Final Project Summary

Project title	**Improvement of soil structure and crop yield by adding organic matter to soil**		
Project number	RD-2012-3787	**Final Project Report**	576
Start date	September 2012	**End date**	December 2016
AHDB Cereals & Oilseeds funding	£774,999	**Total cost**	£1,084,999 plus in kind from Growers and AFBI

What was the challenge/demand for the work?

Improvements in soil structure are thought to bring about increases in crop yields. Organic matter additions are considered to bring about these improvements. It is hypothesised additions do this by stimulating soil organisms that bring about changes in structure to their habitat to the benefit of crops.

The evidence, however, is somewhat equivocal because any organic matter addition usually brings nutrients with it to which crops respond. Results to date have focused on manures but other amendments, such as anaerobic digestate, have yet to be investigated.

Other means of increasing soil organic matter, such as reducing tillage, the use of rotations and cover crops, and making better use of crop residues, to improve yields also needed investigation.

How did the project address this?

To investigate changes in yield response to changes in structure, a key requirement in experimentation is to control other factors – especially nutrients. Accordingly, large field trials were set up to measure not only yields but the full response curves of yield to fertiliser nitrogen, in the presence and absence of organic matter amendments.

The research also compared tillage versus reduced tillage, the effect of pre-treating crop residues before incorporation, as well as the ways in which different crops and crop rotations were affected by organic matter amendments.

Earlier work has focused on farmyard manure (FYM) and this was looked at, as well as additions of other materials: anaerobic digestate (AD), compost, and crop residues and mixtures of FYM, AD and compost with crop residues. The effect of different rates of addition of these materials on crop yields, in terms of total amount of carbon added, was also investigated.

The work also sought to understand and quantify the mechanisms by which organic matter might improve soil structure. To this end, penetrometer resistance, water infiltration, microbial biomass, fungal

biomass, earthworm population, resistance to plough draught and concentration of some other nutrients were measured. X-ray Computer Assisted Tomography (CAT) scans of intact cores were made and, in related experiments, the impact of FYM on soil-borne disease and the economics of reducing tillage, in relation to yields, was also assessed. In ongoing work, how long yield benefits persist in soil once annual amendment ceases is also being assessed.

The cost of acquiring and spreading amendments was also determined. Draft guidance on the prices and quality of amendment (in terms of carbon contents), required for a likely improvement in profit rather than simply yield, has also been produced.

Considerable engagement with growers and farmers took place over the course of the project and the essential message that organic matter is dynamic and a food source for soil organisms has been well received.

What outputs has the project delivered?

The project has shown that yields increase quickly in response to successive annual amendment with organic matter.

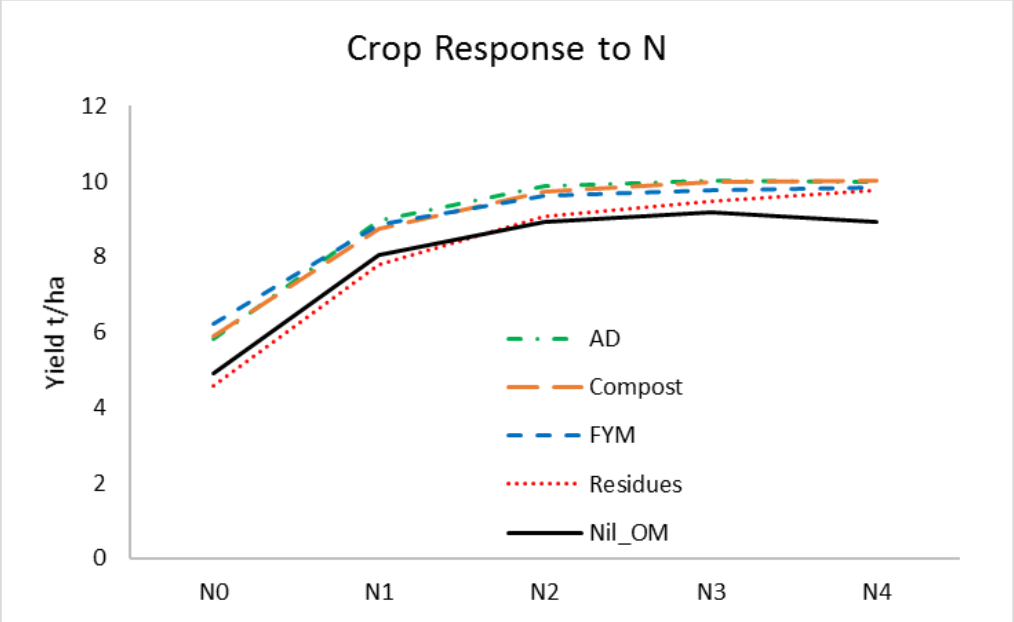

Figure 1. *Averaged crop responses (grain yield) over four years and two crop rotations to applied N along with either anaerobic digestate (AD), compost, farmyard manure (FYM), crop residues or no amendment on Fosters field at Rothamsted. Amendments in this figure were applied at 2.5 t C ha^{-1}. Actual N rates (x-axis) differ according to the crops which were grown in the two rotations over four years: spring barley – oilseed rape – winter wheat – spring barley and winter wheat – spring barley - winter oats – winter wheat. Responses to N and N-rates themselves thus differ between crops*.

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Crops responded to the amendments well and yielded more than might be expected in relation to the fertiliser N applied (Figure 1). Beyond N3, which was the recommended amount of N to apply to each crop according to the Fertiliser Manual (RB209), yields in the absence of applied organic matter generally decreased. The yield at N3, thus, is the maximum that could be expected. The maximum yield achievable with amendments is more than the maximum that can be achieved at any rate of N without amendment. Adding crop residues also increases yields but with the proviso that a slightly larger amount of fertiliser N must be given as well, probably because microorganisms in soil require more N than the residues contain in order to assimilate them.

Despite considerable effort, no clear evidence of a single determinant of these changes emerged from the research. An integrative measure of soil structure – the draught force needed to plough the soil – was well related with the amendment added and the increase in yield, once the background variations in texture were removed. However, simpler, plot-based measures of soil structure did not reflect the effect of amending soil consistently. The mass or number of soil organisms was expected to be a good indicator of change but few statistically significant results were obtained between the biological measurements made and yields. It is possible that the *activity*, rather than the mass of organisms, is responsible for the beneficial changes in structure and future research could be directed to this area.

In related work exploiting pre-existing field experiments, it appears that the organic amendments helped mitigate the effects of soil-borne disease and maintain a greater degree of consistency in yield, from year to year, compared to unamended crops. This suggests amendments confer a degree of stability (or resilience) to yields.

Who will benefit from this project and why?

Farmers, commodity wholesalers, food retailers/suppliers of organic materials and policy regulators of waste materials.

Farmers benefit from better awareness and specific evidence to support the expectation of increases in yield from amending soils with organic matter.

Farmers, wholesalers and retailers benefit from the increased resilience that arises through the use of amendments. Better yield stability increases the reliability of forecasts of production which helps keeps supply and prices stable.

Evidence of a value of organic materials will help to stimulate demand and a market for organic materials.

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Evidence of the benefits of amendments helps with decisions about regulation and the definition and description of materials potentially applied to land.

If the challenge has not been specifically met, state why and how this could be overcome

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Scientific partners	Cranfield University, University of Nottingham
Industry partners	Waitrose, Phil Wallace
Government sponsor	Defra