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Dungs, slurries, composts, digestates and biosolids: fertilisers and soil conditioners

Audrey Litterick

Earthcare Technical Ltd

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Dungs, slurries, composts, digestates, biosolids:

- Soil conditioning benefits
  - Organic matter (amount and type)
  - Neutralising value
  - C:N ratio
- Fertiliser value
  - £how to calculate
  - £how to store and use for maximise financial benefits
  - How to calculate bagged fertiliser requirement when used with dung (etc.)

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Benefits of bulky organic materials

- Slurries and whole/liquid digestates are mainly water! They are just fertilisers.
- Dungs, composts and fibre digestates are both fertilisers AND soil conditioners (due to the organic matter they contain).

Soil-conditioning BOFs (high OM):

- Strawy cattle manure
- Green and food/green compost
- Mushroom compost
- Fibre digestate
- Biosolids (though usually applied at relatively low rate due to high P content),
- Straw

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Where soil organic matter content is low, adding more will:

- ✓ Improve structure and workability
- ✓ Increase water holding capacity, giving greater resilience to dry weather
- ✓ Increase water infiltration giving reduced flooding
- ✓ Increase biological activity
- ✓ Improve retention and turnover of nutrients

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Benefits of solid BOFs for different soils

	Light Soils	Heavy Soils
Crop establishment	√	√
Nutrients	√	√
Structure	√	√
Water holding and infiltration	√	√ (infiltration)
Cation exchange capacity	√	X
Soil organic matter	√	√
Structural drainage characteristics	√	√

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How much organic matter is present in common BOFs?

Organic material	Dry Matter	Organic matter content (%)	Application rate (t/ha) NVZ 250kg N/ha	Organic matter applied (t/ha)
Cattle FYM	25%	13.1	42	5.5
Broiler litter	60%	31.2	8	2.5
Green Compost	58%	24.7	38	9.4
Green/Food Compost	51%	19.0	22	4.2
Biosolids (lime cake)	19%	70.0	4*	2.8

*Rate dependent on phosphate content rather than N content.

Commonly applied organic liquids

- Slurries
- Dirty water
- Whole and liquid digestates

Properties of digestates

- Different AD systems produce widely different products depending primarily on:
  - What you put in (feedstock)
  - The type of system
- Dry matter content profoundly affects both ease of pumping/spreading (and stacking in the case of fibre digestates) and the cost of storage, haulage and spreading.
  - Whole digestates typically 3 – 14% DM)
  - Separated fibre 18 – 42% DM
  - Separated liquid typically 1 – 3 % DM

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To separate or not?.....

- The real costs of using whole digestate can be high:
  - Storage tanks and lagoons
  - Haulage (of a lot of water!)
  - Potential soil damage
  - Loss of nutrients when digestate applied at inappropriate times of year and in inappropriate soil conditions
- Many AD plants are considering separation into fibre and liquid fractions.

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Fibre digestates

- Well made fibre digestates should be dry enough (20-40% DM) to stack and store safely, possibly outdoors uncovered (depends on moisture content and RAN content)
- No panic about having to find land
- Cheaper to haul the nutrients around
- Most can be spread at any time of year and are not subject to NVZ closed periods
- Contain useful amounts of organic matter and are soil conditioners as well as fertilisers
- The best ones have potential for use in high value applications such as growing media and turf topdressings.

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Biosolids (sewage sludges)

- Several different types - important to understand the key properties of those you're dealing with.
  - **Main farmer benefit:** a cost-effective fertiliser, generally rich in P, with useful concentrations of N, S and Mg
  - **Main points to watch:**
    - Will contain PTEs and must be applied to land according to the Safe Sludge Matrix and Sewage sludge regulations [The Sludge (Use in Agriculture) Regulations 1989 and The Sludge (Use in Agriculture) (Amendment) Regulations 1990].
    - Pathogen content varies widely depending on treatment method. Choose appropriate material for intended end use.
    - Odour can cause problems on some sites

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Very important to regularly test the bulky organic materials that you use often (slurries, dung etc.)

- Don’t just guess!
- Only if you test can you be sure you are getting crop fertiliser applications right and are not over or under applying fertiliser.
- Must ensure that you obtain a representative sample.
  - For solids, take multiple sub-samples from various parts (locations, heights and depths) of the pile
  - For liquids, agitate thoroughly, or (much less ideal) take multiple samples from different depths within the tank.

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Test parameters

- Dry matter content (how easy/cheap is it to pump/transport/spread/store)
- Total nutrients (N, P, K, Mg, S)
- Ammonium and nitrate-N
- In the case of liquids (esp. food-based digestates, might test for Na and eC)
- Trace elements if wished (e.g. B, Mn)
- In the case of fibre digestates, composts, and biosolids, NV should also be tested

- May also occasionally test for organic matter content
- Biosolids , composts, digestates and some animal manures should also be tested for PTE's (e.g. Cu and Zn; also Cd, Cr, Zn, Ni, Pb, Hg; and for biosolids, As, F, Se, Mo)
- Biosolids, PAS 100 composts and PAS 110 digestates must also be tested for pathogen content (e.g. *E.coli*, salmonella)

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Nutrient content and value – whole digestates

Major Nutrients	Total	Readily available	Potential value £/t
Whole, food-based digestate (example) (£3.05/m^3)			
Nitrogen (N kg/t)	5.0	3.0 (60%)	£1.95 (Crop available N)
Phosphate (P_2O_5 kg/t)	0.5	0.25 (50%)	£0.28 (total P_2O_5)
Potash (K_2O kg/t)	2.0	1.6 (80%)	£0.82 (total K_2O)
Whole digestate based on energy crops (example) (£2.42/m^3)			
Nitrogen (N kg/t)	3.0	1.8 (60%)	£1.17 (Crop available N)
Phosphate (P_2O_5 kg/t)	0.4	0.2 (50%)	£0.22 (total P_2O_5)
Potash (K_2O kg/t)	2.5	2.0 (80%)	£1.03 (total K_2O)
Based on fertiliser prices: N 65p/kg; phosphate 56p/kg; potash 41p/kg			

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Nutrient content and value – dung and fibre digestate

Major Nutrients	Total	Readily available	Potential value £/t
Strawy cattle manure (typical) 6.0, 3.2 and 8.0 kg N, P_2O_5 and K_2O (£5.46/m^3)			
Nitrogen (N kg/t)	6.0	0.6 (10%)	£0.39 (Crop available N)
Phosphate (P_2O_5 kg/t)	3.2	1.9 (60%)	£1.79 (total P_2O_5)
Potash (K_2O kg/t)	8.0	7.2 (90%)	£3.28 (total K_2O)
Strawy cattle manure (Girrick) 4.1, 1.7 and 4.0 kg N, P_2O_5 and K_2O (£2.86/m^3)			
Nitrogen (N kg/t)	4.1	0.3 (10%)	£0.27 (Crop available N)
Phosphate (P_2O_5 kg/t)	1.7	2.0 (50%)	£0.95 (total P_2O_5)
Potash (K_2O kg/t)	4.0	0.5 (80%)	£1.64 (total K_2O)
Based on fertiliser prices: N 65p/kg; phosphate 56p/kg; potash 41p/kg			

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Nutrient content and value – biosolids

Major Nutrients	Total	Readily available	Potential value £/t
Digested cake (typical) 11.0, 18.0 and 0.6 kg N, P_2O_5 and K_2O (£11.05/t)			
Nitrogen (N kg/t)	11.0	0.6 (10%)	£0.72 (Crop available N)
Phosphate (P_2O_5 kg/t)	18.0	1.9 (50%)	£10.08 (total P_2O_5)
Potash (K_2O kg/t)	0.6	7.2 (90%)	£0.25 (total K_2O)
Lime stabilised (typical) 8.5, 26.0 and 0.8 kg N, P_2O_5 and K_2O (£15.44/m^3)			
Nitrogen (N kg/t)	8.5	0.3 (10%)	£0.55 (Crop available N)
Phosphate (P_2O_5 kg/t)	26.0	2.0 (50%)	£14.56 (total P_2O_5)
Potash (K_2O kg/t)	0.8	0.5 (90%)	£0.33 (total K_2O)
Based on fertiliser prices: N 65p/kg; phosphate 56p/kg; potash 41p/kg			

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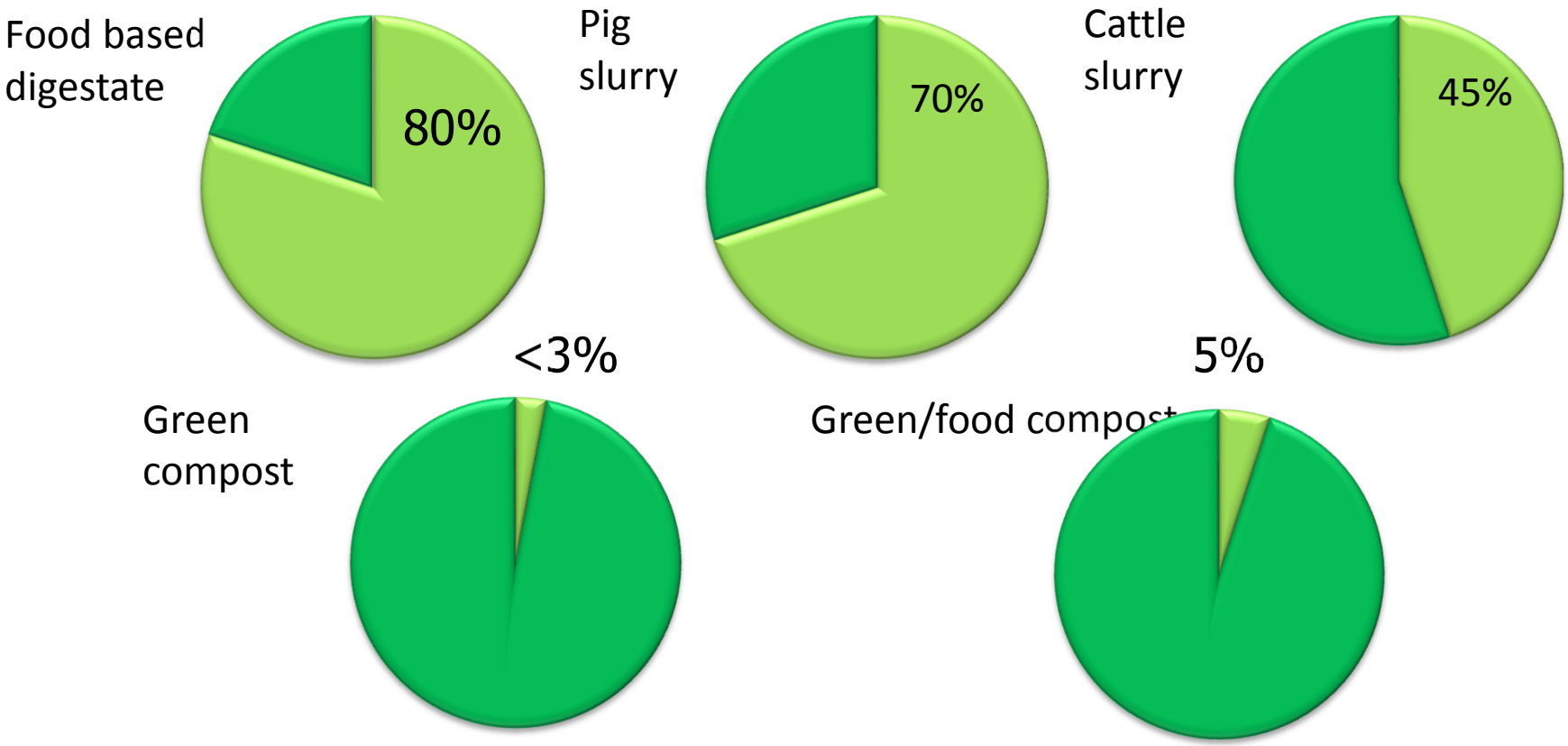
True value of digestate (and other high RAN liquids) will depend on:

1. Crop you apply it to and how the crop uses the nutrients
2. When you apply (spring or autumn)
3. Soil type you apply it to (and the soil depth in some cases)
4. How you apply it (e.g. surface, dribble bar, shallow injection) and whether it is ploughed down straight away.
5. Weather and soil conditions at spreading.

There are many instances in Scotland at present where the great majority of the N applied in digestates is being lost.....



High readily available N >30% total N (NVZs)

Readily available N (RAN) content of food-based digestate based on 250 kg N/ha

Readily Available N i.e. Ammonium-N, Nitrate-N, (Uric-N for poultry manures) by analysis - is *potentially* available for rapid crop uptake

Organic N is broken down slowly to become available over months or years

Crop Available N is the readily available N left for crop uptake after losses are taken into account

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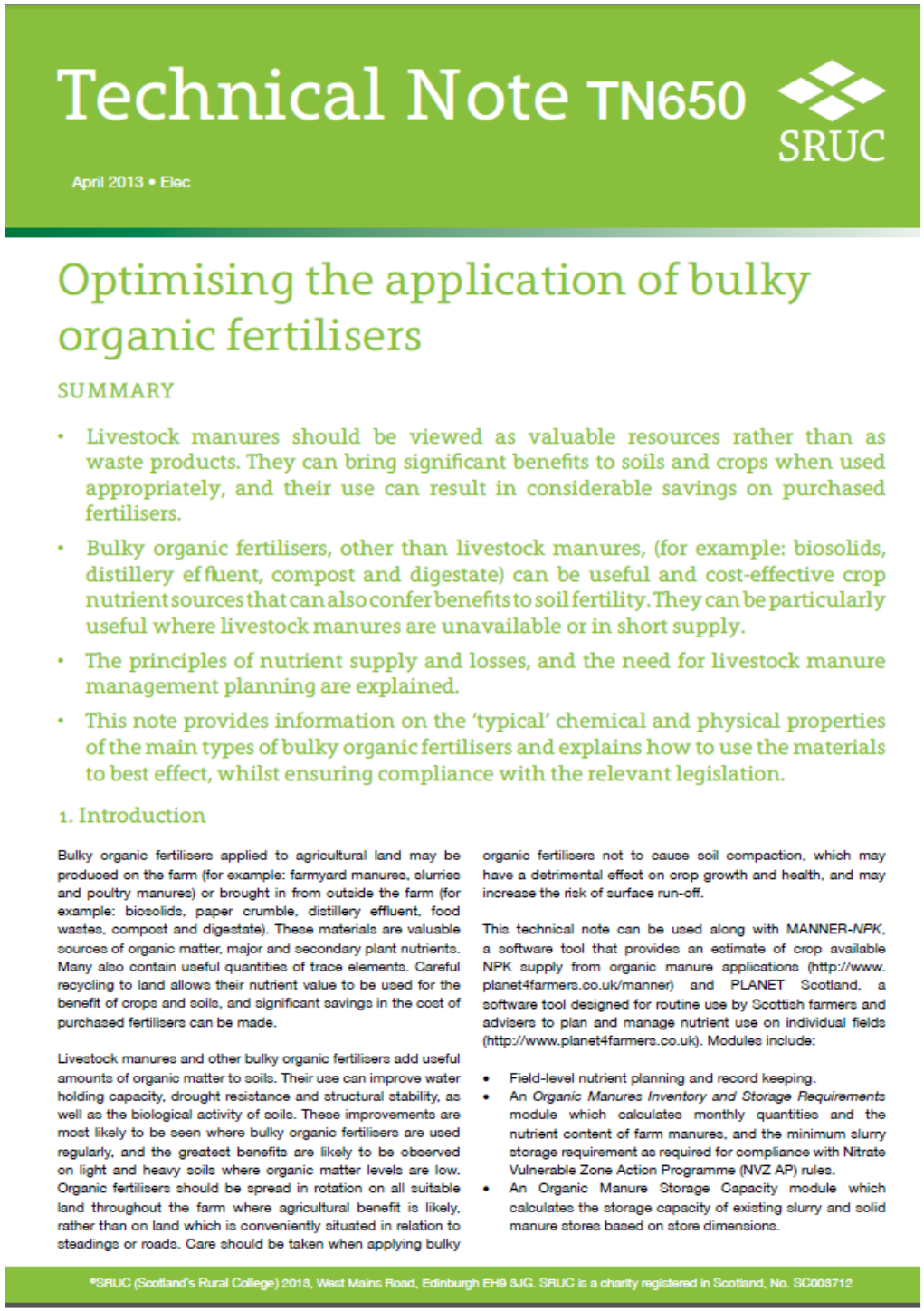
Need to calculate the crop-available N

- Location
- Rainfall
- Soil type, soil depth and drainage
- Timing of application (spring or autumn)
- Method of application (surface, dribble bar, injection and whether p loughed down
- Use MANNER NPK www.planet4farmers.co.uk/manner to calculate crop-available N.
- MUST comply with PEPFAA, Four Point Plan, CAR Regulations and the SEPA Position Statement “Regulation of outputs from Anaerobic Digestion Processes”.

Or if you prefer a more traditional method..... Use SRUC TN 650



Technical Note TN650

SRUC

April 2013 • Elec

Optimising the application of bulky organic fertilisers

SUMMARY

- Livestock manures should be viewed as valuable resources rather than as waste products. They can bring significant benefits to soils and crops when used appropriately, and their use can result in considerable savings on purchased fertilisers.
- Bulky organic fertilisers, other than livestock manures, (for example: biosolids, distillery effluent, compost and digestate) can be useful and cost-effective crop nutrient sources that can also confer benefits to soil fertility. They can be particularly useful where livestock manures are unavailable or in short supply.
- The principles of nutrient supply and losses, and the need for livestock manure management planning are explained.
- This note provides information on the 'typical' chemical and physical properties of the main types of bulky organic fertilisers and explains how to use the materials to best effect, whilst ensuring compliance with the relevant legislation.

1. Introduction

Bulky organic fertilisers applied to agricultural land may be produced on the farm (for example: farmyard manures, slurries and poultry manures) or brought in from outside the farm (for example: biosolids, paper crumble, distillery effluent, food wastes, compost and digestate). These materials are valuable sources of organic matter, major and secondary plant nutrients. Many also contain useful quantities of trace elements. Careful recycling to land allows their nutrient value to be used for the benefit of crops and soils, and significant savings in the cost of purchased fertilisers can be made.

Livestock manures and other bulky organic fertilisers add useful amounts of organic matter to soils. Their use can improve water holding capacity, drought resistance and structural stability, as well as the biological activity of soils. These improvements are most likely to be seen where bulky organic fertilisers are used regularly, and the greatest benefits are likely to be observed on light and heavy soils where organic matter levels are low. Organic fertilisers should be spread in rotation on all suitable land throughout the farm where agricultural benefit is likely, rather than on land which is conveniently situated in relation to steadings or roads. Care should be taken when applying bulky organic fertilisers not to cause soil compaction, which may have a detrimental effect on crop growth and health, and may increase the risk of surface run-off.

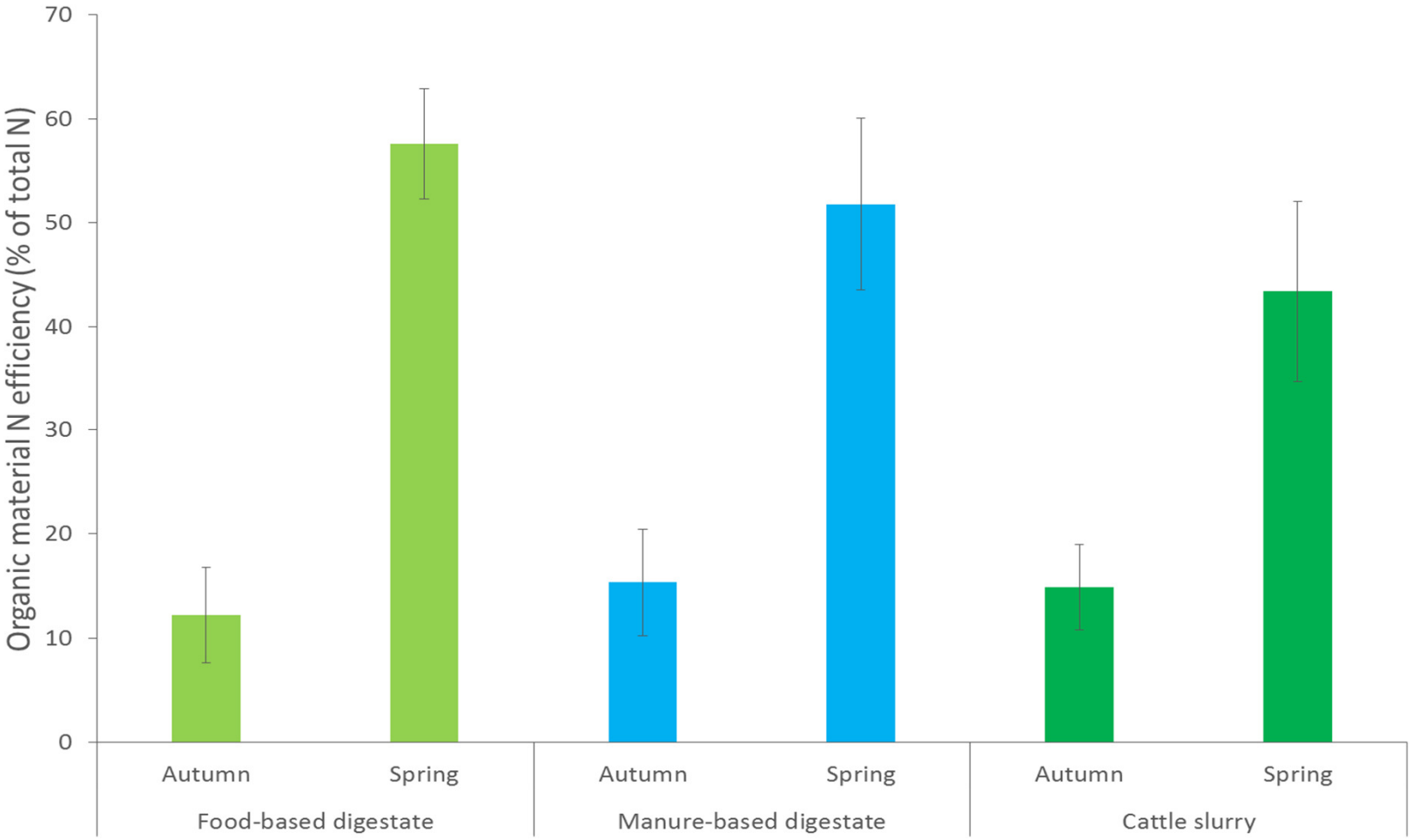
This technical note can be used along with MANNER-*NPK*, a software tool that provides an estimate of crop available NPK supply from organic manure applications (http://www.planet4farmers.co.uk/manner) and PLANET Scotland, a software tool designed for routine use by Scottish farmers and advisers to plan and manage nutrient use on individual fields (http://www.planet4farmers.co.uk). Modules include:

- Field-level nutrient planning and record keeping.
- An *Organic Manures Inventory and Storage Requirements* module which calculates monthly quantities and the nutrient content of farm manures, and the minimum slurry storage requirement as required for compliance with Nitrate Vulnerable Zone Action Programme (NVZ AP) rules.
- An Organic Manure Storage Capacity module which calculates the storage capacity of existing slurry and solid manure stores based on store dimensions.

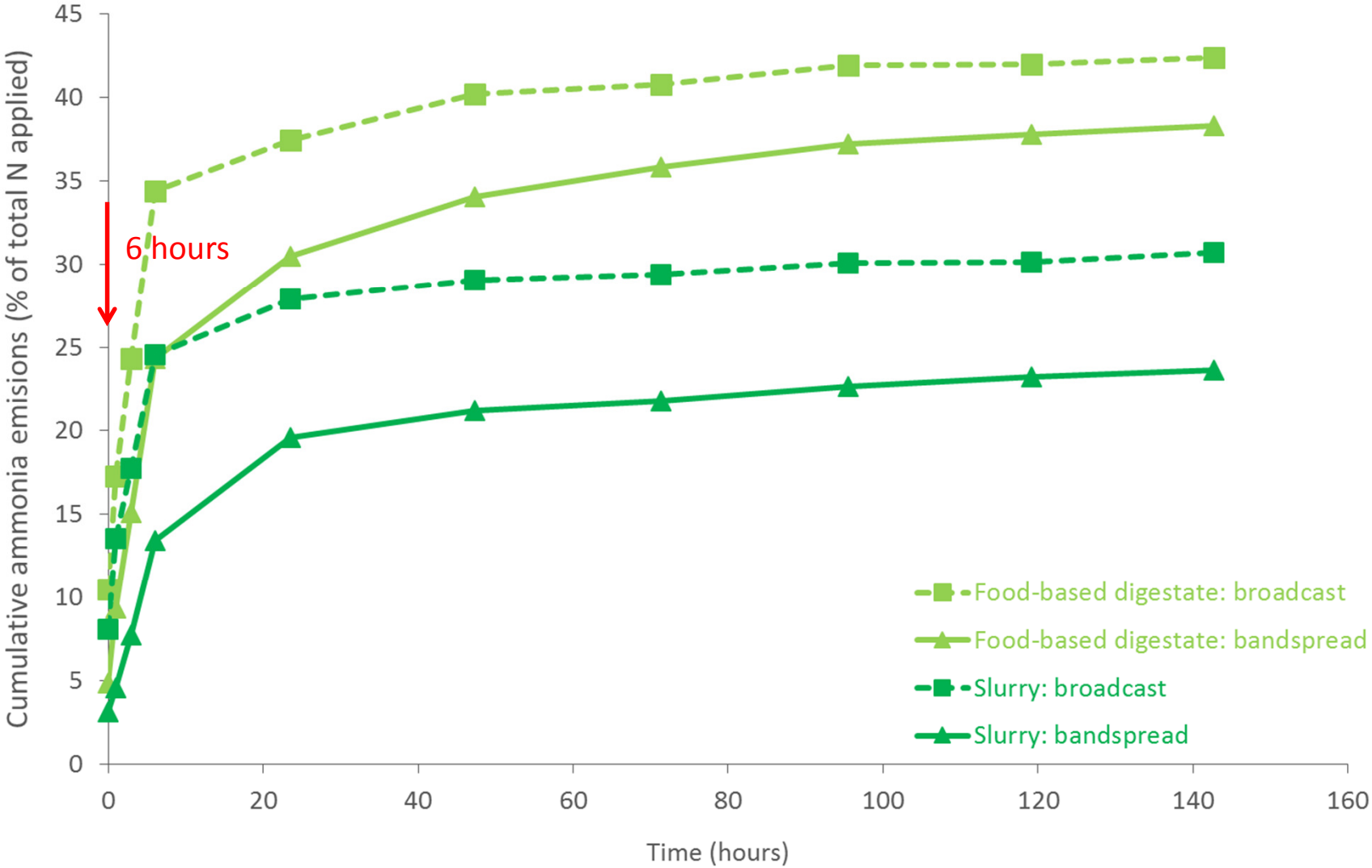
Field experiments for quality digestate and compost in agriculture 2010-2015

DC-*Agri*

WP2.1 – Overall cross-site N use efficiency



WP2.2. – Cross-site ammonia emission curve

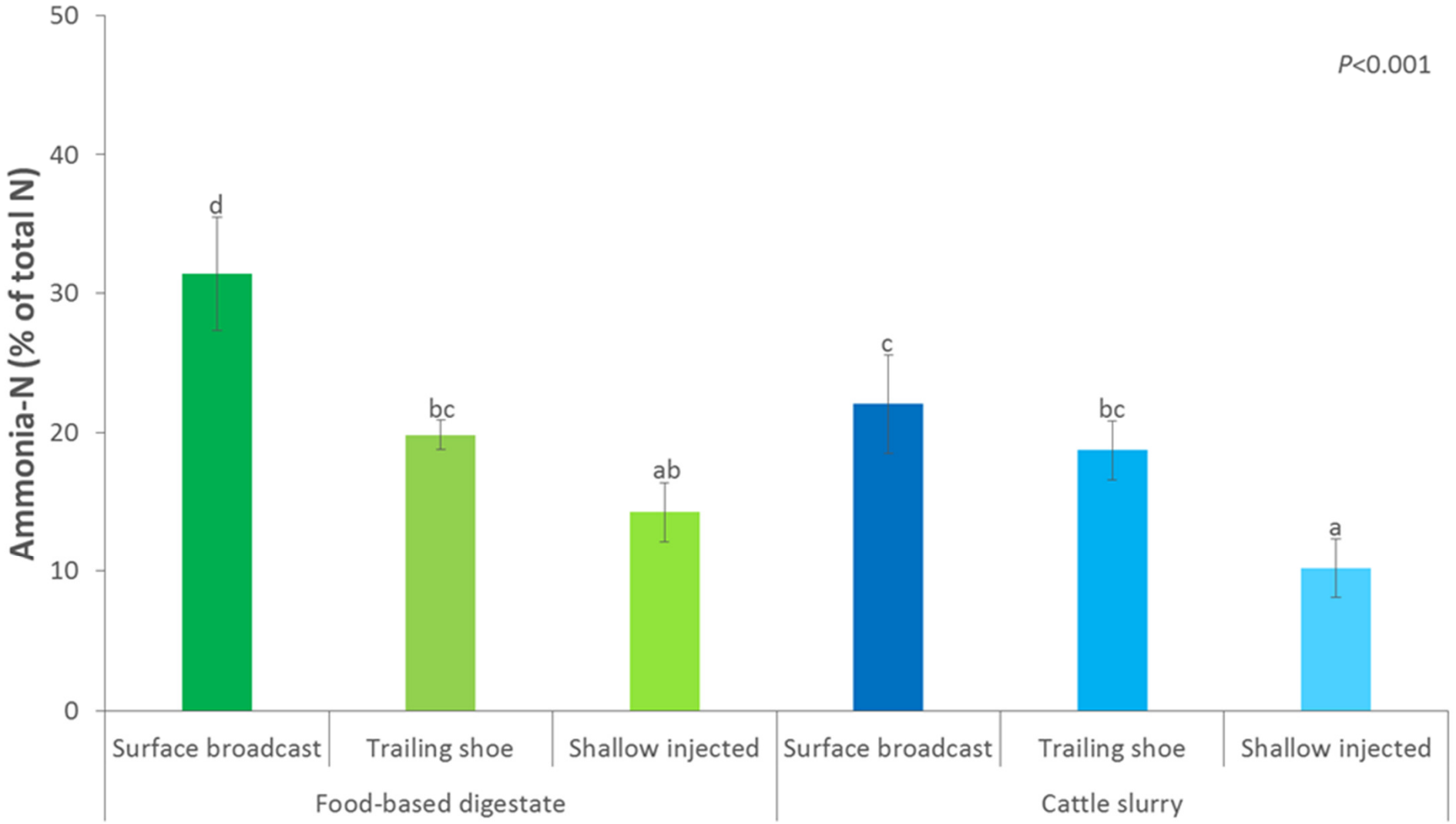


Broadcast application

Bandspread application (trailing shoe)

Shallow injection application

WP2.3 – Cross site ammonia emissions



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Example fertiliser calculation – Girrick dung
(soil nutrient indices at target, dung spread in spring)

Major Nutrients	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Saving on fertiliser costs (£)
Rotational grass Crop requirement (kg/ha)	300	62	212	
Total N, P and K supplied by 20 t/ha dung (kg/ha)	82	34	80	
Percentage counted	10	100	100	
Nutrients counted in the 20 t/ha dung (kg/ha)	8	34	80	
Bagged fertiliser needed (kg/ha)	292	28	132	
Total saving (year 1) Nutrients for following crops	£5.20 £5.20	£19.04	£32.80	£57.04
Based on Girrick dung, which contains 4.1 kg N, 1.7 kg phosphate and 4.0 kg potash/m^3. Based on fertiliser prices: N 65p/kg; phosphate 56p/kg; potash 41/kg				

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Example fertiliser calculation – whole digestate
(soil nutrient indices low, digestate spread in spring, dribble bar)

Major Nutrients	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Saving on fertiliser costs (£)
Winter wheat (8 t/ha) crop requirement (kg/ha)	220	70	120	
Total nutrients supplied by 2 x 20 m^3 digestate/ha (kg/ha)	120	16	100	
Percentage available in year 1	55	50	90	
Available nutrients supplied by 2 x 20 m^3 digestate/ha (kg/ha)	66	8	90	
Bagged fertiliser needed (kg/ha)	154	62	30	
Total saving (year 1) Nutrients for following crops	£42.90	£4.48 £4.48	£39.60 £4.10	£86.98 £8.58
Based on a digestate containing 3 kg N, 0.4 kg phosphate and 2.5 kg potash/m^3. Based on fertiliser prices: N 65p/kg; phosphate 56p/kg; potash 41p/kg				

Conclusions

- Whole digestates are excellent fertilisers, but.....
- They typically contain a high percentage of RAN and must therefore be stored and applied with great care.
- They are also typically heavy in relation to their nutrient values, therefore consideration should be given as to whether to separate or extract the nutrients for easier storage and application and to reduce haulage/spreading costs.
- Whole, separated and fibre digestates vary widely in their nutritional value. Test those digestates available to you regularly!
- We need to know more about potential deleterious effects of using whole digestates on soil structure, soil organic matter content and soil biology.

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THANKYOU!

Audrey Litterick
audrey@earthcaretechnical.co.uk

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Soil respiration

A measure of soil biological activity

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What can soil respiration tell us?

Respiration measurements indicate:

- Biological activity in soil
- Nutrient mineralization
- Toxicity of chemicals to soil organisms
- Management effects

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Plant roots contribute to soil respiration

Collars located at 5 m intervals along transect from bare soil (BS) into maize (M)

Transect Location	Crop	21st May μmol CO_2 m^{-2} s^{-1}	27th May μmol CO_2 m^{-2} s^{-1}
1	BS	1.84	1.42
2	BS	1.45	1.14
3	BS	1.05	1.34
4	BS	0.78	0.81
5	BS	5.54	1.52
6	BS	0.74	1.18
7	BS	0.78	0.72
8	M	8.41	8.66
9	M	2.34	2.65
10	M	7.96	8.16
11	M	2.92	2.75
12	M	3.67	3.25
13	M	4.94	3.16

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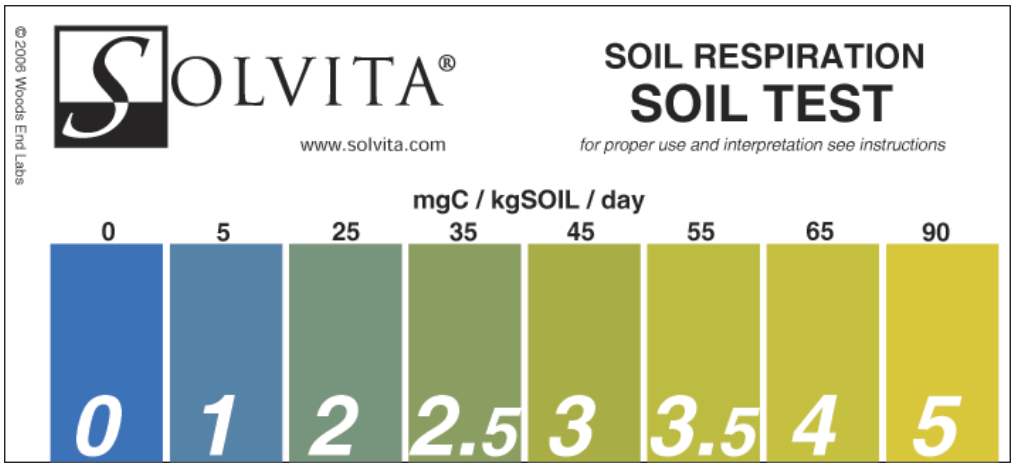
Solvita® Soil Respiration Test

- First generation Solvita test
- Standard volume of soil
- Visual color chart system
- USDA Soil Quality Indicator



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Interpretation of Solvita results

No biological activity - give up!
Very low biological activity - suggest 40t/ha compost
Low biological activity - suggest 30t/ha compost
Near optimum biological activity - suggest 20t/ha compost
Optimum biological activity - suggest 4t/ha
Very high biological activity - ease off on the compost!

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Solvita® 2nd Generation

- Focus on drying-rewetting CO_2 burst
- Standardized moistening method
- Digital Colour Reader (DCR) for accuracy
- Validated by USDA

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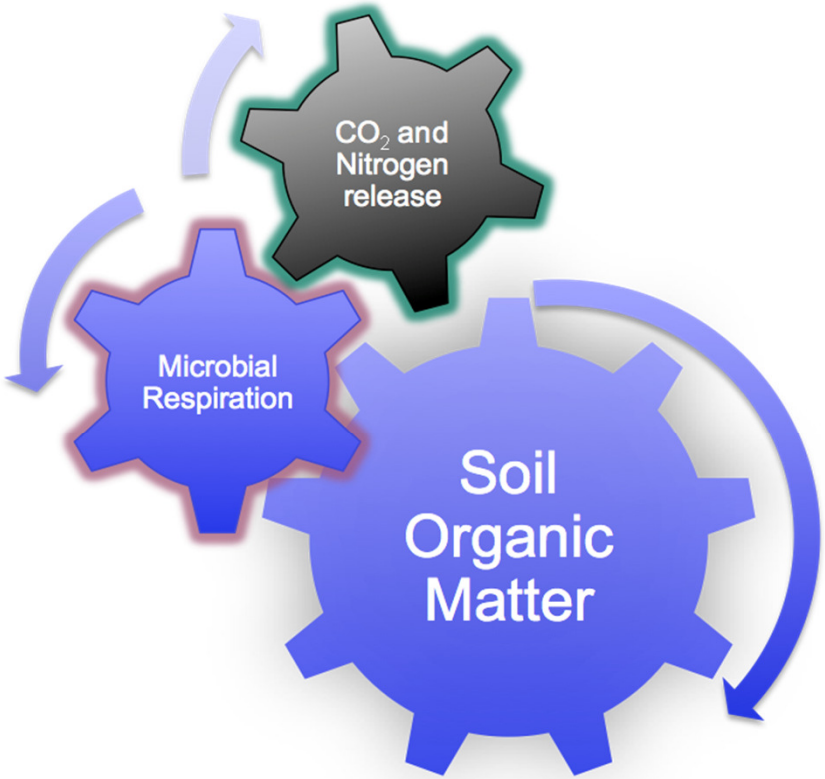
The Basic Concept: Linking CO_2 and N release



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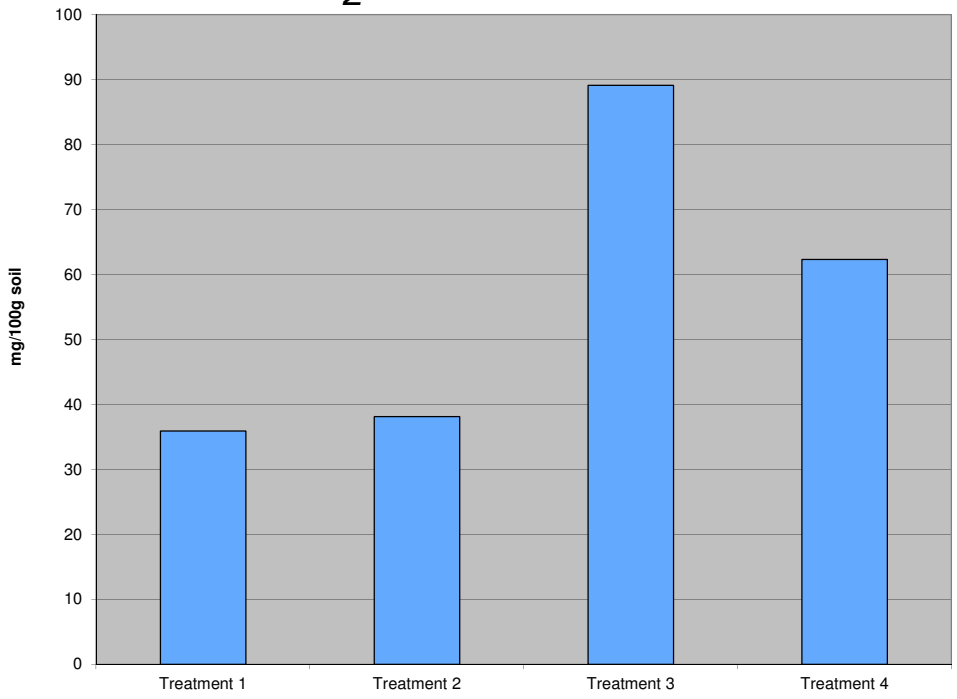
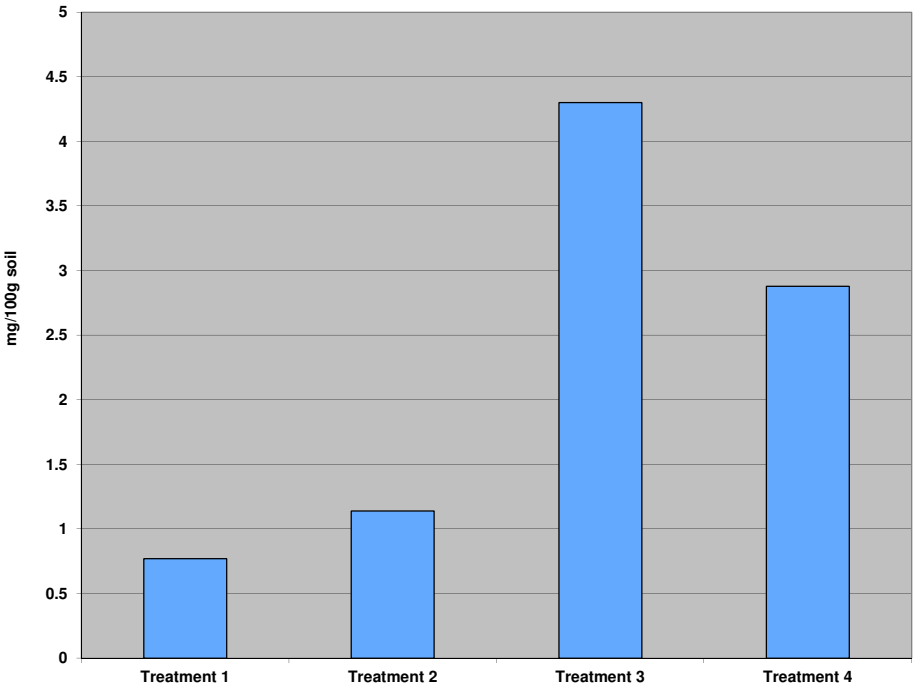
Respiration and N release

Effect of fumigants on a silt loam (Rothamsted, UK)

CO_2 Production



N Mineralization



Jenkinson and Powlson (1970)

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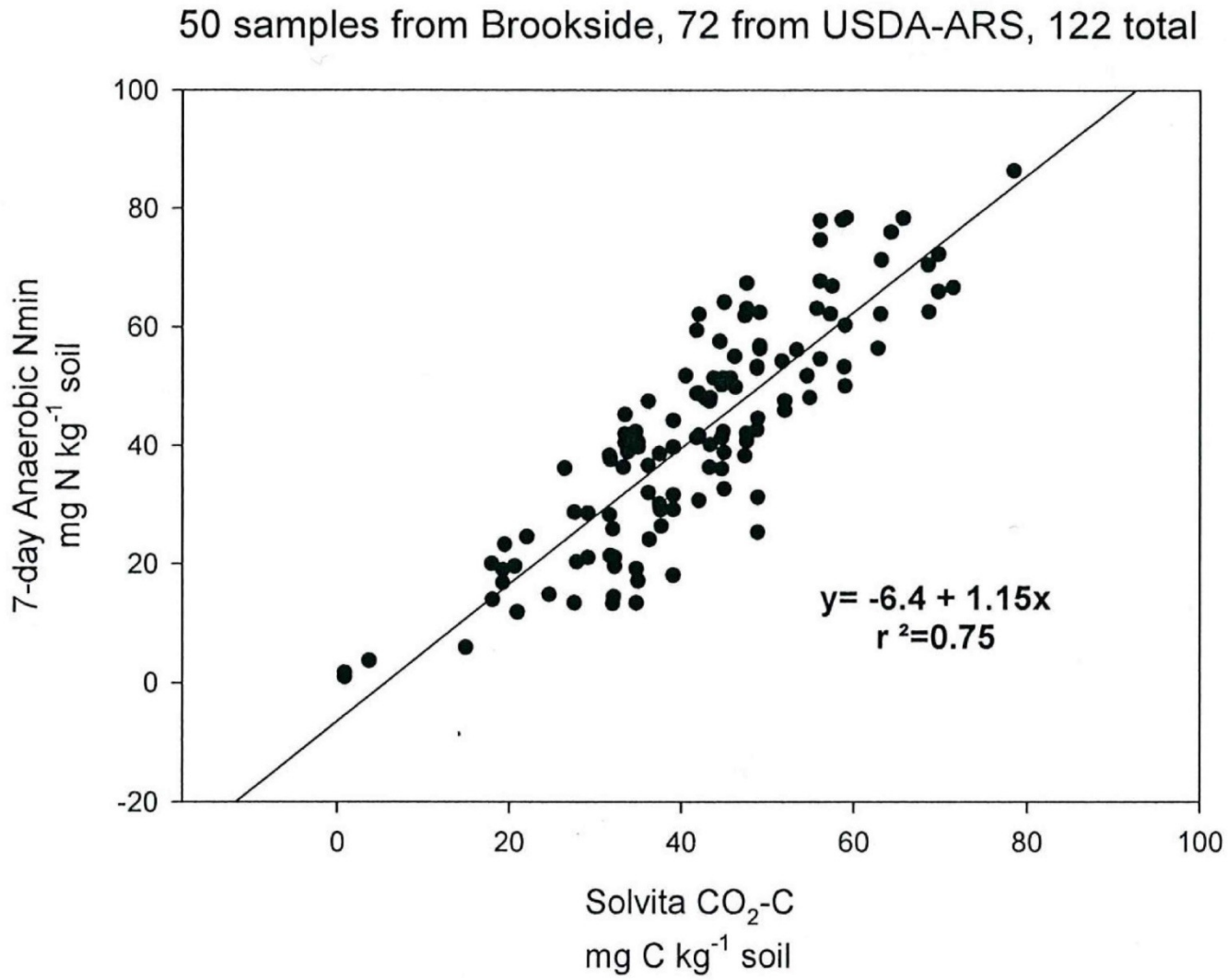
N min correlates with Solvita CO_2 burst



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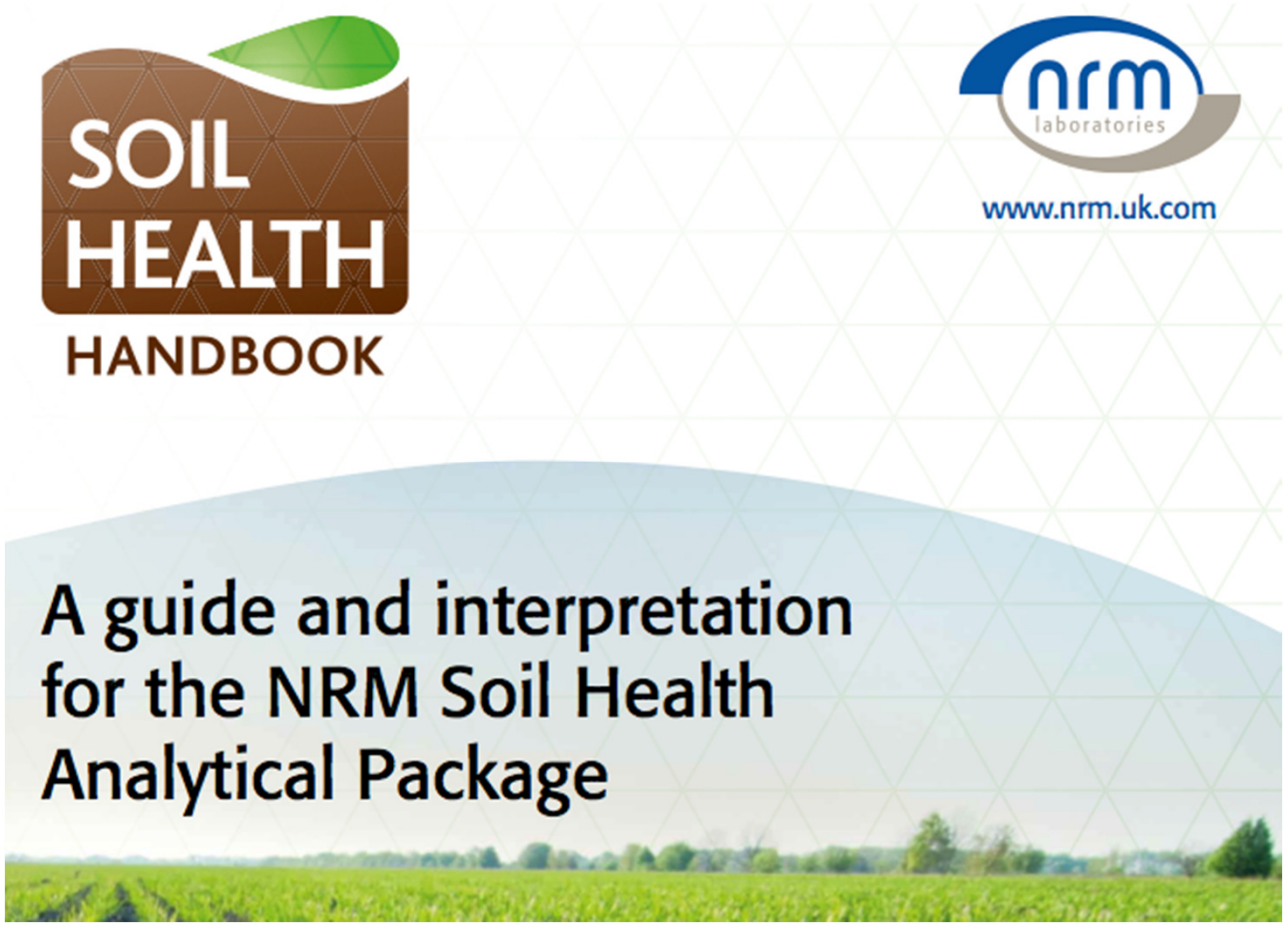
NRM Soil Health Analysis Package

Incorporates CO_2 burst test



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Soil Health - a definition

- The terms ‘soil quality’ and ‘soil health’ are often used interchangeably.
- Soil health = capacity of soil to function as a vital living system.
- Soil health is the preferred term - idea of soil as living dynamic organism that functions in a holistic way depending upon its condition or state. (Doran et al, 1996)

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Symptoms of poor soil structure

- Solid soil with little porosity (few holes)
- Horizontal cracking in the soil (platiness)
- Roots travelling horizontally
- Roots mainly down cracks and earthworm channels
- Layers of wetness in soil held up by compaction
- Unpleasant odour as crop remains rot in wet soil

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Consequences of poor soil structure

- Reduced infiltration of water leading to runoff and erosion pollution
- EU estimates cost of erosion €0.7 – 14.0 billion; organic matter decline €3.4 – 5.6 billion
- Capping of soil leading to slow emergence of seedlings, poor infiltration of water, poor incorporation of agrochemicals, runoff and erosion.