NIAB Soils Programme
Long-term rotational projects

AFCP

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STAR Project

(Sustainability Trial for Arable Rotations)

NIAB TAG

Rotations

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

X

Establishment

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

= 16 treatments

X 3 replicates

Cropping

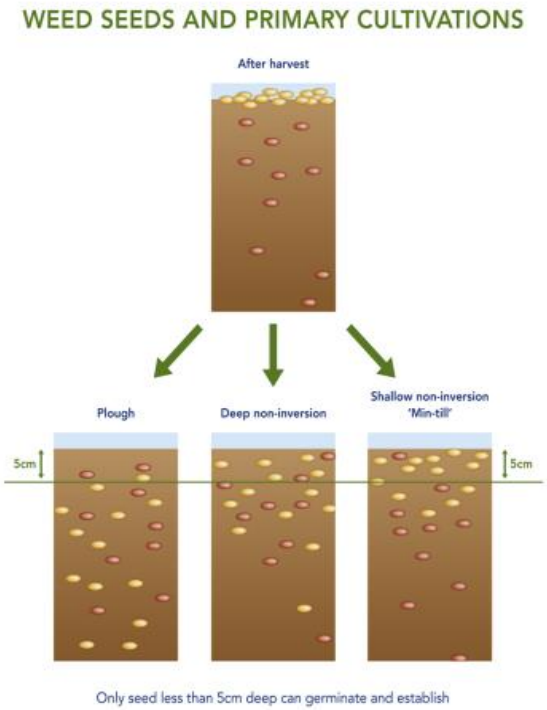
Rotation	2006 (Yr 1)	2007 (Yr 2)	2008 (Yr 3)	2009 (Yr 4)	2010 (Yr 5)	2011 (Yr 6)	2012 (Yr 7)	2013 (Yr 8)	2014 (Yr 9)	2015 (Yr 10)	2016 (Yr 11)	2017 (Yr 12)	2018 (Yr 13)
1 Winter cropping	WOSR	1st Wheat	Winter beans	1st Wheat	WOSR	1st Wheat	Winter Beans	1st Wheat	WOSR	1st Wheat	Winter beans	1st Wheat	2nd Wheat
2 Spring cropping	Spring Beans	1st Wheat	Spring Oats	1st Wheat	Spring Beans	1st Wheat	Spring Linseed	1st Wheat	Spring Oats	1st Wheat	Spring beans	1st Wheat	2nd Wheat
3 Cont wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat	Cont Wheat
4 Alt fallow	Fallow	1st Wheat	Fallow	1st Wheat	Fallow	1st Wheat	Fallow	1st Wheat	Fallow	1st Wheat	Fallow	1st Wheat	2nd 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.

FELIX COBBOLD TRUST
Chadacre Agricultural Trust
THE MORLEY AGRICULTURAL FOUNDATION
JC Mann Trust
AHDB CEREALS & OILSEEDS

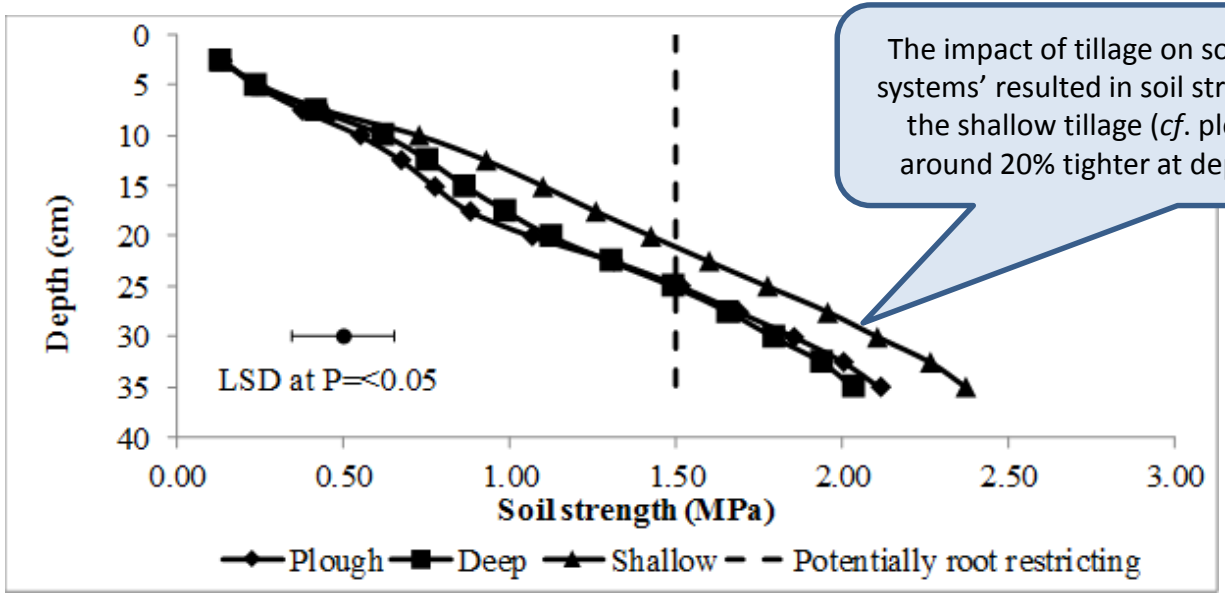
STAR - Soil physical properties

Plough



Shallow non-inversion

STAR - Soil strength with respect to tillage approach.



The impact of tillage on soil strength for the 'consistent systems' resulted in soil strength diverging at c. 7.5 cm in the shallow tillage (*cf*. plough tillage) and remains at around 20% tighter at depths between 15 and 35 cm.

With regard to soil strength, the shallow tillage approach resulted in a tighter soil profile (>15 cm) compared with the plough or deep approaches. (REF: Morris *et al*., ISTRO, 2018)

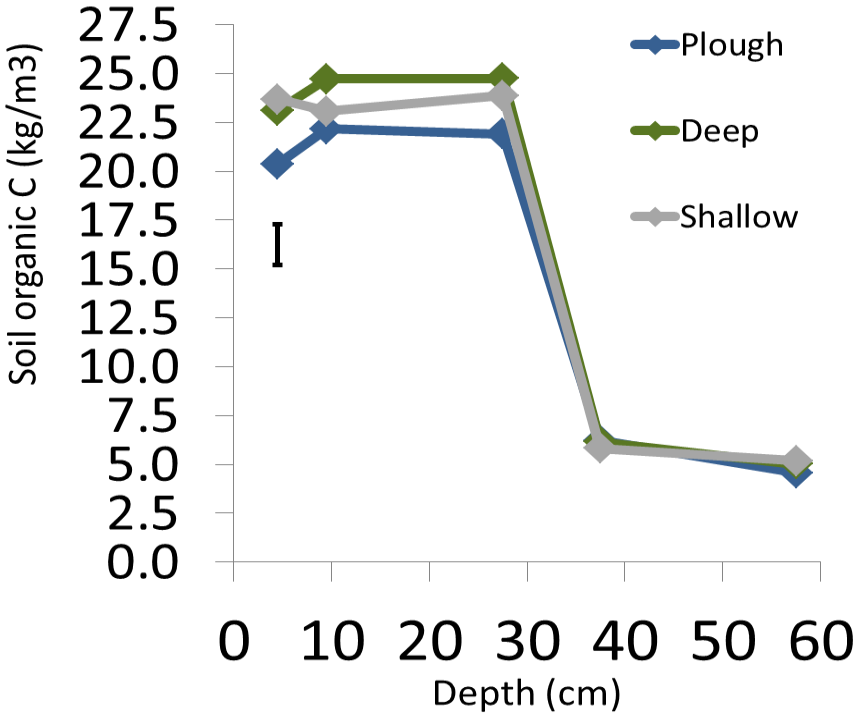
STAR yields and margins

Yield as % plough in each rotation and cumulative margin, £/ha 2006-2018

	Winter	Spring	Cont. Wheat	Alt Fallow	Average
Relative yield (%) (*cf.* plough)					
Plough	100	100	100	100	100
Deep	91 (*98*)	96	97	99	96 (98)
Shallow	89 (95)	*89* (*93*)	101	99	95 (97)
Cumulative margin (£/ha)					
Plough	8228	5621 (5859)	5647	4783	6070
Deep	8145 (8504)	5808 (5994)	5692	5267	6228
Shallow	6772	5720 (6040)	6353	5134	5995
Average	7715	5716	5897	5061	-

Where there were failed crops the calculated relative yield or margin with these failures excluded is shown in brackets (*yield/margin*)

STAR - Soil chemical properties - Soil organic C

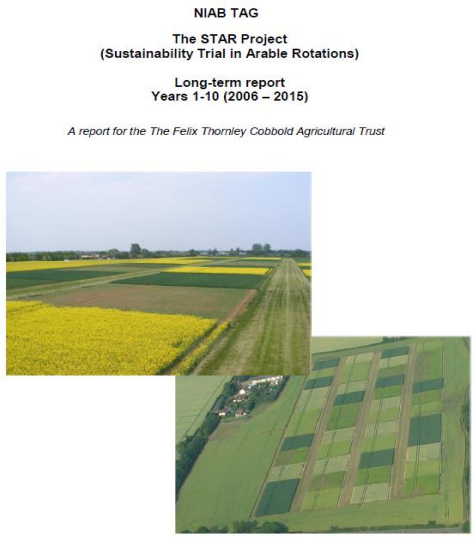


JC Mann Trust

Final Report: AHDB PR574 (2017) 'Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments'

Long-term report : 10 key findings

1. STAR system and rotation choices have had an agronomic impact on factors including mycotoxin risks and weed burden (notably bromes in non-inversion wheat systems).
2. Shallow non-inversion tillage is leading to progressively tighter soils in the continuous wheat rotation and across the winter and spring cropping rotations.
3. Considering yields over all crops in the rotation, the difference between cultivation systems is small, however, of the consistent systems, ploughing is tending to give the highest yields.
4. While ploughing might give high yields, of the consistent cultivation systems across seasons, the highest margins have been associated with the deep non-inversion system: although again differences are relatively small.
5. A variable managed approach (an informed decision each season based on soil, season and agronomic drivers), has performed similarly to the deep non-inversion system.
6. Considering wheat alone across seasons, for the consistent cultivation systems, there is little yield difference, with deep non-inversion systems resulting in the highest margins.
7. Findings perhaps suggest that tillage decisions are more critical in break crops and also highlight the value of informed soil management decisions to maximise performance.
8. Cumulatively, STAR rotational choices have tended to have a bigger impact on margin than primary tillage decisions; with winter cropping rotations giving the higher margins.
9. Consideration of timeliness and speed of working across the farm, as well as yield and margin, is critical when scaling findings from STAR up to a farm level.
10. One key finding is how much we owe to the supporting Trusts, the STAR advisory group and notably our site host John Taylor; without their input this project would not happen


NIAB TAG

The STAR Project
(Sustainability Trial in Arable Rotations)

Long-term report
Years 1-10 (2006 – 2015)

A report for the The Felix Thornley Cobbold Agricultural Trust

Report available on NIAB's website:
http://www.niab.com/pages/id/292/Farming_Systems

The New Farming Systems Experiments

Soil amendments experiment

3 rotations

1. Spring breaks
2. Spring breaks + cover crop
3. Cont. Wheat (spring breaks 2018 onwards)

With or without 35t ha of compost (applied annually between 2008 and 2011)

Rotations experiment

3 Rotations:

1. Winter cropping
2. Spring cropping
3. Mixture of the two

4 cover crop treatments

1. standard practice (stubble)
2. legume (clover) bi-crop
3. legume mix cover crop
4. non legume cover crop

N strategies

1. no nitrogen (N)
2. 50% standard N dose
3. 100% of standard N dose (220kg/ha WW)

Long term (2007-present) set of trials at Morley, Norfolk (medium, sandy loam soil)

Delivered through NIAB TAG supported by the Morley Agricultural Foundation and The JC Mann Trust

Cultivations experiment

4 cultivation systems

1. Plough
2. Deep non-inversion (20cm)
3. Shallow non-inversion (10cm)
4. Managed approach

Stubble or autumn cover crops ahead of spring crops (companion crop in WOSR rape)

JC Mann Trust

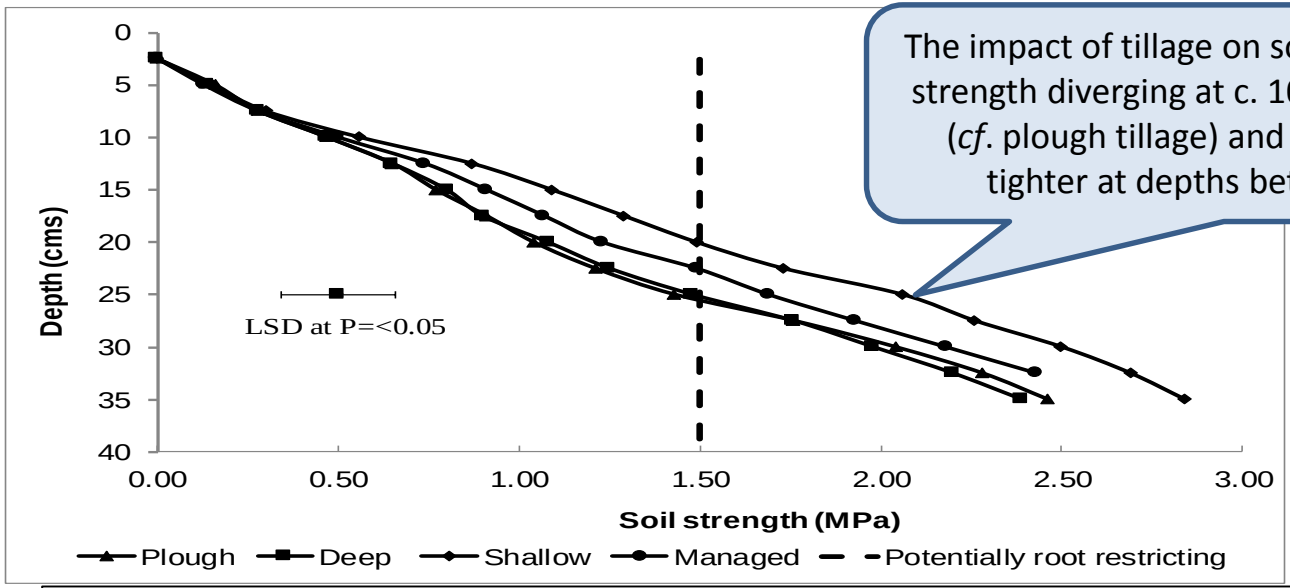
NFS Cultivation experiment

The NFS study explores the interaction between cultivation intensity in a fully replicated experiment on large plots using commercial machinery.

4 cultivation systems:
Plough, Deep and Shallow non-inversion and Managed
± autumn cover crops ahead of spring sown crops

Rotation	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)	Year 4 (2011)	Year 5 (2012)	Year 6 (2013)	Year 7 (2014)	Year 8 (2015)	Year 9 (2016)	Year 10 (2017)	Year 11 (2018)
Winter rotation incl. spring breaks	ww	sosr	ww	sbn	ww	sbrly	wosr	ww	soats	ww	wbrly
Cover crop		✓		✓		✓			✓		

NFS - soil strength with respect to tillage approach.

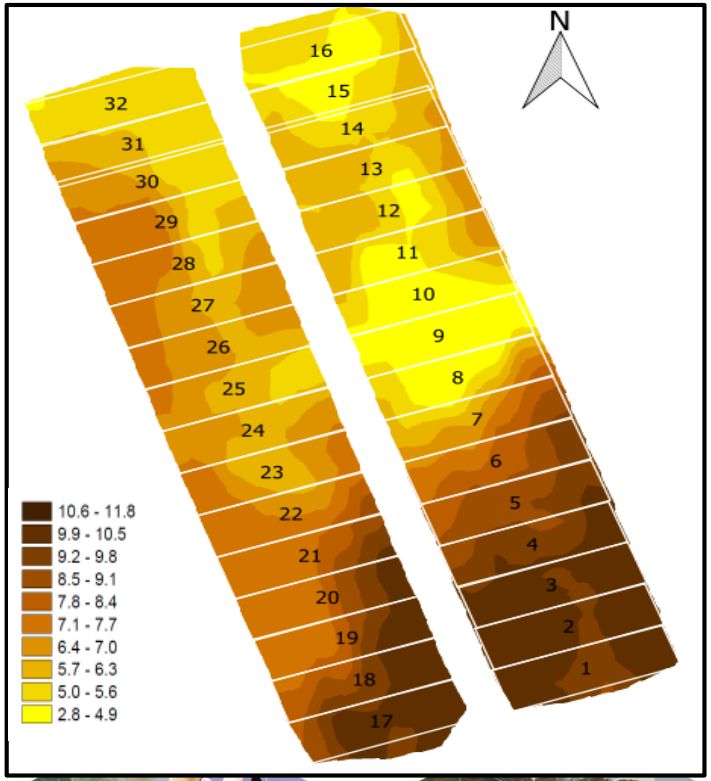


The impact of tillage on soil strength resulted in soil strength diverging at c. 10 cm in the shallow tillage (*cf*. plough tillage) and remains at around 25% tighter at depths between 15 and 35 cm.

With regard to soil strength, the shallow tillage approach resulted in a tighter soil profile (>15 cm) compared with the plough or deep approaches. Compared to plough tillage, the managed approach remains at around 12% tighter at depths between 15 and 35 cm

NFS - Improving trial experimental design and analysis using soil electrical conductivity scanning

- Measure of a materials ability to conduct an electrical current, often reported in milliSiemens/m (mS/m)
- Correlates well to a soils texture, cation exchange capacity, drainage capacity, organic matter content and subsoil characteristics
- The NFS Cultivation study was scanned for shallow (50cm) and deep (150cm) electrical conductivity (May, 2013)



NFS - Effect of EC on wheat productivity at Morley

The plots where split into 3 groups, low EC (4.1-5.8) medium EC (5.9-8.5) and high EC (8.7-11.3)

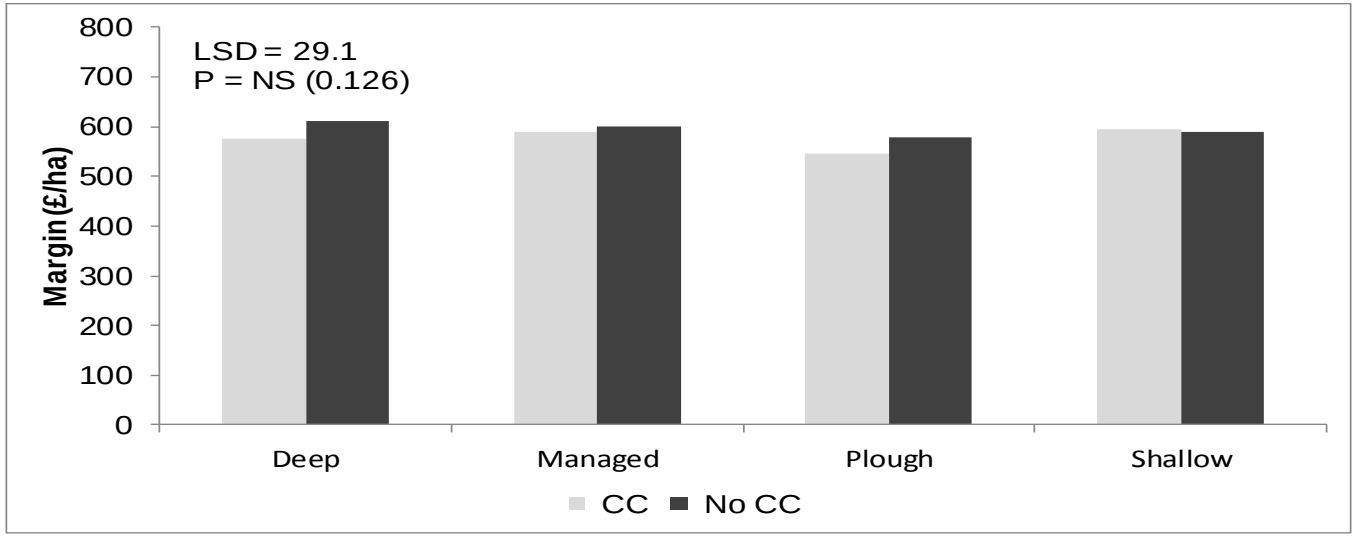
Winter wheat heads/m² (2008-2017) across the three electrical conductivity groups

	2008	2010	2012	2015	2017	Mean
High EC	507	415	446	317	431	423
Medium EC	486	373	485	310	422	415
Low EC	439	342	426	294	390	378
p=(0.005)	0.006	0.02	0.045	0.211	0.034	
LSD	39.7	36.6	46.1	27.46	31.49	

Winter wheat yields (2008-2017) across the three electrical conductivity groups

	2008	2010	2012	2015	2017	Mean
High EC	13	8.8	10.5	11.5	10.2	10.8
Medium EC	12.6	7.8	10.5	10.9	10	10.4
Low EC	11.8	5.9	10.4	9.8	8.8	9.3
p=(0.005)	0.001	0.001	0.272	0.001	0.01	
LSD	0.38	0.67	0.2	0.63	0.57	

NFS - Mean margin (£/ha) data for all seasons (2009-2018)



The inclusion of cover crops (including the associated costs for seed and establishment c. £60-80/ha) resulted in no significant increase, or decrease in overall margin.
Across the rotation non-inversion treatments resulted in a small increase, on average c. 4-7% in margin, compared to plough tillage; however, this is not statistically significant

Implications for Future Agronomy

- In general, ploughing has tended to result in the highest mean yields across the rotation, with a small but not significant drop to deep and shallow non-inversion systems.
- Across the rotation, the decline in yield was more pronounced on the medium soil type at NFS compared to the heavy soil type in STAR.
- Considered on average across seasons, winter wheat performance in NFS or STAR resulted in no significant yield differences across tillage approaches.
- Despite a significant increase in soil strength in the shallow non-inversion tillage; no significant yield reductions under shallow non-inversion tillage compared to plough tillage were observed.

Acknowledgements

- Felix Thornley Cobbald Trust
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- The Morley Agricultural Foundation
- JC Mann Trust
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