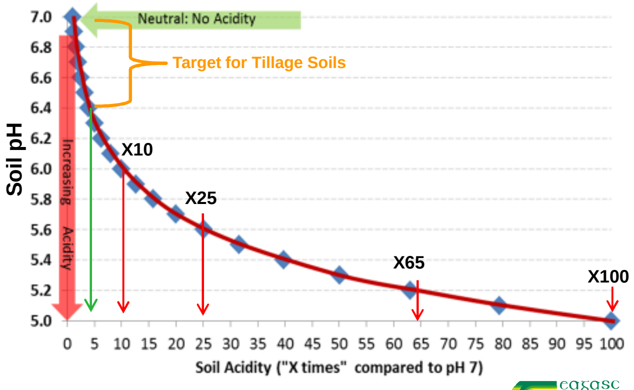
Maintaining soil yield potential

Importance of soil pH

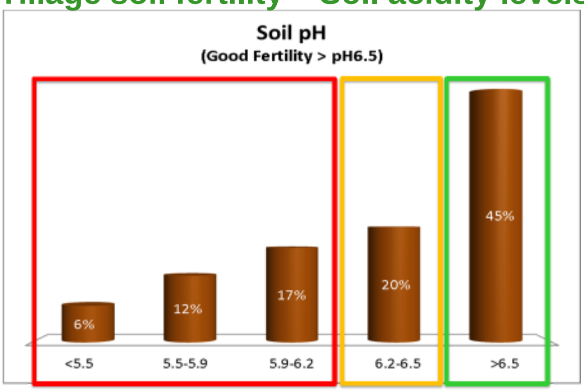
Effect of pH on nutrient availability?

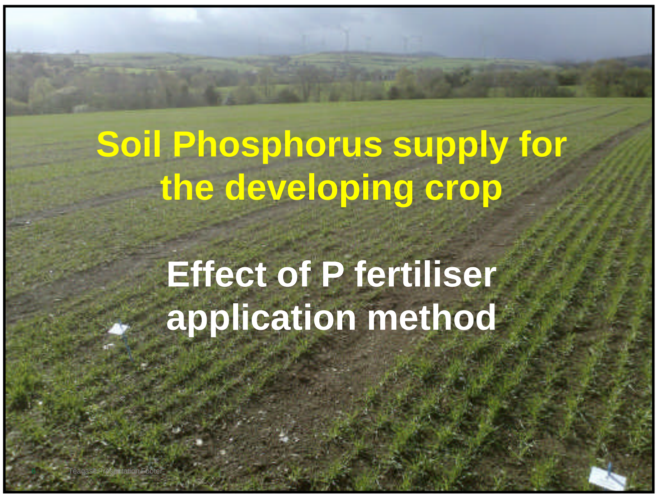


How much Acidity is in my soil?



Tillage soil fertility – Soil acidity levels!





Response to phosphorus in cereal crops

- Requirement to update crop response curves for P fertilisers
- Farmer and Advisory questions
  - *Can soils be managed at lower STP Index without the risk of yield loss?*
  - *What impact is the prohibition of autumn P applications on winter cereal yields having?*
- Experiments conducted in Spring Barley and Winter Wheat
  - Multiple years (2010 – 2014)
  - P fertiliser application rates: 0 – 60 kg /ha P
  - P fertiliser source: Triple Superphosphate (TSP) 16%
  - Different P fertiliser application methods

S. Barley response to P: 11 sites

P Index Soil test	Optimum P (kg/ha)	Yield (t/ha)	Response (%)
1	50	6.2	37
1	40	5.7	25
1	30	7.8	7
1	40	7.7	6
1	20	7.4	8
1	40	6.8	15
1	50	8.3	7
2	30	8.5	12
3	0	7.8	0
4	0	8.8	0
4	(20)	8.9	32

Mean Index 1&2 response: 15%

Late sown – spring 2013

- Higher grain yield response to P fertiliser at low STP levels
- Climate & Site yield potential influenced response to P fertiliser

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W. Wheat response to P: 8 sites

P Index Soil test	Optimum P (kg/ha)	Yield (t/ha)	Response (%)
1	20	8.4	13
1	0	8.5	4
1	0	9.0	0
1	0	10.6	0
1	20	9.1	0
2	0	11.9	6
2	0	10.3	0
2	0	10.8	0

Variable response!

- Variable response to P fertiliser across site-years
- Grain yield potential related to soil P fertility (Soil Test levels)!
- Winter wheat seems to be less dependent on freshly applied P fertiliser

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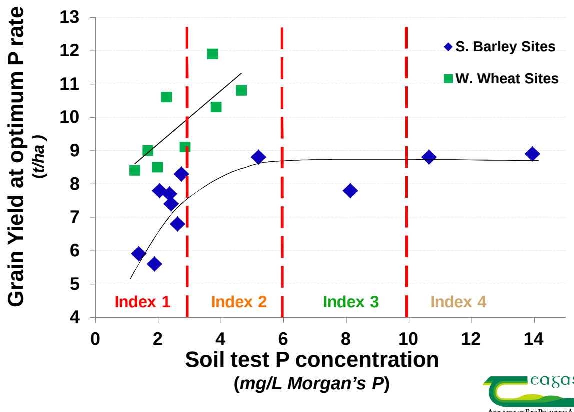
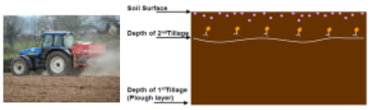
Cereal crop response to P fertiliser

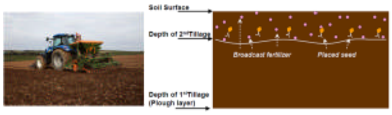


Phosphorus fertiliser application methods

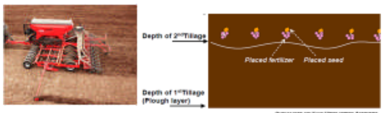
Surface broadcast
- Apply to surface post sowing



Incorporate into seedbed
- Apply to ploughed / cultivated soil
- Incorporate with cultivator during seedbed preparation



Combine drill
- Fertiliser delivered with or adjacent to seed via combine drill

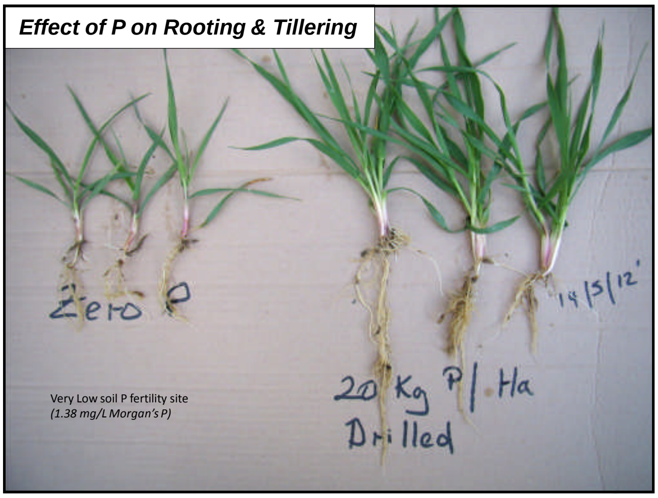


S. Barley response to P application methods

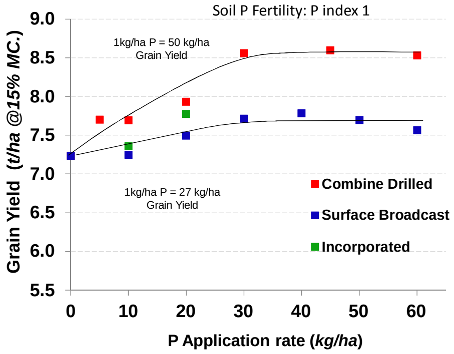
P Index Soil test	Yield S. Broadcast (kg/ha)	Yield Incorporated (kg/ha)	Yield Combine Drill (t/ha)
1	6.2	6.3 ✓	6.6 ✓
1	5.7	5.7	5.7
1	7.8	7.8	7.8
1	7.7	7.8 ✓	8.6 ✓
1	6.8	6.9 ✓	7.2 ✓
1	8.3	8.3	8.3
2	8.5	8.6 ✓	8.9 ✓
Mean	7.29	7.34	7.59

- Higher grain yield response when P fertiliser is applied closer to the seed
- Higher response to P fertiliser placement on more clay rich soil types

Effect of P on Rooting & Tillering

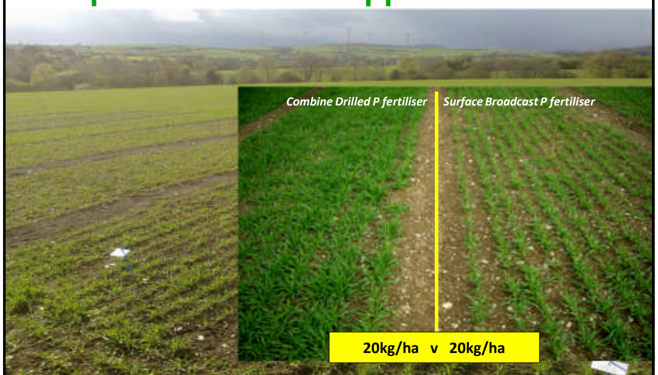


S. Barley response to P application methods

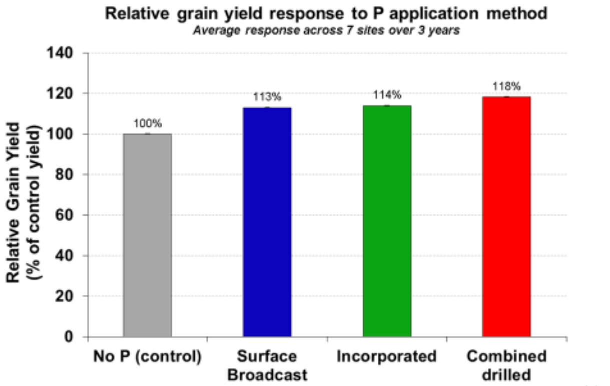


- Margin over P fertiliser cost for a 30 kg/ha *(P fertiliser cost €2/kg and grain price €135/t)*
- *Yield increase 0.5 t/ha for **SB** 1.3 t /ha for **CD** method*
- *Margin over fertiliser **€1/ha for SB** vs. **€96/ha for CD***

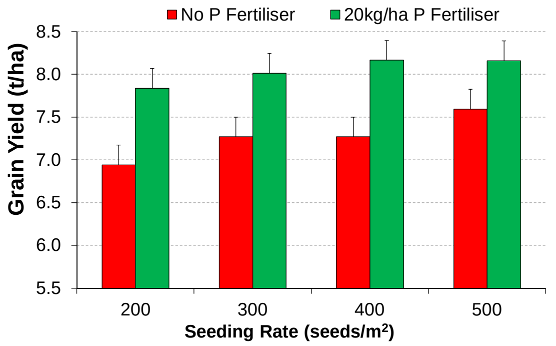
Phosphorus fertiliser application method



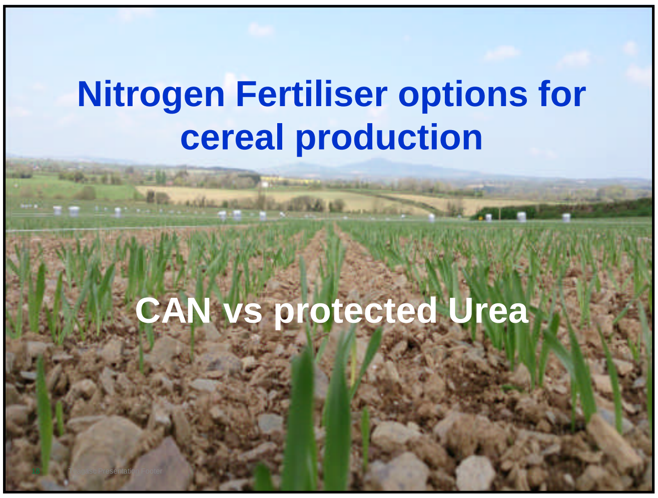
S. Barley response to P application methods



Seeding rate x P fertiliser Interaction



- P availability important for crop establishment and with reduced seeding rates
- *Seed costs €0.65/kg @ 200 seeds/m² = ~€60/ha*
- *20 kg/ha P fertiliser = ~€60/ha*

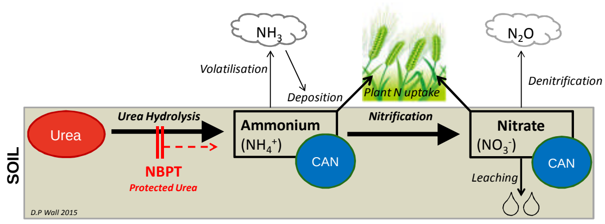


Challenges with nitrogen fertiliser type

- **Greenhouse gas emission (GHG) reduction targets**
  - Agriculture is responsible for 33% of GHGs
  - N fertiliser contributes to GHGs
- **Ammonia emission reduction targets**
  - Agriculture is responsible for 98% of ammonia emissions
  - Urea contributes to ammonia emissions
- **Water Quality targets**
  - Losses of N fertiliser is damaging to water quality
  - Requirements under Water Framework and Nitrates directives
- **Food Wise 2025**
  - Increase the value of primary production by 65%

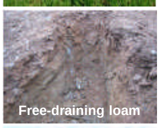
Protected Urea?

- Protected urea fertilisers - available on the market in Ireland
- Urea + N-(n-butyl) thiophosphoric triamide (NBPT) evaluated
- The protected urea product used in these trials contained NBPT at 660 ppm.

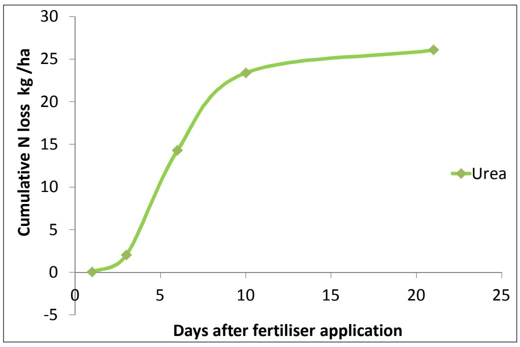


Experimental Design

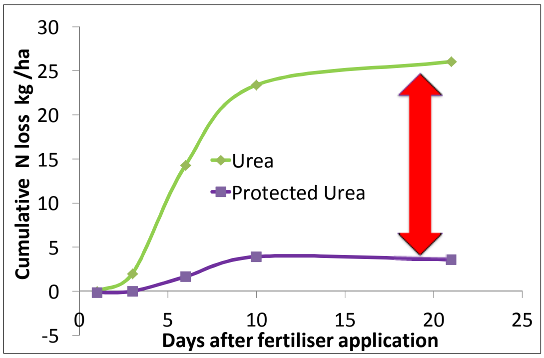
- Field site
  - Marshalstown, Co. Wexford – free draining loam
  - >20 years spring barley production
- N fertiliser treatments used (N rate 150 kg N/ha)
  - Unfertilised control
  - CAN
  - Urea
  - Protected urea (Urea + NBPT)
- Fertiliser N applied in 2 splits
  - 1st split – 30 kg N/ha applied at sowing
  - 2nd split – 120 kg N/ha applied at mid-tillering
- Nitrous oxide emissions measured after N application
- Crop harvested in late August each year



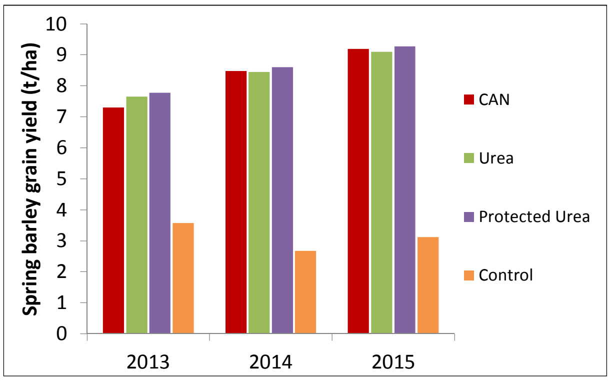
Ammonia emissions



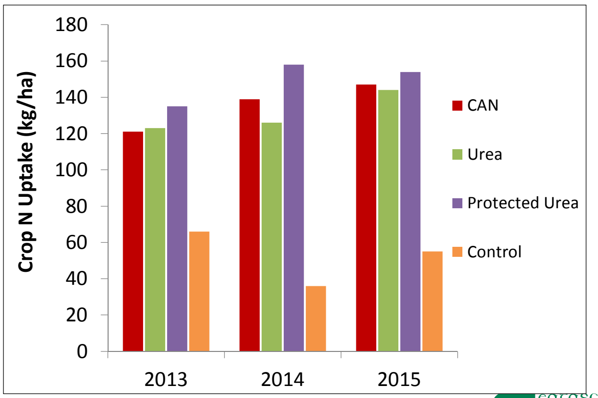
Ammonia emissions



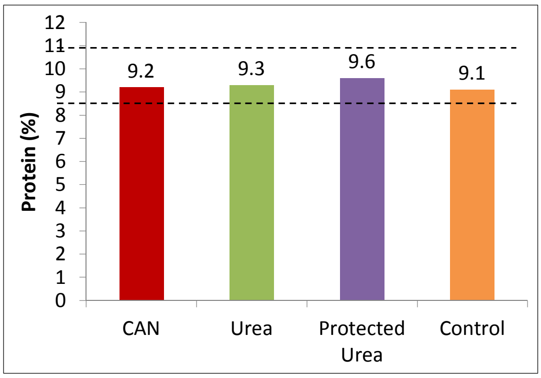
Grain yield over 3 years (2013, 2014, 2015)



N Fertiliser uptake over 3 years (2013, 2014, 2015)



Average protein % over 3 years



Relative star rating of the different N fertilisers

	CAN	UREA	Protected UREA
€ Cost of N	★★★½	★★★★★	★★★★
Yield	★★★★★	★★★★	★★★★★
N Uptake	★★★★½	★★★★	★★★★★
Nitrous Ox loss	★★★	★★★★	★★★★
Ammonia loss	★★★★	★★	★★★½
Leaching loss	★★	★★★★	★★★★½
Spreadability	★★★★★	★★★	★★★

Thank you for your attention

Acknowledgments

- Walsh Fellowship Funding
- DAFM for funding through research stimulus fund
- All field and lab staff at Teagasc Oak Park & Johnstown Castle
- Farmers for access to the field sites





Notes: