The integration of cover crops and soil tillage to improve crop production efficiency in a long running UK field experiment

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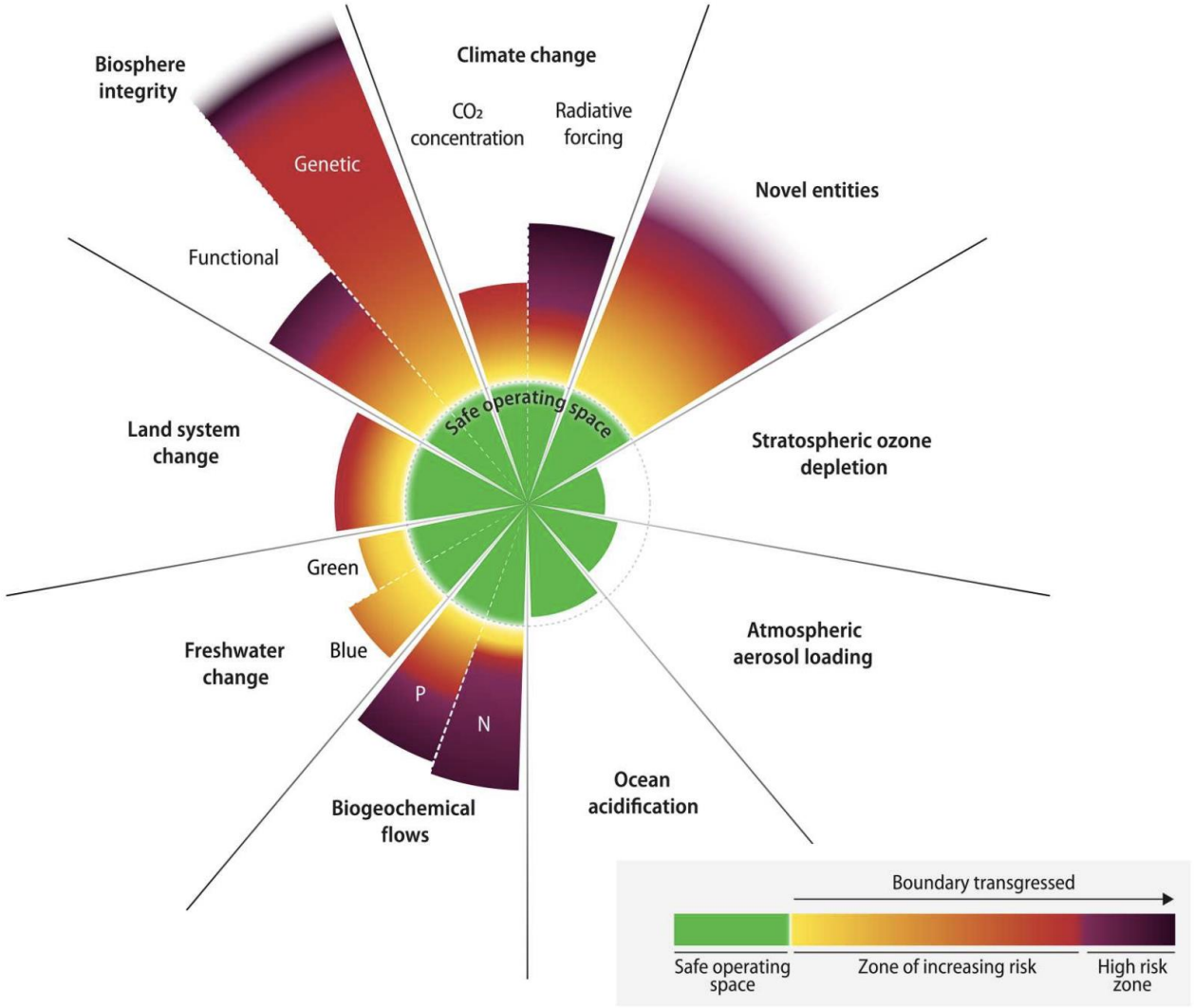
ABOUT NIAB

- Headquarters in Cambridge
- East Malling horticultural R&D centre in Kent
- £33m turnover in 2022/23
- 13 UK regional field trials centres
- 100+ UK field trial sites, 140k+ plots
- 400 staff (incl crop scientists, plant breeders, agronomists, crop specialists)

Global environmental impact of agricultural production

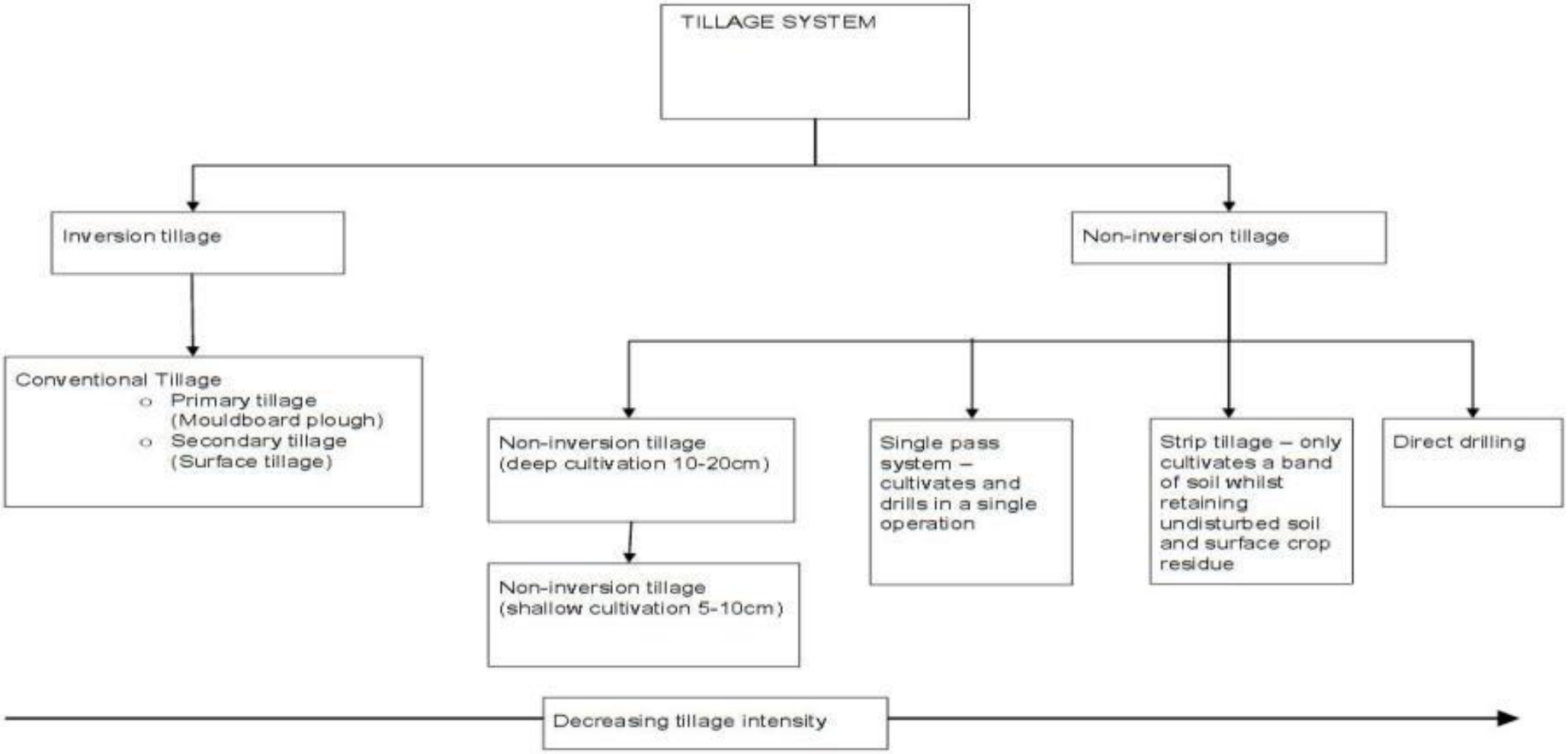
The challenge is to produce sufficient food for a growing world population, growing expectation to a high protein diet while limiting the detrimental environmental effects of our food production.



Rockström et al. 2009 *Nature*; Steffen et al. 2015 *Science,* Richardson et al. 2023 *Science Advances*

Classification of tillage systems by intensity

from Morris *et al*. 2014



New Farming Systems Cultivation Experiment

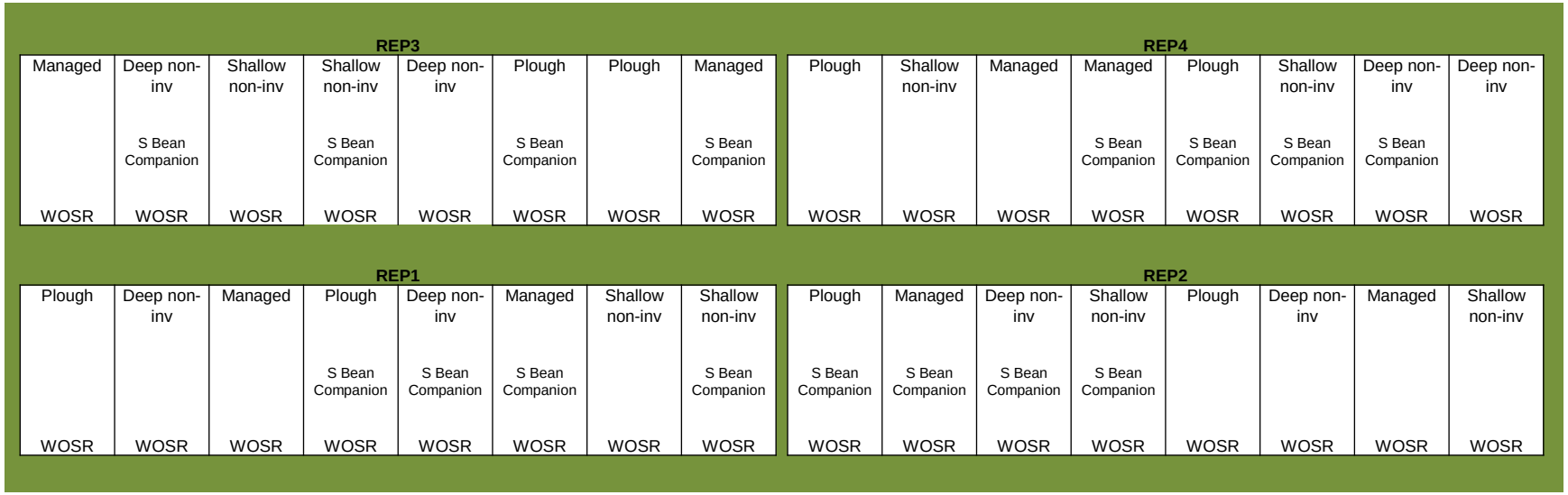
Cultivation approaches

1. Plough (200-250 mm);
2. Shallow non-inversion (ca. ≤100 mm);
3. Deep non-inversion (ca. 200 mm);
4. Managed regime

Two management approaches

1. Current – systems run as farm standard
2. Cover/companion crops

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)	Year 12 (2019)	Year 13 (2020)	Year 14 (2021)	Year 15 (2022)	Year 16 (2023)
ww	sosr Cover Crop	ww	sbn Cover Crop	ww	sbrly Cover Crop	wosr	ww	soats Cover Crop	ww	wbrly	wosr Companion Crop	ww	sbrly Cover Crop	soats	soats Cover Crop



Long term experiment

- Started in 2007
- Supported by the Morley Agricultural Foundation and The JC Mann Trust
- The NFS evaluating cultivation approaches study explores the interaction between cultivation intensity and cover/companion crop use

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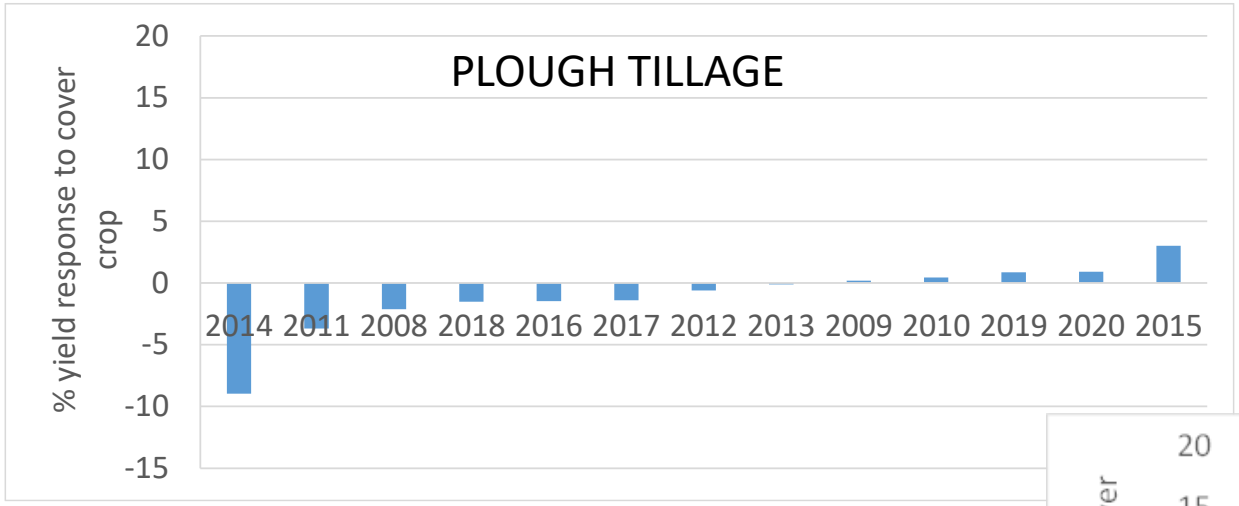
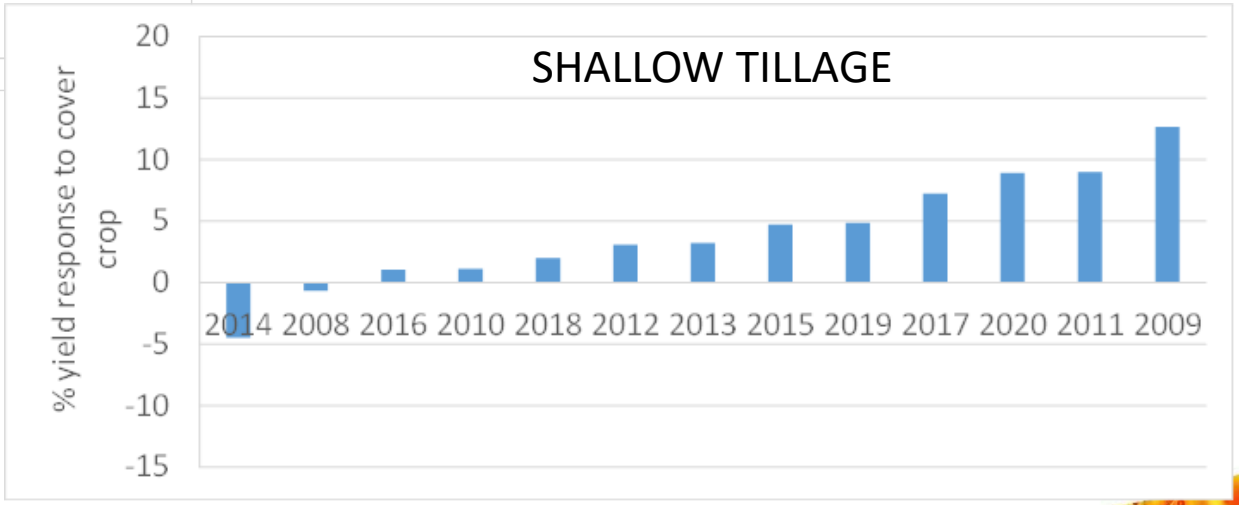
Yield response (%) to the use of a cover crops in the NIAB NFS long term cultivation study at Morley, Norfolk (2008 – 2020).



- Generally positive responses with cover crops and shallow tillage systems. Benefits less clear where plough based systems were used.



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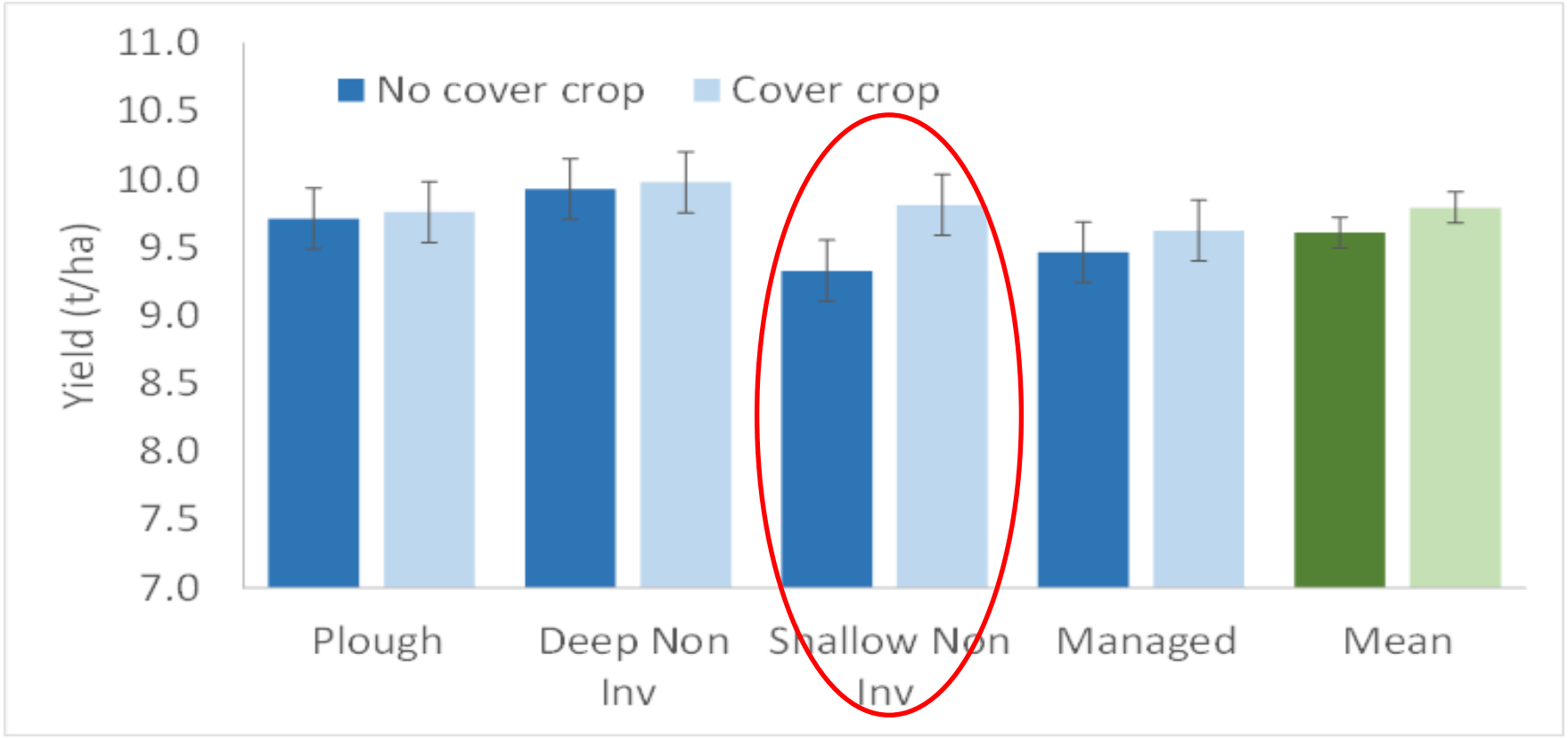
Mean yields for winter wheat based on 2009/10, 2011/12, 2014/15, 2016/17 and 2019/20 cropping



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Error bars show the Standard Errors of the Difference (SED).

Average yield (% of control) and range for years 2 (2008/09) to 13 (2019/20)

		Yield (% of control*)				
Tillage	Rotation	Average	Range	Winter wheat only	Yrs 2-6	Yrs 9-13
Plough	No cover crop	100.0	-	100.0	100	100
	Cover crop	99.0	91.2-102.9	100.4	99	99
Deep	No cover crop	98.6	55.9-110.6	101.9	90	103
	Cover crop	98.1	66.4-112.6	102.5	90	104
Shallow	No cover crop	93.5	48.3-116.0	95.8	83	99
	Cover crop	97.2	52.4-110.8	100.6	87	103
Managed	No cover crop	98.0	81.1-121.7	97.1	91	100
	Cover crop	99.3	76.0-114.2	98.8	93	102
Mean of two rotations	Plough	99.5	95.6-101.5	100.2	100	100
	Deep	98.3	61.2-111.6	102.2	90	103
	Shallow	95.3	50.3-113.4	98.2	85	101
	Managed	98.7	78.6-118.0	98.0	92	101
Mean of four tillage systems	No cover crop	100.0	-	100.0	100	100
	Cover crop	100.9	93.6-103.2	101.9	101	102

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Cumulative margins (£/ha)

For years 2 (2008/09) to years 13 (2019/20). Total cost associated with cover crop inclusion for the twelve-year period was calculated at -£277/ha inc support payment (+£496/ha).

		Margin data (£/ha): Cumulative Total		
Tillage	Rotation	Total	Less cover crop cost	Less cover crop cost & inc support payment
Plough	No cover crop	7,336	7,336	7,336
	Cover crop	7,041	6,764	7,260
Deep	No cover crop	7,867	7,867	7,867
	Cover crop	7,685	7,408	7,904
Shallow	No cover crop	7,481	7,481	7,481
	Cover crop	7,717	7,440	7,936
Managed	No cover crop	7,716	7,716	7,716
	Cover crop	7,662	7,385	7,881
Mean of two rotations	Plough	7,148	7,050	7.298
	Deep	7,764	7,638	7,886
	Shallow	7,586	7,461	7,709
	Managed	7,659	7,551	7,799
Mean of four tillage systems	No cover crop	7,611	7,611	7,611
	Cover crop	7,467	7,190	7,686

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Energy use

The energy consumed has been derived for:

1. Direct (on-farm) from machinery operation: pesticide spraying, fertiliser spreading, tillage depending on soil type, and depth and the type of crop sown.
2. Indirect from product manufacture: pesticides and fertilisers, their packaging, storage and transport (to farm).
3. Indirect from machinery manufacture: estimation of depreciation per operation or hours of use.

The energy input ratio is calculated as:

$$\text{Energy input ratio} = \frac{\text{energy per unit of yield (GJ t}^{-1}\text{) for treatment x in year n}}{\text{energy per unit of yield (GJ t}^{-1}\text{) for plough-only (control) in year } n}$$

Energy input ratio (GJ t-1) for each treatment relative to the conventional plough (control)

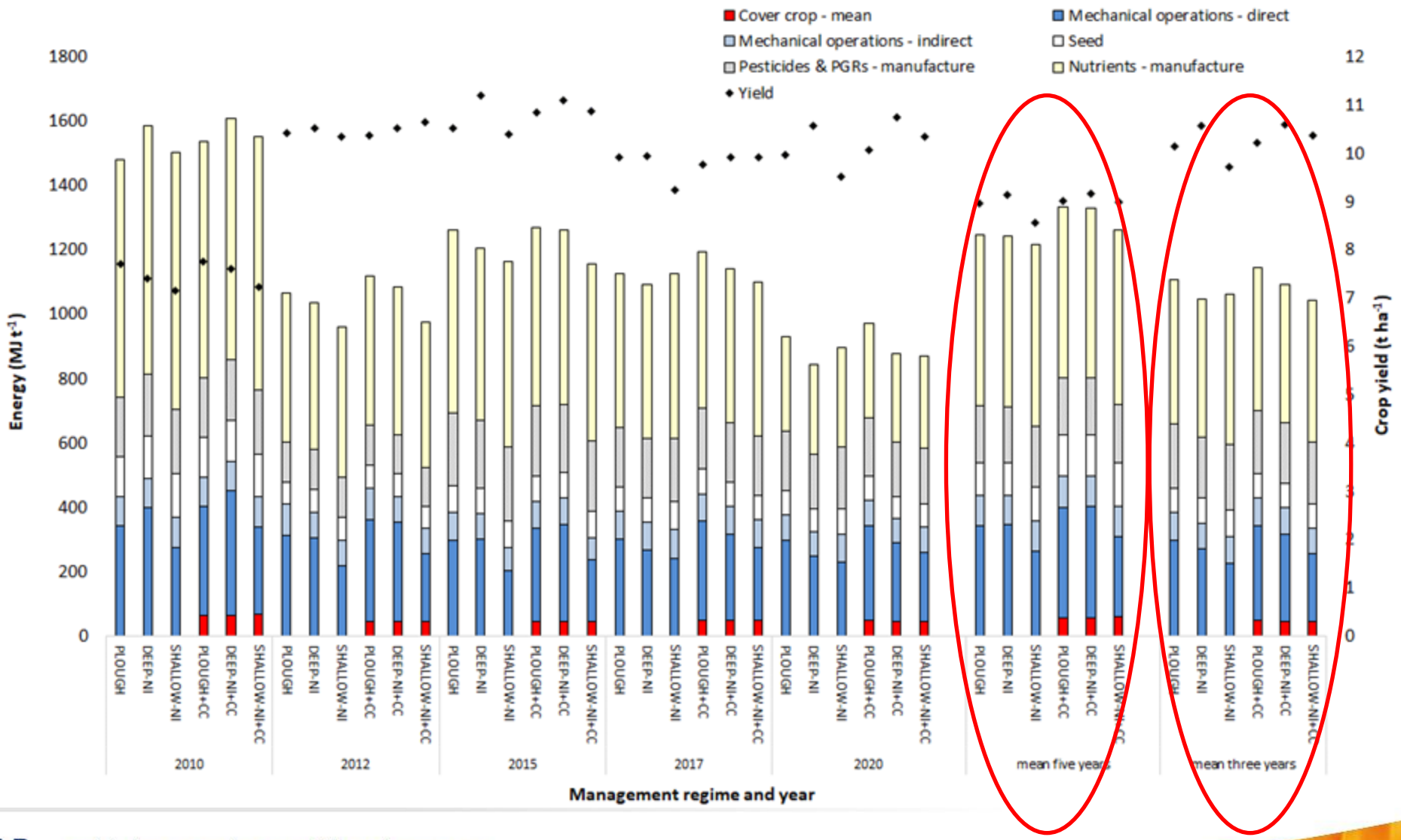
Year	Crop	*Plough (control)*	Deep-NI	Shallow-NI	Plough+CC	Deep-NI+CC	Shallow-NI+CC
2008	WW	*1*	1.04	0.97			
2009	SOSR	*1*	1.21	1.05	1.11	1.53	1.05
2010	WW	*1*	1.07	1.01	1.04	1.09	1.05
2011	SBN	*1*	1.84	1.74	1.14	1.70	1.78
2012	WW	*1*	0.97	0.90	1.05	1.02	0.92
2013	SBRLY	*1*	1.05	1.02	1.19	1.25	1.19
2014	WOSR	*1*	0.89	0.81	1.15	0.99	0.88
2015	WW	*1*	0.96	0.92	1.01	1.00	0.92
2016	SOAT	*1*	0.96	0.92	1.07	1.02	0.96
2017	WW	*1*	0.97	1.00	1.06	1.01	0.98
2018	WB	*1*	0.98	0.93	1.06	1.02	0.96
2019	WOSR	*1*	0.87	0.88	1.04	0.90	0.89
2020	WW	*1*	0.92	0.98	1.03	0.94	0.94
	mean WW2010-	*1*	0.99	0.98	1.07	1.06	1.01
	mean WW2015-	*1*	0.95	0.97	1.03	0.98	0.94

Treatment (green cell = decrease, red cell = increase)
Blue text spring sown crop

The energy ratio of the mean WW 2010- is lower than the plough control in the non-inversion treatments without cover crops only. Where the years 2010 and 2012 are excluded (mean WW 2015-) this extends to the non-inversion treatments with cover crops also.

University of Hertfordshire UH

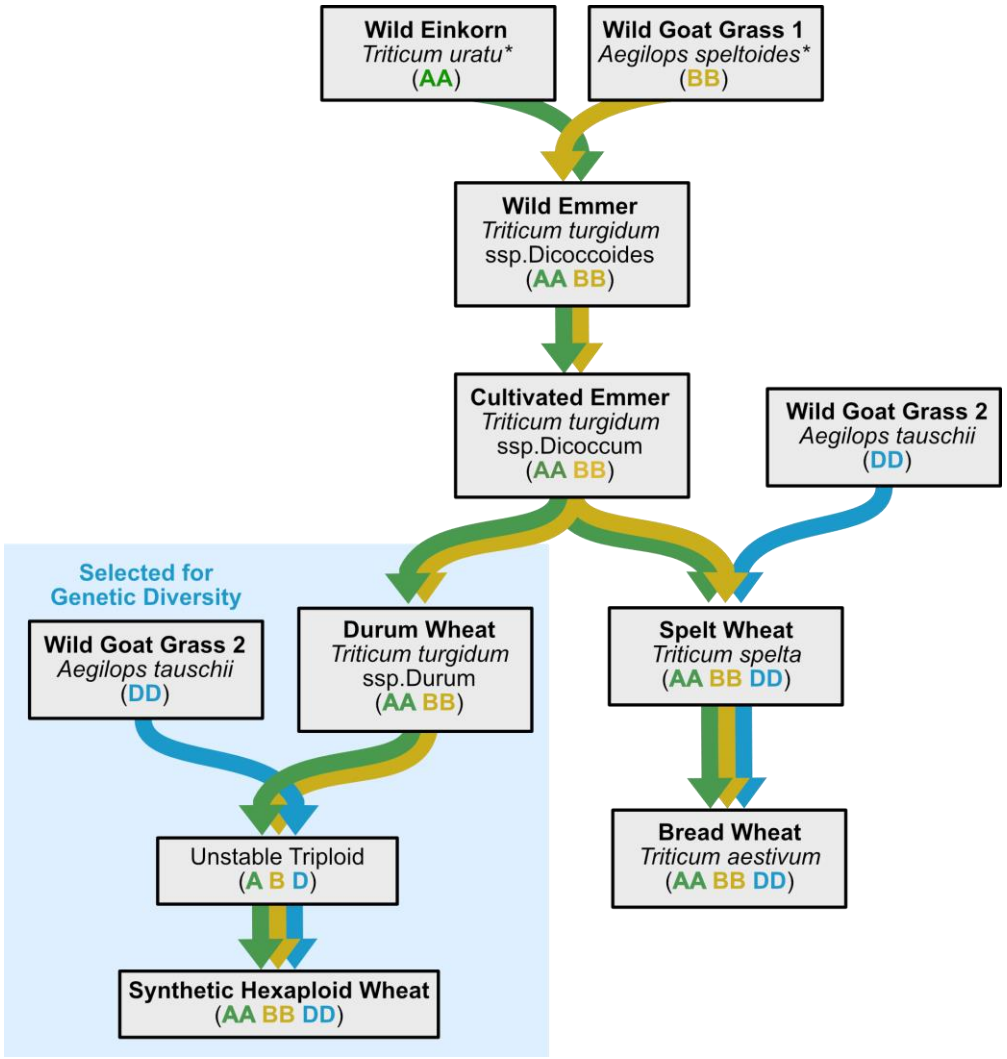
Crop yield (t ha^{-1}) and energy input per unit of yield (MJ t^{-1}) from management interventions in five winter wheat crops



Key findings

- Non-inversion tillage offers a lower energy alternative to conventional plough-based inversion tillage.
- Despite the lower yields in the shallow non-inversion treatment, this is compensated for by the lower energy input per ha, resulting in lower energy inputs per unit of yield compared to the plough control treatment.
- The inclusion of a cover crop appears to confer an additional yield benefit, reducing the energy input per tonne of yield further despite the additional energy associated with the culture of a cover crop in the rotation.
- In reference to winter wheat, shallow non-inversion tillage with a cover crop present with spring sown crops in the rotation was the most energy efficient treatment overall.

Next steps……

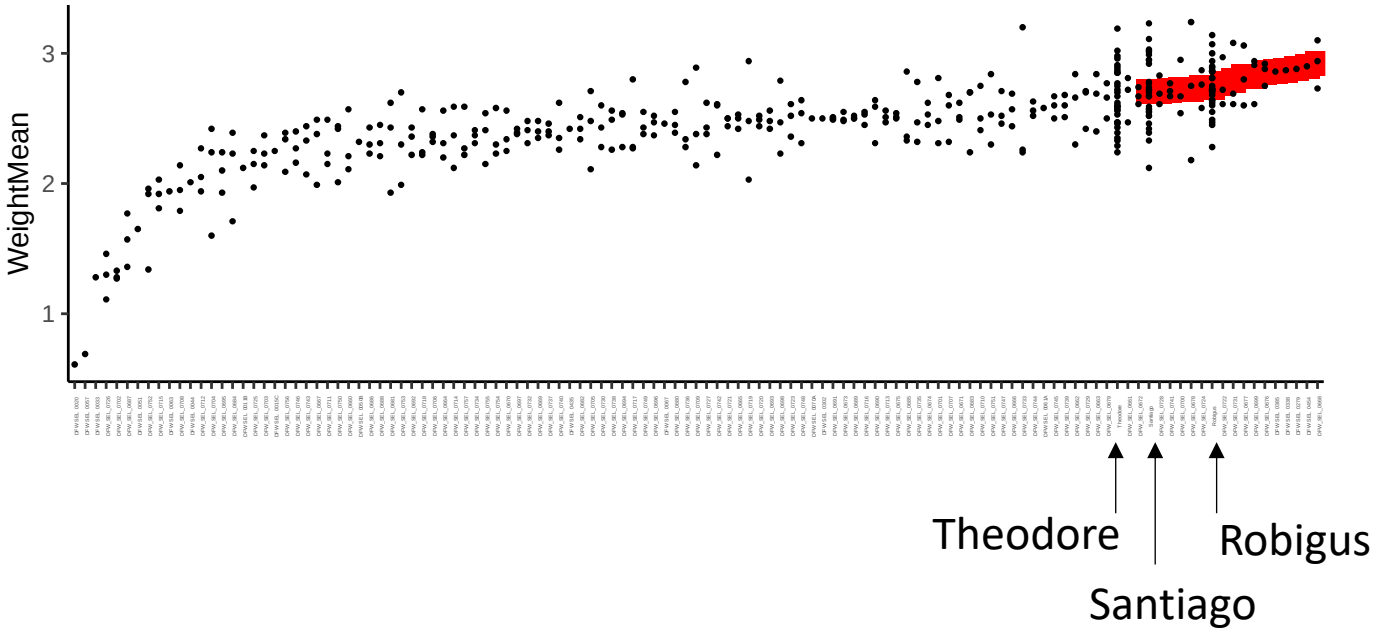


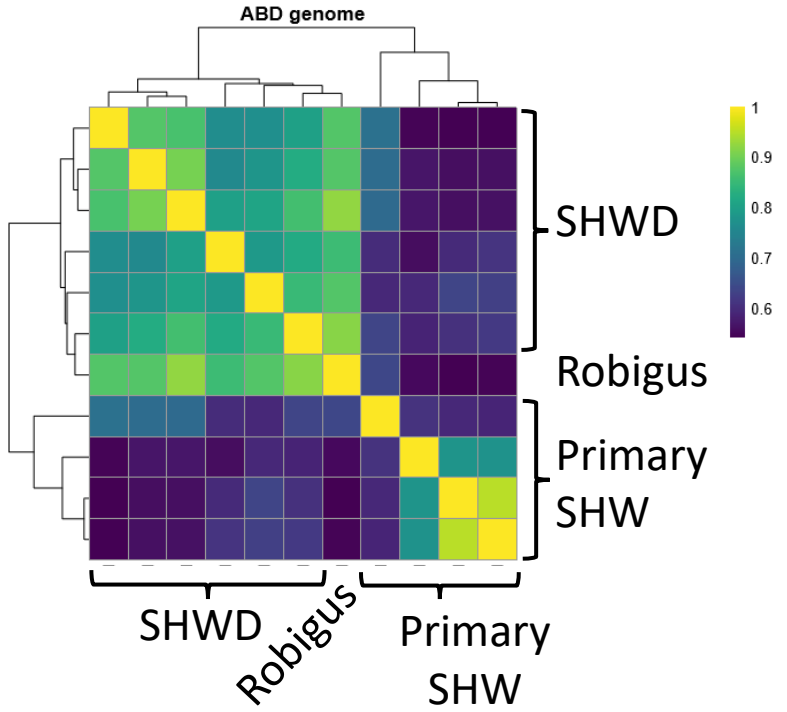
Richard Horsnell and Fiona Leigh

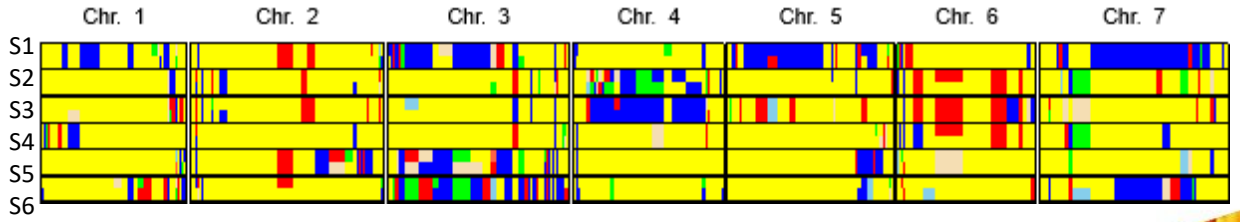
Development of synthetic hexaploid winter wheat Germplasm

Wright et al. TAG 2024

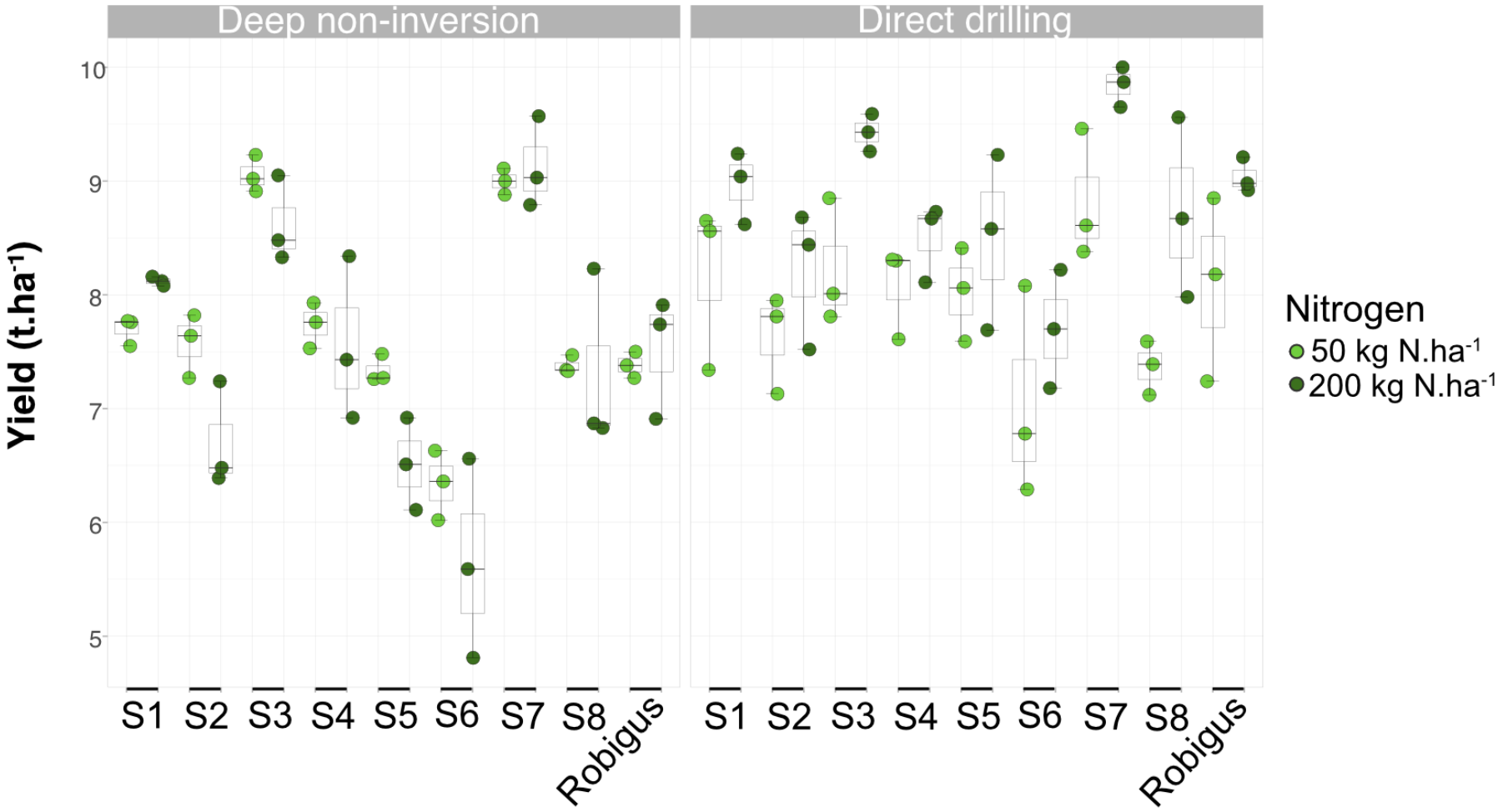
Selecting high performing synthetic wheat-derivatives







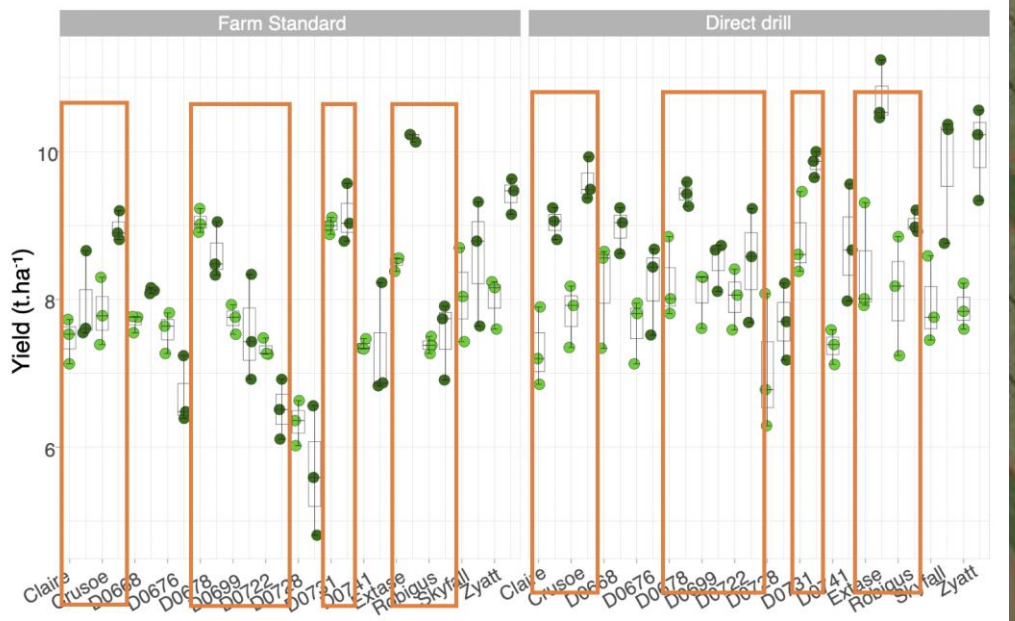
Comparing direct drill vs deep non-inversion tillage



Tillage p<0.01
Nitrogen p<0.01
Variety p<0.01
Tillage : Nitrogen p<0.01
Tillage : Variety n.s.
Nitrogen : Variety p<0.01
Tillage : Nitrogen : Variety n.s.

The New Farming Systems Experiments

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



Subset of selected lines

Cultivations experiment

4 cultivation systems

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

Cover Crop or not

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

Thank you

Acknowledgements

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is managed by NIAB and supported by The Morley Agricultural Foundation and The JC Mann Trust.

https://www.niab.com/research/agronomy-and-farming-systems/research-projects-agronomy-farming-systems/new-farming-systems