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Land and Crop Rotation Management for Improved Soil Health
Overview

- What makes a healthy functional soil
- Soil biomes
- Links to structure and nutrients
- Organic Matter and Cover Crops
- Frontier Demo Site work
Soil Health

What is it and why does it matter?
Why does Soil Health matter?

• Sustainable farming systems –
  – Economical
  – Environmental
  – Future
• Healthy soils are the foundation of all farming
• Legislative changes
Soil Health

- Balance between Physical, Chemical and Biological properties
- Basis for healthy and resilient crops
  - Rooting – structure and aeration
  - Water and nutrient uptake and management
  - Plant health
  - ...
Soil Life – from visible to microscopic
Biological Properties

- Macrofauna
- Microfauna
- Microorganisms
- Roots
- Biological activity
- Organic matter
Soil Biology - Microorganisms

Microorganisms

• Bacteria, fungi, viruses…
• Vast variety of functions, including:
  – Soil stability – aggregate formation
  – Decomposition of OM
  – Nutrient cycling
  – Nutrient uptake by plants
  – Disease suppression
  – Induced systemic resistance
  – Plant growth promotion
  – Production of antibiotics and hormones
  – Toxin breakdown
  – …
Specialist Symbionts
Soil Biology – Beneficial Microorganisms

Beneficial Microbes – Symbioses

- Arbuscular Mycorrhizal Fungi (AMF)
- Plant Growth Promoting Rhizobacteria (PGPR)

Kellum, 2016
Soil Biology – Mycorrhizae

- Symbiotic association between a fungus and a plant – Mycor-Rhiza = Fungal Root
- Obligate mutualistic symbiosis with over 80% vascular plant families → fungus must have host plant to survive
- Non-hosts: Brassicaceae (e.g. OSR), Amerancaceae (e.g. sugar beet)
Soil Biology – Mycorrhizae

Mineral nutrients and water extracted from the soil

Organic carbon compounds transferred to fungus
Soil Biology – Arbuscular Mycorrhizal Fungi

• Benefits

  – Extend surface uptake area (up to 1000 times) for water and nutrients
  – Solubilise P
  – Upregulate internal water use efficiency
  – Induce systemic resistance
  – Improve soil aggregation

Kusner, 2018
Soil Biology – Arbuscular Mycorrhizal Fungi

- Deleterious Factors
  - Tillage
  - Fallow periods
  - Non-mycorrhizal crops
  - Some pesticides

Bowles et al., 2016
Soil Biology – the Link to Structure

Glomalin
• Sticky protein produced by arbuscular mycorrhizal fungi
• Aids formation of aggregates
Soil Biology – the Link to Structure

“Sticky String Bag Theory”

• Fungal network of AMF acts as “string bag”
• Made “sticky” by proteins produced by worms and AMF
• Improved formation of macro- and micro-aggregates
Soil Biology – the Link to Nutrients

Nitrogen
• N Mineralisation
• N Fixation
• Bacteria
• Rhizobia
• PGPR?
Soil Biology – the Link to Nutrients

Phosphorus

- P solubilisation
  - Bacteria – PGPR
  - Mycorrhizal fungi
  - Others – i.e. *Penicillium bilaiiae*

- P transport
  - Mycorrhizal fungi
Frontier Soil Demo Sites
Soil Demo Sites

- How can land management influence soil biology?
- Explore
  - Cultivations
  - Addition of organic materials
  - Cover crops
  - Addition of bioinoculants
Soil Demo Sites - Cultivations

- 2 Northern sites to include different tillage systems
- Cultivations affect microbiomes in a number of ways
  - Physical disruption
  - Nutrient availability
  - Drainage – aerobes vs anaerobes
- But must be carefully balanced with other aspects
  - Weed management
  - Structural management
Soil Organic Matter

- Organic Matter = Any material that contains Carbon compounds that were formed by living organisms
- Sources – plant materials from crops, manures, compost…

Left – OM rich soil. Right – sandy soil devoid of OM
Soilhealth.com, 2019
Soil Organic Matter

- **Organic Matter**
  - Serves as a reservoir of nutrients and water in soil
  - Aids in reducing compaction and surface crusting
  - Increases water infiltration – drainage!
Soil Demo Sites – OM Management

• Explore effects of addition of organic materials
• Straw on both sites chopped and incorporated
• Additions of manure and compost
• Assess different treatments for
  – OM content
  – Structure (VESS)
  – Nutrient content
  – Biological activity
Soil Activity/Health - Testing

Soil Life Tests

- Fundamentals
  - Texture, pH and OM
  - Nutrient analysis
  - Biological analysis including C:N ratio, potential N mineralisation and respiration test
Soil Health and Function – Cover Crops

- Use of cover crops to improve soil health and crop resilience
  - Improve structure and drainage
  - Addition of organic materials
  - Building nutrient bank
  - Supporting soil biology
  - Association with specialist symbionts – eg legumes as hosts of AM fungi and bacteria
Diverse cover crop mixes help build different areas of OM and microbial diversity.
Soil Demo Sites – Cover Crops

• Comprehensive range of cover crop mixes
• Structure – e.g. oil radish and tillage radish
• Soil biology – e.g. strong AMF hosts such as legumes, sunflower…
• Mixes rather than straights for added biodiversity
  – Support greater diversity of biology
  – Different root architectures
• Biomass for addition of organic materials and nutrients
Summary

- Soil Health – Better foundation for sustainable farming systems
- Physical, chemical and biological properties
- Soil biology – a helping hand for resilient crops
- Frontier Demo Sites and soil tests – explore impact of soil management