Joint Bachelor Course on Organic Agriculture 2014

Lecture 5: Soil fertility and organic fertilizers in organic farming

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SNF/SCOPES
Changings of soil pH depending on agricultural systems

Source: Fließbach et al., 2007, Agr Ecosys Environ, 118
Soil properties in agricultural systems (DOK long term trial)

Source: Mäder, Fließbach et al., 2002, Science 296

A Physical

- Percolation stability
- Aggregate stability
- Bulk density

B Chemical

- pH
- Magnesium
- Calcium
- Phosphorus
- Potassium

C Microbial

- Microbial biomass
- Mycorrhiza
- Saccharase
- Dehydrogenase
- Protease
- Phosphatase

D Faunal

- Earthworm biomass
- Earthworm abundance
- Spiders
- Staphilinids
- Carabids

Legend:
- BIODYN
- CONFYM
- BIOORG
- CONMIN

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DOK: soil microbial biomass


Soil microbial biomass (kg C_{mic} ha^{-1})

- NOFERT
- CONMIN
- BIODYN
- BIOORG
- CONFYM

Source: Maeder, FiBL, 2012

Calculated for 0-20cm at average density of 1.4 g cm^{-3}

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Rhizosphere

Contact zone between roots and soil
› Abundance of bacteria around root tip

Zone around roots rich on:
› Organic matter released from the roots, which is abundant food for soil biota Soil micro-organisms

Roots exude mucigel
› Mixture of organic compounds
› Nutrition and energy for MO
Earthworms

› Important soil fertility indicator
› Soil acidity tolerance until pH< 5
› Processing plant residues
› Forming water stable soil aggregates
› Incorporate OM in soil
› Enrich topsoil with nutrients and humus
› Cultivating soil by creating channels
› Facilitating drainage
› Allow roots explore grow deeper, along nutrient occurrence

1. Lumbricus terrestris
2. Allobophora caliginosa

Source: Brady, The nature and properties of soils. 1974
# Compost

<table>
<thead>
<tr>
<th>green</th>
<th>brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh (straw) manure</td>
<td>Straw</td>
</tr>
<tr>
<td>Rotted manures</td>
<td>Cornstalks</td>
</tr>
<tr>
<td>Grass clippings and Green leaves</td>
<td>Dried leaves</td>
</tr>
<tr>
<td>Lawn &amp; garden weeds</td>
<td>Sawdust, wood, paper</td>
</tr>
<tr>
<td>Food wastes</td>
<td>Hardwood bark</td>
</tr>
<tr>
<td>Fruit wastes</td>
<td>Softwood bark</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>Peat moss</td>
</tr>
<tr>
<td>Clover herbage</td>
<td>Branches</td>
</tr>
<tr>
<td>Urine (cattle or sheep)</td>
<td>Rice hulls</td>
</tr>
<tr>
<td>Blood meal</td>
<td>Newspaper</td>
</tr>
<tr>
<td>Coffee grounds</td>
<td>Pine Needles</td>
</tr>
</tbody>
</table>

http://www.norganics.com/applications/cnratio.pdf
http://www.homecompostingmadeeasy.com/carbonnitrogenratio.html
Compost materials

Green and brown components for building up compost heaps

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Approaches to soil fertilization

Conventional
› Provide required nutrients to each crop in a soluble form that plants can use immediately (high input)

Organic
› Provide required nutrients by decomposition of organic matter and natural chemical breakdown of these materials putting the nutrients into forms that are available to crops.
› No chemical nitrogen fertilizers
› No molluscicides
› Manure should be mixed in the soil
› Grass-clover mixtures are common in organic rotations
# DOK experiment

<table>
<thead>
<tr>
<th>Organic</th>
<th>Conventional (Integrated)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BIODYN bio-dynamic</strong></td>
<td><strong>BIOORG bio-organic</strong></td>
</tr>
<tr>
<td>Composted FYM and Slurry</td>
<td>Rotted FYM and slurry rockdust</td>
</tr>
</tbody>
</table>

*Mechanical weed control*
*Indirect disease control*
*Biocontrol for pests*

Herbicides (thresholds)
Fungicides (thresholds)

Diodynamic preparations
Copper-sulphate

Insecticides (thresholds)
Plant growth regulators
Organic fertilizers – benefits

› Physical
  › Soil stability (soil aggregates, erosion)
  › Increase soil porosity (aeration)
  › Improves water holding capacity

› Bio-chemical
  › Cation exchange capacity (CEC)
    › Nutrient availability
    › Provide nutrients (macro and micro elements)
  › Stimulate micro flora and fauna
  › Protects plants from disease

Organic fertilizers

Soil structure: bio-dynamic with composted

Soil structure: conventional without manure

Source: Maeder, FiBL, 2012
Farm Yard Manure FYM

› Animal excrements, urine and bedding materials (straw)
› Varying quantities, decomposition stages, livestock diets cause range of nutrient composition in FYM

› Impacting conditions
  › Type and age of animals
  › Type of forage and food
    › Concentrated food: more excrements (P-rich)
    › Juicy forages: more urine (N and K-rich)
  › Bedding material
    › Enriched with nutrients
    › High usage per livestock unit per day

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On-farm fertilization

Nutritional cycle on farms

livestock → manure and compost

forage crops → soil

mineral elements
On-farm fertilization

- On-farm fertilizer supply in organic agriculture possible
- Fertilizing schedule and outline
  - Sufficient and optimal nutrient use of manure resources
- Priority to manure resources
  - Crops, costly to grow and harvest
    - Cash crops (vegetable), field crops, roughage
  - For livestock production
    - fodder crops
  - Fruit crops and vineyards
Nutrient content of FYM

Source: Dr Popp presentation, IPNI project fertilizer recommendations, 2013
Manure composting

 Advantages

› Cost-efficient application
  › Less volume and mass
  › Directly applicable
› Uniform application
› Org. N and P availability
› Reduced/no NH$_3$-loss
› More Humus
› Increased CEC
› Reduced viable weed seeds
› Reduces pathogens
› No suppress of seed germination

 Disadvantages

› Loss of nitrogen as NH$_3$
› Additional costs/input
  › Time, labor, machinery, land, constructions (e.g. impermeable ground)
› No starter fertilizer effect

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Manure application

EU restrictions on manure application

› Manure quantity limited to nutrient equivalent of produced manure
  › by max. 2.5 to 3 grazing livestock units per hectare

› N quantity per hectare from manure
  › ≤ 170 kg/ha for field crops
  › ≤ 210 kg/ha for pastures

› Organic Aim
  › Use of own livestock manure
Manure application

Time
- Autumn before deep tillage
- Early spring before deeper tillage (the most suitable)
- Application before deep tillage allows manure to be located in deeper soil layers where there is more moisture during summer
  - Continuing mineralization of organic matter

Methods
- Broadcasting - uniformly broadcasting of manure on soil surface
- Side dressing/Band placement (suitable for permanent crops)
- N losses during/after application
  - Primarily: volatilization of NH₃-N
  - Avoid application on hot, dry, windy days
  - Reduced if it rains shortly after application and low air temperature
  - Best: quick incorporation into the soil (max. 12 hours after application)
Nutrient content of slurry of different farm animals

Source: Dr Popp’s presentation, IPNI project fertilizer recommendations. 2013
Summary

› Nutrition of plants in organic system depend mainly on natural cycles of nutritional elements

› Soil microorganisms play important role for plant nutrition
  › Living symbiosis with plants (N fixing bacteria and root mycorrhizae). Nutrients’ delivery (N, P, K, micronutrient) directly in plant roots
  › Free living soil microorganisms decompose organic matter releasing available forms of nutrients for the plants (ions).

› Organic fertilizers (manure, slurry, composts, green manures) are important source of energy for soil ecosystem and nutrients for microorganisms and growing plants.
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