UK Study site experiment #1: COMPACTION ALLEVIATON IN A NO-TILL CROPPING SYSTEM

The problem

In cropping systems soil compaction can be caused by the weight of heavy machinery. If present, it can reduce the pore space within soil, resulting in a poor soil structure that restricts the development of plant roots. It also affects the soil water status, causing waterlogging during wetter periods and drought conditions during drier periods, which in turn limits root and crop development.

The proposed solution

This experiment in the east of England explored the potential of different tillage systems and a mycorrhizal inoculant to alleviate or minimise the impacts of compaction in a direct drilling system on clay soils.

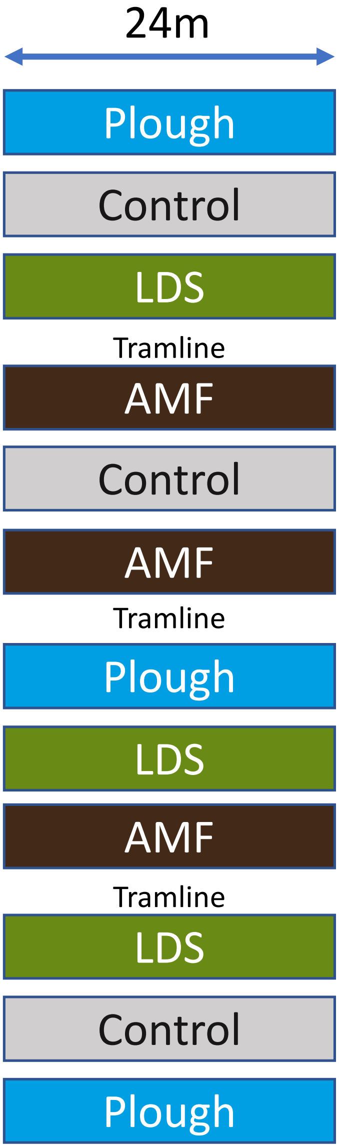
Different tillage practices have the potential to alleviate soil compaction. For example, a low disturbance sub-soiler can loosen the compacted sub-surface soils with minimum disturbance to the surface. These mechanical methods to alleviate compaction may, however, be laborious and expensive. A biological method which takes little time to apply, such as mycorrhiza inoculants may, therefore, be more realistic. Mycorrhizal inoculants work by boosting root growth which in turn reduces the effects of compaction.

Experimental design

A plot trial experiment was carried out from 2017-2019. An area of arable land was deliberately compacted prior to the experiment beginning.

Three experimental treatments and a control plot were set up and trialled over 2 years. The treatments were:

- Ploughing
- Low disturbance sub-soiler (LDS)
- Mycorrhizal inoculant (AMF)
- Control: direct drill only



The crops grown were spring barley in Year 1 and field beans in Year 2.

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Key Results

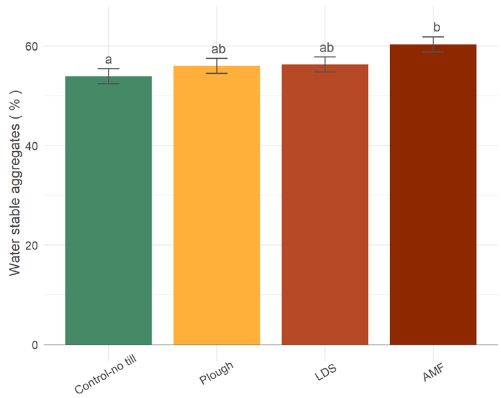

Figure 1. Effect of treatments on water stable aggregates

Water stable aggregates were slightly improved by AMF inoculation as fungi glues aggregates together. A significant difference was found between the control plot and AMF. AMF, therefore, improved soil structure, at least to an extent (figure 1).

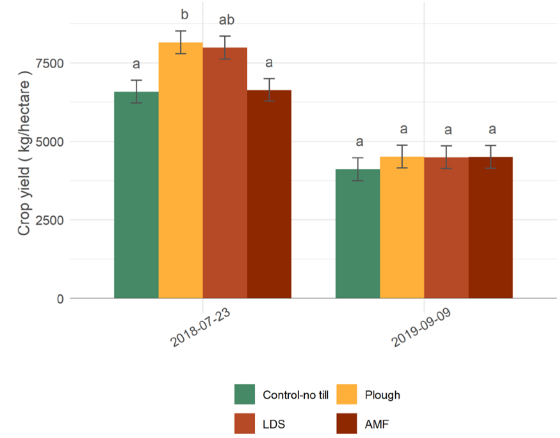

Figure 2. Effect of treatments on crop yield

Both the no till plots showed the lowest crop yields in year 1, with very little difference between the treatments in year 2 (figure 2).

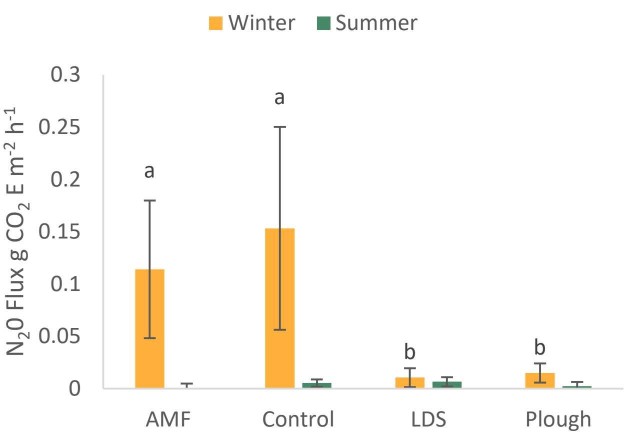

Figure 3. Effect of treatments on N_20 flux in Winter and Summer.

N_2O flux was significantly higher in the compacted AMF and control plots during winter, indicating that greenhouse gas emissions are lower under LDS and ploughing (figure 3) under these circumstances.

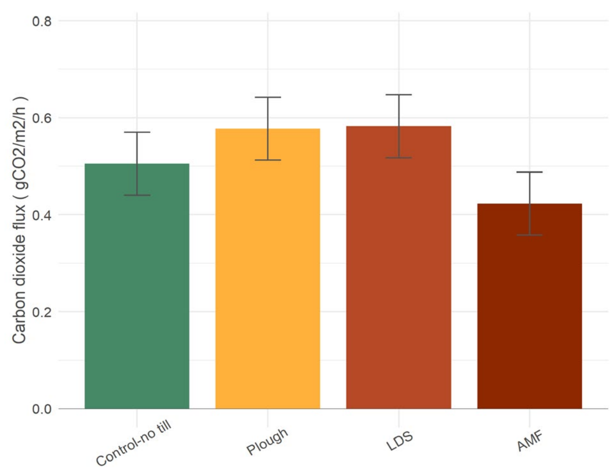

Figure 4. Effect of treatments on CO_2 emissions

CO_2 emissions were higher in the cultivated plots than the two non-cultivated compacted plots (figure 4). Although this does not appear significant when analysed together, this is due to the variability of the data between summer and winter months. When analysing the winter months separately, significantly higher CO_2 emissions from cultivated plots were identified.

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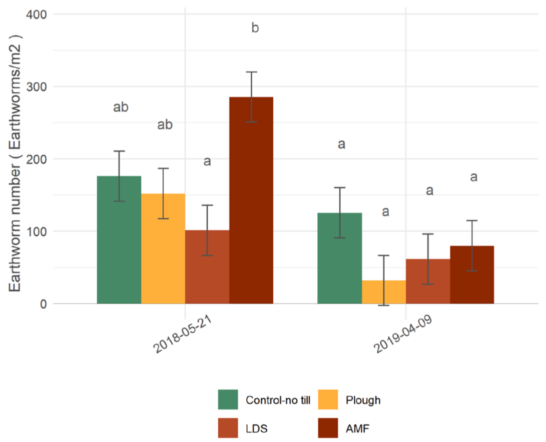

Figure 5. Effect of treatments on earthworm numbers

Earthworm numbers were consistently lower in the two cultivated plots (figure 5). This could have profound implications for soil structure and health.

The visual evaluation of soil structure (VESS) scores were lowest in the ploughed plots. This indicates that whilst ploughing may be good for yields in the short-term, it may not be improving overall structure in the soil profile. This will likely have implications for long-term yields and the resilience of the soils.

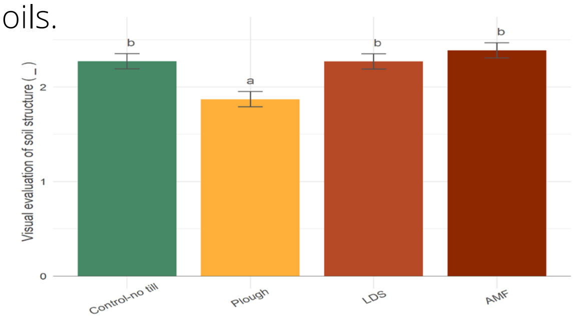

Figure 6. Effect of treatments on visual evaluation of soil structure

Economic impacts

Due to higher yields, the crop income was highest for the plough plots. The gross margin was lowest for AMF plots due to lower yields and costs of the inoculant. When cultivation costs are considered, the no-till control plots were slightly more profitable than the plough plots.

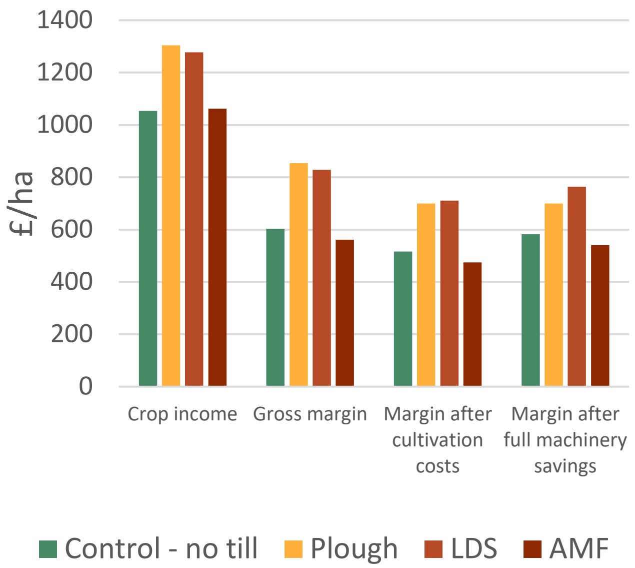

Figure 7. Crop income on different treatment plots during year 1 (Nov 2018, barley).

The economic impact for LDS was positive compared to the control due to an improvement in yield when compaction was alleviated. LDS also performed marginally better than plough, despite lower yields because of the additional cultivations required after ploughing.

	Control	SICS
Agricultural management technique	Direct drill	Sub-soiler
Investment costs	0	0
Maintenance costs	450	450
Production costs	87	117.1
Benefits	1052.8	1278.4
Summary=benefits-costs	515.7	711.26
Percentage change	37.9	

Table 1 Economic impact of LDS (SICS vs control), number in f £/ha

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Stakeholder feedback

Stakeholders were interested in the results showing that subsoiling, where needed, is at least as profitable as ploughing.

The stakeholders recognised that results were relevant to climate change objectives. They were surprised by the results showing N_2O flux was higher in the AMF and control plots during winter, indicating that in these compacted conditions, overall greenhouse gas emissions are comparable to those under LDS and ploughing. However, it was also recognized that these results are just one part of the larger picture for crop establishment and studies in the future should include carbon omissions from field operations.

It was found that farmers are not sure when to time subsoiling. As a result, further trials are being undertaken to provide farmers with real-time soil moisture data so they can determine when their soils are likely to be ready for subsoiling.

The stakeholders felt that 2 years was insufficient time to measure the differences between measures for yield. A longer study carried out across at least a whole rotation would be more meaningful.

Factors encouraging the adoption of subsoiling:

- Subsoiling is a well-known and accepted agronomic practice

Barriers preventing the adoption of subsoiling and mycorrhizal inoculation:

- Limited knowledge of costs/benefits
- Not applicable to shallow/stony soils
- Lack of equipment availability for subsoiling

Key findings

- If there is a compaction problem, direct drilling will result in a yield penalty.
- Earthworm numbers were consistently lower in the two cultivated plots. This supports previous research which found that ploughing reduces earthworm populations.
- Water stable aggregates were slightly improved by AMF inoculation. Fungi are known to stick aggregates together, so inoculation is improving soil structure, although very moderately.
- The compaction resulted in higher N_2O emissions in the compacted direct drilled plots but CO_2 and overall global warming potential was lower.

Conclusion

Overall, when soil compaction forms in a direct drill system traditional methods such as ploughing work well to alleviate compaction and increase yield. However, LDS results in similar economic benefits while maintaining soil health advantages associated with direct drilling.

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