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

- **Date:**
- **Time:**
- **Location:**

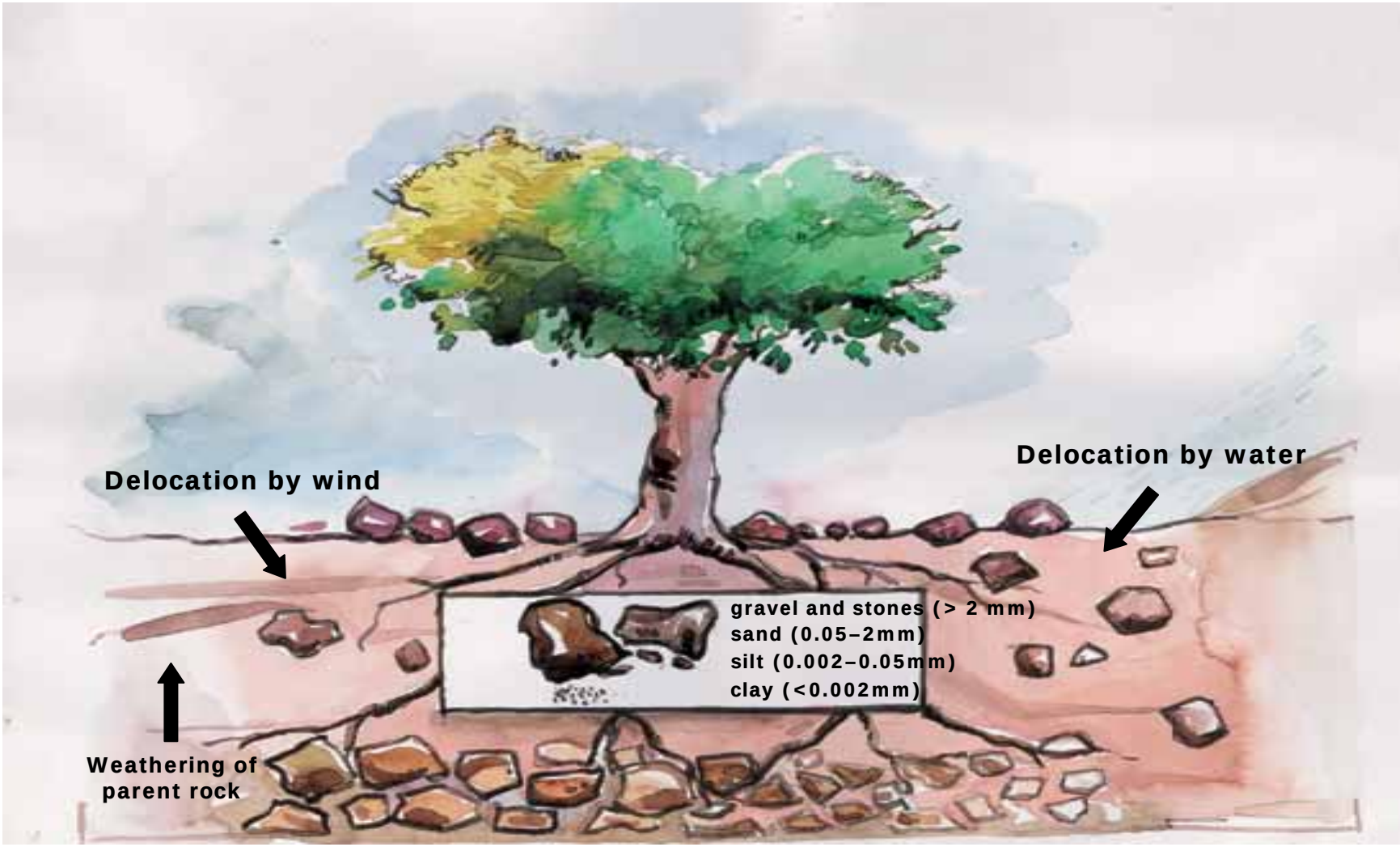
Aims of the workshop:

- **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)

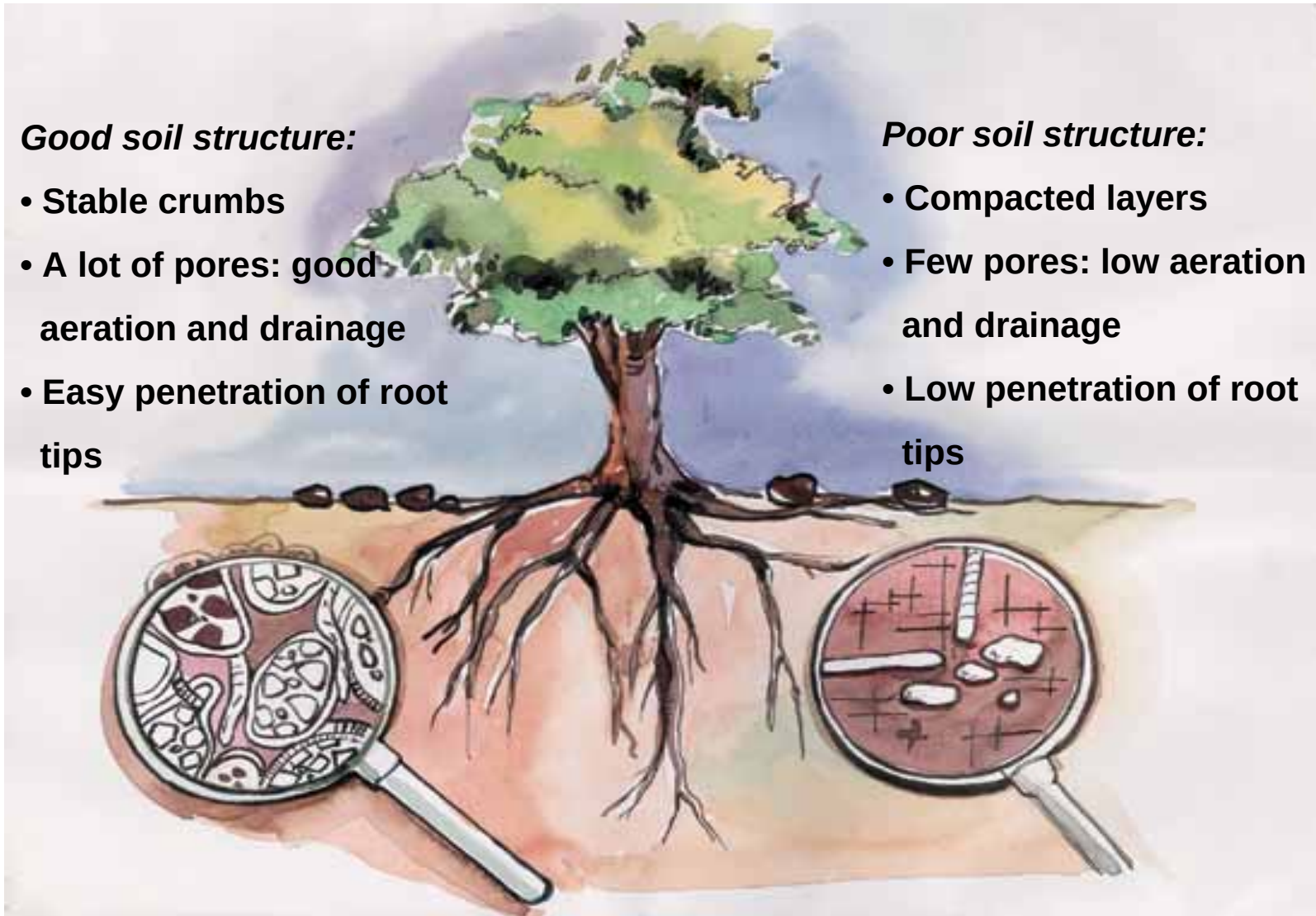
Time	Topic
9.30	Welcome, Introduction to the training / workshop
10.00	Basics of Soil Science
10.30	Familiarizing with soil (practical exercise)
11.15	*Tea break*
11.30	Soils in the region: how to assess their properties?
12.00	Group work: soil properties and management
13.00	*Lunch break*
14.00	Crop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

Texture - Mineral particles



Source: FiBL / IFOAM

Soil structure – What does it mean?



Source: FiBL / IFOAM

The soil micro-cosmos

Larger soil organisms:

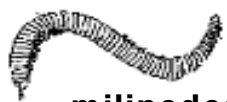
- **Pull dead biomass into the soil**
- **Feed on organic materials and mix them with the soil**
- **Dig tunnels and facilitate aeration and drainage**

earthworm

slater

spring tail

mite



milipedes

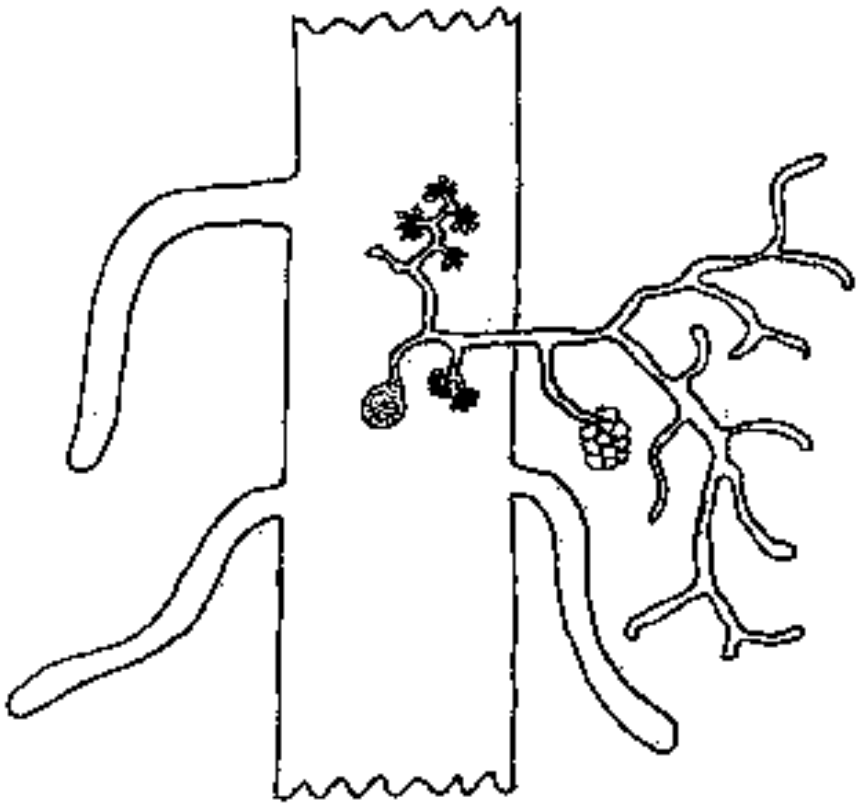
slug

Soil Micro-organisms:

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

Source: FiBL / IFOAM

Mycorrhizza – A beneficial fungus

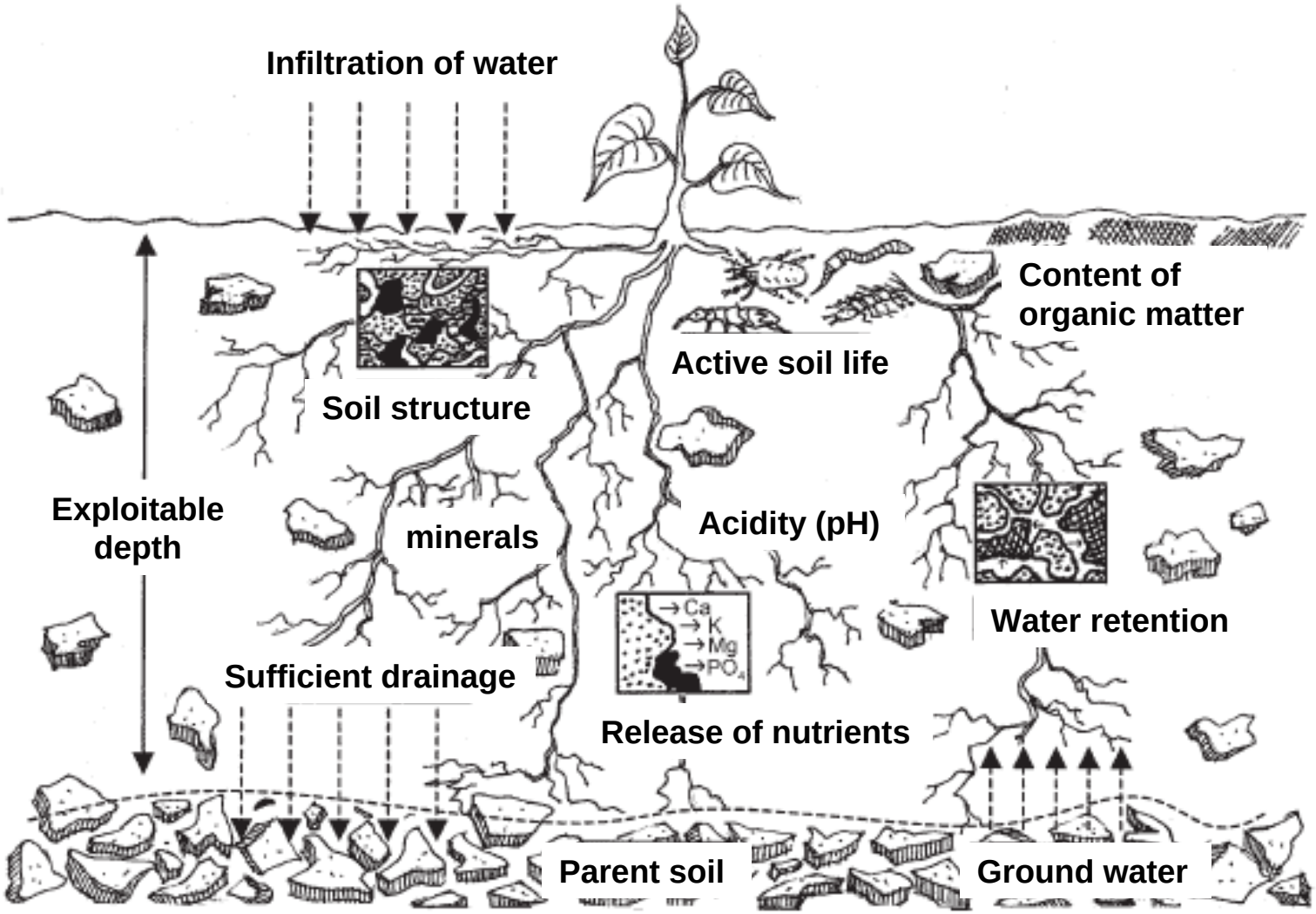


Mycorrhizae...

- **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.**

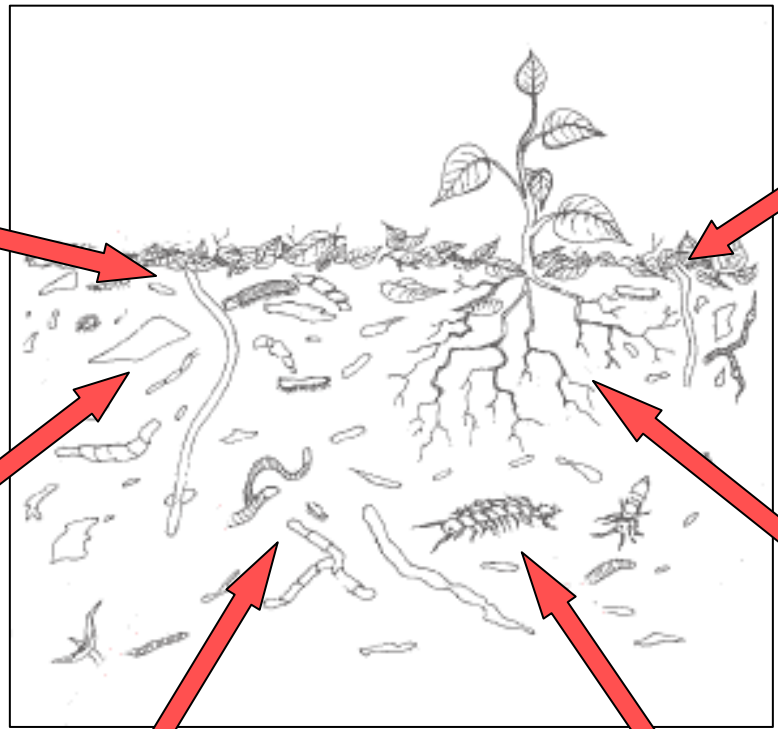
Source: FiBL / IFOAM

Factors influencing soil fertility



Source: FiBL / IFOAM

Why is organic matter so important?



A loose and soft soil structure with a lot of cavities

Good aeration and good infiltration of rain and irrigation water

Visible parts of organic matter act like tiny sponges

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

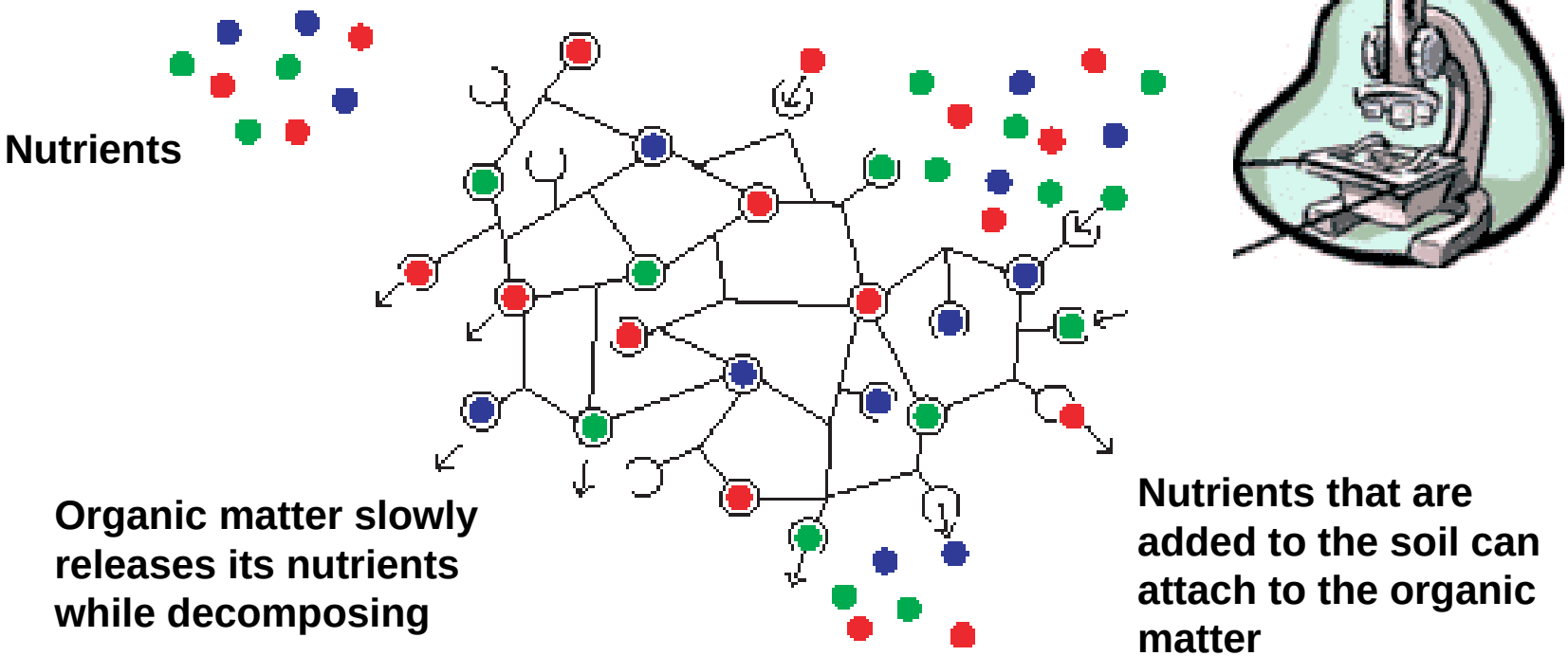
Many beneficial soil organisms such as earth worms are feeding on organic material

Soil organic matter provides a suitable environment for soil organisms

Source: FiBL / IFOAM

Organic matter: Retaining and releasing nutrients

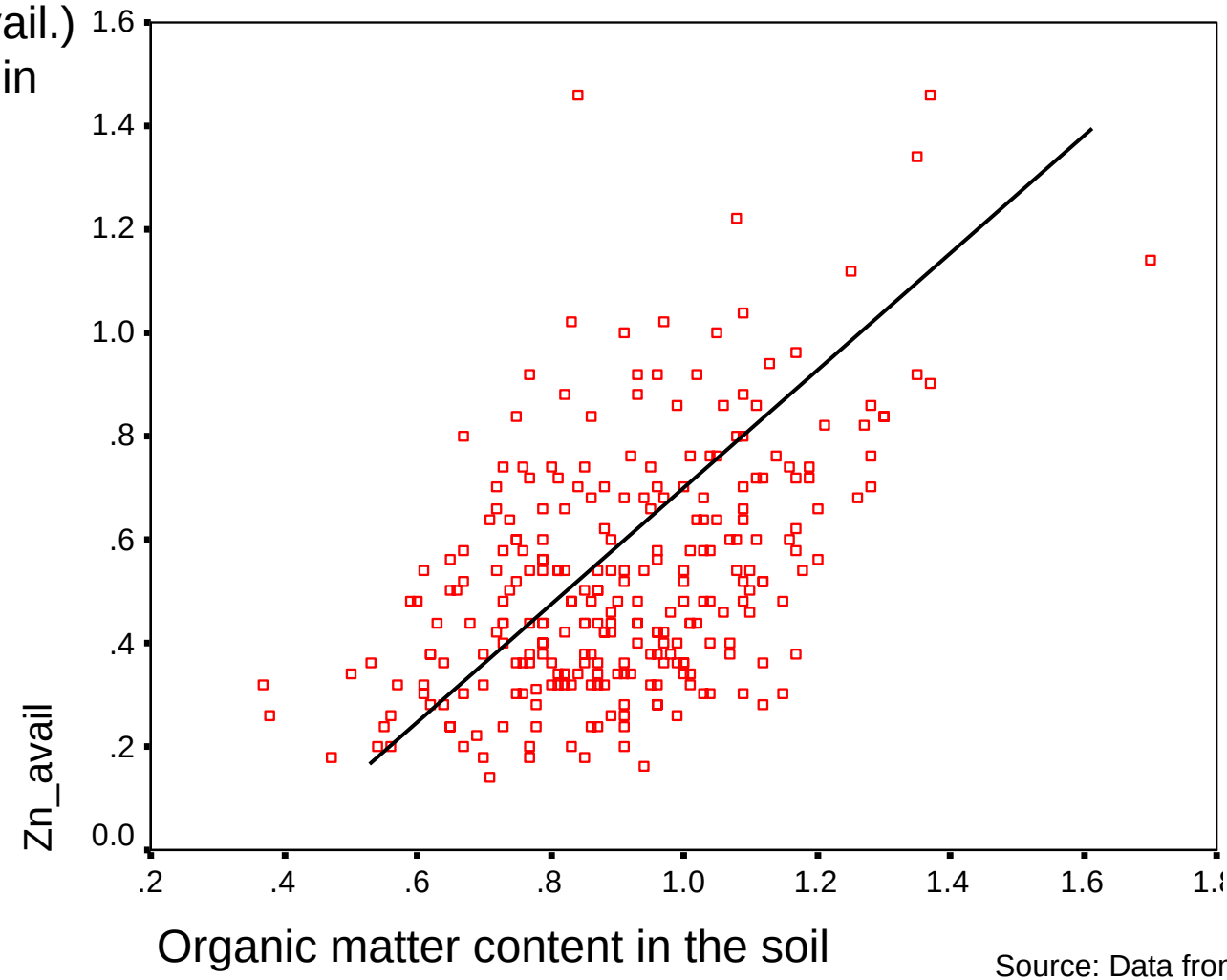
A model of soil organic matter



Source: FiBL / IFOAM

Example: Korrelation between Zinc and organic matter content

Zinc (avail.) content in the soil

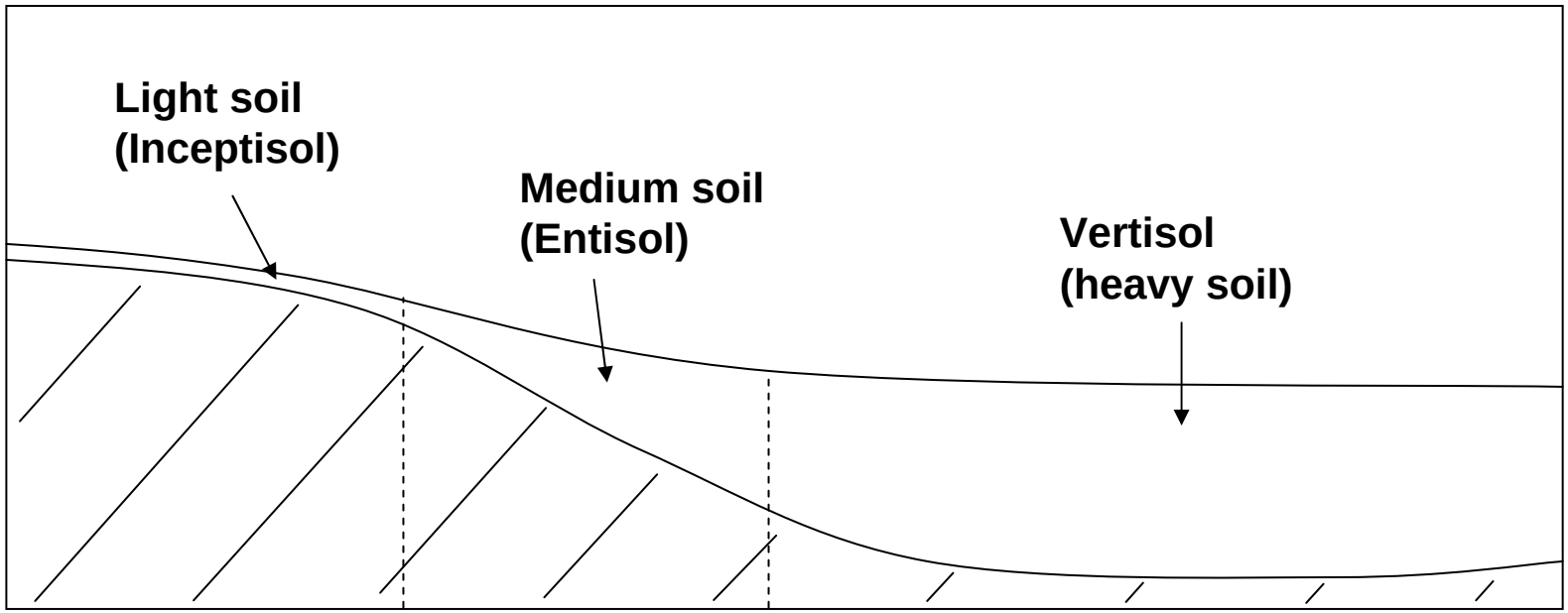


Source: Data from the Maikaal Organic Cotton Research Project

A farmer‘s voice

“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:

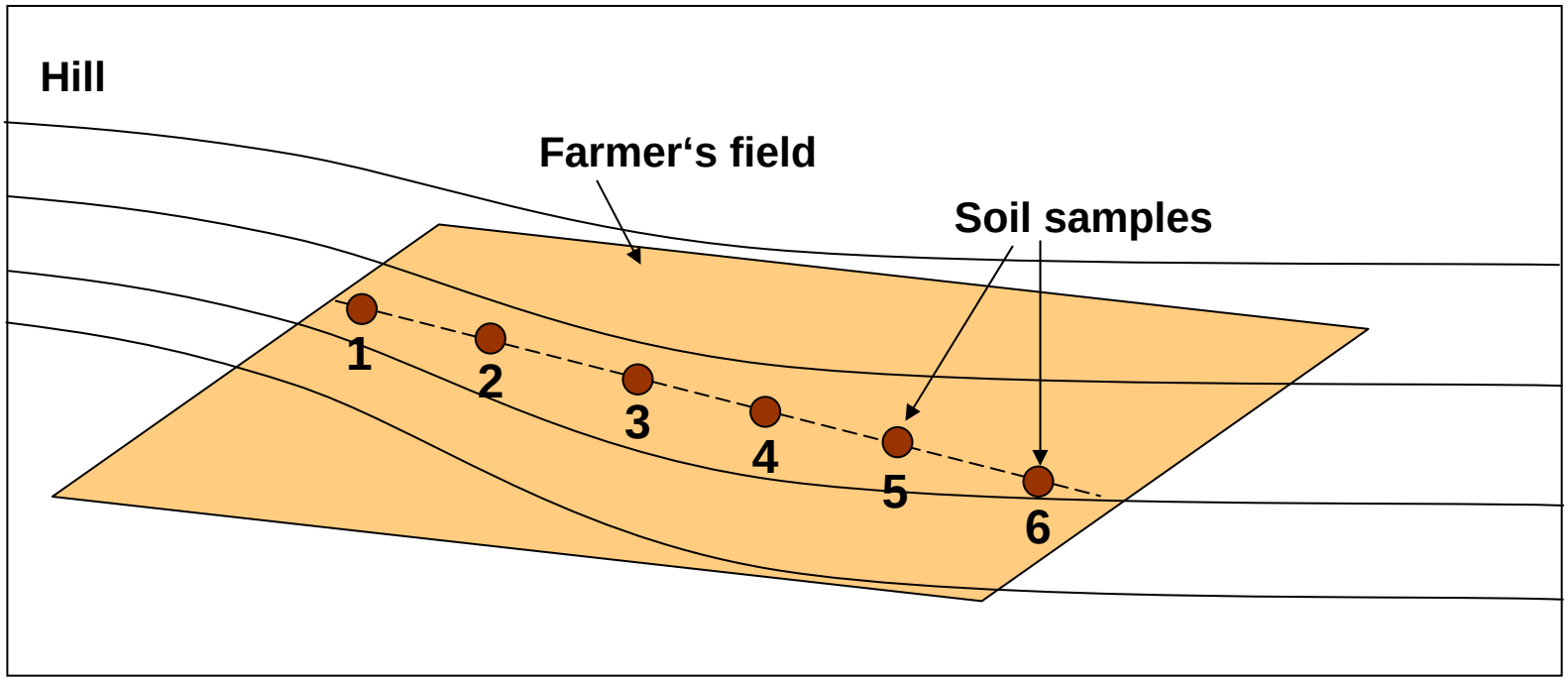
- Medium clay content
- Dark or brown
- Medium depth

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

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

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?

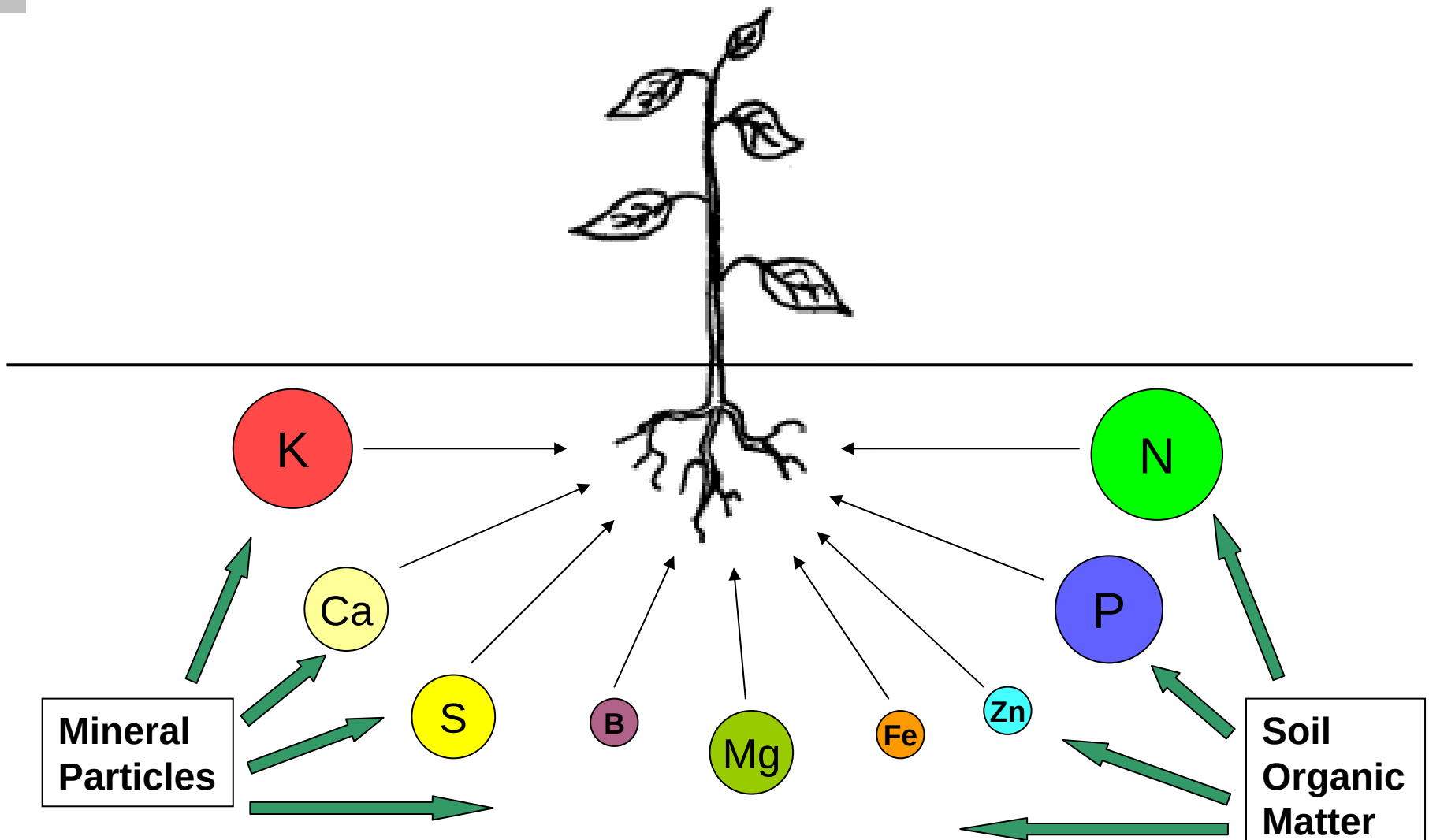
Soil cultivation?

Risk of soil erosion?

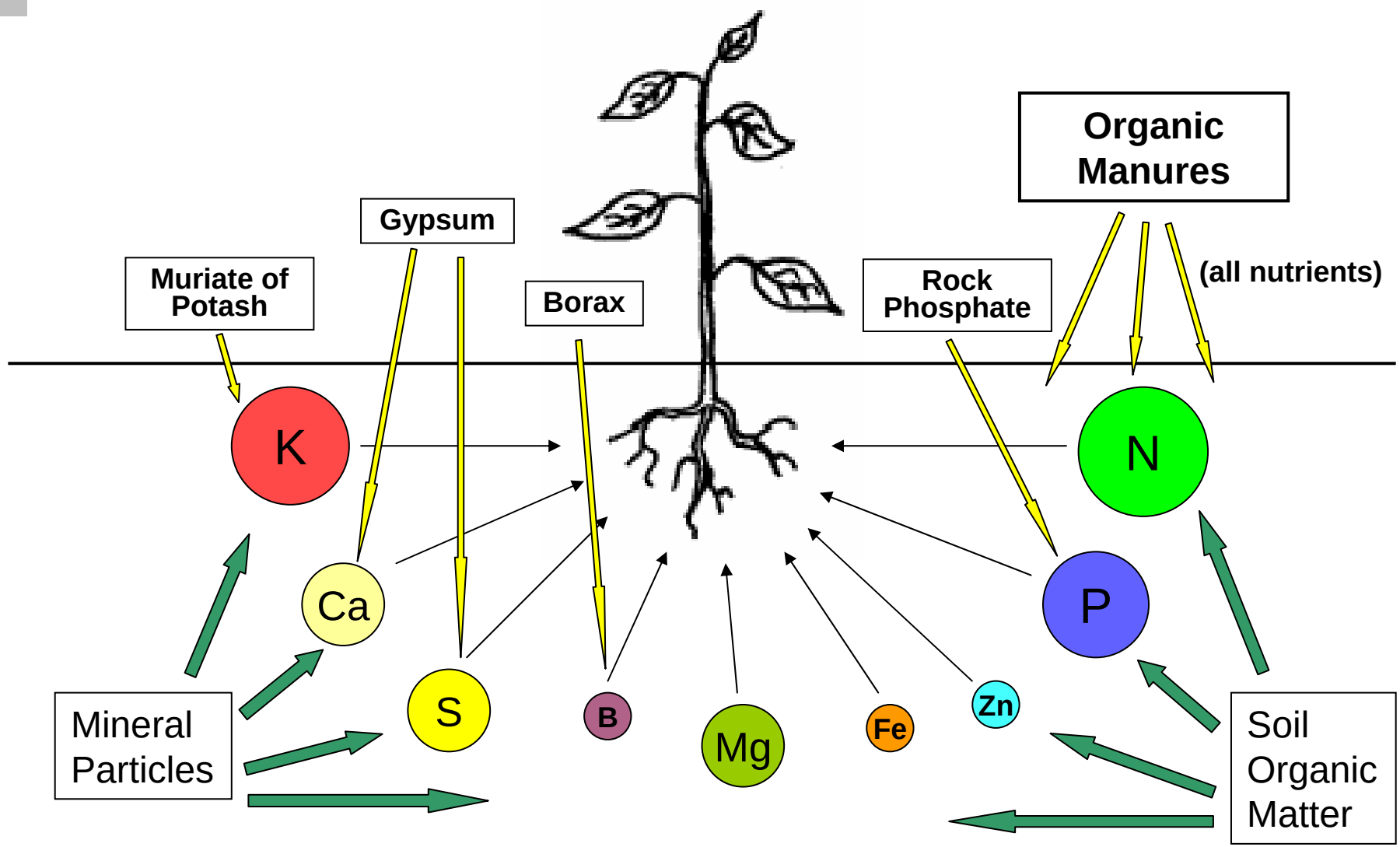
Soil types and their properties: Summary

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

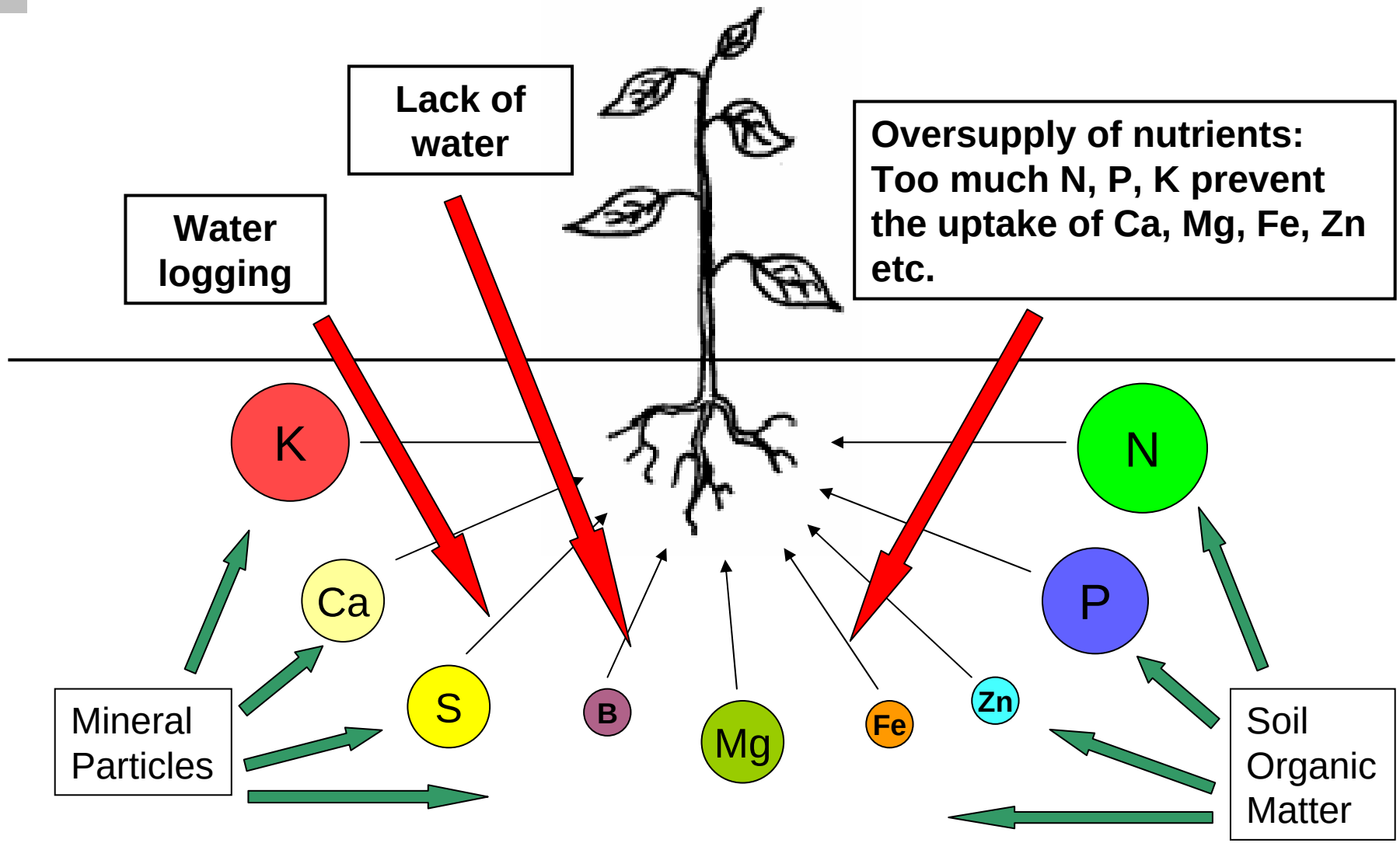
Nutrient supply



Organic manures and natural mineral fertilizers



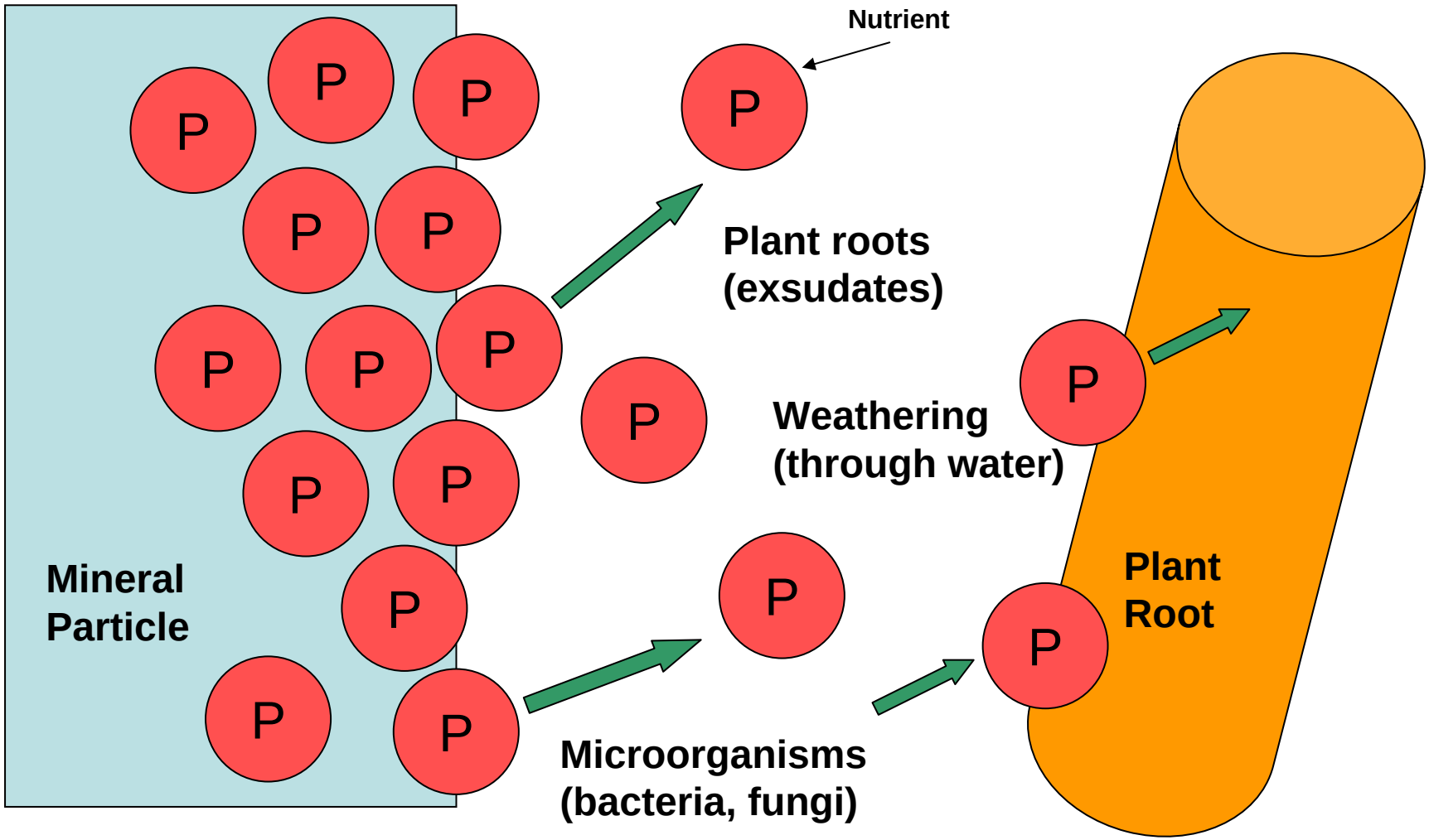
Disturbance of nutrient uptake



Nutrient deficiency symptoms in cotton and suitable manures

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

Which fraction of a nutrient is available to the plant?



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.

Potential for cotton farmers:

- Rough estimate on the nutrient status of P, K, Fe and Zn.
- Recommendations on the amount of manures/ mineral fertilizers.

Constraints:

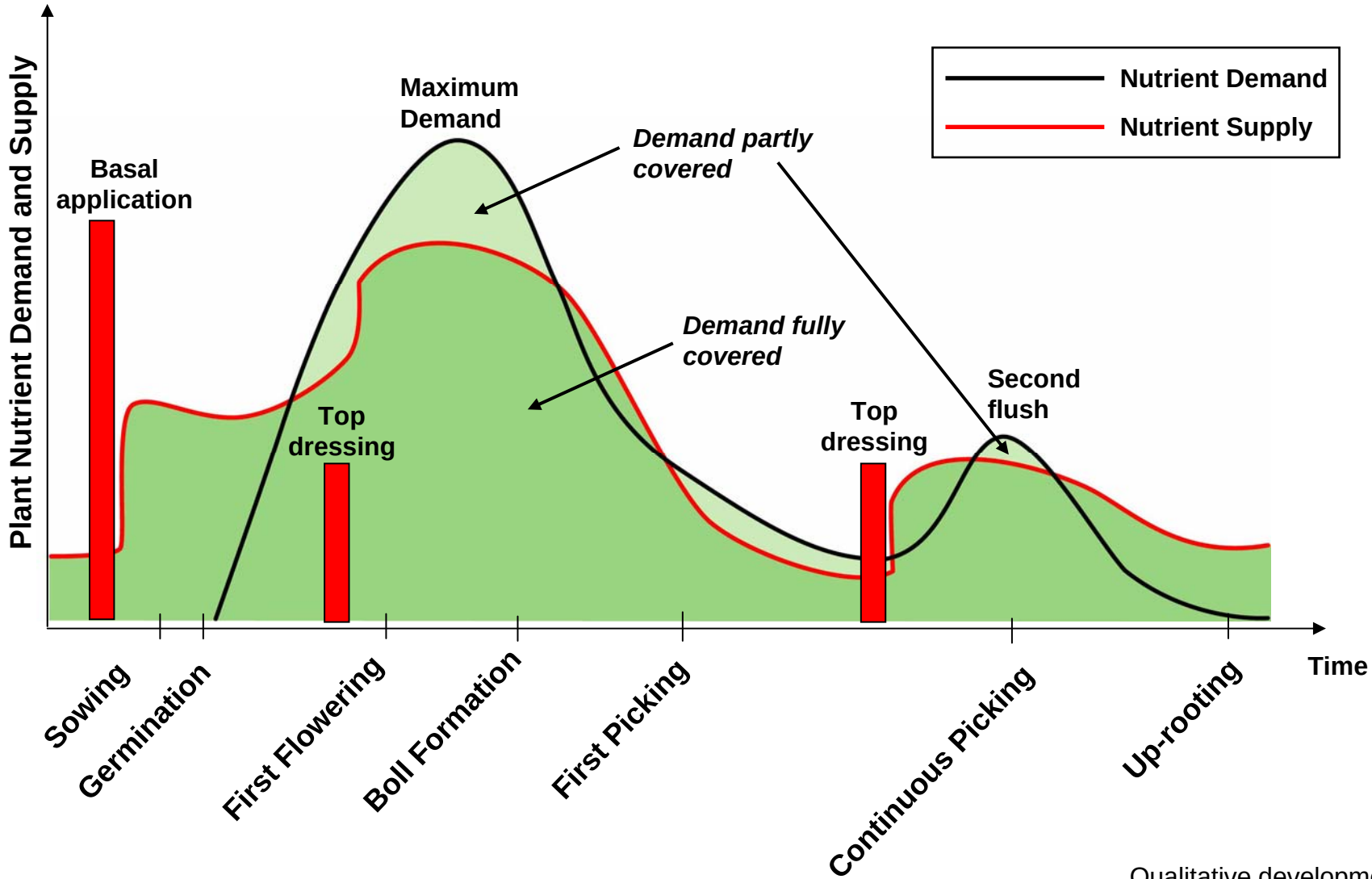
- Only a small part of the nutrients in the soil is available to the crop.
- The extractants for soil nutrient testing are only a rough approximation.
- In organically managed soils, micro-organisms and plant roots usually can extract more nutrients than in conventionally managed soils.
- The nitrogen 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.

Organic manures and natural mineral fertilizers for cotton

Manure/Fertilizer	Comment	Nitrogen (total N)	Phosphate (P_2O_5)	Potash (K_2O)
Compost	Soil improvement	0.6 - 1.5 %	0.5 - 1.0 %	0.5 - 2.0 %
Farmyard manure	Less stable humus	0.7 - 1.5 %	0.5 - 0.9 %	0.4 - 1.5 %
Vermi-compost	Very stable humus	0.6 - 1.5 %	0.4 - 0.9 %	0.5 - 1.0 %
De-oiled Castor	N- and P-supply	4.5 - 6.0 %	0.8 - 1.8 %	1.3 - 1.5 %
Cane press mud	Soil improvement	1.4 - 1.8 %	0.1 – 1.0 %	0.4 - 0.6 %
Rock phosphate	P-supply, in compost heap	0	15 - 30 %	0
Muriate of potash	Natural potassium fertilizer	0	0	ca. 60 %
Wood ash	K, Mg, Ca, Mg etc.	0	1 - 3 %	1 – 8 %

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



Qualitative development, not accurate

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

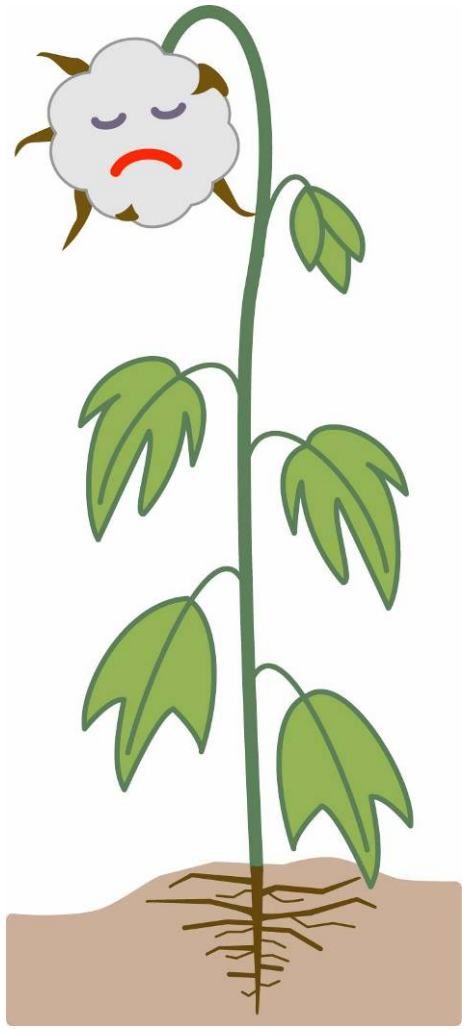
Decomposable material in the soil (half rotten compost or manure, straw, crop residues)

↓

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