Soil Training cum Workshop

"Soil Properties, Soil Fertility Management and Plant Nutrition in Organic Cotton"

- Date:
- Time:
- Location:

Aims of the workshop:
- Fresh-up and share what you already know about soil matters
- Deepen the understanding of soil fertility, supported with scientific aspects
- Discuss what it means for soil fertility management in organic cotton production
## Programme of the Workshop (Example)

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.30</td>
<td>Welcome, Introduction to the training / workshop</td>
</tr>
<tr>
<td>10.00</td>
<td>Basics of Soil Science</td>
</tr>
<tr>
<td>10.30</td>
<td>Familiarizing with soil (practical exercise)</td>
</tr>
<tr>
<td>11.15</td>
<td><em>Tea break</em></td>
</tr>
<tr>
<td>11.30</td>
<td>Soils in the region: how to assess their properties?</td>
</tr>
<tr>
<td>12.00</td>
<td>Group work: soil properties and management</td>
</tr>
<tr>
<td>13.00</td>
<td><em>Lunch break</em></td>
</tr>
<tr>
<td>14.00</td>
<td>Crop nutrition: nutrient availability, manures, fertilizers</td>
</tr>
<tr>
<td>14.20</td>
<td>Soil testing</td>
</tr>
<tr>
<td>14.40</td>
<td>Interpreting soil test results (Group work)</td>
</tr>
<tr>
<td>15.15</td>
<td><em>Tea break</em></td>
</tr>
<tr>
<td>15.30</td>
<td>Presentation of Group work</td>
</tr>
<tr>
<td>16.00</td>
<td>Nitrogen Fixation and Temporary Nitrogen Immobilisation</td>
</tr>
<tr>
<td>16.30</td>
<td>Feedback to the training/workshop</td>
</tr>
<tr>
<td>17.00</td>
<td><em>End of the workshop</em></td>
</tr>
</tbody>
</table>
Texture - Mineral particles

- Soil Basics

- Delocation by wind
- Delocation by water
- Weathering of parent rock

Gravel and stones (> 2 mm)
Sand (0.05–2 mm)
Silt (0.002–0.05 mm)
Clay (<0.002 mm)

Source: FiBL / IFOAM
Soil structure – What does it mean?

**Good soil structure:**
- Stable crumbs
- A lot of pores: good aeration and drainage
- Easy penetration of root tips

**Poor soil structure:**
- Compacted layers
- Few pores: low aeration and drainage
- Low penetration of root tips

Source: FiBL / IFOAM
The soil micro-cosmos

**Larger soil organisms:**

- Pull dead biomass into the soil
- Feed on organic materials and mix them with the soil
- Dig tunnels and facilitate aeration and drainage

**Soil Micro-organisms:**

- Decompose organic matter
- Improve the soil structure
- Make nutrients available for plants
- Protect the plants from disease attack

Source: FiBL / IFOAM
Mycorrhiza – A beneficial fungus

Mycorrhizae...

- Live in symbiosis with plant roots.
- Enlarge the surface of the roots and penetrate small soil pores.
- Support the plants in taking up nutrients and water.
- Improve the soil structure and preserve moisture.
- Are affected by chemical fertilizers and pesticides.

Source: FiBL / IFOAM
Factors influencing soil fertility

- Infiltration of water
- Active soil life
- Content of organic matter
- Soil structure
- Exploitable depth
- Minerals
- Sufficient drainage
- Acidity (pH)
- Water retention
- Release of nutrients
- Parent soil
- Ground water

Source: FiBL / IFOAM

Soil Basics (7)
Why is organic matter so important?

A loose and soft soil structure with a lot of cavities

Visible parts of organic matter act like tiny sponges

Many beneficial soil organisms such as earthworms are feeding on organic material

Good aeration and good infiltration of rain and irrigation water

Non-visible parts of organic matter act like a clue, sticking soil particles together

Soil organic matter provides a suitable environment for soil organisms

Source: FiBL / IFOAM
Organic matter: Retaining and releasing nutrients

A model of soil organic matter

Nutrients that are added to the soil can attach to the organic matter.

Attached nutrients can be released by plant roots.

Organic matter slowly releases its nutrients while decomposing.

Source: FiBL / IFOAM
Example: Korrelation between Zinc and organic matter content

Source: Data from the Maikaal Organic Cotton Research Project
“Fine, it would be good for the soil to apply large amounts of organic material. But from where shall I get biomass if there is nothing growing around?”
Soil topo-sequence in the Nimar region, India

**Inceptisols:**
- Light sandy soils
- Low clay content
- Shallow
- Low nutrient exchange capacity

**Entisols:**
- Medium clay content
- Dark or brown
- Medium depth

**Vertisols (black cotton soil):**
- High clay content
- Deep (one to several meters)
- High water holding capacity
- High nutrient exchange capacity
- Swell- and shrink properties
Taking soil samples in a topo-sequence
Soil samples in a topo-sequence in a farmer's field
## Results of soil samples in a topo-sequence

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth (cm)</th>
<th>Sand (%)</th>
<th>Clay (%)</th>
<th>WRC (%)</th>
<th>Corg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil depth</td>
<td>coarse particles</td>
<td>fine particles</td>
<td>Water retention capacity</td>
<td>Organic carbon content</td>
</tr>
<tr>
<td>1 uphill</td>
<td>7</td>
<td>87</td>
<td>4</td>
<td>29.0</td>
<td>0.26</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>87</td>
<td>6</td>
<td>28.6</td>
<td>0.13</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>79</td>
<td>8</td>
<td>33.1</td>
<td>0.13</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>69</td>
<td>14</td>
<td>41.4</td>
<td>0.19</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>67</td>
<td>18</td>
<td>50.9</td>
<td>0.58</td>
</tr>
<tr>
<td>6 downhill</td>
<td>&gt; 100</td>
<td>65</td>
<td>22</td>
<td>66.7</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Source: Data from Maikaal Organic Cotton Research Project
Soil properties and soil management – Group work

Soil type: □ light □ medium □ heavy
Properties:
Soil depth:
Water retention capacity:
Nutrient holding capacity:

Crop selection:
Which crops are suitable?
Which cotton varieties are suitable?
Suitable crop rotations? intercrops?

Soil management:
Main purpose for applying compost?
Amount of compost to apply?
Soil cultivation?
Risk of soil erosion?
## Soil types and their properties: Summary

<table>
<thead>
<tr>
<th>Light Soils</th>
<th>Heavy Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low water retention capacity → affected by droughts!</td>
<td>High water retention capacity → less risk of drought</td>
</tr>
<tr>
<td>Sandy, easy to cultivate</td>
<td>Rich in clay; muddy when wet, hard when dry</td>
</tr>
<tr>
<td>Nutrients easily get washed out → need sufficient compost; supply of mineral fertilizers in several doses</td>
<td>Very fertile - Need sufficient manure because of high productivity</td>
</tr>
<tr>
<td>Non-hybrid cotton varieties (desi varieties)</td>
<td>Hybrid cotton varieties</td>
</tr>
<tr>
<td>Drought resistant rotation crops: sorghum, maize, pigeon pea, millets, moong bean, castor</td>
<td>High performance rotation crops: chilli, soya bean, banana, sugar cane, wheat etc.</td>
</tr>
<tr>
<td>Intercrop to reduce risk of crop failure</td>
<td>Intensive crop rotation; green manures</td>
</tr>
<tr>
<td>Compost and mulching to improve water holding and nutrient supply</td>
<td>Compost to activate soil live and improve soil structure</td>
</tr>
<tr>
<td>Shallow ploughing, few soil cultivation</td>
<td>Deep ploughing, frequent shallow soil cultivation (intercultural operations)</td>
</tr>
<tr>
<td>Increase infiltration through trenches and bunds</td>
<td>Risk of water logging!</td>
</tr>
</tbody>
</table>
Nutrient supply

Mineral Particles

Weathering & Exchange

Soil Organic Matter

Decomposition & Exchange

K

Ca

S

B

Mg

Fe

Zn

N

P

Soil Basics
Soil Basics

Organic manures and natural mineral fertilizers

Organic Manures

Muriate of Potash
Gypsum
Rock Phosphate

(all nutrients)

Mineral Particles

Mineral Matter

N

S

Ca

K

Borax

B

Fe

Zn

Mg

P

Soil Organic Matter
Disturbance of nutrient uptake

- Lack of water
- Oversupply of nutrients: Too much N, P, K prevent the uptake of Ca, Mg, Fe, Zn etc.

Mineral Particles

Soil Organic Matter

Water logging
### Nutrient deficiency symptoms in cotton and suitable manures

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficiency Symptoms</th>
<th>Possible Reasons</th>
<th>Suitable Manures/Fertilizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>small, pale yellow leaves stunted growth</td>
<td>Few organic matter in the soil; waterlogging or dryness; presence of straw, immature compost etc.; too much irrigation</td>
<td>Crop rotation with pulses, application of organic manure (e.g. DOC) before flowering</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Stunted plants with dark green leaves, purple spots on leaf edges; Pre-mature senescence</td>
<td>Sandy soils; few organic matter content; reduced uptake due to waterlogging or overcast weather;</td>
<td>Application of compost, manure; application of rock phosphate in compost (50 – 100 kg/ha)</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Leaf margins and interveinal areas show yellowish white mottling, then rusty bronze colour, then necrotic spots; small immature bolls; poor fibre quality</td>
<td>Sandy soils; high contents of nitrogen, soda, magnesia or calcium</td>
<td>Application of wood ash in compost; application of muriate of potash (50 kg K/ha)</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>Yellowing of young leaves while old ones remain green; spindly plants with short slender, stem;</td>
<td>Mainly in dry-land crops and sandy soils. Problem of leaching of Sulphate.</td>
<td>Application of gypsum (25 - 50 kg/ha)</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Intervenial chlorosis (yellowing between the leave veins); cupped leaves, bronzing. Short growth.</td>
<td>Poorly soluble in the soil, thus association with VAM improves uptake. Low VAM due to long fallow or dry conditions.</td>
<td>Application of 5-10 kg Zn-Oxide or Zn-Sulphate per ha once in several years</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>Young leaves become light green at their base, older leaves become twisted; flowers are malformed; deformed bolls</td>
<td>Mainly in sandy soils, easily leached; alkaline soils. Main supply from organic matter.</td>
<td>Application of 0.5 – 1 kg Borax salt per ha, applied just before sowing. Attention: high application has toxic effects!</td>
</tr>
</tbody>
</table>
Which fraction of a nutrient is available to the plant?

- **Mineral Particle**
  - Nutrient
  - Microorganisms (bacteria, fungi)
  - Weathering (through water)
  - Plant roots (exudates)

Soil Basics (22)
# Soil testing: Potential and constraints

## Potential for science:
- Relating the yields to the general fertility of the soil (physical properties, texture).
- Comparing the nutrient status of organic and conventional fields.
- Monitoring the organic matter content during conversion.
- Identifying yield influencing parameters.
- Etc.

## Constraints:
- Only a small part of the nutrients in the soil is available to the crop.
- The extractants for soil nutrient testing are only a rough approximation.
- In organically managed soils, microorganisms and plant roots usually can extract more nutrients than in conventionally managed soils.
- The nitrogen content can change rapidly with changing weather conditions.
- Soil samples need to consider the variation within the field.
- Costs of sending and analysis.
- Correct interpretation of the results is not easy.

## Potential for cotton farmers:
- Rough estimate on the nutrient status of P, K, Fe and Zn.
- Recommendations on the amount of manures/mineral fertilizers.
### Organic manures and natural mineral fertilizers for cotton

<table>
<thead>
<tr>
<th>Manure/Fertilizer</th>
<th>Comment</th>
<th>Nitrogen (total N)</th>
<th>Phosphate (P₂O₅)</th>
<th>Potash (K₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>Soil improvement</td>
<td>0.6 - 1.5 %</td>
<td>0.5 - 1.0 %</td>
<td>0.5 - 2.0 %</td>
</tr>
<tr>
<td>Farmyard manure</td>
<td>Less stable humus</td>
<td>0.7 - 1.5 %</td>
<td>0.5 - 0.9 %</td>
<td>0.4 - 1.5 %</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>Very stable humus</td>
<td>0.6 - 1.5 %</td>
<td>0.4 - 0.9 %</td>
<td>0.5 - 1.0 %</td>
</tr>
<tr>
<td>De-oiled Castor</td>
<td>N- and P-supply</td>
<td>4.5 - 6.0 %</td>
<td>0.8 - 1.8 %</td>
<td>1.3 - 1.5 %</td>
</tr>
<tr>
<td>Cane press mud</td>
<td>Soil improvement</td>
<td>1.4 - 1.8 %</td>
<td>0.1 – 1.0 %</td>
<td>0.4 - 0.6 %</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>P-supply, in compost heap</td>
<td>0</td>
<td>15 - 30 %</td>
<td>0</td>
</tr>
<tr>
<td>Muriate of potash</td>
<td>Natural potassium fertilizer</td>
<td>0</td>
<td>0</td>
<td>ca. 60 %</td>
</tr>
<tr>
<td>Wood ash</td>
<td>K, Mg, Ca, Mg etc.</td>
<td>0</td>
<td>1 - 3 %</td>
<td>1 – 8 %</td>
</tr>
</tbody>
</table>

Note: Figures are given in percent of dry matter. The nutrient contents vary from source to source.
Timing of nutrient supply in the cotton crop

- **Timing of nutrient supply in the cotton crop**

- **Plant Nutrient Demand and Supply**

- **Maximun Demand**

- **Demand partly covered**

- **Demand fully covered**

- **Basal application**

- **Top dressing**

- **Top dressing**

- **Continuous Picking**

- **Second flush**

- **Time**

- **Qualitative development, not accurate**

- **Soil Basics (25)**
Nitrogen fixation through leguminous plants

- There is plenty of Nitrogen in the air (78% Nitrogen-Gas)
- Leguminous plants fix Nitrogen from the air and make it available to the plant
- Examples: pigeon pea, soya bean, moong, cow pea, chick pea, daal etc.
- The fixation happens through bacteria living in root nodules (Rhizobium species)
- The nitrogen fixed by the leguminous crop gets available to the associated or following crop (e.g. cotton)
- If a lot of fertilizer is available in the soil, legumes fix less nitrogen
Nitrogen immobilisation in soil → retarded growth

Symptoms
- Yellowish leaves
- Stunted growth
- Delayed development

The reason
Decomposable material in the soil (half rotten compost or manure, straw, crop residues)
The decomposition of carbon-rich organic material requires nitrogen
Little organic material with high nitrogen content (e.g. oil cake)

Preventive measures
- Remove sturdy crop residues (stalks) from the field and compost them
- Ensure that the compost is well decomposed
- Apply compost at least two weeks before sowing
- Apply sufficient nitrogen-rich organic manures (e.g. de-oiled cakes)
- Note: Organic manures need 1-3 weeks until they release nitrogen
- Shallow soil cultivation helps to accelerate decomposition of organic matter