Crops
Environment
& Land Use
Programme

National Tillage Conference 2014

Understanding variability to improve precision and profit

Teagasc

Agriculture and Food Development Authority

NATIONAL TILLAGE CONFERENCE 2014

'Understanding variability to improve precision and profit'

Published by

Teagasc

Crops Environment and Land Use Programme

Oak Park Crops Research

Carlow

Thursday, 30th January 2014

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Programme

09.30	Registration /Tea/Coffee
10.30	Conference Opening ***Frank O'Mara, Director of Research, Teagasc***
Session I:	***Chaired by Andy Doyle, Irish Farmers Journal***
10.45	Accounting for variability in N requirement ***Dan Kindred, ADAS***
11.15	Variation in crop growth and yield formation in Spring Barley ***Shane Kennedy, Teagasc***
11.45	Spring barley N response ***Richie Hackett, Teagasc***
12.15	The BETTER Farms - Results ***Michael Hennessy, Teagasc***
12.30	BETTER Farms II – Being more precise ***Dermot Forristal, Teagasc***
12.45	Discussion
13.00	Lunch
Session II:	***Chaired by John Spink, Head of Crops Research, Teagasc***
14.30	Aphicide resistance in grain aphids ***Steve Foster, Rothamsted***
15.00	Aphid control in cereals ***Tom Kennedy, Entomologist***
15.30	Cereal disease control ***Steven Kildea, Teagasc***
16.00	Close of Conference ***Professor Gerry Boyle, Teagasc Director***
16.15	Tea/Coffee

Contents

Accounting for variability in N requirement

Daniel Kindred,
Senior Research Scientist, ADAS Boxworth, CB23 4NN, UK

SUMMARY

Nitrogen requirements are found from N response experiments where yield is measured across a range of N fertiliser rates from zero to a level expected to be super-optimal, usually more than 300 kg N/ha. By fitting a function to the response data we can find the rate at which economic profitability (ie the value of grain minus the cost of fertiliser) is maximized. This is defined as the N optima or the N fertiliser requirement, it is the appropriate rate of N fertiliser for a farmer to have applied to that area of the field in that year to get the highest profits. Whilst this rate is affected by the price of grain and price of fertiliser, this affect is generally small compared to the variability seen between response experiments.

UK fertiliser recommendations are comprised from multiple N response experiments. They attempt to account for the major factors affecting N requirements such as soil type, climate and previous cropping, but they can only ever be right on average and conceal a lot of variation that exists between fields. Accounting for the variation in N requirements seen between fields is challenging because normally many factors are confounding – for example experiments have been undertaken on different fields on different farms with different management and different varieties in different years.

We can seek to understand N requirements in terms of three components: Crop N Demand, Soil N Supply (SNS) and Fertiliser Recovery. Crop N Demand is the total amount of N that a crop needs to take up to meet its requirement for yield and protein. SNS is the amount of N available to the crop from the soil. Fertiliser Recovery is the efficiency with which applied fertiliser N gets into the crop. Fertiliser N requirement = (Crop N Demand – SNS) / Fertiliser recovery.

Any variation in N requirement must be due to variation in at least one of these components. Variation in N requirement exists at different scales. Recent ‘chessboard’ experiments in the ‘Auto-N’ LINK project have shown large variation in N requirements within fields which relates to variation in yield and SNS. The use of precision farming technologies and variable rate applications offer scope to deal with intra-field variation. Whilst variation within and between fields is large, so precision in N management can not be high, what matters is that N rates are correct on average across the farm or management block.

There is evidence that there may be variation between fields independent of fields, ie that some farms consistently need more nitrogen than recommendations would advise, and vice versa. A new HGCA project called LearN is seeking to test this and develop tools and metrics for farmers to know if they are getting N use on their farm about right, too high or too low. The best approach may be for farmers to apply 50kg N/ha more to one tramline and less to another, and note any differences in crop appearance and yield.

Accounting for Variability in N requirements

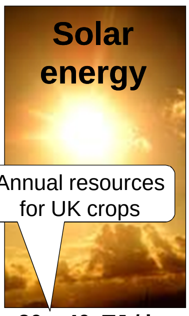
Daniel Kindred
& Roger Sylvester-Bradley
ADAS UK Ltd

30 January 2014

Overview

- **Nitrogen for yield**
- **Variability**
  - **Scales, causes & predictions**
  - **Accuracy vs precision**
- **Variation between Fields & Farms**
- **Spatial experiments as a new tool for research**
  - **And for use on-farm**

Higher yields require more resources



30 – 40 TJ / ha | **300 – 700 mm** | **∞ kg / ha**

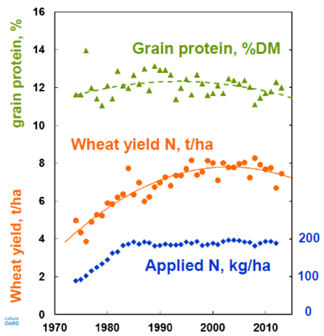
= 800 – 1,100 kWh / m² / year

World Record Yield ... 2010

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

Yield achieved : ***61% of potential***

Could N rates be constraining UK yields?

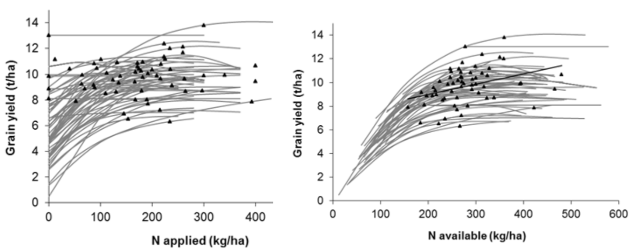


Average E&W N use static for 30 years BSFP

Average UK yields stagnant .. or worse Defra stats

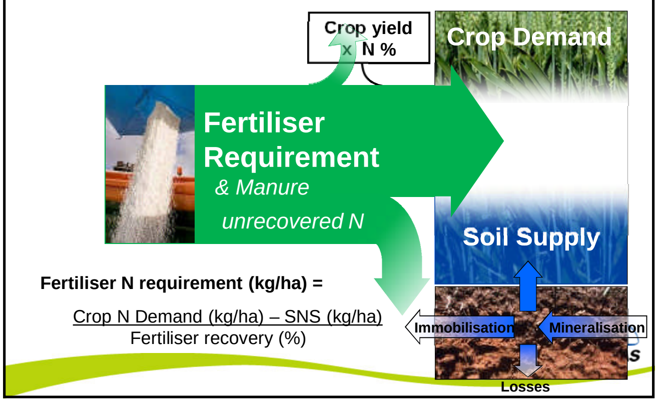
Average UK protein … decrease since 1990s? HGCA CQ Survey … (ignoring 1976)

Variation in N responses across sites

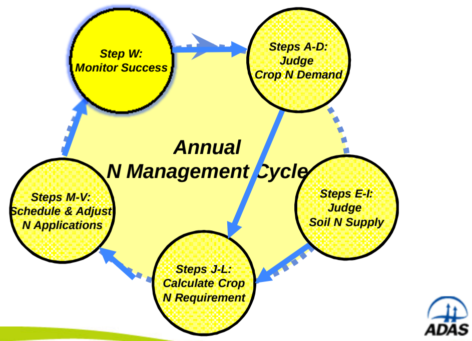


Much of the variation is explicable by soil N supply and yield potential

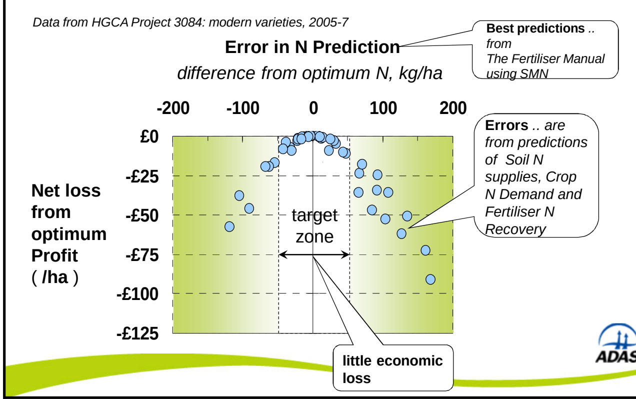
Understanding N requirements



HGCA Guidelines



Uncertainties in N use *... are large*



Scales of Variation in N Requirements

- **Within fields**
  - Contributing to unexplained variation in previous research?
  - Can inform variable rate applications or use of management zones
- **Between fields** (or management blocks) on a farm
  - Includes: rotation, soil, genotype & other management
  - Basis of current recommendation systems
- **Between farms**
  - Long term differences in management, N use & yields achieved
  - Farms need to know where they sit in relation to RB209
- **Between regions**
  - Climate, soils & systems
  - Local empirical advice required?
- **Between seasons**
  - Weather … better forecasting important opportunity to improve N recs?

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LINK project LK09134 *HGCA project RD-2008-3350*

"Reducing GHG emissions, nitrate pollution and 'lost' productivity by fully automating N fertiliser management"

Auto-N project

Jan 2010- Dec 2014

Aims to develop systems for automated calculation of fertiliser N requirements for cereals

- **Between & within fields**

Using *existing* commercial technologies…

…integrated with best N management approaches.

LINK collaborative research, defra, ADAS, TAG, Agrii, ROTHAMSTED RESEARCH, HGCA, soilessentials, SOYL, Ag Leader Technology, YARA, Precision Decisions, Zeltex Inc., farmade, BASF, Hill Court Farm Research, FOSS

ADAS

Auto-N Approach

Start with the best *Principles* for N management

Use available technologies to provide relevant information

Develop the logic for interpretation

Chessboard trials to ask

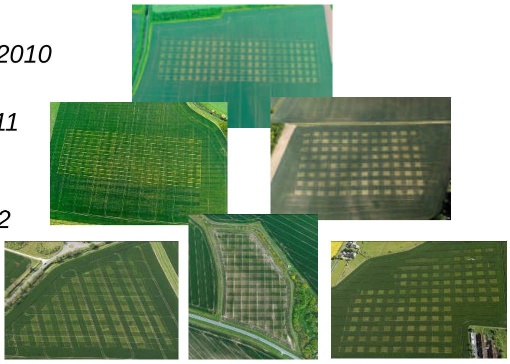
- **How much variation in**
  - **N requirements**
  - **Crop N Demand, SNS & Recovery**
- **Can these be predicted?**

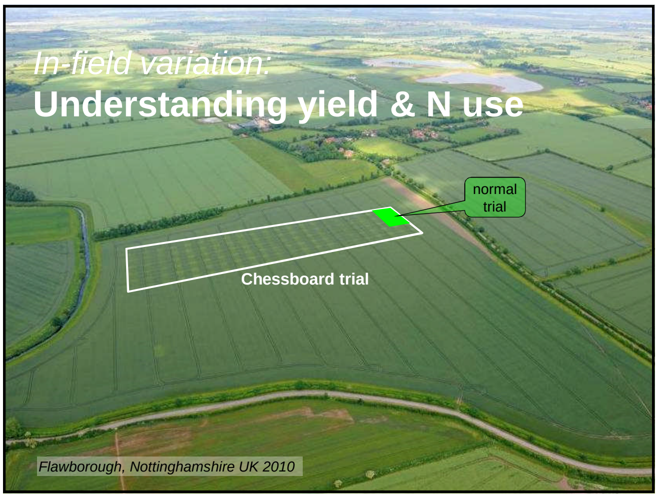
Chessboard trials

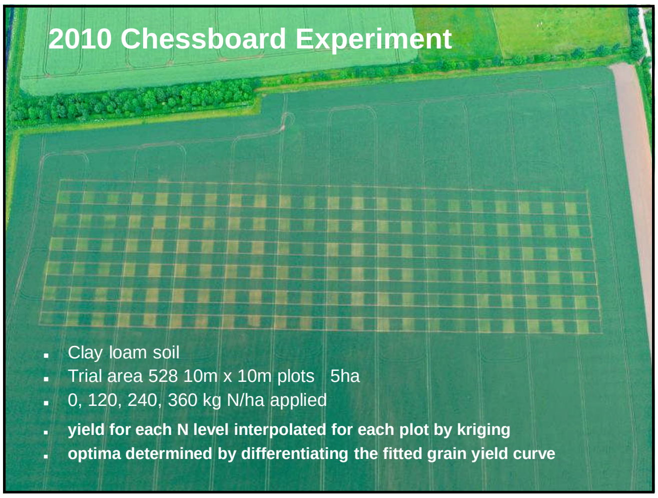
2010

2011

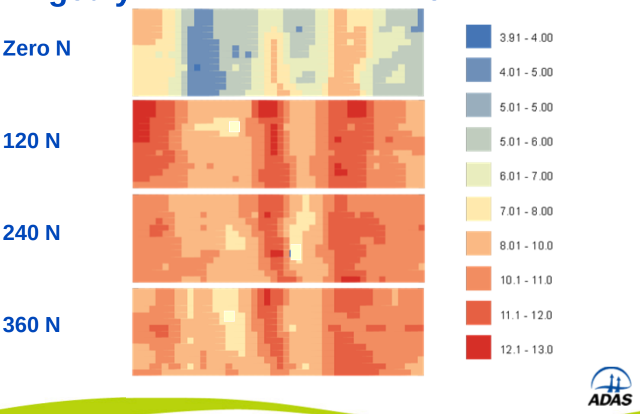
2012



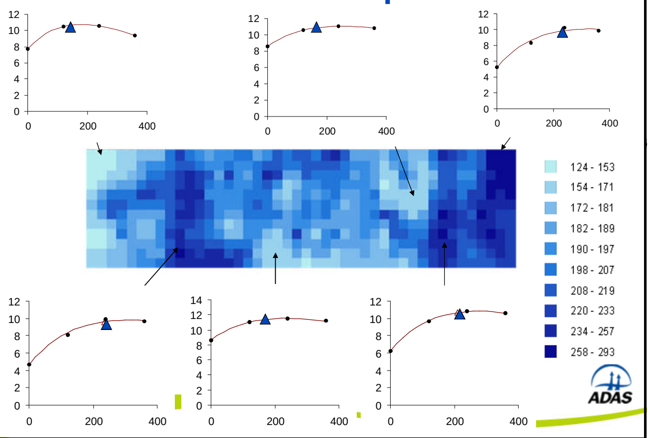




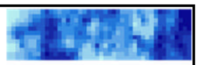
Kriged yields for each N rate

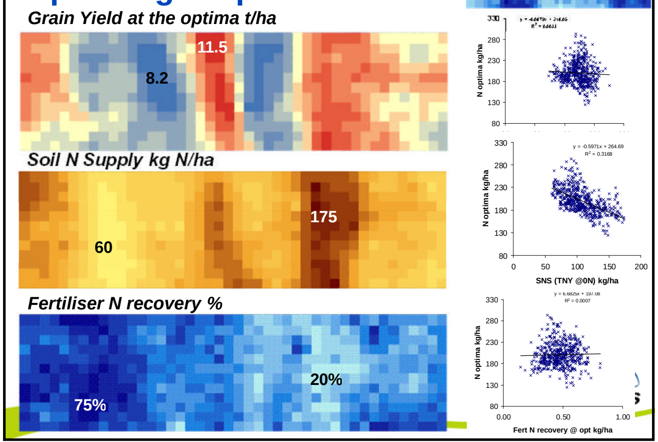


Fitted N optima for each plot

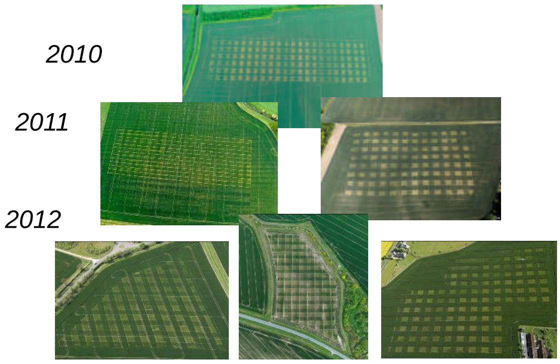


Explaining N optima





Chessboard trials



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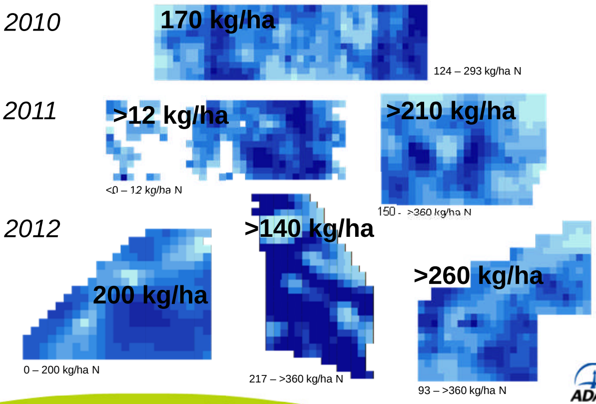
Variation in N requirements i.e. N optima



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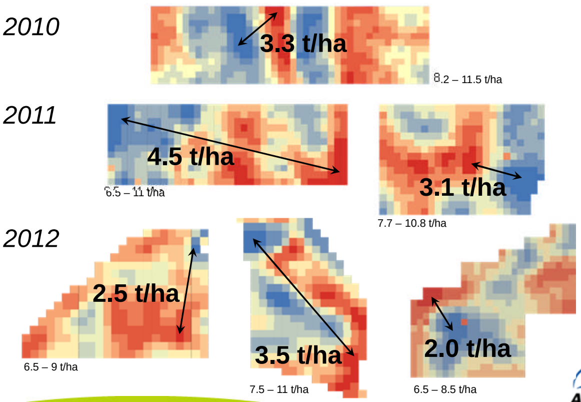
Auto-N LINK project LK09134

Variation in 'optimal' yield



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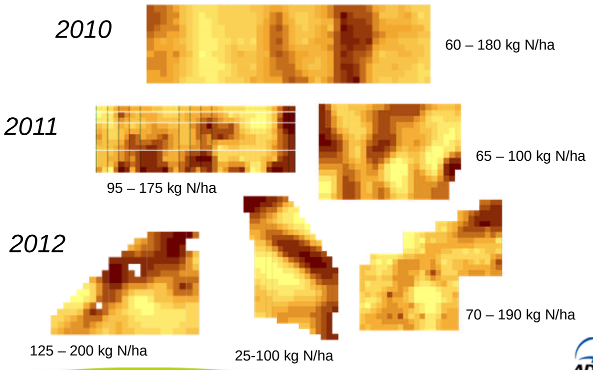
Auto-N LINK project LK09134

Variation in SNS

Total N yield at zero-N



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Lessons from Chessboard trials

- **High intra-field variation**
  - Due to both yield and soil N … but predictions are poor because
    - … High unexplained variation in fertiliser recovery
    - … Yield is correlated with SNS
- **Yield maps** … do help to predict **Crop N Demand**
- **Canopy Sensing** … does help to predict **SNS**
- **Fertiliser Recovery** … not yet predictable
- **Most important is to get *accurate average***
- **Potential benefits from Precision Farming technologies ...**
  - Providing new ways of measuring **Soil Type effects** & **interactions**
  - Enabling **On-farm Testing.**

LearN … *adaptive N management*

- **New HGCA 'LearN' project … 2014 – 2017**
  … using Precision Farming approach … with farmer involvement
- **Assessing variation in N requirements between farms**
- **Some farms may need consistently more or less than RB209**
  - **Need metrics to check, but few metrics available**
    - **Lodging, yellowing & poor yields … only helpful if very wrong**
    - **Soil tests … onerous, expensive & imprecise ?**
    - **Grain Protein … best routine measure .. but crude**
- **Best metric is .. N response itself**
  - Tested on-farm … by applying +/- 50 kg/ha N on alternate tramlines
    - … if no differences in yield .. *super-optimal*
    - … if >0.3 t/ha difference .. *sub-optimal*

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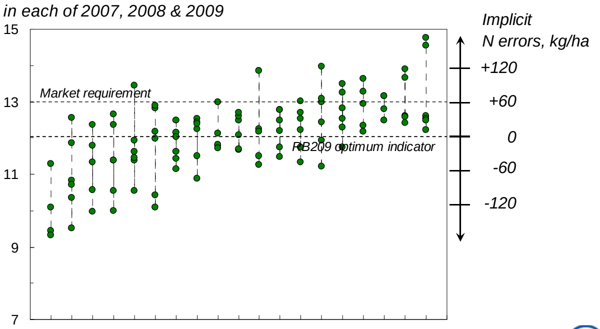
Variation between farms

.. example of 19 milling wheat growers

Grain protein %: ~2 fields of milling wheat per farm
in each of 2007, 2008 & 2009



Farms: *in order of average grain protein*

MALNA LINK Project

LearN … Aims & Objectives

- **To enable individual farms to determine whether, on-average, their N use on wheat is about right …
… or too much … or too little.**
- **To evaluate the proportion of UK farms that are getting N fertiliser rates right …
… or too high … or too low.**

- Test the extent & consistency of variation in N optima
- Test predictors of variation in Nopt
- Test the value of on-farm tramline trials

Conclusions

- **Variation in N requirements is large**
  - Within fields & between fields
  - Causes are in the soil … but not well understood
- **Most important is to get *accurate average* N rate** … at each scale
  - Requires ability to test & measure
- **On-farm line trials provide opportunity to learn**
  - For farmers, agronomists & researchers
  - Unique opportunity to study soil interactions
  - Needs new stats & data processing … Agronômics
- **Get involved in YEN & LearN**
  - **email** daniel.kindred@adas.co.uk

Overall lessons for N management

- Accept that **Errors are common** … & **Larger** than you'd like!
- Predicting **Gross Variation** is most important .. esp over large areas
- Predicting **Secondary Variation** has less value

1. Characterise 'typical' fields on the farm
   - Accumulate evidence from multiple sources to judge 'N sufficiency'
   - Consider testing N responses
2. Identify situations where N use may be very different
   - Accumulate evidence from multiple sources
   - Be bold in making N adjustments .. so you LearN.

Variation in crop growth and yield formation in Spring Barley

Shane Kennedy and John Spink
Teagasc, CELUP, Oak Park

SUMMARY

Ireland, as a result of its temperate maritime climate, achieves the second highest yields per hectare of barley in the world; but yields are variable. This research attempts to better understand this seasonal variability and identify whether further yield increases are possible.

Monitor crops of spring barley were established at sites in Carlow, Wexford and Cork for the 2011, 2012 and 2013 growing seasons. Crops were managed as per standard farm practice and growth and development were assessed in detail on a weekly basis throughout the season.

High yields were achieved in 2011 across all three sites (mean of 9.9t/ha) as a consequence of high grain numbers m^{-2} and to a lesser extent high grain weights. A warmer than average early season promoted good leaf and shoot initiation. A cooler than average late season resulted in an extended grain filling period. These factors coupled with slightly above average solar radiation ensured that the high grain numbers per m^2 established early in the season were adequately filled.

Grain weight in 2012 was lower than both 2011 and 2013 and this is attributed to low solar radiation levels in that year along with high levels of ear blight. Stem storage reserves, which can be utilised for grain growth alongside the dry matter produced directly from photosynthesis, were also found to be lower in 2012. Low overall grain numbers per m^2 in 2013 were a consequence of poor establishment at one site due to an unusually cool and damp spell in late March.

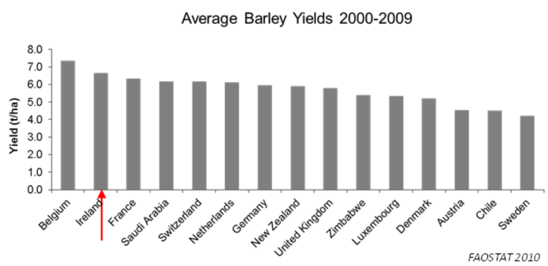
Evidence from this and other work suggests that barley has the potential to create more dry matter than it has grains to store it. This suggests that yield can be increased by managing or breeding for crops of increased grain number per m^2.

Increasing shoot number per m^2 has been identified as the most powerful tool for achieving high grain numbers. Plot trials at Carlow and Kilkenny in 2013 employed varying seed rates to achieve both very high and very low shoot numbers. At very high shoot numbers grain number per ear was reduced. An optimum of approx. 1000 shoots per m^2 at harvest was identified, above which no further grain number increase was achieved. Future yield increases may lie in achieving high numbers of grains per ear *in conjunction* with high shoot numbers per m^2, provided lodging does not become an issue.

Variation in crop growth and yield formation in spring barley

Shane Kennedy & John Spink
Teagasc CELUP
Oak Park Crops Research

Yields of barley in Ireland are high….



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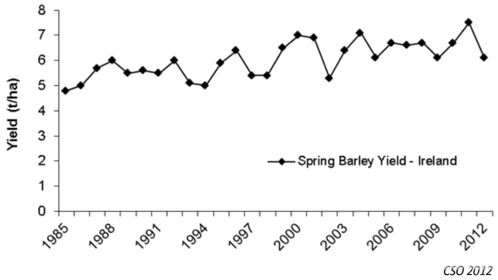
…..but variable



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Research questions

1. **Why are yields so variable?**
2. Can we increase yields further and if so, how?

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Spring barley monitoring

- 3 sites (Carlow, Wexford, Cork)
- 3 seasons (2011-2013)
- Variety: Quench
- Sowing date: mid-March to early-April
- 350 seeds/m^2

- N ≈ 135-150 kg/ha split @ tramlines visible and during tillering
- Fungicides: pre-stem extension and ear emergence
- Weed control, aphicide, P & K as required

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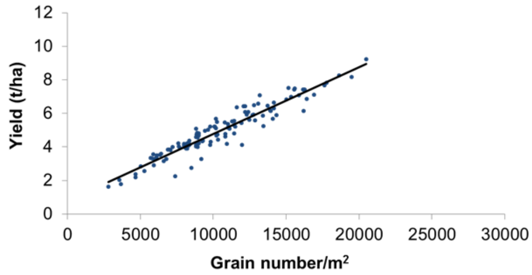
Yield = grain number x grain weight

Grain number determines yield in barley

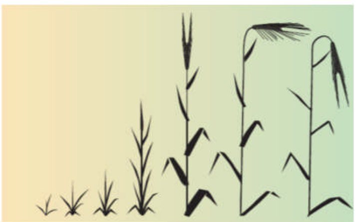


6 site/seasons 2000-02, 4 varieties, 5 seedrates, UK, (HGCA, 2003)

Yield data (average of all 3 sites)

	2011	2012	2013
Grain Yield (t/ha)	9.9	7.9	7.5
Grain Number/m2	20,423	18,559	15,310
Grain weight (mg)	48.8	42.4	49.0

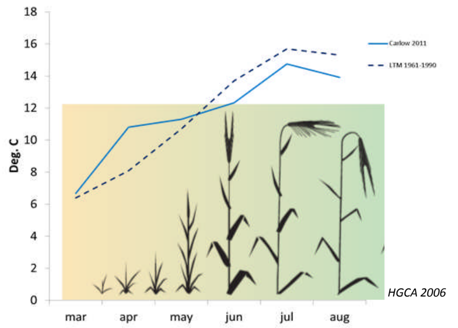
Temperature drives development



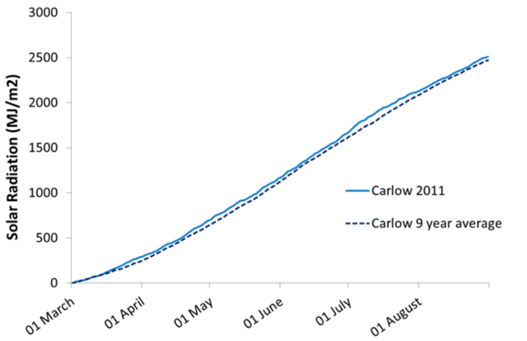
HGCA 2006

Solar radiation drives growth

Temperature Carlow 2011



Solar radiation Carlow 2011



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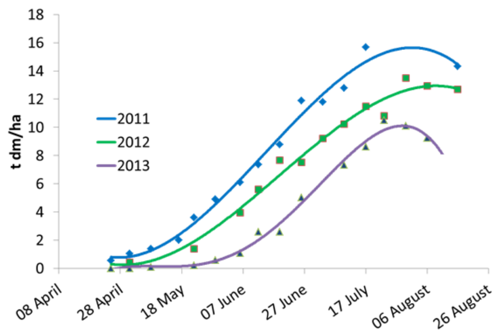
Total biomass Carlow



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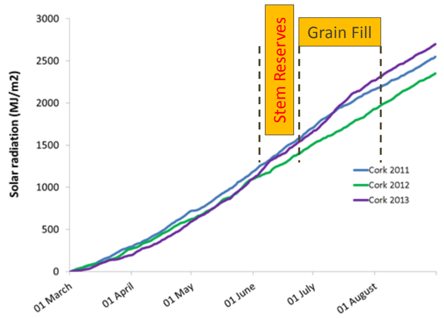
Low solar radiation in 2012



Low stem reserves (sugars) 2012

t/ha of sugar pre grain-filling

	2012	2013
Average of all three sites	0.42 (t/ha)	1.13 (t/ha)

Effects of fusarium/ear blight 2012

- Across all sites…
  - 92% of ears
  - 2.7 grains/ear

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Ear growth rates Cork

	2011	2012	2013
t/ha/day	0.20	0.17	0.29

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Yield data (average of all 3 sites)

	2011	2012	2013
Grain Yield (t/ha)	9.9	7.9	7.5
Grain Number/m2	20,423	18,559	15,310
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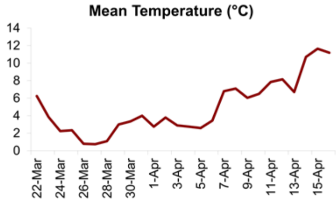
Establishment 2013

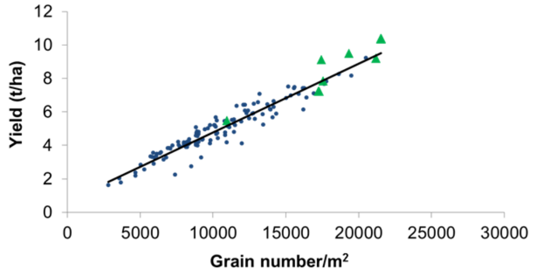
	Sowing Date	Plants/m²	Shoot number/m²	Yield (t/ha)
Carlow 2013	20th March	200	664	5.49
Wexford 2013	3rd April	284	973	9.13
Cork 2013	4th April	247	870	7.85



Research questions

- Why are yields so variable?
- **Can we increase yields further and if so, how?**

Grain number determines yield in barley



6 site/seasons 2000-02, 4 varieties, 5 seedrates, UK, (HGCA, 2003) + current Irish data

Is pushing grain number a sound strategy?

♦ Will the extra grains abort?

Shading after ear emergence

Effect of shading (2011 and 2012)

♦ No abortion of grains – growth buffered by stem reserves

♦ Will higher grain numbers = smaller grains?
  - ► In barley, grain number generally doesn't have a big influence on grain weight.
  - ► Usually there is an excess of resource for grain filling

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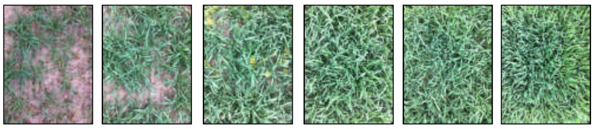
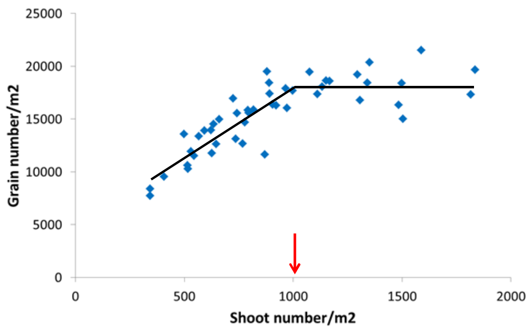
- Crops can sustain high grain numbers
- How can a grower actually increase grain number?
  - Shoot number……..

Carlow & Kilkenny 2013

40 seeds/m^2 80 seeds/m^2 160 seeds/m^2 320 seeds/m^2 640 seeds/m^2 1280 seeds/m^2



What is the optimum shoot number?



1100 shoots/m^2

What is the optimum seed rate?

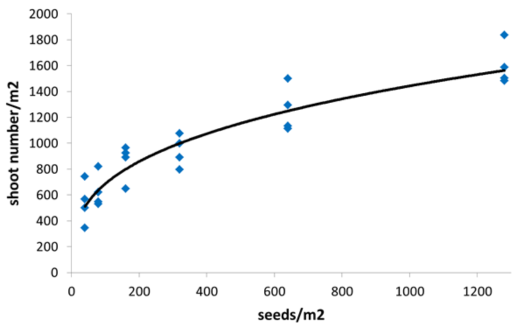
- Across 3 sites and 3 seasons…..

Seeds/m^2	% establishment	Plant number/m^2	Shoot number/m^2
347	78	270	991

$$kg/ha = \frac{Seeds/m^2 \times TGW}{100}$$

(divide kg/ha by 15.7 to convert to st/ac)

Kilkenny 2013



Kilkenny 2013

Seeds/m²	Shoot number/m²
300	978
310	988
320	998
330	1008
340	1018
350	**1028**
360	1037
370	1046
380	1055
390	1064
400	1073

Path to increasing yield in spring barley

- Grain number determines yield
- Crops can fill very high grain numbers
- Shoot number has the most influence on grain number
- Early season development crucial for shoot number
- Optimum shoot number ≈ 1000/m^2
- 350 seeds/m^2 gives1000 shoots/m^2
- Future: high grains/ear *in conjunction* with high shoots/m^2 – agronomy or breeding

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Acknowledgements

- Supervision from Ian Bingham (SRUC)
- Growers: George & Ken Williamson,
  John Hogan & Damien Fewer (Teagasc),
  Seamus Kearney & Elizabeth Hyland (DAFM)
- Technical, student, admin. and other support.

Teagasc
The Irish Agriculture and Food Development Authority

Thank you

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Spring barley N response

Richie Hackett
Teagasc, CELUP, Oak Park

SUMMARY

Recent years have seen wide fluctuations in grain proteins in malting barley and concern amongst grower of feed barley that N allowances are not sufficient to optimise yield. A series of trials were carried out over the last three seasons on a range of sites to examine the effect of rate, timing and splitting of fertiliser N on yield and protein content of spring barley. The trials were mostly carried out on long term tillage soils where a low supply of N from the soil would be expected.

Results showed that there is wide variation in the optimum amount of fertiliser N required for yield between sites and seasons. While differences in the economic optimum between sites can to some extent be explained by differences in soil N supply and yield potential of a site, much of the variation is difficult to explain. This suggests that predicting the optimum N to apply to spring barley at the normal N application timing (i.e. mid tillering to early stem extension) is difficult as it would be difficult to predict yield potential with accuracy and methods used abroad to predict soil N supply at early stages of crop growth are currently unproven under Irish conditions.

The results indicate that in relation to the effect of fertiliser N on protein content, total amount applied, rather than when it is applied, is the most important factor influencing protein content. However, examination of all of the trials indicated that there is considerable variation between sites and seasons in the protein content achieved for any given fertiliser N rate. This makes determination of the fertiliser N input required to achieve the protein content necessary for malting for every site in every year very difficult. The results indicate the fertiliser N rates of 150-160 kg N/ha gives the highest probability of meeting malting specifications on sites where soil N supply is modest, no other sources of N (e.g. organic manures are applied) are used and where yield is not limited by factors other than insufficient N (e.g drought, disease). For sites where other sources of N are applied or sites where soil N supply is likely to be high (e.g. sites close to grass in the rotation) lower rates of N would be required to ensure that protein content falls within the malting specification.

There appeared to be little consistent effect of applying the first nitrogen in the seedbed compared to applying it at emergence of the crop on either yield or protein. There was little effect on yield of splitting the main split of nitrogen (i.e. keeping back some of the main split to apply as a third split). However there was a small effect on protein; delaying a portion of the main split tended to lead to increased protein contents.

Examining the reasons for variation in protein content over the past three seasons would indicate that the low protein levels experienced in 2011 were due to reduced soil N supply combined with relatively low fertiliser N recovery. In 2012 the higher proteins were due to higher soil N supply compared to 2011. In 2013 soil N supply was similar to 2012 but fertiliser N recovery was higher and in some areas yields appeared to have been limited by drought which further increased proteins.

Spring barley N response

Richie Hackett
Teagasc CELUP
Oak Park Crops Research

Outline

- Yield response to fertiliser N
- Protein response to fertiliser N
  - Reasons for differences between seasons
- Effect of variety on response to N
- Effect of N timing on yield and protein

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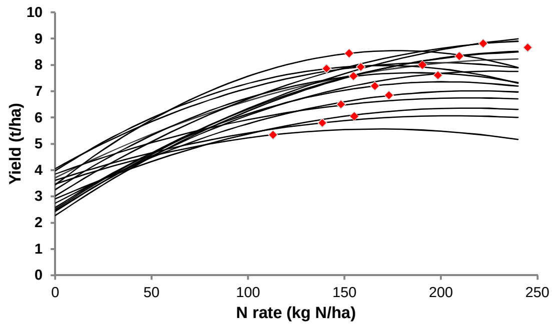
Effect of N rate on grain yield and Nopt over sites and seasons



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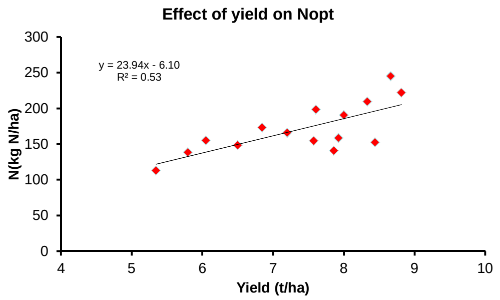
N opt increased as yield increased at rate of ~24 kg N/ha per 1 t/ha yield



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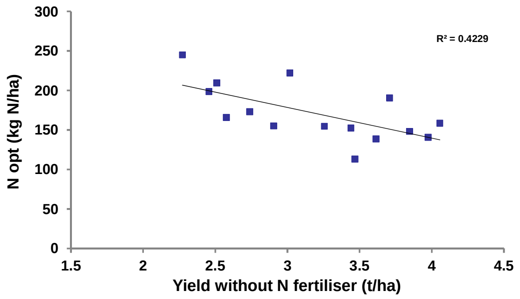
Nopt decreased where yield without fertiliser N (proxy for soil N supply) increased



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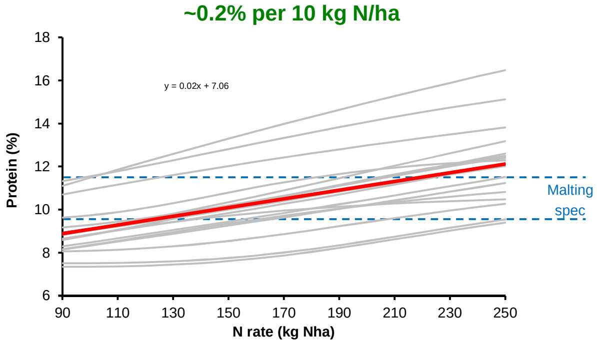
Increase in N application increased protein by ~0.2% per 10 kg N/ha



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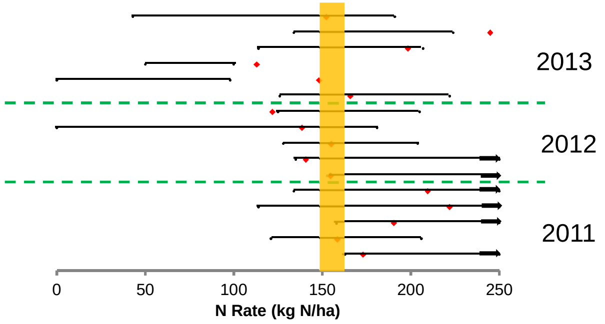
Large variability in amount of N required to give protein between 9.5% and 11.5%



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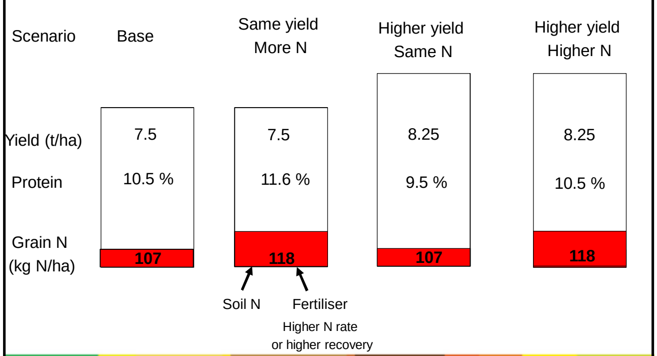
Interaction between N content of grain and grain yield



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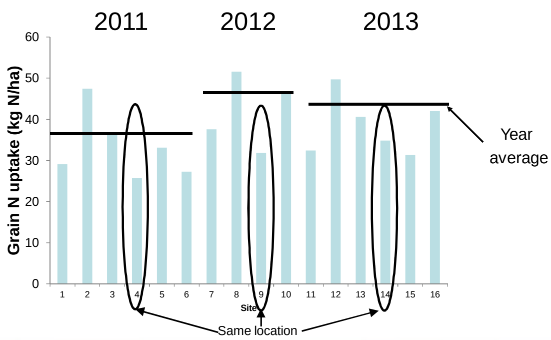
Considerable variation between sites in soil N supply to grain, Year differences also apparent



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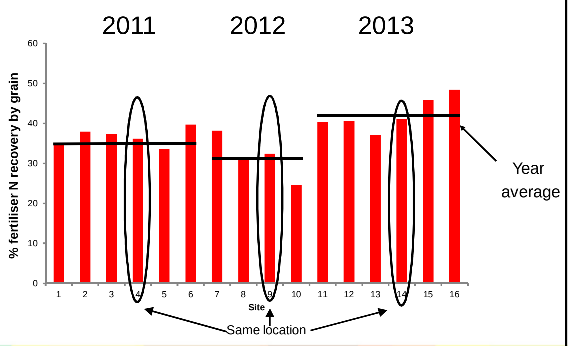
Fertiliser N recovery varies with site and season



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Different factors affect proteins in different years; soil N supply and % fertiliser N recovery are important

Average results from all trials within a year

Year	Soil N supply to grain (kg N/ha)	% fertiliser N recovery in grain	Protein at 150 kg N/ha (%)	Yield at 150 kg N/ha (t/ha)
2011	33	37	8.8	7.0
2012	42	32	10.0	6.8
2013	38	42	11.1	6.8

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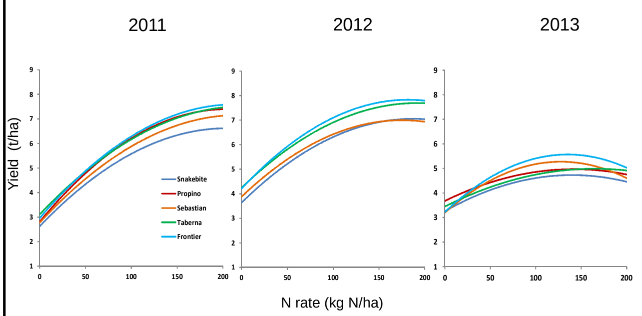
No consistent effect of variety on the response to fertiliser N



Light sandy soil

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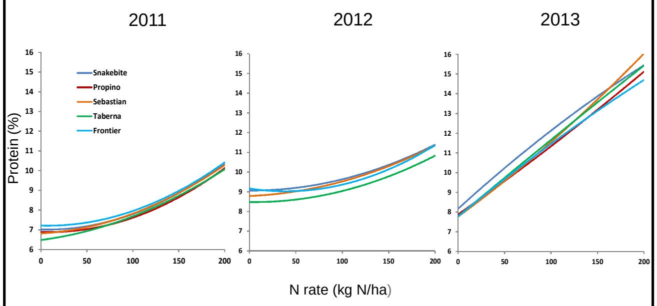
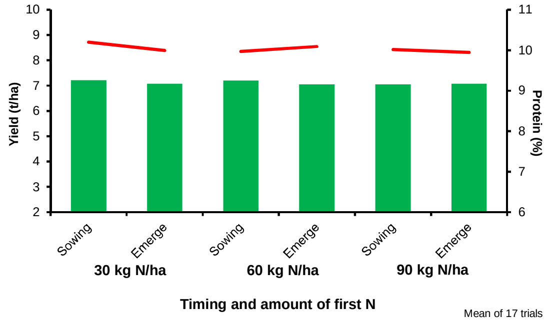
Effect of increasing N rate on protein similar across varieties
Small differences between varieties at any given N rate



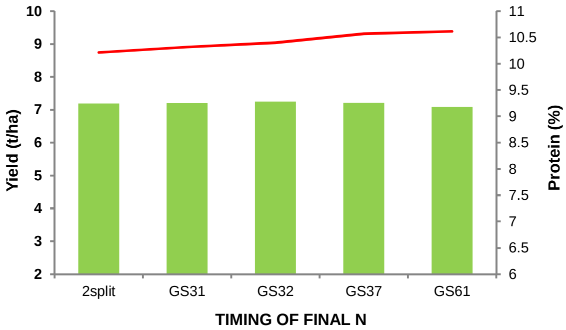
Light sandy soil

Little difference between applying first N in seedbed versus at emergence



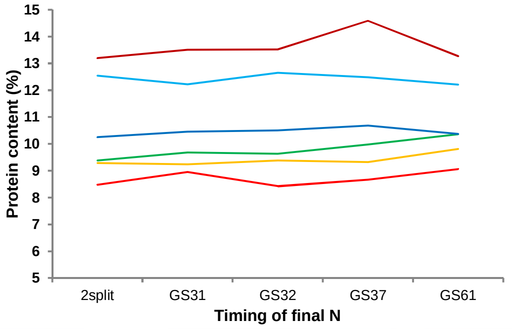
Mean of 17 trials
No significant effect of timing or amount

Little effect of delayed split on yield; small positive effect on protein



Note: Applications at GS61 can lead to immature (green) tillers at harvest

BUT effect of delayed N on protein was variable across sites and seasons



Conclusions

- Large variation in optimum N for yield
- Effect of N on protein variable between sites and seasons
  - Due to differences in yield, soil N supply and % recovery of N
  - Predicting protein early in season unlikely
  - Difficult to achieve malting protein specification consistently
- Timing of N not as important as rate for yield
- Late N (at flag leaf) can increase protein but effects are usually modest
- Little difference between varieties in terms of protein and yield response to N
- Suggested programme for spring barley
  - 15-30 % of total at sowing
  - 60-70 % of total early/mid tillering
  - Remainder at GS 30/31

The BETTER Farms - Results
Small adjustments to reshape your business

Michael Hennessy
Teagasc, CELUP, Oak Park

SUMMARY

The BETTER farm crop program used the concept of many small adjustments to improve the profitability and sustainability of the tillage systems on three farms from 2010-2012.

All farms entered the program as good tillage farmers and returning profits* well above the average. The BETTER farms returned an average common profit* of €821/ha in 2010 which was 67% higher than equivalent farms (>= 100ha) in the average National Farm Survey (NFS). In 2012 the BETTER farm average common profit per hectare was down to €668/ha due to it being a low yielding year, but this was nearly 2.5 times the NFS average.

The farming families involved in the BETTER Farm program are the Crowleys in Cork, O'Donoghues in Meath and Williamsons in Wexford. Two of the farms rent over 80% of their land and two farms have a continuous cereal cropping system. All are farming in excess of 140 hectares.

Increased profits were supported by increased output combined with a tight rein on costs. Farm advice revolved around small adjustments to the existing system on each farm which included; realigning the cropping program, matching crops to soil type, machinery costs and matching to crops sown, agronomy changes, planning purchasing, soil nutrition, succession planning, etc.

The program particularly focused on the management of soil nutrients as national statistics show that 86% of all tillage soils are low in one or more of the major soil nutrients. Intensive soil sampling and subsequent nutrient balance calculations resulted in changes of practice on all farms. These included increased inputs of phosphate (P) and potash (K), change of N,P,K compounds, addition of organic manures and a realisation that regular soil analysis and tracking of nutrient balance is necessary.

During the program over 2000 people attended farm events. 11 major research trials were on view during these farm events giving farmers in the region a chance to see and comment on major agronomic trials.

Teagasc greatly appreciates the openness; cooperation and enthusiasm of all the BETTER farms through the program and Teagasc extend our appreciation to each BETTER farm family.

**Common profits = Grain plus straw minus Common Costs. Common Costs = all costs except hired labour, interest and land rental. Common profit is therefore used to pay for land rental, hired labour, interest and a return from the years endeavour.*

The BETTER Farms – Results
Small adjustments to reshape your business

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The Irish Agriculture and Food Development Authority

Improving profits through whole farm analysis,

Demonstrating best practice, and

showcasing national trials locally

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BETTER Farmer comments

Crowleys

“*the program has helped us evaluate our financial costs and trials on our farm has given us fresh agronomy insights*”

O’Donoghues

“*we are now making better use of our information from a whole farm, enterprise and field basis. This information is shaping day to day decisions on our farm*”

Williamsons

“the input from Teagasc has shown us an alternative way to structure our farm business to make it more workable and profitable”

The Irish Agriculture and Food Development Authority

Outline

- Outline of the BETTER program
  - BETTER farms
- Review of program 2010-2012
  - Financial Costs and Returns
  - Other outputs from the program

BETTER Farm Program

- **B**usiness, **E**nvironment and **T**echnology through **T**raining **E**xtension and **R**esearch
  - Demonstrate best practice & introduce new ideas
    - Improve growers profitability
      - Business skills
      - Technology developments
    - For Growers (Region)
      - View current research trials
      - Demonstrate proven research
      - Give feedback to Tillage Research

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BETTER Farmers

- Crowley Family, **Cork**
  - Tillage area 392 ha (5% rented)
  - Continuous cereals
    - W.B., W.W., S.B.

- O'Donoghue Family, **Meath**
  - Tillage area 323ha (80% rented)
  - Continuous cereals
    - W.W., S.B., W.B.

- Williamson Family, **Wexford**
  - Tillage area 140ha (80% rented)
  - Continuous cereals (mixed)
    - W.W., S.B., W.O.,S.O., S.W.

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Supporting Farmers Regionally

- During the program
  - 11 large research projects (33 trial sites & over 2,500 plots)
    - DAFM variety trials
    - N trials on Winter wheat
    - Disease control in W. Wheat/Barley and S. Barley
    - Weed Control in W. Wheat and S. Barley
    - P & K nutrition and trace elements
  - Over 2,000 people attended open days
    - Major open days and local events
    - Discussion group visits
    - International visitors
    - National Conferences papers

Financial Results

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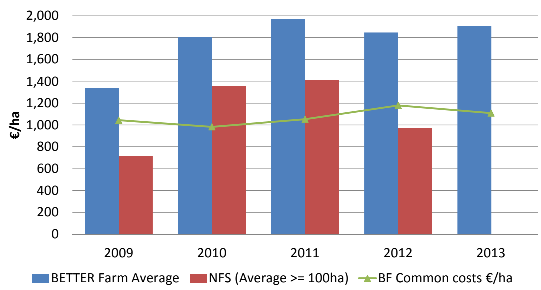
Tillage enterprise Output: Grain and Straw



(Common costs =all costs except: labour, interest and land rental)

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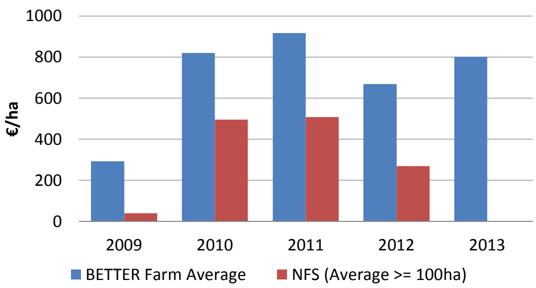
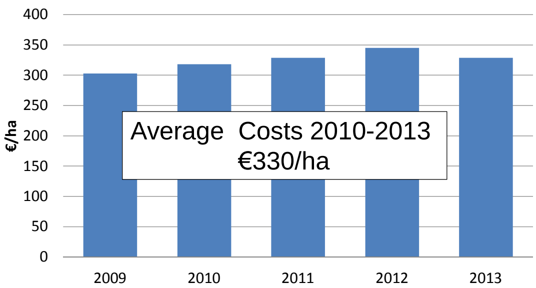
Tillage enterprise: Common Profit



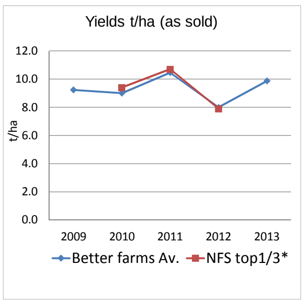
Common Profit: Grain & Straw minus Common Costs

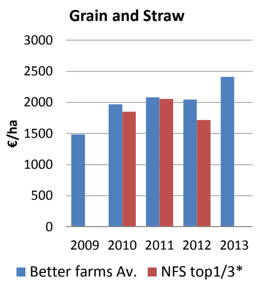
BETTER Farm Machinery Costs



Includes: Grain dryers, Lorry

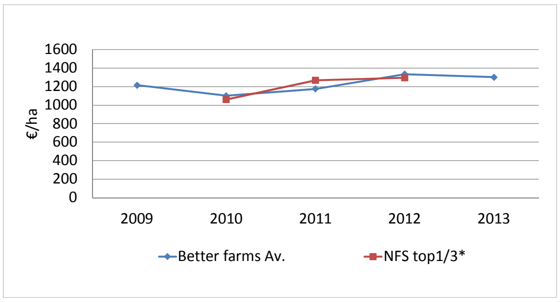
Winter Wheat





**NFS based on family farm income (top1/3)*
Note: Most of grain from BETTER farms is sold @15% MC

Winter Wheat 2009-2013
Common Costs/ha



** NFS based on family farm income (top1/3)*

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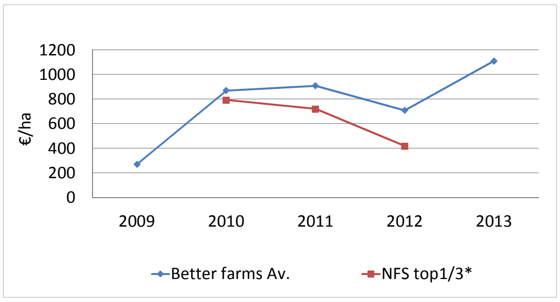
Winter Wheat 2009-2013
Common Profit/ha



** NFS based on family farm income (top1/3)*

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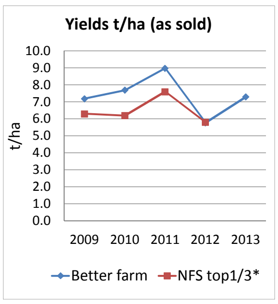
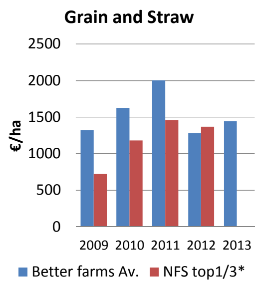
Spring Barley 2009-2013





**NFS based on family farm income (top1/3)*
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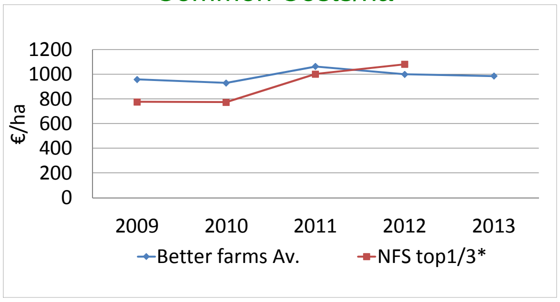
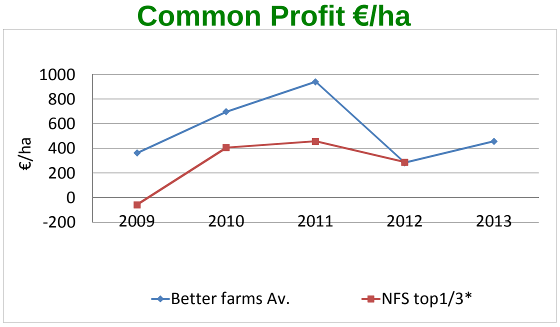
Spring Barley 2009-2013 Common Costs/ha



* NFS based on family farm income (top1/3)

Spring Barley 2009-2013 Common Profit €/ha



* NFS based on family farm income (top1/3)

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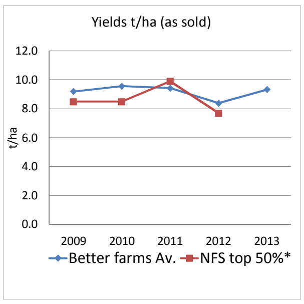
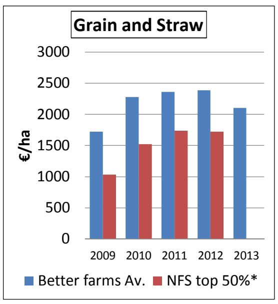
Winter Barley: 2009-2013

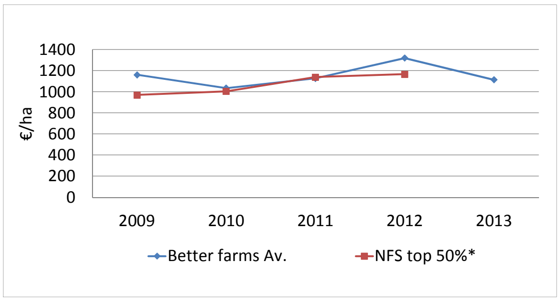




*NFS based on family farm income (top 50%)
Note: Most of grain from BETTER farms is sold @15% MC

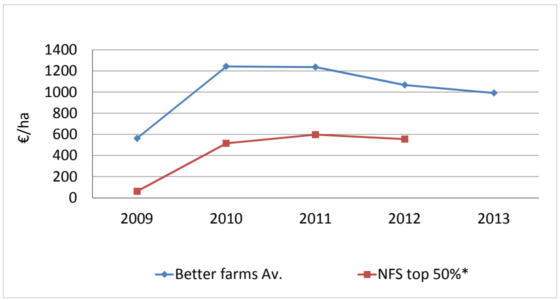
The Irish Agriculture and Food Development Authority

Winter Barley 2009-2013
Common Costs €/ha



** NFS based on family farm income (top 50%)*

Winter Barley 2009-2013
Common Profit/ha



** NFS based on family farm income (top 50%)*

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Supporting Yields

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Soil Nutrition

- Annual Farm Nutrient Management Plans

- Focus on specific areas of the farm
  1. intensively soil sampled (each year)
  2. Nutrient balance – Grain + straw ⇩ ⇧ P + K applied
  3. Match nutrient balance to soil tests
  4. Correct imbalances

Outcome

- Increase potash use
- Re-evaluate compound –change to higher P and K
- Increased use of P and K (higher rates)

KT supporting changes on farm

Area of Concern	Action taken	On Farm
Costs increasing	e-pm, business plan, Machinery Cost Cal.	- Focus on analysis each year - Focus on input costs
Land Access - a major concern	Developed Share Farm Model	- 2 farms active in this area
Sustainability of the farm system	Soils workability and sustainability	- introduce organic material
Improving output and stabilising yields	Cropping mix	- Match crop to soil type - Diversify to spread risk - Spread machine work load
Labour use	Workload at peek times	- Changes to cropping system and crops planted
Agronomy	Tweaked current practice	- Improved use fungicides - Adjusted weed control - Use trace elements
Disease control	Look at Decision Support Tool	- Used Septoria timer

The Irish Agriculture and Food Development Authority

Thanks to

- Special thanks to
  - Crowley Family
  - O'Donoghue Family
  - Williamson Family

  - Local advisors
  - Specialists
  - Researchers
  - Staff from variety testing, Department of Agriculture, Food and the Marine
  - Trade partners

The Irish Agriculture and Food Development Authority

BETTER farm
crops programme

BETTER Farm program
Small adjustments to reshape your business

Improving profits through whole farm analysis,

Demonstrating best practice, and

Showcasing national trials locally

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Agriculture and Food Development Authority

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BETTER Farms II - Being more precise

Dermot Forristal
Teagasc, CELUP, Oak Park

SUMMARY

In a tillage farming context, precision agriculture can be considered in two categories based on how it's used: 1) managing within-field variability (spatial variability) and; 2) machine guidance. While managing variability was the original primary goal for the use of precision agriculture systems, more progress has been made on the simpler concept of machine guidance. Managing spatial variability involves the gathering, and usually the mapping, of information which varies in different parts of a field, using GPS systems to give locations and computer applications to generate maps. Yield and soil nutrient maps for example are generated using a yield monitor on a combine and geo-referenced soil samples respectively. Following analysis, this information may then be used to generate a variable-rate input map for the field which varies the rate of inputs applied, to optimise performance, provided there is the research available on which to base the decision making process. This is quite a complex task and has proved a stumbling block for the adoption of spatially variable management systems. Slow but steady progress is being made in this area. Conversely machine guidance systems such as 'auto-steer' and GPS-controlled headland management systems, have made significant strides, both in development and adoption, by machinery manufacturers. GPS systems have become more precise with full RTK-GPS giving 2cm positioning accuracy. Automated guidance systems can make larger machines much easier to control precisely. Their use can save costs by more accurately matching machine working bout widths and improved control of input application on field headlands or narrower bouts. However growers must ensure that their size and scale of operation can justify the cost, as the savings made can be quite small relative to the equipment cost.

In the next BETTER farm programme, a key aim will be to assess and demonstrate precision farming technology. The emphasis will be on determining its role in improved management of crops using spatially variable technology. This work will have three components: 1) to quantify and investigate within-field variability; 2) to evaluate appropriate crop management responses and 3) to demonstrate precision agriculture technologies. Following the selection of growers with an interest in, or previous experience of precision agriculture, for the BETTER farm programme, yield variability will be mapped and analysed with possible causes of variation investigated. A number of input management strategies will then be imposed on high and low yielding areas in replicated field trials. This will help determine the optimum response approach to variability, as measured by impact on yield and crop margin. Newer technologies such as the use of both satellite and proximal crop-sensing technologies will be demonstrated and may be used in the crop management trials. This work will demonstrate current precision agriculture technology and indicate whether gains can be made from using variable crop management systems. It will also help focus future research efforts in this area.

BETTER Farms II:

Being More Precise

Dermot Forristal
Teagasc CELUP
Oak Park Crops Research

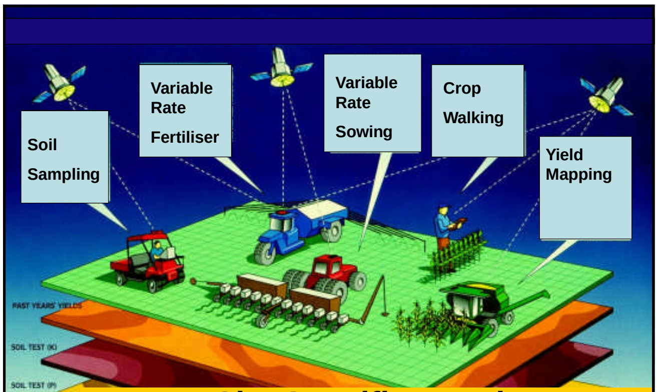
Outline

- **Precision Ag: what is it?**
  - Managing within-field variability
  - Machine Guidance
- **BETTER Farm II programme**
  - Research / Demonstration Precision Ag**.**

What is Precision Agriculture?

- **Many different definitions**
- **Two main divisions in Tillage:**
  1. Managing Spatial Variation (Managing within field variability; Site Specific Farming)
  2. Machine Guidance

     (More efficient machine operation)

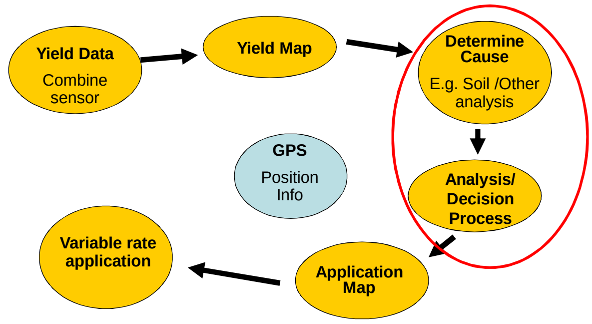


1. Site Specific Farming: Managing Spatial Variability

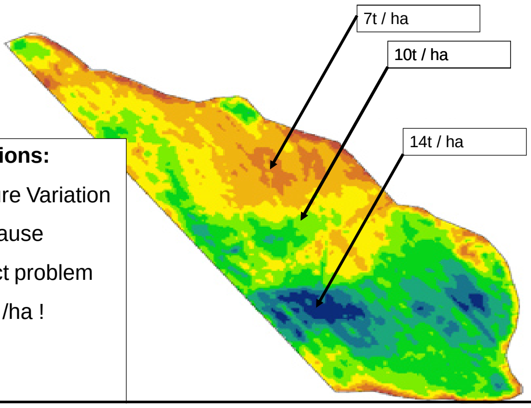
Also Real Time sensors: Non-GPS

Crop Reflectance Estimating N need

Managing Spatial Variability



1990s: Mesmerised by Yield Maps !



Expectations:

- Measure Variation
- Find cause
- Correct problem
- All 14t /ha !

1990s vs Today

- GPS complex, expensive, unreliable → GPS much improved
- Data interpretation challenging → Limited progress
- Finding the 'cause': → Limited progress
  - Difficult and Expensive
- Response unclear. → Limited Progress
  - More or Less Inputs?

Concept valid: must challenge fixed blueprint approach

2. Machine Guidance: Steering, Headland systems

2. Machine Guidance

Improved GPS (RTK = 2cm) facilitates this

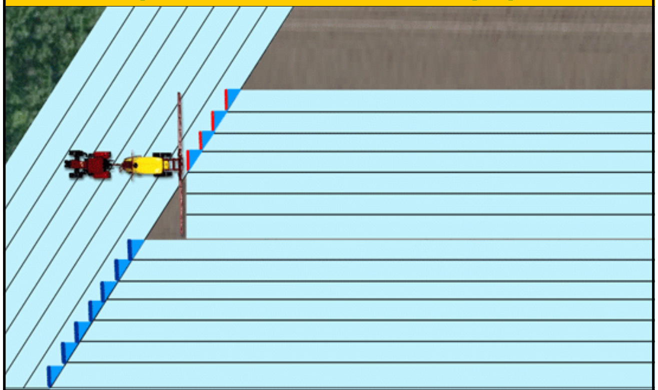
1. **Auto-Steer**
   - Reduces overlaps on machine operations
   - More efficient? – beware over estimates!

Machine Guidance

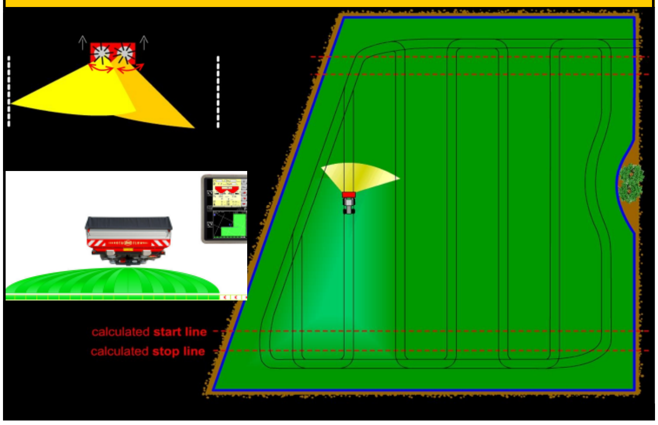
2. **Headland control – Sprayer and Spreader**

- Automating sprayer turn-off by section
- Consistent overlaps, less chemical waste / crop scorch.
- Requires careful set-up.
- Adjust Spreader pattern to match bout width, shape and headland

2. Sprayer section control (avoids excess overlaps)



2. Spreader headland control

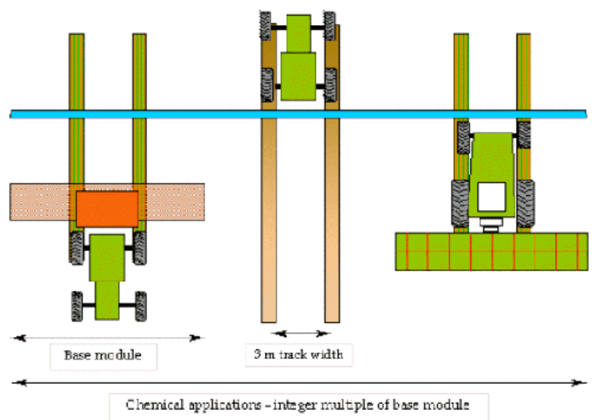


Machine Guidance

3. Controlled Traffic

- **Large areas without traffic**
  - Less compaction
  - Reduced draught / cultivation power
- **Controls exact position of wheelings**
- **E.g. 6m base: cultivator, drill, combine**
  - Some use 8m, 9m or even 12m (or 4m?)

Teagasc The Irish Agriculture and Food Development Authority



How do we Progress this Area?

- ‘Precision’ element to many projects
  - e.g. Crop N Requirement (Richie Hackett)
- Initiate Precision Ag approach in BETTER farm programme
- Look for future opportunities to contribute by collaborating with others

BETTER Farms II – Next Programme

- **Financial management / planning**
  - e- Profit monitor
  - 3 yr Business Plan
- **Agronomy**
  - Crop Choice/rotations
  - Nutrient management
  - Crop management
- **Managing Variability (Precision Agriculture)**

Demonstration Platform

Precision Ag Component

Research + Knowledge Transfer components

Overall aim

To assess and demonstrate a more precise and responsive SMART crop management approach

Specifically to:

1. Quantify and investigate within-field variability
2. Evaluate crop management responses
3. Demonstrate Precision Ag technologies

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1. Quantify + Investigate Variability

- **Select BETTER farms (3) with interest / capacity in Precision Ag.**
- **Examine within-field variability history if available**
  - Yield maps
  - Nutrient maps
  - Satellite information (NDVI etc at adequate resolution)
- **Begin yield mapping if necessary**
- **Develop analysis approach dependent on data available**

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1. Quantify + Investigate Variability

- **Consider additional 'grid- based' or 'targeted' assessments (expert led decision making):**
  - Nutrient analysis
  - Visual soil assessment (VSA)
  - Other: electrical conductivity (EC) etc

2. Evaluate Management Response

- **'High' and 'Low' yielding areas of fields selected**
- **Possible 'Causes' determined**
- **Treatment strategies developed**
  - Fixed 'High' Input
  - Fixed 'Low' Input
  - Fixed 'Standard' Input
  - 1 or 2 'Targeted' Treatment Strategies where 'causes' known
- **Replicated trials**
- **Crop and economic response measured**

3. Evaluate / Demo Technologies

- **Crop sensing methodologies to be selected. E.g.:**
  - Satellite reflectance sensing
  - Hand / held or tractor-based reflectance sensing
  - Smart phone LAI sensing
- **Demonstrate technologies on BETTER farms**
  - Assess ability to predict crop performance, input requirement
  - Consider use as treatment determinants in management response trials
  - Complex: True utility will be determined by focused research trials (e.g. N prediction: Richie Hacketts work etc)

What this will deliver:

- Better understanding of Precision Ag components and where they might fit in
- 'Fixed' approach not optimal
- Experience dealing with maps and data
- Variable management options trialled
- Future research approach determined

Conclusions

- **Precision Ag has 2 main elements:**
  - Managing within field variability
  - Machine Guidance
- **Managing variability challenging but valid aim**
- **Machine guidance progressing rapidly**
- **BETTER FARM II programme will**
  1. Quantify and investigate within-field variability
  2. Evaluate crop management responses
  3. Demonstrate Precision Ag technologies

Aphicide resistance in grain aphids

Steve Foster
Rothamsted Research, Harpenden, Herts., UK

SUMMARY

In practical terms, the evolution of insecticide resistance has undoubtedly contributed to overall increases in the application of chemicals to crops. Despite these increases, resistant insects continue to affect our agricultural productivity. As a result, the phenomenon imposes a huge economic burden upon much of the world. Only by monitoring, characterising and predicting the appearance and spread of resistance can we hope to continue using insecticides in a sustainable manner.

Of the thousands of aphid species that exist globally, only a few have been reported as having developed insecticide resistance. However, some of these are ranked among the most problematic pests worldwide. This has resulted in them being subjected to intense selection by aphicides which has led to the evolution of a variety of resistance mechanisms.

Until recently, the only UK aphid species found on field crops known to carry pyrethroid resistance was the peach-potato aphid (*Myzus persicae*). However, in response to growing concerns that the grain aphid (*Sitobion avenae*) was becoming difficult to control in England, samples were collected in June 2011 from several wheat fields in Cambridgeshire that had pyrethroid control problems. Aphids were tested for the knock-down mechanism (kdr) known to confer moderate pyrethroid resistance in a wide range of other insects. Analysis of these samples identified the well-known single kdr mutation with potential serious implications for transmission of the damaging *Barley Yellow Dwarf Virus* (BYDV) as grain aphids are an important vector. Indeed, in spring 2012 high levels of BYDV were found in cereals across England which may, in part, have been caused by the presence of pyrethroid-resistant aphids. Fortunately, much of the remaining season was not conducive to an aphid epidemic and this continued into 2013 where a very late spring kept grain aphid numbers down.

Laboratory bioassays applying lambda-cyhalothrin to live grain aphids have shown that kdr forms are approximately 40-fold more resistant to lambda-cyhalothrin than non-kdr (susceptible) forms. The subsequent development of a quick DNA-based diagnostic test has allowed us to effectively screen large numbers of aphids (alive or dead) to investigate the presence and frequency of kdr. This has given us a clear picture of its spread in 2012 and 2013 in the UK with resistant aphids exceeding 50% in some samples (collected from more intensive UK cereal growing regions). Furthermore, a sample collected in 2013 from spring barley in County Cork, Ireland, also contained kdr aphids.

Our findings are enabling us to provide up-to-date advice (available on the IRAG-UK Website: www.pesticides.gov.uk/committees/resistance) for growers and agronomists, including best spray practice measures to limit the risk of any further resistance build up. The Guidelines on kdr in Grain aphids state: "When grain aphids are clearly the main aphid pest present then growers need to be aware that pyrethroid sprays may not be effective. If they spray and suspect that control has been poor they should not spray again with a pyrethroid-based product but switch to another insecticide with an alternative mode of action."

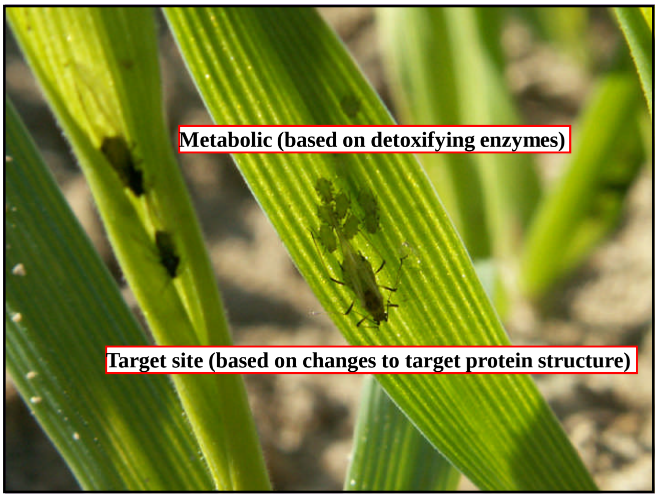
Aphicide resistance in grain aphids

Steve Foster

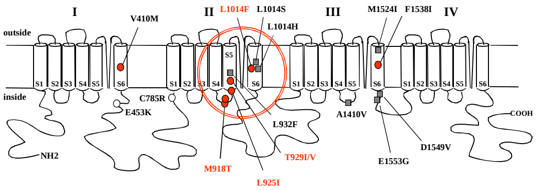
Rothamsted Research

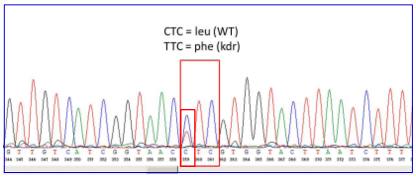
Sitobion avenae

- Important pest on wheat, barley (oats)
- Reduces grain yield
- Transmits BYDV
- Previous good control with pyrethroids



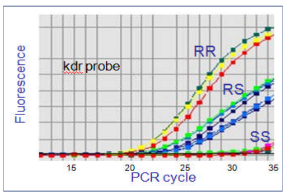
Sodium channel mutations implicated in pyrethroid resistance



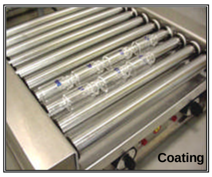


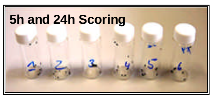
2011 *Sitobion avenae* sample contained kdr mutation, L1014F

Mechanism-specific diagnostics TaqMan PCR



Bioassay approach





Response to lambda-cyhalothrin

S. avenae **Clone**	**LC_{50} ng ai/cm^2**	**Resistance Factor**
SS Baseline (Suffolk, 2011)	0.08 (0.01-0.20)[a]	**1**
SR (Suffolk, 2011)	3.21 (1.90-7.34)[b]	**36**
SR (Norfolk, 2011)	3.24 (2.46-4.43)[b]	**39**

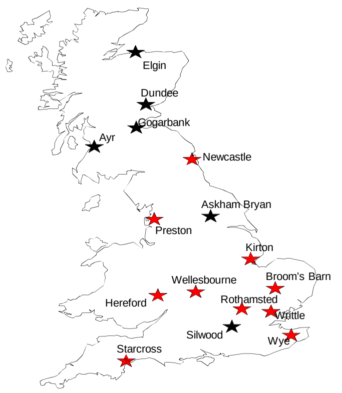
What about Grain aphids on cereals in the field?

2012 samples of *S. avenae* tested using vial tests

Site	Date collected	date tested	% mortality at 3ng/cm2	% mortality at 0.3 ng/cm2	Resistance classification
Elveden, Norfolk	20-Feb	18-Jun	95	75	S
Fair Green, Norfolk	16-Apr	18-Jun	90	65	S/R?
Narborough, Norfolk	16-Apr	18-Jun	95	80	S
Oxborough, Norfolk	16-Apr	11-Jun	80	5	R
Collingham, Notts	25-May	15-Jun	90	70	S
Newton on Trent, Lincs	07-Jun	18-Jun	90	35	R
Chedburgh, Suffolk	08-Jun	24-Jun	100	35	R
Takely, Essex	10-Jun	24-Jun	100	95	S
Welnetham, Suffolk	18-Jun	18-Jun	80	95	S
Morley, Norfolk	21-Jun	30-Jun	100	80	S
Feltwell, Norfolk	22-Jun	24-Jun	95	90	S
Wickhambrook, Suffolk	23-Jun	24-Jun	80	55	S/R?
Prickwillow, Cambs	27-Jun	30-Jun	95	75	S
Sutton Scotney, Hamps	28-Jun	30-Jun	100	93	S
Whittlesey, Cambs	29-Jun	30-Jun	100	100	S
Luton, Beds	10-Jul	17-Jul	95	40	R
Baldock, Herts	10-Jul	17-Jul	100	88	S

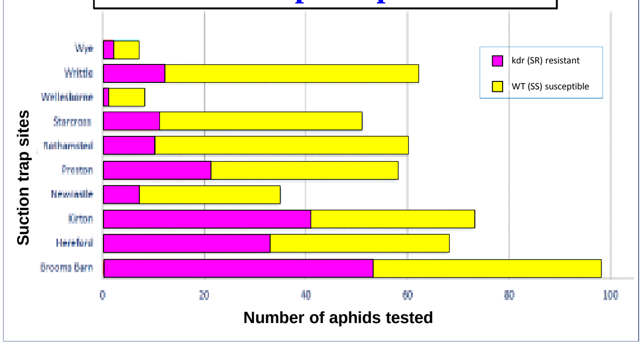
Survey funded by Syngenta Crop Protection

UK suction trap sites

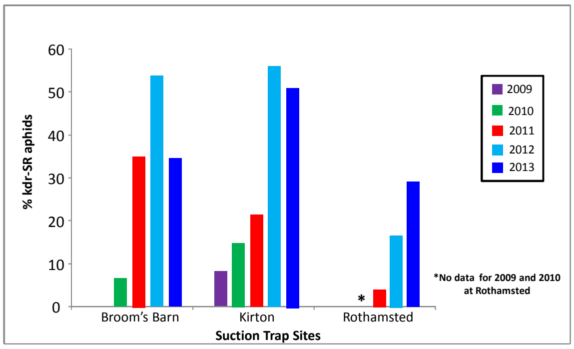


http://www.rothamsted.ac.uk/insect-survey/STTrapSites.php

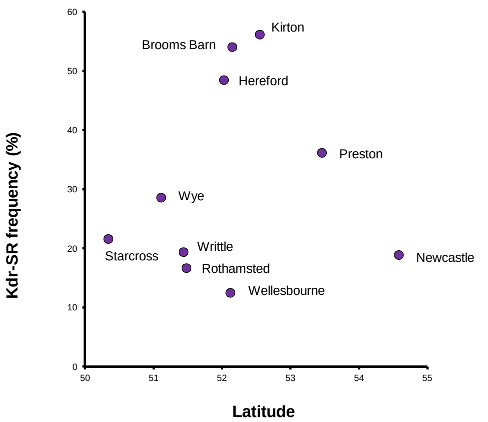
kdr-SR and -SS *Sitobion avenae* in suction trap samples in 2012



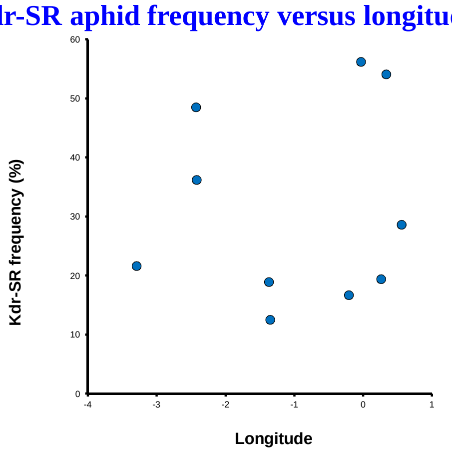
Frequency of kdr-SR *Sitobion avenae* in three suction traps (2009-2013)



kdr-SR aphid frequency versus latitude 2012



kdr-SR aphid frequency versus longitude 2012

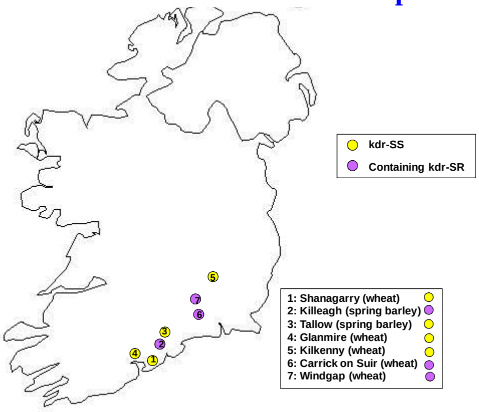


kdr-SR Grain aphids have also been found in:

Ireland and Germany

A few samples received from Denmark and the USA (Kentucky) contained only kdr-SS aphids

kdr status of 2013 Irish *S. avenae* samples



Samples supplied by Michael Gaffney, Tom Gartland and Billy Cotter

October 2013

Insecticide Resistance Action Group - UK

HGCA

Knock-down resistance (kdr) in Grain Aphids

This IRAG Guideline provides advice on the control of grain aphid (*Sitobion avenae*) populations that may contain individuals with knockdown resistance (kdr) to pyrethroid insecticides commonly used for aphid control on UK cereals.

What about insecticide foliar sprays applied in the field against *Sitobion avenae*?

HGCA cereal aphid trials

Broom's Barn, Suffolk

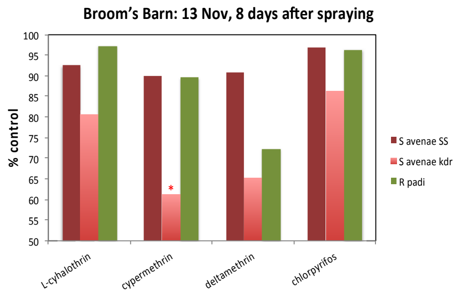
Yellow sticks show location of inoculated plants

- Test aphids were confirmed as kdr-SR forms
- These had been isolated from a crop that had been treated twice with cypermethrin

Comparison of efficacy of pyrethroids against susceptible and resistant aphids

- Main field trials only used one population of resistant aphids, partly due to constraints on space (to allow for virus spread), and partly to availability of other populations in large numbers
- Smaller numbers of both susceptible and resistant aphids became available in October, so a smaller scale trial was set up with one infested location per plot instead of six
- These aphids were not infective with BYDV, so there was no need to allow for spread of infection later
- A population of the bird cherry aphid, *Rhopalosiphum padi,* was also tested alongside the two *S. avenae* populations

Efficacy of pyrethroids against cereal aphids: small trial results



* Significantly less than chlorpyrifos at P<0.05

Take-home messages

- Preliminary recommendations are to continue using pyrethroids to control *S. avenae*, but ensure that you apply at the full rate and monitor spray efficacy
- Chlorpyrifos is the only other product tested that is approved for autumn/winter use in cereals, mainly to control wheat bulb fly and leather jackets, but it would give excellent control of aphids too
- However, it would also have a greater adverse impact on non-target organisms, particularly carabids, which are important aphid predators

Diversity/clonal nature of UK *Sitobion avenae* population?

Search for kdr-RR homozygotes continues!

Summary

- The knockdown resistance (kdr) mutation L1014F has been identified for the first time in field populations of *Sitobion avenae*
- The mutation confers ~40-fold resistance to lambda-cyhalothrin and is found in areas with control failures
- Analysis of suction trap samples shows that the kdr mutation is now present in the UK at high frequency (>50%) in some areas BUT ONLY as heterozygotes (SRs)
- The mutation was first seen at low levels in 2009 but took hold in the UK in 2011 when control failures were first reported

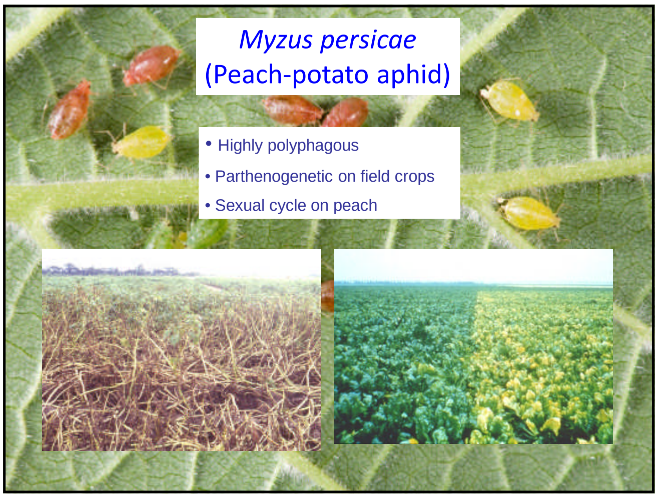
Insecticide Resistance Action Group:

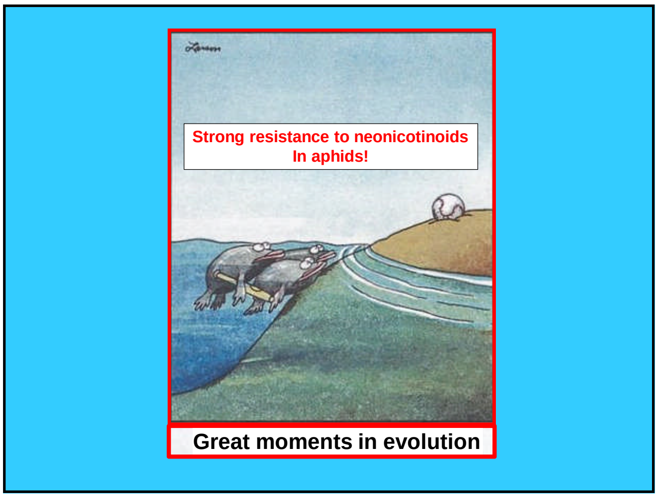
www.pesticides.gov.uk/committees/resistance

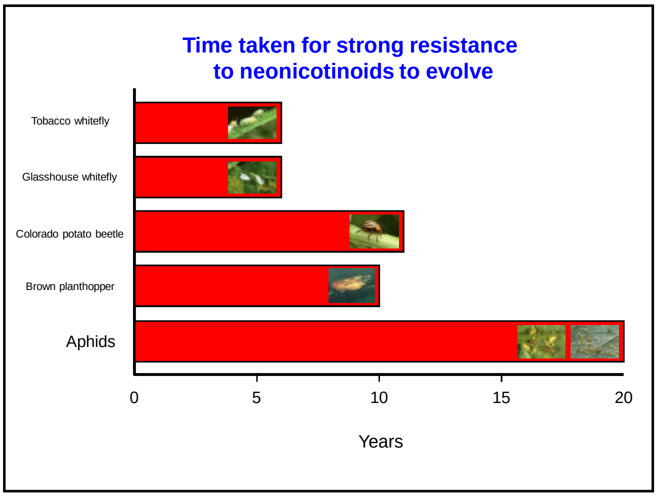
INSECTICIDE RESISTANCE ACTION GROUP

kdr Resistance in Grain Aphids

"When grain aphids are clearly the main aphid pest present then growers need to be aware that pyrethroid sprays may not be effective. If they spray and suspect that control has been poor they should not spray again with a pyrethroid-based product but switch to another insecticide with an alternative MOA"


Myzus persicae
(Peach-potato aphid)
• Highly polyphagous
• Parthenogenetic on field crops
• Sexual cycle on peach


Strong resistance to neonicotinoids
In aphids!
Great moments in evolution


Time taken for strong resistance
to neonicotinoids to evolve
Tobacco whitefly
Glasshouse whitefly
Colorado potato beetle
Brown planthopper
Aphids
0
5
10
15
20
Years

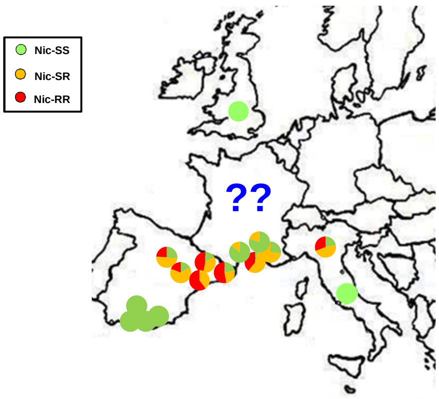
Nic-R$^{++/+++}$ *Myzus persicae* in mainland Europe

LC_{50} responses of *Myzus persicae* clones in imidacloprid topical bioassays (ordered by Resistance Factor)

	Clone	Nic Cat[a]	N[b]	LC_{50}[c]	95% CL[c]	Slope[d]	RF[e]	Viability[f]
SS	4106A	S	1109	0.424	0.312-0.549[a]	1.5	1.0	0.05
SS	4255A	S	256	0.383	0.200-0.693[a]	1.5	0.9	0.05
SS	926B	R	1474	5.018	4.302-5.650[b]	2.9	12	1
SS	T13	R	278	6.223	3.230-9.290[b]	1.5	15	1
SS	Sel4	R	202	6.755	4.310-10.67[b]	1.1	16	1
SS	T25	R	335	6.981	5.098-9.217[b]	1.4	16	1
SS	T43	R	254	8.960	5.300-17.64[bc]	1.3	21	1
SS	T52	R^+	286	17.24	10.83-28.98[c]	1.3	41	1
SS	5191A	R^+	603	18.25	11.15-29.37[c]	1.0	43	3
SS	Sel2	R^+	362	23.16	16.17-33.60[c]	1.2	55	3
SR	5485A	R^{++}	226	` 3,460	2,241-6,194[d]	1.3	>8,000	30
SR	SPN	R^{++}	205	3,528	1,511-20,382[de]	1.0	>8,000	30
RR	5444B	R^{+++}	352	14,412	6,690-75,695[e]	0.9	>30,000	6,000
RR	FRC	R^{+++}	290	24,426	7,475-828,613[e]	0.8	>30,000	6,000

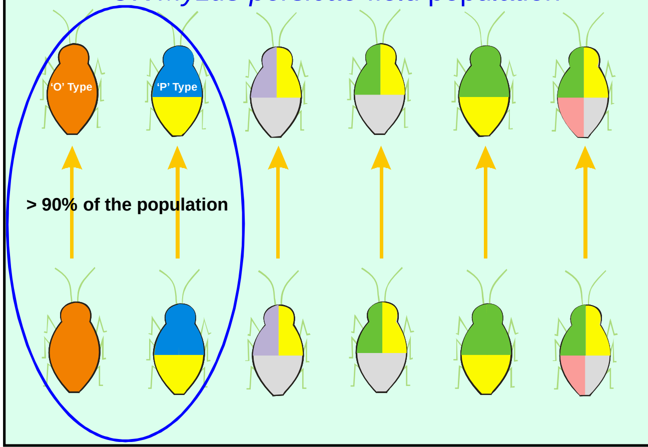
[a] Neonicotinoid Resistance Category allocated on basis of topical LC_{50}.
[b] Total number of aphids tested (including untreated controls).
[c] Concentration (ppm) resulting in 50% aphids dead or irreversibly poisoned.
[d] Confidence Limits at 95%; values followed by the same letter do not differ significantly (i.e. they overlap).
[e] Resistance Factor of clone LC_{50}/LC_{50} for 4106A.
[f] Highest dose (ppm) where viable offspring were produced.

Monitoring for R81T (neonicotinoid-R) mutation in *Myzus persicae* populations in Europe



Slide X

UK *Myzus persicae* field population



Neonicotinoid restriction as seed treatments from December 2013

This will mainly affect OSR with growers probably using more pyrethroids and/or pymetrozine. *Myzus persicae* are currently mostly super-kdr in the UK so they should be poorly controlled by pyrethroids unless there is a big change in the population.

If problems with virus control (e.g. TuYV) then ensue, some growers MAY even stop growing OSR. This will have negative implications for bee foraging….

Farmers Guardian

30th September, 2013

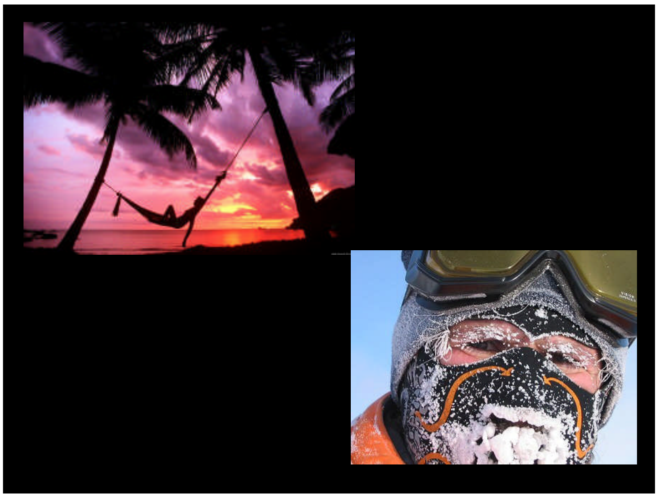
Ninety per cent of pesticides under threat from EU bee plans

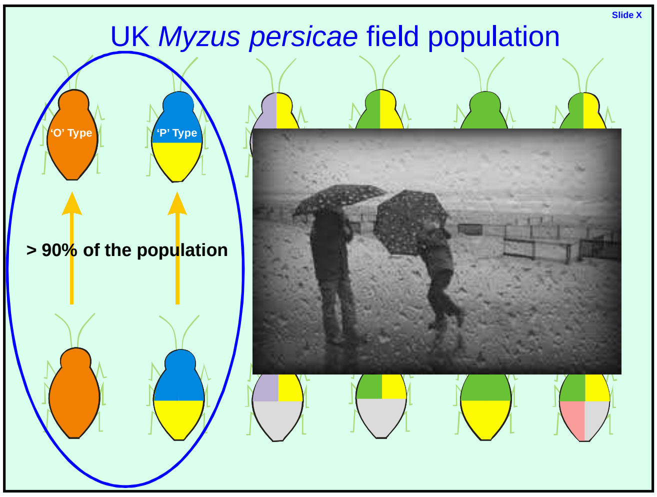
"Syngenta has warned up to 90% of pesticides currently available to EU farmers could be banned under European Commission plans to widen its approach to protecting bees from agrochemicals."

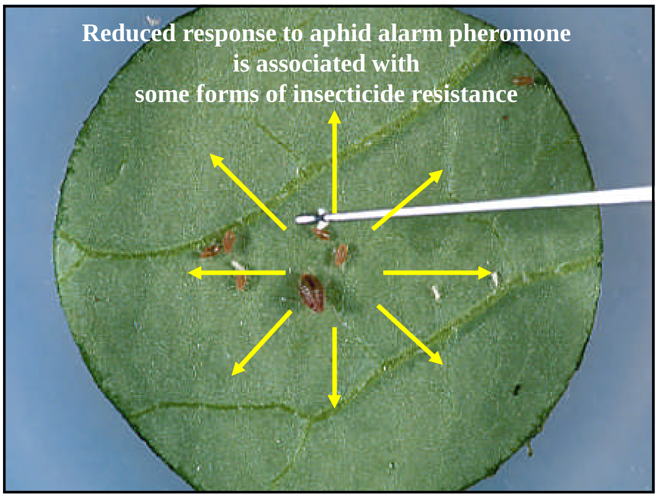
To combat resistance
we need as many insecticides
with different Modes of Action
as we can get!

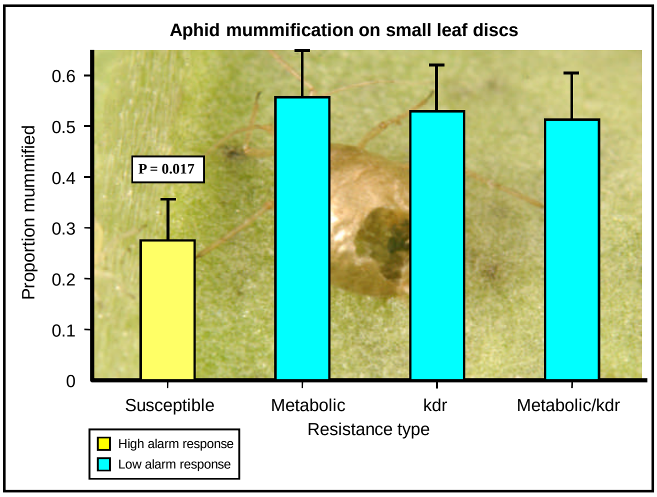
Fitness costs associated with insecticide resistance

INSECTICIDES	NO INSECTICIDES
ADVANTAGES DRAWBACKS	ADVANTAGES **DRAWBACKS**




Slide X
UK Myzus persicae field population
'O' Type
'P' Type
> 90% of the population


Reduced response to aphid alarm pheromone
is associated with
some forms of insecticide resistance


Aphid mummification on small leaf discs
Proportion mummified
0.6
0.5
0.4
0.3
0.2
0.1
0
P = 0.017
Susceptible
Metabolic
kdr
Metabolic/kdr
Resistance type
High alarm response
Low alarm response

Acknowledgements:

AHDB-HGCA
AHDB (Horticulture)
AHDB (Potato Council)
ADAS
Bayer CropScience
BBSRC
Belchim
British Beet Research Organisation
Certis
Chemicals Regulation Directorate
Dewar Crop Protection
DuPont
NuFarm (UK) Ltd
Sumitomo/InterFarm
Syngenta

Special thanks to:

Rothamsted Insect Survey

Suzanne Clark
Diana Cox
Ian Denholm
Mark Mallott
Linda Oliphant
Deepa Paliwal
Robin Thompson
Monique Tomiczek
Martin Williamson

Aphid control in Cereals

Tom Kennedy
Research Entomologist (Retired), Teagasc, Oak Park

SUMMARY

Aphids are the most serious pests of cereal crops in Ireland. Damage occurs in two ways; (i) by transmitting virus disease (BYDV) to and within crops; (ii) by direct feeding on tillers. Yield reductions, at Oak Park, due to virus disease has been as great as 3.7 t/ha in winter barley and almost 2 t/ha in late-April sown barley. Yield reductions due to Aphid feeding on winter wheat crops have exceeded 1 t/ha with 0.8 t/ha recorded for late-April sown barley. Wheat and oat crops are as susceptible to BYDV as barley but because they are sown later in autumn and earlier in spring, than barley, they are less affected by virus. Recommendations for BYDV control are based on trials at Oak Park carried-out over a number of seasons. Early-September sown barley should be sprayed with aphicide at the 2-3 leaf stage and again during early November. Crops sown from late-September need only a single aphicide during early November. In general, cereal crops sown from the first week in November and before the middle of March have no requirement for aphicide spray treatment even in seasons when aphids and virus are prevalent in early autumn-sown crops.The most damaging aphid species affecting cereals in Ireland is the grain-aphid *Sitobion avenae*. The most effective means of controlling this pest has been the application of properly timed pyrethroid type insecticides. Recent research in the UK has confirmed the development of resistance to pyrethroid insecticides in the grain-aphid. During summer 2013 a small proportion of Irish grain aphids were confirmed to have resistance to pyrethroids. While the frequency of resistance may be low it is important that a strategy is adopted that gives effective aphid control while limiting the potential for the development of resistant populations and thereby prolong the effectiveness of pyrethroid insecticides. Such a strategy would require that cereal growers use no more than the recommended number of pyrethroid applications for aphid control and should never use pyrethroids to control aphids on the heads of cereals.

There are only a limited number of alternatives to pyrethroids for aphid control. Of the 30 insecticide products registered with PRCD (Dept. of Ag. Website, 3 January 2014), 17 are pyrethroids. Ten products belong to the organophosphate group, 5 dimethoate and 5 chlorpyrifos compounds. Dimethoate is no longer permitted for use on barley or oats. In the case of autumn sown cereals (barley, wheat and oats) growers may purchase seed treated with an effective insecticide for BYDV control. The only alternative non-pyrethroid insecticide for winter barley and oats is chlorpyrifos. Both dimethoate and chlorpyrifos may be used on winter wheat.

Seed insecticide treatments are not permitted on any spring sown cereals or indeed on winter cereals sown in spring. Spring wheat and oats are usually sown in January and February and do not require insecticide treatment. Pirimicarb or chlorpyrifos may be used as alternatives to pyrethroids to control aphids and BYDV in late-April sown barley.

Irrespective of whether resistant aphids are present or absent in the previous season, control of grain-aphids on the ears of wheat post GS 60 should be by use of either dimethoate or pirimicarb. Where aphids infest the ears of spring barley, which is infrequent, control can currently be got by using pirimicarb.

Aphid control in cereals

Tom Kennedy
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Outline

- Scale of the problem (BYDV)
- Components of problem
- Trial results; basis for recommendations
- Summaries
- Recommendations

Yield loss due to BYDV

Crop	Yield reduction (t/ha)
Winter barley (Early Sept)	3.7 t/ha
Spring barley (Late April)	1.99 t/ha
Winter wheat	1.2 t/ha
Winter oats	?

Wheat and oats as susceptible as barley - sowing date

Virus transmission by aphids

- Cereal aphid flight:
  - Not below 10-12 °C,   14-15 °C
  - Wind speed < 8 kmh^{-1}
  - Light > 1000 lux
  - RH < 70%
  - Sept/Early Oct.   - Mid-May

BYDV   components

- **APHIDS:**

  - Grain aphid
    (*Sitobion avenae*)

  - Rose-grain aphid
    (Metopolophium dirhodum)
  - Bird-cherry aphid
    (Rhopalosiphum padi)

BYDV   components

- **Virus Serotypes:**

  - Grain aphid
    (*Sitobion avenae*)

  - Rose-grain aphid
    (Metopolophium dirhodum)

MAV   **Mild strain**

  - Bird-cherry aphid
    (Rhopalosiphum padi)

RPV   **Severe strain**

BYDV components

- Virus Serotypes:
  - Grain aphid (*Sitobion avenae*)
  - Rose-grain aphid (*Metopolophium dirhodum*)
  - Bird-cherry aphid (*Rhopalosiphum padi*)

MAV Mild strain

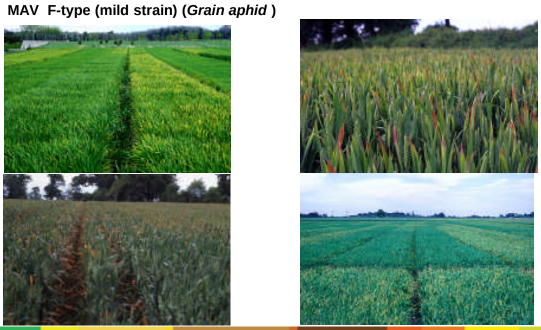
PAV

RPV Severe strain

BYDV components

- Virus:

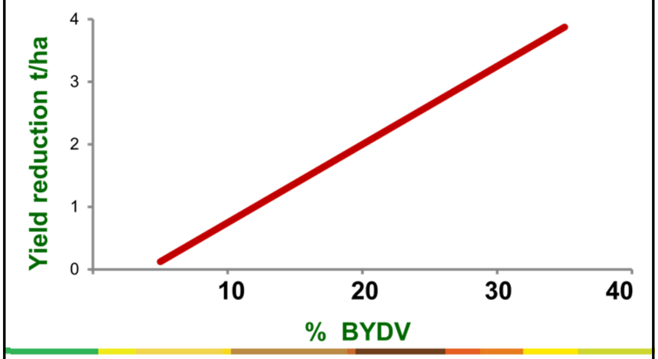
MAV F-type (mild strain) (*Grain aphid*)



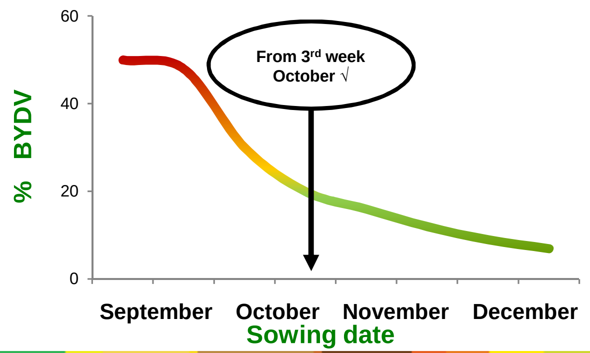
BYDV components

- Virus: RPV B-type (severe strain) (Bird-cherry aphid)

BYDV and yield reduction

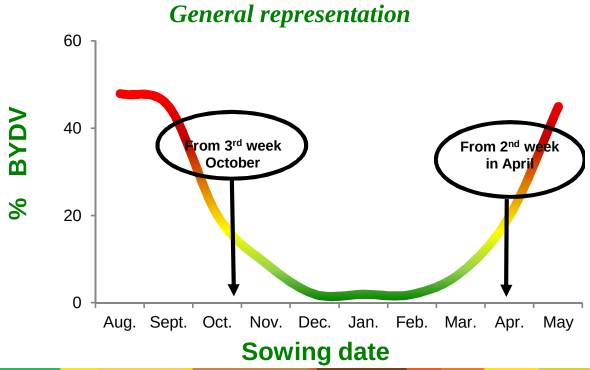


BYDV Infection and sowing date



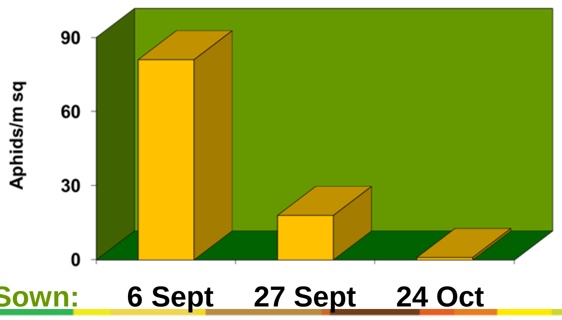
BYDV Infection and sowing date

General representation



Aphid No/ m² in barley sown on three dates

Sampled 30 November



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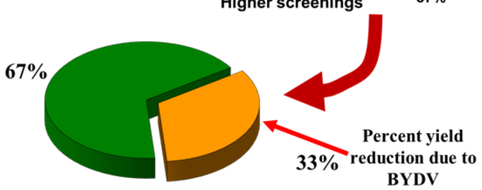
Effects of BYDV on yield, Oak Park trials

MAV (Sitobion avenae)

	% Diff. sprayed V unsprayed
Fewer ears	39%
Fewer grains per ear	23%
Lower specific wts	13%
Lower 1000 grain wts	33%
Higher screenings	87%



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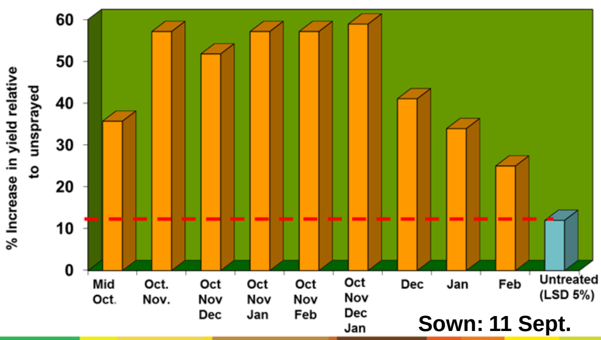
W. barley, effect of aphicide timing



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W. Barley Seed treatment vs Spray BYDV (%)

	Min-till Sprays			Conv-till Sprays		
	None	GS 25	GS 22 + 25	None	GS 25	GS 22 + 25
Seed treat	0.9	0.5	0.0	2.9	0.4	0.1
Control	14.1	1.3	0.4	44.3	1.6	1.6

sed 1.89

W. Barley Seed treatment vs Spray BYDV (%)

	Pyrethroid spray		
	None	GS 25	GS 22 + 25
Seed Tr.	2.9	0.4	0.1
Control	44.3	1.6	1.6

W. Barley Seed treatment vs Spray Grain yields (t/ha)

	Pyrethroid spray		
	None	GS 25	GS 22 + 25
Seed Tr.	6.3	6.4	6.5
Control	4.9	6.2	5.9

s.e.d. 0.61; D. F. 24

W. wheat Seed treatment vs Spray Aphids/m2

	Pyrethroid spray		
	None	GS 25	GS 22 + 25
Seed Tr.	1.4	0.7	0.0
Control	10.8	0.7	0.0

W. wheat Seed treatment vs Spray BYDV (%)

	Pyrethroid spray		
	None	GS 25	GS 22 + 25
Seed Tr.	1.0	2.0	1.0
Control	10.0	1.0	2.0

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Seed Treatment v Spray gs 25

(summary of six comparisons)

- Spray - fewer aphids than seed treatment
- Spray - less BYDV than seed treatment
- Spray - slightly higher yield than seed treatment

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Spray treatment of Winter cereals

1. Early-Sept. sown crops, spray at 2/3 leaf stage + 2nd early-Nov.
2. Late- Sept. sown crops, spray 1st week Nov.
3. Even when aphid and virus occurrence high, NO benefit for extra sprays
4. Late spraying of previously unsprayed crops --- beneficial when virus is widespread, e.g. Dec., 2.3 t/ha; Jan., 1.9 t/ha and Feb., 1.4 t/ha
5. Crops emerging after end of Nov. do not need spraying --- except in mild winters when aphids are plentiful

Recommendations

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10 Insecticide a.i.s– PRCD (3 Jan 2014)

Pyrethroids	Organo-phos	Neonicotinoid	Carbamate	Pyridine-carboxamide
5	2	1	1	1

5 dimethoate
5 chlorpyrifos

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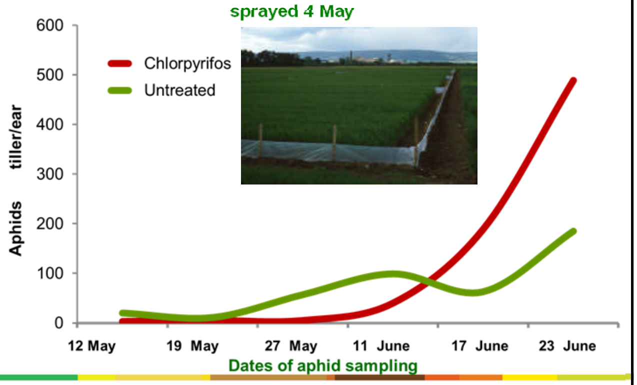
Chlorpyrifos - problems

sprayed 4 May



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Recommendations - Winter cereals

Winter barley:

- Early sown
  - Seed treatment or first spray
  - + later (second) spray
- Late sown
  - Seed treatment or first spray
  - (no later (second) spray needed)
- Where pyrethroid fails - Chlorpyrifos (Rates)

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Recommendations - Winter cereals

Winter wheat:

- Early sown as barley, otherwise:
- Seed treatment alone√
- No seed treat. – use Pyrethroid
- If pyrethroid fails - Dimethoate OR chlorpyrifos

Winter oats:

- Seed treatment OR pyrethroid
- If pyrethroid fails - chlorpyrifos

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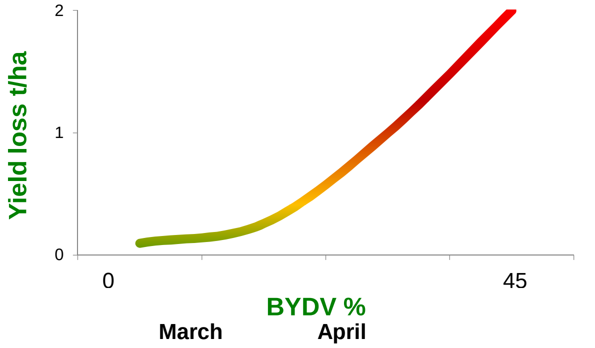
BYDV Spring barley

BYDV SPRING barley - yield loss



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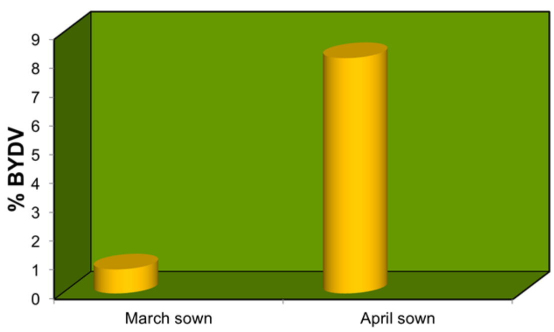
March v April % BYDV

Mean of 8 seasons



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Aphicide timing – BYDV & Grain yield
Barley sown 26 April

G.S. Spraying	%BYDV	Yield t/ha
2-leaf	17.2	5.1
4-leaf	8.6	5.6
2-leaf + 4-leaf	8.0	5.5
4-leaf + first node	6.7	5.5
First node	24.7	5.1
Second node	27.5	4.8
G.S. 12 + 14 + 24 + 31	5.7	5.5
Untreated	36.4	4.3
LSD (5%)	5.986	0.506

Aphicide timing – BYDV & Grain yield
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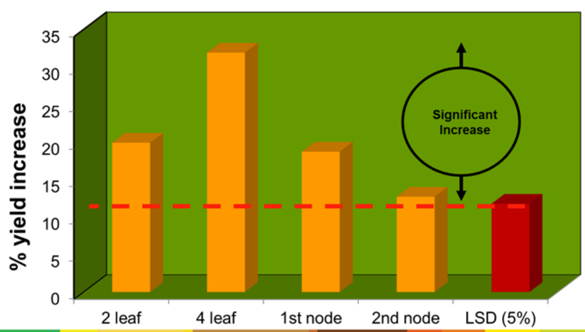
S. Barley effect of spray timing



Summary - Spring barley

- BYDV widespread - up to 20-fold more BYDV in April than in March sown barley
- Control: Early-March sown no spray
  April sown, single spray at g.s. 14
- Reduction in grain yield due to high, moderate and low BYDV in April sown barley was 1.1 t/ha, 0.65 t/ha and 0.36 t/ha, respectively

Recommendations

Recommendations S. barley

- Crops at risk: those sown AFTER mid-April
- Seed treatments & dimethoate - NOT permitted
- Spray: pyrethroid @ 3-4 leaf
- If control failure use chlorpyriphos or pirimicarb

Recommendations S. wheat & oats

- Normal sowing dates (pre-April) – negligible risk
- Jan. & Feb. sown: No treatment needed
- IF sown after mid-April
- Seed treatments - not permitted
- Spray: pyrethroid @ 3-4 leaf
- If control failure use chlorpyriphos, dimethoate √ or pirimicarb

Yield reduction - aphid feeding

Ears, stems and leaves

Crop	t/ha	(%)
Winter wheat *(grain-aphid)*	**1.1**	**(15)**
Spring barley *(grain-aphid)*	**0.83**	**(11.3)**
Spring barley *(Rose-grain aphid)*	**0.48**	**(5.6)**

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Aphids on cereal ears

- **Winter wheat: 5 aphids/ear**
  GS 60-65 (50 – 67% of tillers – GS 61 – 85)
- **Dimethoate, pirimicarb**
- **Aphids on barley ears (rarely occurs) pirimicarb only**

<u>NEVER</u> use pyrethroids on ears

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Further reading

Kennedy, T. F. and Connery, J. (2001). Barley yellow dwarf virus in winter barley in Ireland: yield loss and timing of autumn aphicides in controlling the MAV-strain. *Irish Journal of Agricultural and Food Research,* **40**: 55-70.

Kennedy, T. F. and Connery, J (2005). Grain yield reduction in spring barley due to barley yellow dwarf virus and aphid feeding. *Irish Journal of Agriculture and Food Research*, **44:** 111-128.

Kennedy, T. F., McDonald, J. G., Connery, J. and Purvis, G. (2010). A comparison of the occurrence of aphids and barley yellow dwarf virus in minimum-till and conventional-till autumn-sown cereals. *Journal of Agricultural Science, Cambridge,* **148:** 407-419.

Kennedy, T. F. and Connery, J. (2012). Control of barley yellow dwarf virus in minimum-till and conventional-till autumn-sown cereals by insecticide seed and foliar spray treatments. *Journal of Agricultural Science, Cambridge,* **150:** 249-262.

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Cereal disease control

Steven Kildea & Liz Glynn
Teagasc, CELUP, Oak Park

SUMMARY

A prolonged cold spring and unseasonably dry summer led to extremely low disease levels in cereal crops during the 2013 season. This low disease pressure resulted in exceptional field control which limited responses to fungicide programmes on both winter wheat and spring barley. Although septoria was infrequent in commercial wheat crops sufficient samples were obtained (mostly from the lower leaf layers, leaf 2 or below) to perform sensitivity analysis. Sensitivity of 220 isolated strains was determined to the triazole fungicides epoxiconazole and tebuconazole and the SDHI isopyrazam. No changes in sensitivity to the SDHIs were detected among the strains compared to previous years and no-cross resistance was detected between the SDHIs and triazoles. A further decrease in the sensitivity of the Irish *Septoria* population to both triazole fungicides was detected. The mean sensitivity of the Irish population is now 10 times less sensitive to epoxiconazole when compared to the mean sensitivity detected in 2005. An increase in frequency of strains exhibiting decreased sensitivity to both groups of triazoles was also detected. As triazoles are integral to fungicide programmes on wheat it is important to ensure anti-resistance measures are adhered to. These must include the addition of a multisite fungicide, the benefit of which was clearly demonstrated during the year.

Although scarce during the summer months net blotch was abundant in the lush growth of spring barley volunteers and could also be found on newly emerged winter barley crops. Sensitivity of a collection of 95 isolates from 9 crops (both spring volunteers and commercial winter crops) to the strobilurin and SDHI fungicides was determined by molecular analysis for resistance mutations. No known SDHI mutations were detected in any of the isolates. Two mutations which confer reduced sensitivity in net blotch to specific strobilurin fungicides and can impact upon field efficacy of these if applied at reduced doses were found. F129L was detected in two of the collections (from a winter barley crop in Tipperary and volunteers in Wexford) and the mutation G137R was detected in a further two collections (both volunteers in Wicklow and East Cork).

The performance of the main barley fungicides for Rhynchosporium control was determined as part of the dose response programme at Oak Park in 2013. Although disease levels were low the strength of the SDHI triazole mixes Adexar and Silta Xpro was evident. As part of the same trial Siltra Xpro and Proline also provided excellent control of mildew which is likely to have contributed to their final yield response. As with wheat, it is essential that anti-resistance measures are taken when applying barley fungicides. This includes the mixing of fungicides with different modes of action.

Cereal Disease Control

Steven Kildea & Liz Glynn
Teagasc CELUP
Oak Park Crops Research

Disease control 2013

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Outline

- Septoria sensitivity
  - Triazole & SDHI
  - Cross-Resistance and consequences
- Fungicide performance
- Net Blotch sensitivity
  - SDHI & QoI (strob)
- Fungicide performance (*Rhyncho & Mildew*)

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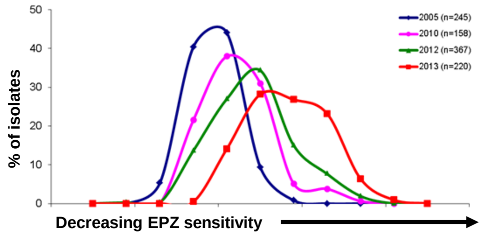
Pathogen sampling

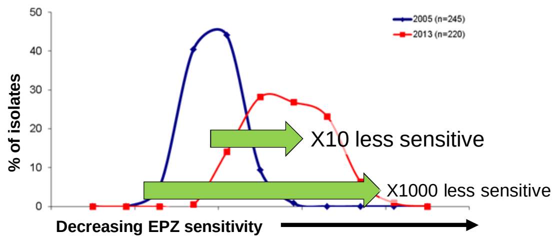
2013 Monitoring

- 12 wheat commercial crops (blue)
- 9 barley crops & stubble (red)
- Septoria on wheat / net blotch on barley
- Sensitivity to triazoles (epoxiconazole & tebuconazole)
- Sensitivity to SDHIs (IZM)
- QoIs

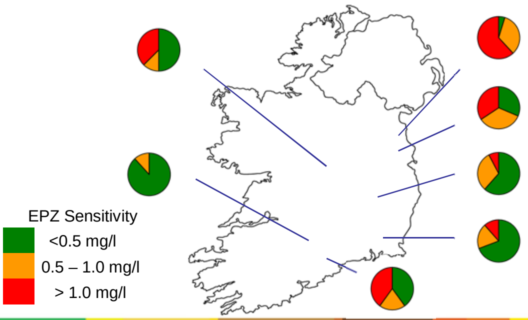
Changes in epoxiconazole (EPZ) sensitivity



Changes in epoxiconazole (EPZ) sensitivity



2012 sensitivity varied between crops



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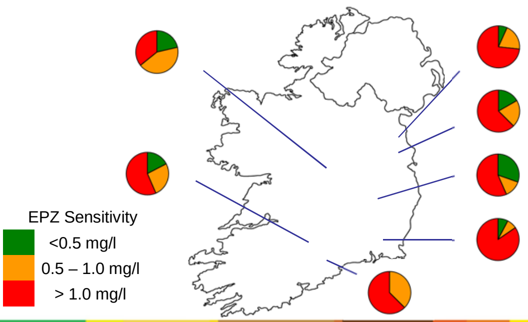
2013 decreased sensitivity in all crops



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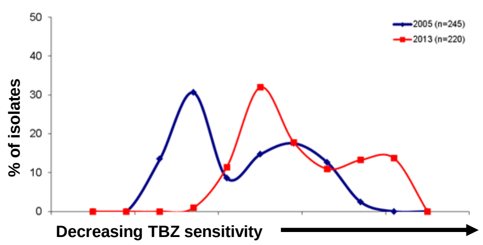
Changes in tebuconazole (TBZ) sensitivity



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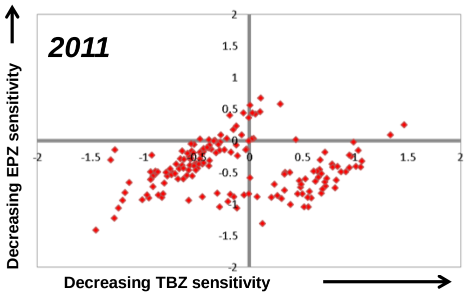
Cross-Resistance between triazoles



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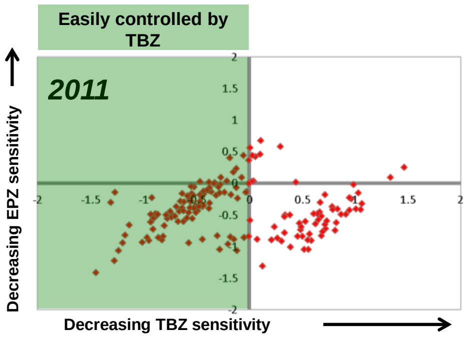
Diversity of triazole activity 2011



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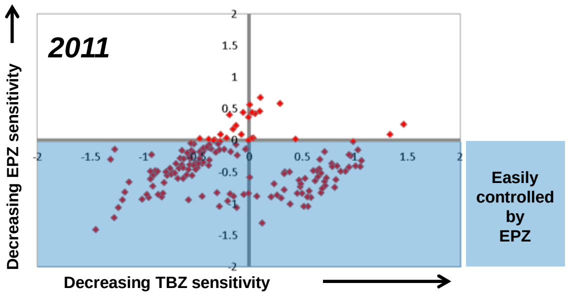

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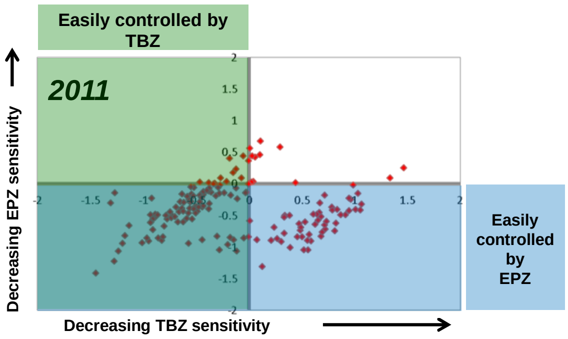
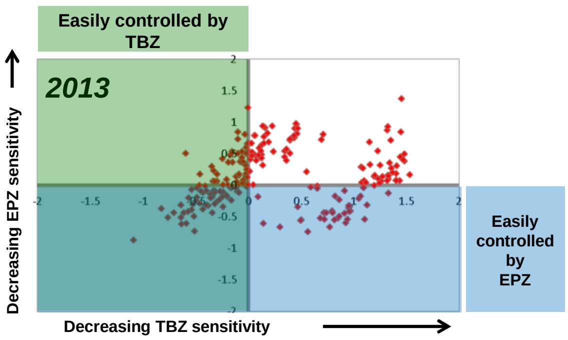


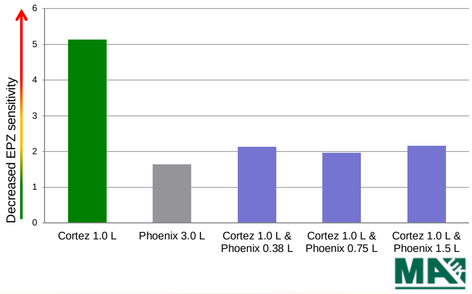
Continued evolution 2013



Can we slow selection?

Action I: Including multi site fungicides

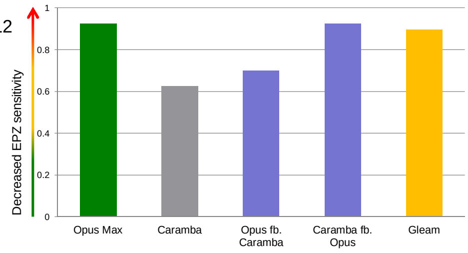
- Trials 2013
  - Meath
  - Oak Park
- T1 & T2 applications
- Sensitivity of septoria



Can we slow selection?

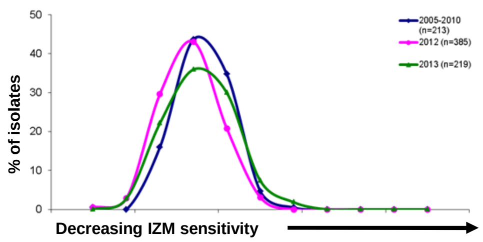
Action II: Alternating / mixing triazoles

- Trials 2011/2012
  - 6 sites
- T1 & T2 applications
- Sensitivity of septoria

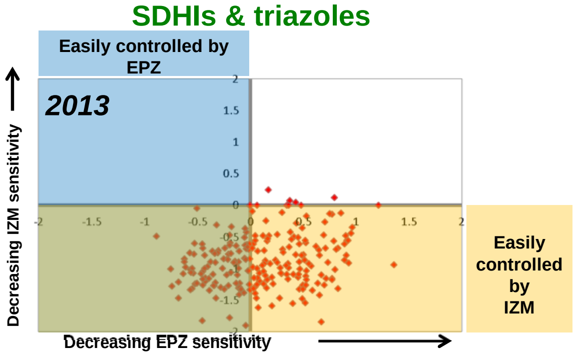


Data courtesy of Hilda Dooley

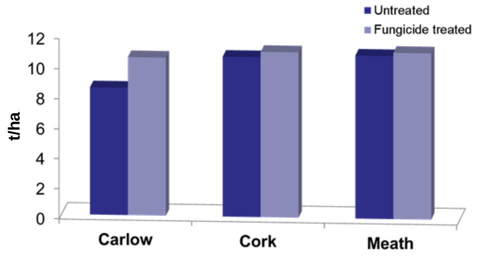
No changes in SDHI sensitivity



No cross-resistance between SDHIs & triazoles



Low response to fungicide programmes



T0	T1	T2	T3
Bravo 1.0L	Proline 0.8L Bravo 1.0L	Adexar 1.6L Bravo 1.0L	Prosaro 1.0L

Wheat summary

2013

Low disease pressure = Low fungicide response

- Erosion of triazole sensitivity continues
- No change in SDHI sensitivity
- Can slow selection for resistance

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Wheat 2014

Winter	T0	T1	T2	T3
Diseases	• Septoria • (Rust)	• Septoria • Stem Diseases	• Septoria	• Fusarium • Septoria
Low Disease	------	100% Triazole & Multisite	SDHI/Triazole & Multisite	Triazole (mix) +/- Multisite
High Disease	Multisite & (Strob)	SDHI/Triazole & Multisite	SDHI/Triazole & Multisite	Triazole (mix) +/- Multisite

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Net Blotch Sensitivity

95 isolates from 9 sites in 2013

QoI (Strobs)

- F129L detected at 2 sites
  - Tipperary: 3:12 isolates
  - Wexford: 1:9 isolates
- G137R detected at 2 sites
  - Cork: 2:14
  - Wicklow: 2:5

SDHI

- No mutations detected

Fungicide Comparison

- Trial at Oak Park 2013 cv. Saffron
- Low – moderate disease
  - Rhynchosporium
  - Mildew
- Single Application
  - T2 – GS33
  - Triazoles/SDHIs
  - Assessed GS59 – Leaf 2

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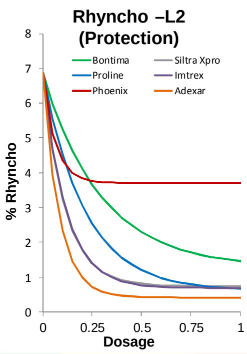
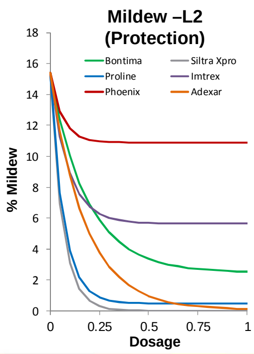
Fungicide Comparison





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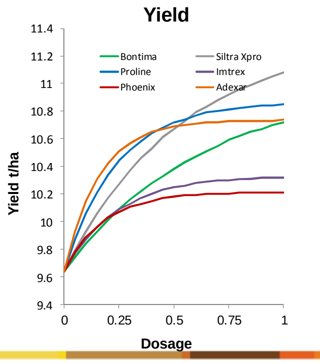
Fungicide Comparison



Barley summary

2013

- Low levels of mutations affecting strobilurins
  - Poorer disease control at reduced rates
  - Impact on 'Older strobs' > 'Newer strobs'
- NO resistance to SDHIs found

Barley 2014

Winter	T1 (GS 25-30)	T2 (GS 32-37)	T3 (GS 39-49)
Diseases	• Rhynchosporium • Net Blotch • (Mildew) • (Rust)	• Rhynchosporium • Net Blotch • (Mildew) • (Rust)	• Rhynchosporium • Net Blotch • Ramularia • (Mildew) • (Rust)
Programme	Triazole (e.g. Proline) & Additional active MOA* (mildewicide)	Triazole & Additional active MOA* (mildewicide)	Triazole & Additional active MOA* (mildewicide)

*Strob *or* SDHI *or* multisite (CTL / folpet)

Barley 2014

Spring	T1 (GS <32)		T2 (GS 37-49)
Diseases	• Rhynchosporium • Net Blotch • (Mildew) • (Rust)		• Rhynchosporium • Net Blotch • Ramularia • (Mildew) • (Rust)
Programme	Triazole (e.g. Proline) & Additional active MOA* (mildewicide)		Triazole & Additional active MOA* (mildewicide)

*Strob *or* SDHI *or* multisite (CTL / folpet)

Thank You

Notes:

Contact Information

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www.teagasc.ie

NDP
National Development Plan 2007 - 2013

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