

Save Out Soils!
Thursday, 18 February 2010



Organic Matter – How to Increase Carbon Storage in Agricultural Soils

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What is soil organic matter?

The *carbon* containing material in the soil that is derived from living organisms (e.g. plants, fauna and manure).

Soil organic matter - measurement

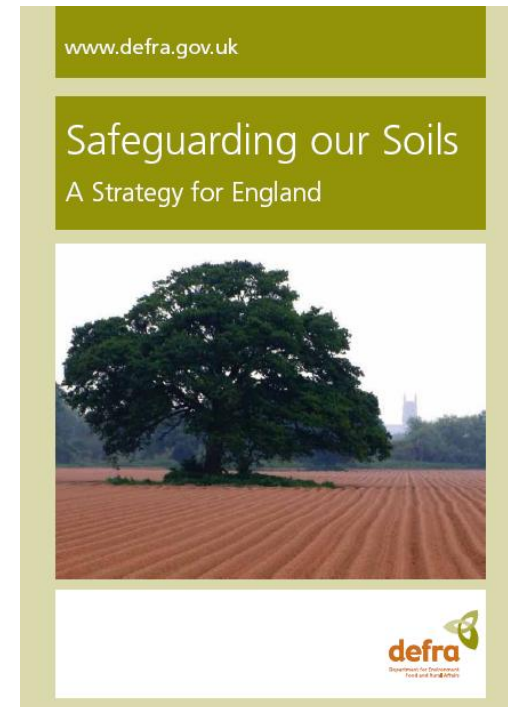
- **Organic carbon x 1.724 = organic matter (MAFF 1986).**
 - *Walkley Black/Tinsley*
- **Loss on ignition - used to estimate organic matter (moisture, coal, free lime)**

**“Soil just isn’t soil without
organic matter.....”**

Arable Farming, 15th August 2005

Soils – coming up the agenda!

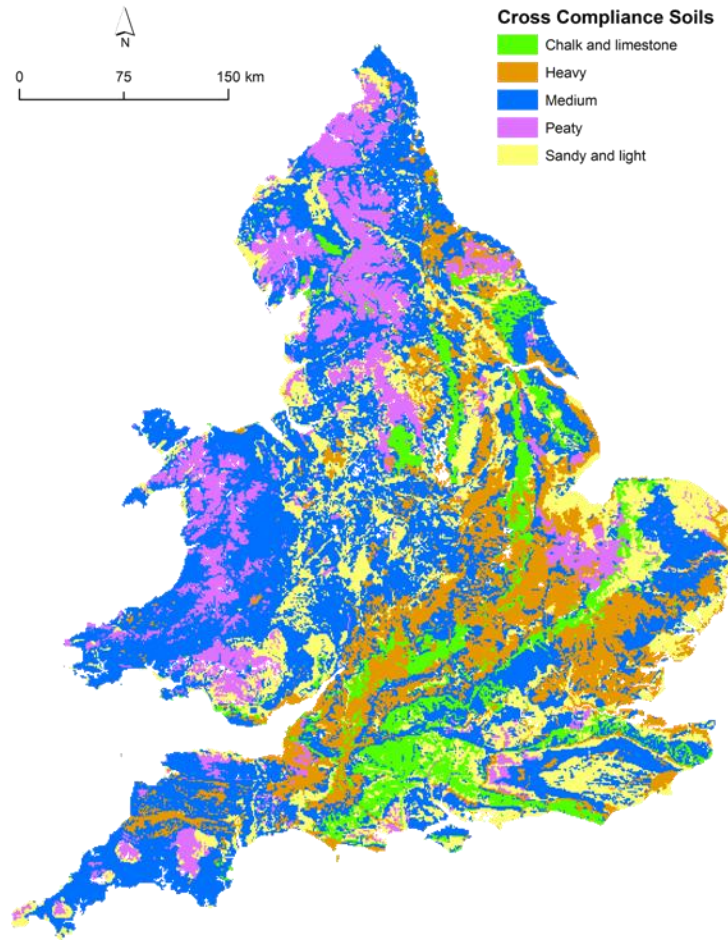
- **Sustainable Use of Soil:**
 - Defra's Soil Strategy for England (Wales and Scotland)
 - EU Soil Framework Directive
 - Defra's Food 2030 Strategy
- **Main soil concerns:**
 - organic matter decline/carbon storage
 - soil erosion
 - compaction



Organic matter - arable soils

- **Soil organic matter reserves are reaching ‘critically’ low levels:**
 - annual cultivation (oxidation).
 - crop production may not be sustainable in the long-term on some soils.
- **Soil organic matter:**
 - Defra’s headline indicator for soil quality.
 - Maintenance and enhancement is a cross compliance requirement.

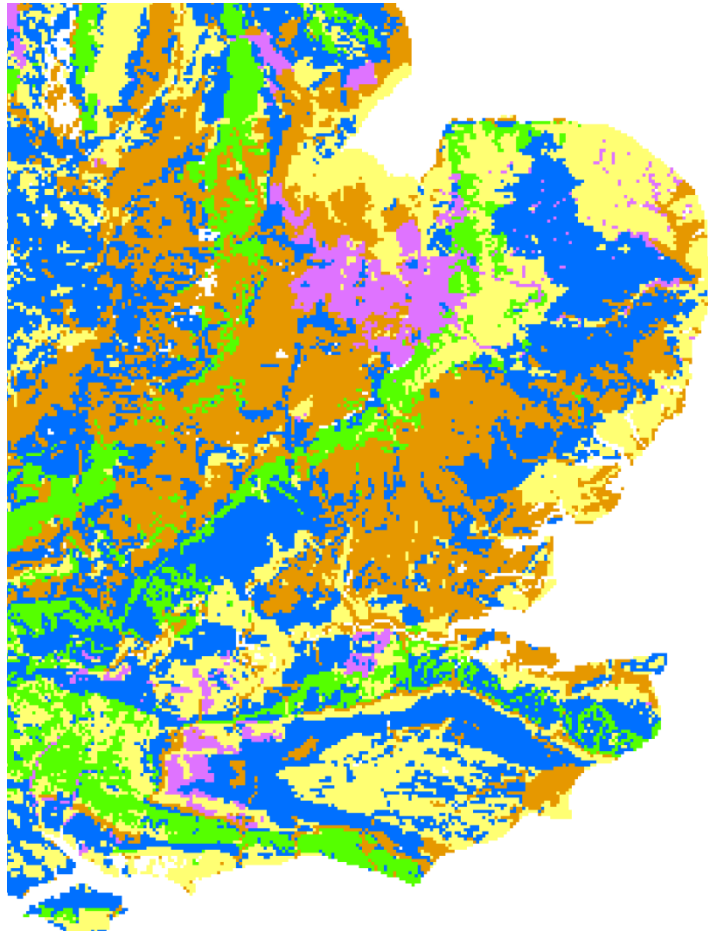
Soils in England and Wales



Original data sourced from NATMAP 1000 Dominant Soil Series. Copyright Cranfield. Data provided under Defra funded R&D.



Soils in Eastern England



Cross Compliance Soils

-  Chalk and limestone
-  Heavy
-  Medium
-  Peaty
-  Sandy and light

Original data sourced from NATMAP 1000 Dominant Soil Series. Copyright Cranfield. Data provided under Defra funded R&D.

Increasing agricultural soil organic matter (carbon) storage

Stern Review (2006)

- **Reduced tillage and the recycling of organic materials could sequester carbon in agricultural soils.**
 - **Stern Review (2006) - “Agricultural management practices (e.g. crop tilling practices) could be an important source of CO₂ emission savings”**
 - **Chicago Climate Exchange paid farmers \$1-2 /acre/year (£1.25-2.5/ha/yr) to zero till land (4 year commitment)**

Reduced tillage

5 million hectares of tillage land in UK



Conventional plough:

- to at least 20cm depth
- 50% of primary tillage practices



Reduced tillage:

- discs (or tines) to 10-15cm or less
- 43% of primary tillage practices

Zero tillage: no cultivation (direct drill or broadcasting); 7%

Potential increase in soil organic matter (SOM) following *zero or reduced* tillage compared with conventional tillage (95% CI in brackets)

Cultivation practice	SOM increase (kg OM/ha/a)	% of SOM stocks ^a
Zero tillage	540 (-240 to 1300)	0.35
Reduced tillage^b	270	0.18

^a Assuming 4.8% SOM in top 25cm (Webb *et al.*, 2001) & a bulk density of 1.3 g/cm³ = 157 tOM/ha

^b Assumed to be half the C storage of zero tillage on the basis of depth of soil disturbance

Database: 6 UK experiments over timescale of 2-23 years.

Note: These figures should be regarded as initial rates of increase

Conclusions – Zero/reduced tillage

- The amount of soil organic matter (carbon) potentially stored by changing to zero/reduced tillage is *relatively small* - but there are other benefits (e.g. lower production costs, lower runoff risks).
- SOM accumulation is reversible - not likely to continue zero/reduced tillage indefinitely (weed, disease, compaction build-up).
- The benefit may be completely offset!
 - studies in Canada and UK have measured increased nitrous oxide emissions of up to 700 kg/ha CO_{2e} (wetter soil conditions?), but few studies ('pollution swapping').

Organic material returns



Provide a valuable means of replenishing SOM and maintaining the inherent fertility of arable soils.

Estimated quantities of organic materials recycled to land in the UK

Manure type	Fresh weight (million tonnes)
Livestock manures	90.7
Biosolids	3-4
Compost	1.3
Paper crumble	0.7
Digestate	0.1
Industrial 'wastes'	6-7

Typical organic matter loadings (250 kg/ha total N)

OM type	Application rate (t or m ³ /ha FW)	Organic matter (t/ha)
Cattle FYM	40	5.5
Dairy slurry	80	3
Broiler litter	8	3
Biosolids cake	23	3.5
Green compost	33	4.5
Paper crumble	50^a	13

^atypical application rate of paper crumble

Research sites in Britain: long-term SOM storage



Farm manures - 8 study sites (4 sites at Rothamsted; 4 sites Defra SOIL-QC project)



Biosolids - 10 study sites (Woburn market garden experiment; 9 “Long-term Sludge Experiment” sites)



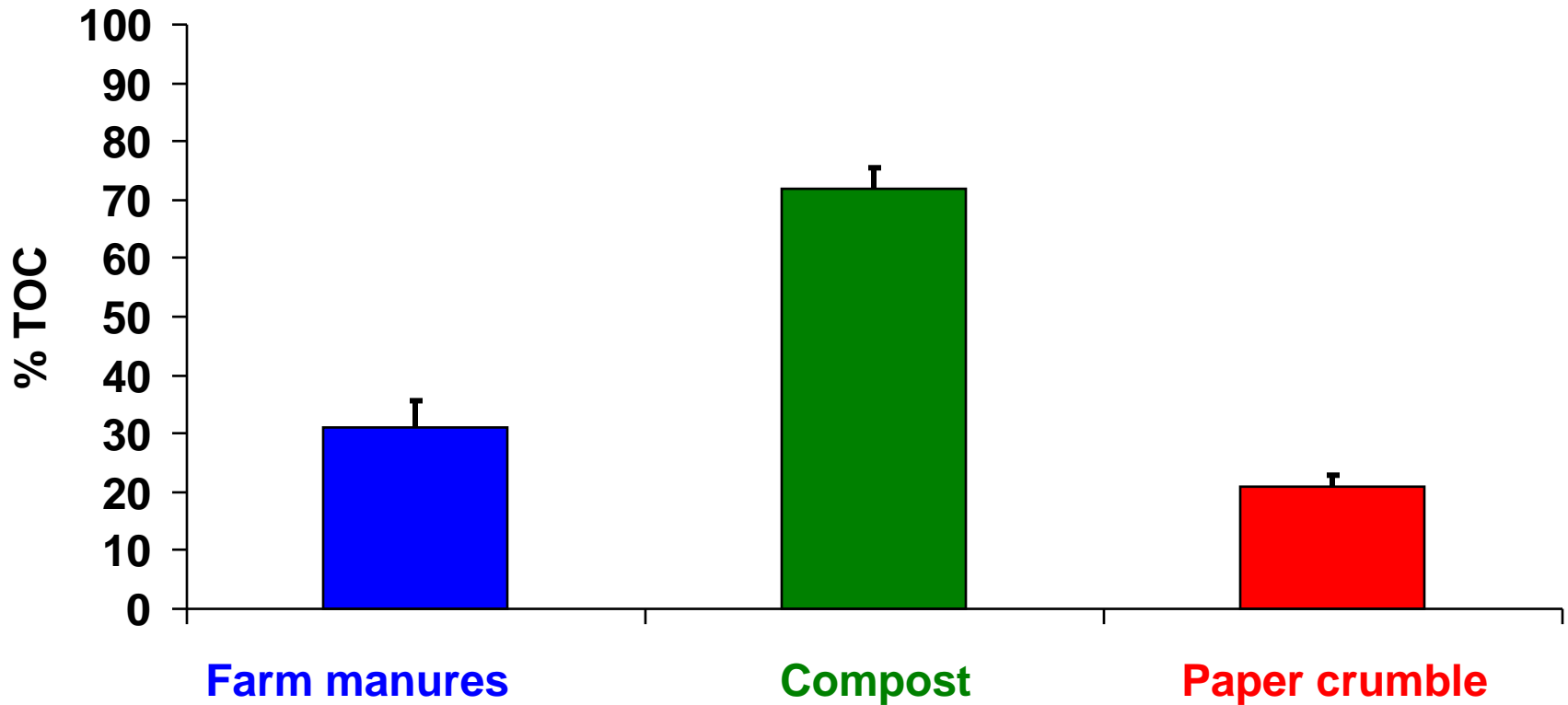
Green compost – 4 Enviros study sites

Potential increase in soil organic matter (SOM) following organic material additions

OM type	% C applied retained
Farm manures	23
Biosolids cake	56
Green compost	43

Note: These figures should be regarded as initial rates of retention (*i.e.* up to c.20 years)

Long lasting organic matter – Lignin **as % of total organic carbon**



Potential increase in soil organic matter (SOM) following typical rates of organic material additions

OM type	Application rate (t/ha ds) ^a	SOM increase (kg/ha/yr)	% of SOM stocks ^b
FYM	10	1300	0.8
Biosolids cake	6	1900	1.2
Green compost	20	1900	1.2

^aOrganic manures applied at 250 kg/ha total N

^bAssuming 4.8% SOM in top 25 cm (Webb *et al.*, 2001) & a bulk density of 1.3 g/cm³ = 157 tOM/ha

Benefits of organic matter to soils

Defra Soil-QC experimental platforms – *soil carbon storage*

Organic materials(4)

(farm manures, compost, paper crumble)

Crop residues (3)

Ropsley
(medium loam soil)

Harper Adams
(light loam soil)

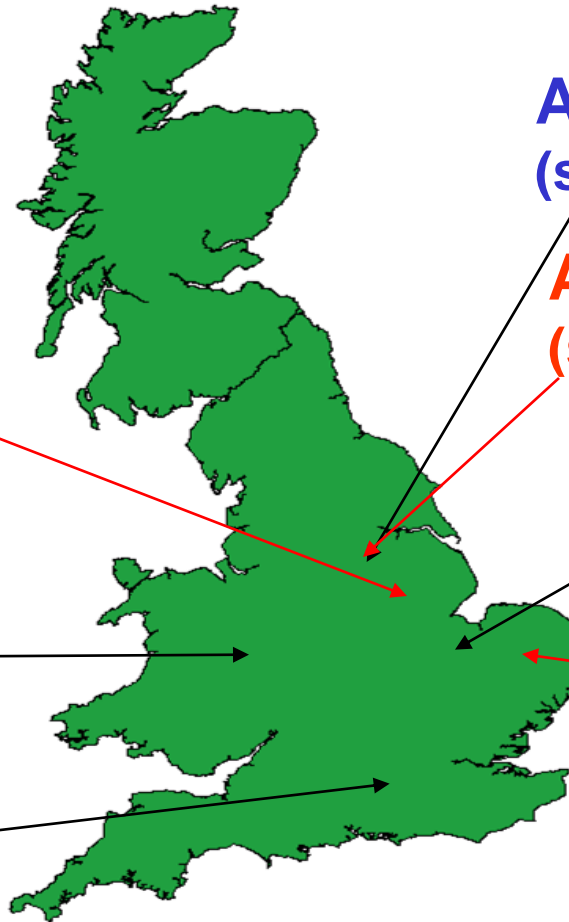
ADAS Bridgets
(calcareous medium silt soil)

ADAS Gleadthorpe
(sandy soil)

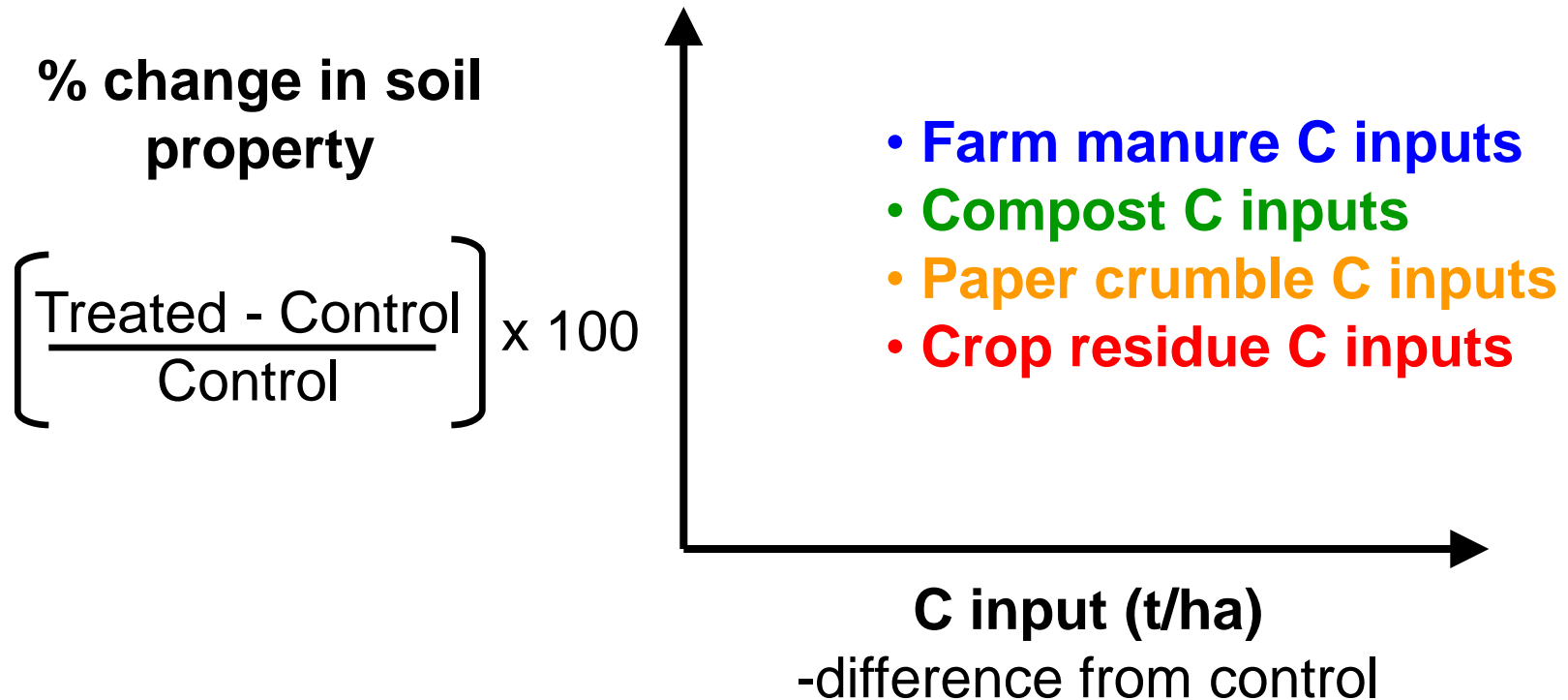
ADAS Gleadthorpe
(sandy soil)

ADAS Terrington
(medium silt soil)

**Morley
Research
Centre**
(light loam soil)

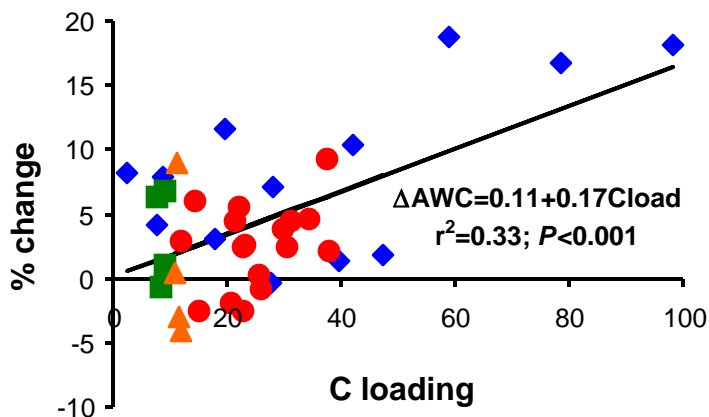


Soil quality results



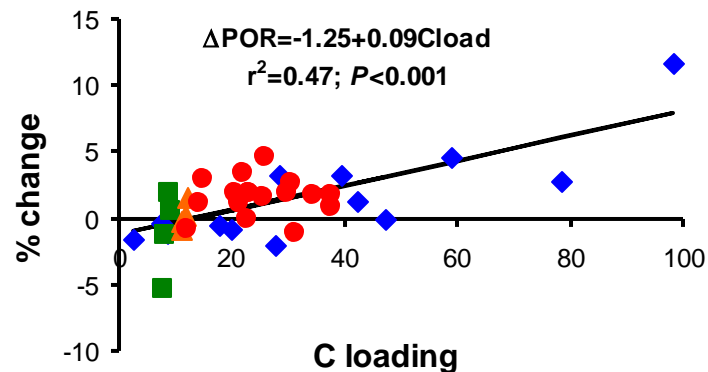
Soil physical properties

Available Water Capacity



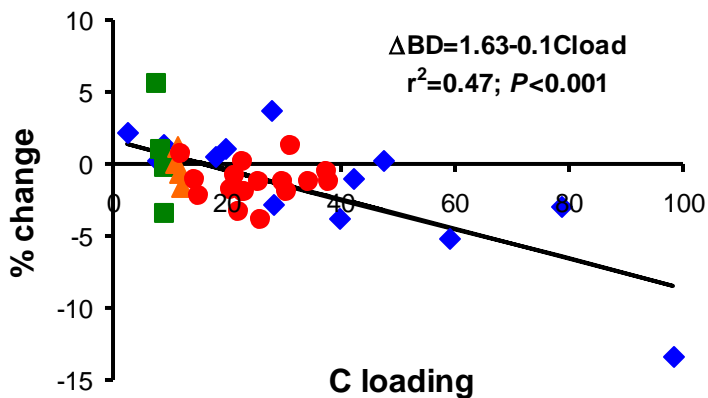
- ◆ Farm manures
- Compost
- ▲ Paper Crumble
- Crop residues

Porosity



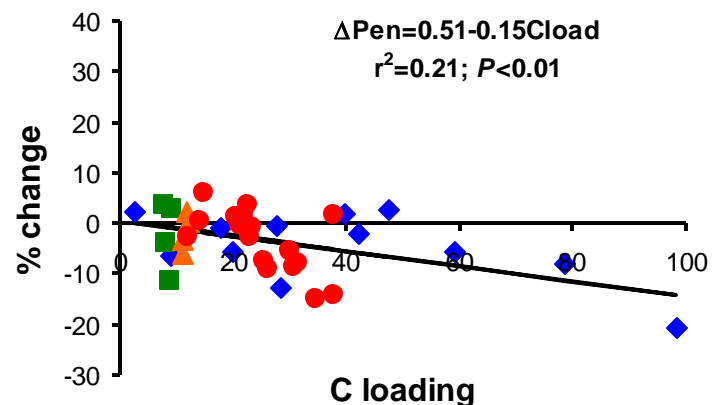
- ◆ Farm manures
- Compost
- ▲ Paper Crumble
- Crop residues

Bulk Density



- ◆ Farm manures
- Compost
- ▲ Paper Crumble
- Crop residues

Penetration Resistance



- ◆ Farm manures
- Compost
- ▲ Paper Crumble
- Crop residues

Plant available water capacity - benefit to crop yields (sandy soil sites)

Harper
40 t/ha/yr FYM
:10+years

10% ↑ AWC

1.5 t/ha ↑

Potatoes

£150/ha

0.78 t/ha ↑

Carrots

£71/ha

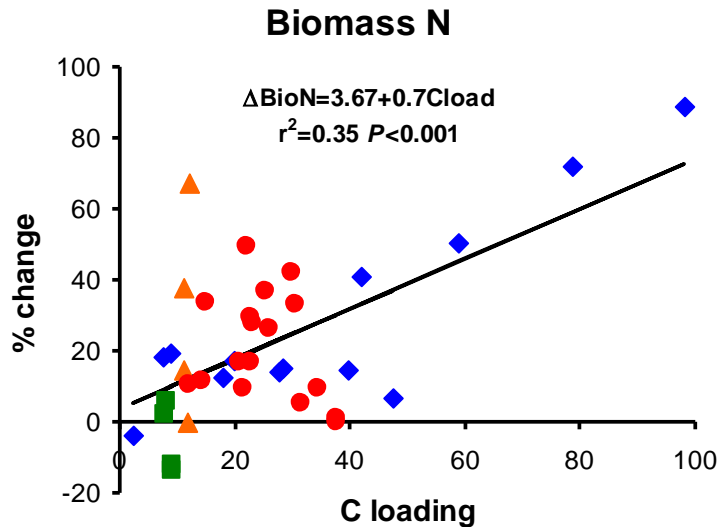
Gleadthorpe
10 t/ha/yr BL
:10+years

0.04 t/ha ↑

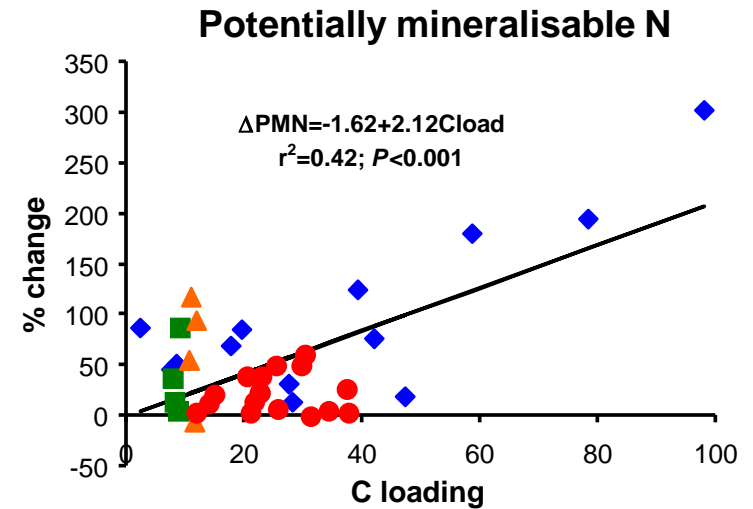
Cereals

£4/ha

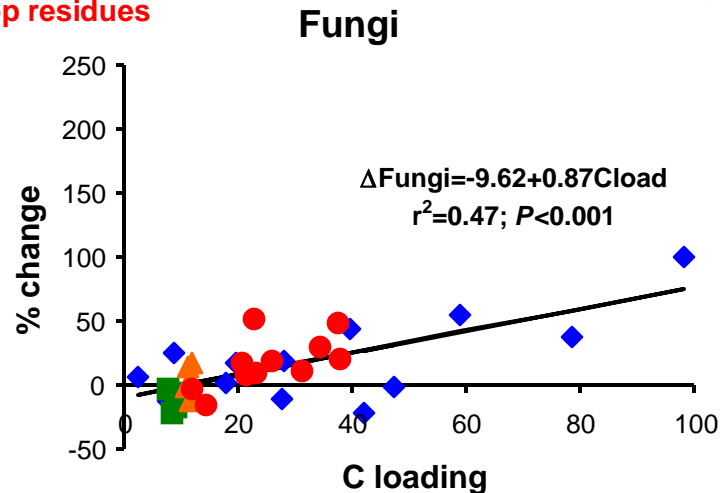
Soil biological properties



◆ Farm manures ■ Compost
▲ Paper Crumple ● Crop residues



◆ Farm manures ■ Compost
▲ Paper Crumple ● Crop residues



◆ Farm manures ■ Compost
▲ Paper Crumple ● Crop residues (excluding Morley)

SOIL-QC conclusions:

Soil Quality Benefits

- **OM inputs changed a large number of soil properties**
 - Chemical (organic C storage, total N, extractable P/K, cation exchange capacity)
 - Physical (AWC, POR, BD, penetration resistance)
 - Biological (biomass N, PMN, fungi)
 - *But long-term inputs were needed.....*
- **There were very few differences between forms of OC applied**
 - Farm manure (compost, paper crumble) and crop residue OM

In Summary

- **Reduced tillage – *limited* potential to increase soil organic matter (carbon) storage.**
- **Organic material additions to land can increase soil organic matter (carbon) storage:**
 - **soil quality**
 - **water retention**
 - **economics of crop production**
- **Reverting arable land to *permanent* uncultivated land (e.g. woodland, buffer strips etc)... *but not food*...**

Thank you – Questions?

