BCPC Pests & Beneficials Review

Building confidence in beneficials

31 January 2018

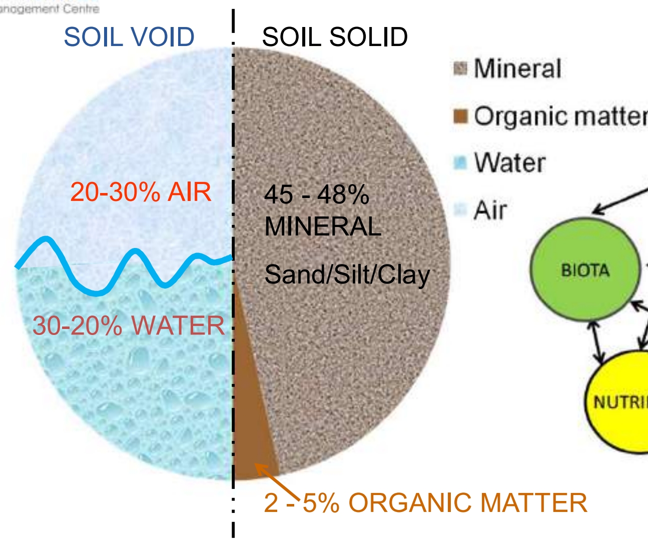
Cultivations and the Health of Soils

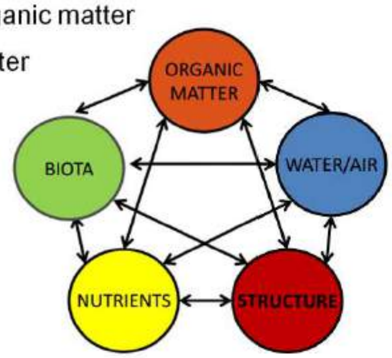
Dick Godwin,

Lucy Crockford, Simon Jeffery & Paula Misiewicz

"*Soil health is the capacity of soil to function as a living system, with ecosystem and land use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health*" – FAO (2008)

Soil constituents and health

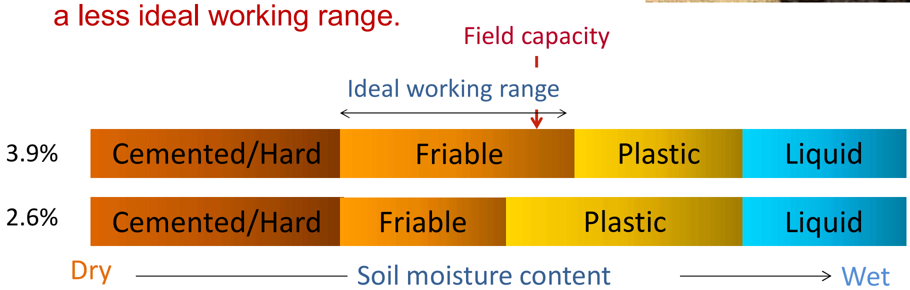




Only "living" things can have health, so viewing soil as a living ecosystem reflects a fundamental shift in the way we care for our soils.

Organic matter depletion

- Silt loam soils in Missouri showed a decline in organic matter from 3.9% to 2.6% over a 60 year period.
- Affects biological and physical aspects of the soil.
- This corresponded to a change in plastic limit moisture content from 27% to 22% and a less ideal working range.



After: Baver et. al., 1972

Soil Organic Matter

House of Commons
Environmental Audit Committee

Soil Health

First Report of Session 2016–17

Harper Adams University

For the Government to meet its ambition for all soils to be **managed sustainably** by 2030, and to ensure **agricultural resilience** and minimise the **effects of climate change**, urgent action is required to reverse this trend and increase carbon levels in all soils.

Every ton of carbon maintained in soil gives **greater flexibility** to the rest of the economy in meeting our carbon budgets.

Calling for a **1% increase in SOM/year** for 20 years
(i.e. from 3% > 3.6%)

Tillage Options

Soil & Water Management Centre

Harper Adams University

- Conventional - Overall disturbance and inversion
- Deep - Overall disturbance
- Shallow
- Minimum tillage

  Shallow and Minimum tillage: Overall disturbance to a shallow depth
- Strip tillage - Till/plant a specific zone
- Direct drill
- No-Till

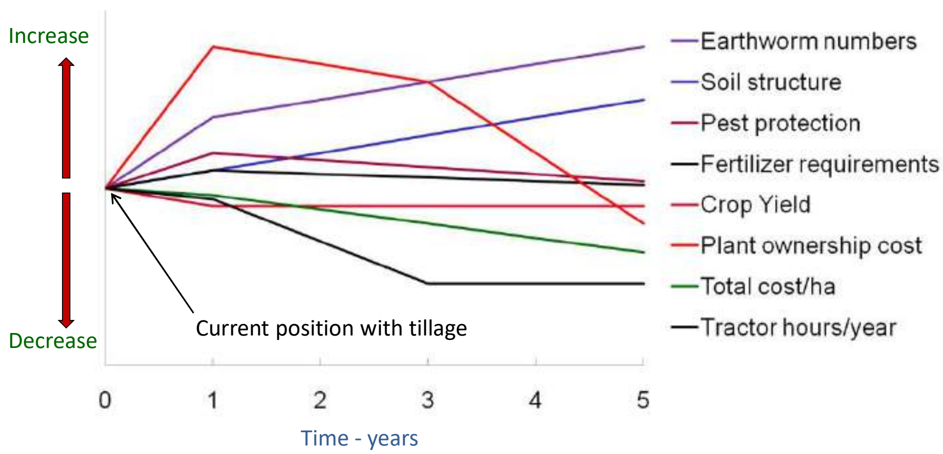
  Direct drill and No-Till: Plant directly into the soil





"Reduced tillage"

Potential effects in converting from tillage to “No-till”

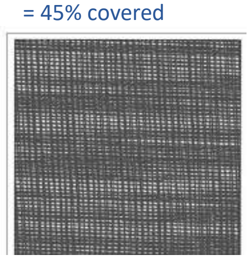


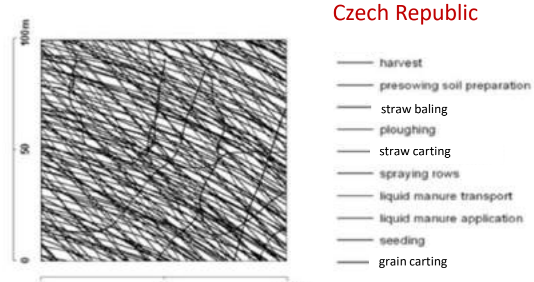
After: Carter, 1994

Random Traffic Problems

Extensive areas of the field are exposed to trafficking

- Random Traffic + plough = 85% covered
- Minimum Tillage = 65% covered
- Direct Drilling = 45% covered





Wheat
Czech Republic

Kroulik et al, 2011

Potato establishment
Shropshire: 84%

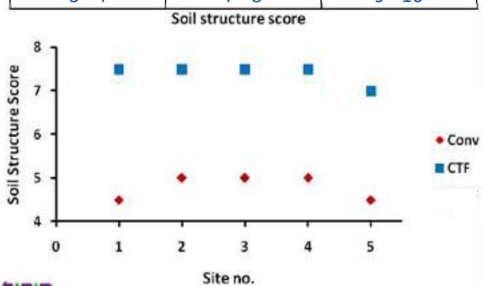
Kroulik , Misiewicz, White and Godwin, 2012

Soil & Water Management Centre

Controlled traffic and soil structure

Harper Adams University

Soil structure score after broccoli harvest		
Conventional traffic & tillage	Controlled traffic	40 year pasture fence line
3 - 4	7 - 8	9 - 10



tia

McPhee et al., 2015

Soil & Water Management Centre

Traffic and Tillage Systems Study

Harper Adams University

Aim: To compare the effects of alternative traffic and tillage systems on crop yield, energy and economics, water holding and infiltration rates over an extended period circa 10 years.

3 x 3 factorial design

9 treatments replicated in 4 randomised complete blocks
= 36 plots in total (each 4m wide)

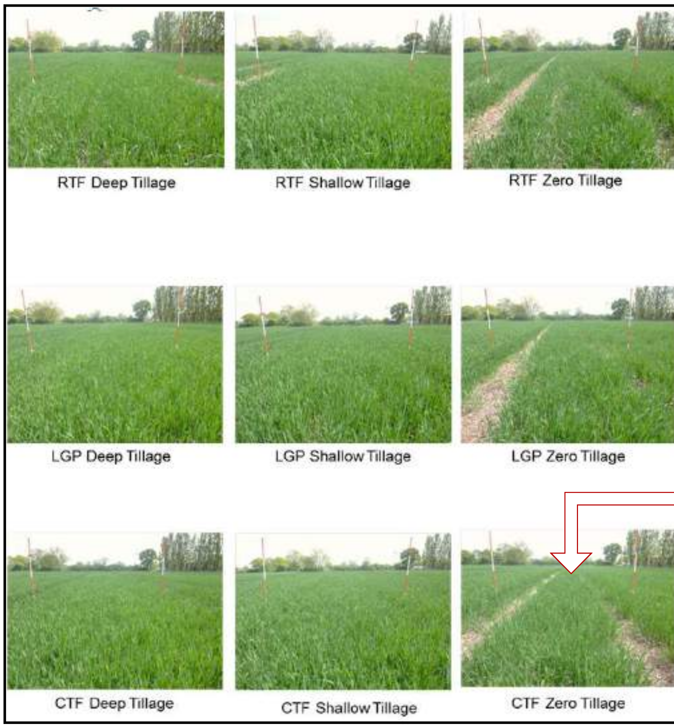
Traffic / Tillage	Random Traffic Farming	Low Ground Pressure	Controlled Traffic Farming
Deep tillage	250mm	250mm	250mm
Shallow tillage	100mm	100mm	100mm
Zero tillage	0mm	0mm	0mm

2011 - 12: Winter Wheat (normalisation year)
2012 - 13: Winter Wheat
2013 - 14: Winter Barley
2014 - 15: Winter Barley
2015 - 16: Cover crop & Spring Oats
2016 - 17: Cover crop & Spring Wheat
2017 - 18: Beans

After: Smith, Misiewicz, Chaney, White and Godwin, 2013/2014

Harper Adams University

Crop condition on 29th May 2013



Zero tillage has a problem in wheel marks in all traffic systems

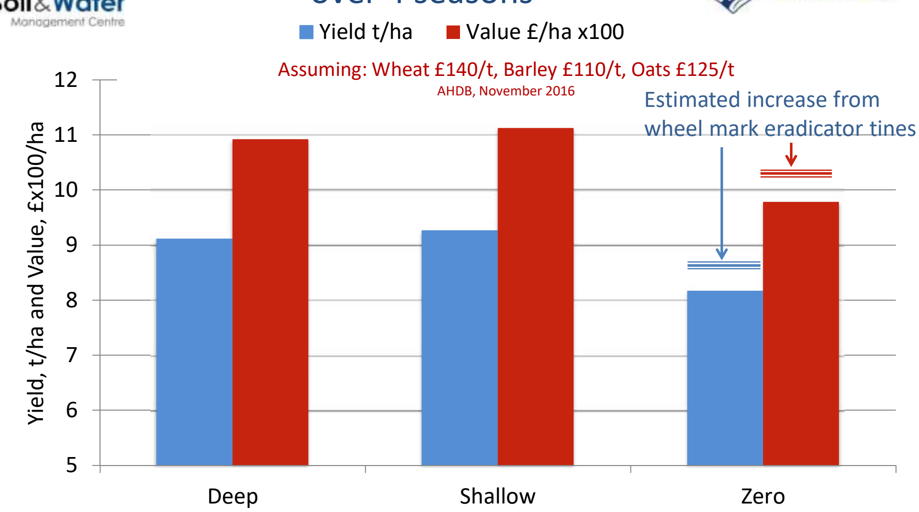
Over 4 years Shallow till performed +15% over Zero till in wheel marks

Smith et al., 2014

Soil & Water Management Centre

Harper Adams University

Average tillage system effects over 4 seasons



Yield of Zero-till is 1.0t/ha (11%) less than mean of Deep and Shallow

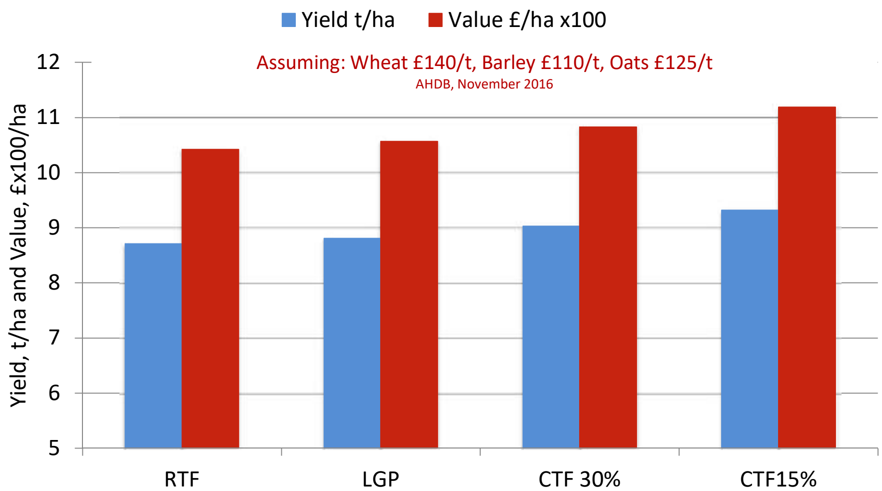
Value of Zero till is £124/ha (11%) less than mean of Deep and Shallow

Yield and value of Shallow are 0.15t/ha and £20/ha greater than Deep

Soil & Water Management Centre

Average traffic system effects over 4 seasons

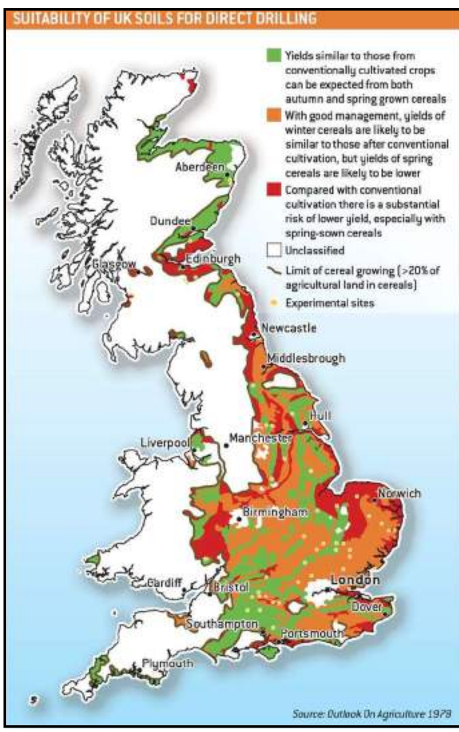
Harper Adams University



Yield of $CTF_{30\%}$ & $CTF_{15\%}$ are 0.32t/ha and 0.61t/ha greater than RTF

Value of $CTF_{30\%}$ & $CTF_{15\%}$ are £41/ha and £77/ha greater than RTF

Yield and value of LGP are 0.1t/ha and £15/ha greater than RTF



Harper Adams University

Provisional classification for soil suitability for Direct Drilling (No-Till) of combine harvested crops.

50 sites; 214 site x years

After: Cannell et al., 1978.

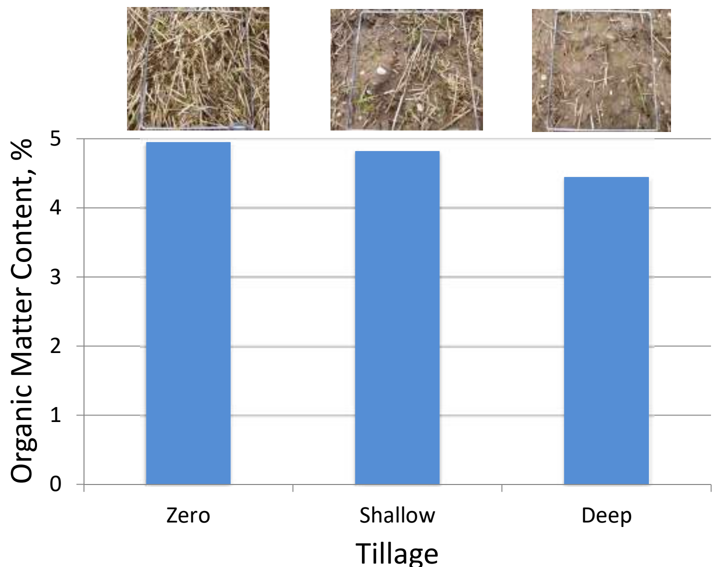
Redrawn by Farmers Weekly, 2015

Soil & Water Management Centre

Harper Adams University

Effect on Soil Organic Matter*

P = 0.005



Traffic effect was not significant

Wookey, 2016

* Loss on ignition – surface layer

Soil & Water Management Centre

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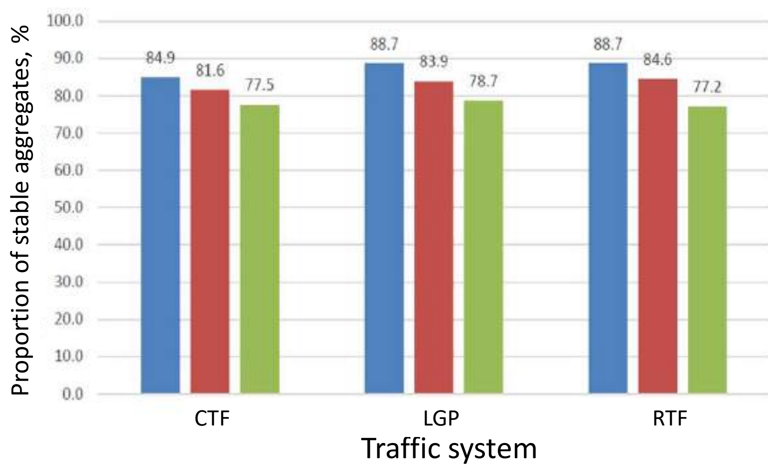
Effect of Traffic and Tillage on Aggregate Stability*

P = 0.02



Tillage
Zero
Shallow
Deep

- Wet sieve test: 80mm diameter x 50mm deep sample; 0.6mm sieve size

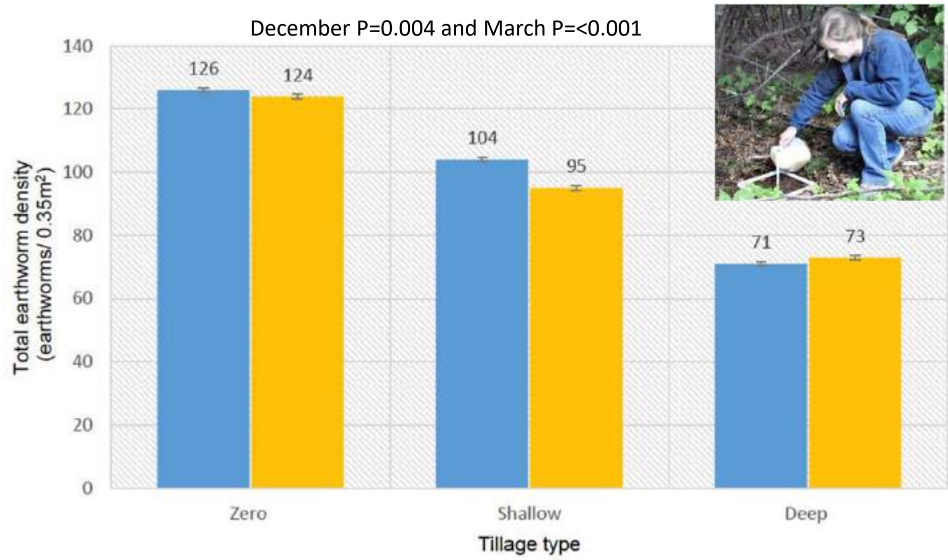
Eijkelkamp, 2008

Abel, 2016

Effect of Tillage on Earthworm Population*

Soil & Water Management Centre — Harper Adams University

December P=0.004 and March P=<0.001



*Mustard solution

Smith V L ., 2016

Benefits of worms and Good Husbandry Practices

Soil & Water Management Centre — Harper Adams University

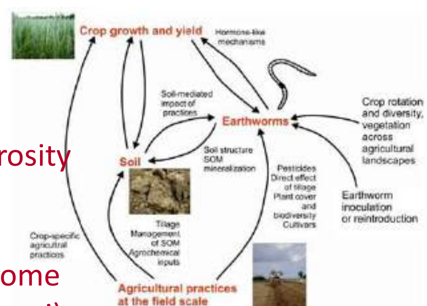
Potential Benefits

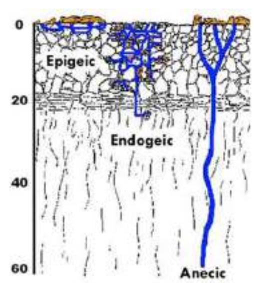
- Improve aggregation and macro-porosity
- Stabilise soil organic matter
- Accelerate nutrient mineralisation
- May decrease negative impacts of some pests and pathogens (nematodes, fungi)

Practices to maintain worm population

- Reduced tillage or No-till
- Reduced use of pesticides
- Increase soil organic matter
- Diversify cropping
- Winter tillage is preferable to Spring

Crockford, 2017





Bertrand et al., 2015

Soil&Water Management Centre

Effect of earthworms

Harper Adams University

- Increased aggregate bulk density by between 0.07 and 0.11 g cm^{-3}
  Lavelle et al. 2004
- Increased porosity by 21%
  Blanchart et al. 1997
- **40t soil/ha/year = 0.4cm topsoil/year**

- Reduce severity of soil borne fungal pathogens
  Stephens et al. 1994
- Reduce damage by plant parasitic nematodes
  Blouin et al. 2005
- Affect aphid development through nutrient content and enhance plant growth
  Scheu et al. 1999 and Eisenhauer and Scheu, 2008

Crockford, 2017

Soil&Water Management Centre

Impact on Nematode Population

Harper Adams University

- Controlled Traffic maintained the sensitive* nematodes more than the other traffic systems. *Larger with a slow reproduction rate.
- Zero tillage combined with High Pressure Traffic plots had significantly higher total abundance of Root-knot nematodes ** than the other treatment combinations. **(*Meloidogyne*)
- The disturbance-tolerant nematodes were most associated with Low Pressure traffic system. i.e. Disturbance is good, compaction is bad.
- Although CTF-Zero-till might appear to be the most conservative method, CTF-Deep tillage was the most beneficial for controlling the parasitic nematodes while maintaining a good population of microbivorous ones.

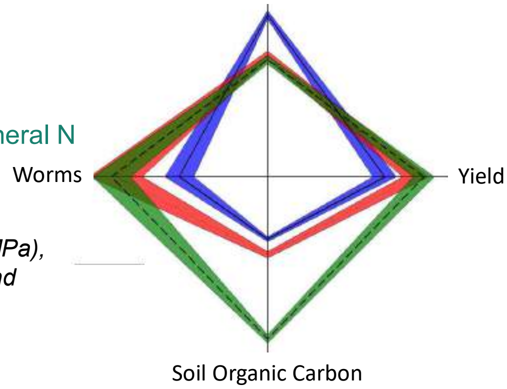
Ahmed et. al., in press Soil Tillage Research

Improving soil structure and crop yield by increasing soil organisms (earthworms).

Harper Adams University

The best additive is FYM
Jeffery, 2017

Hoosfield at Rothamsted



Mineral fertiliser only
FYM since 2001 plus mineral N
FYM annually since 1852 plus mineral N

*Barley yield (7.74, t ha^{-1}),
Topsoil Mechanical Impedance (4.2 MPa),
Earthworm fresh mass (32.2 g m^{-2}) and
SOC (35.3 g kg^{-1}).*

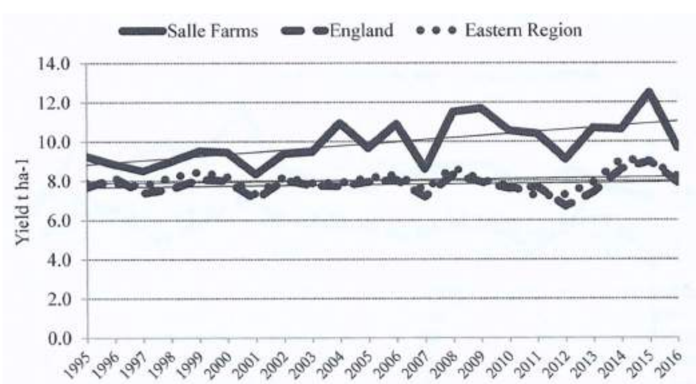
Whitmore, 2016

Benefits of a 7 year rotation

Soil & Water Management Centre

Harper Adams University

Including Limex 70, cover crops & turkey manure
Winter wheat yields for Salle Farms, Norfolk



Wheat and Spring Barley yield increased on average 0.10t/year
3 machines established all combinable crops - Carrier, Opus, Rapid
Anticipate further reductions in tillage depth (& power requirement).
Hovesen, Aspects of Applied Biology 134, 2017

Conclusions

- Minimising cultivation depth and disturbance can help improve soil health by raising soil organic matter content, worm and some nematode populations and soil structure, with little negative impact on crop yield.
- Pay attention to the effect of field traffic: reducing tyre inflation pressure and controlled traffic systems can help maintain soil structure, crop yield, soil fauna (and water infiltration rates).
- FYM is the best source of additional organic matter.
- To test for soil health – bury 2 pairs of cotton underpants for 8 weeks!

Ploughed No-till

McKenzie, 2017 and AHDB, 2017

Acknowledgements

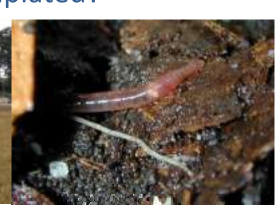
To the many students and staff of Harper Adams University that assisted in the data collection and analysis of the

Tillage x Traction study:

namely

David White, Keith Chaney, Ed Dicken, Matt Back, Keith Chaney
Emily Smith, Anthony Millington, Mohammed Ahmed,
Martin Abel, Vicky Smith, William Wookey, Tim Dicker

With a 6 year experiment well underway should a "Beneficials" study be contemplated?

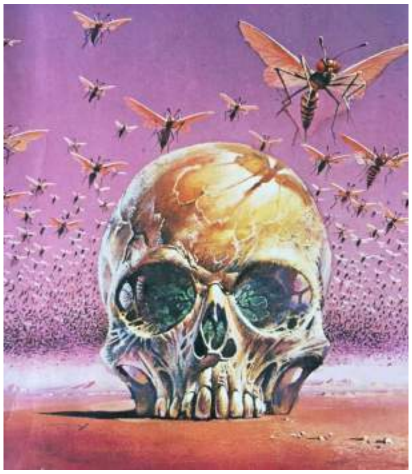


Conservation Agriculture,

Experiences and Possibilities

Andrew Barr

Pulling out the arms race…



…before it's too late !




AHDB (2014), *Encyclopaedia of pests and natural enemies in field crops,* Agriculture and Horticulture Development Board

Clark, S., Szlavecz, K., Cavigelli, M.A. and Purrington, F. (2006) Ground beetle (Coleoptera: Carabidae) assemblages in orga nic, No-till and chisel-till cropping systems in Maryland. *Environmental Entomology* 35, 1304-1312

Davis, H.N., Currie, R.S., French, B.W. and Buschman, L.L. 2009. Impact of land management practices on carabids (Cole optera: Carabidae) and other arthropods on the Western High Plains of North America. *Southwestern Entomologist* 34, 4 3-59.

Dosdall, L.M., Dolinski, M.G., Cowle, N.T. and Conway, P.M. (1999) The effect of tillage regime, row spacing and seeding rate on feeding damage by flea beetles, Phyllotreta spp. (Coleoptera: Chrysomelidae), in canola in central Alberta, Cana da. *Crop Protection* 18: 217--224

Holland J. M., Oakley J., (2007) Importance of arthropod pests and their natural enemies in relation to recent farming practice changes in the UK. *HGCA Research Review*, 64

Kennedy, T.F., McDonald, J.G., Connery, J. and Purvis, G. (2010) A comparison of the occurrence of aphids and barley y ellow dwarf virus in minimum--till and conventional--till autumn--
-sown cereals. *The Journal of Agricultural Science* 148: 406--419.

Schmidt, M.H., Lauer, A., Purtauf, T., Carsten, T., Schaefer, M., Tscharntke, T. (2003) Relative importance of predators and parasitoids for cereal aphid control. Proceedings of the Royal Society of London 270, 1905-1909

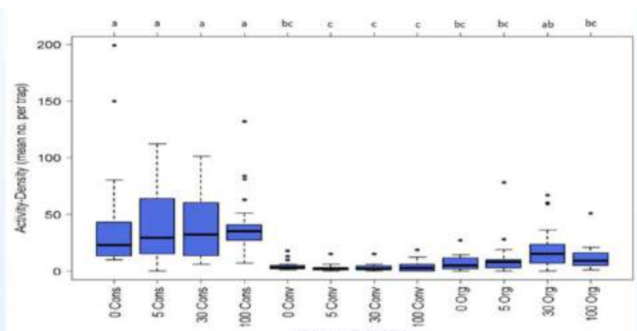
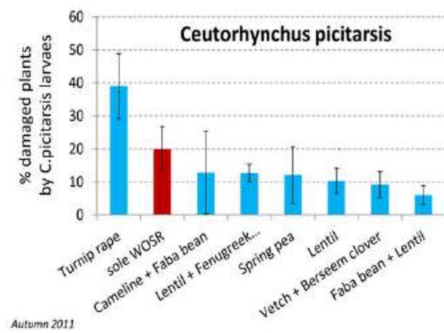


Figure 3. Mean carabid activity-density on farms at different distance into crop in 2014

S. Springate & J. P. Haggar Natural Resources Institute,
University of Greenwich, UK

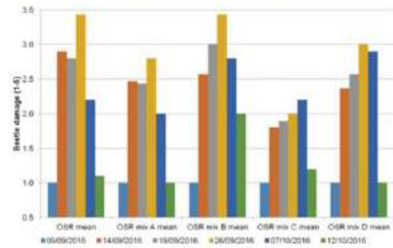
Companion Cropping Potential



CETIOM, France

Companion Cropping oilseed rape and vetch
- any effect on flea beetle or aphid numbers ?

Figure 1. Cabbage stem flea beetle damage interactions with companion crop mixtures – Morley – mean of three OSR seed rates



Results and observations from both Hinxton and Morley suggest that there is scope for the use of companion crops, on a commercial scale, to protect emerging crops from the most damaging attacks by cabbage stem flea beetles.

Of the species investigated over a two year period, the most likely candidate for this role is white mustard.

NIAB

Wheat Companion Cropping

NIAB

IGER

Reading University

Flex 840	20: 8: 0 plus	S
Flex 1163	16: 13: 0 plus	S, Mn, B, Zn
Flex 4071	7: 18: 1 plus	S, Mg, Mn, B
Flex 2844	8: 15: 0 plus	S, Mg, Mn, B
Yara	16.5: 33: 0	
Yara	18:27:00	
Yara	24:18:00	
Yara	08:24:00	
Bio 8301	Urea plus	N, Molasses
Bio 9802	9: 14: 1 plus	S, Mn, Zn
Bio 9806	9: 14: 0 plus	Molasses
Bio 983,1	N 10 plus B	Boron
Bioplus	Biological	N, P, rooting
Bioplus T	Biological	N, P, rooting
Bacillus	Biological	Rooting
Digest	Biological	Digestion
Amino A	Amino acids	Microbial Partner
Trikelp	3 Seaweeds	Microbial Partner
Biostim XI	Liq Seaweed	Microbial Partner
Flex 466,5	N6 plus Fe	S, Mg, Mn, Cu, Zn, Fe
Flex 466,6	N6 plus	S, Mg, Mn, Cu, Zn
Flex 471,1	N2 plus Fe	S, Mg, Mn, Fe
Flex 471	N2 plus	S, Mg, Mn

"The gardener or farmer also

benefits in that they

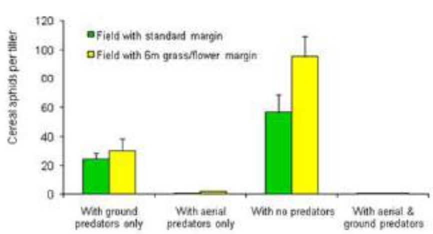
soon learn that any crop with 12 or

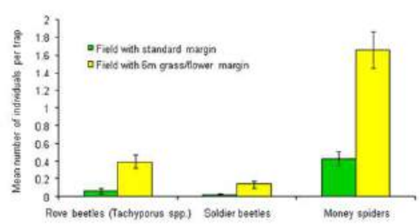
better leaf Brix

will not be bothered by insect pests."

www.bionutrient.org

Housing Shortage ?





Game and Wildlife Conservation Trust

FLOWERS

Common name	Family name	Latin bi-nomial
Fennel PER NATURAL	Apiaceae	Foeniculum vulgare
Tansy PER NATIVE	Asteraceae	Tanacetum vulgare
Yarrow PER NATIVE	Asteraceae	Achillea millefolium
Perennial cornflower PER NonNATIVE	Asteraceae	Centaurea montana
Oxeye daisy PER NATIVE	Asteraceae	Leucanthemum vulgare
Bird's foot trefoil PER NATIVE	Fabaceae	Lotus corniculatus
Red clover PER NATIVE	Fabaceae	Trifolium pratense
White clover PER NATIVE	Fabaceae	Trifolium repens
Tufted vetch PER NATIVE	Fabaceae	Vicia cracca
Cornflower ANN NATURAL	Asteraceae	Centaurea cyanus
Borage ANN NonNATIVE	Boraginaceae	Borago officinalis
Scorpion weed ANN NonNATIVE	Boraginaceae	Phacelia tanacetifolia
Common vetch ANN NATURAL	Fabaceae	Vicia sativa
Red dead nettle ANN NATURAL	Lamiaceae	Lamium purpureum
Yellow rattle ANN NATIVE	Orobanchaceae	Rhinanthus minor
Buckwheat ANN NonNATIVE	Polygonaceae	Fagopyrum esculentum
Bishopsweed ANN NATURAL	Apiaceae	Ammi majus
Viper's bugloss BI NATIVE	Boraginaceae	Echium vulgare
Teasel BI NATIVE	Dipsacaceae	Dipsacus fullonum

	Premium	Budget
3 ha light soil	**£5,800**	**£5,500**
2 ha heavy soil	**£4,100**	**£3,700**

GRASSES

Common name	Family name	Latin bi-nomial
Common bent grass	Poaceae	Agrostis capillaris
Creasted dog's tail	Poaceae	Cynosurus cristatus
Cat's tail	Poaceae	Phleum bertolonii

	Premium	Budget
3 ha light soil	**£2,500**	**£2,500**
2 ha heavy soil	**£3,600**	**£3,600**

£ 2,667 to

£ 3,850

per hectare

Feeding…. the plants , the soil, the predators, the pests?

Bell J. R., Traugott M., Sunderland K. D., Skirvin D. J., Mead A., Kravar-Garde L., Reynolds K., Fenlon J. S., Symondson W. O. C. (2008) Beneficial links for the control of aphids: the effects of compost applications on predators and prey. *Journal of Applied Ecology*, 45, 1266–1273

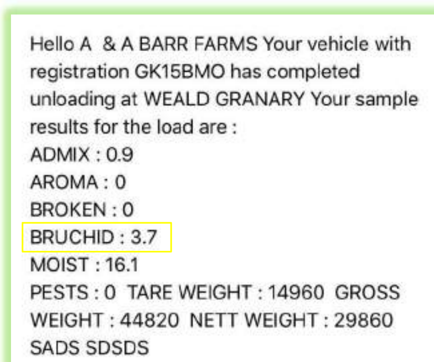
SPRAYING LESS MEANS LESS SPRAYING ?

Insecticides are used to manage pests, however, in some cases they also disrupt biological control, leading to unintended outbreaks of target or non-target pests (Geiger et al., 2010; Settle et al., 1996; Stern et al., 1959).

Meta-analysis reveals that seed-applied neonicotinoids and pyrethroids have similar negative effects on abundance of arthropod natural enemies
Margaret R. Douglas, John F. Tooker
Published December 7, 2016

No early fungicides –
Dwayne Beck, Dakota Lakes Research Centre
Dr Kristine Nicholls, Rodale Institute

Gull H. T., Saeed S., Khan F. Z. A. (2014) Entomopathogenic fungi as effective insect pest management tactic: a review. *Applied sciences and business economics,* 1, 10-18



Anti-pesticide farm initiative passes the signature stage

THIS CONTENT WAS PUBLISHED ON JANUARY 18, 2018 3:29 PMJAN 18, 2018 - 15:29

SWI swissinfo.ch

Campaigners have handed in 114,420 signatures by Swiss citizens in favour of the "Clean Drinking Water and Healthy Food" initiative, which aims to cut direct subsidies to farmers who use pesticides or antibiotics.

A Plan…

Osr
Architect
Companion crop – beans /clover/ cereal volunteers
Trap crop – turnip rape / kale
HSS and prepare to be flexible
Do not spray for pollen beetle or seed weevil

Wheat
Skyfall / Zyatt?/ Deter ?
Clover understory / keep osr vols
Not too early / apply compost
No T0 fungicide
No aphicide in autumn

Beans
Spraying pointless ?
Or parasitic fungi ?
Plant into rye /oats cover crop mulch

Backed up by
No-till
Compost / manure
Urea / UAN / foliar nutrients
Countryside Stewardship
LEAF Marque
Field specific monitoring alerts
Patience, flexibility

Andrew Barr

a.barr@eastlenhamfarm.co.uk

Effect of Different Intensities of Soil Cultivation on Extended Phenotypes and Predator Dynamics of *Tenuiphantes Tenuis*

NIAB uclan Myerscough College Opportunities for all to succeed

Anna Harper

Background

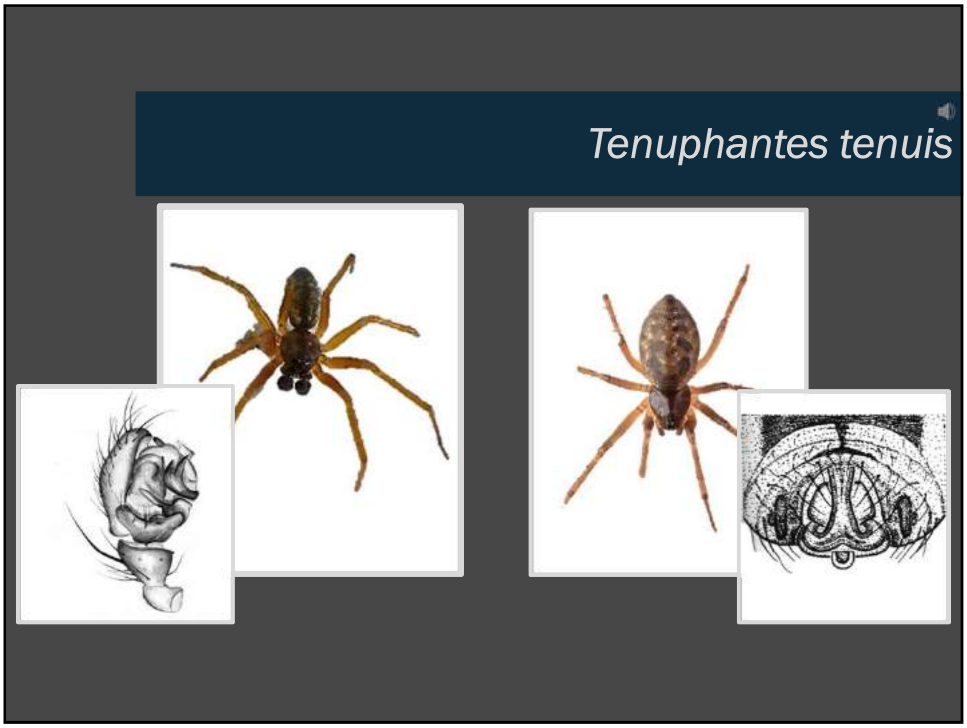
Childerley Farm, Cambridge
Examining impact of a direct drilling on soil and crop performance.

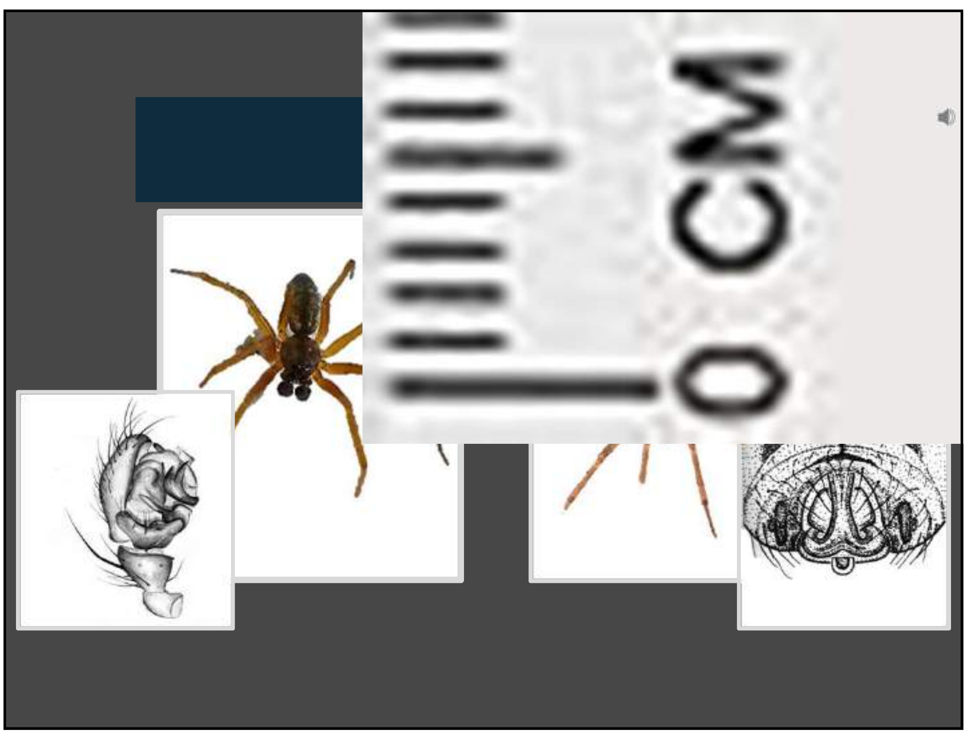
Conventional

Secondary Cultivation

Direct Drill

Conventional vs Direct Drill


Tenuphantes tenuis



Why *T. tenuis*

- 100 % Carnivorous
- They capture more pests than they eat
- They can gorge and starve themselves
- They are not vectors of crop disease

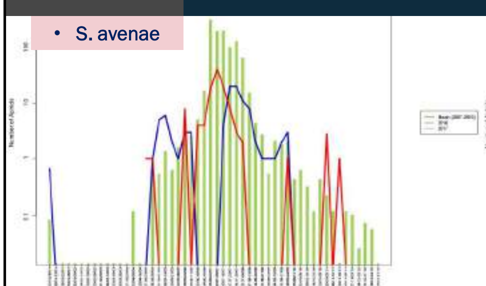
Why *Are Aphididae spp* A Problem?

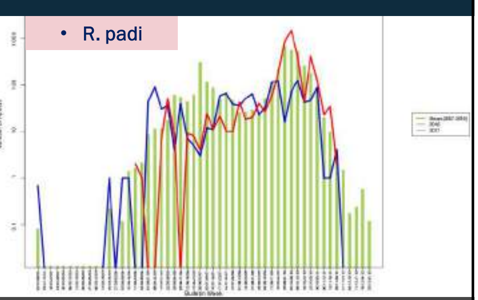
- Direct feeding of phloem depletes photo assimilates - monosaccharides
- They are vectors of disease
- Increasing resistance to insecticides
- *A. Pisum* – honeydew they produce encourages fungal growth

❖ Loss of yields = Loss of income

Acyrthosiphon pisum

Why *Are Aphididae spp* A Problem?





- April 2017 – Scotland - First cereal aphids were caught in traps 3 weeks earlier than average. (SASA, 2017)
- December 2017 – Preston - Bird cherry - oat aphid numbers were unusually high. Sites are at or near their ten-year mean. Early emergence dates have presented a build-up of virus vector pressure. (AHDB, 2017)

Project Aims and Objectives

Aims:
To identify the potential biological control of *T. tenuis* of Aphididae spp. within different intensities of tillage in an arable crop.

Objectives:
- Observe behavioural changes in *T. tenuis*
- Identify differences in extended phenotypes – Webs
- Measure web location

In the different tilled areas

- Quantify *T. tenuis* biological control -
  Compare Aphididae spp. numbers in *T. tenuis* webs & *T. tenuis* gut with Aphididae spp. population

Methodology – In The field

Methodology – In The field

Methodology – In The field

Methodology – In The field

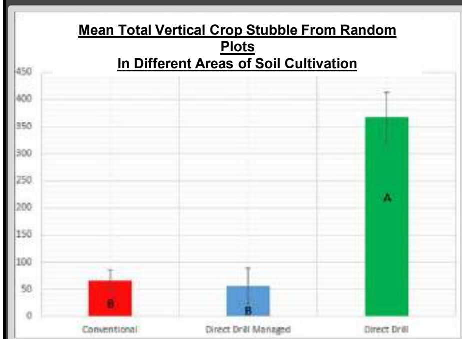
Methodology – In The field


Methodology – In The field


Methodology – In The field

Results from the field

April – Spring Barley



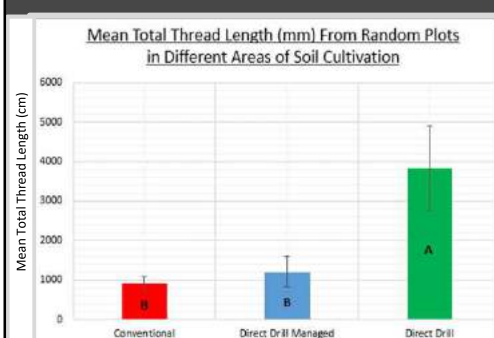
P-Value - 0.001


Conventional

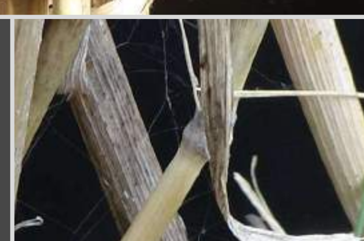

Direct Drill

Results from the field

April – Spring Barley



P-Value - 0.001



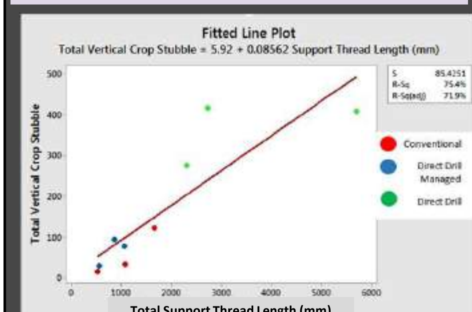
Results from the field

April – Spring Barley

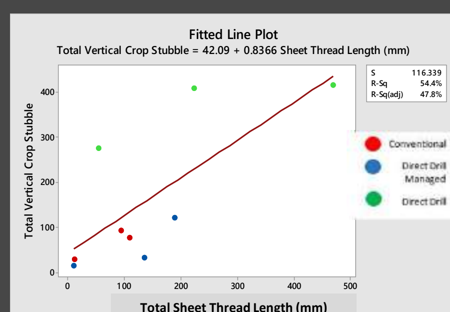
P-V

Results from the field

April – Spring Barley



P-Value - 0.002



P-Value - 0.023

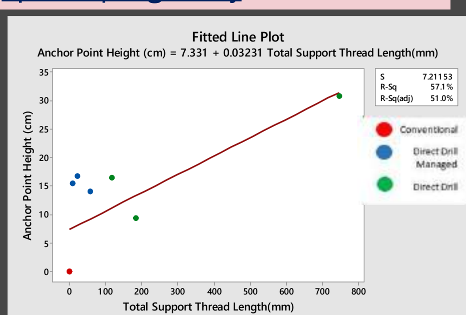
Results from the field

April – Spring Barley

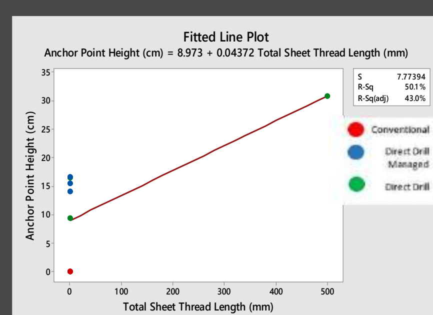
P-Value - 0

Results from the field

April – Spring Barley



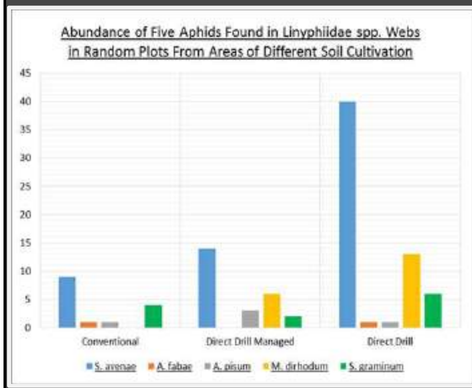
P-Value - 0.020

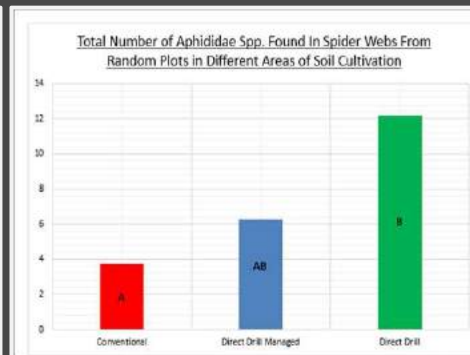


P-Value - 0.033

Results from the field

July – Winter Wheat



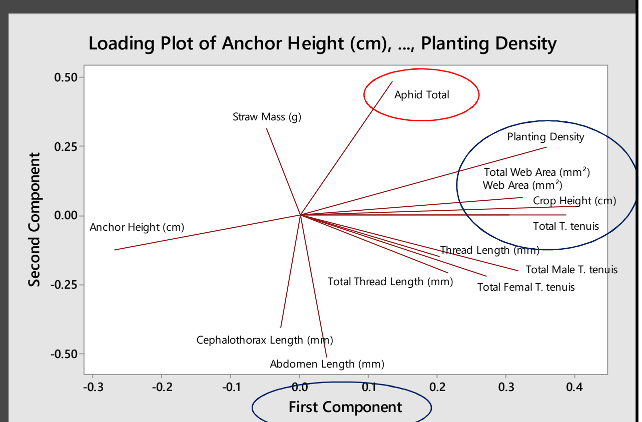


P-Value - 0.037

Results from the field

PCA – Loading Plot
Field Data June 2017

- Total *T. tenuis* - 0.388
  Male - 0.317
  Female - 0.272
- Total Web Area - 0.407
- Planting Density - 0.358
- Aphid Total - 0.135



Discussions from the field

- Significant Positive Regression – Total Stubble Vs Total Thread Length

Stubble may provide a sturdier base for attachment than crop.
The highly mobile *T. tenuis* is inclined to construct webs at a fast pace.

- Significant Positive Regression – Anchor Height Vs Total Thread Length

T. tenuis have preference to anchor their webs high in a habitat. A high web will intercept an increased number of prey.

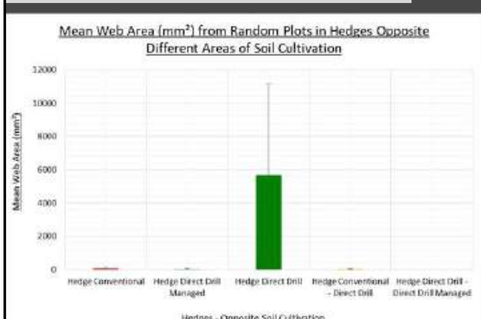
- PCA- First Component = Total *T. tenuis,* Planting Density – High Association
  Male more influence than females
  Second Component = Aphid Total – Lower Association

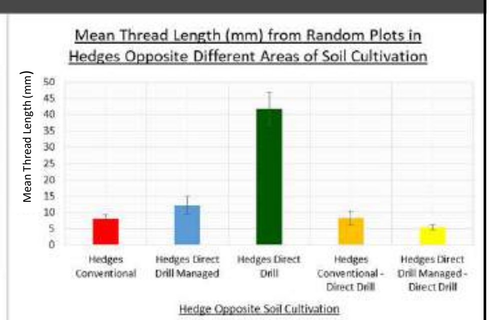
Less reliance on stubble. Higher heterogeneity with crop.
Males ready to mate – create sperm induction webs.

Are *T. tenuis* numbers associated with abundance of Aphididea spp?

Results from the field - Hedges

November – Winter Wheat





P - Value – 0.001 Kruskal Wallis

P - Value – 0.001

Results from the field - Hedges

November – Winter Wheat

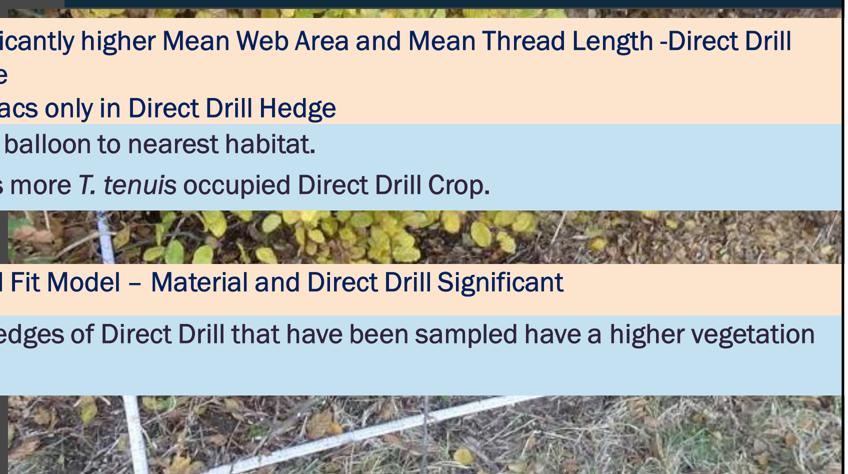
- General Linear Model
- Anchor Height against
  - Soil Cultivation, Material, Distance from Field Margin
- R-Sq = 81.36% - Model fits the data
- Material
  Branch *P – Value 0.001* Grass *P – Value 0.003*
- Soil Cultivation
  Direct Drill Cultivation *P – Value 0.026*
  = Statistically significant association between response variable and the term

Results from the field - Hedges

December – Winter Wheat

- No Significance Difference –
  Egg Sac Dimensions & Anchor Point Height
- Egg Sacs only found in Direct Drill hedges.

Discussions from the field - Hedges



- Significantly higher Mean Web Area and Mean Thread Length -Direct Drill Hedge
- Egg Sacs only in Direct Drill Hedge

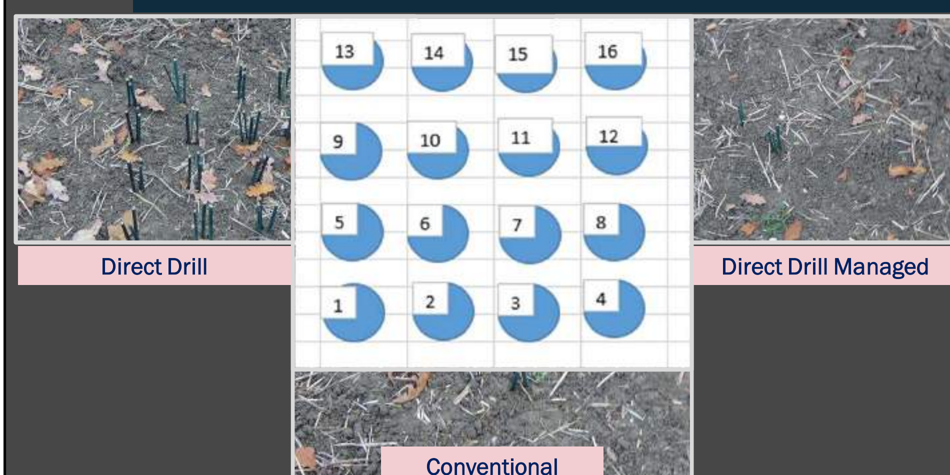
T. Tenuis balloon to nearest habitat.

Suggests more *T. tenuis* occupied Direct Drill Crop.

- General Fit Model – Material and Direct Drill Significant

Do the hedges of Direct Drill that have been sampled have a higher vegetation density?

Stubble on Conventional

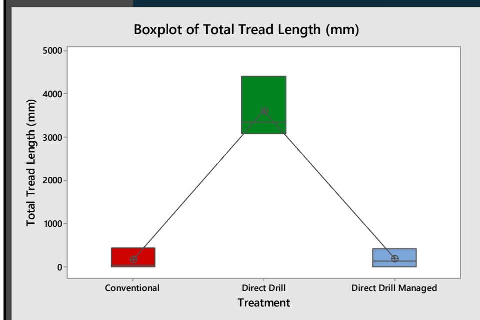


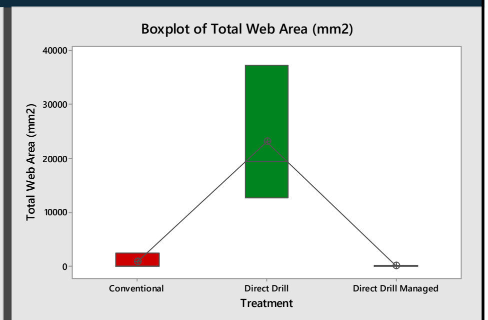
Direct Drill

Direct Drill Managed

Conventional

Results from Stubble on Conventional





P – Value - 0.001

P – Value - 0.013

- No significant difference to anchor points on outside stubble or inside stubble.

Discussion Stubble on Conventional

- Significance Difference in Total Thread Length & Total Web Area – Greatest in Direct Drill

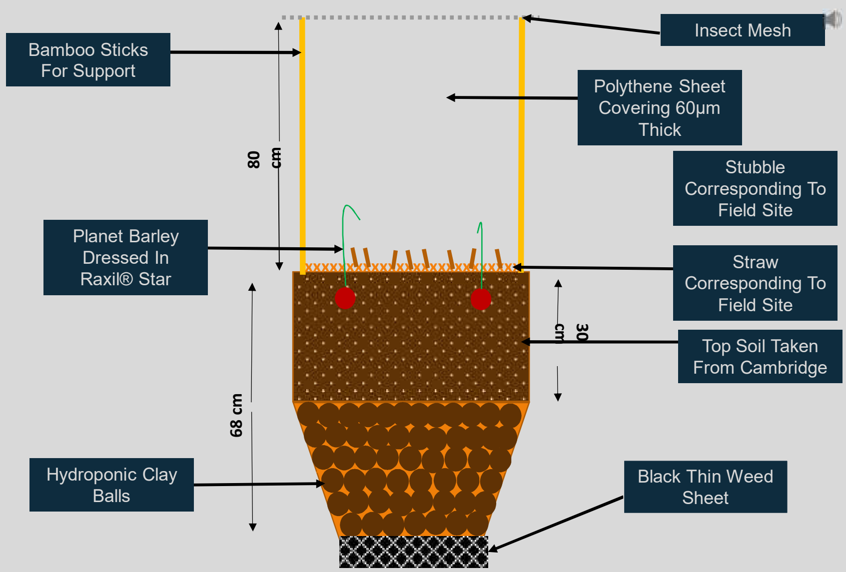
Again stubble huge importance.
How can the stubble be left after conventional tillage?

Laboratory Experiments

Mesocosm One – Growth of Barley in The Glass House

Why?
Remove External Variables
- Wind / Rain
- Shelter

Allow for closer examination
- Web Design



Methodology – Mesocosm One

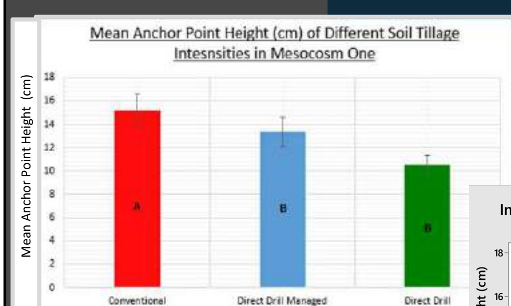
Imitating Intensity of Soil Cultivation

Conventional

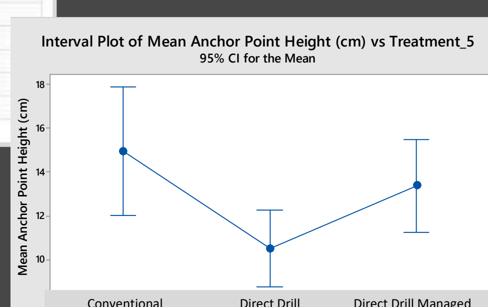
Direct Drill Managed

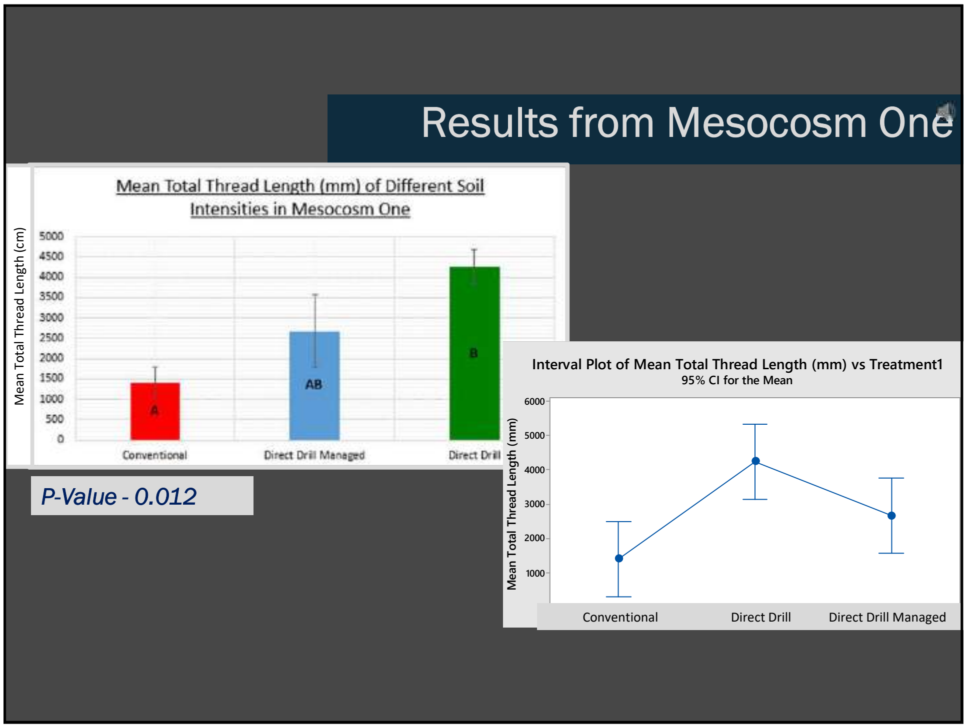
Direct Drill

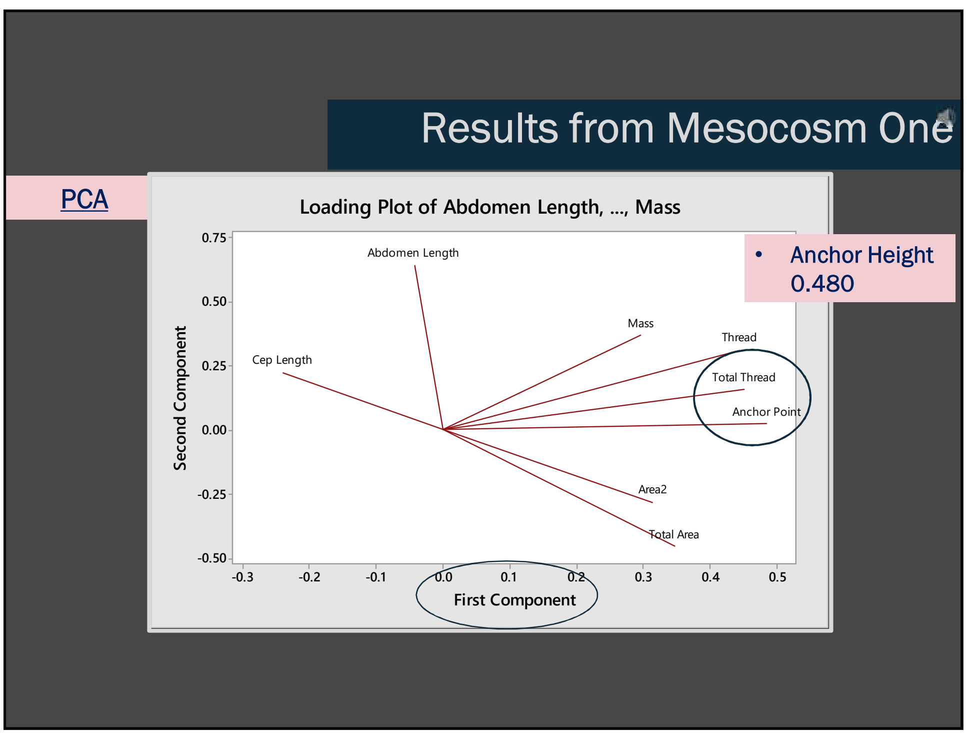
Results from Mesocosm One



P-Value - 0.017




Results from Mesocosm One
Mean Total Thread Length (mm) of Different Soil Intensities in Mesocosm One
Mean Total Thread Length (cm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
A
AB
B
Conventional
Direct Drill Managed
Direct Drill
P-Value - 0.012
Interval Plot of Mean Total Thread Length (mm) vs Treatment1
95% CI for the Mean
Mean Total Thread Length (mm)
6000
5000
4000
3000
2000
1000
Conventional
Direct Drill
Direct Drill Managed


Results from Mesocosm One
PCA
Loading Plot of Abdomen Length, ..., Mass
Second Component
0.75
0.50
0.25
0.00
-0.25
-0.50
Abdomen Length
Cep Length
Mass
Thread
Total Thread
Anchor Point
Area2
Total Area
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
First Component
• Anchor Height 0.480

Discussion Mesocosm One

- Significance Difference in Total Thread Length

Direct drill has shown to support more *T. tenuis* activity due to a more complex environment.

- Significance Difference in Anchor Height

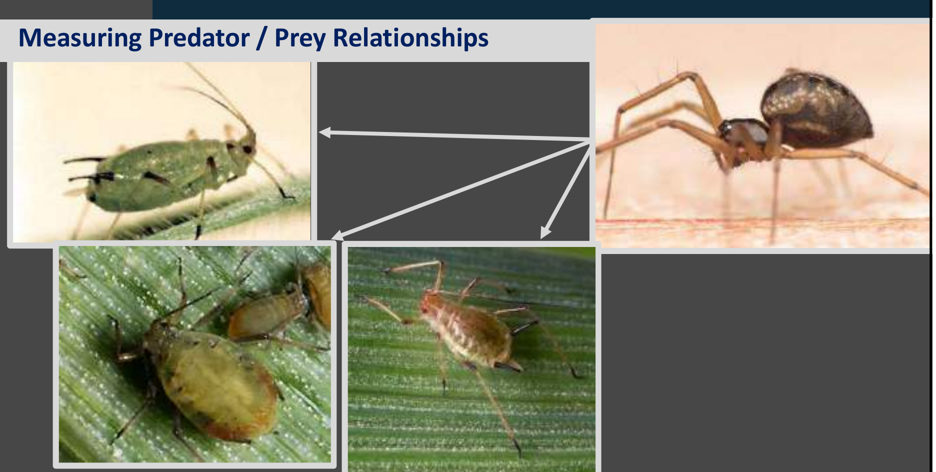
High attachment points in conventional may be due to less stubble.

- PCA shows Anchor Height and Thread Length are closely associated.

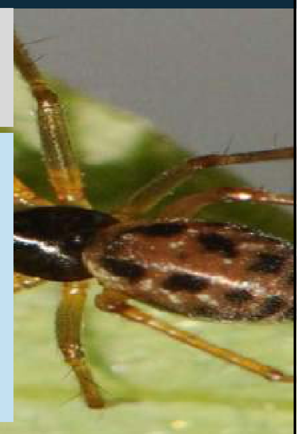
The decision where a thread is anchored is key for thread spinning for web creation.

DNA Barcoding for Gut Analysis

Measuring Predator / Prey Relationships



Further work



Field Work

- Carry on Field Work until December 2018

Laboratory Work

- Specific Aphid DNA Primers - Validate
- Aphid DNA analysis in *T. tenuis* gut and on webs

- Mesocosms to see how soil tillage intensity may effect:

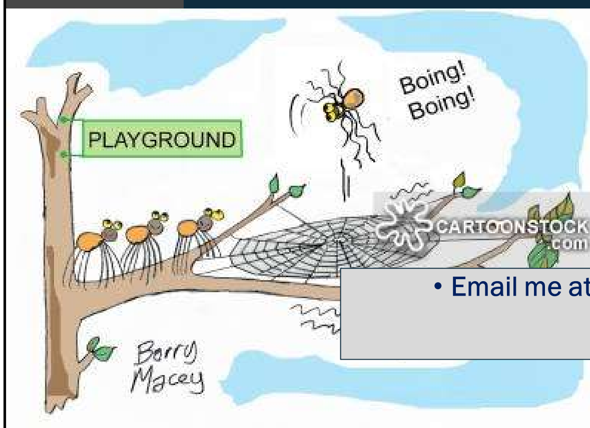
❖Renewal of webs
❖Occurrence of 2-layered sheet web

Acknowledgements

- Thank you to my Spider Supervisors -

- Dr. Richard Collins
- Dr. Jaime Martin
- Dr. Kevin Butt

Any Questions



- Email me at acampbell@myerscough.ac.uk

I will be happy to answer!!!

BCPC

Refreshments
11:15 – 11:30

SPONSORS

We are very grateful to the following companies who have sponsored the BCPC Pests & Beneficials Review 2018

BAYER Bayer CropScience CERTIS DOW Dow AgroSciences DUPONT syngenta

Successful application of biocontrols in outdoor crops

Michelle Fountain, Chantelle Jay, Jean Fitzgerald, Jerry Cross, Csaba Nagy, Alvaro Delgado, Adrian Harris, Bethan Shaw, Maddie Cannon

Introduction

- **Biological control**
- Parasitoids, predators and pathogens

- **Conservation biological control** (Kenneth W. McCravy)
- practices - maintain and enhance reproduction, survival and efficacy of natural enemies
- avoidance of harmful practices
- knowledge of biology and requirements needed
- **Inductive (augmentation)** - large population of natural enemies administered for quick pest control – PREVENTATIVE or CURATIVE
- **Classical (importation)** - where a natural enemy of a pest is introduced in to a new area

Plant Science into Practice

NIAB EMR

- Conservation biological control

Plant Science into Practice

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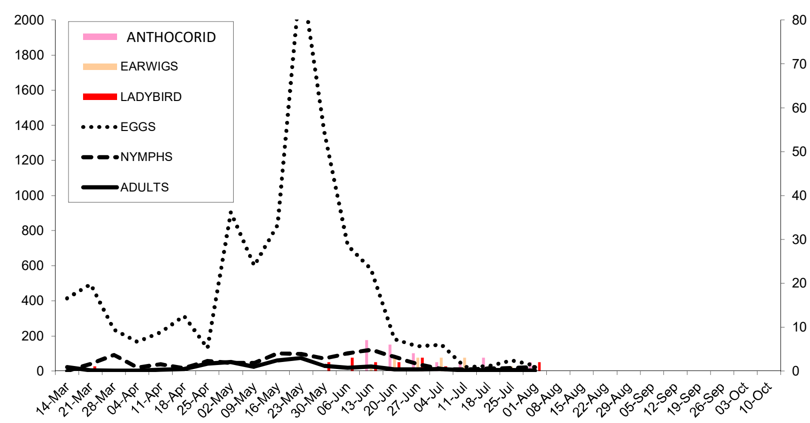
Pear sucker damage

Pear sucker out of control



Plant Science into Practice

Plant Science into Practice

NIAB EMR

Modern Italian alder windbreaks

Devoid of biological control

Plant Science into Practice

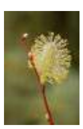
NIAB EMR

Sources of anthocorids

Early



Stinging nettle
(*Urtica dioica*)




Goat and grey
willow (*Salix*)



Hawthorn
(*Crataegus*)

Late



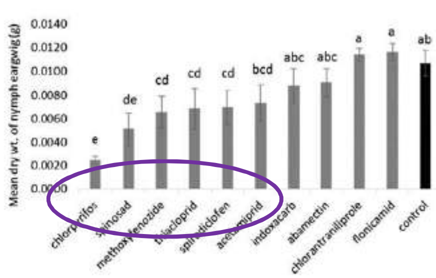
Hazel
(*Corylus avenana)*

Plant Science into Practice

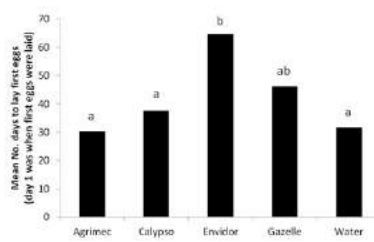
Common earwig
(Forficula auricularia)

Lab tests of sub-lethal effects on nymphs

Growth



Egg laying

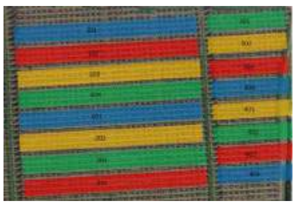


- Combined autumn and spring earwig mortality and delayed egg laying = third fewer eggs the following year with some insecticides

Plant Science into Practice

Field applications

- Single applications of some insecticides early or late in the growing season had no discernible effect on earwig numbers in the field
- However earwig nymphs may be more sensitive to products from May onwards when they move into the trees

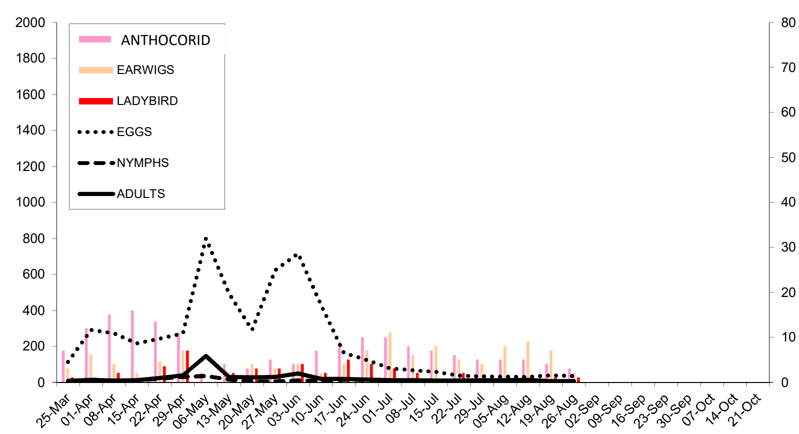


a.i.	NIAB EMR	Other researchers	Reference*
abamectin	Some long-term mortality	Harmful	1
acetamiprid	Minimal effects	-	
Bacillus thuringiensis	-	Safe	9
chlorantraniliprole	No detectable effects	Safe to adults	10,12
chlorpyrifos	Harmful	Harmful	1,2
cypermethrin	-	Harmful (nymphs), knockdown	1,8
deltamethrin	-	Harmful, knockdown	1,4,7,8
diflubenzuron	-	Harmful	9,11
dimethoate	-	Harmful	1,8
flonicamid	Safe (lab) harmful to nymphs field)	Safe, harmful	1,3,5
indoxacarb	Harmful (males), knockdown	Harmful, knockdown	1,3,4,5,10
methoxyfenozide	Harmful to nymphs (growth)	Safe to adults	4, 10
pirimicarb	-	Safe	1,8
potassium bicarbonate	-	Safe	12
spinosad	Harmful, knockdown	Harmful	1,2,3,5,6, 10
spirodiclofen	Long-term mortality, delayed laying	-	
thiacloprid	Harmful, some long-term mortality	Harmful	1,3,5,10

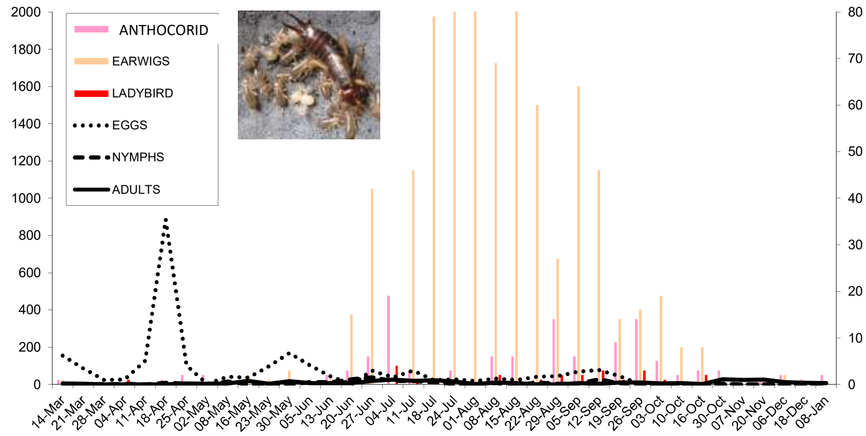
*1 Peusens and Gobin 2008; 2 Cisneros *et al*. 2002; 3 Vogt *et al*. 2010; 4 Peusens *et al*. 2010; 5 Vogt *et al*. 2009; 6 Peusens *et al* 2009; 7 Colvin and Cranshaw 2010; 8 Ffrench-Constant and Vickerman 1985; 9 Maher *et al*. 2006; 9 Sauphanor *et al*. 1993; 10 Shaw and Wallis 2010, 11 Ravensberg 1981, 12 Beliën 2012

Plant Science into Practice

Anthocorids



Earwigs



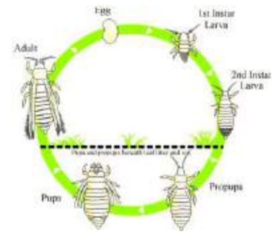
Plant Science into Practice

- Inductive (augmentation) biological control

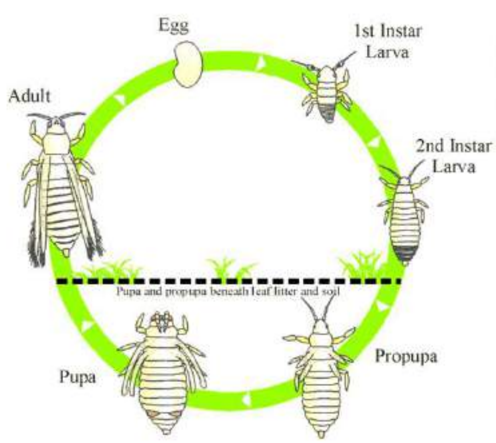
Plant Science into Practice

Neoseiulus cucumeris in strawberry

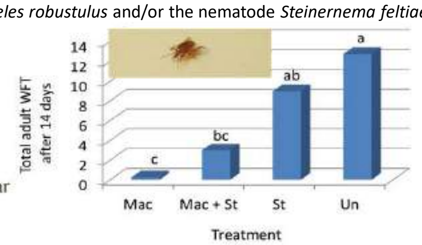
- For control of Western Flower Thrips
- Eggs and first instars
- Long use
- Fortnightly application
- Mechanisation
- Used in combination with other biocontrols including *Phytoseiulus persimilis* for spider mite control and parasitoids for aphid control



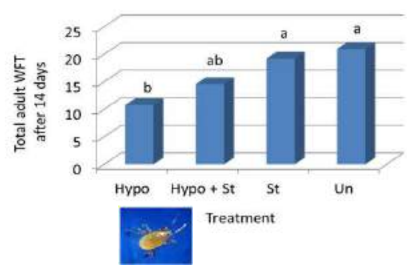
Other lifecycle stages of Thrips



Machrocheles robustulus and/or the nematode *Steinernema feltiae*



Hypoaspis miles (*Stratiolaelaps scimitus*) and/or the nematode *Steinernema feltiae*

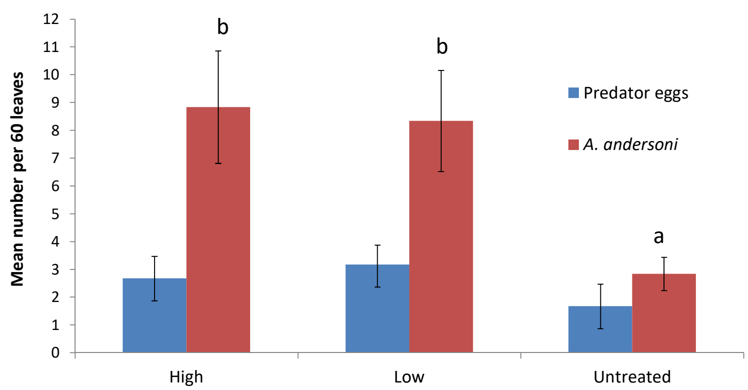


Plant Science into Practice

Can this work in cherry?

- *Amblyseius andersoni*
- Growing cherries under protection
- Two spotted spider mite (*Tetranychus urticae*)
- European fruit tree red spider mite (*Panonychus ulmi*)
- one Gemini sachet per tree
- one Gemini sachet per 5 trees

More predatory *A. andersoni* where sachets applied



Plant Science into Practice

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Fly in the ointment

Plant Science into Practice

- ***Drosophila suzukii*** **– Spotted Wing Drosophila**
- Invasive from Asia
- Lays eggs in ripening fruit
- Causing collapse of fruit before harvested
- Identify native parasitoids of *D. suzukii*
- Over 280 SWD sentinel traps
- Range of sites – crops and wild areas

Species of parasitoid discovered in England




Family, Species	Habitats	Individuals	Traps
Pteromalidae			
Pachicrepoydeus vindemmiae	Woodland, Brambles, Elderberry edge, Farmyard, Hedgerow, Raspberry and Strawberry edges, Wild cherry orchard and Vineyard	1100	31
Spalangia erythromera	Woodland, Hedgerow, Raspberry and strawberry edges, Wild cherry orchard	219	14
Figitidae			
Leptopilina heterotoma	Woodland	15	2
Braconidae			
Asobara tabida	Woodland	9	2

Conservation Biocontrol or Classical Biocontrol (Gnapsis sp. from Asia)

Plant Science into Practice

Many thanks for listening

Berry Gardens

NATURAL HISTORY MUSEUM

NIAB EMR

UNIVERSITY of GREENWICH
NRI | Natural Resources Institute

AHDB HORTICULTURE

UK fruit growers

Cost-benefits of thresholds

Mark Ramsden
Crop Protection

ADAS

www.adas.uk

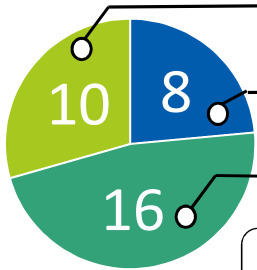
What is a thresholds?

The role of beneficials

Farm focused research

ADAS

Economic thresholds



Pollen beetle

Virus vectors (e.g. aphids)

Cabbage seed weevil

34

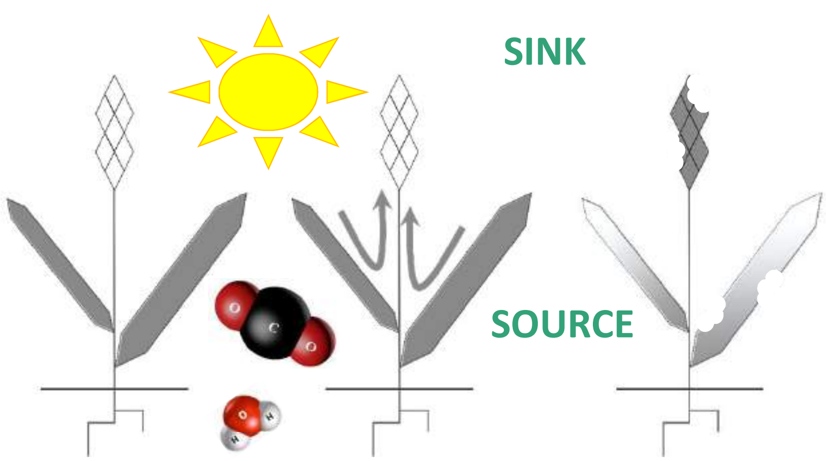
More than 0.5/plant in northern Britain
1/plant elsewhere

- No threshold
- Anecdotal thresholds
- Peer reviewed threshold

Ramsden et al. (2017) Crop Protection 96, 30-43

ADAS

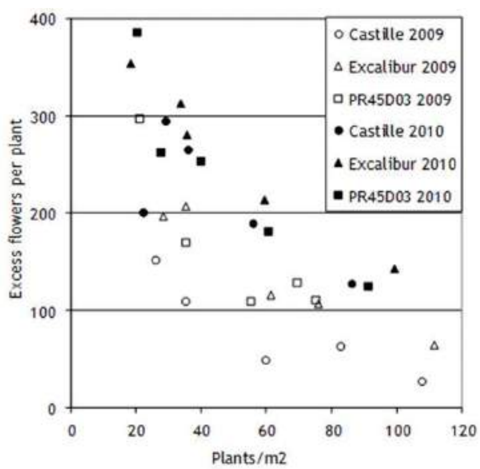
A little bit of crop physiology…



ADAS

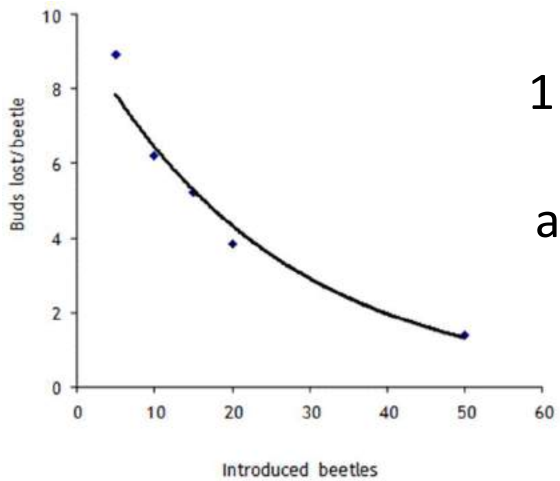
Summary example – Pollen beetle

Summary example – Pollen beetle



Denser crops produce fewer excess flowers per plant

Summary example – Pollen beetle



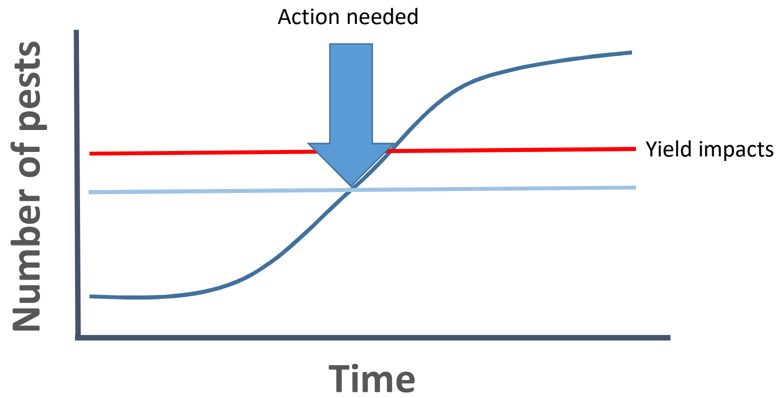
1 adult pollen beetle eats about 9 buds

Summary example – Pollen beetle

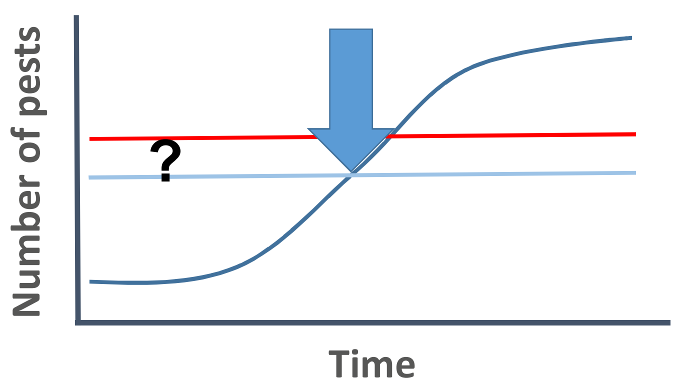
If there are less than 30 plants/m²	the threshold is 25 pollen beetles per plant
If there are 30–50 plants/m²	the threshold is 18 pollen beetles per plant
If there are 50–70 plants/m²	the threshold is 11 pollen beetles per plant
If there are more than 70 plants/m²	the threshold is 7 pollen beetles per plant

Excess pods can be lost with no impact on yield

Is action needed?



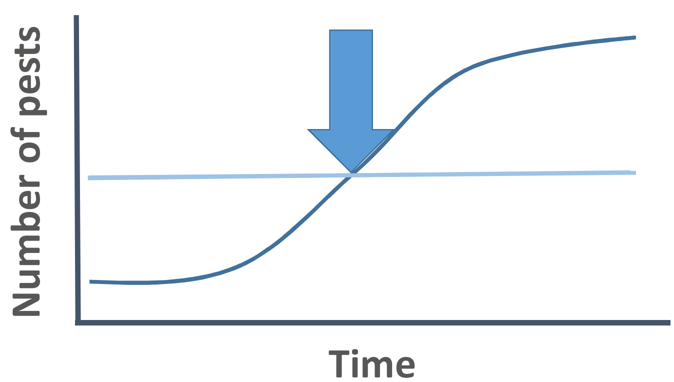
How to avoid exceeding thresholds



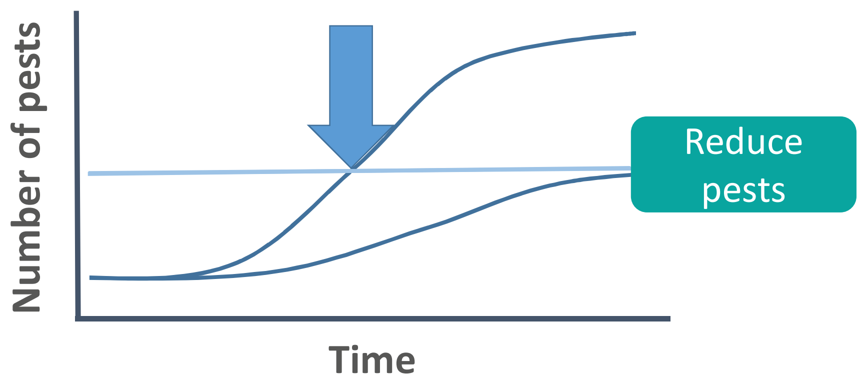
What is a thresholds?

The role of beneficials

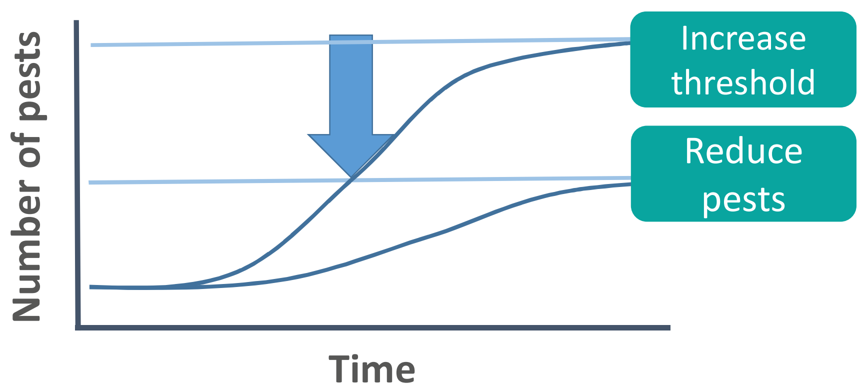
How to avoid exceeding thresholds



How to avoid exceeding thresholds

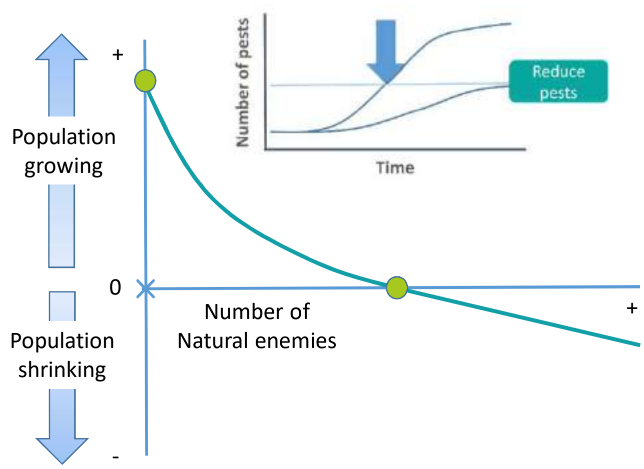


How to avoid exceeding thresholds

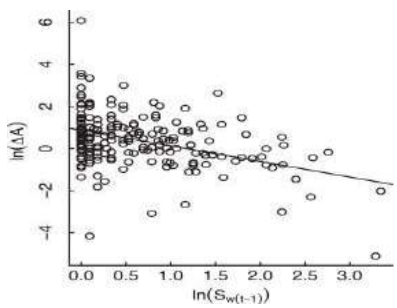


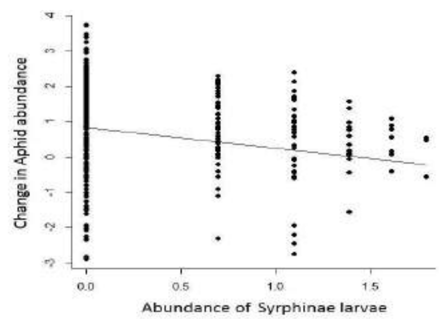
How to avoid exceeding thresholds

Reduce pests - role of beneficials



Do natural enemies make a difference?





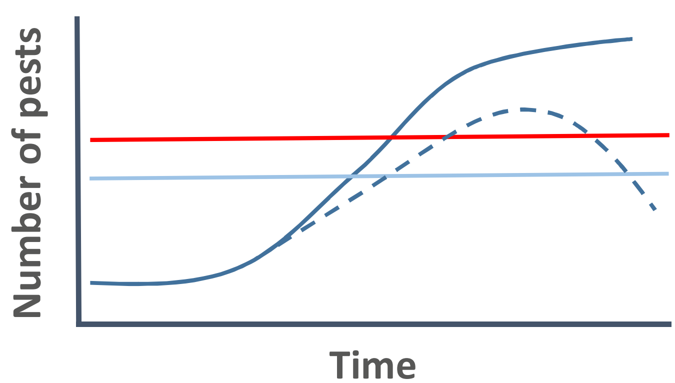
Chaplin-Kramer *et al.* (2013)
Agricultural, Ecosystem and Environment, 181, 203-212

Ramsden *et al.* (2016)
Agricultural and Forest Entomology

Reduce pests - role of beneficials

Population lag

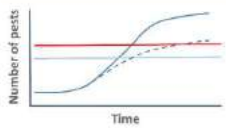
Scale of interactions

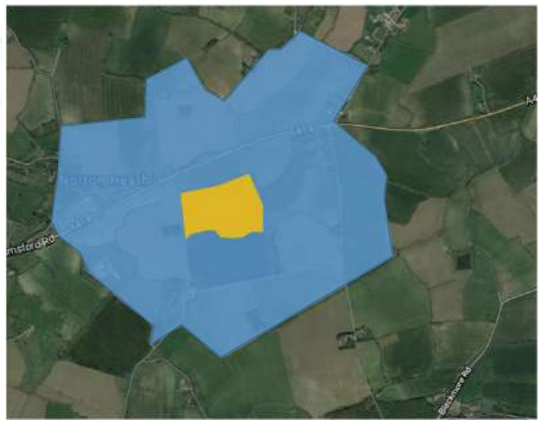


Reduce pests - role of beneficials

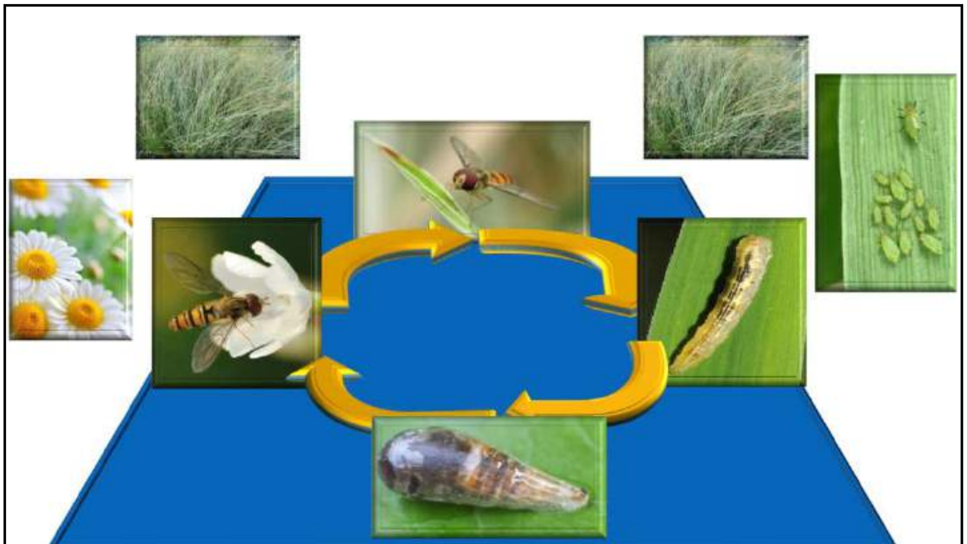
Population lag

Scale of interactions





ADAS



ADAS

Floral Resources

Shelter

Availability of prey

Resource provision needs to be targeted, and takes place at different scales to crop management

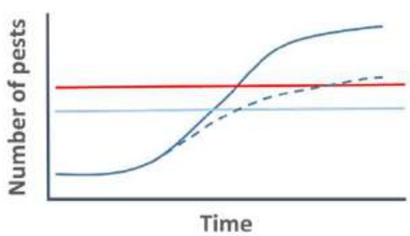
Ramsden *et al.* 2014
Agriculture, Ecosystems and Environment 199, 94–104

ADAS

Reduce pests *increase predation*

Population lag

Scale of interactions



IPM solutions may need to be implemented a multiple scales, across several crops, over several years.

Success will be dependent on understanding the ecology of the pest.

ADAS

What is a thresholds?

The role of beneficials

Farm focused research

Obstacles to implementing thresholds

Calendar/insurance based insecticide application
- Obvious results — all insects gone
- Forgiving application — sub-optimal application still works
- Established methods — fits with existing systems
- Cheap — relatively low short-term costs
- Quick — Can have immediate effect

Threshold based applications

Farm Focused Research

- Relative results — pest remains in crop
- Difficult to get right — IPM solutions may not work
- Complex systems — numerous spatially varying techniques
- Investment needed — establishing field margins
- Slow — benefits accumulate over years

Farm focused research

Thresholds provide a mechanism for testing ideas

ADAS

What is a thresholds?

The role of beneficials

Farm focused research

ADAS

Credits from past research

Department for Environment Food & Rural Affairs

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AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

fera
The Food and Environment Research Agency

Chemicals Regulation Directorate

ADAS

Pete Berry
Steve Ellis
Sarah Kendall
Kate Storer
Sacha White

ADAS

Cost-benefits of thresholds

Mark Ramsden
Crop Protection

Questions…

ADAS

www.adas.uk

Rothamsted Research
where knowledge grows

Building Confidence in Beneficials: Conservation BioControl in Oilseed rape

ROTHAMSTED RESEARCH

Sam Cook
Biointeractions & Crop Protection Department

BBSRC

Insects love oilseed rape!

ROTHAMSTED RESEARCH

BBSRC

Oilseed rape is important for farmland biodiversity

Oilseed rape supports a wide variety of invertebrates:

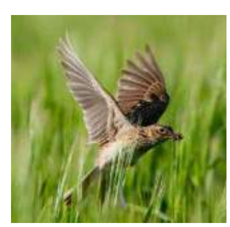
Surveys in UK using a range of techniques…

…collected 151 species + c. 40 additional groups id to genus or higher taxonomic rank

Skellern & Cook in prep

Oilseed rape is important for farmland biodiversity

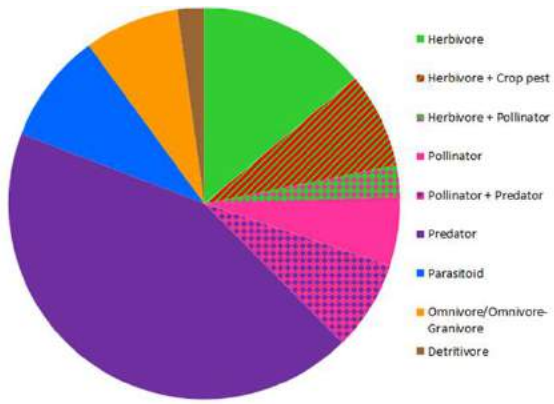
Oilseed rape crops support populations of bees, butterflies & other pollinators, natural enemies of crop pests, detritivores & invertebrates used as food resources for farmland birds



British Ornithologists Union

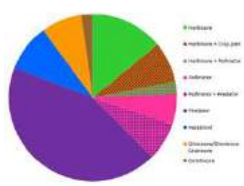
Skellern & Cook in prep

Oilseed rape is important for farmland biodiversity



Skellern & Cook in prep

Can we manage the crop to boost biodiversity… …and make it work for us?



Talk outline:

- What is Conservation Biocontrol?
- What are the natural enemies of oilseed rape pests in UK?
- What's their impact on crop pests?
- How can we manage crops to protect populations of natural enemies and encourage pest regulation?

What is Conservation BioControl (CBC)?

Biological control is a method of controlling pests using other organisms (natural enemies)

Predation

Parasitism

Pathogens

What is Conservation BioControl (CBC)?

Conservation Biological Control = Use of **agronomy** & **habitat management** methods to conserve the natural enemies of crop pests in the agri-environment to provide pest regulation

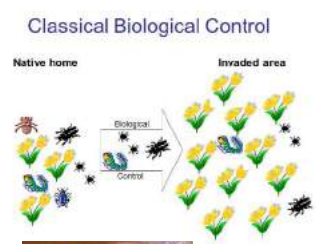
…as opposed to:

- **Classical** biological control = introducing natural enemies from a pest's native range into a new area where native natural enemies do not provide sufficient control

- **Augmentation** biological control:

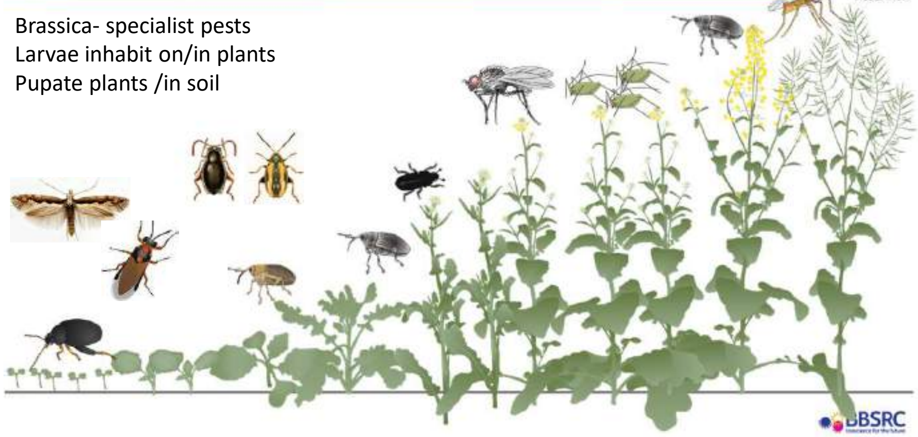
- **Incolulative** biological control = periodically releasing natural enemies to re-establish a balance

- **Inundative** biological control = massive production and release of natural enemies to control the pest quickly (e.g bio-insecticides)



What are the pests in OSR – and their natural enemies?

Brassica- specialist pests
Larvae inhabit on/in plants
Pupate plants /in soil



What are the natural enemies of OSR pests?

Generalists prey on several groups: canopy active

Ladybirds: prey on aphids and small larvae e.g. pollen beetle from flowers
Maybe lacewings? Maybe hoverfly larvae? Ballooning / money (Linyphiid) spiders?

What are the natural enemies of OSR pests?

ROTHAMSTED RESEARCH

Generalists: ground-active (some species may climb plants)

Spiders:
Lyconid wolf spiders e.g. *Pardosa agresttis*
Tetragnathidae (long jawed spiders)

Stapylinid (rove) beetles

Carabid (ground) beetles 42 species common in OSR fields; some with very high density
Spatial association between:

- CSFB eggs and larvae and 2 spp (*Trechus quadristriatus* & *Pterostichus madidus)* (Warner et al., 2003)

- Pollen beetle larvae and 6 spp (*Amara similata, Anchomenus dorsalis, Nebria brevicollis, Harpalus affinis, H. rufipes, Poecilus cupreus*) (Felsman & Buchs 2006; Warner et al 2008)





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What are the natural enemies of OSR pests?

ROTHAMSTED RESEARCH

Specialists: parasitic wasps (parasitoids) 80 spp in total

The pest | The parasitoid

Psylliodes chrysocephala

Tersilochus microgaster

Meligethes aeneus

Phradis interstitialis

Tersilochus heterocerus

BBSRC

What are the natural enemies of OSR pests?

Specialists - attack 1 or a few related species : parasitic wasps (parasitoids)

The pest

The parasitoid

Trichomalus perfectus

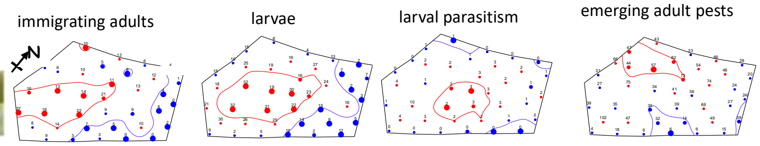
Platygaster subuliformis

Omphale clypealis

BBSRC

Effects of natural enemies on OSR pests

- Biocontrol potential of several spider and carabid spp. confirmed by gut analyses
- Biocontrol potential of carabids and parasitoids confirmed by analysis of spatio-temporal distributions



Warner et al

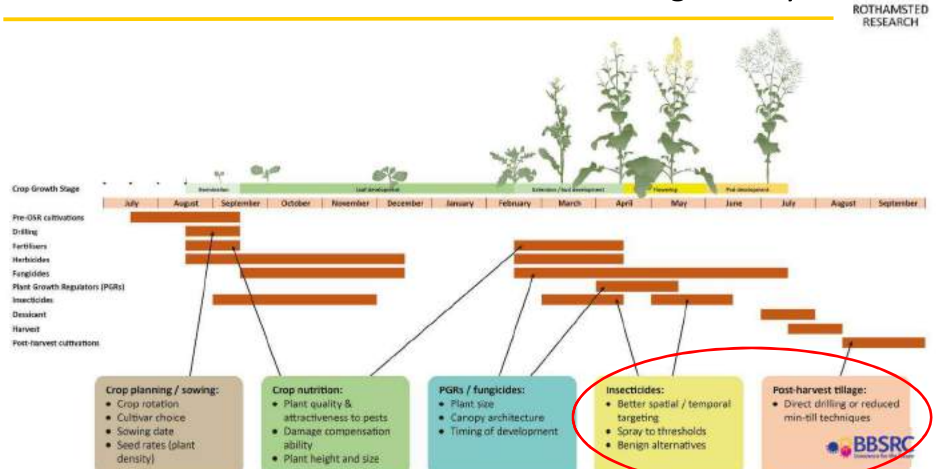
Effects of natural enemies on OSR pests

ROTHAMSTED RESEARCH

- Predators – data on effects on pests in OSR are scarce; c. 20% of total pollen beetle mortality (Büchi, 2002; reviewed by Büchs 2003).
- Parasitoids – parasitism rates for pollen beetle can reach c. 80% in untreated crops
- 'Parasitoids more important than predators for biocontrol' ((Nilsson & Andreasson 1987; Hokkannen 1988)
- Key parasitoids only attack larvae (no good for pest management in the current crop!
- To improve confidence in beneficials for biocontrol: more research needed into quantifying control effects and relating these to yield!

Conservation biocontrol: Conservation via agronomy

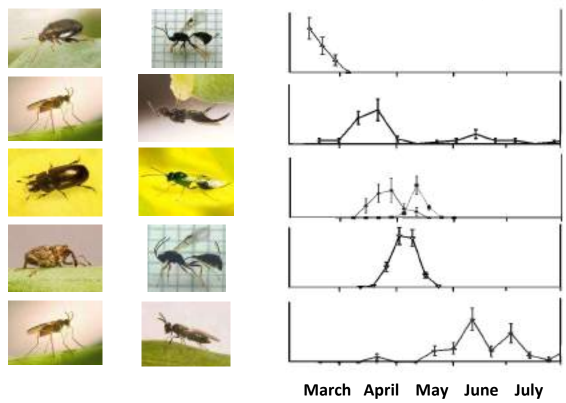
ROTHAMSTED RESEARCH



Skellern & Cook (2018) Arthropod-Plant-Interactions

Conservation via agronomy : Insecticides

Temporal succession of parasitoid emergence

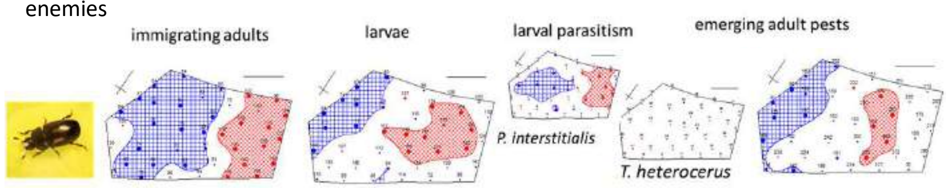


Spray ONLY when necessary!

Ferguson et al

Conservation via agronomy : Insecticides

Spatial targeting of insecticides in pest hot-spot areas will help to conserve natural enemies



Warner et al

Conservation via agronomy : Tillage

- Most parasitoids of OSR pests overwinter as cocoons in the soil after dropping from OSR plants

- Ploughing in preparation for wheat crop buries the cocoons reducing emergence ☹
- Minumum/ zero-til systems significantly improve parasitoid survival ☺ (Nilsson et al 2003, 2010)
- … and also benefit populations of spiders and carabids

Conservation via habitat management : field margins

Delivering conservation biocontrol via Field margins

- Areas of uncropped land, between the arable crop and the boundary (e.g. hedge)
- Activiely managed; sown to annual, but usually biannial or perennial plants; 3, 6 or 12m wide
- Introduced in several countries as part of Agri-environment schemes (EU CAP)

Commercial mixtures for birds, bees/butterflies but none for biocontrol!

- Plant composition needs to be optimised to maximise biocontrol potential

Reviewed by Skellern & Cook (in press)

Conservation via habitat management : field margins

ROTHAMSTED RESEARCH

- Uncultivated field margins can act as refuges for tillage-susceptible parasitoid populations to thrive
- Flowering field margins can improve pollen beetle parasitism on neighbouring crops (by provision of pollen and nectar resources) (Thies & Tscharntke (1999); Buchi (2002))
- Brassicas needed to build-up populations of brassica-specialist parasitoids (!)

- Insect samples & plant composition was monitored from 16 margins sown to 4 different types of semi-natural habitat: (1) wild bird cover (2) florally-enriched grassland (3) insect rich cover (4) natural regeneration

- 50 parasitoids of OSR pests were identified; only 3 were in margins containing no brassicas

Skellern, Clark, Ferguson, Watts & Cook *In Prep*
Data from UK Defra project IF0139

Department for Environment Food & Rural Affairs

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Conservation via habitat management : field margins

ROTHAMSTED RESEARCH

What Brassica(s) best support parasitoids of OSR pests?

- 14 Brassica types screened

***Brassica napus* subsp. Biennis Forage rape** best 'all-rounder' - Good for parasitoids of:

Pollen beetle

Seed weevil

Pod midge

Skellern, Clark, Ferguson, Watts & Cook *In Prep*
Data from UK Defra project IF0139

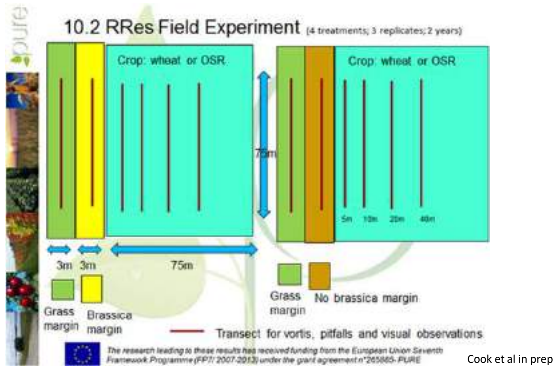
Department for Environment Food & Rural Affairs

BBSRC

Conservation via habitat management : field margins

ROTHAMSTED RESEARCH

Do brassica margins improve biocontrol in crops?



The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/ 2007-2013) under the grant agreement n°265865- PURE

Cook et al in prep

BBSRC

Conservation via habitat management : field margins

ROTHAMSTED RESEARCH

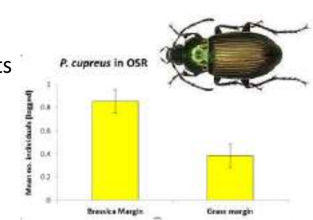
Do brassica margins improve biocontrol in crops?

Brassica Margins: Increased biodiversity and biocontrol agents particularly brassica specialists

Crop:

Wheat: No significant differences between margin treatments

OSR: More spiders and several carabid spp in OSR crops next to brassica margins than grass margins



The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/ 2007-2013) under the grant agreement n°265865- PURE

Department for Environment Food & Rural Affairs

Cook et al in prep

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Summary

- OSR crop support a wide variety of invertebrates, including predators and parasitoids of pests
- Biocontrol agents of OSR pests well known but more research needed on quantitative effects on pest control and yield
- Agronomical methods (reduced sprays & tillage) and habitat management methods (field margins) can increase populations of beneficials

- Field margins containing brassicas increased beneficials (particularly specialists) at field edges
- Abundance tends to decrease with distance into the field
- Little evidence of significant biocontrol effects in the crop
- Challenge for future:
  - -move biocontrol agents into the open field
  - - show positive effects on yield

Acknowledgements

Rothamsted colleagues in PURE & Defra-funded projects:

Matthew Skellern
Nigel Watts
Lucy Nevard
Andrew Moss
Jason Baverstock
Martin Torrance

Collaborators:

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Dr Judith Pell (JK Pell Consulting)
DR Gabor Lövei (AU, Denmark)

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/ 2007-2013) under the grant agreement n°265865- PURE

BCPC

Lunch
13:00 – 13:45

SPONSORS
We are very grateful to the following companies who have sponsored the BCPC Pests & Beneficials Review 2018

Bayer CropScience | CERTIS | Dow AgroSciences | DUPONT | syngenta

Field Margins (and beyond…)

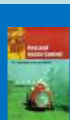
David George, Stockbridge Technology Centre

Background
Why bother & will any seed mix do?

Case Study
Multi-functional field margins

"…and beyond"
Whole farm habitat management

Why bother? Natural checks on pests can be a highly effective alternative to chemistry…



This time next year in a world with no constraints on pest populations*…

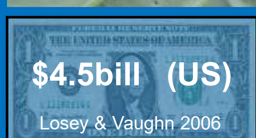
The 200 000 million descendants of 1 pair of houseflies cover the earth to a depth of 15km

The descendants of 1 aphid mother – at 250 million tonnes – circle the equator a million times

The descendants of 1 pair of cabbage whites - with wings closed - cover Australia with a tower rising into the stratosphere faster than the speed of light

*Assumes max. fecundity and zero mortality…fortunately unrealistic!

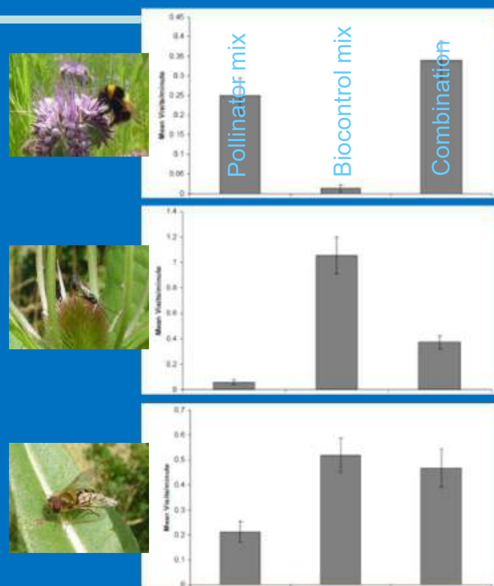
These checks have inherent monetary value, and promoting ecosystem services is likely to result in future policy-driven payments



We hold our natural environment in trust for the next generation. By implementing the measures in this ambitious plan, ours can become the first generation to leave that environment in a better state than we found it and pass on to the next generation a natural environment protected and enhanced for the future.

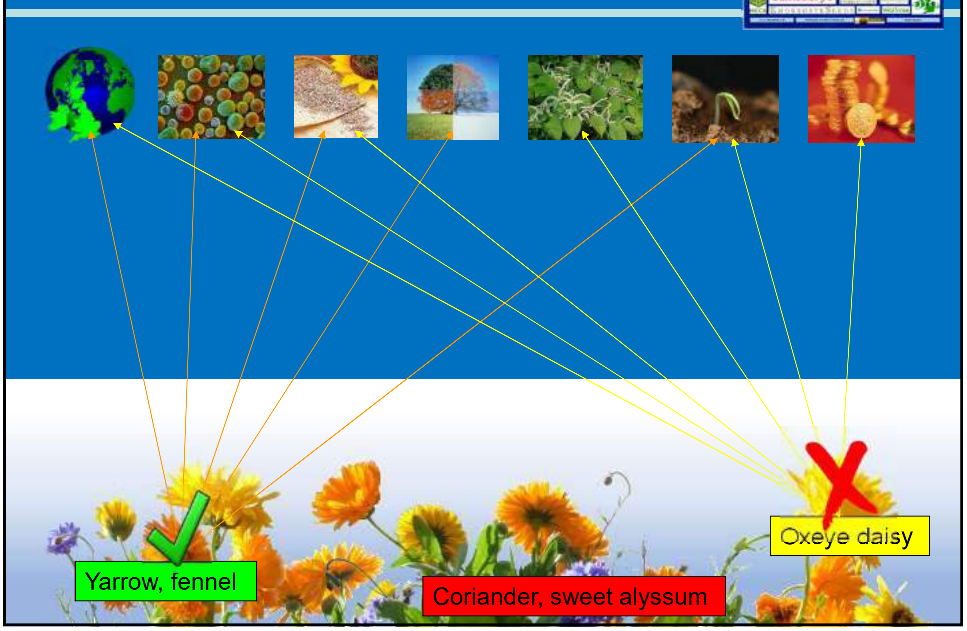
The Prime Minister

But, not all seed mixes deliver for biocontrol

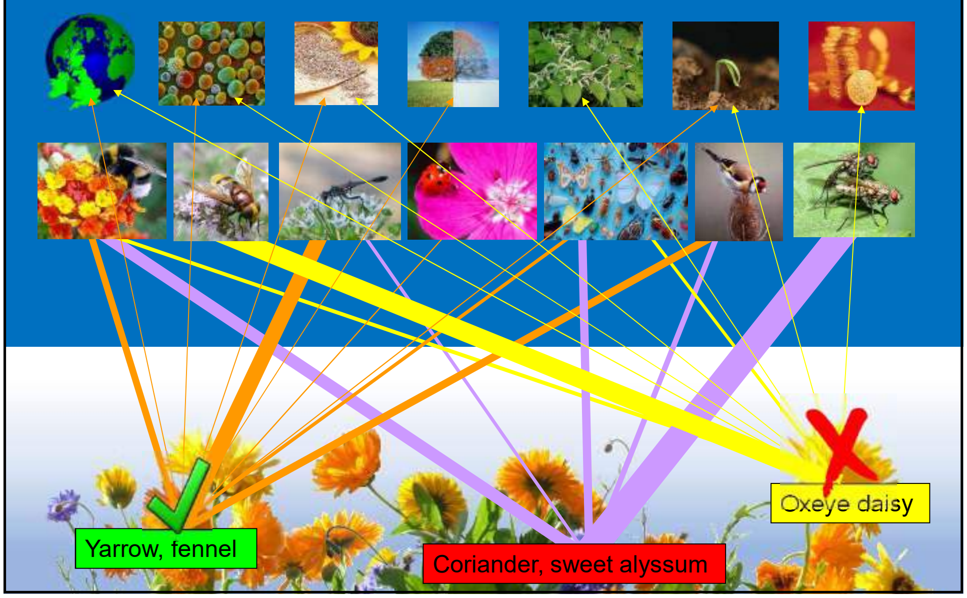


Campbell, Biesmeijer Varma & Wäckers, 2012. Basic & Applied Ecology 13: 363-370

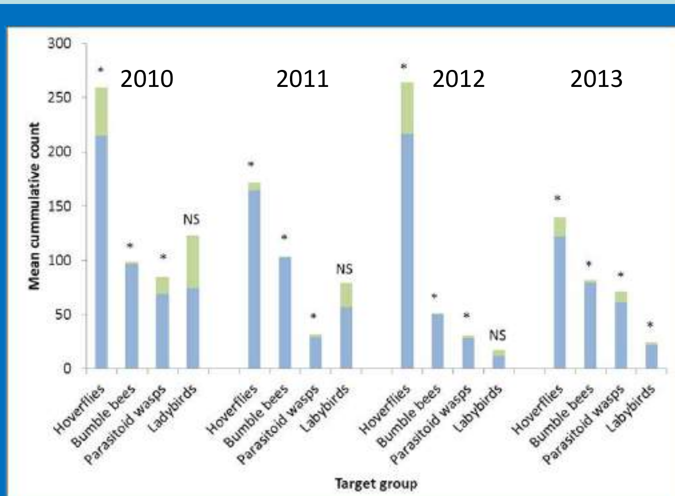
Considered seed selection is key



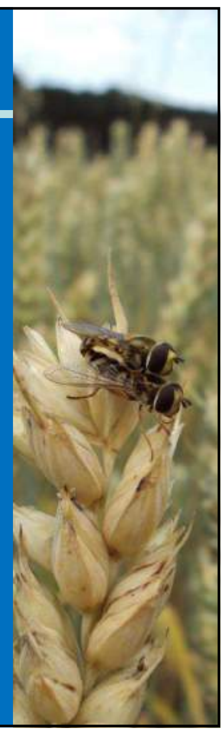
Considered seed selection is key



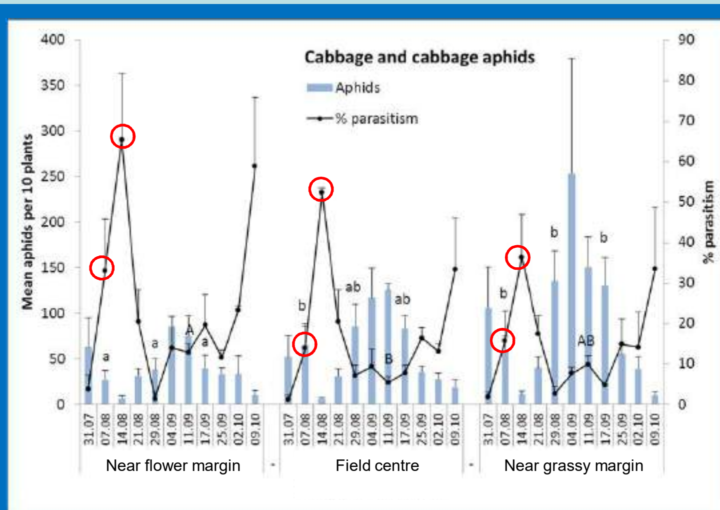
Visitation by beneficial insects



Blue = observed in flower margins; Green = observed in grassy margins. Sum of 6 visits per year, n = 4.



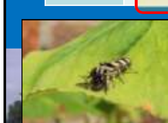
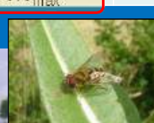
Aphids in cabbage planted with a margin

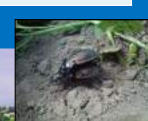


- Parasitism rates increased more rapidly near flower margins
- Reduced aphid loads near to flower margins on some dates

Crop yield across crops planted with margins

	YIELD			
YEAR	**Carrots**	**Cereals**	**Peas**	**Cabbages**
2010	No difference	No difference	Could not be analysed: poor crop	No difference
2011	No difference	Yield increased near margin by 22.5%$_{max}$	Yield increased near margin by 41.1%$_{max}$	Yield increased near margin by 15.8%$_{max}$
2012	No difference	No difference	Yield higher near margin and field centre by 74.2%$_{max}$	Yield increased near margin by 29.9%$_{max}$
2013	Yield decreased near margin by 25.4%$_{max}$	No difference	No difference	No difference

Biological systems are inherently variable and benefits of even the very best seed mixes may not be seen year-on-year

Crop yield across crops planted with margins

Margins + trap crops?

Margins + in-crop measures

Increasing in-crop biodiversity could be especially beneficial in meeting 'new CAP' requirements – 'Polycultural Potential'

- Pest, disease, weed control
  - Reduced pesticide
- Improved cover and reduced erosion/runoff
  - More sustainable / robust soils
- Improved OM input and water retention
  - Better drought tolerance
- Increased floral resource
  - More bees
- N fixation and carbon storage
  - Reduced env impact

But could polyculture fit with high yielding conventional UK farming models?

How do we drill into this?

How do we manage this?

High tech machinery with sub-inch accuracy

Preliminary 2016 data encouraging

Treatment	Dry ear (from 10 g sub sample) weight (g)	Fresh ear (from 50 x 50 cm quadrat sample) weight (g)	Dry straw (from 10 g sub sample) weight (g)	Fresh straw (from 50 x 50 cm quadrat sample) weight (g)
Conventional bare soil	45.29 ± 1.51	149.39 ± 40.82	9.26 ± 0.63	96.60 ± 35.16
Direct-drill living mulch	45.55 ± 0.48	139.42 ± 24.07	8.83 ± 0.41	85.28 ± 24.54
Strip-till living mulch	45.66 ± 0.93	173.59 ± 42.51	10.57 ± 2.48	100.98 ± 22.93

Treatment	Nitrogen content (% of the total weight)	Moisture (% of the total weight)
Conventional bare soil	1.94 ± 0.08	15.50 ± 0.15
Direct-drill living mulch	1.88 ± 0.04	15.68 ± 0.15
Strip-till living mulch	1.91 ± 0.03	15.53 ± 0.08

The present for many; past for some…

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Linking Biodiversity & Profitable Farming:

Introducing Hillesden and ASSIST

Richard Pywell
rfp@ceh.ac.uk

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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Structure

1. Designing & testing habitat for 'beneficials'
2. Benefits to the farm business: Hillesden
3. Where next? The ASSIST programme

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1) Designing Habitat for 'Beneficials'

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the buzz project

Creating farmland habitats

- Six commercial farms
- Six new AES prescriptions tested
- Conventional crop control
- 5 years monitoring

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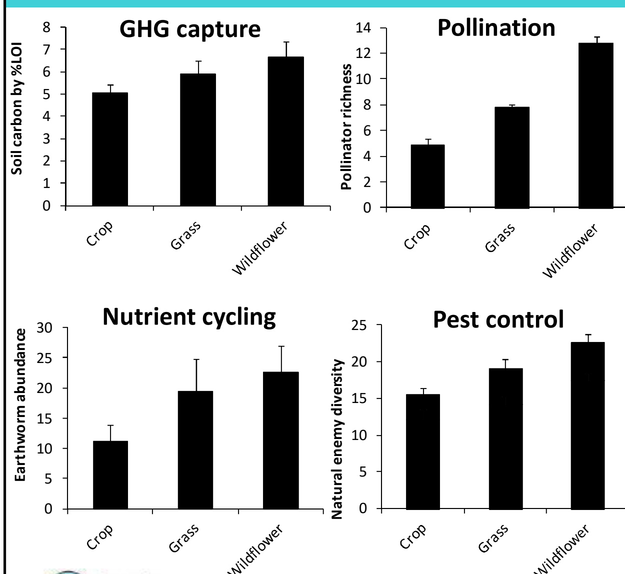
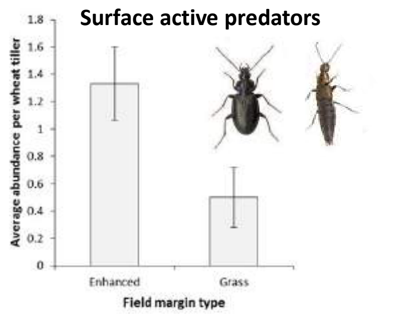
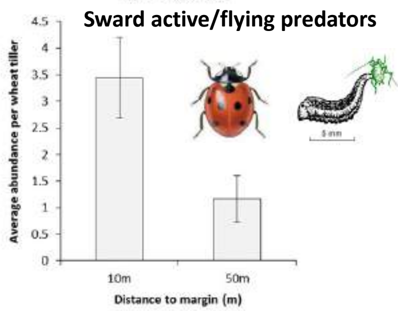
Multiple Benefits from Wildflower Margins

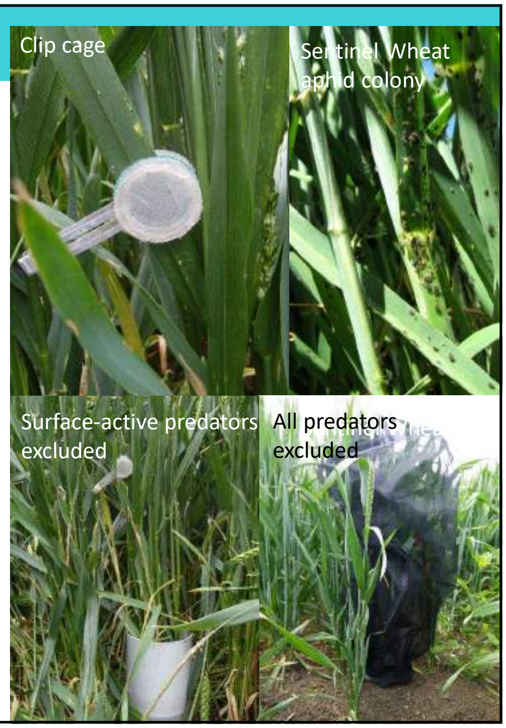


Enhancing Natural Pest Control

Natural pest control



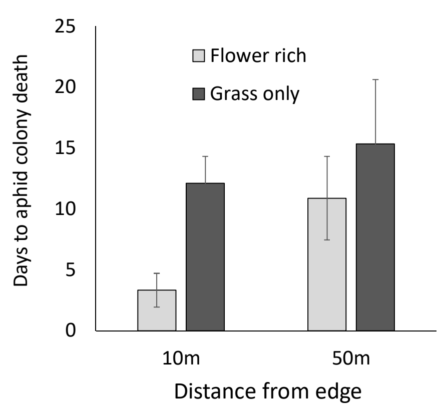




Testing this in the under field conditions

- Natural pest control reduced the survival of aphid colonies
- The best pest control is next to flower rich field margins
- Spill-over into the crop remains a problem

Colony survival when open to all predators



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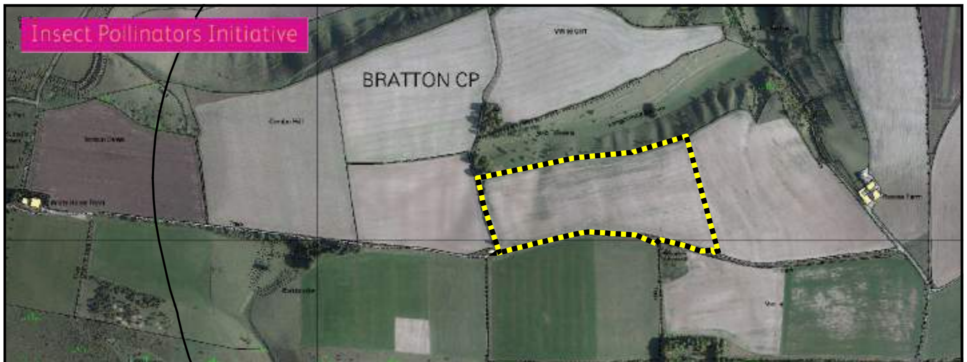

Benefits to Pollinator Populations

Centre for Ecology & Hydrology — ZSL Zoological Society of London — University of Bristol — UEA University of East Anglia — NERC Science of the Environment

Pollinator methods

Field surveys

- Sampled DNA from live queens and workers in every habitat patch across the 20km^2 landscape (ca. 3,200 bees)

Molecular genetics

- Genotyped samples then grouped individuals into nests and 'families'

Landscape modelling

- Relate bumblebee data to detailed maps of the landscape obtained using field surveys and high-resolution aerial remote sensing data

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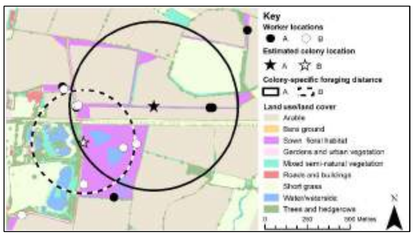
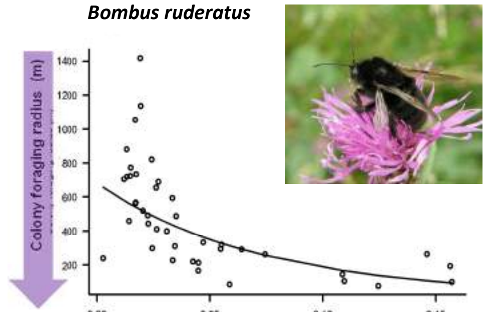
Effects of habitat on bee foraging distance



The more flowers in the landscape, the less distance bumblebees forage for resources

Bombus ruderatus



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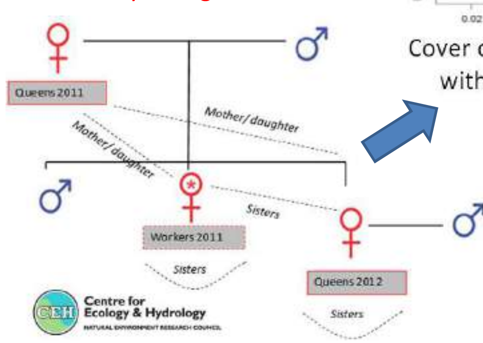
Insect Pollinators Initiative

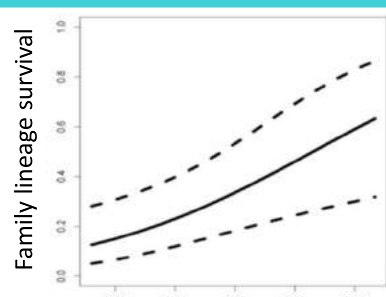
Redhead et al (2016) Ecological Applications

Effects of habitat on between-year survival

First evidence that habitat creation benefits bumblebee populations

"Family lineage survival"





Cover of semi-natural vegetation within 1000m of the colony

n = 456 colonies


LETTER nature

Bumblebee family lineage survival is enhanced in high-quality landscapes

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2) Benefits to the Farm Business:
Hillesden Farm Platform

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Hillesden Farm Platform

- Commercial 1000ha lowland arable farm
- Heavy soil growing autumn-sown crops (WW / OSR & beans)
- FIFTEEN 50-60ha 'farmlets' = three treatments replicated FIVE times:
  - **Cross Compliance (0% land removed)**
  - **Typical Entry Level AES (3% land removed for two wildlife habitats)**
  - **Entry Level Extra AES (8% land removed for six wildlife habitats)**
- Habitat creation in awkward/low yielding areas (mostly margins/corners)
- Test bed for AES policy

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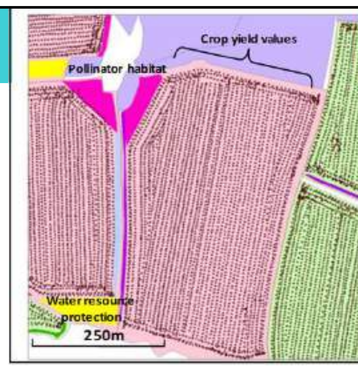
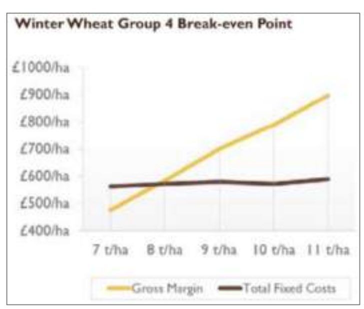
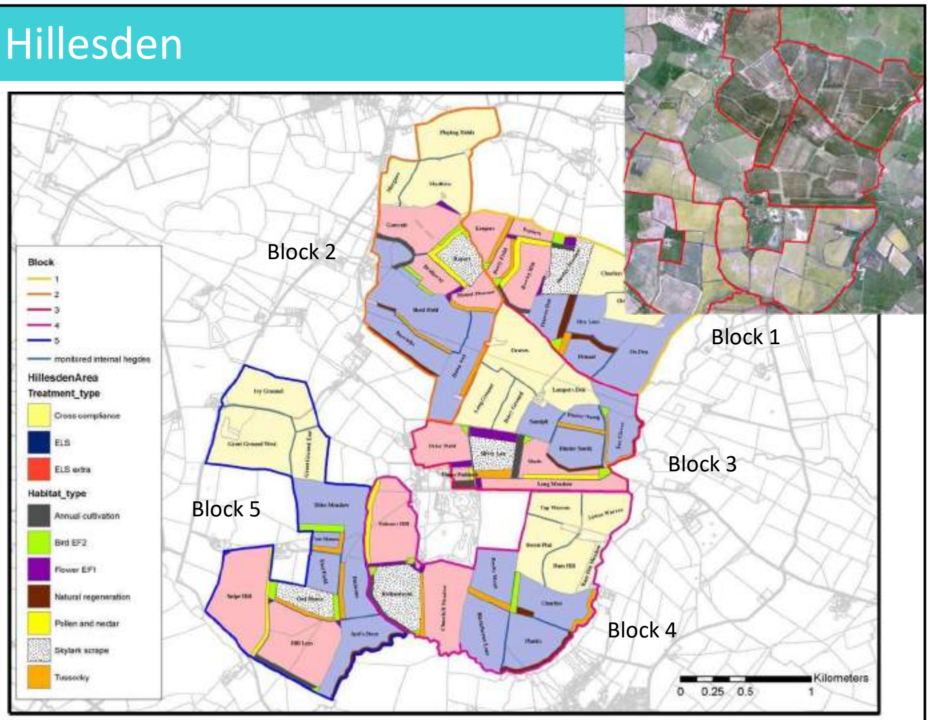
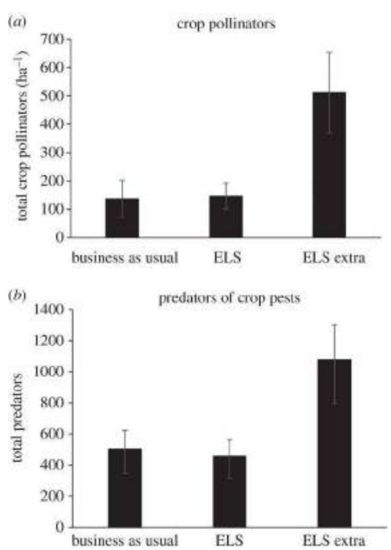




Hillesden



Abundance of 'Beneficials'



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Richard F. Pywell et al. Proc. R. Soc. B 2015;282:20151740

PROCEEDINGS OF THE ROYAL SOCIETY B

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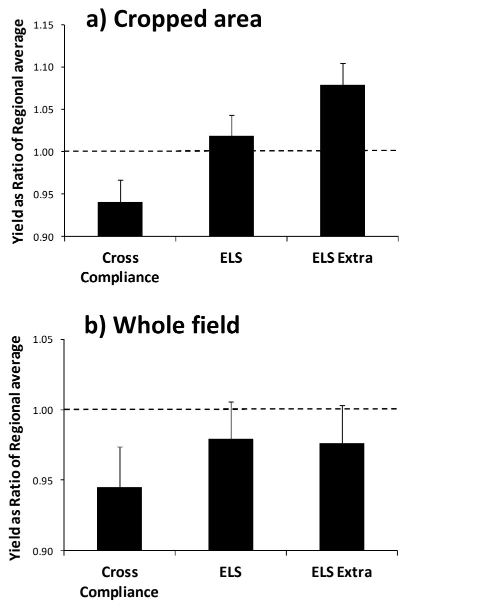
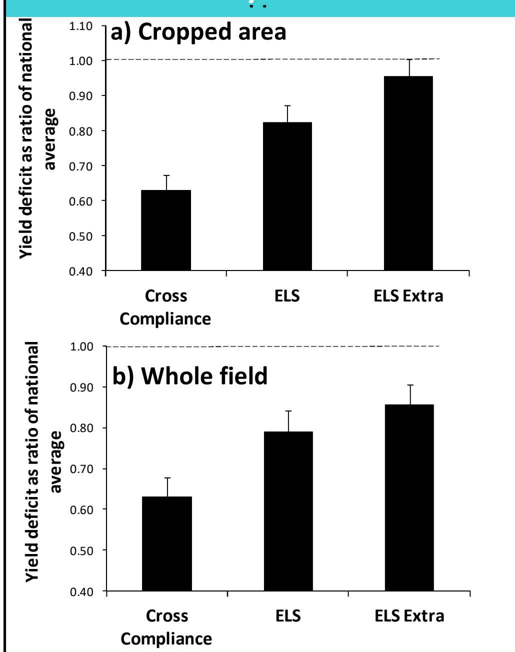
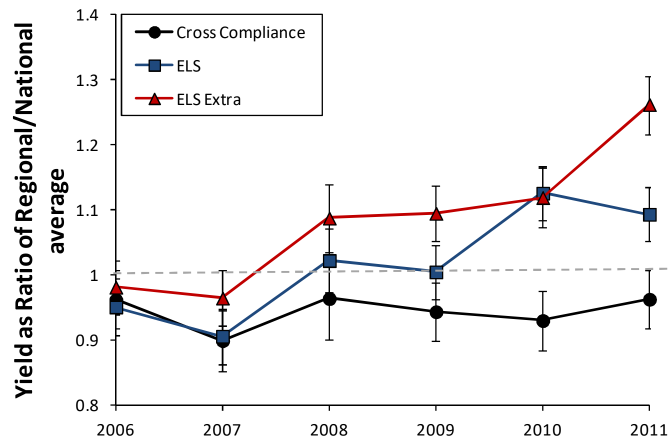
Effects on yield (6yrs): all crops



Effects on yield: Beans



Crop yield performance



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The Theory: Ecological intensification

'Optimal management of **ecological processes** and **beneficial biodiversity** to improve agricultural productivity, efficiency and resilience to future shocks'

Integrated within precision farming systems


PROCEEDINGS B
rspb.royalsocietypublishing.org
Research

Wildlife-friendly farming increases crop yield: evidence for ecological intensification

Richard F. Pywell[1], Matthew S. Heard[1], Ben A. Woodcock[1], Shelley Hinsley[1], Lucy Ridding[1], Marek Nowakowski[2] and James M. Bullock[1]

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3) What next?

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ROTHAMSTED RESEARCH

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

www.assist.ceh.ac.uk

funded by BBSRC bioscience for the future NERC SCIENCE OF THE ENVIRONMENT

assist Achieving Sustainable Agricultural Systems

- 5+ year £11M research programme
- Uniting expertise from NERC and BBSRC institutes, with support from the farming industry
- Develop innovative farming systems to increase efficiency of food production & resilience to future shocks
- Reduce the environmental footprint of agriculture

assist WP1 LIMITATIONS ON CROP PRODUCTIVITY

- **Understanding limitations on crop yield**
- **Overcoming the yield gap**
- **Influence of bio-physical factors on yield resilience**
- **Predicting future crop yields**

Data collection & analysis
Detailed infield measures
National surveys

- **Long-term yield data**
- **Crop input data**
- **Soil data**

The Yield Gap

WP2 Environmental impacts of future agriculture

- Predict impacts of current and future agriculture
- Inform future mitigation strategies
  - ➢ Scenarios of intensification / extensification
  - ➢ New process models of water quality and GHG emissions
  - ➢ Predict resilience of beneficial biodiversity
  - ➢ Complement national monitoring

WP3 Sustainable solutions

- Network of 18 commercial study farms
- Real world test of ecological intensification with best agri-tech farming
- Co-designed by industry
- Enhance soil function, pollination & pest control
- Opportunity for technology transfer/ complementary research


assist
• Bringing the 'Beneficials' into the field
• Infield strips of bespoke flower habitat for natural enemies & pollinators
Image Copyright Matthias Tschumi


assist
WP4 Synthesis: optimisation of future landscapes
• Develop modelling framework to optimise farm management for multiple objectives (production, ecosystem services, biodiversity):
➢ Where to intensify/extensify production (WP1),
➢ Impacts of changed agricultural management on natural capital and biodiversity (WP2), and
➢ Application of intervention measures to mitigate/enhance these effects (WP3)
➢ Build resilient future agro-ecosystems

Thank you

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Essex 'desert' changes tack to beat the drought

Dry conditions have created a virtual desert in one part of Essex. **Edward Long** finds out how one combineable crops farmer is responding

CHANGES in the seasonal weather pattern and a severe lack of rain are forcing an Essex farm to change its strategy and tailor cropping to the new arid conditions.

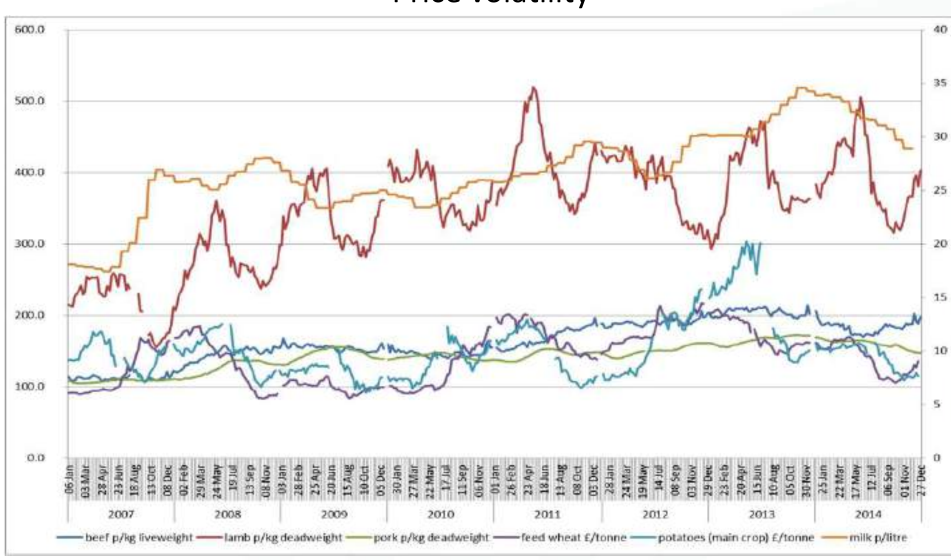
Between 1964 and 1982 the average annual rainfall measured at an official weather station at Lee Wick Farm, St Osyths, part of Wigboro Wick Farm, was just 513mm (20.2in). That was low enough for it to gain a listing in *The Guinness Book of Records* as the driest farm in the country.

"But since then we have had even less rainfall," says Guy Smith, who, with brother Philip and father Andrew, farms 520ha (1300 acres) of combineable crops and potatoes on the coast near Clacton. "Last year we recorded just 12.3in, the lowest rainfall total for over 40 years and far worse than the 1976 drought year when 19in fell.

WATER WATCH

He's a record breaker — but for all the wrong reasons. Guy Smith's Essex farm is officially the driest in Britain, prompting key management changes. Where crop growth varies according to soil type precision farming could help (left).

Price volatility



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There's strength in members.

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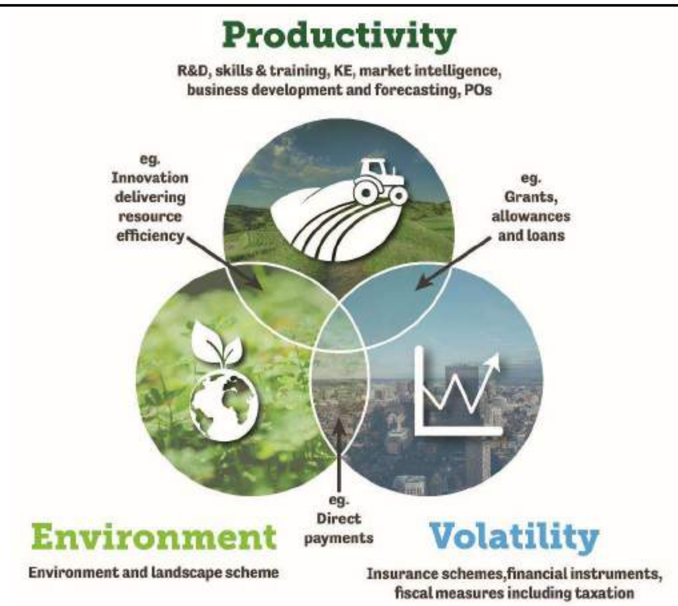

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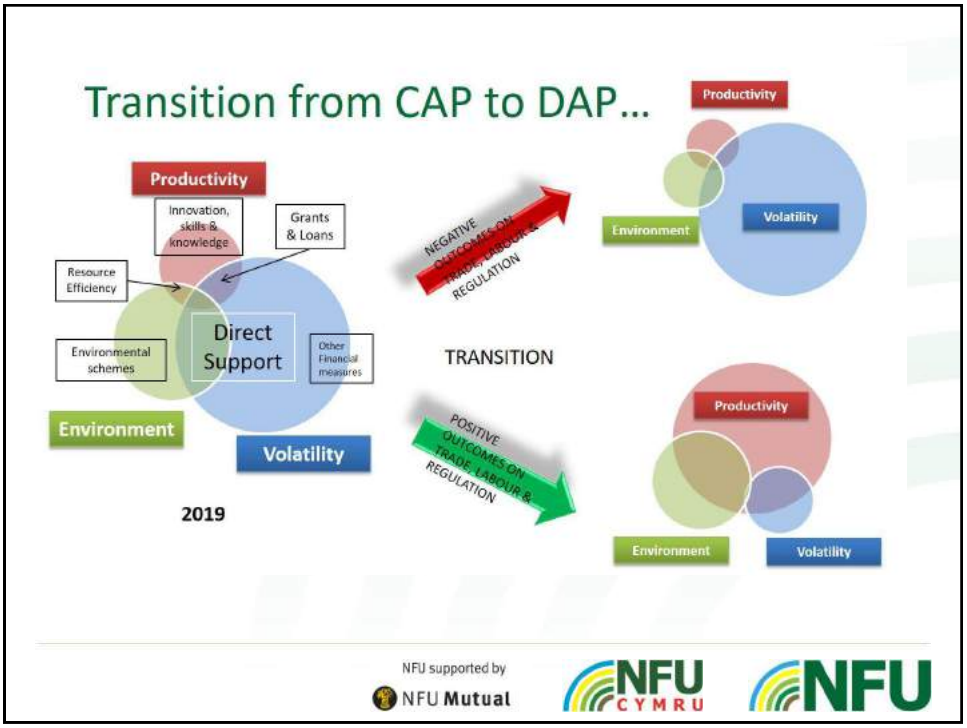
Transition from CAP to DAP…
Productivity
Innovation, skills & knowledge
Grants & Loans
Resource Efficiency
Direct Support
Environmental schemes
Other Financial measures
Environment
Volatility
2019
NEGATIVE OUTCOMES ON TRADE, LABOUR & REGULATION
TRANSITION
POSITIVE OUTCOMES ON TRADE, LABOUR & REGULATION
Productivity
Environment
Volatility
Productivity
Environment
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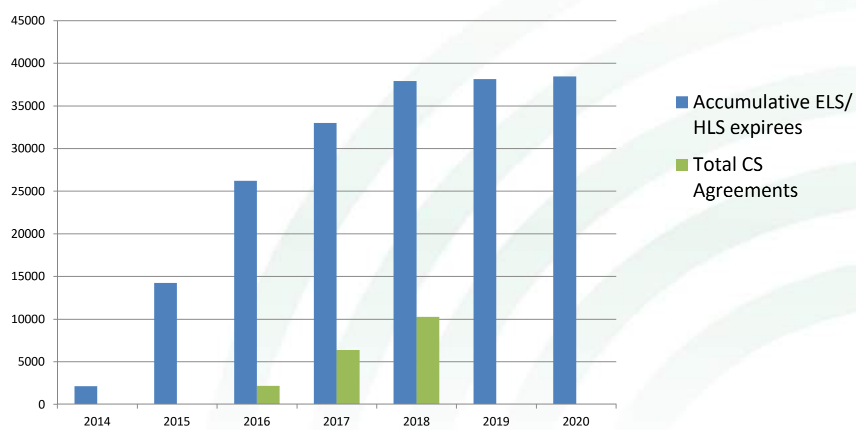
ELS/ HLS Expirees Compared to CS Uptake



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Discussion

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