Theme 1: Forage production and pasture management

SOIL FERTILITY MANAGEMENT

Level 3 – Part I

Topic	Training & information Content
1.1	Planning of fodder/feed requirements for the dry season
1.2.1	Integrated soil fertility management I
1.2.2	Integrated soil fertility management II
1.3	Use of natural resources, compost making, farmyard manure, manure storage and use
1.4	Growing maize and sorghum for fodder and estimating time of harvest and yield
1.5	Brachiaria, Panicum, & Napier (cut and carry) grass management
1.6	Growing fodder trees and use of feed
1.7	Estimating of dry matter content, feeding value and yield of various fodder crops
1.8	Guidelines for Tropical pasture management and grazing management
1.9	Scaled mechanization of forage production and pasture management (harvesting practices)
1.10	Operating farm equipment and self-propelled tractors
1.11	Mechanization of feeding management
1.12	Economics of forage and pasture production

Soil Fertility Management (Level 3 – Part I)

Learning Activities - You will learn about:

- Key characteristics of Soil
- Soil organic matter, its benefits and sources
- Soil sample collection for analysis
- Plant nutrients

Soil Fertility Management (Level 3 – Part I)

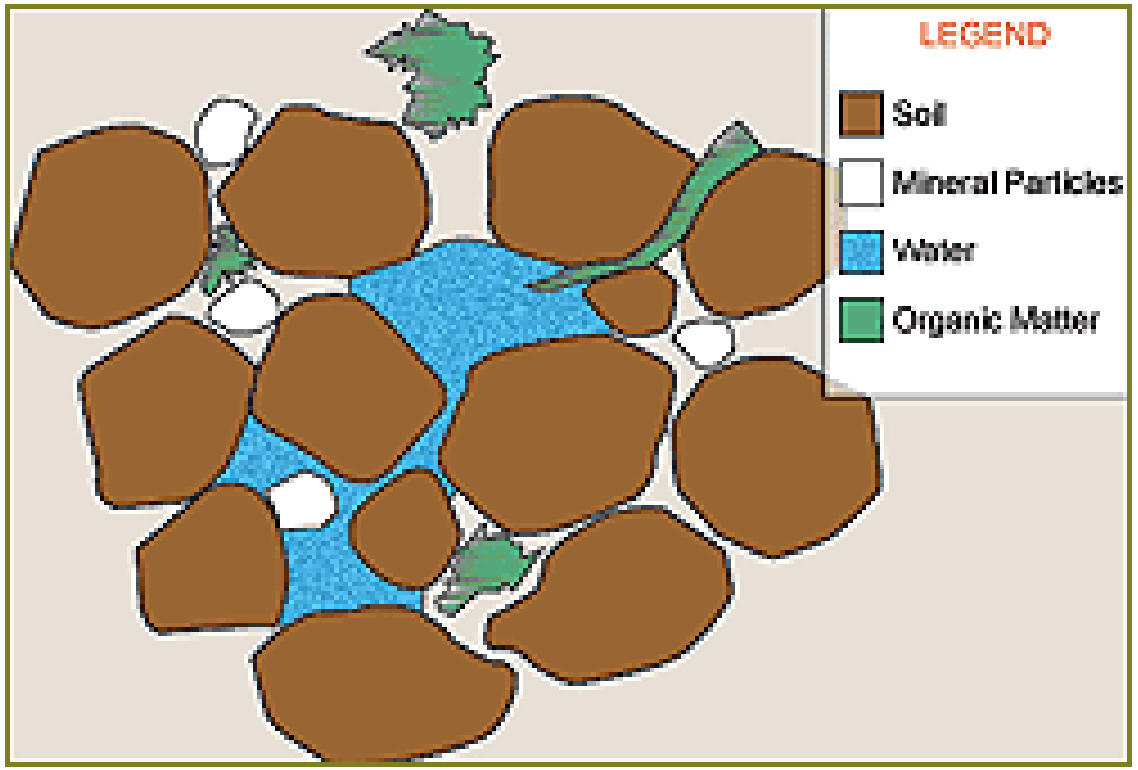
Introduction

What is Soil?

- Soil can be living or dead. A living/healthy soil consists a mixture of:
  - Minerals (Sand, Silt and Clay)
  - Organic matter
  - Water
  - Oxygen

- With these, soil is said to be living/healthy and viable for crop farming. A dead/degraded soil cannot support crop production

- Knowledge of the soil and application of appropriate soil management practices are important in attaining a healthy/living/fertile soil.



Soil Fertility Management (Level 3 – Part I)

Characteristics of Soil

- There are three characteristics of soil that are important for plant growth and productivity:
  i. Physical - e.g. Soil texture
  ii. Biological - e.g. Soil (micro-) organisms
  iii. Chemical - e.g. Soil pH, Nutrients.

Sandy soil

i. Physical Characteristics

Soil Texture

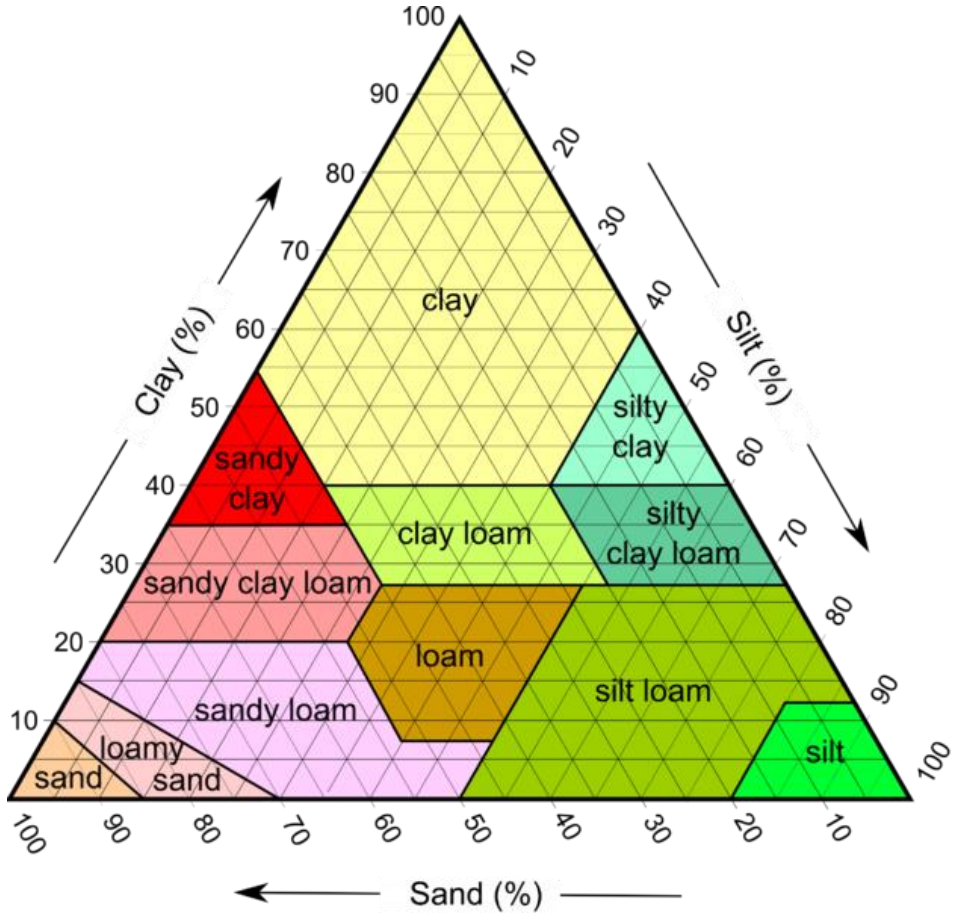
- Soil texture provides a good way of characterising soils. It indicates the relative content of particles of various sizes, such as (examples):
  1. Sand
  2. Silt
  3. Clay

Loam Clay

Soil Fertility Management (Level 3 – Part I)

- Sometimes soils may have a range of particle sizes and types. For instance:
  - Loam
  - Sandy loam: Loam with sand dominating
  - Silt loam: Loam with silt dominating
  - Clay loam: Loam with clay dominating

Note: *Texture influences the ease of working soil, the amount of water and oxygen it holds, and the rate at which water can enter and move through soil.*

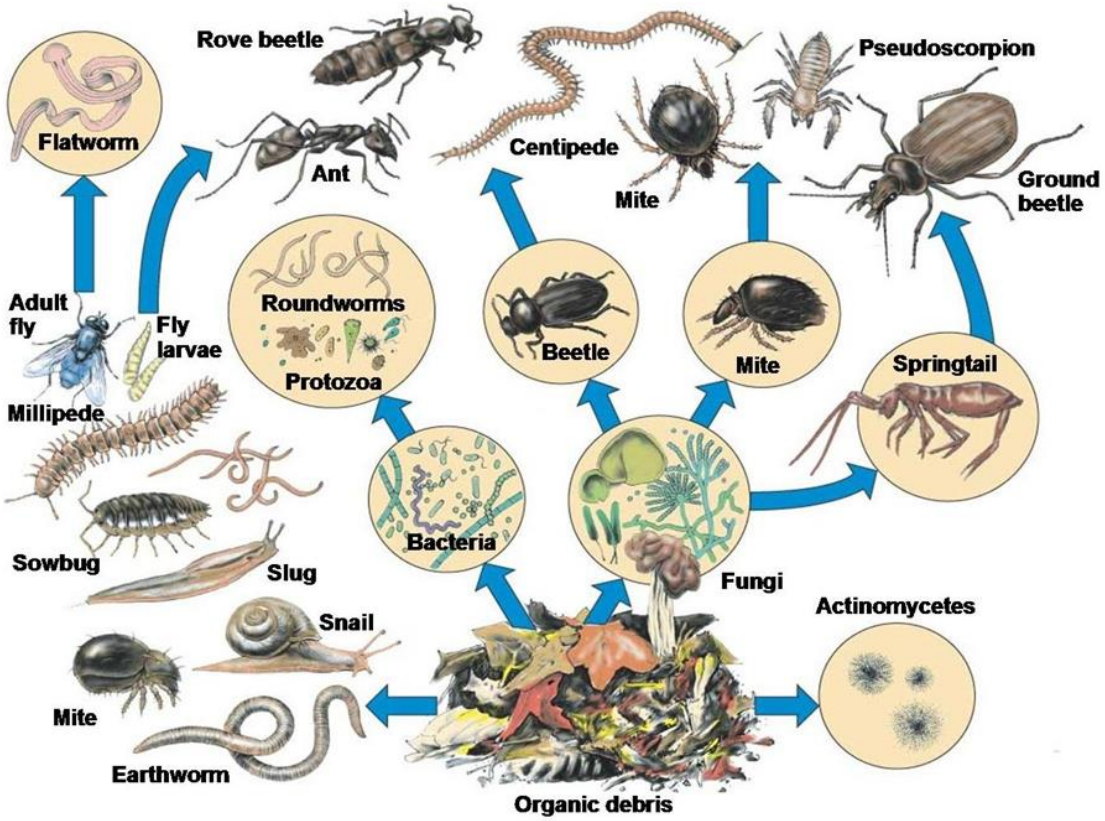


Soil Fertility Management (Level 3 – Part I)

ii. Biological Characteristics

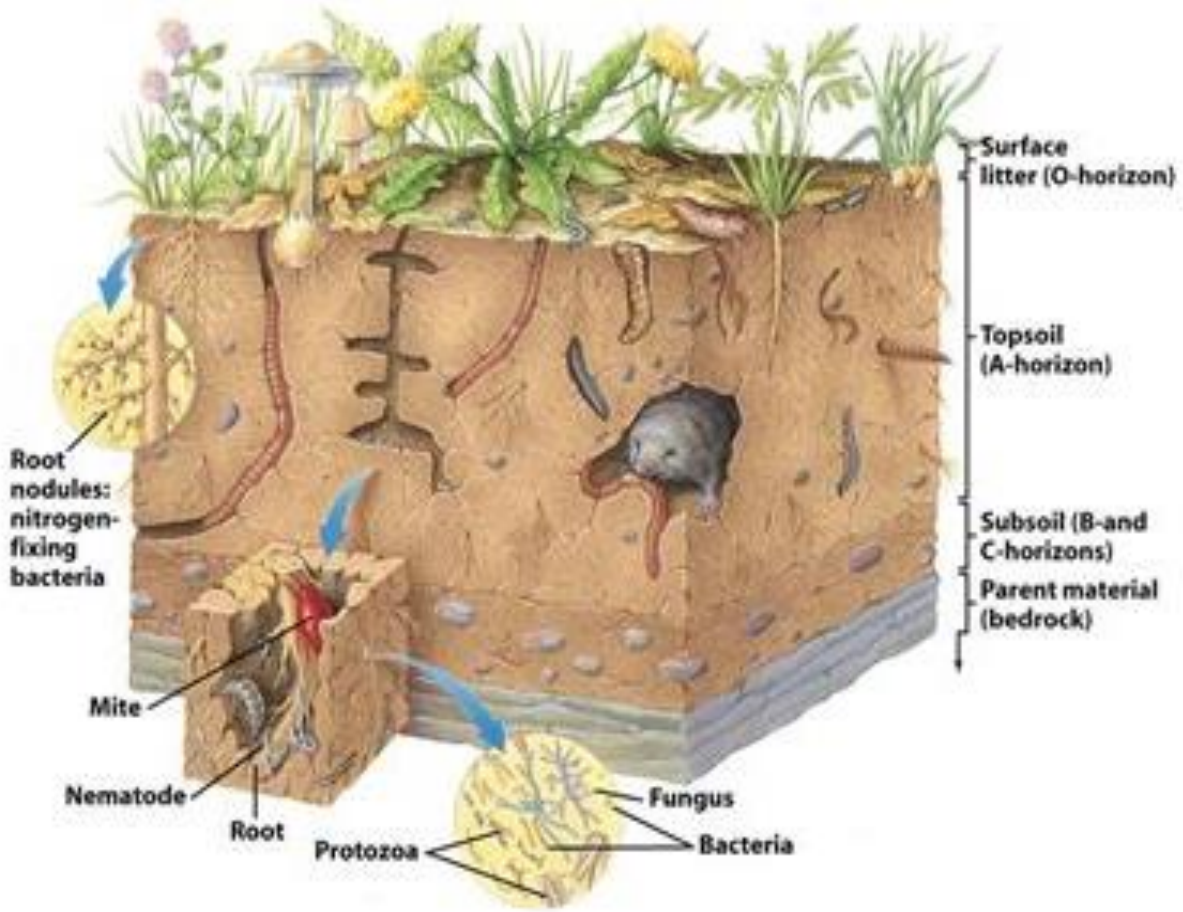
Soil Organisms

- Soil organisms are essential for keeping plants well supplied with nutrients.
- A soil rich in organic matter and continually supplied with different types of fresh residues is a good environment for diverse living organisms than soil depleted of organic matter
- The diverse community of organisms benefits the soil. For instance, they form the best protection against major pest outbreaks and soil fertility problems



Soil Fertility Management (Level 3 – Part I)

- The greater diversity of organisms also helps ensure that fewer potentially harmful organisms will be able to develop sufficient populations to reduce crop yields



Source: *https://www.scienceabc.com/wp-content/uploads/2020/01/Editable-vector-illustration-of-earthworms-in-garden-soilRobert-Adrian-Hillmans.jpg*

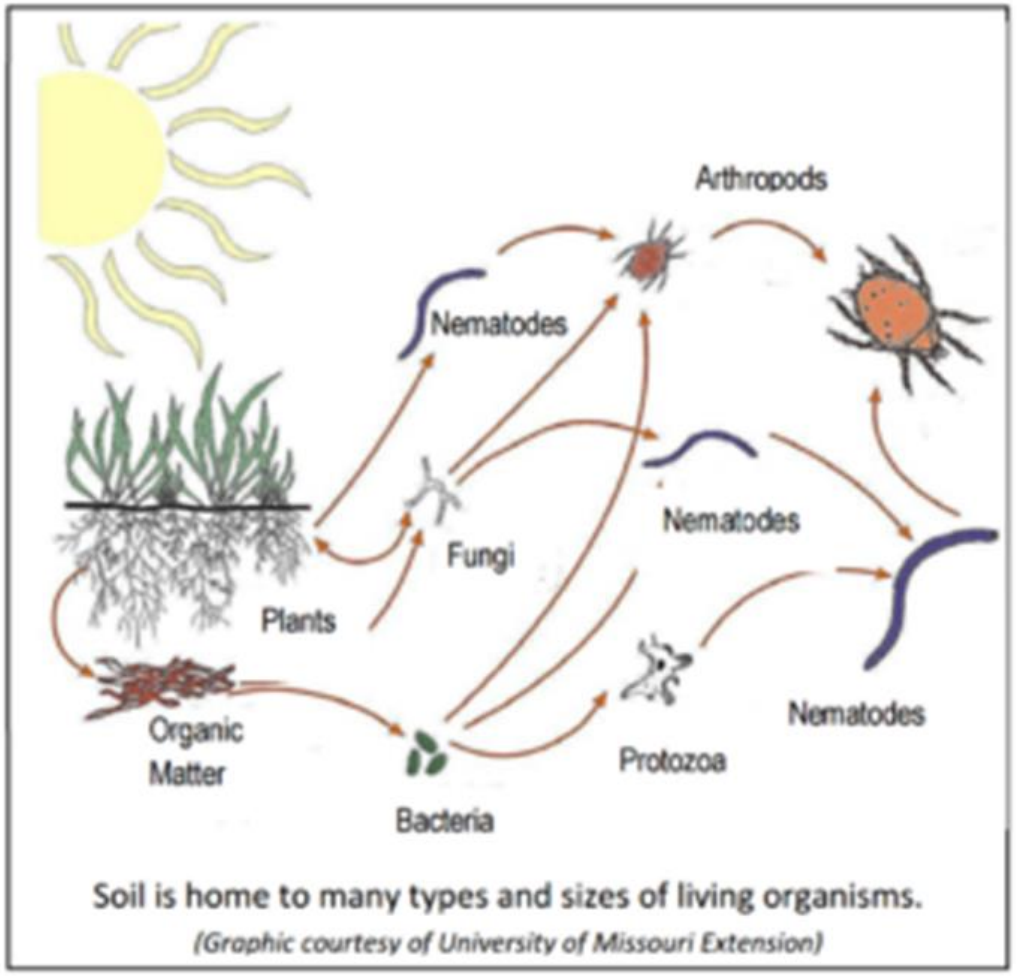
Soil Fertility Management (Level 3 – Part I)

Beneficial effects of soil organisms

- Naturally, nutrients in soil strongly depends on the presence of soil organisms because they break down organic matter. These organisms make nutrients available to plants by freeing them from organic molecules

- Some bacteria fix nitrogen gas from the atmosphere, making it available to plants

- Other organisms dissolve minerals and make phosphorus more available. If soil organisms aren't present and active, more fertilizers will be needed to supply plant nutrients



Soil is home to many types and sizes of living organisms.

(Graphic courtesy of University of Missouri Extension)

Soil Fertility Management (Level 3 – Part I)

Soil fertility

Plants obtain nutrients from two natural sources namely Organic matter and Minerals.

Soil Organic matter (SOM)

- Organic matter is the component of soil, consisting of plant and animal material at various stages of decomposition, cells and tissues of soil microbes, and substances that soil microbes synthesize.

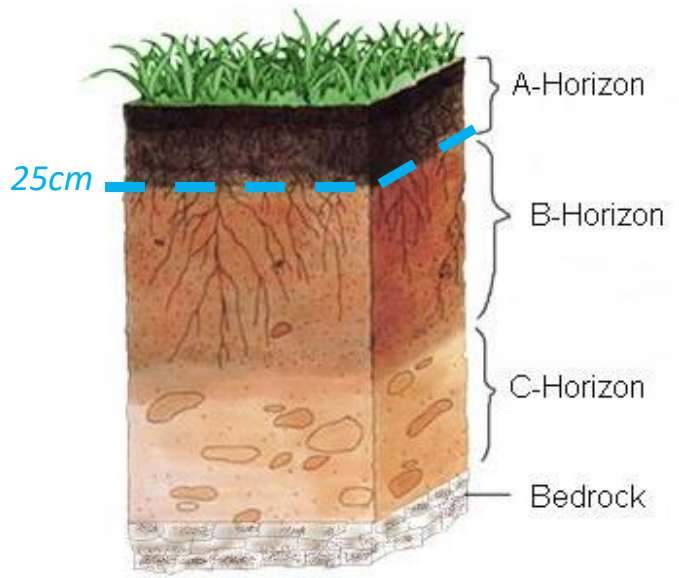
Note: *Enhance soil organic mater and soil organisms.*

Soil Fertility Management (Level 3 – Part I)

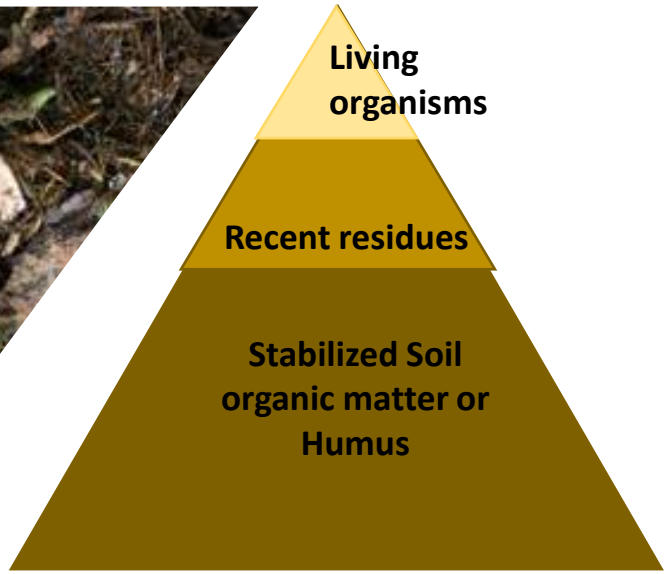
Benefits of Soil Organic Matter (SOM)

- Soil organic matter gives an indication of the measure of a soil's ability to supply nutrients for plant growth

- Organic Matter is especially critical for soil functions and quality in horizon A

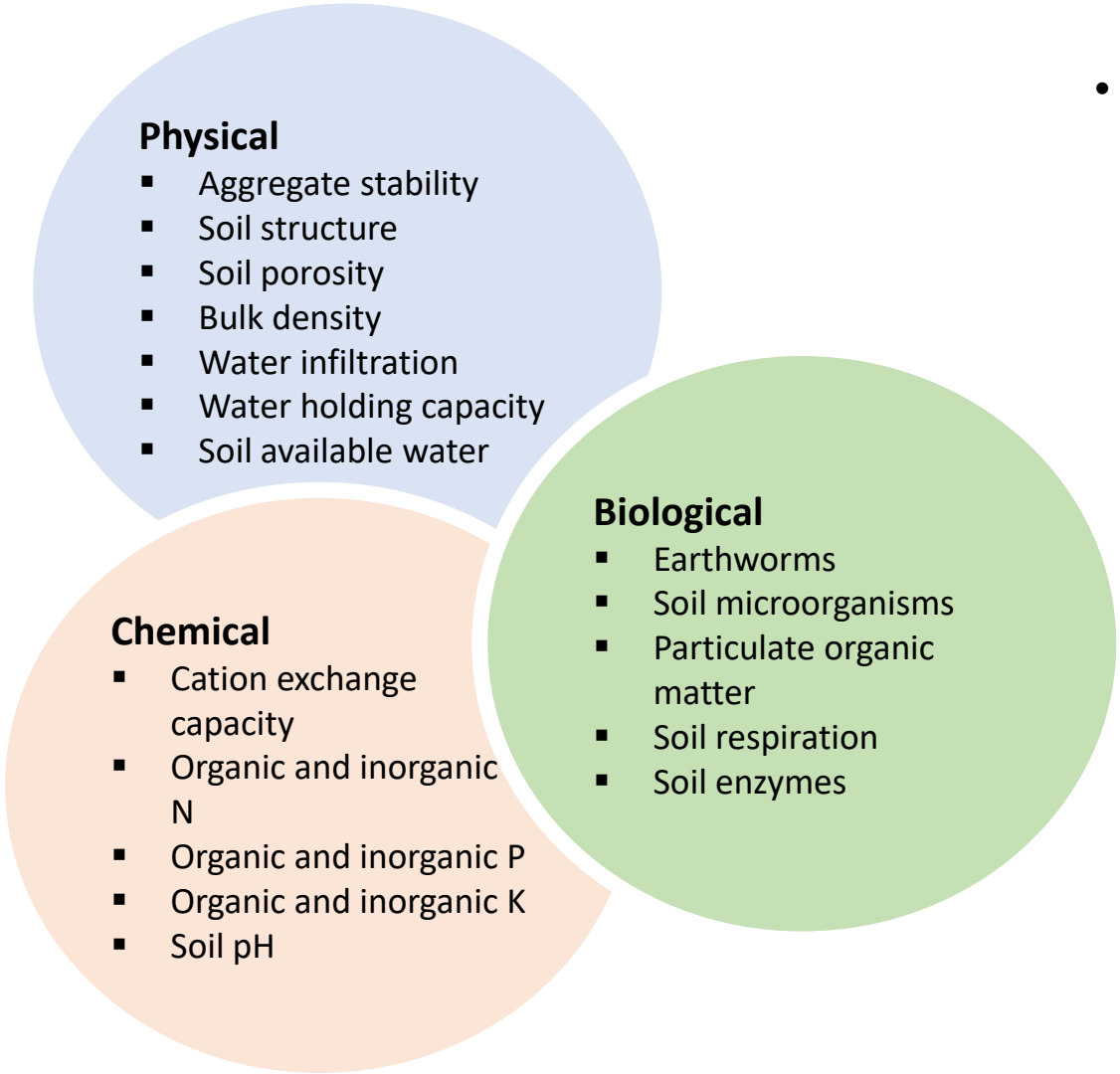


- A fertile soil has organic matter that: -
  - improves soil structure
  - improves soil moisture retention/holds moisture
  - improves nutrient retention
  - regulates soil pH, which determines the ability of nutrients to being soluble and available to plants.



Source: *Adapted from Magdoff and Weil 2003*

Soil Fertility Management (Level 3 – Part I)

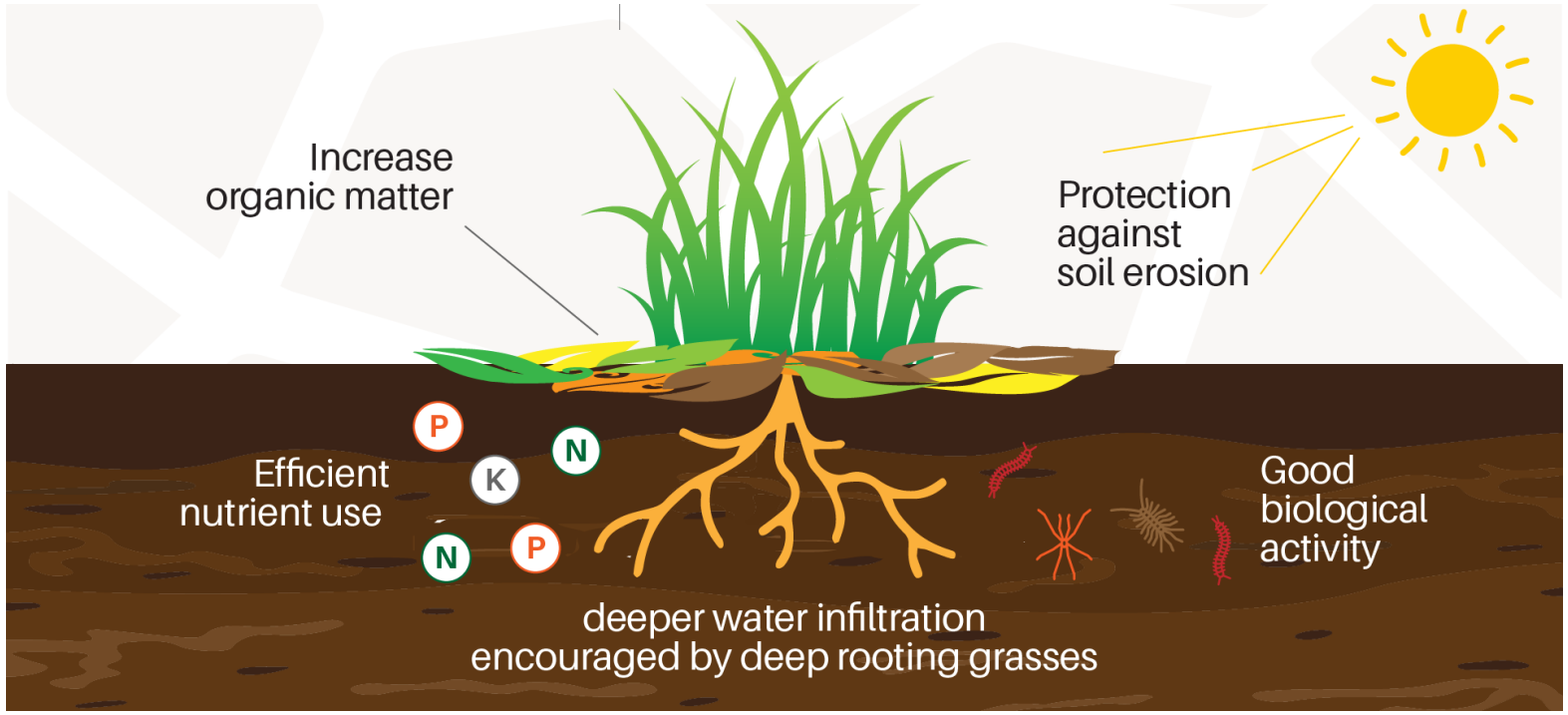


- Organic matter in the soil also provides benefits to the physical (e.g. stability in soil structure) and chemical (buffering capacity and nutrient availability) properties of soil and its capacity to provide regulatory ecosystem (food source habitat) services.

Soil Fertility Management (Level 3 – Part I)

Decomposition of organic matter

- Soil organisms contribute to the building of soil organic matter.
- Soil organisms decompose into organic matter, mineral forms to become available for plants to easily use.



Soil Fertility Management (Level 3 – Part I)

Sources of organic matter

- Soil organic matter is maintained or even improved from the following sources:

  - Green/Farm yard manure
  - Green (cut) plant material
  - Mulch
  - Planting leguminous trees
  - Dead animals
  - Dead plant material (crop residues)
  - Compost

Farm yard manure

Soil Fertility Management (Level 3 – Part I)

What you need to know about Compost

- Compost is more than a just fertiliser, it helps build the soil
- Making Compost is cheap; it relies on materials that are available on the farm and does not require any specialized equipment
- Compost is made from animal manure and fresh plant materials, including dry materials. Wood ashes and old compost may be added too.

Source: *https://s3.amazonaws.com/newhobbyfarms.com/wp-content/uploads/2019/03/07214702/trench-composting-00-161674781-600x347.jpg*

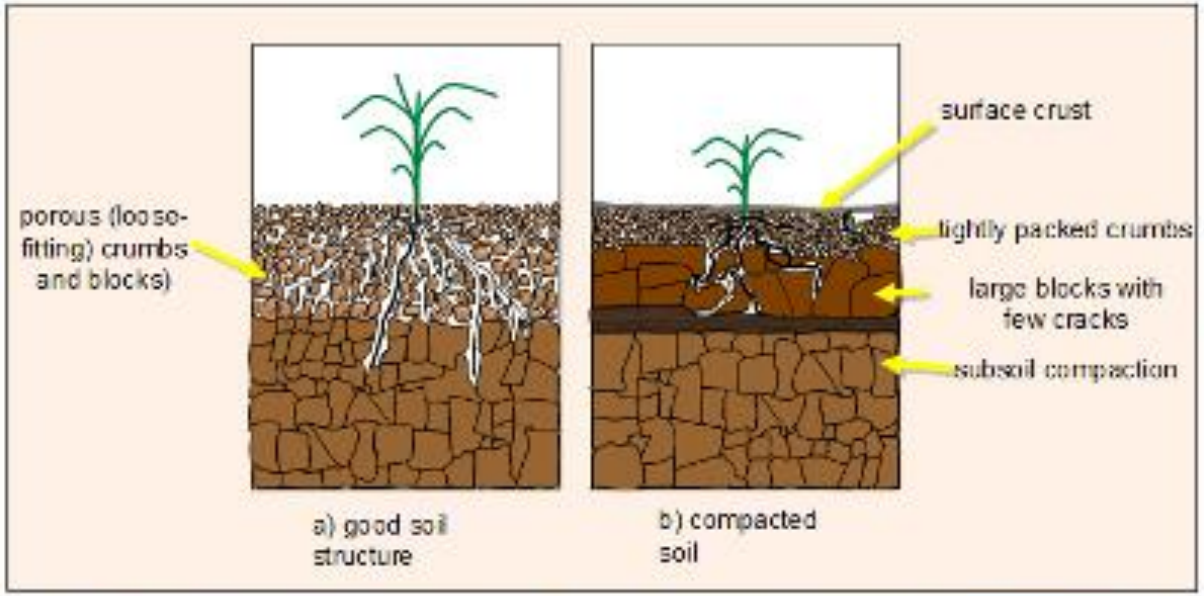
Sources of organic matter: How to make Compost

Soil Fertility Management (Level 3 – Part I)

Soil Fertility Management (Level 3 – Part I)

Soil Organic Matter: Compaction

- Soil compaction occurs when soil particles are pressed together, reducing pore space between them.
- Organic matter in the soil benefits the structure of the soil.
- A compacted soil has a reduced rate of both water infiltration and drainage

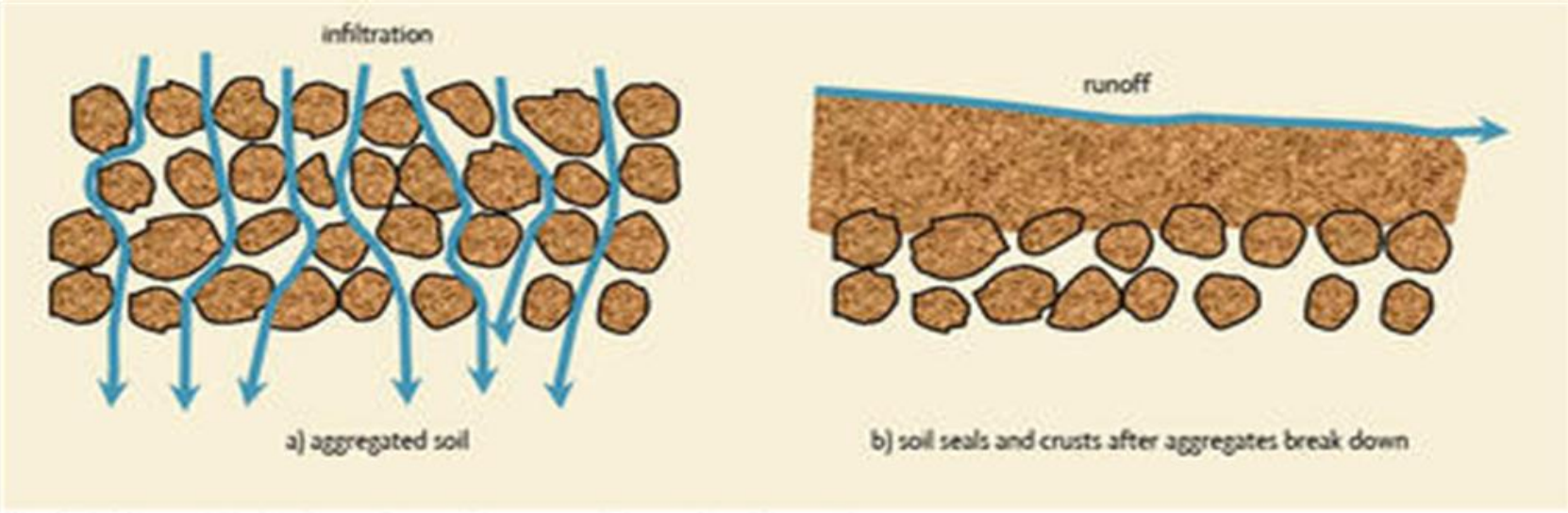


Source: *https://www.waldeneffect.org/20150226soilcompaction.jpg*

Soil Fertility Management (Level 3 – Part I)

- Compaction problems are likely to persist for a prolonged period of time, the best remedy is avoiding compacting the soil altogether.

Note: *Prevent Soil compaction*



Soil Fertility Management (Level 3 – Part I)

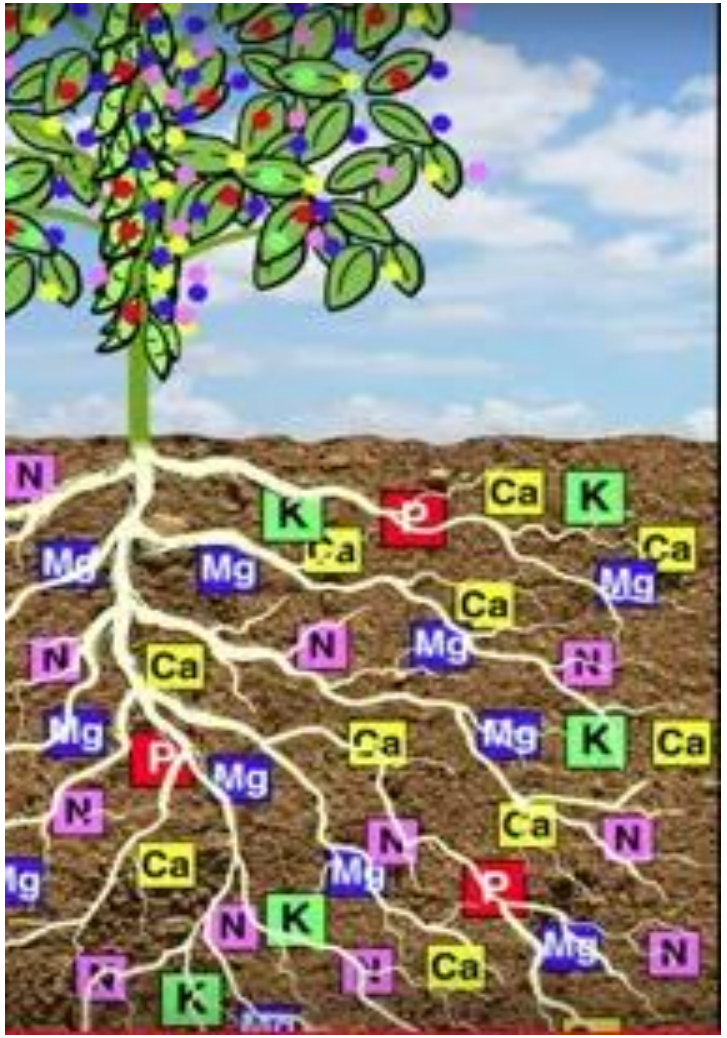
iii. Chemical Characteristics

1. Nutrients

- A fertile soil contains all the major nutrients (macro-nutrients required in larger quantities) for basic plant nutrition as well as other nutrients needed in smaller quantities (micro-nutrients)

- Unfortunately, many soils do not have high enough levels of all the necessary plant nutrients, or conditions in the soil are unfavourable for plant uptake of certain nutrients

- Such soils deficient of nutrients need to be identified and rectified through Soil sampling and analysis.



Source: *Plants – and the crops they grow – get their nutrients from the soil they grow in. Crops grown in nutrient-rich soil have higher nutrient content. Illustrator: J. Toomey*

Soil Fertility Management (Level 3 – Part I)

Soil Sampling: How to assess soil fertility

- Soil sampling and analysis is a possible way to determine the health/fertility of a soil.

- To carry out soil sampling, you will need the following equipment:
  1. Sample bags
  2. Auger or shovel
  3. Bucket
  4. Sample submission forms
  5. Field logbook
  6. Labels or marker pens
  7. Tape measure and;
  8. Mobile testing kit (for soil screening)

Source:
http://t2.gstatic.com/images?q=tbn:ANd9GcQxFNfo5VjNZ7eUukOX0joX9kLlxYKozEMMv9hzXqk3ooK7UazTdyRUAsumQmPLLNREp0GRIw27pplTypRXiAE

Soil Fertility Management (Level 3 – Part I)

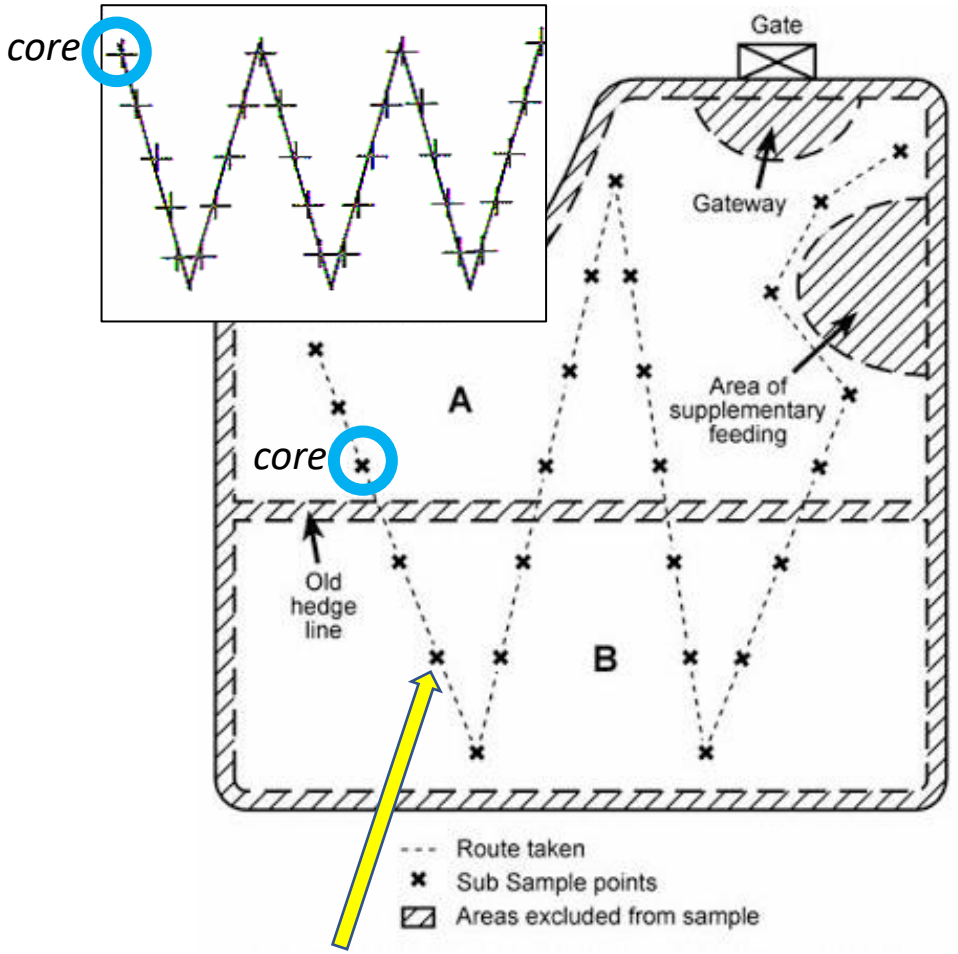
Procedure for Soil sampling

1. One sample should consist of between 20-30 cores taken from the set area of sampling. It is recommended that the cores be taken from the area in a zigzag pattern as shown in the field alongside

2. Scrape away surface litter and crop residues and sample the whole core from the true soil surface to 25 cm depth

3. Take between 20-30 cores from each uniform soil area. Place each core in a bucket and mix them thoroughly once you have taken all the cores

4. Fill the soil sample bag half full (**500g**) from this mixed representative sample.

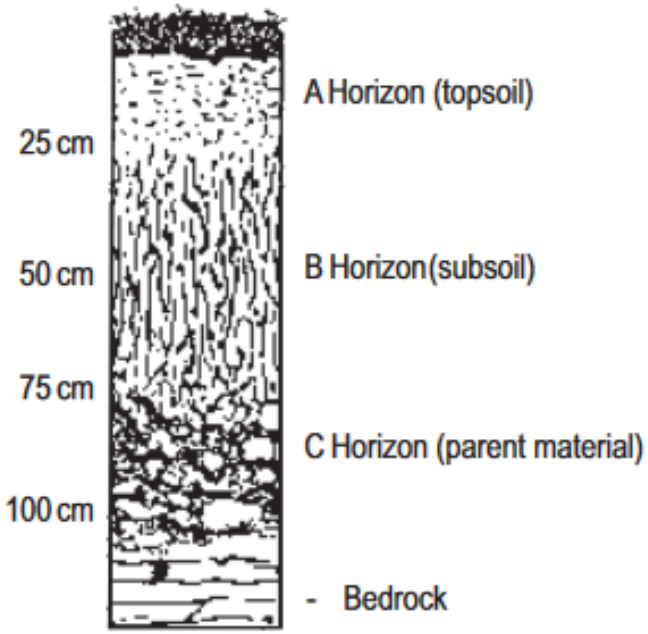


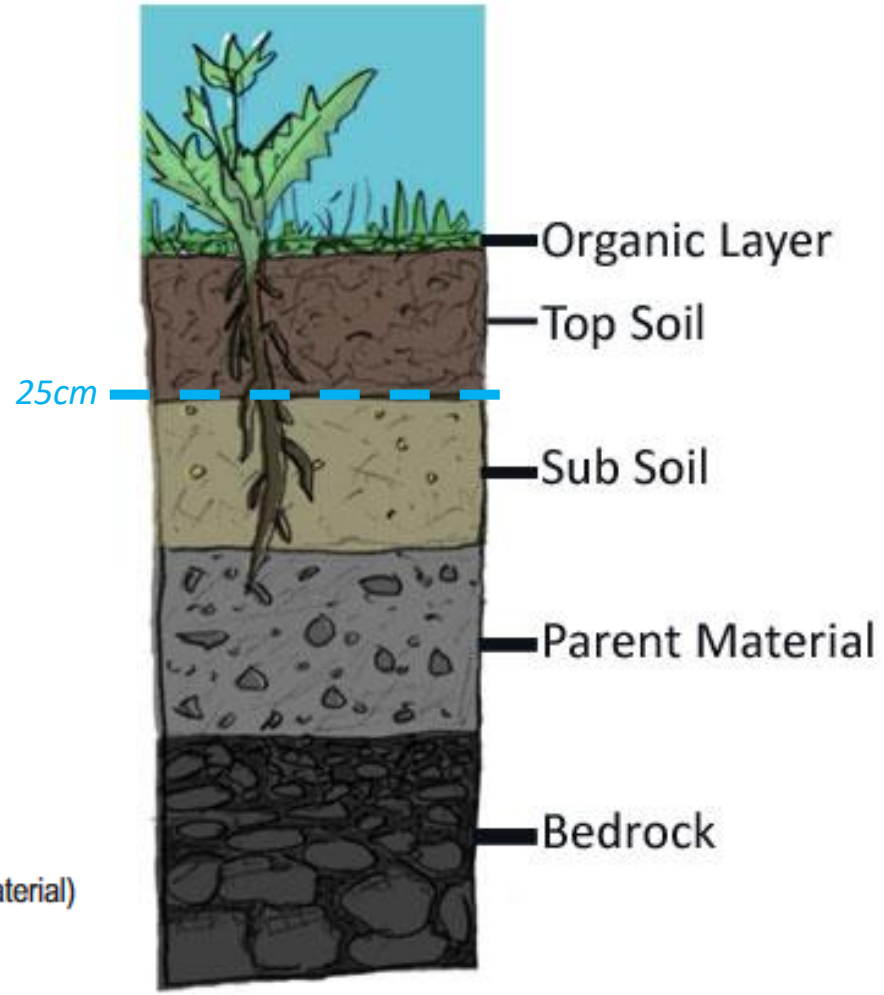
Zig-zag sampling helps sample each soil type equally (ensures homogeneity). X or + shows number of cores

Soil Fertility Management (Level 3 – Part I)

Sampling depth

Plant roots, biological activity and nutrient levels occur mainly in the surface layers (0-25 cm) hence most of the soil samples are collected within this layer.





Soil Fertility Management (Level 3 – Part I)

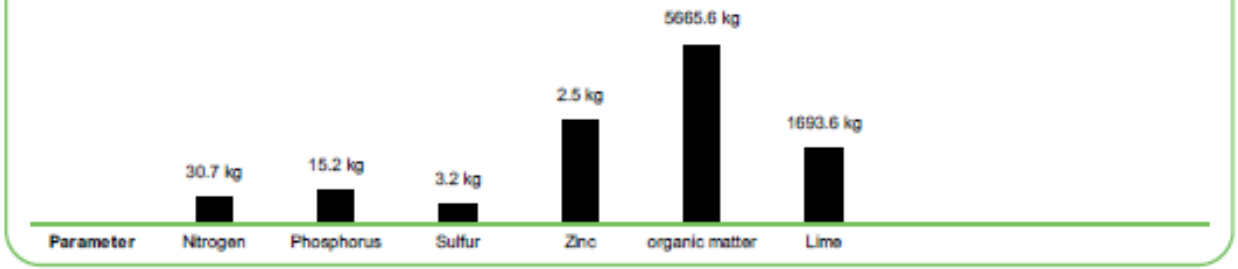
Sample analyses

- Send the collected sample for analyses and wait for results
- Once results are out, follow the recommendations with the aim to correct those nutrients with status low (meaning deficient). Avoid increasing the nutrients with status high.

General Information

Sample Number : AAASA00502A18 | Date : 2018-02-20 | Field Name : FIT | Field Size : 5 acre | Soil Texture : Clay loam
Crop Name : maize | Target Yield : 3000 kg

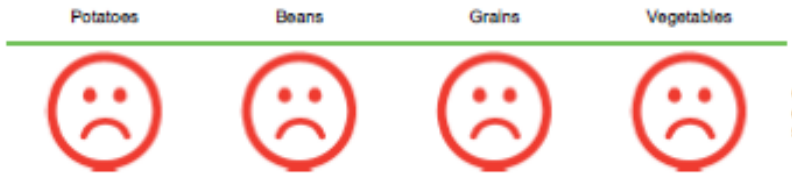
Actual Nutrient Need(in kg)



Fertilizer Recommendations

	Activities	Instructions	Best Option	First Alternative	Second Alternative
1	Before Planting	If Available	1700 kg Agricultural Lime		
2	Before Planting	If Available	5666 kg Compost or Animal Manure		
3	At Planting	Place the fertiliser at the bottom of the planting holes, put 10 cm of soil on top, add the seed and cover the seed with soil.	112 kg Mav 30:5:5 & 5M	51 kg Mav 12:34:10 & 5M and 61 kg urea	51 kg Mav 12:34:10 & 5M and 102 kg CAN

Suitable Crop Types



Growing potatoes, grains, vegetables and beans on your soil is difficult. Improving your soil acidity should have your priority.

Soil Fertility Management (Level 3 – Part I)

Soil Status

Parameter	Unit	Analysis Result	Range Low	Range High	Low	Adequate	High
pH (KCl)	pH Value	4,4	4,90	6,40	■		
Organic Carbon	g/kg	12,7	20,00	50,00	■		
Total Nitrogen	g/kg	1,1	1,00	2,00		■	
Total Phosphorus	g/kg	0,7	0,20	0,60			■
Total Sulfur	g/kg	0,2	0,30	0,50	■		
Potassium (exch.)	mmol+/kg	8,7	1,50	3,00			■
Calcium (exch.)	mmol+/kg	33,9	15,00	25,00			■
Magnesium (exch.)	mmol+/kg	23,3	4,50	10,00			■
Zinc (M3)	mg/kg	3,9	2,50	4,00		■	
Copper (M3)	mg/kg	4,5	1,00	2,00			■
Cation Exchange Capacity	mmol+/kg	88,7	75,00	200,00		■	
Clay	%	36,8	25,00	50,00		■	
Sand	%	42,5	35,00	55,00		■	
Total Aluminium	g/kg	80,4	56,00	91,00		■	
Total Potassium	g/kg	11,1	9,80	22,00		■	
Total Silicium	g/kg	282,7	250,00	330,00		■	
Total Iron	g/kg	53,4	27,00	72,00		■	
Phosphorus (M3)	mg P/kg	49,1	20,00	40,00			■
Total Manganese	g/kg	689	610,00	2300,00		■	

Status Low - *To correct*

Status Adequate - *Just right*

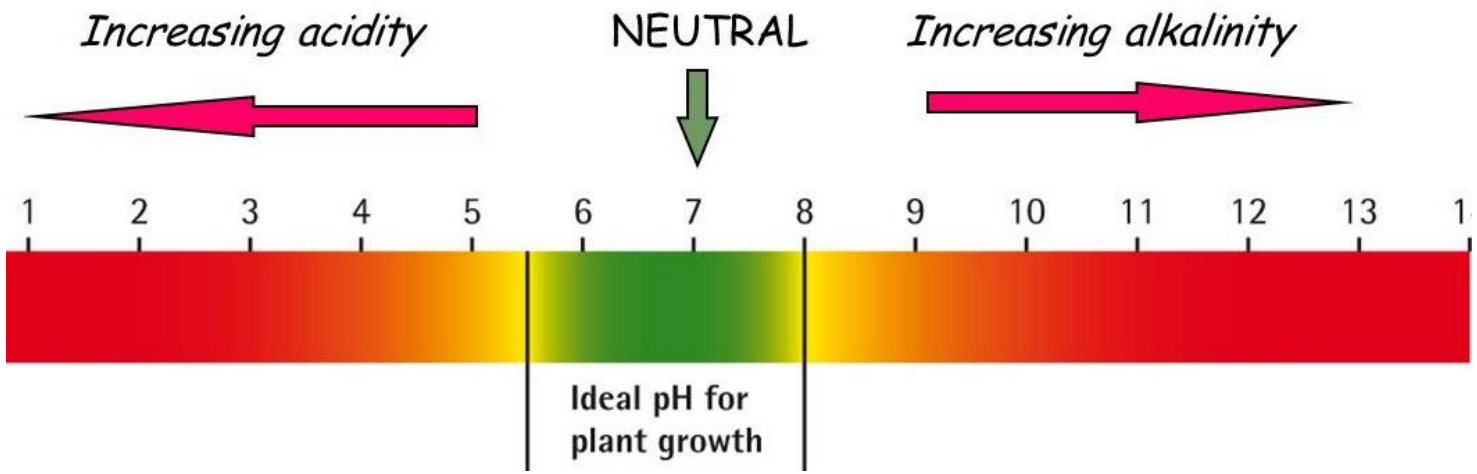
Status High - *Avoid increasing*

- The <u>detailed status</u> of soil sample analysis could be presented as shown alongside, specific to each nutrient.

Soil Fertility Management (Level 3 – Part I)

2. Soil pH

- Soil pH is a measure of the acidity and alkalinity in soils
- pH levels range from 0 to 14
- The optimal pH range for most plants is between 5.5 and 7.0.



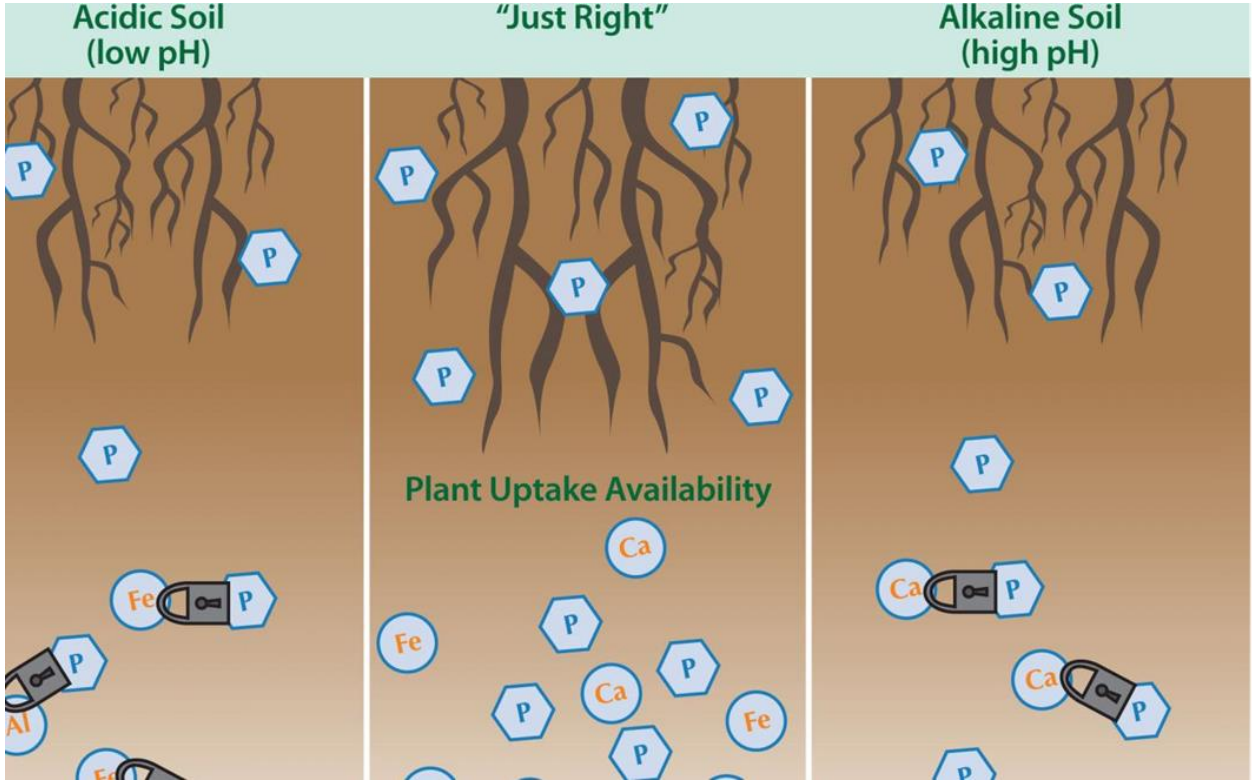
Soil Fertility Management (Level 3 – Part I)

Effect of Soil pH on Nutrient availability to plants

Soil pH affects availability of plant nutrients:

i. Phosphorus availability

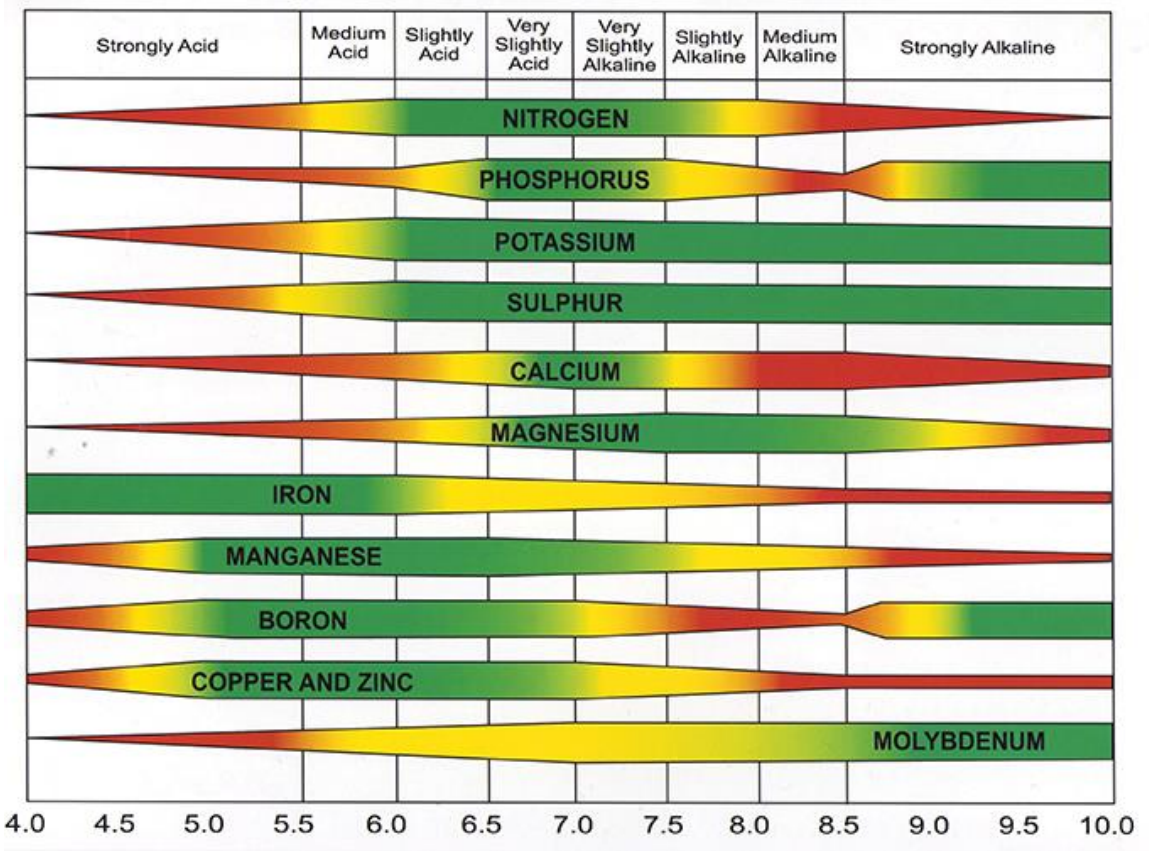
- When then the soil pH is just right, between 5.5 and 7. Phosphorus (P) is freely available
- In acidic soils (low pH) Phosphor is “locked in” with Iron (Fe)
- In alkaline soils (high pH) Phosphor is “locked in” with Calcium (Ca)



Soil Fertility Management (Level 3 – Part I)

ii. Other nutrients availability

- Green means the range in which a nutrient is easily absorbed
- Yellow implies the range that absorption is compromised
- Orange indicates that absorption is difficult; while
- Red denotes that absorption is extremely difficult

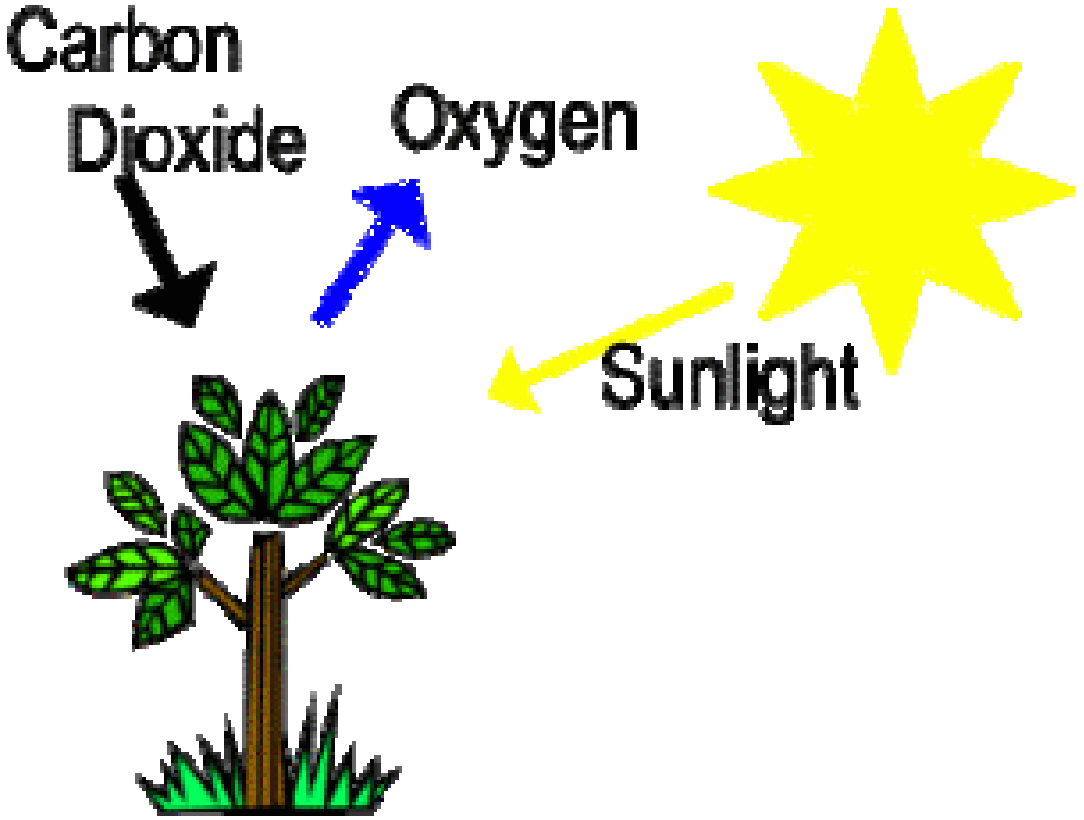


Soil Fertility Management (Level 3 – Part II)

Plant Nutrients

1. Plants can obtain Nutrients from the Air

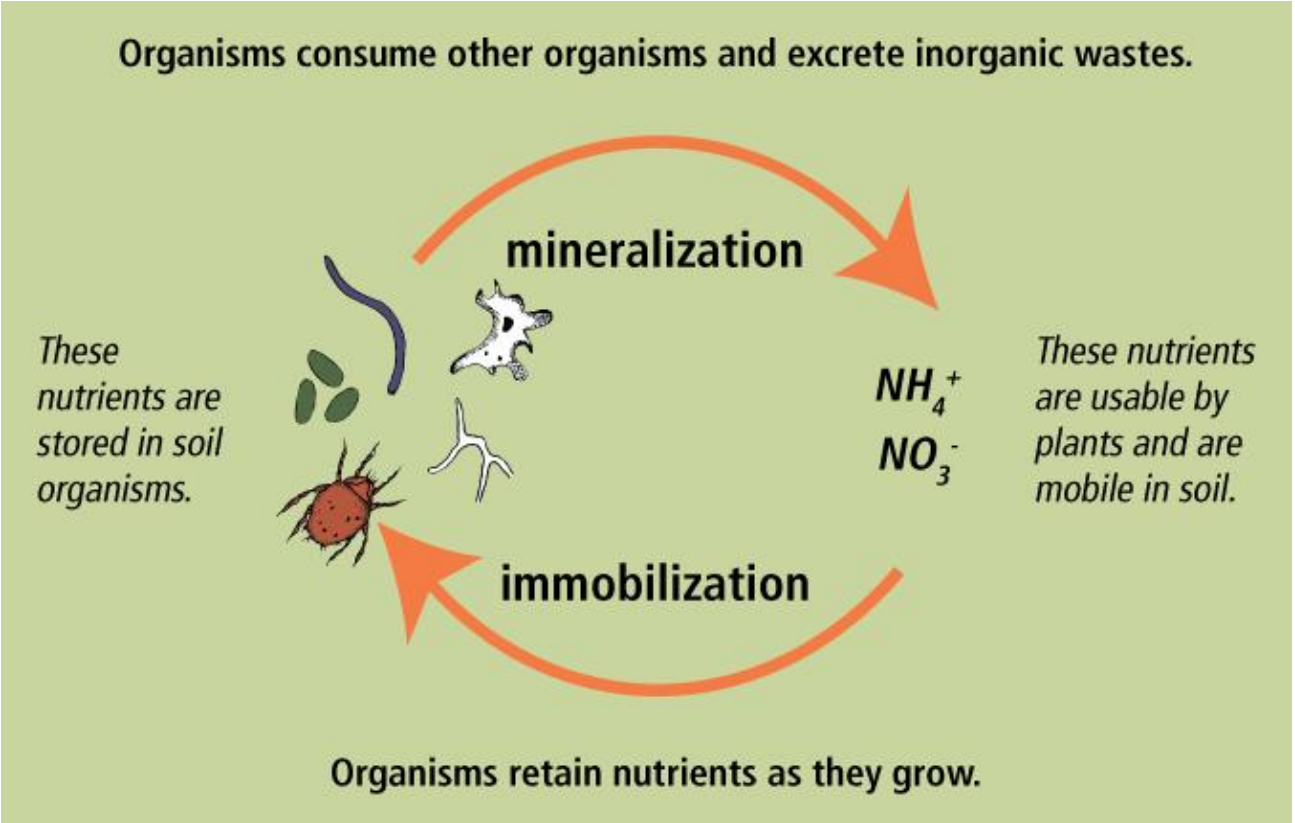
- Plants obtain carbon as carbon dioxide (CO_2) and oxygen partially as oxygen gas (O_2) from the air
- The remaining essential elements are obtained mainly from the soil. The availability of these nutrients is influenced either directly or indirectly by the presence of organic matter.



Soil Fertility Management (Level 3 – Part II)

Mineralization

- The process that provides much of the nitrogen that plants need by converting it from organic matter is called mineralization.
- For example, proteins are converted to ammonium (NH_4^+) and then to nitrate (NO_3^-)

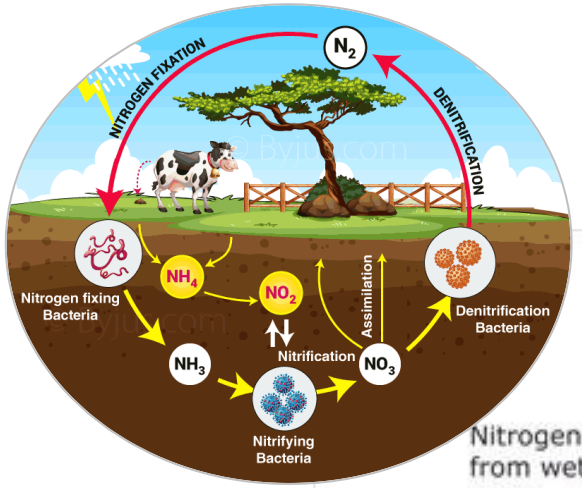


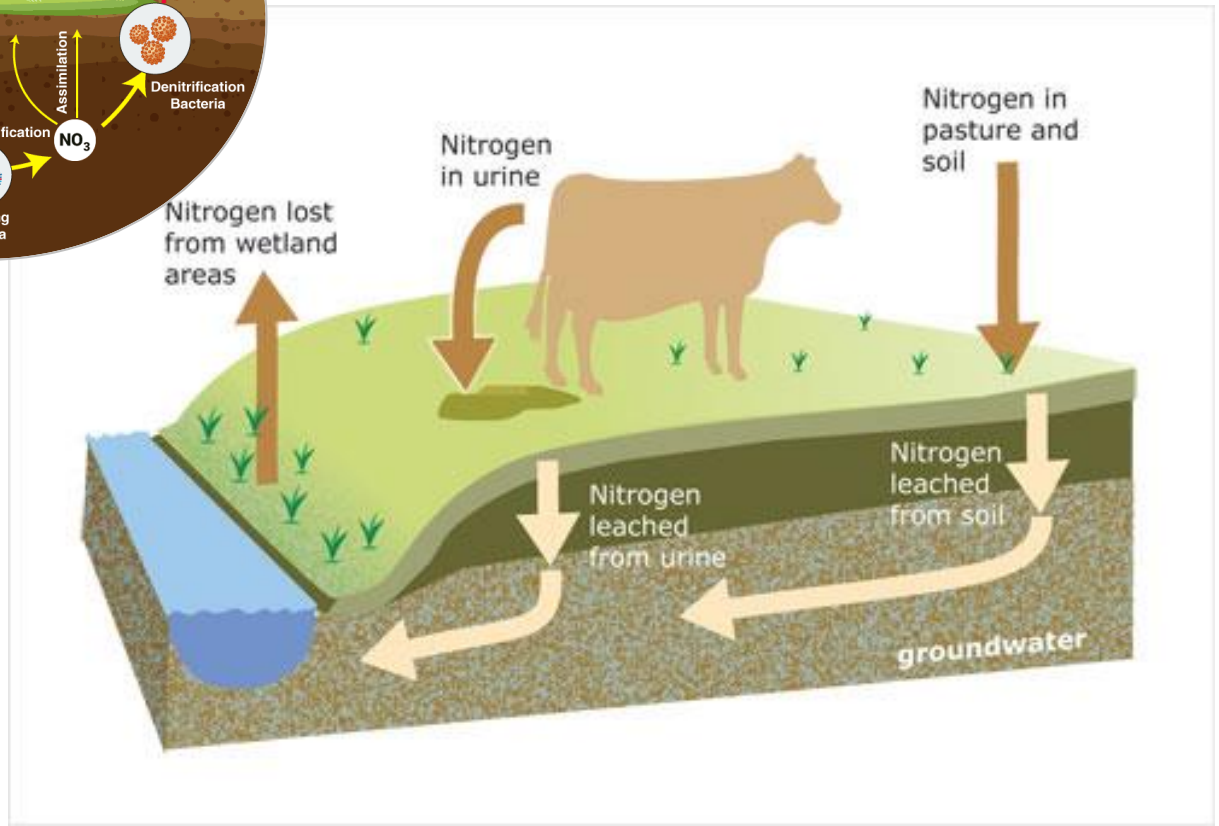
Soil Fertility Management (Level 3 – Part II)

Mineralization Cycles

i. Nitrogen cycle

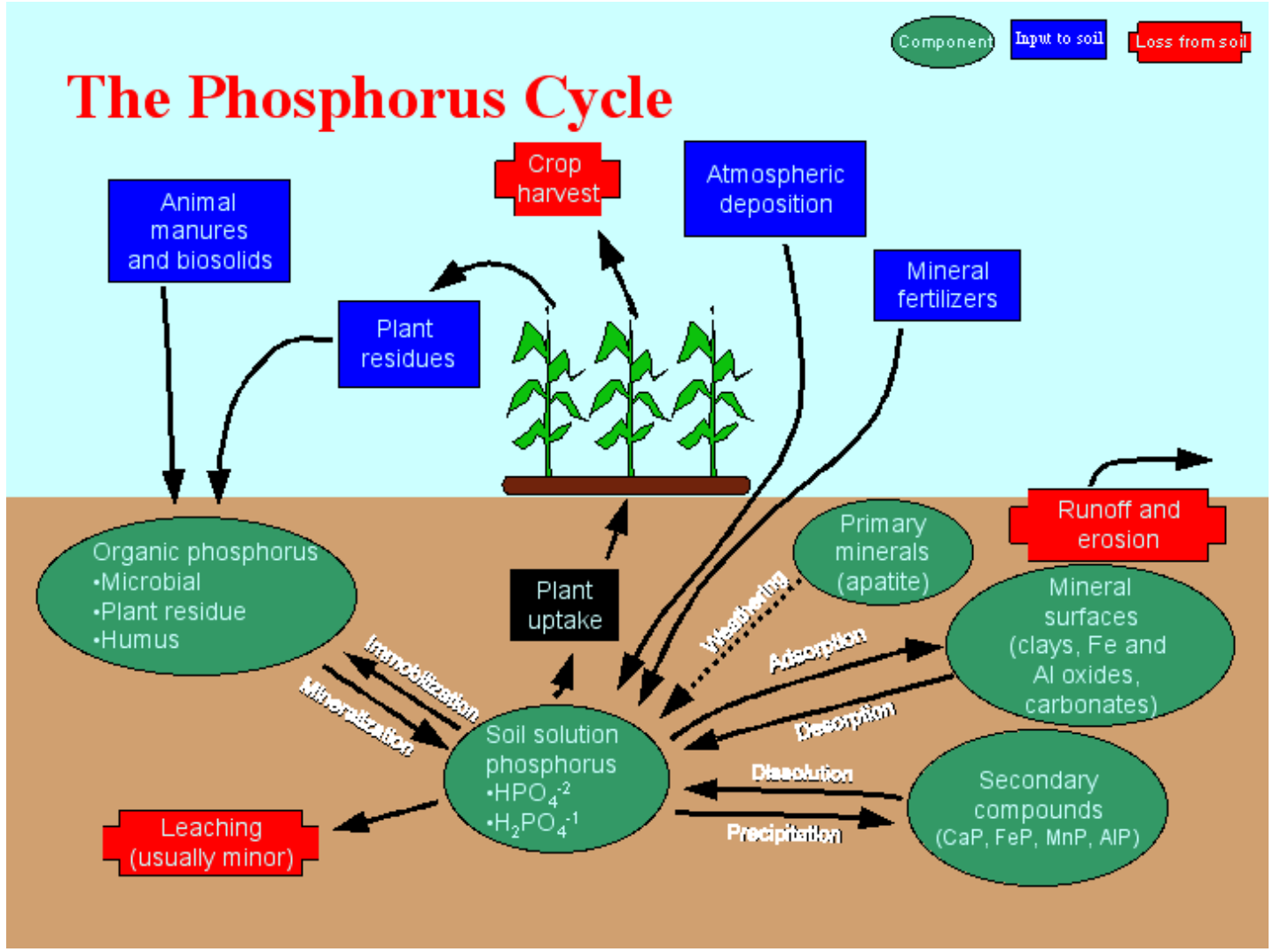
Most plants will take up the majority of their <u>nitrogen</u> from soils in the form of nitrate.





Source: *http://www.TeAra.govt.nz/en/diagram/17906/the-nitrogen-cycle-in-grazed-pasture (accessed 17 June 2020) | Story by Julia Haggerty and Hugh Campbell, published 24 Nov 2008*

Soil Fertility Management (Level 3 – Part II)



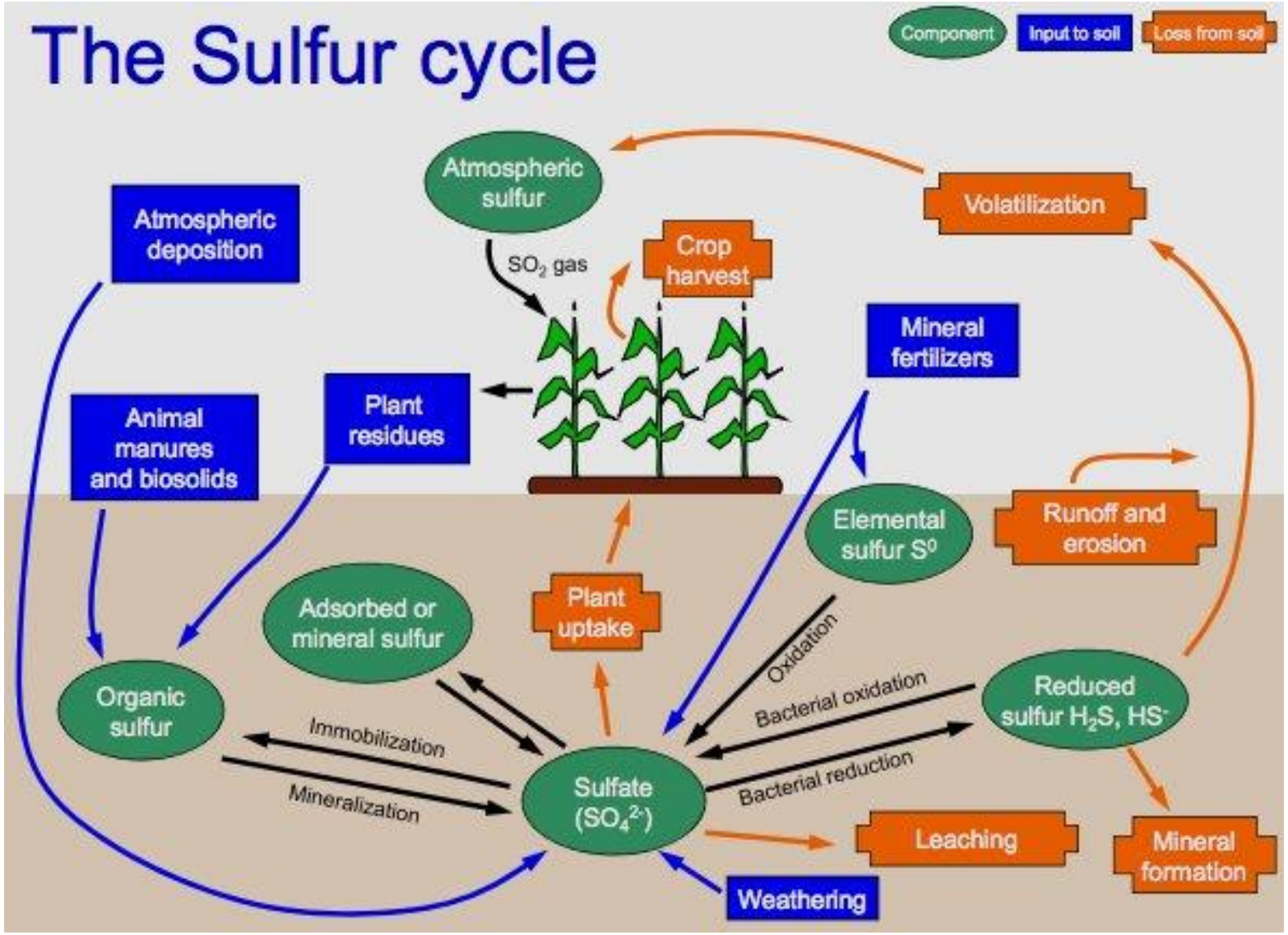
Source: *https://useruploads.socratic.org/ndxGCsYmRKOpTEJ3csdu_phosphorus.gif*

ii. Phosphorus cycle

Mineralization of organic matter is also an important mechanism for supplying plants with nutrients such as phosphorus and sulphur and most of micronutrients.

Soil Fertility Management (Level 3 – Part II)

iii. Sulfur cycle

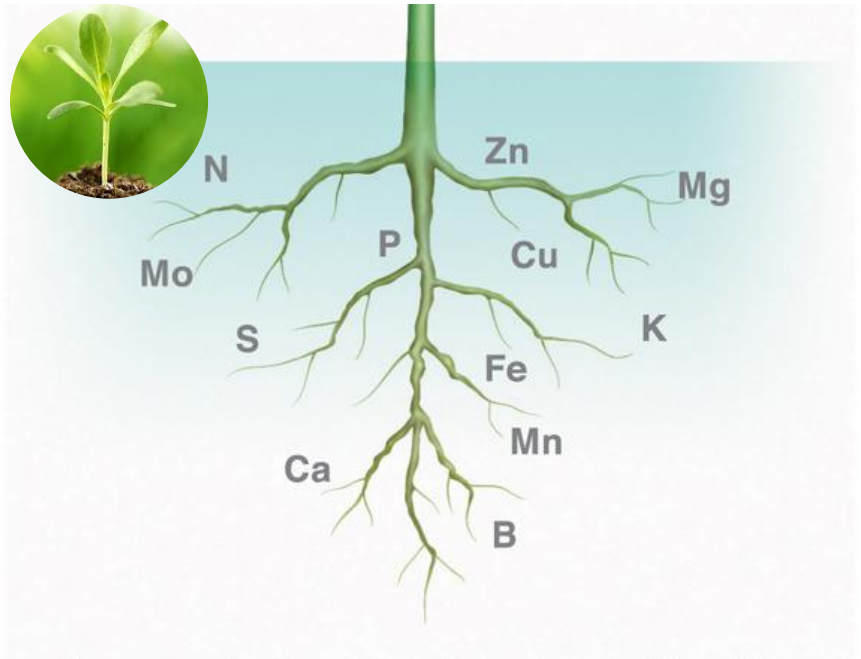


Source:
https://upload.wikimedia.org/wikipedia/commons/7/71/SulfurCycle_copy.jpg

Soil Fertility Management (Level 3 – Part II)

2. Plants also obtain Nutrients from the Soil

- **Macro Elements** are nutrients in the soil that are required by plants in large quantities. Plants therefore depend mainly on these nutrients
    - macronutrients include nitrogen, phosphorus and potassium, sulfur, calcium and magnesium.
- **Micro Elements** are nutrients found in the soil that are required by plants in tiny quantities. When they are supplied in large quantities it might be detrimental to the plants
    - Micronutrients are essentially boron, chlorine, copper, iron, manganese, molybdenum and zinc.



Macro Elements	Secondary Elements	Micro Elements
N - Nitrogen	**Ca -** Calcium	**Fe -** Iron
P - Phosphorous	**Mg -** Magnesium	**B -** Boron
K - Potassium	**S -** Sulphur	**Zn -** Zinc
		Cu - Copper
		Mn - Manganese
		Mo - Molybdenum

Soil Fertility Management (Level 3 – Part II)

Let's have a quick look at the Macronutrients:

1. The role of Nitrogen (N)

Plants absorb nitrogen in the form of nitrates. Plants use nitrogen to produce amino acids, proteins and compounds like chlorophyll. Therefore, nitrogen forms a crucial component of plant structure and materials. It is needed critically for proper growth and development.

Nitrogen deficiency symptoms

- It produces small, yellow leaves and results in stunted growth. Plants grow poorly.

Soil Fertility Management (Level 3 – Part II)

2. The role of Phosphorus (P)

Phosphorus is available to plants in the soil in the form of phosphate. Phosphorus is used as critical components of compounds such as proteins, enzymes, ATP (Adenosine triphosphate) etc. it is needed for establishment of roots and proper growth of plant nob.

Phosphorus deficiency symptoms

- Poor growth and development of plant nob. Poor growth or stunted growth of plants and grass plants tend to have slender/ slim stems

Purple leaf discoloration

Soil Fertility Management (Level 3 – Part II)

3. The role of Potassium (K)

Potassium is available to plants in the form of potassium ions. Potassium is used in the transport of nutrients and water from the soil. It serves as a cofactor that activates certain enzymes responsible for photosynthesis and respiration in plants.

Potassium deficiency symptoms

- Plants die prematurely. Leaf margin or edges of plants tend to be yellowish in colour

Soil Fertility Management (Level 3 – Part II)

The role of Magnesium (Mg)

Magnesium deficiency symptoms

Leaf of plants tend to be yellowish in colour along the plant nerves.

Soil Fertility Management (Level 3 – Part II)

Economic effects of nutrient deficiency in crop production

- Low yield of crops
- Poor quality of harvested crops
- Crops are susceptible to diseases and decay
- Loss of market value of crops
- Harvested crops may lack nutrients required for healthy growth when eaten
- Crops may not grow well and may die early without any harvest.

Soil Fertility Management (Level 3 – Part I)

Take Home Messages

1. A Healthy soil is the foundation of the food system; maintaining a healthy soil demands care and effort from farmers

2. Soil organic matter (a product of onsite biological decomposition) affects the chemical and physical properties of the soil and its overall health. Farmers should embrace sustainable soil use and management practices that enhance Soil organic matter!

Healthy soils support growth of crops

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