STAR Project

Sustainability Trial in Arable Rotations

Year 17 - 2021/22

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

Winter 2023

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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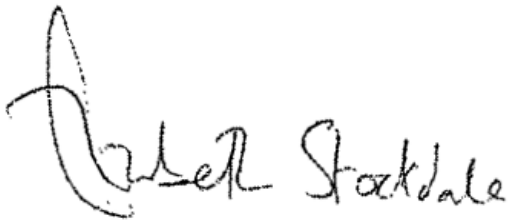

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Results and conclusions for the 17th year of the STAR Project (2021-22) are contained in this document. This report is based on feedback, guidance and interpretation delivered by the STAR Project steering group.

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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 17 (2021/22) 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).

The Study, for the last three seasons, has grown a herbal ley in one of the rotations to examine the ability of improving and building fertility in arable rotations. In 2021/22 the Study returned to first 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 (140 kg/ha N) and high (230 kg/ha N).

Plant populations in spring 2022 resulted in no significant differences between tillage or rotation, with plant populations ranging from 186 to 237 plants/m^2. Ear counts, assessed both in low nitrogen (140 kg N/ha applied) and high nitrogen (230 kg N/ha applied) resulted in no significant differences, although, winter and spring cropping resulted in higher counts than continuous or herbal ley rotations, regardless of nitrogen dose

Winter wheat yields, both in low and high nitrogen rates applied showed no significant difference, with a mean yield of 10.51 t/ha and 10.46 t/ha respectively. The margin (calculated as gross output minus input costs and direct machinery costs) is driven strongly by fertiliser input dose. Margin, in general, reflected yield with the highest yield and margin obtained with winter and spring cropping. However, due to the high fertiliser price, even accounting for a premium on grain price for attaining a milling specification of 12.5% grain protein the high nitrogen rate would have achieved a margin on a par with the lower nitrogen rate. Overall, the herbal ley did not significantly increase yields or margin compared to a conventional combinable arable rotation after the first season returning to wheat.

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. Long-term findings demonstrate clear impacts of rotation and cultivation on agronomy and production, including (but not limited to) weed burden, soil condition and mycotoxin risks. Further performance of the herbal ley will be examined in 2022/23 when the trial is in a second wheat.

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 Felix Thornley Cobbold Trust, The Morley Agricultural Foundation 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.

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)
1	wosr	ww	wbn	ww	wosr	ww	wbn	ww	wosr	ww	wbn	ww	ww	wosr	sw	wb	ww
2	sbn	ww	soats	ww	sbn	ww	Sln	ww	soats	ww	sbn	ww	ww	sbeet	sw	sb	ww
3	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	ww	sw	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

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.

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 (previous page).

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

Table 2: Summary of trial information

Trial Id	**WW22-002**	
Location	Nelson Field, Stanaway Farm, Otley, Ipswich, Suffolk	
Cropping	*Rotation description* Winter cropping: Spring cropping: Continuous wheat: Alternate fallow / herbal ley:	*Cropping in 2021/22* 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	17/10/2021
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 (Low & high): Granular Urea (46%) - 100 kg N/ha 2nd dose (Low & high): Ammonium nitrate (33.5%) - 40 kg N/ha 3rd dose (High only): Ammonium nitrate (33.5%) - 90 kg N/ha	 18/03/2022 12/04/2022 05/05/2022
Harvest date	Winter Wheat	30/07/2022
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	

(The New Farming Systems (NFS) study funded by TMAF 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.

5. METHODS

Detailed trial information and outline methods are set out in Table 2. In 2021/22 the study was in a first wheat.

6. RESULTS & DISCUSSION

Results contained in this report are ostensibly from a single season (Year 17, 2021/22) 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 2022 was particularly dry in East Anglia. Met Office anomaly rainfall maps (Figure 1) for the spring 2022 rainfall was around 70% of the 1991 – 2020 average. However, despite the lack of spring rainfall, summer sunshine duration was 125% the 1991 – 2020 average, with higher solar radiation interception during grain fill.

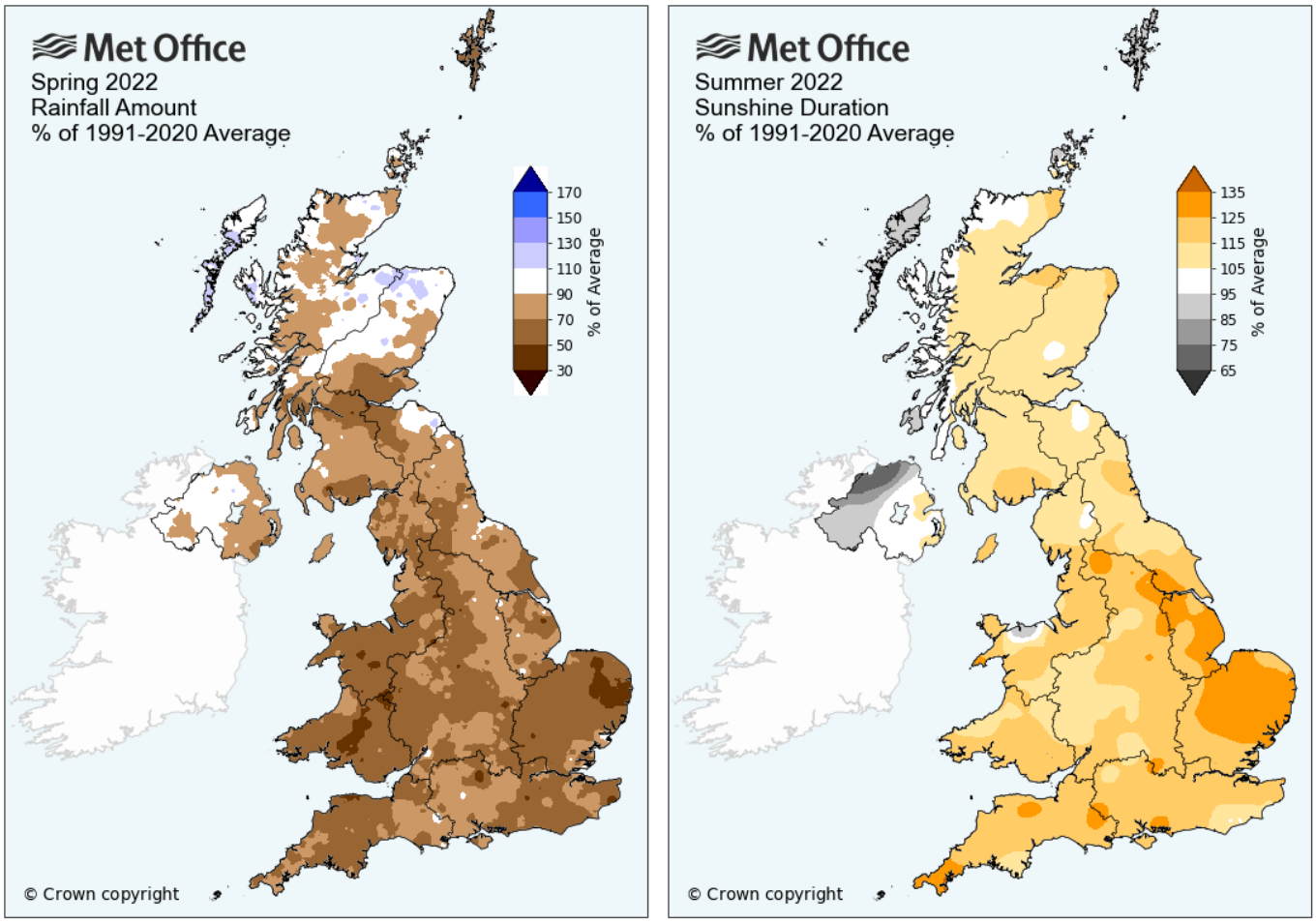

Figure 1: MET Office anomaly maps for rainfall during spring 2022 and sunshine duration during summer 2022.

In the 2021/22 season, STAR Project Year 17, the study was in a first wheat (see Table 2) all sown with winter wheat (cv. KWS Extase, sown 17/10/21). The wheat plant populations were similar for winter, spring and continuous wheat cropping (Table 3) with, on average, 210, 197 and 218 plants/m^2 respectively. Although not significantly different, the herbal ley rotation resulted in slightly lower plant population than the other three rotations, averaging 192 plants/m^2, and this is believed to partially be as a result of poorer seedbed tilth following the destruction and cultivation of the herbal ley.

Soil penetration resistance (PR) was measured in March 2022 (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 12.5-35 cm soil profile. The managed approach was intermediate in strength, with higher soil strength than the plough / deep tillage but lower soil strength than the shallow tillage.

Plant populations in spring 2022 resulted in no significant differences between tillage or rotation, with plant populations ranging from 186 to 237 plants/m^2. Crop green area index (GAI), an indication of canopy size and biomass, resulted in some differences, most notably between winter and spring cropping (both following beans) and the continuous and herbal ley rotations. Ear counts, assessed both in low nitrogen (140 kg N/ha applied) and high nitrogen (230 kg N/ha applied) resulted in no significant differences, although, winter and spring cropping resulted in higher counts than continuous or herbal ley rotations, regardless of nitrogen dose (Table 4).

Yield and margin data from the 2021-22 season are presented in Figure 3 with a breakdown of costs presented in Appendix 2. Winter wheat yields, both in low and high nitrogen rates applied showed no significant difference (P=0.733), with a mean yield of 10.51 t/ha and 10.46 t/ha respectively. Irrespective of tillage, the highest yield in the low nitrogen rate was 11.16 t/ha in the winter rotation; the highest yield in the high nitrogen rate was 11.08 t/ha in the herbal ley rotation. Irrespective of rotation, the highest yield in the low nitrogen rate was 10.86 t/ha in the plough tillage; the highest yield in the high nitrogen rate was 10.53 t/ha in both 'managed' and deep tillage. The herbal ley did not significantly increase yields compared

Table 3: Plant population and crop green area index (GAI) at STAR Year 17 (2021/22), assessed 11/03/2022

	Plants/m^2				GAI			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal ley**	**Winter**	**Spring**	**Cont**	**Herbal ley**
Plough	208	202	194	186	1.5	1.4	1.1	1.1
Managed	200	193	222	204	1.4	1.3	1.1	1.0
Shallow	233	189	237	188	1.5	1.4	1.2	1.0
Deep	197	204	220	191	1.5	1.4	1.2	1.1
Average	*210*	*197*	*218*	*192*	1.5	1,4	1.1	1.1
LSD (5%)	38				0.2			
CV %	11.2				8.9			

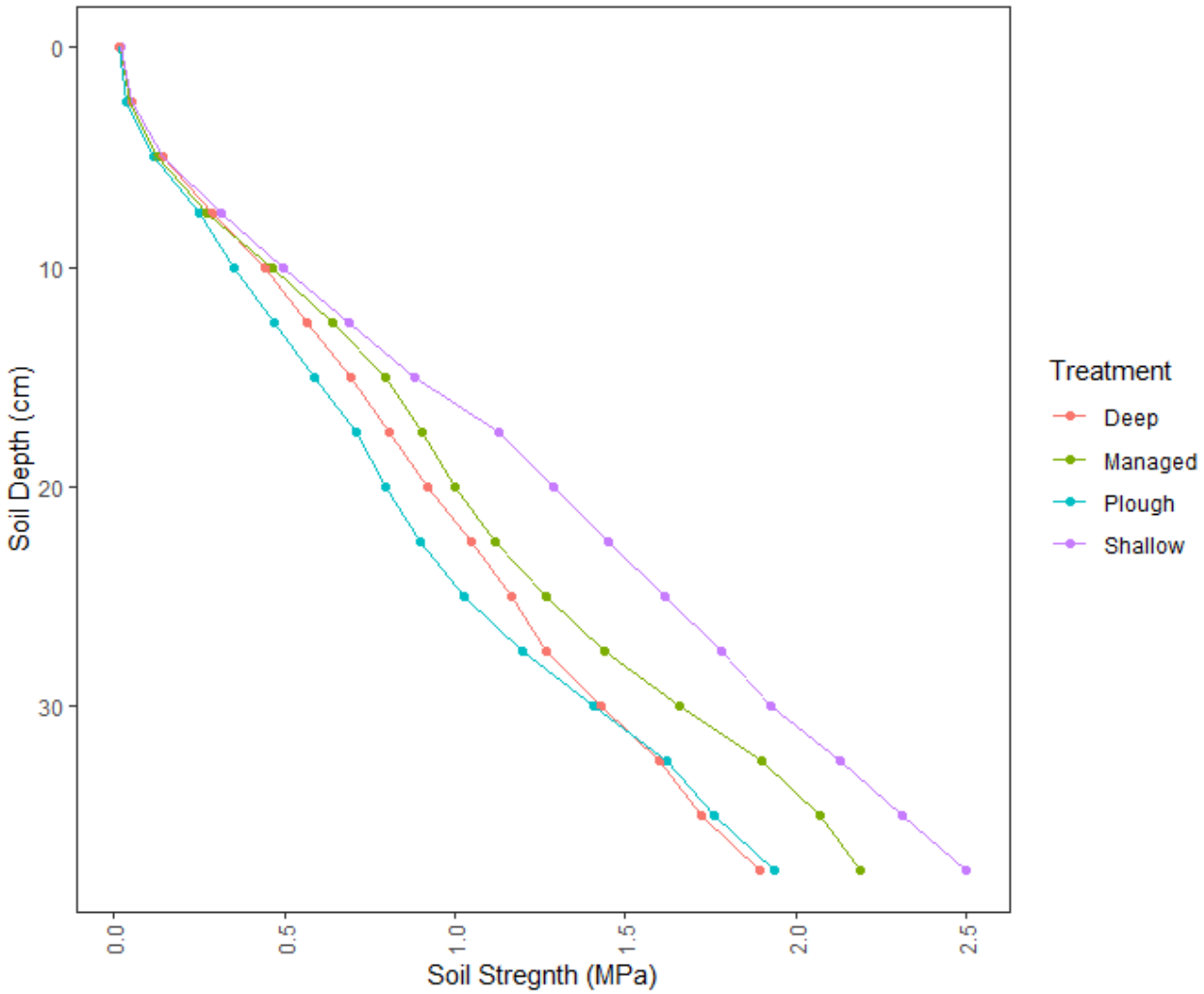

Figure 2.: The effect of cultivation, irrespective of rotation, on soil penetration resistance.

Table 4: Ear counts (heads/m2) in low and high nitrogen splits in STAR Year 17 (2021/22), assessed 13/07/2022

	Low nitrogen				High nitrogen			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal Ley**	**Winter**	**Spring**	**Cont**	**Herbal Ley**
Plough	361	393	355	310	397	419	330	331
Managed	375	415	339	375	389	390	370	339
Shallow	395	333	349	389	399	357	354	383
Deep	399	376	343	377	371	379	305	371
Average	*383*	*379*	*347*	*363*	*389*	*386*	*340*	*356*
LSD	62							
CV %	10.3							

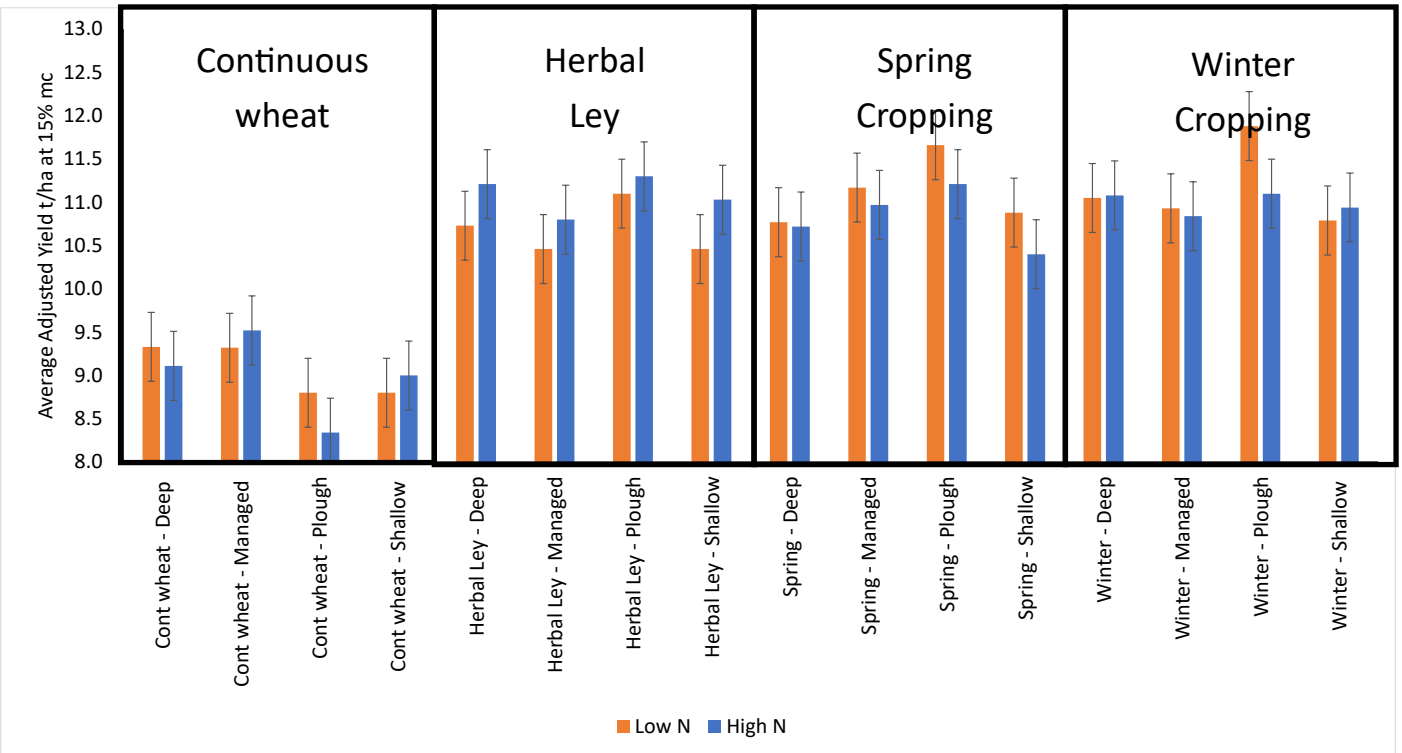

Figure 3: Winter wheat yield (t/ha) for each treatment with low and high nitrogen applications.

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. 1.95 t/ha compared to other rotations, and irrespective of nitrogen rate.

Grain protein results show that the low nitrogen application resulted in a significant reduction in gain protein compared to the high nitrogen application (P=<.001). On average, grain protein was 9.8 % in the low nitrogen and 11.0 % in the high nitrogen. When comparing rotations, the low nitrogen, increased the variation in grain protein, with mean grain proteins 8.9 - 10.3 %. Under high nitrogen grain protein rose to an average 10.8 - 11.2 %.

This suggests that in a season where spring rainfall was significantly lower than the long-term average but sunshine hours during grain fill increased, resulted in a similar yield level being attained at lower nitrogen rates but grain protein were reduced, likely due to yield dilution. To attain higher grain protein and yield required the higher nitrogen dose. There was no clear trend for the herbal ley to significantly increase grain protein compared to a conventional combinable arable rotation. At the high nitrogen dose, there was little difference in grain protein across the rotations.

Summary financial analysis from the 2021-22 season are presented in Table 4. The margins represent a gross output minus direct input and machinery costs. The margin is driven strongly by fertiliser input dose, due to the high cost of nitrogen fertiliser this season. On average, irrespective of rotation or cultivation, the mean margin with low nitrogen was £1,981/ha compared to £1,818/ha with high nitrogen. With regards to rotation, under low nitrogen, winter and spring cropping resulted in the highest margin followed by the herbal ley rotation with the lowest margin resulting from continuous wheat. With the high nitrogen the mean margin in relation to rotation was similar for winter, spring and herbal ley, with the continuous wheat margin the lowest. This reflects the lower yield attained from in the continuous wheat rotation.

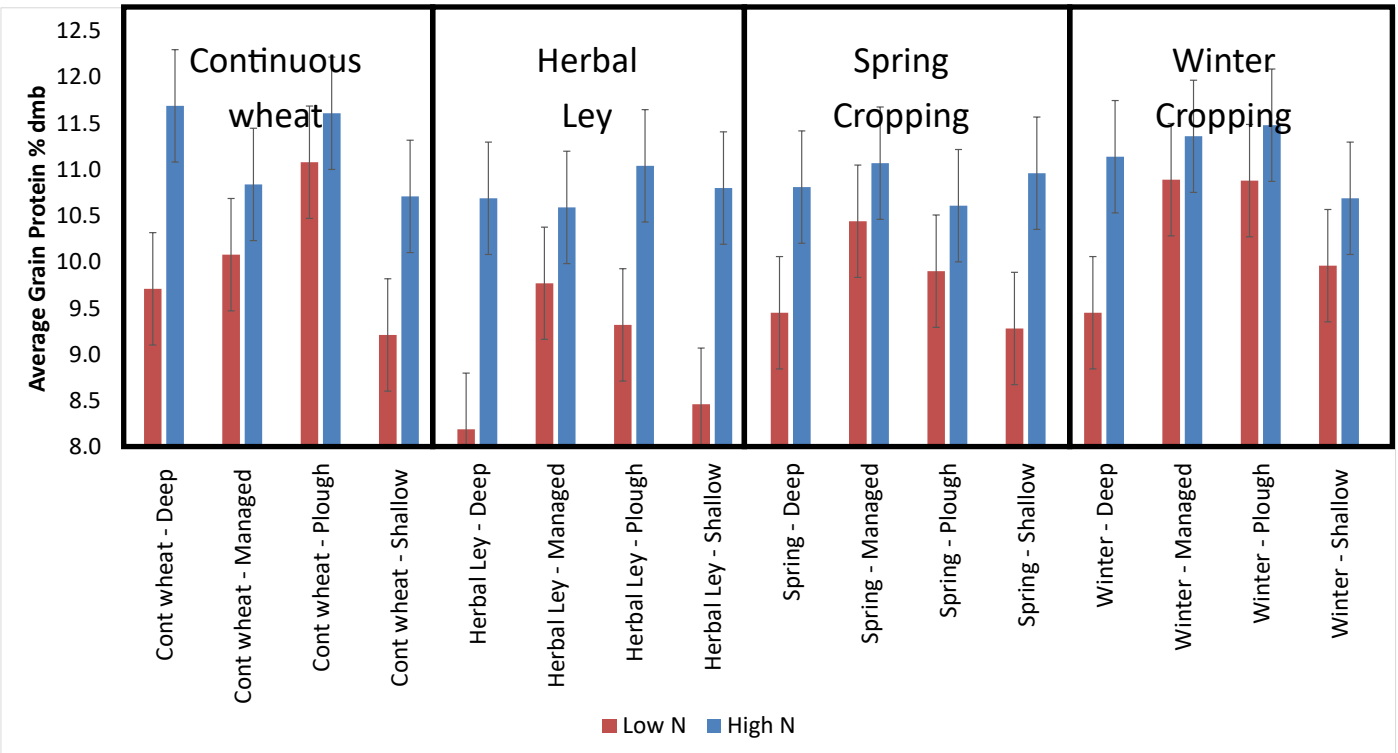

Figure 4: Winter wheat grain protein (% DM) for each treatment with low and high nitrogen applications.

The target grain protein (12.5%) to achieve a premium grain price over feed wheat was not attained in this study. Even with the premium the margin would be similar to the low nitrogen dose. If yields under low nitrogen had been substantially reduced then this would likely be reflected in lower margin performance.

Table 4: Gross margin minus machinery cost (£/ha) at STAR Year 17 (2021/22)

	Low nitrogen				High nitrogen			
Tillage	**Winter**	**Spring**	**Cont**	**Herbal ley**	**Winter**	**Spring**	**Cont**	**Herbal ley**
Plough	2316	2257	1499	2109	1955	1984	1223	2008
Managed	2114	2178	1658	1989	1936	1970	1559	1925
Shallow	2079	2101	1549	1987	1962	1819	1448	1986
Deep	2119	2045	1660	2034	1973	1877	1451	2007
Average	*2157*	*2145*	*1592*	*2030*	*1957*	*1913*	*1420*	*1982*

Margins represent a gross output minus direct input and machinery costs. Margins use diesel at £0.91/l; N at £1.59/kg N (AN), £1.41/kg N (Urea); wheat at £265/t.

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.

The Study, for the last three seasons, has grown a herbal ley in one of the rotations to examine the ability of improving and building fertility in an arable rotations. In 2021/22 the Study returned to first 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 (140 kg/ha N) and high (230 kg/ha N).

Met Office anomaly rainfall maps for spring 2022 rainfall was around 70% of the 1991–2020 average, however, higher than average sunshine during grain fill produced excellent yields, averaging 10.50 t/ha regardless of nitrogen dose. The herbal ley did not significantly increase yields compared to a conventional combinable arable rotation after the first season returning to wheat.

The margin is driven strongly by fertiliser input dose. Margin, in general, reflected yield with the highest yield and margin obtained with winter and spring cropping. However, due to the high fertiliser price, even accounting for a premium on grain price for attaining a milling specification of 12.5% grain protein the high nitrogen rate would have achieved a margin on a par with the lower nitrogen rate. If yields under low nitrogen had been substantially reduced then this would likely have reflected in lower margins. 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 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. The Project has also received exceptionally good media coverage including a session at the The Oxford Farming Conference, 6th January 2022.

In July 2022 a specific open access field event was held with a focus on how cropping approaches can impact on soils and system resilience. Proactive 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:

- Used in NIAB training courses on rotations, Professional Development Training for Farmers, with various farmer groups (e.g. NFU regional group) and other parties (e.g. consultant groups, Colleges and Universities)
- Article in the NIAB Landmark magazine;

  'The management of soil health within crop ping systems'

APPENDIX A: CULTIVATION APPROACH SUMMARY

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

	Winter cropping	**Spring cropping**	**Alternate Fallow / Herbal Ley**	**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 (20 cm) Rexus Press Weaving Drill Roll	Sumo (10 cm) Rexus Press Weaving Drill Roll	Sumo (10 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 2021/22 (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)	**10.80**	**11.05**	**10.93**	**11.88**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2862**	**2928**	**2896**	**3148**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	205	205	205	205
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**569**	**569**	**569**	**569**
GROSS MARGIN - (£/ha)	**2293**	**2360**	**2328**	**2579**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	22	22	22	22
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/ha)	**214**	**241**	**214**	**264**
MARGIN MINUS COSTS (£/ha)	**2079**	**2119**	**2114**	**2316**

Appendix Table 2b: STAR cost and margin breakdown 2021/22 (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)	**10.94**	**11.08**	**10.84**	**11.10**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2899**	**2936**	**2873**	**2942**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	348	348	348	348
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**712**	**712**	**712**	**712**
GROSS MARGIN - (£/ha)	**2187**	**2224**	**2161**	**2230**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	33	33	33	33
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/ha)	**225**	**252**	**225**	**275**
MARGIN MINUS COSTS (£/ha)	**1962**	**1973**	**1936**	**1955**

Appendix Table 2c: STAR cost and margin breakdown 2021/22 (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)	**10.88**	**10.77**	**11.17**	**11.66**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2883**	**2854**	**2960**	**3090**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	205	205	205	205
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**569**	**569**	**569**	**569**
GROSS MARGIN - (£/ha)	**2314**	**2285**	**2391**	**2521**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	22	22	22	22
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/ha)	**214**	**241**	**214**	**264**
MARGIN MINUS COSTS (£/ha)	**2101**	**2045**	**2178**	**2257**

Appendix Table 2d: STAR cost and margin breakdown 2021/22 (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)	**10.40**	**10.72**	**10.97**	**11.21**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2756**	**2841**	**2907**	**2970**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	348	348	348	348
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**712**	**712**	**712**	**712**
GROSS MARGIN - (£/ha)	**2044**	**2129**	**2195**	**2259**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	33	33	33	33
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/ha)	**225**	**252**	**225**	**275**
MARGIN MINUS COSTS (£/ha)	**1819**	**1877**	**1970**	**1984**

Appendix Table 2e: STAR cost and margin breakdown 2021/22 (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)	**8.80**	**9.32**	**9.31**	**8.80**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2332**	**2470**	**2467**	**2332**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	205	205	205	205
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**569**	**569**	**569**	**569**
GROSS MARGIN - (£/ha)	**1763**	**1901**	**1898**	**1763**
FIELD OPERATIONAL COSTS				
Plough				95
Deep Sumo		72	72	
Shallow Sumo	45			
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	22	22	22	22
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs	**214**	**241**	**241**	**264**
MARGIN MINUS COSTS (£/ha)	**1549**	**1660**	**1658**	**1499**

Appendix Table 2f: STAR cost and margin breakdown 2021/22 (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)	**9.00**	**9.11**	**9.52**	**8.34**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2385**	**2414**	**2523**	**2210**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	348	348	348	348
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**712**	**712**	**712**	**712**
GROSS MARGIN - (£/ha)	**1673**	**1702**	**1811**	**1498**
FIELD OPERATIONAL COSTS				
Plough				95
Deep Sumo		72	72	
Shallow Sumo	45			
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	33	33	33	33
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs	**225**	**252**	**252**	**275**
MARGIN MINUS COSTS (£/ha)	**1448**	**1451**	**1559**	**1223**

Appendix Table 2g: STAR cost and margin breakdown 2021/22 (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)	**10.45**	**10.73**	**10.46**	**11.10**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2769**	**2843**	**2772**	**2942**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	205	205	205	205
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**569**	**569**	**569**	**569**
GROSS MARGIN - (£/ha)	**2201**	**2275**	**2203**	**2373**
FIELD OPERATIONAL COSTS (£/				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	22	22	22	22
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/	**214**	**241**	**214**	**264**
MARGIN MINUS COSTS (£/ha)	**1987**	**2034**	**1989**	**2109**

Appendix Table 2h: STAR cost and margin breakdown 2021/22 (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)	**11.03**	**11.21**	**10.80**	**11.30**
Price (£/t)	**265**	**265**	**265**	**265**
OUTPUT (£/ha)	**2923**	**2971**	**2862**	**2995**
VARIABLE COSTS:				
Seed (W Wheat)	127	127	127	127
Fertiliser	348	348	348	348
Sprays	238	238	238	238
Other				
VARIABLE COSTS (£/ha)	**712**	**712**	**712**	**712**
GROSS MARGIN - (£/ha)	**2211**	**2259**	**2150**	**2283**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				95
Deep Sumo		72		
Shallow Sumo	45		45	
Power Harrow (x1)				
Double press	40	40	40	40
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Cultivator Drill	48	48	48	48
Rolls	22	22	22	22
Quad				
Fertiliser (x2 or x3) @ £11	33	33	33	33
Sprayer (x8 or x5) @ £4.60	37	37	37	37
Total Field Operational Costs (£/ha)	**225**	**252**	**225**	**275**
MARGIN MINUS COSTS (£/ha)	**1986**	**2007**	**1925**	**2008**