Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments

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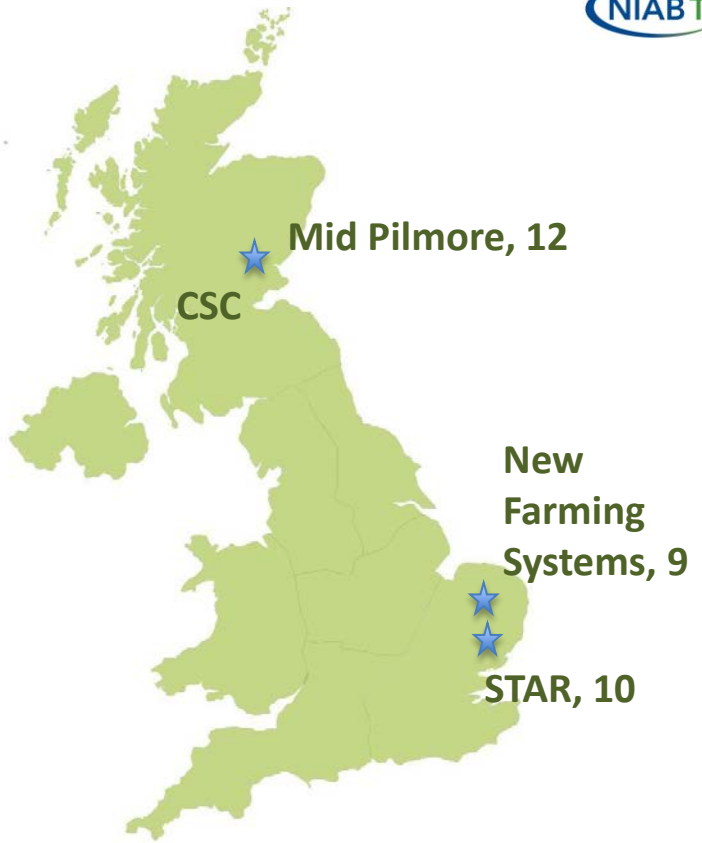
Outline

- Introduction to the Platform Project (s)
- Crop response to cultivation
- Standardize approaches to soil quality
- Margins
- The future

What does this project offer that is unique and useful?

- Large shifts in soil management take years to establish a new equilibrium
- Conventional and non-inversion cultivation at all sites
- Combined with experiments on rotational design and nutrients to determine best soil management practices
- Not all studied every year

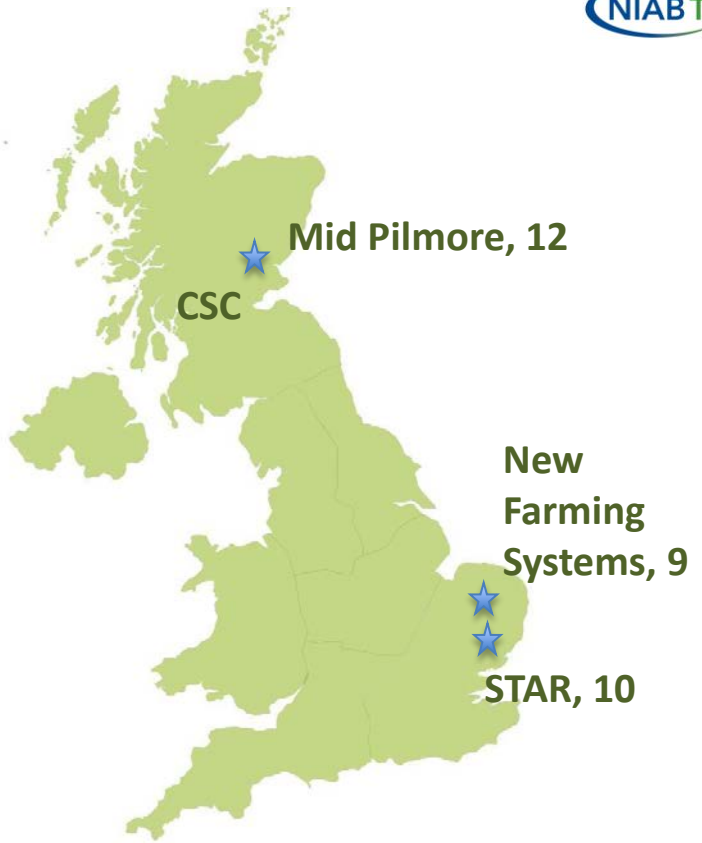


What does this project offer that is unique and useful?

Fewer varieties

Closer to real farm practice

- Mid-Pilmore: lots of varieties but at plot scale x cultivations
- CSC Balruddery: 2 systems and 5 varieties
- Sustainability Trial for Arable Rotations: 4 rotations x 4 cultivations
- New Farming Systems: cover crops, amendments x cultivations



Who is involved?

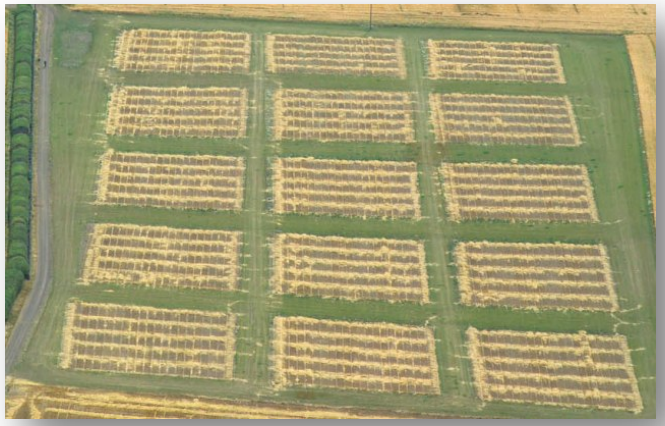
- At Hutton
    - Blair McKenzie, Tim George, Tracy Valentine, Adrian Newton
    - Jen Brown, Anna Taylor, Dave Guy, Kirsty Binnie, Lawrie Brown
- At NIAB
    - Ron Stobart, Nathan Morris
- Uni Aberdeen
    - Paul Hallett

Who is involved?

NIAB TAG

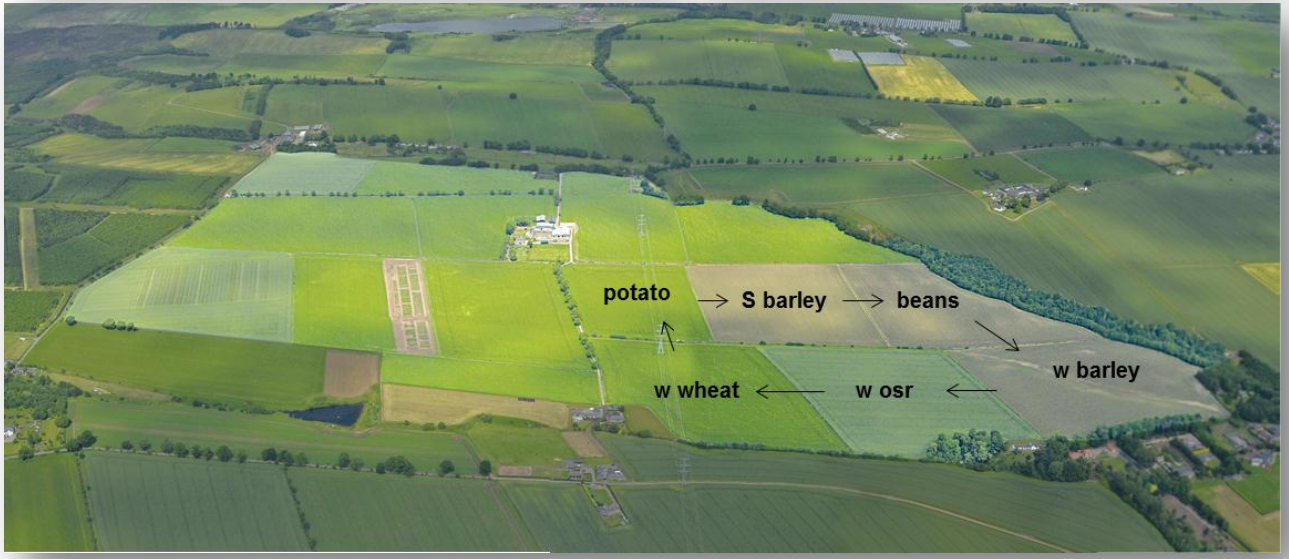
The James Hutton Institute

Mid Pilmore, Hutton



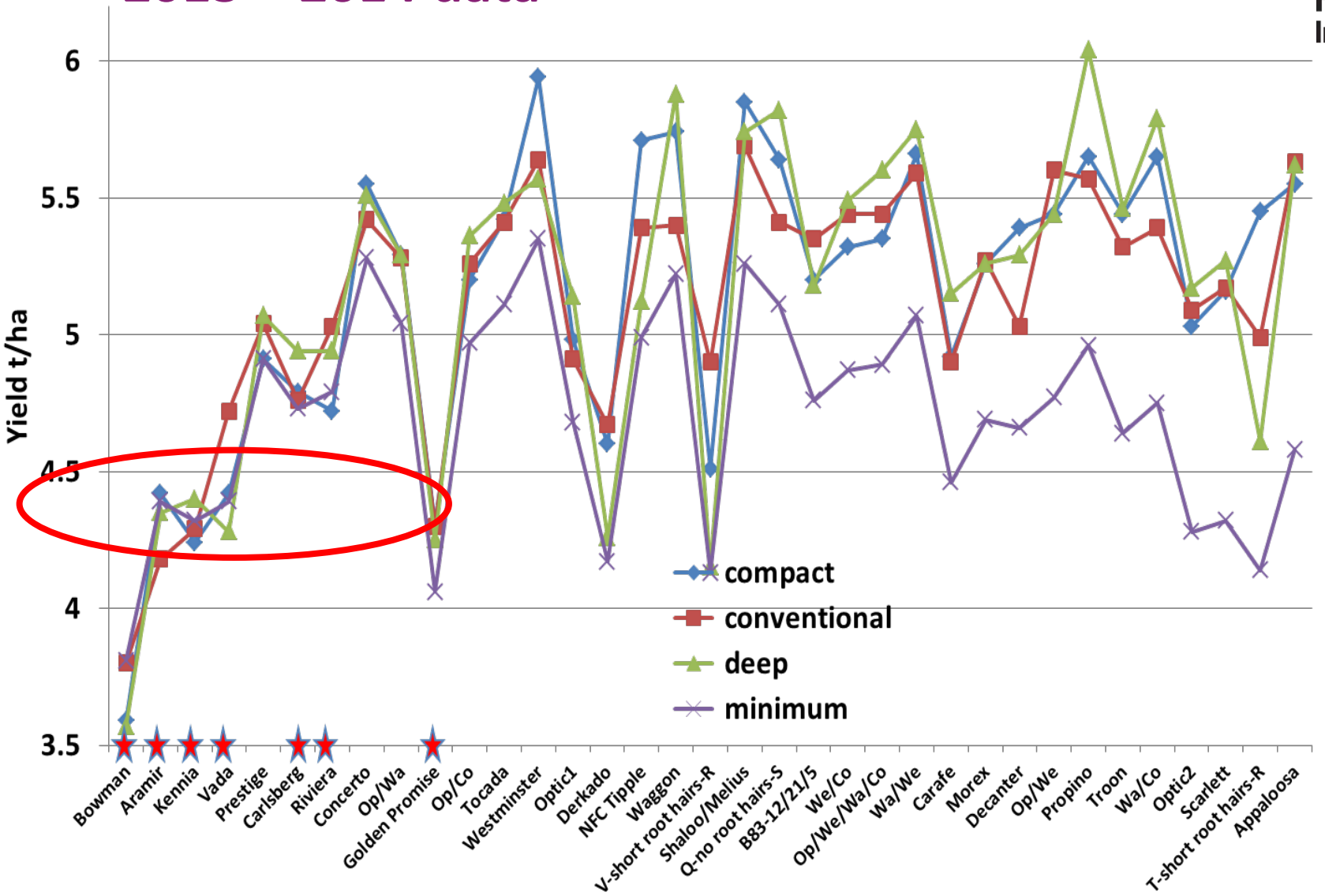
STAR, NIAB-TAG

NFS, NIAB-TAG



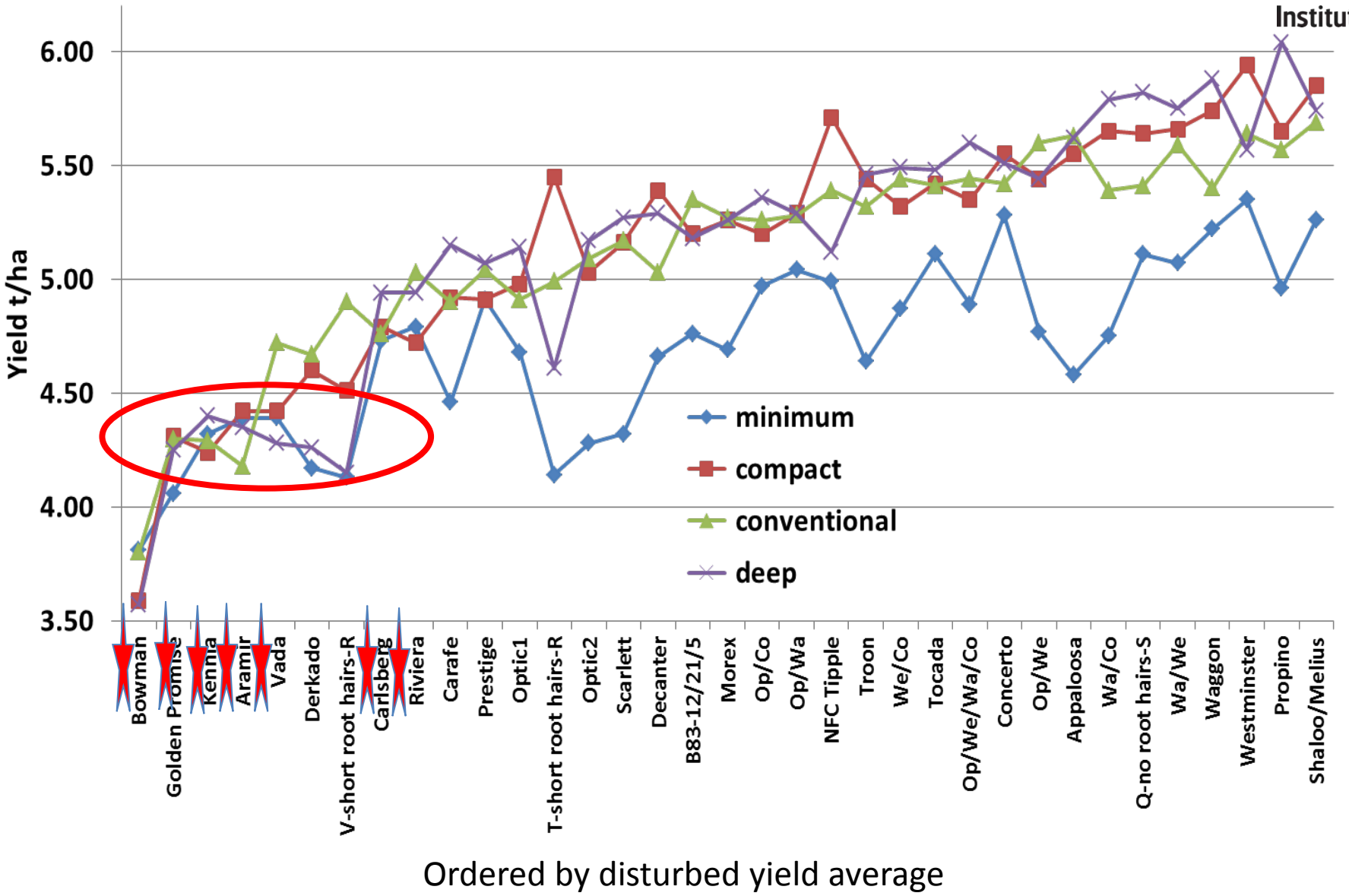
Centre for Sustainable Cropping, Hutton

Yield in minimum cf. disturbed
2013 + 2014 data

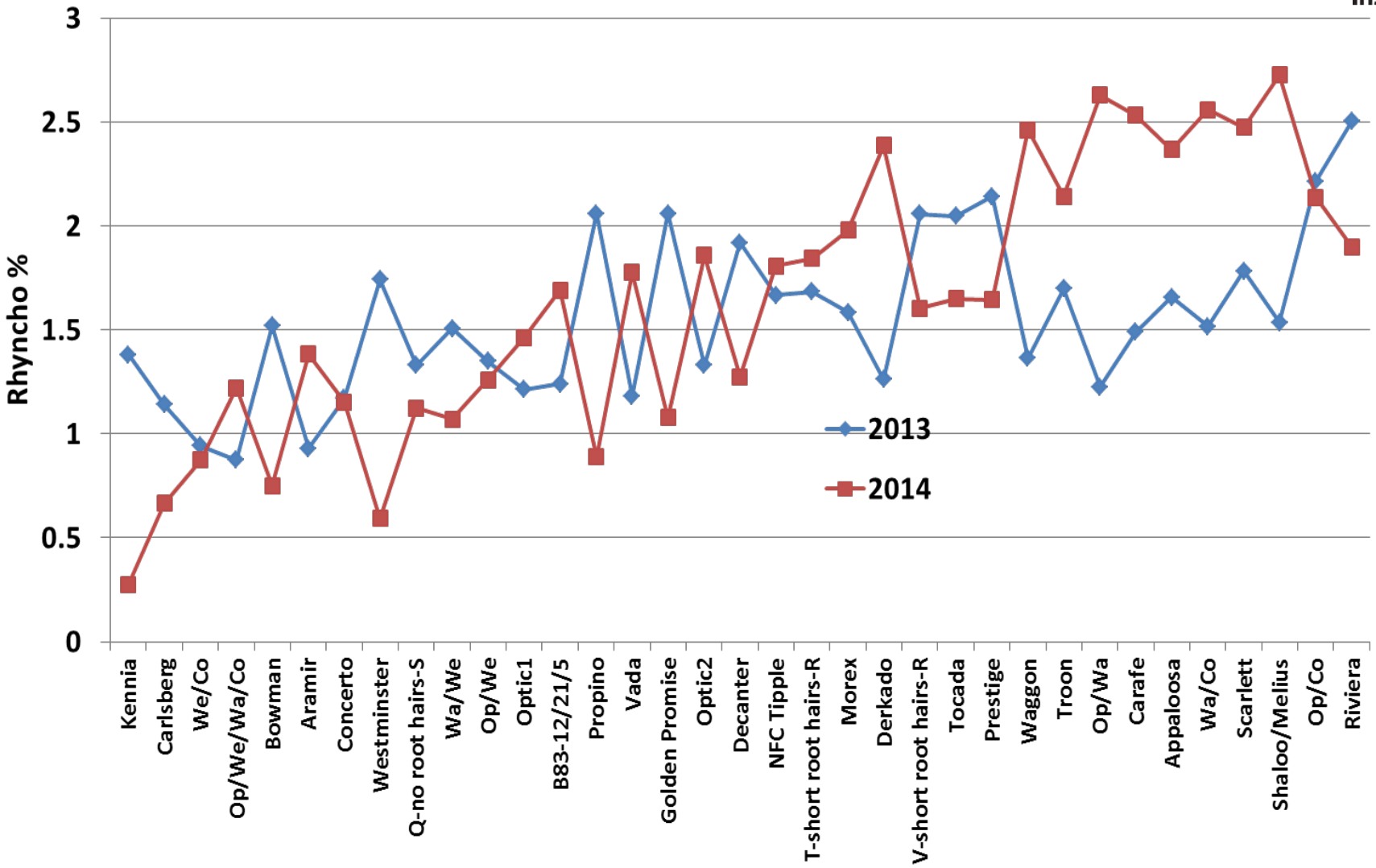


Ordered by difference between minimum & disturbed av.

Yield in minimum cf. disturbed 2013 + 2014 data

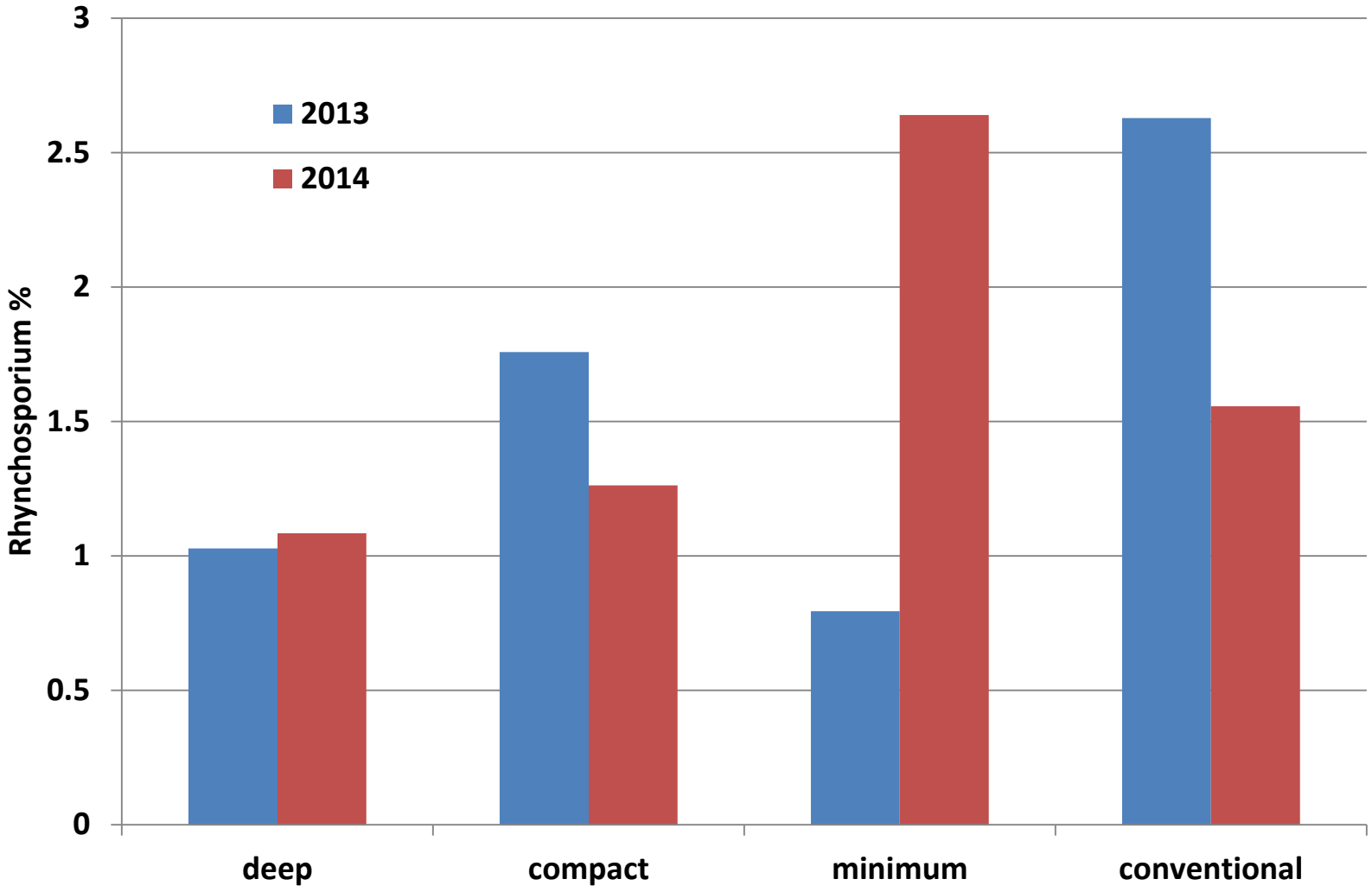


Rhynchosporium infection
2013 + 2014 data



Ordered by 2 year average

Rhynchosporium infection 2013 + 2014 data



Comments

- **Spring** cultivars show differential response to soil cultivation (as for winter cultivars)
- Higher-yielding cultivars respond to soil disturbance better
- Older and lower-yielding cultivars tend not to respond differentially to soil disturbance
- Effect of disturbance on Rhynchosporium varies with season

But what about the soil?

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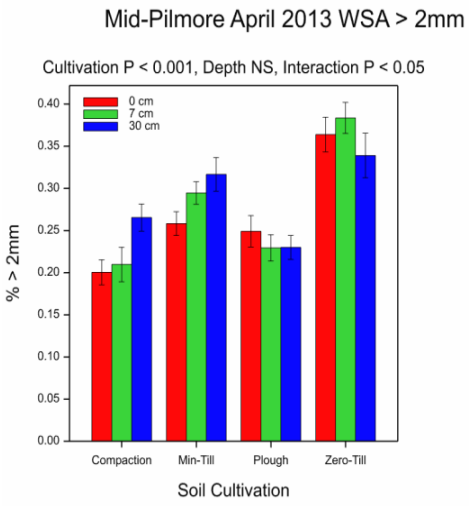
Soil stability

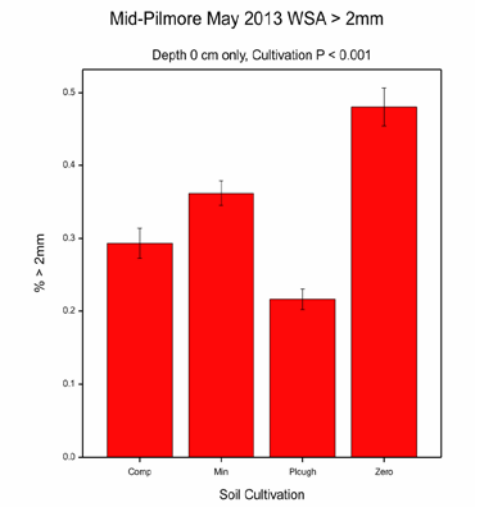
- Water stable aggregation -

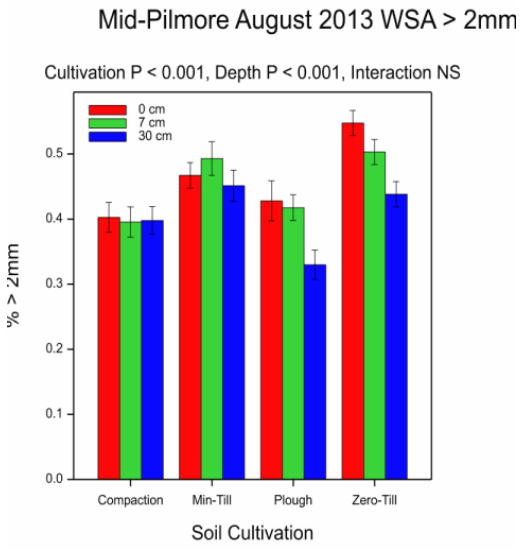
  >0.25mm associated with plant and microbial exudates

  >2mm associated with roots and hyphae

Mid-Pilmore 2013 WSA

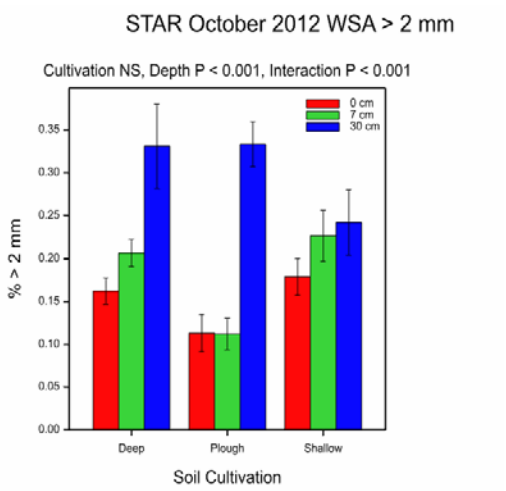


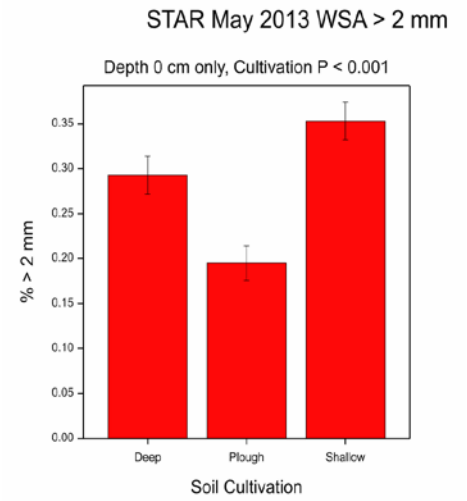


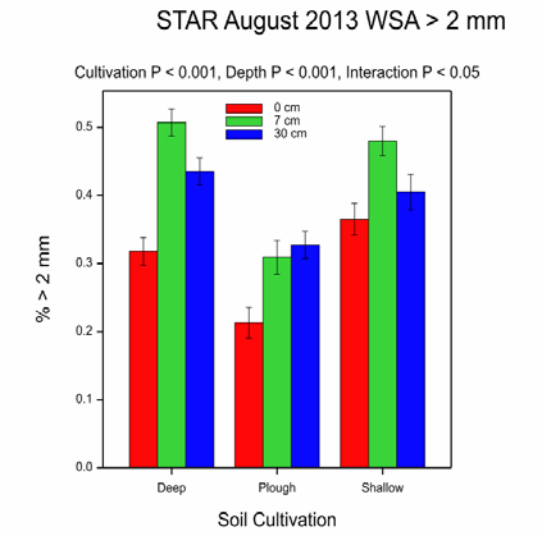


- Spring barley
- At planting (April), after crop establishment (May), preharvest (August)
- Generally More disturbance = less stable
- Different rates of recovery of stability

STAR 2013 – 2012 WSA







- Winter cereal

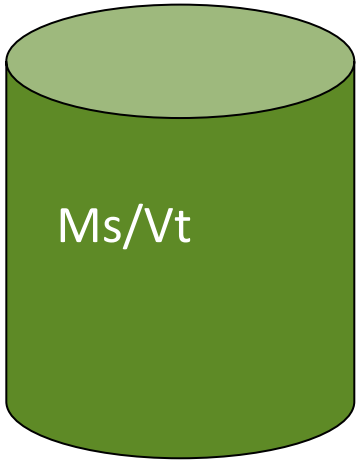
- October 2012 after cultivation and drilling
- May 2013 crop established
- August 2013 before harvest

- Generally more disturbance = less stable

- Different rates of recovery of stability

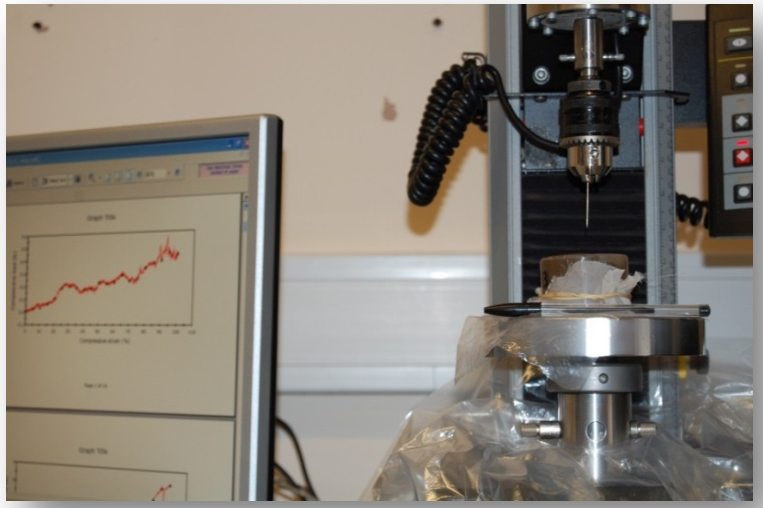
Traditional measure of structure: bulk density

- Mass of solid material per unit volume
- Need to relate to root growth
- Variability!



Measures to assess soil physical status

- What are the conditions for crop growth as affected by soil management?
- Plant available water –
  - θfield capacity – θwilting point
  - Pore size distribution
  - Macroporosity
- Least Limiting Water Range –
  - links aeration, hardness and water
  - uses micropenetrometer
  - measured on soil core samples



Familiar concept: Plant Available Water

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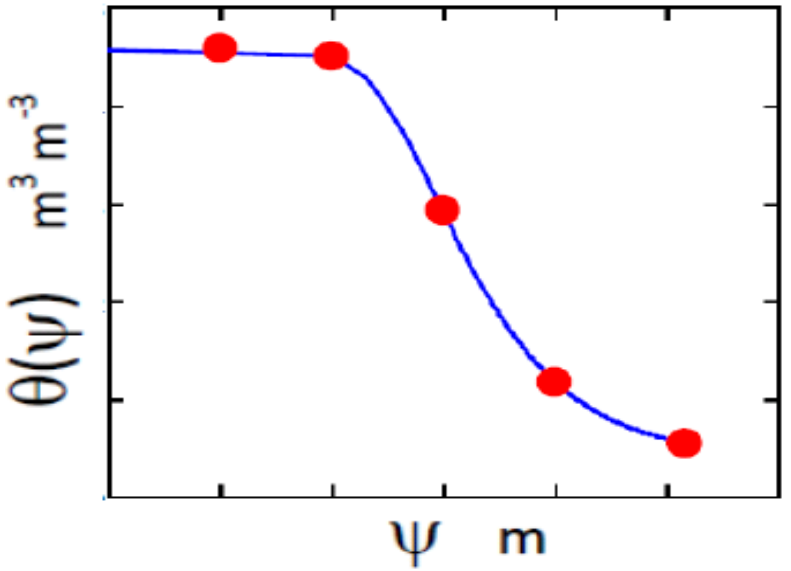
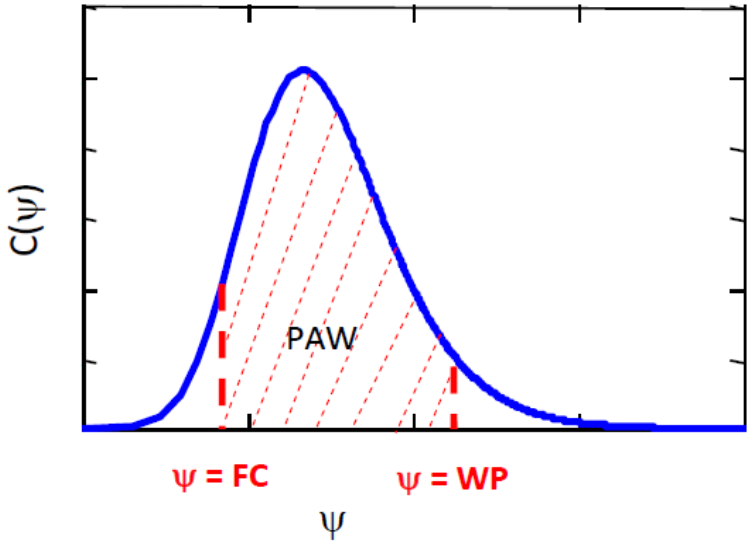
Water retention curve

$$\theta = f(\psi)$$



$$\frac{d\theta}{d\psi} = differential\ water\ capacity, C(\psi)$$

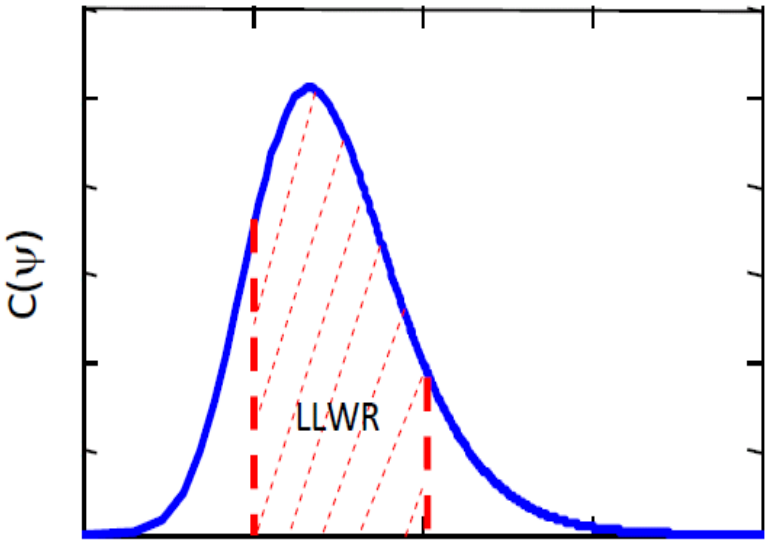
$$PAW = \int_{\psi=FC}^{WP} \frac{d\theta}{d\psi} d\psi$$



Concept: Least Limiting Water Range

Can also determine volume of macropores and their size distribution.

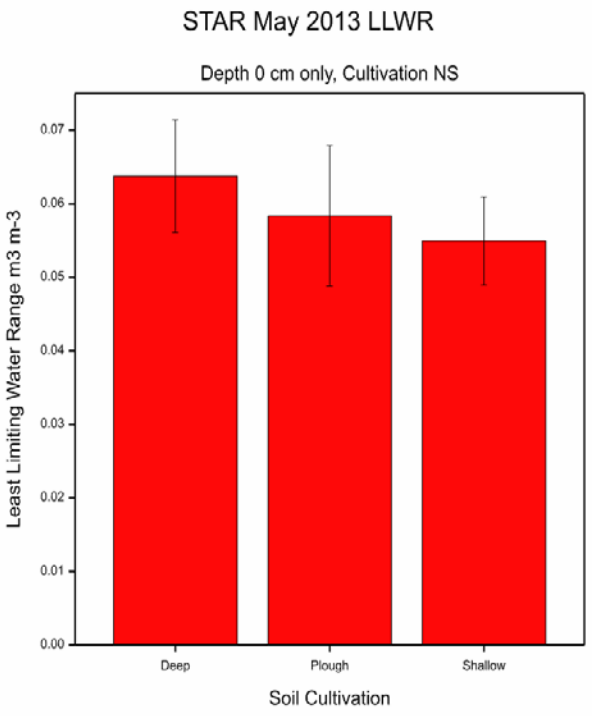
How do we know the relationship between water content θ when Soil Resistance = 2MPa?

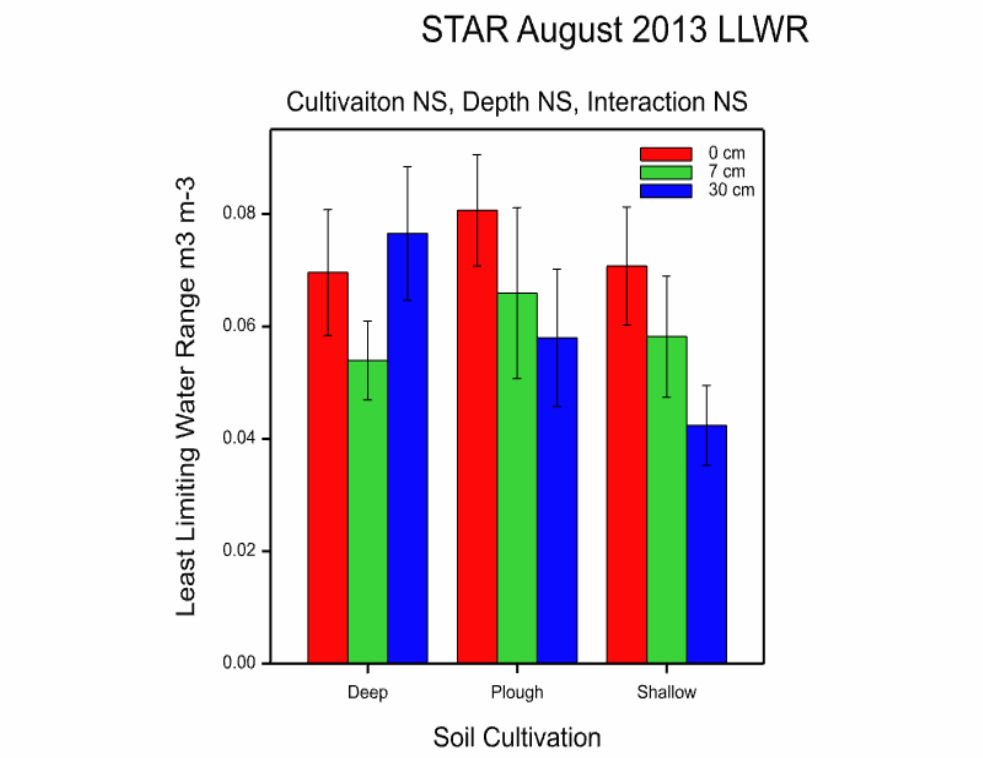


$$LLWR = \int_{\substack{\psi=FC \\ or \\ \psi@10\%\,\theta_{air}}}^{\substack{WP \\ or \\ \psi@SR=2MPa}} \frac{d\theta}{d\psi} d\psi$$

da Silva and Kay 1994

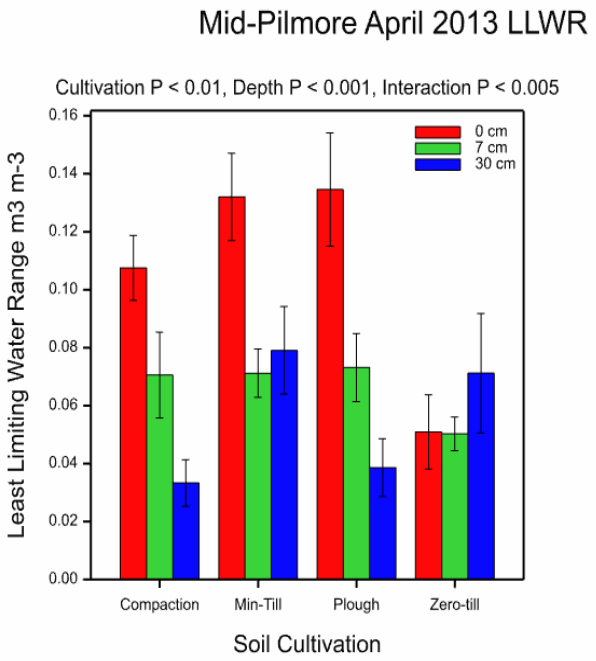
STAR 2012 – 2013 LLWR

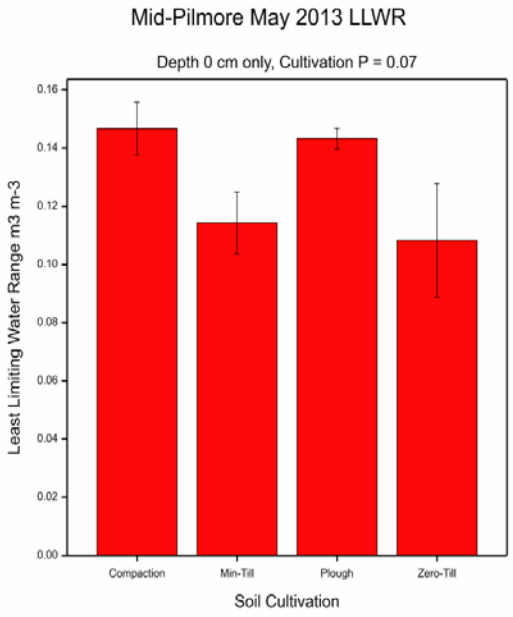


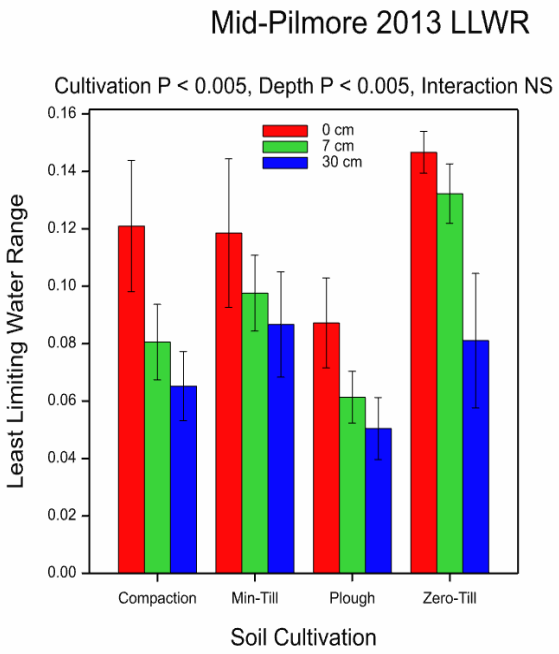


LLWR varies with time and depth

Mid-Pilmore 2013 LLWR







Changes over growing season

STAR Project
(Sustainability Trial for Arable Rotations)

NIAB TAG
National Agronomy Centre

Rotations
- Winter Cropping
- Spring Cropping
- Continuous W Wheat
- Alternate Fallow

Establishment
- Annual Plough
- Deep non-inversion
- Shallow non-inversion
- Managed Approach

= 16 treatments

X 3 replicates

		Cropping									
	Rotation	2006 (Year 1)	2007 (Year 2)	2008 (Year 3)	2009 (Year 4)	2010 (Year 5)	2011 (Year 6)	2012 (Year 7)	2013 (Year 8)	2014 (Year 9)	2015 (Year 10)
1	Winter cropping	WOSR	Wheat	Winter beans	Wheat	WOSR	Wheat	Winter Beans	Wheat	WOSR	Wheat
2	Spring cropping	Spring Beans	Wheat	Spring Oats	Wheat	Spring Beans	Wheat	Spring Linseed	Wheat	Spring Oats	Wheat
3	Cont wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat
4	Alt fallow	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat

In the managed approach the cultivation regime is decided annually by the project steering group; this decision is based on soil conditions / assessments, previous cropping, weed burden and local best practice. The techniques used have ranges from single pass approaches through to ploughing.

Cobbold Trust · HGCA · Chadacre Agricultural Trust

STAR yields and margins 2012-13 (winter wheat)

(Draft data – margins as gross output minus input costs and direct machinery costs)

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	Yield (t/ha)					Gross margin – machinery cost (£/ha)			
	Winter	Spring	Cont	Alt Fallow		Winter	Spring	Cont	Alt Fallow
Plough	9.39	9.04	7.08	8.91		768	716	422	696
Managed	8.92	9.50	7.84	8.23		743	830	581	652
Deep non-inversion	8.66	9.16	6.48	8.91		704	779	377	741
Shallow non-inversion	8.62	8.92	5.85	8.65		711	756	295	715
Average	*8.90*	*9.16*	*6.81*	*8.68*		*732*	*770*	*419*	*701*
LSD t/ha	1.14								
CV %	8.2								

Margins based on diesel at 68ppl; nitrogen at 80p/kg N and wheat at £150/t – spot prices in year of production

The yields reflect the difficult establishment conditions experienced in autumn 2012 and other local farm results.

STAR yields and margins 2013-14 (break crop year)

(Draft data – margins as gross output minus input costs and direct machinery costs)

The James Hutton Institute

	Yield (t/ha)					Gross margin – machinery cost (£/ha)			
	Winter (OSR)	Spring (oats)	Cont (WW)	Alt Fallow		Winter	Spring	Cont	Alt Fallow
Plough	4.68	6.47	10.66	-		774	250	664	-
Managed	4.12	6.21	10.54	-		719	284	693	-
Shallow	3.78	6.27	10.73	-		624	302	728	-
Deep	4.67	5.89	10.38	-		861	185	674	-
Average	*4.31*	*6.21*	*10.58*	-		*745*	*255*	*690*	-
LSD t/ha	0.58	0.71	0.96	-					
CV %	6.4	5.9	4.5	-					

Margins based on diesel at 64ppl; nitrogen at 72p/kg N (for AN) and wheat (£120/t), OSR (£280/t), oats (£100/t) – spot prices in year of production

Cumulative long term trends in yield data
Years 2006-2014

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	Relative yield return (relative to ploughed approach)				
	Winter	Spring	Cont	Alt Fallow	**Average**
Plough	100	100	100	100	**100**
Managed	95	103	108	92	**99**
Shallow	92	92	100	97	**95**
Deep	99	97	97	98	**98**
Average	-	-	-	-	

Cumulative long term trends in yield and margin data: Years 2006-2014

	Cumulative gross margin minus machinery cost (£/ha)					Relative margin (relative to ploughed approach)				
	Winter	Spring	Cont	Alt Fallow	**Average**	Winter	Spring	Cont	Alt Fallow	***Average***
Plough	5367	3130	3332	2333	**3541**	100	100	100	100	100
Managed	5278	3552	3981	2062	**3718**	98	113	119	88	105
Shallow	4559	3197	3571	2350	**3419**	85	102	107	101	99
Deep	5733	3280	3274	2382	**3667**	107	105	98	102	103
Average	**5234**	**3290**	**3540**	**2282**						

Offspring from Mid-Pilmore

- 14 years of monoculture
- Originally 5 cultivations (Zero has failed to produce yield)
- Min Till (shallow non-inversion) struggling
- Surface pH approaching critical
- Weeds becoming uncontrollable
- Slugs, pigeons and other pests
- The end looms – what next?

Discuss

- What questions need answers?
- I have ideas – but want to hear from others

Acknowledgements

- AHDB (HGCA and Potato Council) & Scottish Government funding
- Hutton staff – lots but especially farm staff
- Colleagues
- Collaborators

Sedewa UTOPUS

The James Hutton Institute

- http://sedewa.com/utopus.html

We know a lot about what conditions roots want

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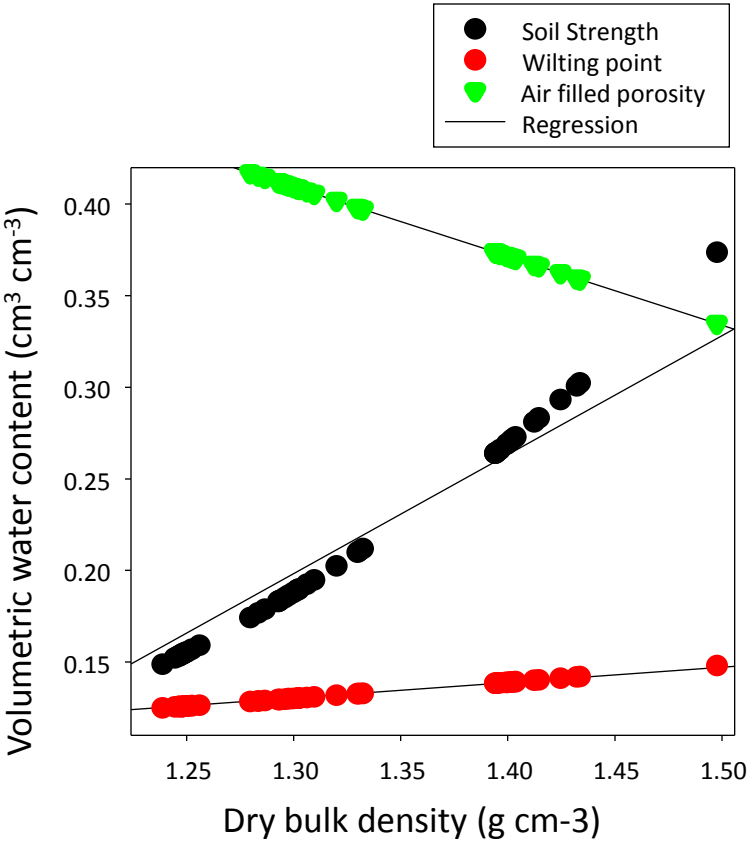
Water Retention (including aeration) & Penetrometer Resistance



Putting the ideas together.