Field Lab: Less Toil, Better Soil

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Management Options

1. pH - getting the basics right
2. Cultivation – damage limitation
3. Organic manures - compost and digestate
4. Mulches (improved water use and nitrogen use efficiency)
5. Rotation
6. Green manures (including use of legumes and mixed planting)

What are your challenges?

- Increased weight of machinery
- Increased frequency of tillage
- Moving to reduced or no tillage
- Demand for increased work rates.
- Ability to work soils at sub-optimal moisture levels.
- Low and reducing nutrient content (of the produce)

Market Pressures

- Higher product specification (more frequent harvest).
- Expectation of higher marketable yield (less room for waste or “growing for insurance”)
- Supply throughout an extended season?
- More specialised production (limited rotation)

Your experience?

How do we measure Soil?
It's ability to sustain high yield, reliably?
Healthy plant growth?
Nutrient content?
Trafficability?
Workability?

Physical measurement
Crop performance
Rooting depth
Compaction
Water infiltration
Visual Assessment
Aggregate stability

Identify desirable characteristics, measure, monitor and set clear long term objectives.
AHDB Visual assessment methods

Compaction

Subsoiling not as effective as perceived by growers.

Yield loss due to:

Lack of rooting depth (root impedance)

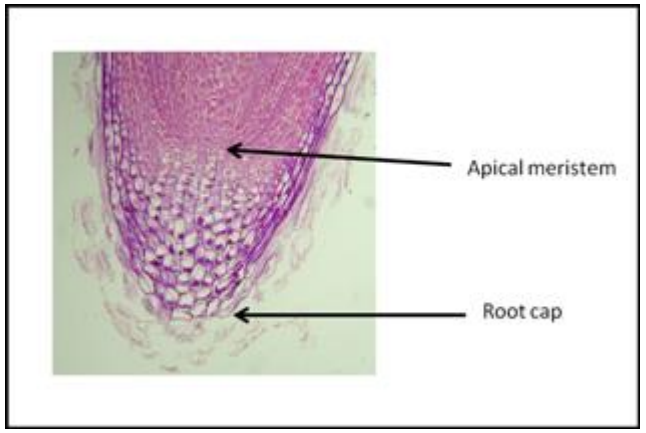
Lack of root spread

Poor aeration. Risking anaerobicity, limiting rate of respiration, potential acidification.

Lack of water reserve (poor infiltration limiting water at depth.)

Potential denitrification

Cause?



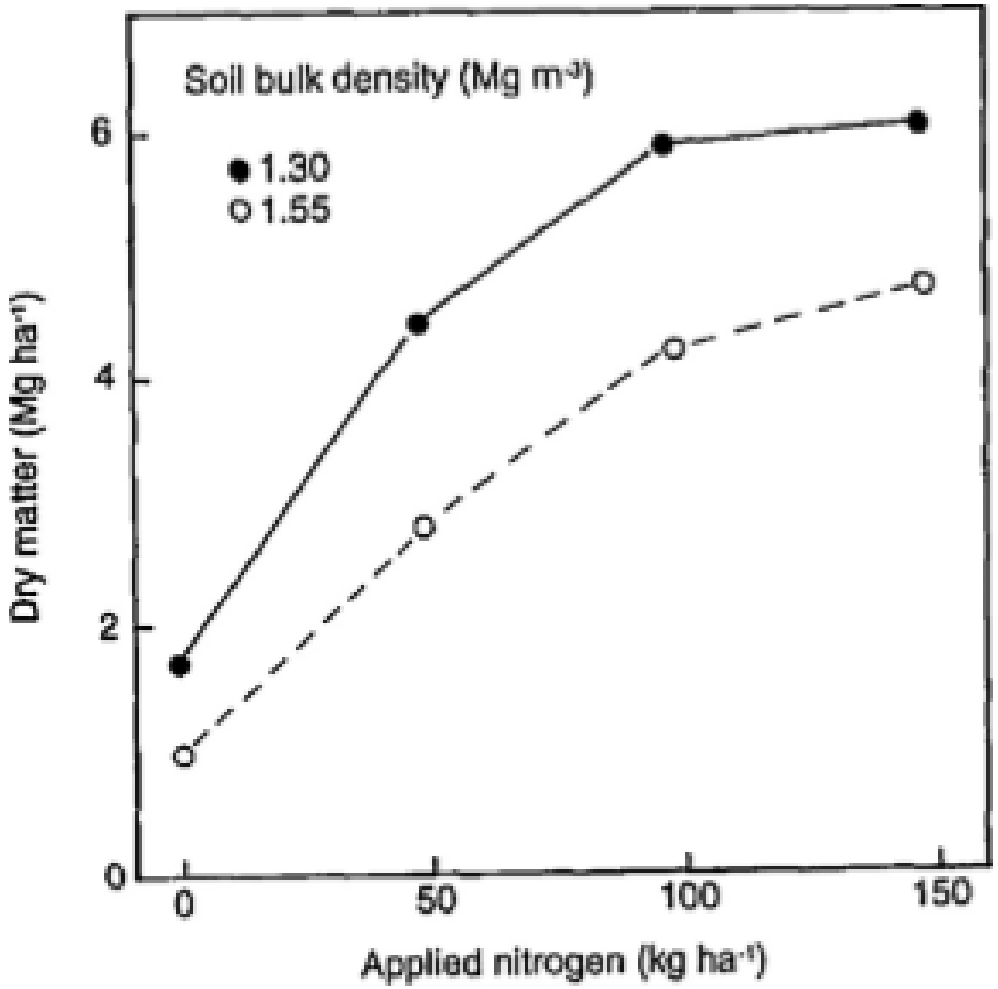


Fig. 7. The relationship between the amount of N applied and crop yield under different compaction regimes. A compacted soil (i.e. 1.55 Mg m^{-3}) may require more N to obtain similar yield to a non-compacted soil (i.e. 1.30 Mg m^{-3}). From (Soane and van Ouwerkerk, 1995).

Soil Physical Characteristics

Low ground pressure vehicles are a good way to prevent damage to top-soils, but may not protect sub-soils from the effect of compaction.

The benefit of subsoiling may be limited to improved infiltration and porosity, but only when carried out extremely carefully both during and in subsequent operations. (Said 2003. Effect of tillage implements on the state of compaction in different soils. J Soil Sci., 43, 91-107)

(Andrew Sutton, Huntapac)

Protecting Physical Characteristics

Controlled Traffic -

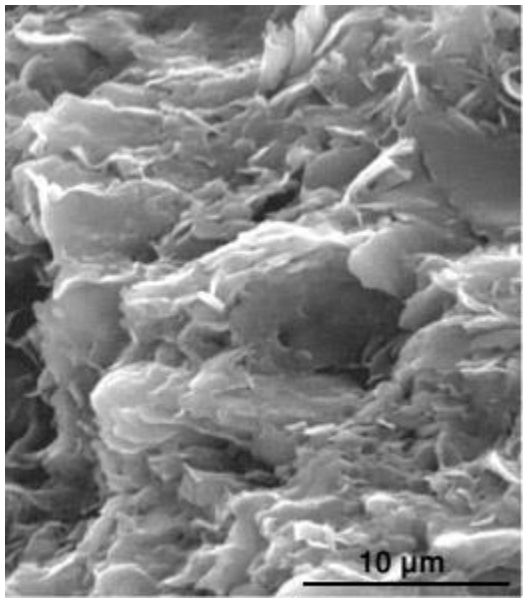
- Difficult to achieve in veg. production
- Mis-match of machinery axel width particularly between different crops
- Significant investment required

But, evidence of:

- Improved soil conditions (infiltration, pore space/size, penetration)
- Reduced inputs.
- Fewer tillage operations required.
- Improved productivity.

(Photo: Great Soils, Huntapac – pre-visit)

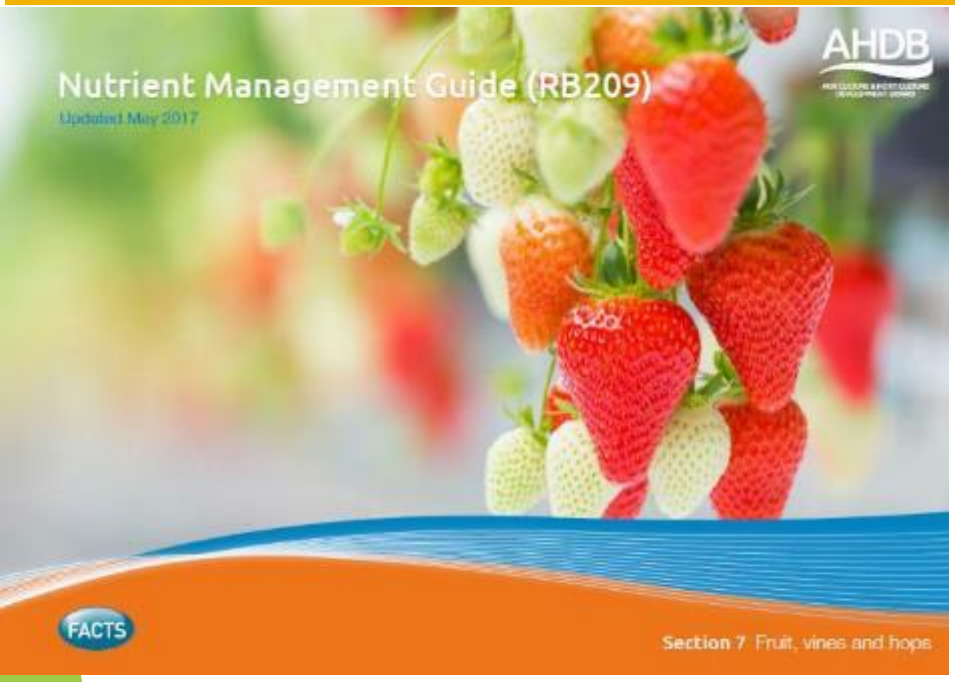
(J.E. McPhee. Effect of controlled traffic on soil physical properties and tillage requirements for vegetable production. Soil Till Res. June 2015)



Physical Characteristics
Possible role for Gypsum in Clay Soils

- Studies that suggest gypsum has an impact on soil physical properties, including soil flocculation, impacting aggregate size and stability.
- A study by Lebron et al. (2002) found that soil aggregate break down was prevented by the incorporation of gypsum in the soil.
- There was a direct correlation between the amount of gypsum added and aggregate stability.

- "Innovative Farmers" research is currently investigating this, with initial samples taken and gypsum applications about to be made.
- Follow this investigation and others on-line.



Soil Chemistry

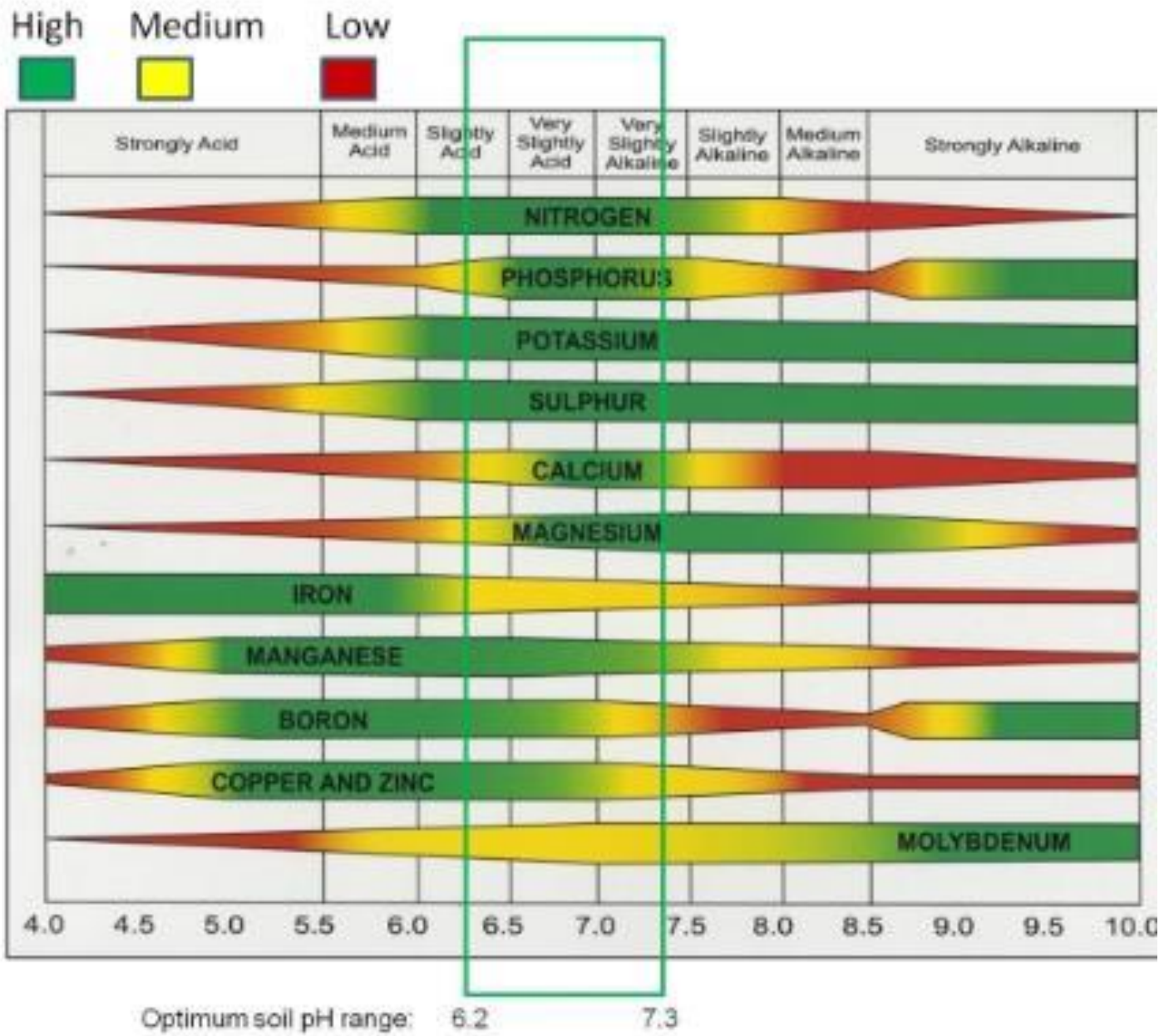
Standard Lab tests
Macro Nutrient content
Micro Nutrient content
RB209 Recommendations

Perhaps a more familiar part of soil management?

But are we using all the tools where appropriate?

Assessing soil Nitrogen supply accurately?
Accounting for winter rainfall?
More frequent testing on light soils?
Relating applications to product price and quality?
Adjusting for expected yield?
Using plant tissue analysis for more accurate estimation?

How soil pH affects availability of plant nutrients



aglime.org.uk

Log Scale

Planet Permaculture

Soil ph how to measure and manage it based on an understanding of soil texture

Case Study by Dr Audrey Litterick, Earthcare Technical

Action points for farmers and growers

• Know the texture and type of soils on your holding

• Test your soil pH regularly (at least once every four years and ideally once every two years … interpret the results correctly for your own soil types

• Choose an appropriate sampling strategy … and be prepared to spend money on more samples where you find evidence that soil pH could be impacting on crop yield or where you suspect big differences in soil pH within fields

• Be aware that some organic materials applied to improve soil health … have a liming (or neutralising) value. It is easy to test for

• Be aware of the differences between different types of liming agents and their relative advantages and disadvantages.

As well as bearing in mind price, choose those appropriate for your own soil.

Martin Evans
Fresh Growers Ltd.

Fine tuning nutrient provision Case Study by Dr Martin Wood (Earthcare Technical) as part of the GREAT Soils programme for AHDB

Taking a fresh look at soil testing for carrot production

- High P – index 5!
- Low Ca – but need low pH for potatoes!
- Low organic matter 2.5%
- Low clay content 7%

Action points

Soil tests and the recommendations associated with them are an important tool but they need to be used by farmers and advisors along with other information to make the best decision on how much fertiliser or other amendments to apply to a particular crop in a particular field in a particular year. So it's important to use **common sense** when interpreting soil test results (Magdoff and van Es, 2009)

- Yearly soil testing can be useful for intensive vegetable production on light soils
- Analysing for additional nutrients as well as the standard nutrient analysis can indicate further requirements for fertilisers
- The balance of nutrients can be important for intensive vegetable production on light soils.

Soil Biology

The area of greatest development in our understanding?
Still much to learn

Microorganisms perform a variety of functions, including:

- soil stability (aggregate formation)
- decomposition of organic matter
- nutrient cycling
- nutrient uptake by plants
- disease suppression
- plant growth promotion
- production of antibiotics and hormones
- toxin breakdown (pesticides, pollutants)

Symphony of the Soil

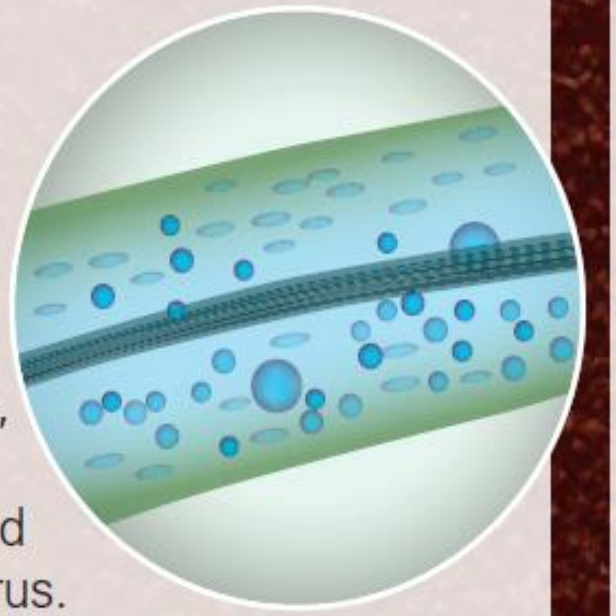
Soil (Biological) Health Testing

This can include respiration rate, species number, type and composition, soil organic matter.

An introduction to soil biology AHDB

Mycorrhizal fungi

Ectomycorrhizal fungi form a sheath around the root, extending the volume of soil that can be 'tapped' for nutrients.



Arbuscular mycorrhizal fungi form associations with most plant species, and live within the root tissue itself. Benefits to the plant include improved nutrient uptake, particularly phosphorus.

Induced systemic resistance

Defence responses to foliar pathogens can also be triggered by root-associated microorganisms.

Nitrogen-fixing rhizobia

Bacteria that associate with the roots of leguminous plants fix atmospheric nitrogen into a form that is useable by the plant.

Plant growth-promoting rhizobacteria (PGPR)

PGPRs are bacteria that colonise plant roots and benefit plants through mechanisms such as suppression of plant disease, production of antibiotics, improved nutrient acquisition, or phytohormone production.

Importance of Earthworms Contribute to

- Soil structure formation
- Soil porosity
- Water infiltration
- Organic matter incorporation
- Nutrient cycling
- Aeration
- Rooting depth

Earthworms are uncommon in

- Water logged soils
- Compacted soils
- Extremes of pH

An introduction to earthworms

The very deep burrowing anecic worms are uncommon in intensively cultivated soils.

Further research is taking place as part of Innovative Farmers

Higher levels of Organic matter are associated with:

- Nutrient holding capacity
- (Cation Exchange Capacity)
- Water retention and infiltration
- Structural stability
- Trafficability
- Easier working

Compost is Good News for Soil Health

Case Study. Dr Audrey Litterick, Earthcare Technical

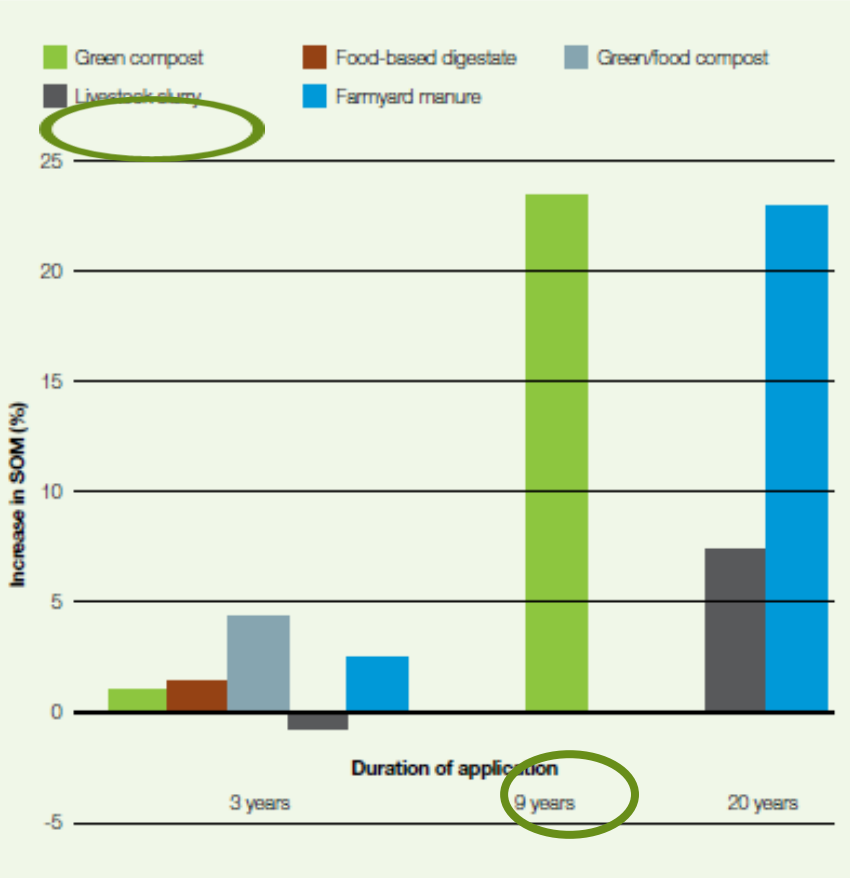


Figure 3. Increases in soil organic matter following continuous application of different organic materials for 3, 9 and 20 years (relative to an untreated control)

Action points

- Aim to increase your Soil Organic Matter levels, as this can have multiple benefits for soil health.

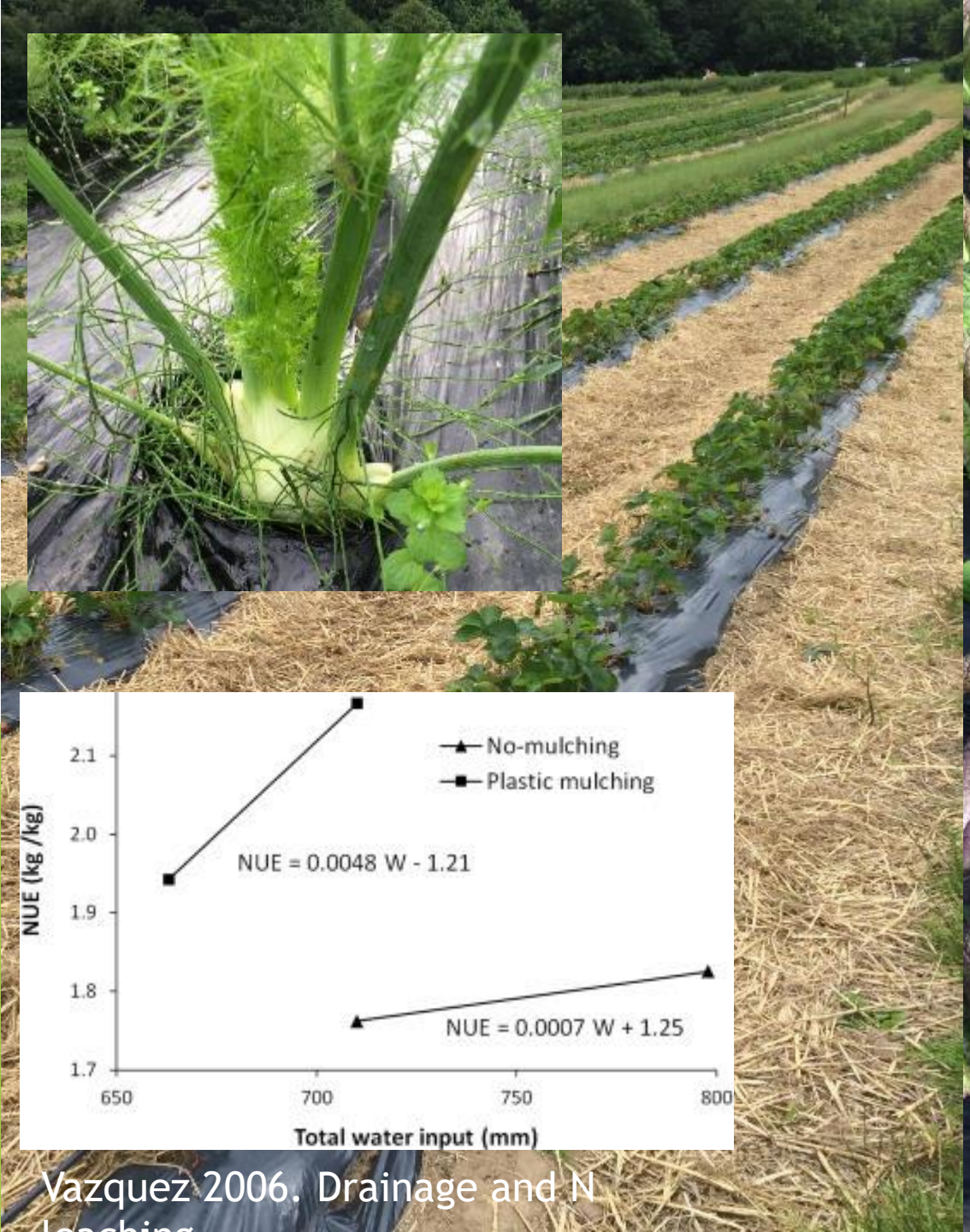
In trials, compost increased organic matter in half the time of farmyard manure.

- Check guidelines before using compost.

Most UK farm assurance schemes now permit the use of quality PAS 100 composts, as do most produce buyers

- Determine if adding compost to your soil is cost-effective
- Soil quality and yield benefits can take several years to improve

Nearby compost suppliers can be found at: qualitycompost.org.uk



Vazquez 2006. Drainage and N leaching

Attempts to provide moisture retention, weed suppression and nitrogen mineralisation.
Increased soil temperature (N use efficiency)
Increased area capability
Reduced weed viability. (Mare's Tail)

Inter-row crop of late season brassica, mizuna, mibuna, pak choi.
Ground cover.
Additional transpiration when rainfall is likely to exceed requirement.
Nutrient recovery?
Additional financial return largely within an extended rotation.

Trying to diversify crops and find more winter cover

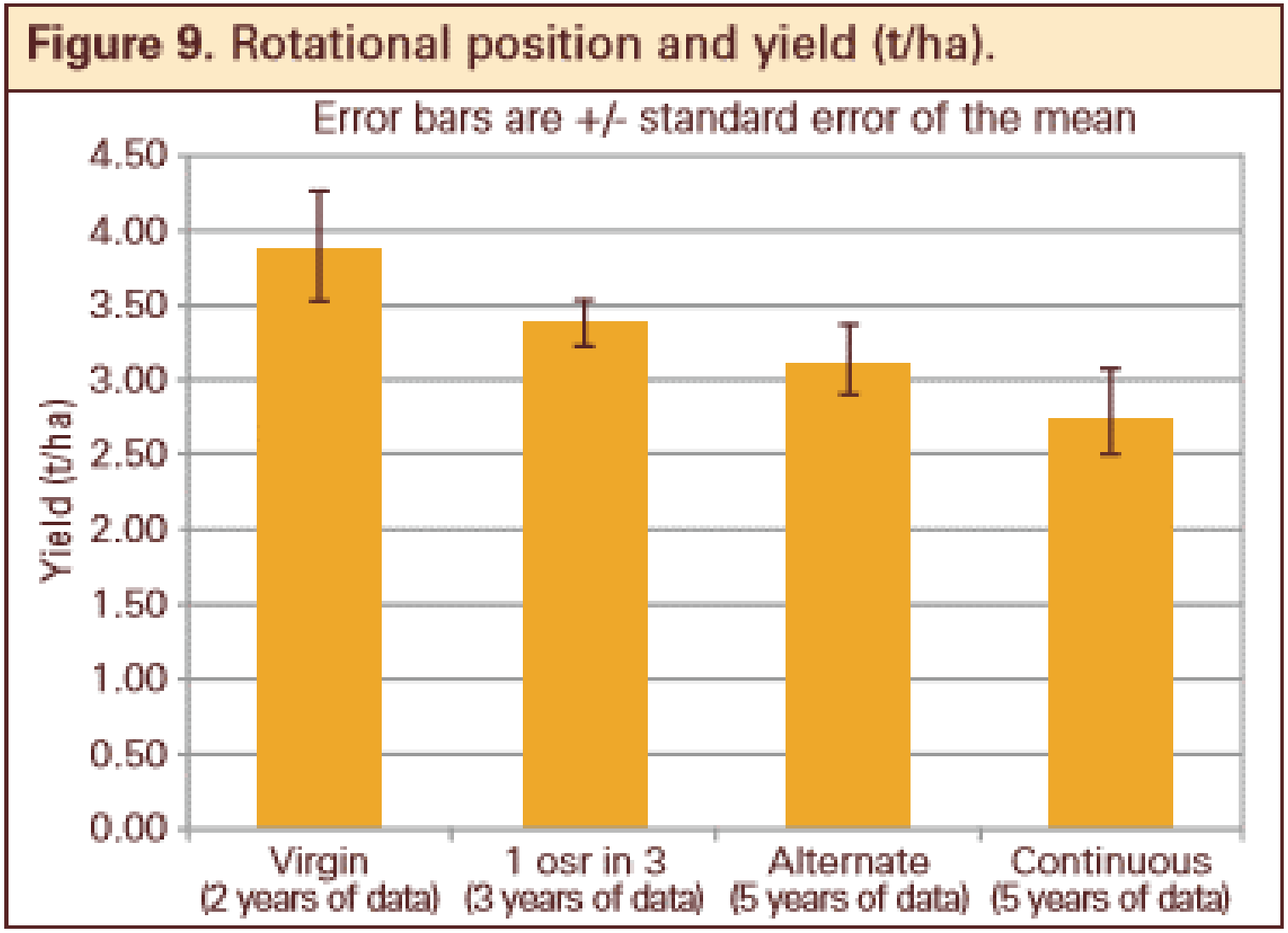
Winter purslane (thug!)
Japanese brassica.
Sorrels. E.g. Red veined

Diversifying the rotation

- Using soil improving crops/ecosystem services…but income loss
- Or…something with a market?
- More diverse rotations are associated with increased yields

Effect of Crop Rotation on Yield in Oil Seed Rape

Figure 9. Rotational position and yield (t/ha).



Oilseed rape Growth Guide AHDB 2015

Effect of Green Manures

- Maintain soil cover
- **Maintain transpiration rate** (water cycle)
- **Interception of rainfall?**
- Reduce soil erosion
- Prevent soil compaction
- Contribute to soil organic matter
- **Protect/maintain plant available nutrients**
- Prevent nutrient leaching
- **Can contribute to Nitrogen retention and production**

Combinations of cover crops can
Increase the N-use of the non-legume

- Improve N-use efficiency
- Improve the C:N ratio of the cover crop on incorporation.

(Giacombo T., Green manuring effect of pure and mixed barley. European Journal of Agronomy. Vol 43, Nov 2012, pg 136-146)

Grazing Rye *(Secale Cereale)*

Domesticated 3000-4000 BC.
Prefers well-drained sandy loams
Frost hardy after establishment
pH range 5.6-6.5
Sown Sept-Oct.
Higher rates of Nitrogen absorbed when sown with a legume.
Very **deep rooted** under the right conditions 1.5m
Grows very high, 1.5m in full season – normally grown as a winter cover crop.

Incorporated March-April

Hairy Vetch *(Vicia Villosa)*

Rapid cover and large amounts of N to the soil.
Height 30-70cm, higher if supported.
Prone to lodging if not supported
pH 6-7.5
Fast growing legume
Very high yielding
Cannot withstand water logging
Some toxicity to livestock – though widely grown!
Allelopathic
Hairy vetch improves biological activity in the soil.
It is a P scavenger and reduces excess P in the soil
A very good source of pollen and nectar for honey bees

Berseem (Egyptian) Clover

Prefers moist alkaline soils. pH 6.5-8
Not suited to acidic or poorly structured soils.
TGW 3.17g (higher than most)
Can be autumn sown
Frost hardy down to -6, -15 for some.
Can grow in high rainfall 550-750mm.
Can cope with short periods of drought and waterlogging.
Increasingly used in no-till UK systems
(E.g. BASE-UK members in Co. Durham)
Attracting interest from organic growers
Height: 30-80cm
Fast growing

Crimson Clover (*Trifolium Incarnatum)*

Sown at 15Kg/Ha. 15000g/10,000m^2 = 1.5g/m^2
Versatile, prefers neutral/acid well drained soils, but not alkaline.
Reasonable weed control from dense early spring growth
Sociable! (Mixes well)
Cut above 8cm, not before 10-15cm
Short lived annual – dies after seeding in July/August
Becomes sparse cover at flowering, reaching around 70cm high, hence low total dry matter yield.
Nitrogen fixing: Approx 100Kg N/Ha
Red clover diseases: Sitonia weevil and downy mildew.
But a different stem nematode.

Photo: Jean Tosti)

Persian Clover ***(Trifolium Resupinatum)***

Annual plant

Sowing rate 10Kg/Ha=1g/m² March-May

Some claim it is slow to establish and grow at low temperatures, ideally spring sown.

(But fastest of all in Hollanders expt!

High emergence at day 5, full at day 8 and highest growth rate, 16g/day/m²)

Develops rapidly after establishment

Shorter growing period than most

Height: 60-70cm (mow at 30cm)

Used widely as an intercrop (rice, cereals)

Attracts beneficial insects (aphid predators)

Short lived, more persistent than Crimson – senescence from 75 days after sowing (DAS)

Frost resistant

Pictures: Leo Mitchels

Phacelia (*Phacelia Tanacetifolia)*

Family: Boraginaceae (Forget-me-not)

Includes Comfrey and Borage

Seed rate 10Kg/Ha

Rapid establishment

Normally spring sown (Not frost hardy)

Deeply rooted

Can become very stemmy, slow to decompose.

Not a brassica, unrelated to most other crops, so can be used to control Club Root

Can contribute to controlling soil erosion

Attracts pollinators

Discourages flea beetle (kings crops)

Can become a problem weed in following crops

Other Green Manures

Chicory: Potassium uptake of 95Kg/Ha/yr (3 yr trial)
Also high levels of boron, Mn, Mo and Zn.
Buckwheat: Increase phosphate mobility by exudation of organic acids
Lupins: Phosphate uptake ten times that of wheat. (1 study)
Cruciferous crops (forage rape, fodder radish) Prevent leaching of sulphur.

Green Manure as a weed control?

- Mechanical weed control is not always effective
- Weed control can be problematic in low-input systems
- Mechanical control can cause damage to soil structure
- **Exposed soils can be more easily eroded**
- Strong dependency on weather conditions
- Removing weeds manually is limited by labour availability and is costly

Green manure research summary

- Strong correlation between early ground cover and nitrogen fixation
- Small seeded varieties are more vulnerable to poor establishment conditions
- Early leaf area development, early leaf height and final height are all associated with weed suppression, but also with yield limitation of the main crop

Persian clover was the stand-out fastest to emerge and attain:

- 50% cover 41 days after sowing and…
- Complete ground cover (57 days) well before other species.

Clover as a cover crop for weed suppression in an intercropping design. Characteristics of several clover species. N.G. den Hollander ∗, L. Bastiaans, M.J. Kropff. European Journal of Agronomy 26 (2007) 92-103

Direction of travel?

Strip tillage in White Clover

Placement of fertiliser

Liquid fertiliser (phosphorus)

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https://www.feedipedia.org/node/243
Abigail Saunders MSc Project Proposal. Principle Supervisor Dr Julia Cooper, Univ. Newcastle.

Earthworm communities in arable fields and restored field margins, as related to management practices and surrounding landscape diversity
Joana Frazãoa et al. Agriculture, Ecosystems and the Environment 248 (2017) 1-8.

AHDB Green Manures – Effects on Soil Nutrient Management and Soil Physical and Biological Properties

AHDB Green Manures – Species Selection

AHDB Implications of economic and environmental benefits on rotational management

Clover as a cover crop for weed suppression in an intercropping design. Characteristics of several clover species. N.G. den Hollander ∗, L. Bastiaans, M.J. Kropff. European Journal of Agronomy 26 (2007) 92-103

Robert Rosa
THE STRUCTURE AND YIELD LEVEL OF SWEET CORN DEPENDING ON THE TYPE OF WINTER CATCH CROPS AND WEED CONTROL METHOD
Journal of Ecological Engineering, Volume 15, No. 4, Oct. 2014, pages 118–130

Photographs: GO Local CSA, Ovington, Northumberland
Keenan. Compost processing

Manure-based biogas fermentation residues e Friend or foe of soil fertility?

Heribert Insam [a, *], María Gomez-Brandon [a], Judith Ascher [a, b]