STAR Project

Sustainability Trial in Arable Rotations

Year 18 - 2022/23

A report for The Felix Thornley Cobbold Agricultural Trust and The Morley Agricultural Foundation

Winter 2024

This project was delivered through NIAB in accordance with the agreed protocol and associated Standard Operating Procedures. The results presented fully and accurately reflect our interpretation of the data generated.

Signed:

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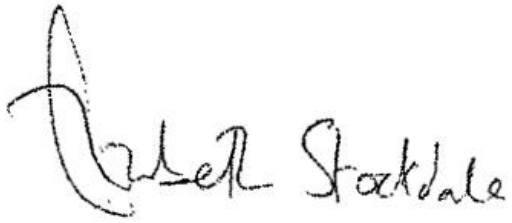

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Results and conclusions for the 18th year of the STAR Project (2022/23) are contained in this document. This report is based on feedback, guidance and interpretation delivered by the STAR Project steering group.

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1. SUMMARY

The STAR Project (Sustainability Trial in Arable Rotations) is a long-term study at Stanaway Farm, Otley, Suffolk on a Beccles/Hanslope Series clay soil. Research delivered through NIAB, supported by The Felix Thornley Cobbold Trust, The Morley Agricultural Foundation and historically, the Chadacre Agricultural Trust and guided by an independent steering group, is examining the interaction of four rotations and four cultivation techniques. During Year 18 (2022/23) the trial was cropped with winter wheat, across all treatments. Cultivation techniques are described as annual ploughing, deep tillage (non-inversion to 20 cm), shallow tillage (non-inversion to 10 cm) and a managed approach (where cultivation decisions are based on best practice guided by field conditions at the time of cultivation and past soil assessments).

In 2022/23 the Study continued with a second winter wheat that allowed not only to explore the performance of wheat under different cultivations and rotations, but also to explore the performance under two nitrogen input rates, low (130 kg/ha N) and high (220 kg/ha N).

Plant populations in spring 2023 resulted in the herbal ley rotation having a significantly higher plant population than either the winter or continuous wheat rotations, averaging 137 plants/ m^2. Ear counts, assessed both in low nitrogen (130 kg N/ha applied) and high nitrogen (220 kg N/ha applied) resulted in significant differences, between cultivation, rotation and nitrogen dose. On average, ear counts were between 271 and 300 ears/m^2 in the low nitrogen and 308 and 346 ears/m^2 in the high nitrogen. Lower ear counts were most apparent in the continuous wheat, particularly at the higher nitrogen dose.

The average yields achieved in high and low nitrogen were 8.67 t/ha and 7.58 t/ha, respectively. Irrespective of tillage, the herbal ley increased yields under low nitrogen by an average of 0.53 t/ha compared to a conventional break crop arable rotation. However, there was no difference in the rotational performance of the herbal ley at high N dose, this season.

The highest grain protein achieved was 11.0 % in the high nitrogen, herbal ley, plough and shallow tillage. Grain protein at the economic optimum rate of nitrogen is about 11% (1.9% N) for feed wheat and 12% (2.1% N) for bread-making wheat. This would suggest that for the high N an additional 50 kg/ha N may have been required to achieve 12 % grain protein for milling specification.

The margin (calculated as gross output minus input costs and direct machinery costs) is driven strongly by fertiliser input dose and yield. With regards to rotation, under low nitrogen, the herbal ley rotation resulted in the highest margin. The winter and spring rotations resulted in the highest margins in the high nitrogen. Interpreting these measurements in the context of these replicated experiments helps to generate a wider generic understanding of these impacts across a range of soil types.

Further long-term trends from the STAR Project (Years 1-10) can be read in the long-term report available at www.niab.com.

2. AIM & OBJECTIVES

AIM

- To examine different cultivation systems for sustainable arable production.

OBJECTIVES

- To examine different rotation systems and to explore how they interact with cultivation systems and required inputs.
- To demonstrate to Suffolk farmers on Beccles/ Hanslope series clay loam soil alternative systems of cultivation across the rotation.

3. ACKNOWLEDGEMENTS

The STAR Project is delivered through NIAB, supported in part by The Morley Agricultural Foundation and The Felix Thornley Cobbold Trust, and historically by the Chadacre Agricultural Trust.

In recent seasons some support has also been delivered through external projects making use of the platform and a number of PhD research projects. The research has also benefitted from an independent steering committee. This includes local farmers and consultants; thanks and acknowledgement are extended to John Taylor (our host farmer) and other members of this group.

4. BACKGROUND

In autumn 2005 a field experiment was set up at Stanaway Farm, Otley (Suffolk), funded by the Felix Thornley Cobbold Trust, to study different cultivation techniques within a series of arable rotations; this research project was termed the STAR Project (Sustainability Trial in Arable Rotations). The experiment was established in Nelson Field as a fully replicated, large plot (36 m x 36 m), trial on a Beccles/Hanslope soil (which is representative of many farms in the region). The large plot system ensures that modern techniques and farm scale equipment can be utilised to reflect local farm practice, unlike many previous experiments. Four cultivation techniques and four rotations are employed, resulting in 16 treatments. These treatments are outlined in Table 1.

Data interpretation and key grower messages from this project come from both direct information (e.g. impacts on soil parameters, grass weed populations, crop disease levels, grain/seed yields and grain mycotoxin levels) and from derived financial analysis (e.g. gross margins minus machinery costs for each scenario). These results help farmers to make informed strategic decisions in relation to their businesses. Further, over recent seasons, a parallel research project being undertaken through NIAB at Morley in Norfolk (The New Farming Systems (NFS) study funded by The Morley Agricultural Foundation and the JC Mann Trust) containing analogous long-term replicated cultivation research (with similar measurements and financial assessments) has helped to extend and develop the interpretation and ensure that findings can be applied across a wider range of soil types.

Table 1: Summary of STAR Project rotation and cultivation treatments

Rot	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)	2019 (Yr 14)	2020 (Yr 15)	2021 (Yr 16)	2022 (Yr 17)	2023 (Yr 18)
1	wosr	ww	wbn	ww	wosr	ww	wbn	ww	wosr	ww	wbn	ww	ww	wosr	sw	wb	ww	ww
2	sbn	ww	soats	ww	sbn	ww	Sln	ww	soats	ww	sbn	ww	ww	sbeet	sw	sb	ww	ww
3	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	sw	ww	ww	ww
4	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+slcc	ww	ww	herbal ley	herbal ley	herbal ley	ww	ww

Rotation key – 1 winter cropping, 2 spring cropping 3 continuous wheat, 4 Alt fallow + cc / herbal ley
Cropping key – ww (winter wheat), sw (spring wheat), wosr (winter oilseed rape), soats (spring oats), sbn (spring bean), wbn (winter bean), sln (spring linseed), fal+scc (fallow with spring cover crop), fal+slcc (fallow with season-long cover crop), herbal ley (3 year herbal ley)

	Cultivation	
1	Annual plough	Treatment is ploughed every year.
2	Managed approach	Decision on cultivation regime varies with season and is based around soil/weather conditions, previous cropping, weed burden, soil assessments etc.
3	Shallow tillage	Treatment is cultivated to »10 cm using a non-inversion technique.
4	Deep tillage	Treatment is cultivated to »20-25 cm using a non-inversion technique.

5. METHODS

Detailed trial information and outline methods are set out in Table 2. In 2022/23 the study was in a second wheat.

6. RESULTS & DISCUSSION

Results contained in this report are ostensibly from a single season (Year 18, 2022/23) of a long term project and should therefore be treated with some caution and considered in context with previous STAR reports.

The weather through spring and summer 2023 was much more in line with long-term averages. Met Office anomaly rainfall maps (Figure 1) with the spring 2023 rainfall around 110% of the 1991 – 2020 average. Summer sunshine duration was close to the 1991 – 2020 average.

In the 2022/23 season, STAR Project Year 18, the study was in a second wheat (see Table 2) all sown with winter wheat (cv. KWS Extase, sown 11/10/22). A full summary of cultivations can be found in Appendix A. The wheat plant populations were similar for winter, spring and continuous wheat cropping (Table 3) with, on average, 121, 129 and 126 plants/m^2 respectively. These were lower plant populations than were expected, considering the high seed rate used.

Table 2: Summary of trial information

Trial Id	**WW23-002**	
Location	Nelson Field, Stanaway Farm, Otley, Ipswich, Suffolk	
Cropping	*Rotation description* Winter cropping: Spring cropping: Continuous wheat: Alternate fallow / herbal ley:	*Cropping in 2022/23* Winter wheat: *cv.* KWS Extase Winter wheat: *cv.* KWS Extase Winter wheat: *cv.* KWS Extase Winter wheat: *cv.* KWS Extase
Cultivations	*Description* *Annual plough* – Ploughed *Managed approach* – where cultivation decisions are based on best practice *Shallow non-inversion* – Sumo Trio - working with discs and legs raised (10 cm) *Deep non-inversion* – Sumo Trio - working with discs and deeper legs (20 cm) *Full details of cultivation methods are shown in Appendix A.*	
Drilling date	Winter Wheat	11/10/2022
Seed rate	Winter Wheat	400 seeds/m^2
Inputs & husbandry	Appropriate to treatment and best practice. Apart from nitrogen, split into low dose or high dose 1st dose: SULFAN (26% N, 35% SO_3) - 46 kg N/ha 2nd dose (Low & high): Granular Urea(46%) - 80 or 104 kg N/ha 3rd dose (High only): Ammonium nitrate (34.5%) - 70 kg N/ha	 21/02/2023 05/04/2023 03/05/2023
Harvest date	Winter Wheat	10-11/08/2023
Trial design	Factorial	
No. of replicates	3	
Plot size	36 m x 36 m approx. (drilled with commercial farm equipment)	
Analysis	REML with LSD quoted at P = 0.05	

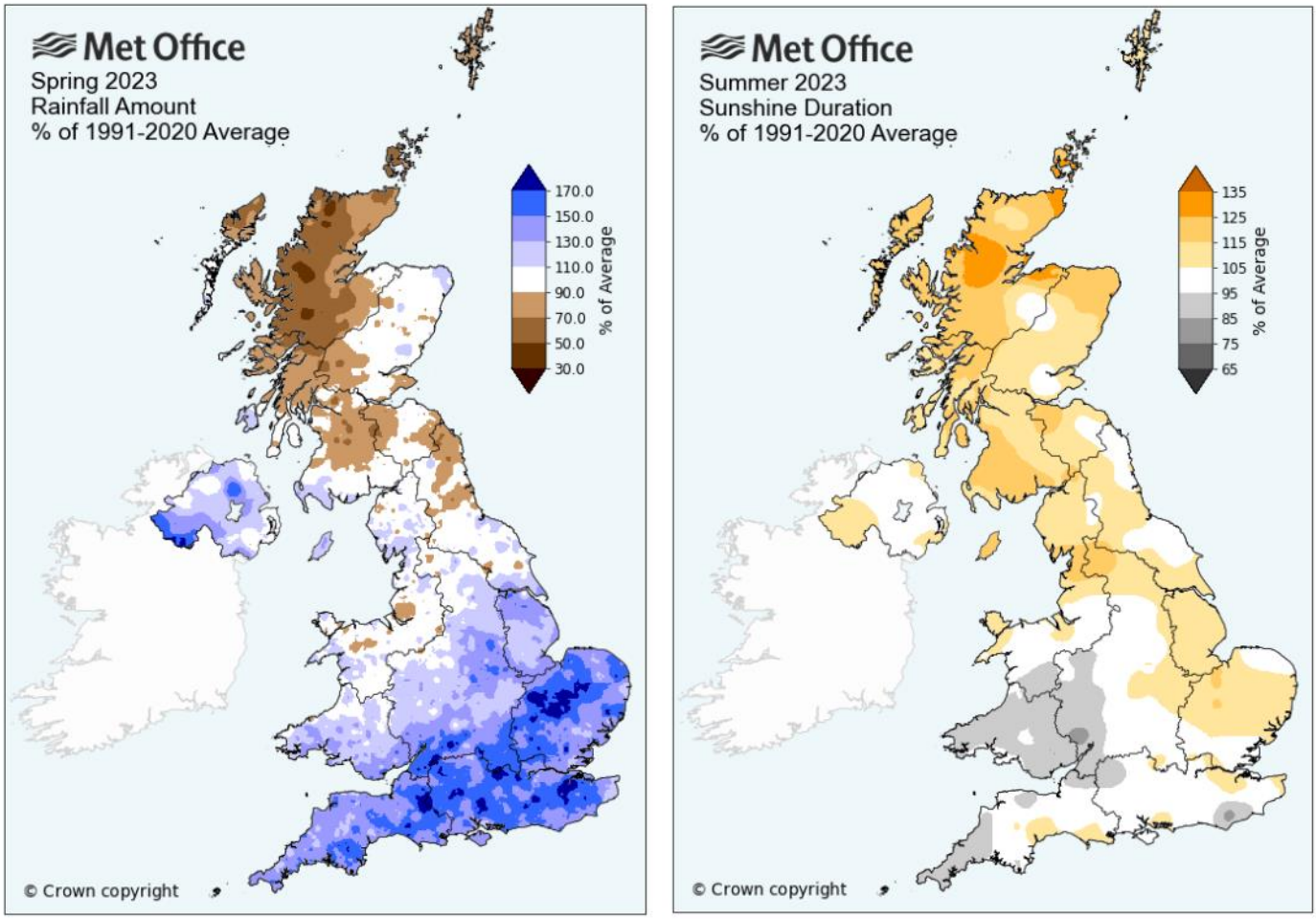

Figure 1: MET Office anomaly maps for rainfall during spring 2023 and sunshine duration during summer 2023.

The herbal ley rotation resulted in a significantly higher plant population than either the winter or continuous wheat rotations, averaging 137 plants/m^2 (P=<.001). Crop green area index (GAI) did not differ between cultivation or rotation with the average GAI across the four rotations between 0.98 and 1.03 (Table 3). The lowest GAI score of 0.90 was in the continuous wheat; shallow tillage. The highest GAI score of 1.17 was in the herbal ley; managed approach.

Soil penetration resistance (PR) was measured in January 2023 (Figure 2). This indicated that shallow tillage approaches are continuing to exhibit increasing soil strength compared to the plough and deep tillage approaches in the 12.5-37.5 cm soil profile. The plough, managed and deep tillage resulted in similar soil strength to each other but all lower than the shallow tillage approach.

Ear counts, assessed both in low nitrogen (130 kg N/ha applied) and high nitrogen (220 kg N/ha applied) resulted in significant differences, between cultivation (P=0.01), rotation (P=0.01) and nitrogen dose (P=<.001) On average, ear counts were between 271 and 300 ears/m^2 in the low nitrogen and 308 and 346 ears/m^2 in the high nitrogen (Table 4). Lower ear counts were most apparent in the continuous wheat rotation, particularly at the higher nitrogen dose.

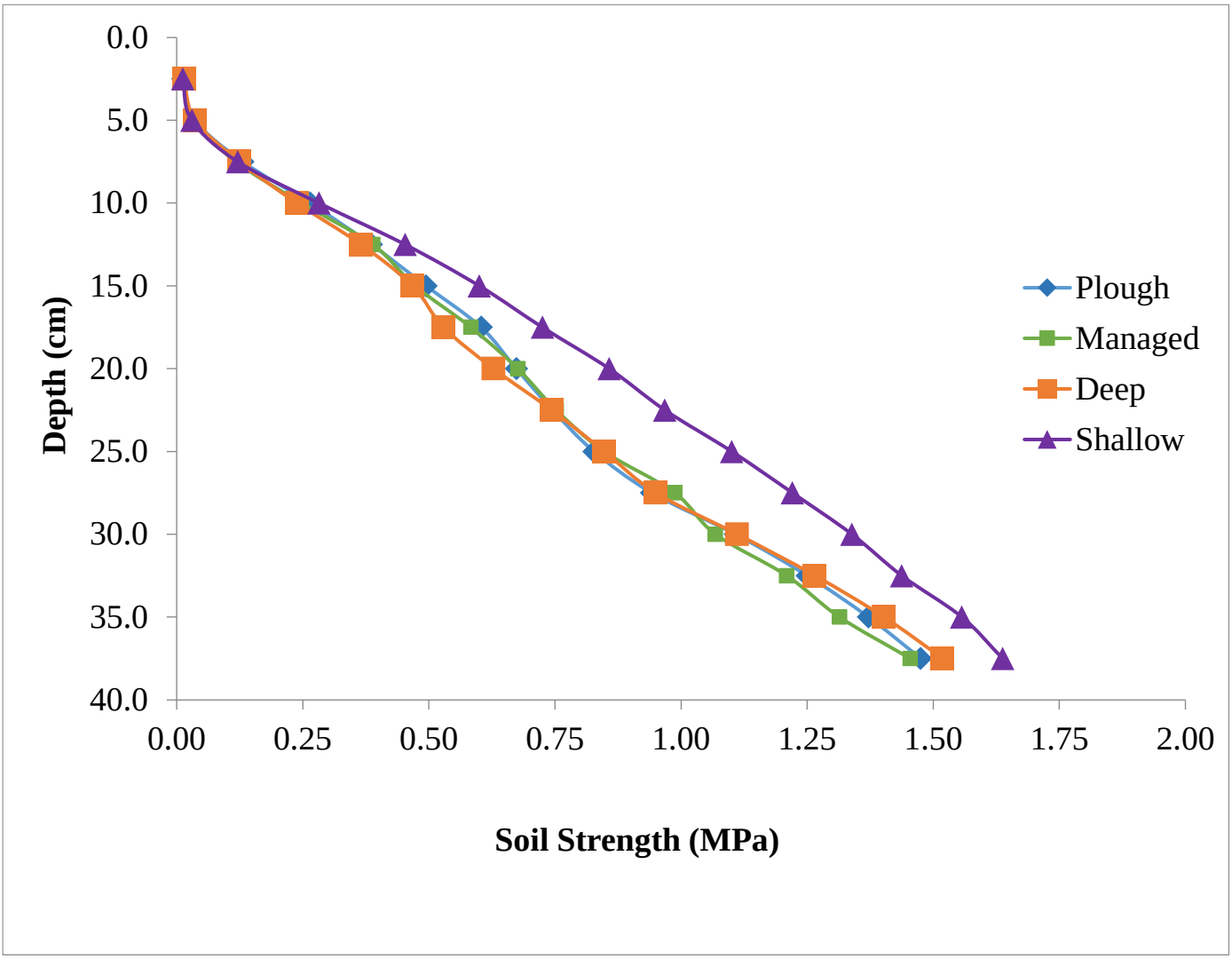

Figure 2.: The effect of cultivation, irrespective of rotation, on soil penetration resistance.

Table 3: Plant population and crop green area index (GAI) at STAR Year 18 (2022/23), assessed 21/03/2023

	Plants/m^2				GAI			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal ley**	**Winter**	**Spring**	**Cont**	**Herbal ley**
Plough	104	126	109	120	1.03	1.00	1.03	1.00
Managed	118	134	128	143	1.00	1.03	1.03	1.17
Shallow	134	128	126	148	1.07	1.07	0.90	1.07
Deep	129	129	126	136	1.00	1.00	0.97	1.00
Average	*121*	*129*	*122*	*137*	1.03	1.03	0.98	1.06
LSD (5%)	15				0.2			
P-Value (Tillage)	<.001				0.389 (NS)			
P-Value (Rotation)	<.001				0.294 (NS)			

Table 4: Ear counts (heads/m^2) in low and high nitrogen splits in STAR Year 18 (2022/23), assessed 15/06/2023.

	Low nitrogen				High nitrogen			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal Ley**	**Winter**	**Spring**	**Cont**	**Herbal Ley**
Plough	292	281	254	287	349	316	295	324
Managed	263	331	264	282	328	333	317	330
Shallow	326	306	275	291	383	345	323	346
Deep	290	282	290	260	325	344	298	301
Average	*293*	*300*	*271*	*280*	*346*	*335*	*308*	*325*
P-Value (Tillage) and LSD	0.01 20							
P-Value (Rotation) and LSD	0.01 20							
P-value (N rate) and LSD	<.001 13							

Yield data from the 2022-23 season are presented in Figure 3. Winter wheat yields, at low and high nitrogen rates applied showed a significant difference (P=<.001), with a mean yield of 8.67 t/ha and 7.58 t/ha respectively. Irrespective of tillage, the highest yield in the low nitrogen rate was 8.21 t/ha in the herbal ley rotation; the highest yield with the high nitrogen rate was 9.15 t/ha in the spring rotation. Irrespective of rotation, the highest yield in the low nitrogen rate was 7.92 t/ha in the plough tillage; the highest yield in the high nitrogen rate was 8.83 t/ha in the plough tillage. Whilst the herbal ley did not significantly increase yields at high nitrogen rates there was a tendency for increased yields under the herbal ley at low nitrogen rates compared to a conventional combinable arable rotation. Crop yield was significantly lower (P=<.001) in the continuous wheat rotation, with an average yield drop of c. 1.53 t/ha at high nitrogen and 1.12 t/ha at low nitrogen compared to other rotations, irrespective of tillage.

Grain protein from the 2022-23 season is presented in Figure 4. Grain protein results show that the low nitrogen application resulted in a significant reduction in grain protein compared to the high nitrogen application (P=<.001). On average, grain protein was 8.0 % in the low nitrogen and 10.2 % in the high nitrogen. When comparing rotations, the herbal ley resulted in a grain proteins of 10.9 % and 7.9 % in high and low nitrogen, respectively. The highest grain protein achieved was 11.0 % in the high nitrogen, herbal ley, plough and shallow tillage. Grain protein at the economic optimum rate of nitrogen is about 11% (1.9% N) for feed wheat and 12% (2.1% N) for bread-making wheat. This would suggest that for the at the high N an additional 50 kg/ha N may have been required to achieve 12 % grain protein for milling specification.

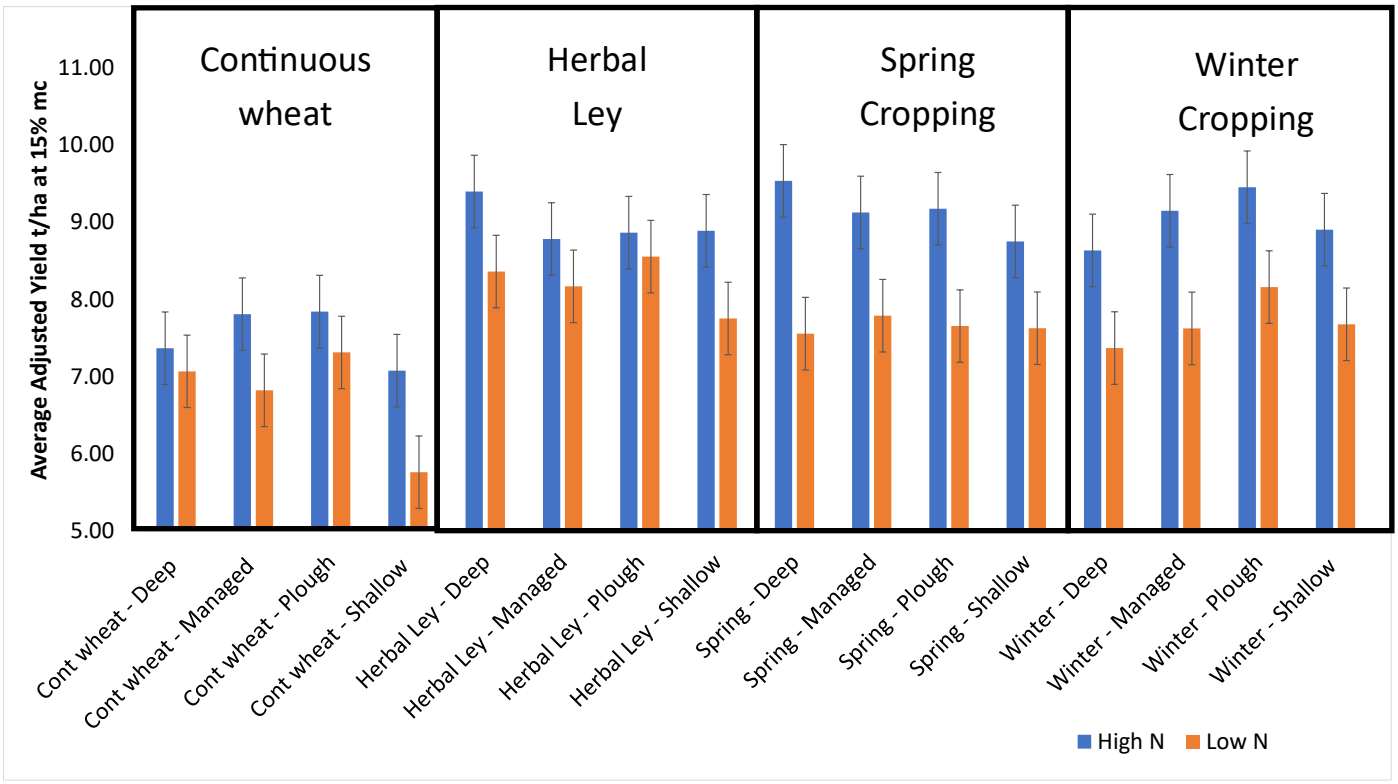

Figure 3: Winter wheat yield (t/ha) for each treatment with low and high nitrogen applications.

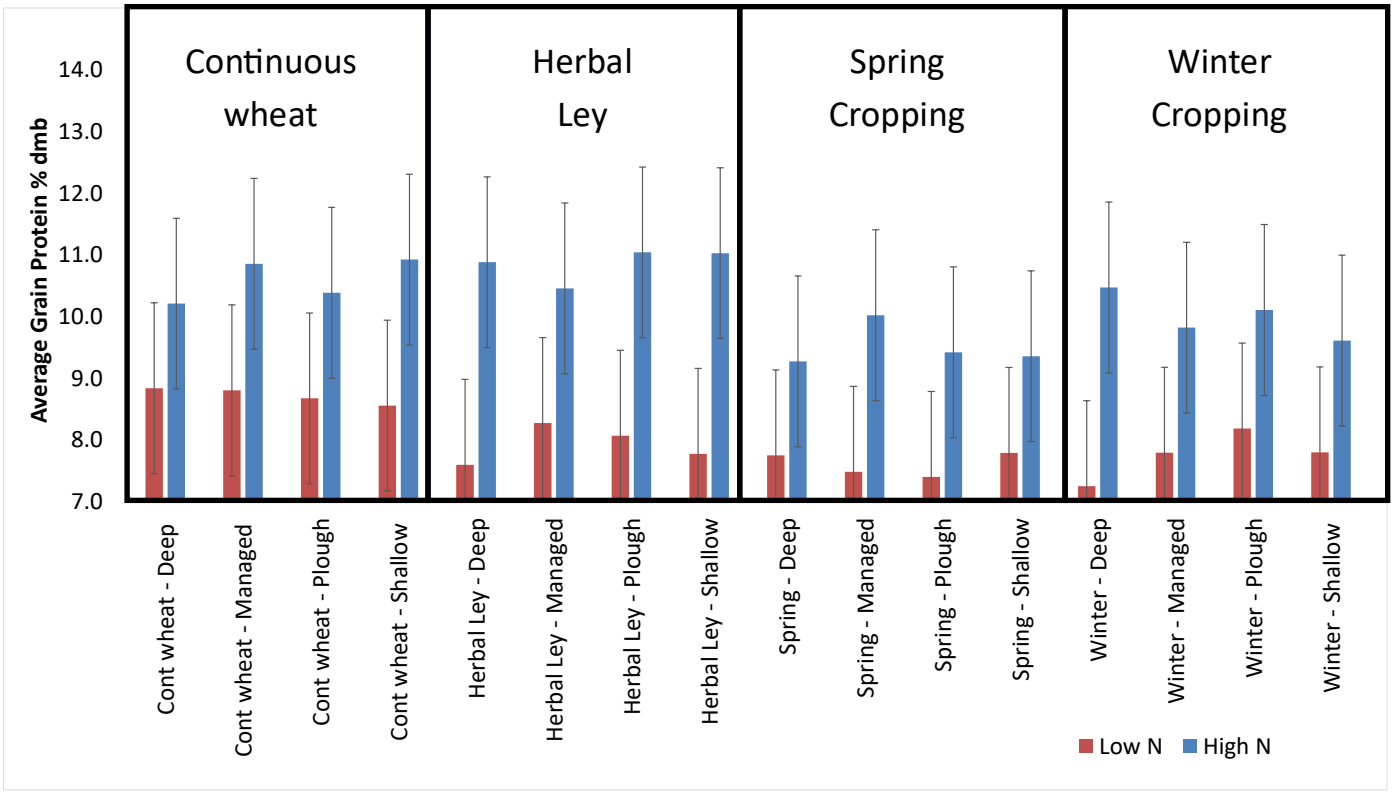

Figure 4: Winter wheat grain protein (% DM) for each treatment with low and high nitrogen applications.

Table 4: Gross margin minus machinery cost (£/ha) at STAR Year 18 (2022/23).

	Low nitrogen				High nitrogen			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal ley**	**Winter**	**Spring**	**Cont**	**Herbal ley**
Plough	1001	899	831	1079	1165	1109	841	1047
Managed	936	970	761	1031	1146	1142	863	1057
Shallow	948	938	564	962	1096	1066	732	1094
Deep	871	909	811	1069	1027	1209	775	1181
Average	*939*	*929*	*742*	*1035*	*1109*	*1132*	*803*	*1095*

Margins represent a gross output minus direct input and machinery costs. Margins based on diesel, 99 ppl; nitrogen (urea), £0.75 /kg N, (AN), £1.00 /kg N, (Sulfan) £0.66 /kg N; wheat, £200/t.

Summary financial analysis from the 2022-23 season are presented in Table 4. The margins represent a gross output minus direct input and machinery costs.

On average, irrespective of rotation or cultivation, the mean margin with low nitrogen was £911/ha compared to £1,034/ha with high nitrogen. With regards to rotation, under low nitrogen, the herbal ley rotation resulted in the highest margin followed by the winter and spring rotations with the lowest margin resulting from continuous wheat. With the high nitrogen the mean margin in relation to rotation was spring > winter > herbal ley > continuous wheat (ranked highest to lowest). This reflects the lower yield attained in the continuous wheat rotation.

The impact of cultivation indicated that deep tillage gave the highest margin under high nitrogen and the second highest margin in low nitrogen. The plough tillage also performed well across low and high nitrogen.

7. CONCLUSIONS

As with previous seasons, the STAR Project continues to develop and produce strategic information for a wide range of audiences including growers, agronomists and commercial organisations.

In 2022/23 the Study continued with a second winter wheat that allowed not only to explore the performance of wheat under different cultivations and rotations, but also to explore the performance under two nitrogen input rates, low (130 kg/ha N) and high (220 kg/ha N).

Met Office anomaly rainfall maps for spring 2023 rainfall were near to the 1991–2020 average, as was the average sunshine during grain fill resulting in lower yields that in 2022. The average yields achieved in high and low N were 8.67 t/ha and 7.58 t/ha, respectively. Irrespective of tillage, the herbal ley increased yields under low N by an average of 0.53 t/ha compared to a conventional break crop arable rotation. However, there was no difference in the rotational performance of the herbal ley at high N dose, this season.

The margin is driven strongly by fertiliser input dose and yield. Margin, in general, reflected yield with the highest yield and margin obtained with winter and spring cropping in the high N and the herbal ley rotation at low N. Interpreting these measurements in the context of these replicated experiments helps to generate a wider generic understanding of these impacts across a range of soil types. The continuous wheat rotation performed poorly, with respect to yield and margin and underlines the importance of diversifying rotations to aid soil fertility and crop performance.

The STAR Project provides an excellent opportunity to demonstrate farming systems to local farms in East Anglia and continues to help farmers, both locally and nationally, to make informed decisions on the possible impacts that rotations and cultivations can have on their businesses. The site also acts as a platform to help facilitate wider research into changes in farming systems and ecosystem services that are becoming of increasing focus under social and political change. It also continues to provide a valuable resource for supporting researchers and industry collaborations.

8. KNOWLEDGE TRANSFER

The STAR Project continues to attract a high level of interest both regionally and nationally. The Project has been presented at a range of conferences and training events run through NIAB as well as events run by other organisations.

In June 2023 we held a joint field event at the Saxmundham Experimental site in Suffolk with circa. 55 attendees. The event focused on soil management and crop nutrition. Pro-active and effective knowledge transfer both locally and to the whole industry remains an integral part of NIAB's delivery of the STAR project; this ensures that messages reach the widest possible audience. A few key events and publications highlighted below:

- Presented a poster at the AAB 'Long Term Experiments: Meeting future challenges' at Rothamsted Research, June 2023.
- Used in NIAB training courses on rotations, Professional Development Training for Farmers, with various farmer groups and other educational groups.

APPENDIX A: CULTIVATION APPROACH SUMMARY

Appendix Table 1: Cultivations and equipment used to establish each treatment

	Winter cropping	**Spring cropping**	**Alternate Fallow /**	**Continuous wheat**
Plough	Plough Rexus Press Weaving Drill Roll	Plough Rexus Press Weaving Drill Roll	Plough Rexus Press Weaving Drill Roll	Plough Rexus Press Weaving Drill Roll
Man-aged	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (20 cm) Rexus Press Weaving Drill Roll	Sumo (20 cm) Rexus Press Weaving Drill Roll
Shallow	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (10 cm) Rexus Press Weaving Drill Roll
Deep	Sumo (20 cm) Rexus Press Weaving Drill Roll	Sumo (20 cm) Rexus Press Weaving Drill Roll	Sumo (20 cm) Rexus Press Weaving Drill Roll	Sumo (20 cm) Rexus Press Weaving Drill Roll

APPENDIX B: COST AND MARGIN BREAKDOWN

Appendix Table 2a: STAR cost and margin breakdown 2022/23 (winter cropping — Low nitrogen)

	Low Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**7.68**	**7.37**	**7.62**	**8.16**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1536**	**1474**	**1524**	**1632**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	90	90	90	90
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**457**	**457**	**457**	**457**
GROSS MARGIN - (£/ha)	**1079**	**1017**	**1067**	**1175**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48		
Shallow Sumo	33		33	
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x2) @ £8	16	16	16	16
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**131**	**146**	**131**	**174**
MARGIN MINUS COSTS (£/ha)	**948**	**871**	**936**	**1001**

Appendix Table 2b: STAR cost and margin breakdown 2022/23 (winter cropping — High nitrogen)

	High Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**8.90**	**8.63**	**9.15**	**9.46**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1780**	**1726**	**1830**	**1892**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	178	178	178	178
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**545**	**545**	**545**	**545**
GROSS MARGIN - (£/ha)	**1235**	**1181**	**1285**	**1347**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48		
Shallow Sumo	33		33	
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x3) @ £8	24	24	24	24
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**139**	**154**	**139**	**182**
MARGIN MINUS COSTS (£/ha)	**1096**	**1027**	**1146**	**1165**

Appendix Table 2c: STAR cost and margin breakdown 2022/23 (spring cropping — Low nitrogen)

	Low Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**7.63**	**7.56**	**7.79**	**7.65**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1526**	**1512**	**1558**	**1530**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	90	90	90	90
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**457**	**457**	**457**	**457**
GROSS MARGIN - (£/ha)	**1069**	**1055**	**1101**	**1073**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48		
Shallow Sumo	33		33	
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x2) @ £8	16	16	16	16
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**131**	**146**	**131**	**174**
MARGIN MINUS COSTS (£/ha)	**938**	**909**	**970**	**899**

Appendix Table 2d: STAR cost and margin breakdown 2022/23 (spring cropping — High nitrogen)

	High Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**8.75**	**9.54**	**9.13**	**9.18**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1750**	**1908**	**1826**	**1836**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	178	178	178	178
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**545**	**545**	**545**	**545**
GROSS MARGIN - (£/ha)	**1205**	**1363**	**1281**	**1291**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48		
Shallow Sumo	33		33	
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x3) @ £8	24	24	24	24
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**139**	**154**	**139**	**182**
MARGIN MINUS COSTS (£/ha)	**1066**	**1209**	**1142**	**1109**

Appendix Table 2e: STAR cost and margin breakdown 2022/23 (continuous wheat – Low nitrogen)

	Low Nitrogen			
	Shallow Till W Wheat	Deep Till W Wheat	Managed App W Wheat	Annual Plough W Wheat
Yield (t/ha)	**5.76**	**7.07**	**6.82**	**7.31**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1152**	**1414**	**1364**	**1462**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	90	90	90	90
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**457**	**457**	**457**	**457**
GROSS MARGIN - (£/ha)	**695**	**957**	**907**	**1005**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48	48	
Shallow Sumo	33			
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x2) @ £8	16	16	16	16
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**131**	**146**	**146**	**174**
MARGIN MINUS COSTS (£/ha)	**564**	**811**	**761**	**831**

Appendix Table 2f: STAR cost and margin breakdown 2022/23 (continuous wheat– High nitrogen)

	High Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**7.08**	**7.37**	**7.81**	**7.84**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1416**	**1474**	**1562**	**1568**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	178	178	178	178
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**545**	**545**	**545**	**545**
GROSS MARGIN - (£/ha)	**871**	**929**	**1017**	**1023**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48	48	
Shallow Sumo	33			
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x3) @ £8	24	24	24	24
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**139**	**154**	**154**	**182**
MARGIN MINUS COSTS (£/ha)	**732**	**775**	**863**	**841**

Appendix Table 2g: STAR cost and margin breakdown 2022/23 (Herbal Ley – Low nitrogen)

	Low Nitrogen			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**7.75**	**8.36**	**8.17**	**8.55**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1550**	**1672**	**1634**	**1710**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	90	90	90	90
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**457**	**457**	**457**	**457**
GROSS MARGIN - (£/ha)	**1093**	**1215**	**1177**	**1253**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48	48	
Shallow Sumo	33			
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x2 @ £8	16	16	16	16
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**131**	**146**	**146**	**174**
MARGIN MINUS COSTS (£/ha)	**962**	**1069**	**1031**	**1079**

Appendix Table 2h: STAR cost and margin breakdown 2022/23 (Herbal Ley – High nitrogen)

	HIGH NITROGEN			
	Shallow Till Winter Wheat	Deep Till Winter Wheat	Managed App Winter Wheat	Annual Plough Winter Wheat
Yield (t/ha)	**8.89**	**9.40**	**8.78**	**8.87**
Price (£/t)	**200**	**200**	**200**	**200**
OUTPUT (£/ha)	**1778**	**1880**	**1756**	**1774**
VARIABLE COSTS:				
Seed (W Wheat)	110	110	110	110
Fertiliser	178	178	178	178
Sprays	257	257	257	257
Other				
VARIABLE COSTS (£/ha)	**545**	**545**	**545**	**545**
GROSS MARGIN - (£/ha)	**1233**	**1335**	**1211**	**1229**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				76
Deep Sumo		48	48	
Shallow Sumo	33			
Power Harrow				
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill	33	33	33	33
Claydon Drill				
Cultivator Drill				
Rolls	16	16	16	16
Quad				
Fertiliser (x3) @ £8	24	24	24	24
Sprayer (x7) @ £4.74	33	33	33	33
Total Field Operational Costs (£/ha)	**139**	**154**	**154**	**182**
MARGIN MINUS COSTS (£/ha)	**1094**	**1181**	**1057**	**1047**