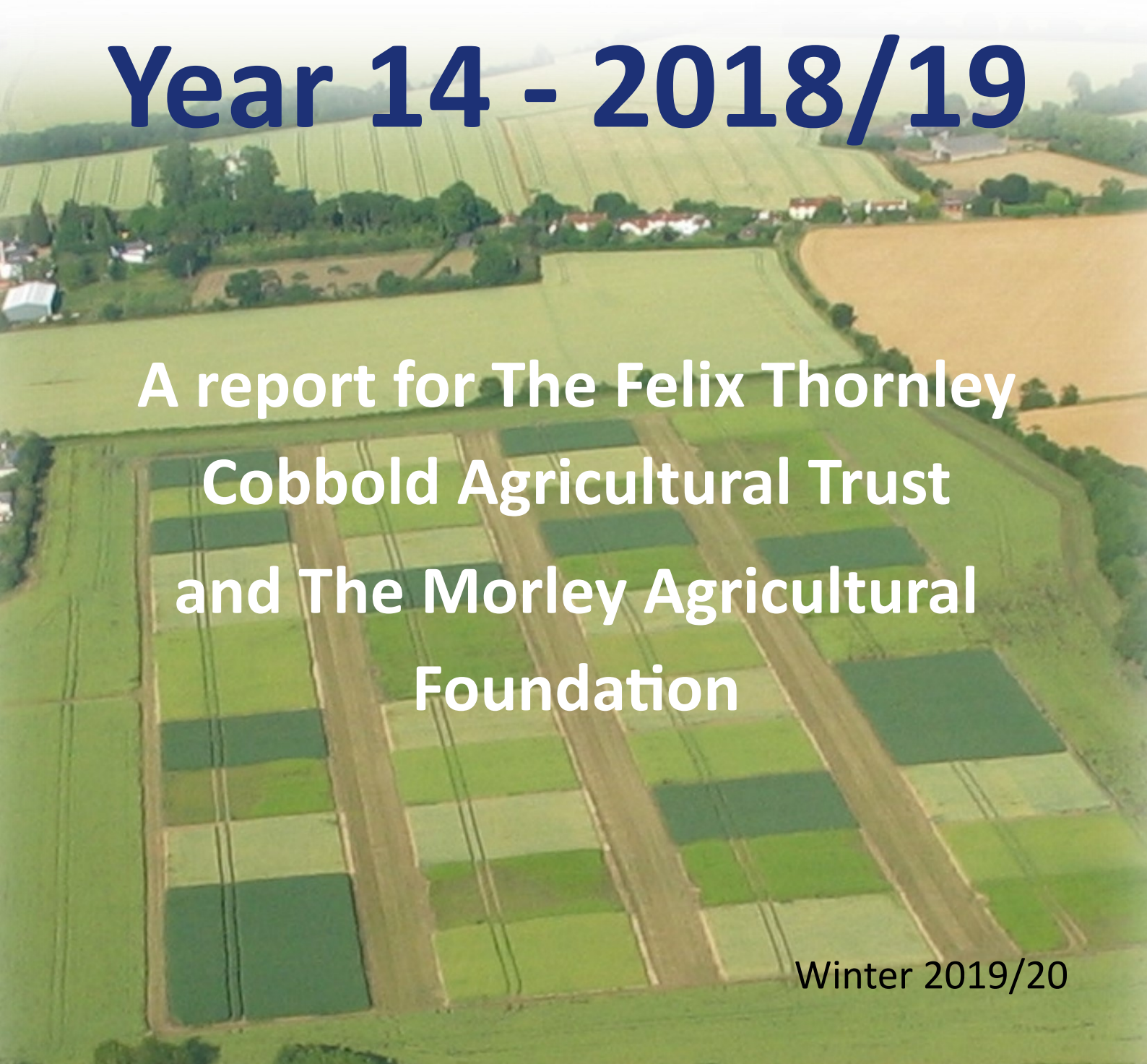
STAR Project

Sustainability Trial in Arable Rotations

Year 14 - 2018/19



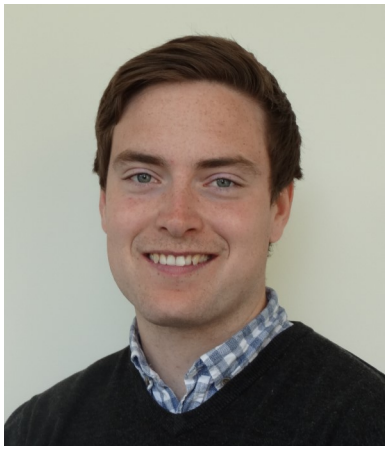
A report for The Felix Thornley Cobbold Agricultural Trust and The Morley Agricultural Foundation

Winter 2019/20

Results and conclusions for the fourteenth year of the STAR Project (2018-19) are contained in this document. This report is based on feedback, guidance and interpretation delivered by the STAR project steering group.

CONTENTS

Dr Nathan Morris
Farming systems and soils specialist



David Clarke
Soils and farming systems technician

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 TAG, 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 14 (2018/19) the study was in a 'break crop year' other than the continuous wheat and herbal ley. The break crops grown were winter oilseed rape and sugar beet. 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 year 14, the highest crop yields were generally associated with ploughing or deep tillage within the winter and spring cropping. The impact of tillage on grass weeds in the continuous wheat became apparent in this season, resulting in substantial yield losses in deep and shallow tillage. This underlines the importance of maintaining cultural control strategies (both cultivation and rotation) that ensure grass weeds remain at manageable levels. Margins (calculated as gross output minus input costs and direct machinery costs) were highest in the deep tillage approach for the winter (oilseed rape) and spring cropping (sugar beet) but highest in the managed approach in the continuous wheat. The farming system platforms created through the STAR project are being seen increasingly as valuable research and knowledge transfer tools in their own right.

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. With regard to yields and margins, differences between cultivation systems have been relatively small, however, the highest yields and margins, considered over all crops, have been associated with the managed approach. 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. AIMS & 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 TAG, 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. In 2018/19, in collaboration with BBRO, the STAR project was able to assess the performance of sugar beet in the experiment for the first time.

The research has also benefitted from an independent steering committee. This includes local farmers and consultants; thanks and acknowledgement are extended to John Taylor (the 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)	2017 (Yr 12)	2018 (Yr 13)	2019 (Yr 14)	2019 (Yr 14)
1	wosr	ww	wbn	ww	wosr	ww	Wbn	ww	wosr	ww	Wbn	ww	ww	ww	wosr	wosr
2	sbn	ww	soats	ww	sbn	ww	Sln	ww	soats	ww	Sbn	ww	ww	ww	sbeet	sbeet
3	ww	ww	ww	ww	ww	ww	Ww	ww	ww	ww	Ww	ww	ww	ww	ww	ww
4	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+scc	ww	fal+slcc	ww	ww	ww	herbal ley	herbal ley

Rotation key – 1 winter cropping, 2 spring cropping 3 continuous wheat, 4 Alt fallow + cc / herbal ley
Cropping key – ww (winter 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). This 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 TAG at Morley in Norfolk (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 2018/19 the study was in a 'break crop year' other than the continuous wheat and herbal ley.

6. RESULTS & DISCUSSION

Results contained in this report are ostensibly from a single season (year 14, 2018/19) of a long term project and should therefore be treated with some caution and considered in context with previous STAR reports.

In the 2018/19 season, STAR project year 14, the study was in a 'break crop year' (see Table 2) and sown with winter oilseed rape (cv. Campus, sown 02/09/18, then re-sown on 06/09/18 in the Shallow or 04/10/18 in the Managed; winter cropping), sugar beet (cv. Sabatina, sown 02/04/19; spring cropping) and winter wheat (cv. Siskin, sown 29/09/18; continuous wheat).

The oilseed rape establishment was variable across the tillage approaches. In both the plough and deep approaches the crop established well. However, in the shallow and managed approaches, the first sowing failed and had to be re-sown, either by broadcasting in the shallow approach or by drilling with a tine drill set to place the seed just into the soil (<15mm) in the managed approach.

The reason for the crop failure is uncertain although it may have suffered from sulfonylurea damage (applied to the previous wheat crop in 2018) and the subsequent dry conditions reducing the speed of breakdown within the soil. Both approaches were cultivated with low soil disturbance and this may have also increased the risk of herbicide damage to the oilseed rape seedlings during emergence.

The oilseed rape plant populations were similar for plough, shallow and deep tillage (Table 3) with, on average 50 plants/m^2 but in the managed approach, where reseeding occurred, this significantly increased plant populations to 224 plants/m^2. The resulting GAI assessed on 01/11/2018 clearly showed the difference in the size of the canopy following the different cultivation approaches. The smallest GAI was 0.3 (managed approach) and the largest GAI was 2.0 (deep tillage).

The sugar beet, sown in the spring cropping rotation, resulted in plant populations ranging from 81,000/ha (deep) to 101,000/ha (plough) with the shallow and

Table 2: Summary of trial information

Trial Id	**WW19-002**	
Location	Nelson Field, Stanaway Farm, Otley, Ipswich, Suffolk	
Cropping	*Rotation description* Winter cropping: Spring cropping: Continuous wheat: Alternate fallow / herbal ley:	*Cropping in 2018/19* Winter oilseed rape: *cv.* Campus Sugar Beet: *cv.* Sabatina Winter wheat: *cv.* Siskin Herbal Ley (3-year)
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	*Cropping in 2019* Winter oilseed rape: Sugar beet: Winter wheat: Herbal Ley (3-year)	 02/09/18 then 06/09 or 04/10 where re-sown 02/04/19 29/09/18 03/09/18
Seed rate	Cropping in 2019 Winter oilseed rape: Sugar beet: Winter wheat: Herbal Ley:	 7 kg/ha then 9 kg/ha where re-sown 1.3 Units/ha 175 kg/ha (350 seeds/m^2) -
Inputs & husbandry	Appropriate to treatment and best practice.	
Harvest date	*Cropping in 2019* Winter oilseed rape: Sugar beet: Winter wheat: Herbal Ley:	 07/08/19 05/09/19 05/08/19 -
Trial design	Factorial	
No. of replicates	3	
Plot size	36 m x 36 m approx. (drilled with commercial farm equipment)	
Analysis	ANOVA with LSD quoted at P = 0.05	

managed approaches intermediate (Table 3). Canopy cover in the sugar beet, assessed in July, using the Canopeo App, showed no difference between tillage approaches, all being 60%. The plant populations in winter wheat in the continuous wheat rotation, showed no significant difference between cultivation approaches, ranging from 202 to 206 plants/m^2. The GAI in the winter wheat showed some differences between approaches with the largest canopy in the managed approach, with a GAI of 2.9. The smallest canopies, with a GAI of 2.0 were in the plough and deep tillage approaches (Table 3).

Soil penetration data was not able to be collected this season due to equipment malfunction. However, analogous data collected as part of a PhD research project at Cranfield University collected data from the continuous wheat rotation in January 2019. This indicated that shallow tillage approaches are continuing to exhibit increasing soil strength compared to the plough tillage in the 0-25 cm soil profile. The alternate fallow / herbal ley plots were sown on 03/09/18 with a herbal ley consisting of 14 species of both legumes, grasses and forb (herbaceous flowering plants) species with a range of rooting depths, some

Table 3: Plant population and canopy cover from STAR year 14 (2018/19)

	Plant populations *[1]					Canopy size *[2]			
Tillage	Winter (/m^2)	Spring ('000s/ha)	Cont (/m^2)	Herbal ley		Winter	Spring	Cont	Herbal ley
Plough	55	101	206	-		1.6	60	2.0	-
Managed	224	93	202	-		0.3	60	2.9	-
Shallow	48	91	202	-		0.8	60	2.5	-
Deep	48	81	203	-		2.0	60	2.0	-
Average	*94*	*92*	*203*	-		1.1	0.6	2.4	-
LSD	17.1	18.5	35.9			0.3	0.34	0.1	-
CV %	22.1	10.7	21.5			28.8	30.0	27.2	-

*[1] Plant populations were assessed on 01/11/18 for the winter and continuous wheat cropping and in early July for the spring cropping.

*[2] Canopy size was assessed by Green Area Index (GAI) for the winter and continuous wheat cropping on 01/11/18. Canopy size was assessed using the Canopeo App for the spring cropping in early July.

being deep rotted with the aim to aid soil fertility and structure. This ley will remain for three years before being returned to arable production. In-season management will involve mowing when required with the material baled and wrapped for silage.

Grass weeds (predominantly brome species and black-grass) have been present in the non-inversion (deep and shallow tillage) continuous wheat for a number of years, however, with the use of a herbicide programme these have remained at relatively low levels. In autumn 2018, a herbicide programme including flufenacet + pendimethalin + diflufenican followed in the spring by mesosulfuron-methyl + propoxycarbazone-sodium was applied. Despite this, a significant level of grass weeds, mainly black-grass were present and a decision was made to spray off the affected areas to reduce seed return to the seed bank (and is typical farm practice). The plough and managed approaches remained almost clean of grass weeds whilst 59% of the area in the deep tillage and 60% of the area in the shallow tillage were sprayed off (Figure 1).

Yield and margin data from the 2018-19 season are presented in Table 4 with a breakdown of costs presented in Appendix B. In the winter oilseed rape, the plough, deep and shallow approaches all yielded very similarly, despite the re-sowing in the shallow tillage, with yields of 4.4, 4.5 and 4.5 t/ha respectively. However, the managed approach yielded 3.6 t/ha which was significantly (P=<0.01) lower than the other treatments.

In the sugar beet, yields were significantly different (P=0.05) between deep tillage and managed approach with yields of 83.4 t/ha and 73.9 t/ha respectively. Whilst yields were lower in the shallow and plough tillage, *cf*. deep tillage, they were not significantly lower. No significant differences between tillage approaches were found for sugar, sodium (Na), potassium (K) or alpha amino nitrogen (AN).

No statistically significant yield differences were apparent in the continuous wheat rotation (NS, P=0.543) where the yields (shown as the main figures) were taken from the areas least affected by black-grass. However, both the deep and shallow approaches in the continuous wheat were substantially affected by black-grass (see above). Therefore, yields were adjusted to reflect the lost cropping area and resulted in yields of 3.9 t/ha and 4.0 t/ha in the shallow and deep tillage, respectively (shown in bracketed figures).

Figure 1: Black-grass heads in a) shallow tillage b) plough tillage approaches in the continuous wheat rotation.

Summary financial analysis from the 2018-19 seasons are presented in Table 4. In the winter oilseed rape rotation the margin was highest in the deep tillage (£861/ha) and this is reflected through from the higher yield. In the managed and shallow approaches, where the oilseed rape was re-sown, two figures are presented.

The main figures show the margin, taking account of the additional seed and establishment costs for re-sowing with the figures in brackets not accounting for the additional costs. Interestingly, despite the additional costs (£110/ha), the yield and reduced establishment costs associated with the shallow approach resulted in negligible difference in margin *cf*. plough. However, the managed approach which had additional costs of £131/ha and a significantly lower yield that resulted in a lower margin of £490/ha.

Table 4: Yield and margin summary information from break crops in STAR Year 14 (2018/19)

	Yield (t/ha)					Gross margin – machinery cost (£/ha)			
	Winter	Spring	Cont	Alt Fallow		Winter	Spring	Cont	Alt Fallow
Plough	4.4	81.3	10.4	-		808	978	688	-
Managed	3.6	73.9	10.0	-		490 *(621)*	848	706	-
Shallow	4.5	77.5	9.7 *(3.9)*	-		795 *(905)*	927	-90	-
Deep	4.5	83.4	9.9 *(4.0)*	-		861	1044	-91	-
Average	*4.3*	*79.0*	*10.0*	-		*739*	*949*	*686*	-
LSD	0.4	6.5	1.2	-					
CV %	5.3	7.1	5.7	-					

Margins represent a gross output minus direct input and machinery costs. Margins use diesel at £0.59/l; N at £0.56/kg N; wheat at £130/t; oilseed rape at £325/t and sugar beet at £21.90/ t

In sugar beet, the difference in yield reflected through into margin, with the highest margin obtained from deep tillage (£1,044/ha) and the lowest margin of £848/ha in the managed approach. In the continuous winter wheat margins were similar in the plough and managed approaches, £688/ha and £706/ha respectively. However, where the grassweeds were sprayed off to reduce seed return to the seedbank, the margins were substantially affected, resulting in a negative margin of around -£90/ha in both shallow and deep tillage.

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 substantial affect from black-grass in the non-inversion continuous wheat treatments became very evident this season and resulted in a substantial loss in yield and a negative margin despite a robust herbicide programme. This highlights the importance of maintaining cultural control strategies (both cultivation and rotation) that ensure grass weeds remain at manageable levels.

The impact of growing sugar beet within the rotation was assessed for the first time in 2018/19. Margin reflected yield with the highest yield and margin obtained with deep tillage. Further measurements in the following season will assess the impact of growing sugar beet on the following crop.

Quantification of system impacts on soils within the STAR Project will continue over coming seasons (to assess long term changes) and will also continue to be carried out in the analogous treatments in the NIAB TAG New Farming Systems study at Morley. 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 PhD students to collect samples from as part of their research study.

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 TAG as well as through events run by other organisations. The project has also received exceptionally good media coverage including articles in conference proceedings and a range of farming press articles.

In May 2019 a specific open access field event was held. This event attracted about 50 attendees (Figure 2). The event received press coverage in the Farmers Weekly 'Why herbal leys have been added to arable rotation trial' published on 10th June 2019.

Pro-active and effective knowledge transfer both locally and to the whole industry remains an integral part of NIAB TAG's delivery of the STAR project; this ensures that messages reach the widest possible audience. A list of all KT activities is captured in the Steering Group meeting minutes, with a few key events and publications highlighted below:

- An article 'Primary cultivation and wheat yields – Long-term work at NIAB, Lessons from STAR and NFS' featured in Direct Driller Magazine, January 2019
- Use of material at NIAB TAG open days, STAR open day and Cereals Event.
- Two articles in the NIAB Landmark magazine;
    - Conventionalising cover crops - (ICASE PhD awarded to study 'Cover crops and below ground

biodiversity' (NIAB, UEA/JIC and Syngenta))

- Subsoil compaction – extent, impact and alleviation- (FTCT / Chadacre / TMAF PhD awarded to study ' Deep seated soil compaction' (NIAB and Cranfield University))

- Used in NIAB TAG 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).

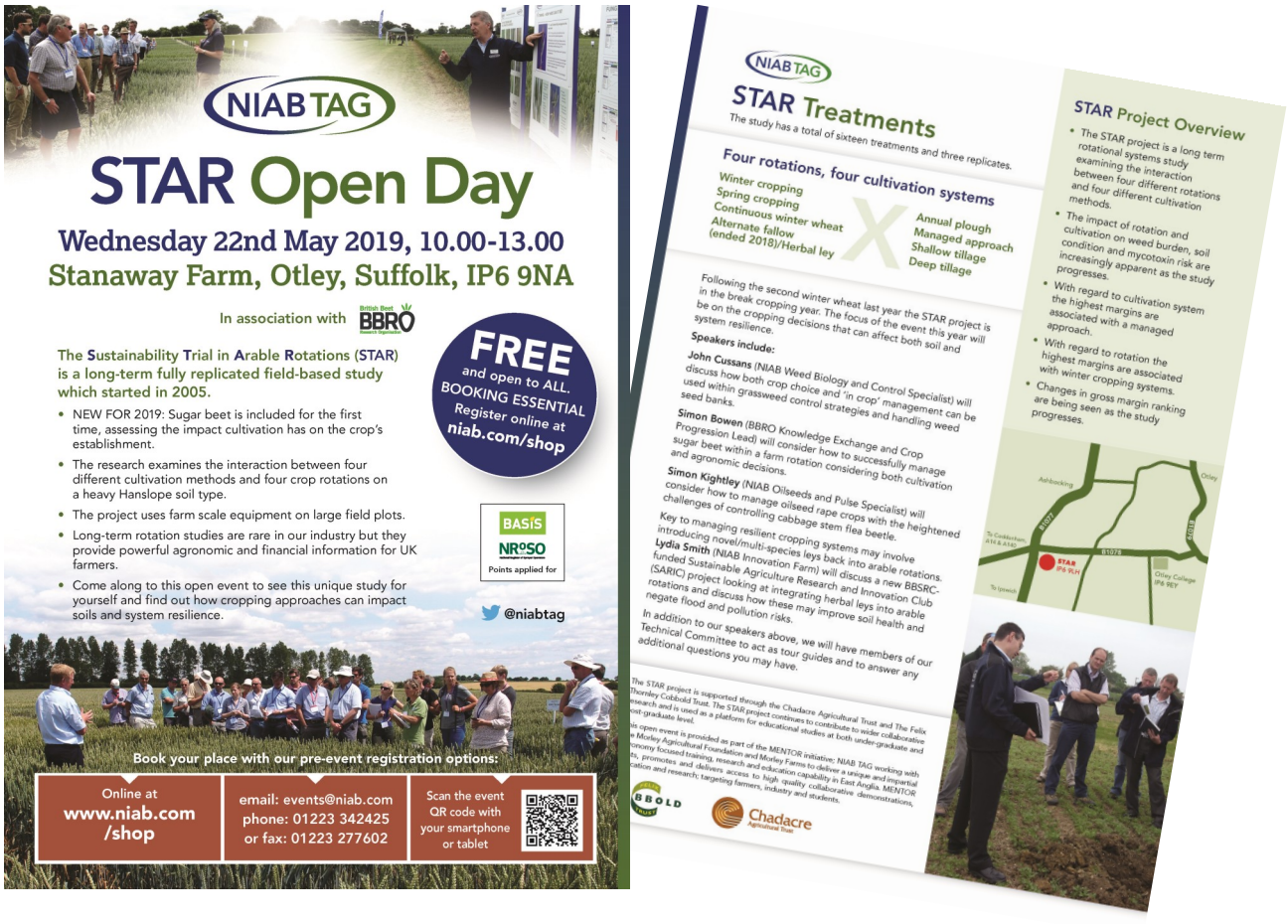


Figure 2: Event flyer for the STAR open event held as a Technical Field Day.

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 (20 cm) Power Harrow (x1) Weaving tine drill	Plough (20 cm) Power Harrow (x2) Monosem Precision Drill	-	Plough (20 cm) Power Harrow (x2) Weaving tine drill
Managed	Low disturbance sub-soiler	Sumo (10 cm) Power Harrow (x2) Monosem Precision Drill	-	Sumo (10 cm) Power Harrow (x1) Weaving tine drill
Shallow	Mzuri drill	Sumo (10 cm) Power Harrow (x2) Monosem Precision Drill	-	Sumo (10 cm) Power Harrow (x1) Weaving tine drill
Deep	Sumo (20 cm) Power Harrow (x1) Weaving tine drill	Sumo (20 cm) Power Harrow (x2) Monosem Precision Drill	-	Sumo (20 cm) Power Harrow (x1) Weaving tine drill

APPENDIX B: COST AND MARGIN BREAKDOWN

Appendix Table 2a: STAR cost and margin breakdown 2018/19 (winter cropping)

	Shallow Till WOSR	Deep Till WOSR	Managed App WOSR	Annual Plough WOSR
Yield (t/ha)	**4.5**	**4.5**	**3.6**	**4.4**
Price (£/t)	**325**	**325**	**325**	**325**
OUTPUT (£/ha)	**1462.50**	**1462.50**	**1170.00**	**1430.00**
VARIABLE COSTS:				
Seed (7kgs)	79.80	79.80	79.80	79.80
Seed (9kgs)	102.60		102.60	
Fertiliser	199.43	199.43	199.43	199.43
Sprays	143.50	143.50	143.50	143.50
Other				
VARIABLE COSTS (£/ha)	**525.33**	**422.73**	**525.33**	**422.73**
	(422.73)		**(422.73)**	
GROSS MARGIN - (£/ha)	**937.17**	**1039.77**	**644.67**	**1007.27**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				61.00
Deep Sumo		41.00		
Shallow Sumo	29.00			
Power Harrow		38.00		38.00
Double press (x1)				
Single Pass Drill			54.80	
Combi Drill				
Tine Drill		28.00	28.00	28.00
Claydon Drill	33.80			
Broadcast	6.95			
Precision Drill				
Rolls	13.00	13.00	13.00	13.00
Quad (x1)	2.45	2.45	2.45	2.45
Fertiliser (x4)	28.00	28.00	28.00	28.00
Sprayer (x7)	28.49	28.49	28.49	28.49
Total Field Operational Costs (£/ha)	**141.69**	**178.94**	**154.74**	**198.94**
	(134.74)		**(126.74)**	
MARGIN MINUS COSTS (£/ha)	**795.48**	**860.83**	**489.93**	**808.33**
(Without re-seeding costs)	**(905.03)**		**(620.53)**	

Appendix Table 2b: STAR cost and margin breakdown 2018/19 (spring cropping)

	Shallow Till S Beet	Deep Till S Beet	Managed App S Beet	Annual Plough S Beet
Yield (t/ha)	**77.5**	**83.4**	**73.9**	**81.3**
Price (£/t)	**21.90**	**21.90**	**21.90**	**21.90**
OUTPUT (£/ha)	**1697.25**	**1826.46**	**1618.41**	**1780.47**
VARIABLE COSTS:				
Seed	223.00	223.00	223.00	223.00
Fertiliser	112.19	112.19	112.19	112.19
Sprays	225.17	225.17	225.17	225.17
Other				
VARIABLE COSTS (£/ha)	**560.36**	**560.36**	**560.36**	**560.36**
GROSS MARGIN - (£/ha)	**1136.89**	**1266.10**	**1058.05**	**1220.11**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				61.00
Deep Sumo		41.00		
Shallow Sumo	29.00		29.00	
Power Harrow (x2)	76.00	76.00	76.00	76.00
Double press				
Single Pass Drill				
Combi Drill				
Tine Drill				
Claydon Drill				
Precision Drill	58.30	58.30	58.30	58.30
Rolls				
Quad				
Fertiliser (x2)	14.00	14.00	14.00	14.00
Sprayer (x8)	32.56	32.56	32.56	32.56
Total Field Operational Costs (£/ha)	**209.86**	**221.86**	**209.86**	**241.86**
MARGIN MINUS COSTS (£/ha)	**927.03**	**1044.24**	**848.19**	**978.25**

Appendix Table 2c: STAR cost and margin breakdown 2018/19 (continuous wheat)

	Shallow Till Cont WW	Deep Till Cont WW	Managed App Cont WW	Annual Plough Cont WW
Yield (t/ha)	**9.7**	**9.9**	**10.0**	**10.4**
	(3.88)	(3.96)		
Price (£/t)	**130**	**130**	**130**	**130**
OUTPUT (£/ha)	**1261.00**	**1287.00**	**1300.00**	**1352.00**
	(504.40)	**(514.80)**		
VARIABLE COSTS:				
Seed	79.56	79.56	79.56	79.56
Fertiliser	129.57	129.57	129.57	129.57
Sprays	224.12	224.12	224.12	224.12
Other				
VARIABLE COSTS (£/ha)	**433.25**	**433.25**	**433.25**	**433.25**
GROSS MARGIN - (£/ha)	**827.75**	**853.75**	**866.75**	**918.75**
FIELD OPERATIONAL COSTS (£/ha)				
Plough				61.00
Deep Sumo		41.00		
Shallow Sumo	29.00		29.00	
Power Harrow	38.00	38.00	38.00	76.00
Double press (x1)				
Single Pass Drill				
Combi Drill				
Tine Drill	28.00	28.00	28.00	28.00
Claydon Drill				
Precision Drill				
Rolls				
Quad				
Fertiliser (x3)	21.00	21.00	21.00	21.00
Sprayer (x11)	44.77	44.77	44.77	44.77
Total Field Operational Costs (£/ha)	**160.77**	**172.77**	**160.77**	**230.77**
MARGIN MINUS COSTS (£/ha)	**666.98**	**680.98**	**705.98**	**687.98**
(After accounting for grass weeds)	**(-89.62)**	**(-91.22)**		