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Getting the Most out of Cover Crops

The impact of repeated brassica cover crops use on system performance and oilseed rape yield

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Abstract

The New Farming Systems (NFS) research project is being undertaken on a sandy loam soil at Morley (Norfolk, UK). The programme is funded by The Morley Agricultural Foundation and The JC Mann Trust and is a series of large scale, long term, replicated experiments examining routes to augment the stability and output of conventional arable farming systems. Within this study cultivations follow plough, deep non-inversion, shallow non-inversion and managed (where decisions are made annually based on field assessments) systems. Rotations consist of winter wheat with a combinable break crop in intervening seasons (typically spring sown break crops). Where spring breaks are grown the rotational approaches are differentiated further by the presence or absence of an autumn brassica cover crop (radish, *Raphinus sativus*). In 2013/14 season all treatments grew winter oilseed rape for the first time. This facilitated a comparison between rotations with a short (four times in an 8 year period) or long (two times in an 8 year period) brassica inclusion. Yield reduction in oilseed rape is associated with short rotations, and understanding whether this outcome is also associated with frequent brassica cover crop use is an important question for growers. Findings show some reduction in oilseed rape yield associated with short (alternate) rotations of brassica cover crops (*c*. 6%), although to a lesser degree than would be expected from a short (alternate) oilseed rape rotations (*c*. 12%). The research also suggests some interaction between the yield reduction and cultivation system; with greater reductions being associated with inversion tillage.

Key words: Brassica, cover crop, farming systems, management, oilseed rape, tillage

Introduction

The New Farming Systems (NFS) research programme is an ongoing series of long term and fully replicated field studies seeking to examine and develop sustainable practices in conventional arable cropping systems. The NFS programme is funded by The Morley Agricultural Foundation (TMAF) and The J C Mann Trust and is being carried out at Morley (Norfolk, UK) on a sandy loam soil (Ashley series). Research within the NFS programme is examining three inter-related themes: fertility building, tillage systems and soil amendments (Stobart & Morris, 2011, 2013, 2014). This paper focuses on the NFS 'Cultivations' experiment and considers aspects of cover crop use, rotational frequency and tillage on system performance. Specifically, whether repeated use of autumn sown brassica cover crops impact on oilseed rape yield and how tillage approach might influence this relationship.

In the NFS 'Cultivations' study, rotations alternate between winter wheat and a combinable break crop. Spring breaks are gown typically and the presence or absence of an autumn brassica (radish) cover crop (*Raphinus sativus*), ahead of the spring break crop, further differentiates the rotations. The selection of winter oilseed rape as a break crop in 2013/14 facilitated a comparison between rotations with a short (four times in an 8 year period, that is with other brassica break crops and/or cover crops every other seasons) or long (only two brassica crops in an 8 year period) rotation for brassica inclusions. Research has shown yield reductions associated with 'short' oilseed rape rotations (Christen & Sieling, 1999; Stobart & Bingham, 2013) and rotational issues associated with oilseed rape have also been linked to the 'yield plateau' effect in this crop (Knight *et al*., 2012). The growing popularity of brassica cover crops has raised further questions regarding whether these impacts are also associated with frequent use of brassica cover crop in rotations.

Materials and Methods

The NFS long term field studies began in autumn 2007. The research programme employs conventional, practical farming approaches and the fully replicated experiments use large plot studies with permanent grass pathways to allow plots to be accessed independently. Drilling dates vary according to season, but crops (and cover crops) are sown in keeping with local best practice and seed rates are appropriate for the prevailing conditions. All other inputs are consistent with local best practice. Within the NFS programme the 'Cultivations' experiment is examining the interaction of cultivation method and cover crop on crop performance. Four different cultivation methods are repeated with and without the presence of a deep rooted brassica (radish, *Raphinus sativus*) cover crop (grown ahead of spring sown crops); this forms part of a fully factorial design delivering eight treatments. A summary of treatments is set out in Table 1 with further detail in Stobart & Morris (2013, 2014). During 2013/14 the oilseed rape crop (cv. PR46W21) was drilled on the 26/08/13 at 2.5 kg ha^{-1} and harvested on the 16/07/14. The 'managed approach' for this season of cropping was deep non-inversion.

Table 1. *Treatment and rotational progression details for the 'cultivations' experiment*

Rotation

	2008 (Year 1)	2009 (Year 2)	2010 (Year 3)	2011 (Year 4)	2012 (Year 5)	2013 (Year 6)	2014 (Year 7)
Spring break based rotation	ww	sosr	ww	sbn	ww	sbly	wosr

Key: ww (winter wheat), sosr (spring oilseed rape), sbn (spring bean), sbly (spring barley), wosr (winter oilseed rape).

Management

i. Current; systems run as standard with regard to fertiliser inputs
ii. Cover crops; as 'i' but with a deep rooted brassica (radish, *Raphinus sativus*) cover crop autumn sown and destroyed overwinter ahead of spring sown crops

Cultivation

a) Annual plough: treatment is ploughed every year.
b) Shallow tillage: treatment is cultivated to ≈5–10 cm using a non-inversion technique.
c) Deep tillage: treatment is cultivated to ≈20–25 cm using a non-inversion technique.
d) Managed approach: cultivation regime decided annually, based around soil conditions/assessments, previous cropping, weed burden and local best practice.

Results

Selected data from the 2013/14 harvest season are presented in the following section. Further selected field data and yield information from earlier years of study are presented in Stobart & Morris (2011, 2013, 2014).

Early season oilseed rape establishment, vigour and green area index (GAI) data pertaining to tillage system and cover cropping regime are presented in Table 2; data suggests some differences with respect to tillage approach but less impact due to cover cropping history. Yield, lodging and margin data for the tillage approaches are presented in Table 3; the highest yield and margins were associated with the 'managed approach'. Yield responses with respect to the interaction of tillage and cover cropping are presented in Fig. 1 (interaction of yield, cover cropping history and tillage) and Fig. 2 (yield difference associated with cover crop in relation to tillage regime).

Table 2. *Plant populations (per m^2), crop vigour (relative 1–9 score where 9 is high vigour) and green area index (GAI) for oilseed rape (OSR) where brassica cover crops have (+CC) or have not (-CC) been included in the rotation historically. New Farming Systems 'Cultivations' study (2013/14)*

	OSR population			OSR vigour			GAI		
Previous cropping	-CC	+CC	Mean	-CC	+CC	Mean	-CC	+CC	Mean
Primary Cultivation									
Plough	47	44	46	7	7	7	2.3	2.4	2.4
Deep non-inversion	40	41	41	6	7	7	2.0	2.2	2.1
Shallow non-inversion	31	36	34	4	5	5	1.4	1.5	1.5
Managed	34	36	35	5	4	5	1.6	1.5	1.6
Mean	38	39		6	6		1.8	1.9	
LSD (t ha^{-1})	5.8 (P=0.0001)			1.7 (P<0.001)			0.42 (P=0.0001)		
CV (%)	10.1			20.2			15.6		

Table 3. *The impact of tillage on lodging (%), yield (t/ha) and margin (£ ha^{-1}) in oilseed rape in the New Farming Systems 'Cultivations' study in 2013/14 (data shown is the mean of cover crop practice)*

	Lodging (%)	Yield (t ha^{-1})	Margin (£ ha^{-1})
Primary Cultivation			
Plough	32	3.46	517
Deep non-inversion	14	3.84	644
Shallow non-inversion	1	4.09	728
Managed	1	4.27	764
LSD (t ha^{-1})	21.0 (P<0.01)	0.34 (P<0.05)	-
CV (%)	153	8.3	-

Margins calculated as gross output minus direct input and machinery costs based on spot prices in the year of production assuming £280 t^{-1} (oilseed rape), £0.70 kg^{-1} (nitrogen), £0.68 L^{-1} diesel with other prices based on 'Farm Brief' and as agreed with the New Farming Systems advisory group.

Discussion

Findings from the NFS 'Cultivations' study provide information both on the impact of tillage on the performance of oilseed rape and the interaction of this with cover cropping history. With regard to tillage, ploughing tended to result in higher plant populations (although in practice differences were small) and there was some indication that shallower tillage systems tended to have lower populations, early vigour and GAI. With respect to tillage, yields ranged from 3.46 t ha^{-1} to 4.27 t ha^{-1}, with the highest yields associated with the 'managed approach'. However, of the purist systems (i.e. plough, deep and shallow, where systems stay the same every season) the shallow tillage approach was the highest yielding; this approach would also offer higher field work rates at establishment providing time as well as cost savings. The higher levels of lodging associated with the deep and plough based systems may have been associated with the lower yields in these approaches.

With regard to the historic inclusion of a brassica cover crop in the rotation there was little impact on oilseed rape population, GAI or vigour. However, visual observations did indicate some differences in weed burden, although differences were small. Specifically, spring assessments indicated a mean weed ground cover of around 5% in plots that had not historically had a brassica cover crop and around twice this level in treatments which have historically had a brassica cover crop (data not shown); it was noted that volunteer brassica weeds were the main component of the increased weed burden, suggesting a weed legacy from the cover crop inclusion.

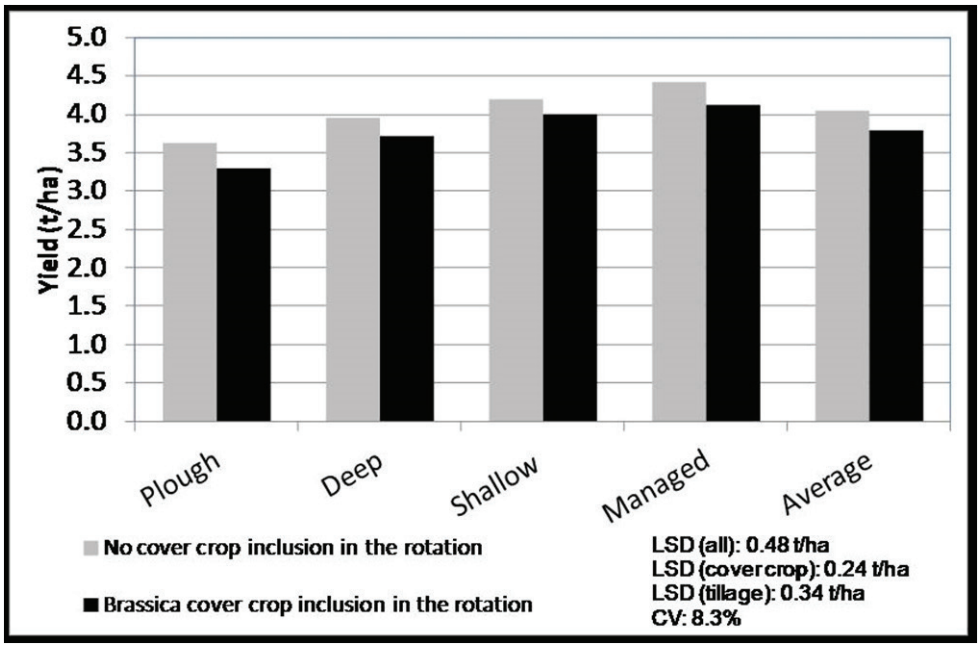

Fig. 1. The interaction of yield, tillage and cover cropping history on oilseed rape yield in the New Farming Systems 'Cultivations' study in 2013/14.

The data presented in Fig. 1 indicate that for each tillage approach the historic inclusion of a brassica cover crop tended to reduce oilseed rape yield. The mean yield loss across all systems was around 0.27 t ha^{-1} (around 6%); while this is small, the difference was statistically significant. Research by Stobart & Bingham (2013) also carried out at Morley (in a neighbouring field) indicated an oilseed rape yield loss of around 12% comparing long (4–5 year gaps) to short (alternate wheat:oilseed rape) rotations of oilseed rape. The yield loss associated with the brassica cover crop use is around half this value; this lesser reduction may be associated with the shorter residence time of the brassica cover crop (typically August to February) compared to an oilseed rape crop (typically August to July). In addition, the findings from the NFS 'Cultivations' study presented in Fig. 2 also suggest some interaction between tillage technique and the yield reduction associated with the cover crop

use. Of the purist tillage approaches (i.e. plough, deep and shallow where systems stay the same every season) there was a tendency for yield loss to be mitigated with reduced tillage intensity (i.e. lowest in the shallow tillage system).

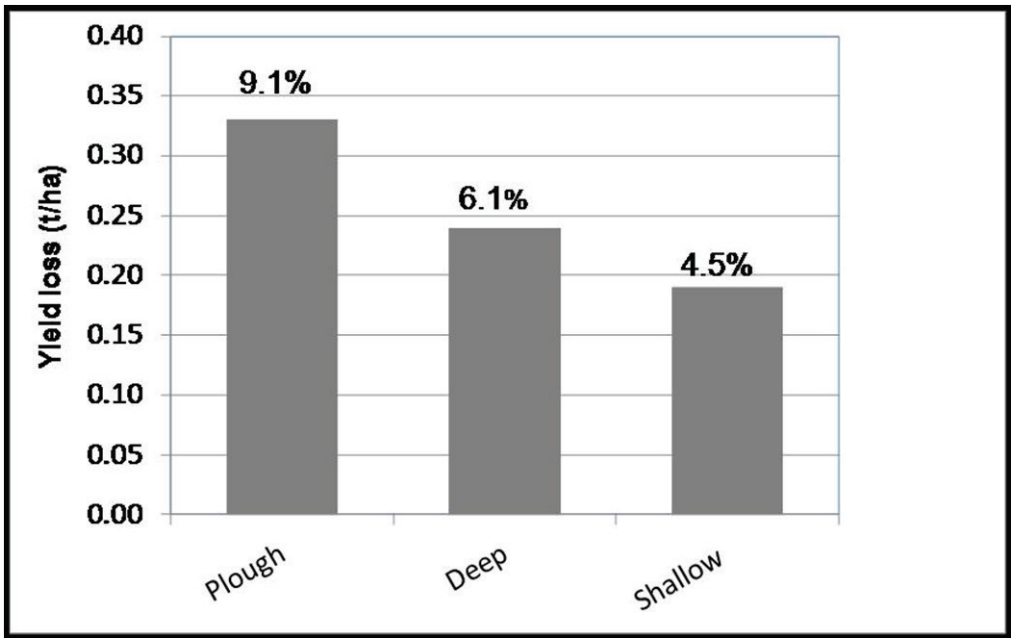

Fig. 2. The yield difference associated with cover crop in relation to tillage regime in the New Farming Systems 'Cultivations' study in 2013/14.

Stobart & Bingham (2013) related the yield loss in oilseed rape to changes in crop performance in the spring around rooting, seed set and seed recovery. Further work by Hilton *et al*. (2013) associated these findings with brassica root pathogens. While further research would be needed to ascribe fully the reasons for the oilseed rape yield reductions recorded in the NFS 'Cultivations' study, a relationship to pathogens associated with brassica cover crops would seem probable. Further it is possible that tillage regimes, perhaps to help manage cover crop volunteers (e.g. shallow tillage may better enable volunteers to be tackled in intervening crops), might have potential as a strategy to at least partially mitigate these losses. Previous findings from the NFS 'Cultivations' study (Stobart & Morris, 2014) have also associated the shallow tillage system where cover crops have been included in the rotation with positive yield responses in winter wheat; potentially providing a complementary benefit. While further long term rotational research to repeat and validate these findings regarding the impact of brassica cover crops on oilseed rape would seem prudent, this dataset does at least in part answer the grower question about the impact of brassica cover crops on oilseed rape yield. This information will better enable informed decision making on cover crop selection and rational planning.

Acknowledgments

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