

# Integrated Soil Management

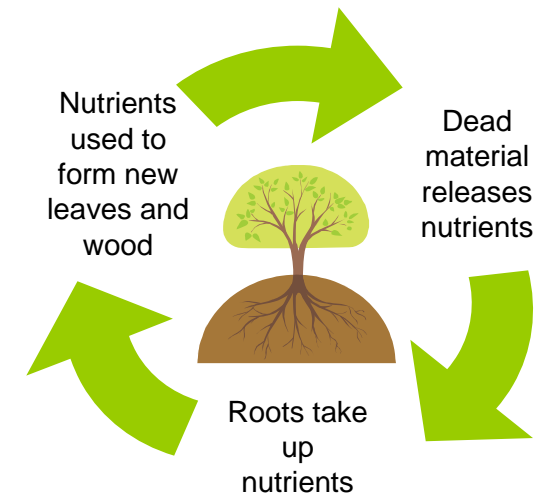


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# 1. Why soil management?

- All plants take up nutrients from the soil
- In a natural forest where no harvesting takes place plants and trees grow in the same location where they will also eventually die. When that happens the nutrients contained in the plant are recycled again when the dead plant decomposes. This results in a nearly closed cycle of nutrients
- When we harvest coffee (or any other crop) we remove nutrients that are contained in the harvested product from the field
- Nutrients can also be washed away during heavy rains, especially when the soil is not covered with organic material
- Nutrients that are lost need to be replaced to maintain soil fertility.
- If this is not done the soil will degrade and production will decline
- Integrated Soil Management (ISM) is an approach to farming that increases land productivity while at the same time minimizing the risk of soil degradation
- ISM techniques commonly practiced in coffee fields are use of organic and inorganic fertilizers, mulching, shading, erosion control measures, cover crops, legumes and intercropping



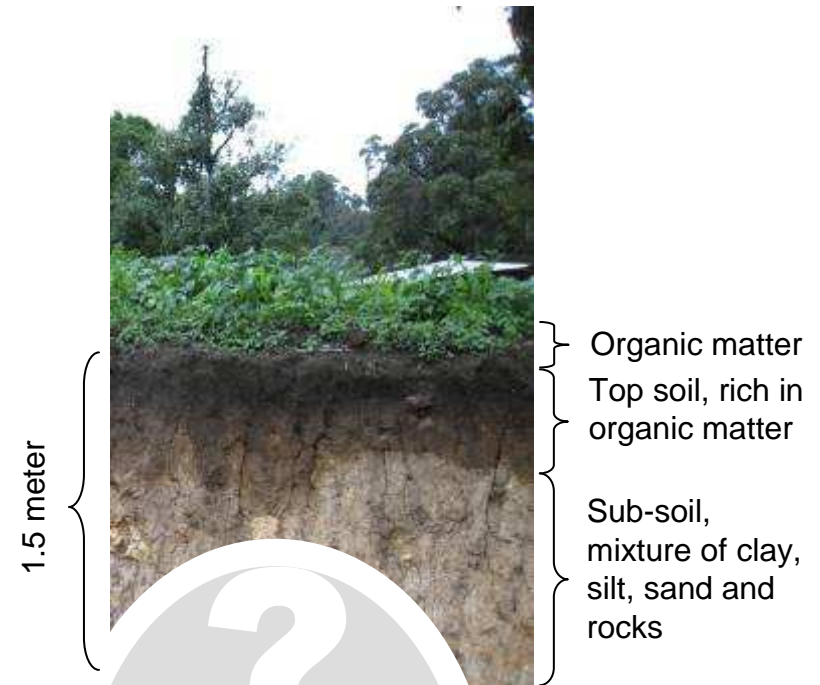
# 1. Why soil management?

- Symptoms of poor soil fertility:
  - Uniform yellowing over whole tree or light yellowing between the leaf veins
  - Death of youngest leaves; dieback of terminal buds.
  - Stunted growth of coffee plants
  - Coffee trees with thin unhealthy stems and leaves
  - Wilting of coffee plants
  - Poor bearing of cherries



## 2. Soil structure - Components

- Soil consists of 6 main components:
  - Organic matter
  - Silt
  - Clay
  - Sand
  - Water
  - Air
- Organic matter can absorb water and supply nutrients to plants
- Silt, clay are very small particles and can bind nutrients and make them available to the plant
- Sand particles are larger and provide structure and stability to the soil (sand is added to cement for the same reason)
- Air and water are found in openings between other soil particles and can be reached by the roots of plants. Both are needed for the roots to function



## 2. Soil structure - Components

- Nearly all soils contain the 6 elements organic matter, silt, clay, sand, water and air.
- But different soils have different ratios of these.
- These ratios influence the potential fertility of the soil.
- Sand does binds nutrients very poorly, soils with a high sand content tend to be less fertile
- Silt and clay bind nutrients much better than sand. Soils with a high clay and silt content tend to be more fertile
- Organic matter is a source of nutrients and also binds nutrients. Soils with a high organic matter content tend to be more fertile. Soil organisms decompose organic matter by feeding on it and play an important role in maintaining soil fertility, however, decomposition also consumes some nitrogen.
- A good indicator of a fertile soil is that it contains a lot of small organisms, some you can't see, but others, like earth worms can be seen. Basically, the more worms (and other organisms) in your soil the better!

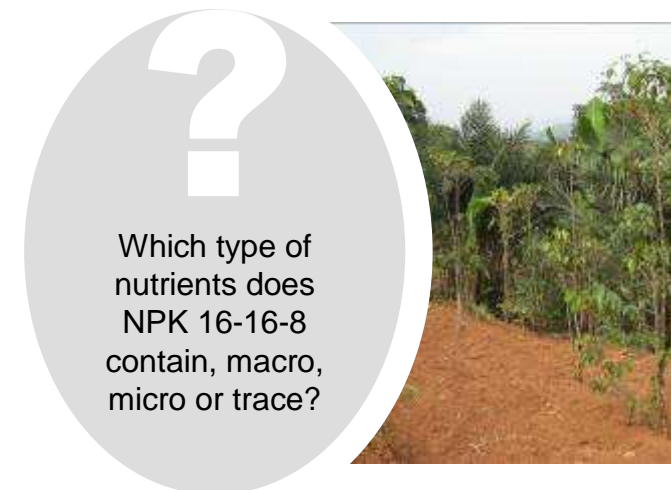


What type of  
soils do you see  
in the 3  
pictures?

## 2. Soil structure – Nutrients

- Nutrients required by plants to grow come in 3 different types:
  - Macro nutrients
  - Micro nutrients; and
  - Trace elements
- Macro nutrients are used by the tree in fairly large quantities
- Micro nutrients are used in smaller quantities
- Trace elements are used in very small quantities
- However, all types of nutrients are needed, if any one of them is lacking this will reduce the growth and production of the tree

Nutrient type	Nutrients
Macro	Nitrogen (N) Phosphorus (P) Potassium (K)
Micro	Calcium (Ca) Magnesium (Mg) Sulfur (S)
Trace elements	Listed on page 23, little deficiencies observed in field



## 3. Composting

- The role of organic matter in maintaining soil fertility is very important
- Most farmers have little funds available to invest in fertilizers, often compost is one of the few ways available to improve soils
- Making compost is more work than just bringing some organic material to the field
- However, coffee trees use large amounts of N and K, often compost alone is not enough to supply sufficient nutrients



What is “wrong”  
with these  
pictures?

## 3. Composting - Steps

1. First, make a base 30 centimeters (cm) high and 2 metres (m) wide with coarse plant material such as twigs. This will ensure good air circulation and drainage.
2. Add a 10cm layer of material that is difficult to decompose such as maize stalks.
3. Add a 10cm layer of material that is easily decomposed such as fruit and vegetable scraps or coffee pulp.
4. Add 2cm of animal manure or old compost. A little bit of nitrogen fertilizer or fresh bean leaves can also be used.
5. Add a sprinkling of earth from the top 10cm of cropped land.
6. Ash and urine can then be lightly sprinkled onto these layers, to accelerate the process of decomposition.
7. Then water the whole pile well.
8. Repeat step 2 to 7, until the heap reaches 1 to 1.5m high. Turning of compost is not necessary for tree crops but to keep the pile moist on the inside it can be covered with grass or banana leaves
9. After about 3 months the compost can be applied in the field



What is the  
importance of  
step 4?

### 3. Composting – Raw materials

Material	Preparation	Notes	Precautions
Fruit and vegetable peelings		Decomposes quickly	
Wood fire ash		High in K and lime	Use in small quantities
Paper and cardboard	Tear up or shred	Decomposes slowly, mix with wet/moist material	
House and compound sweepings		Variable quantity and quality	
Crop residue	Chop up tough material (like maize stalk). If dry, moisten well before use	Though material will decompose slowly	
Dead leaves	If dry, use as above		
Intercrop residues	Chop up if large	Legumes are best	
Manure		Not essential, but an excellent source of nutrients	
Urine (animal and human)	Difficult to collect	Sprinkle on heap. Will speed up decomposition	Use in small quantities
Soil	Use soil from the top 10cm of cropped lands	Not essential but may reduce N loss from hot heaps	

## 4. Mulch

- Instead of composting, organic materials can also be brought directly into the field
- Mulching has the advantages of forming a thick (10-20cm) thick layer on top of the soil, this reduces moisture loss from the soil
- Any vegetative material can be used
- Mulch brings nutrients into the field, but during decomposition some nitrogen is used by bacteria
- However, a moist soil makes it easier for the tree to take up nutrients
- Mulch also suppresses weeds, reducing the amount of labour needed for that activity
- Mulch can be cut elsewhere and brought into the field, or it can be grown in the field itself and cut down later to cover the soil



What are good  
local sources of  
mulch?

## 5. Intercropping

- This is the planting food crops, fruit trees, timber and leguminous shrubs/ tree species in the coffee farm. The benefits of inter cropping and shading\* include:
  - The leaves and pruned soft parts of the plants help to improve the fertility and structure of the soil when incorporated. They also improve the water retention capacity of the soil.
  - The roots and canopy of the plants help to reduce soil and wind erosion.
  - The shades reduces the direct negative impact of rain drops, sun light and destruction by wind
  - These plants can provide additional income to the farmer.
  - They help to regulate the soil's moisture content
  - Leguminous plants and trees increases soil nitrogen through root nodules. It does this by absorbing nitrogen from the air fixing it in its roots. When these decompose the nitrogen becomes available to other plants and trees.
- Examples of leguminous species are:
  - *Cajanus cajans*, *Calliandra*, *Sesbania sesbans*, *Tephrosia*, *Acacia*, *Leucena* etc









The first picture shows coffee intercropped with...?

\* A separate module will go into detail on shading and intercropping

## 5. Intercropping - Species

- Some species that can be used for shading or intercropping are:

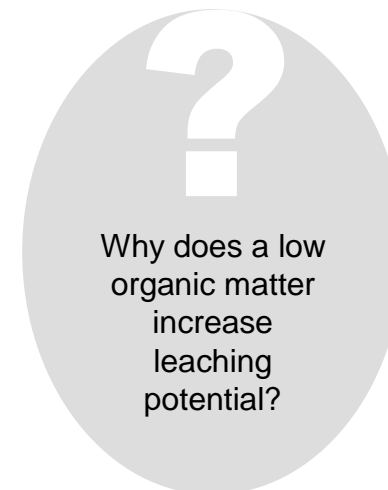
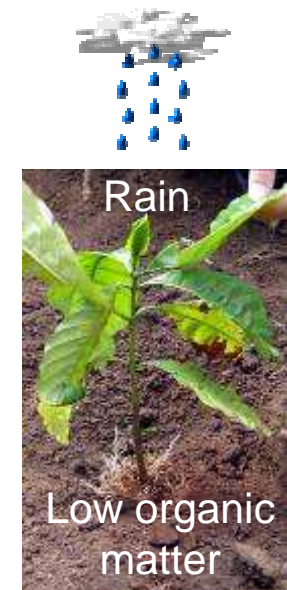
Tree/ plant	Detail	Name	Nr of trees/ha	Nitrogen- fixing	Other use
		Leucena	30-60	Yes	Timber, cattle and goat feed
		Acacia	20-40	Yes	Timber
		Cajanus	-	Yes	No

## 5. Intercropping - Species

Tree/ plant	Detail	Name	Nr of trees/ha	N-fixing	Other use
		Calliandra		Yes	firewood, fodder,
		Sesbania		Yes	Firewood, fodder
		Tephrosia		Yes	Insecticide ***Poisonous to fish

## 6. Fertiliser

- Depending on the type used, some or all macro-nutrients and some micro-nutrients are made rapidly available to the tree;
- Not all fertiliser applied will be available to the tree. Some will be lost by leaching and some may be out of reach of the tree's root system
- Although good nutrient management and fertiliser are important, they will only be fully effective if other activities like pruning are done well!



## 6. Fertiliser - Types

- Fertilisers can be divided in 2 types:
  - Single element fertilisers such as Urea, SA, Kali or Phosphate contain 1 macro nutrient only
  - Compound fertilisers such as Nitrogen (N), Phosphorus (P), Potassium (K) contain all 3 macro nutrients in varying proportions
- Not all the fertiliser consists of nutrients, part of it is used to bind the nutrient. Different fertilisers contain different ratios of nutrients. These ratios are always listed on the bag.



Fertiliser	Nutrient content		
	N	P	K
Urea/Uree	46%	0%	0%
SA	21%	0%	0%
Phosphate	0%	16.5%	0%
Kali	0%	0%	58%
NPK 20-10-10	20%	10%	10%

?

If I apply 100kg of Urea, how many kilos of which nutrient did I apply?

## 7. Nutrient requirements

- Nutrients that are removed with the harvested coffee cherries need to be replenished to maintain soil fertility
- The best way to do this is by using a combination of mulch, compost and fertiliser.
- Mulch and compost ensure that the soil stays moist and deliver some nutrients while fertiliser can deliver the bulk of the nutrients needed
- Before we can decide how much to apply, especially of fertiliser, it is important to know how much the tree needs!

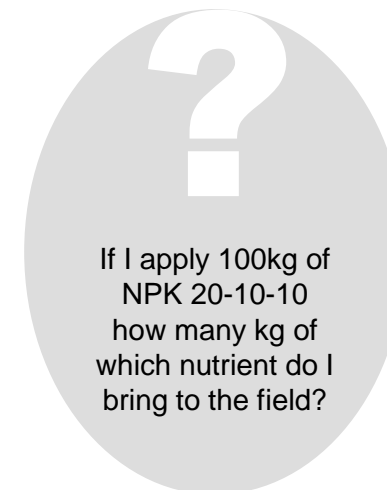


Why is it important to apply both fertiliser and compost or manure?

## 7. Nutrient requirements

- After year 3, the expected level of production becomes important when determining the amount of nutrients needed. An exact calculation would be ideal, but that is quite complicated. The below recommendation is specific to the North Western highlands ecological zone.

Tree age		Dose of application	
		20-10-10	22-6-12+4+2
0-1 year	April	30g/plant	27g/plant
	September	1 level full sardine tin	
1-3	April	35g/plant	32g/plant
	September	2 level full sardine tins	
3-5 years and above	April	250g/plant	230g/plant
	September	3 heap full sardine tins	



## 8. Fertiliser application methods

- When applying fertiliser, weather conditions are very important.
- If the soil is too dry the plant will have difficulties taking up the nutrients
- If it is too wet, most of the nutrients, especially N, can be washed away
- Ideally, fertiliser is applied in moist soil, free of weeds
- Dry but cloudy weather is ideal and it is best when it stays dry for some days after application



## 8. Fertiliser application methods

- The fine roots of the tree are the ones that take water and nutrients
- Roughly speaking the fine roots extend in the soil to a width similar to the canopy circumference
- Therefore fertiliser should be applied in a circle that follows the outer limit of the canopy



Create a shallow furrow that follows the contours of the canopy



Apply fertiliser in the furrow



Mix soil and fertiliser



Cover the furrow

## 9. Nutrient deficiency symptoms for coffee

### Nitrogen is used for:

- Vegetative growth
- Formation of chlorophyll (this gives leaves their green color and is needed create energy from sun light, water and nutrients)
- Water uptake

### Deficiency symptoms are:

- Leaves become pale green
- new leaves uniformly pale green with a dull green colour
- Entire plant becomes pale green with sparse vegetative growth
- leaves become yellow green at advanced stage

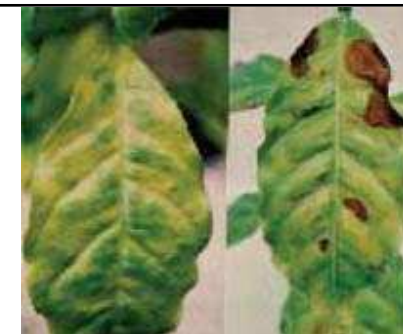


### Phosphorus is used for:

- Root development (especially in young trees)
- Flowering and ripening of cherries

### Deficiency symptoms are:

- Lower leaves exhibiting slight yellowing, young leaves remaining darker green;
- Faint yellowing between the veins of older leaves at advanced stages; small dead spots may be present.



## 9. Nutrient deficiency symptoms for coffee

### Potassium is used for:

- Photosynthesis
- Water uptake
- Formation of proteins

### Deficiency symptoms are:

- Initial yellowing on the leaf edges followed by development of dead spots. Dead tissue increases until the whole leaf edge is covered
- The veins and midrib remain green



### Sulphur is used for:

- Chlorophyll
- Disease resistance
- Seed production

### Deficiency symptoms are:

- Leaves light green to yellow-green, with faint yellowing between veins
- Deficient leaves retaining shiny colour
- Whole plant may show symptoms.



# 9. Nutrient deficiency symptoms for coffee

## Calcium is used for:

- Root and leaf development
- Affects uptake of other nutrients

## Deficiency symptoms are:

- Leaves bronzed along edges
- cupped downward
- new leaves dead
- eventual dieback of shoot tips



## Magnesium is used for:

- Important element of chlorophyll
- Photosynthesis

## Deficiency symptoms are:

- Faint yellowing on leaf edges with sunken
- Yellow-brown to light brown dead spots developing in a wide band along leaf edges;
- Yellowing between veins evident in affected leaves, particularly along the midrib



# 9. Nutrient deficiency symptoms for coffee

## Copper (Cu) is used for:

- Chlorophyll
- Protein formation

## Deficiency symptoms are:

- Young leaves die back
- yellowing of leaves.
- Leaves curl and roll.
- Shoots are weak and restricted



## Iron (Fe) is used for:

- Photosynthesis
- Catalyst for chlorophyll formation

## Deficiency symptoms are:

- Leaves expanding normally, with vein network remaining green and clearly visible against the light green to yellow-green background
- background becoming nearly creamy white in severe cases



# 9. Nutrient deficiency symptoms for coffee

## Zinc is used for:

- Hormones and enzymes
- Plant height
- Production of sugars

## Deficiency symptoms are:

- Leaves not expanding normally; narrow, often strap-shaped;
- Veins visible against a yellow-green background;
- Failure of internodes to elongate properly, giving plants a compact appearance

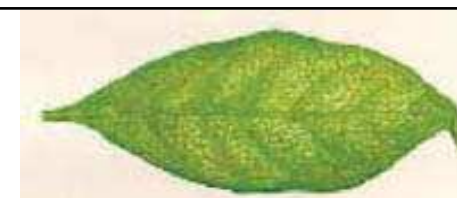


## Manganese is used for:

- Photosynthesis
- Enzymes

## Deficiency symptoms are:

- Yellowing in older or middle leaves
- Mottling, stippling between veins.
- Dead spots along main vein.



# 9. Nutrient deficiency symptoms for coffee

## Boron (B) is used for:

- Development of new shoots and roots
- Fruit set and development

## Deficiency symptoms are:

- Youngest leaves light green
- mottled, with uneven edges
- New leaves with dead spots or tips.



## Molybdenum (Mo) is used for:

- Nitrogen metabolism

## Deficiency symptoms are:

- Bright yellow mottling between veins
- Leaves wither, curl and margins collapse;
- leaves distorted and narrow
- Older leaves affected first.

