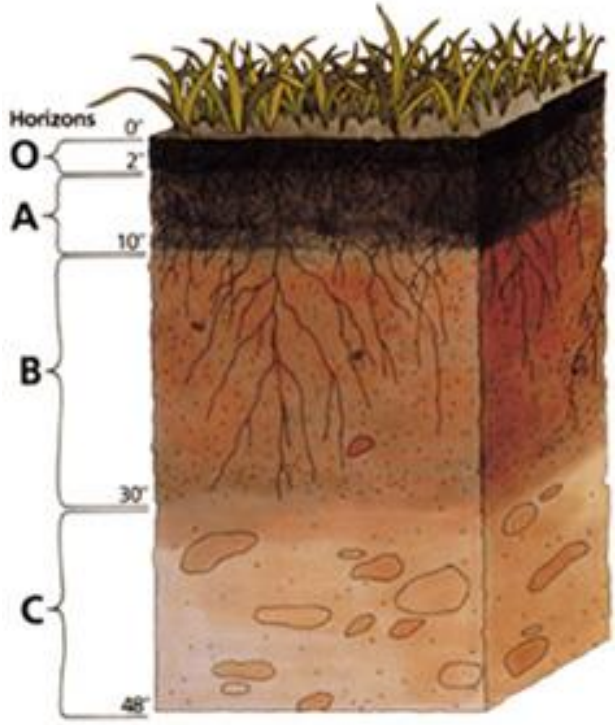



SOIL PROTECTION

SUMMARY - SOIL PROTECTION

- **1. Soil fertility**
- 2. Soils in Sub-Saharan Africa
- 3. Threats to these soils
- 4. Measures to protect these soils

SOIL ORGANIC MATTER



- Soil matter of living origin: composed mainly of C, O, H and N
- Essential for soil fertility and plant nutrition
- Very large specific surface
- Numerous possibilities for molecules to bind
- High CEC (availability of basic cations: K, Mg, Ca etc.)
- Creation of tissues and aggregates: clay-humus complexes: role of "cement" for the soil
  - Central role in the creation and maintenance of a stable soil structure
- Essential energy source for soil life (microbes and insects)
- Crucial importance for the decomposition of organic matter and therefore for crop nutrition

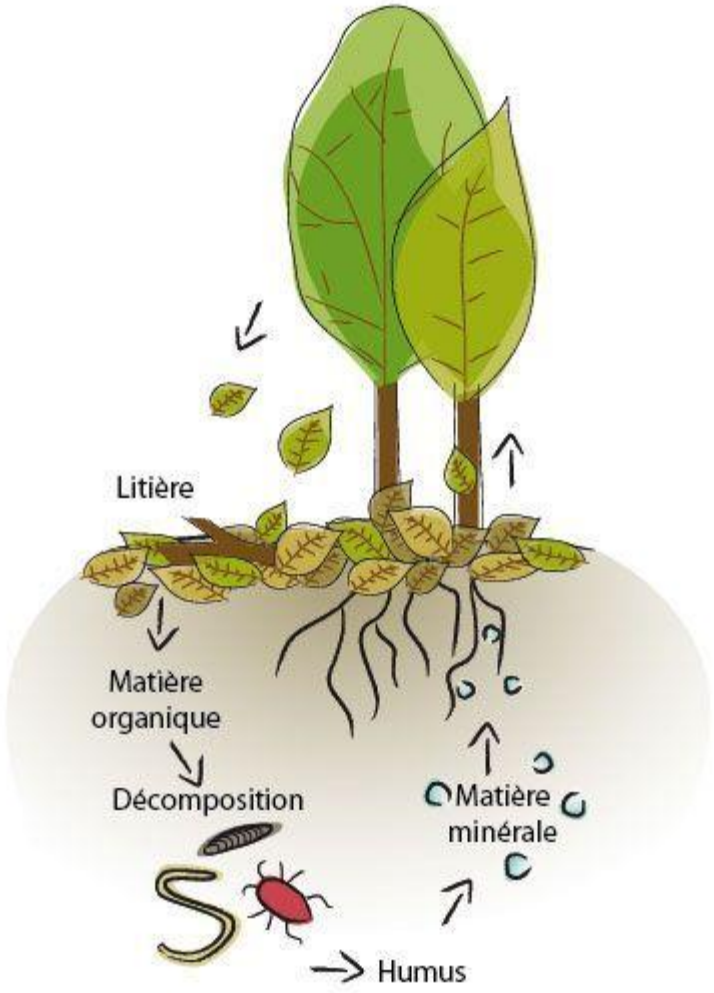
DYNAMICS OF ORGANIC MATTER

Inputs

- Animal defecation
- Plant residues (roots, stems, leaves, fruits)

Losses

- Erosion
- Leaching
- Mining
- Mineralization



MINERALIZATION OF ORGANIC MATTER (OM)

Mineralization: decomposition of OM by soil organisms and production of CO2 and molecules that can be assimilated by the plant (Nitrates, phosphates, ammonium etc.)

- Contact with the air
- Hot and humid climate: if no measures are taken: loss of OM in a few years

Mineral fertilization: causes an accentuated mineralization of OM

- PRIMING EFFECT: the contribution of nutrients (mainly N) will support the growth of microorganisms that will decompose OM
- A MINERAL FERTILIZER CONTRIBUTION MUST ALWAYS BE ACCOMPANIED BY AN ORGANIC CONTRIBUTION

CARBON HYDROGEN RELATION

- [C] / [N]
  - C concentration / N concentration
- High: high carbon, low nitrogen (C/N > 20)
- Hungry for nitrogen: the plant does not grow well because of a lack of nitrogen

- Low: high nitrogen, low carbon (C/N < 15)
  - Accelerated mineralization → loss of SOM → loss of fertility
- 15 < C/N < 20: ideal: nitrogen requirement covered to allow good decomposition of carbonaceous matter

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FERRALITIC SOILS

The soils of the savannah and forest areas of sub-Saharan Africa have been influenced for millennia by a hot and humid climate and intensive rainfall

- Chemical and physical alteration of the parent rock and primary minerals

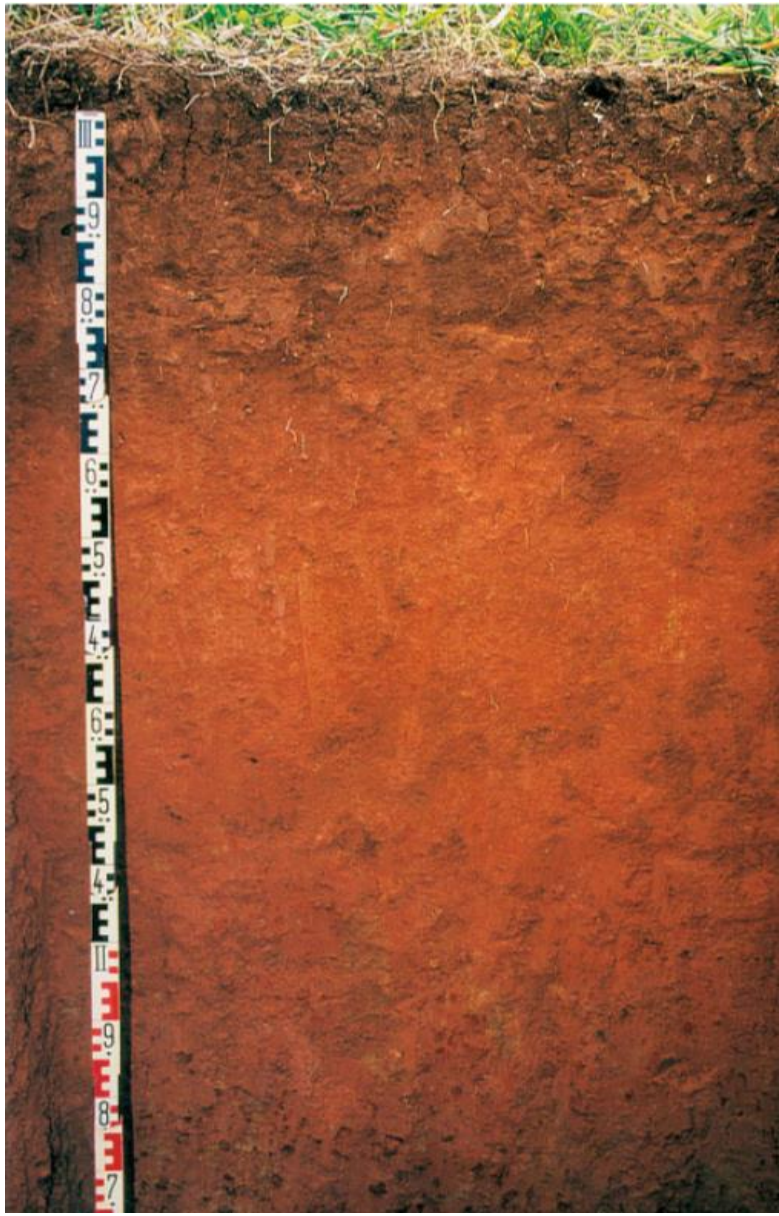
Constant leaching of secondary minerals produced by this process.

- Leached alkali minerals and base cations → loss of buffering capacity → acidification
- Nutrients leached → soil depletion

Relative accumulation of quartz, oxides and unalterable clays

- Low surface loads, low CEC → inability to retain water and nutrients.
- High capacity to fix phosphorus → low availability of phosphorus

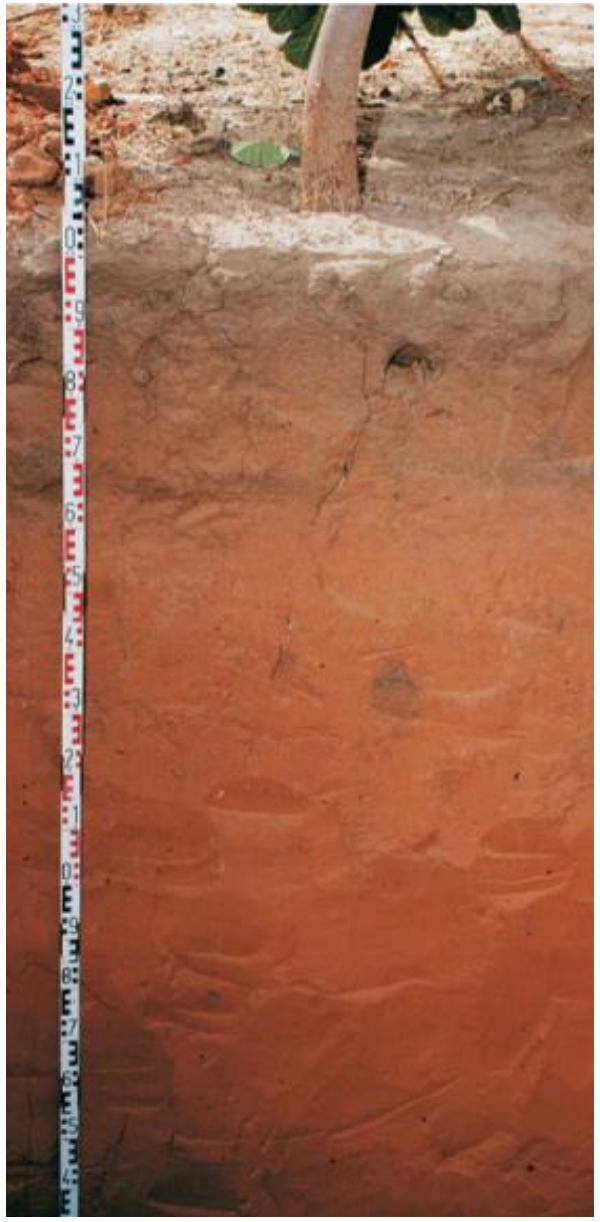
Ferralitic soils or Ferralsols



LEACHED SOILS

The alternation of dry and wet periods can cause:

- Leaching of clays to deeper horizons.
- Soils with low clay content at the surface Low water and nutrient retention capacity
- Leached soils: acrisols and lixisols



PETRIFIED FERRALITIC SOILS

In case of very strong alternation of dry and wet periods: North Cameroon or stagnation zones

- Formation of iron oxide concretions: laterites
- Impoverished soils, low nutrient retention, high P fixation

→ **Petrified ferralitic soils**

THE FERTILE SOILS OF THE TROPICS

Cambisol (brown earth)

- High CEC
- Good availability of nutrients
- Low P fixation

Nitisol

- Medium CEC
- Good nutrient availability
- Moderate P fixation

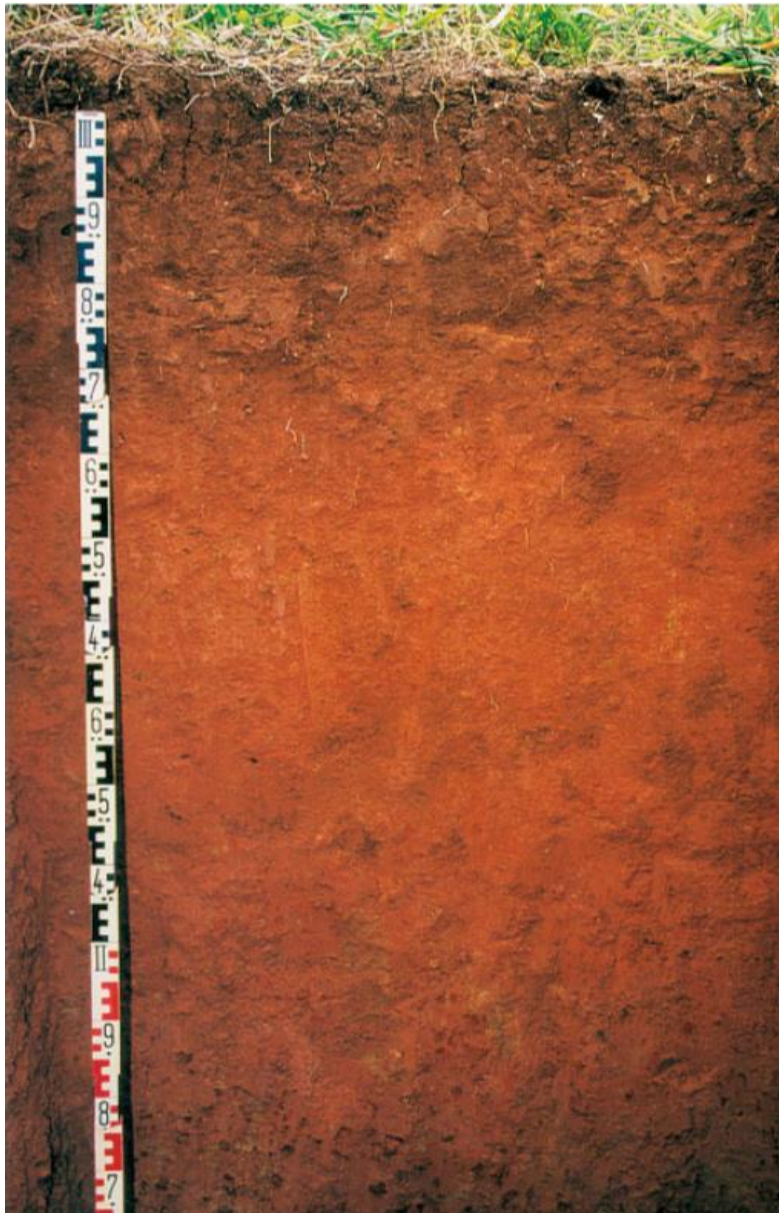
TROPICAL SOILS - CONCLUSIONS

The mineral horizons of tropical soils often have :

- Poor water and nutrient retention
- Low CEC: low availability of basic cations
- Phosphorus fixation
- Low content and availability of nutrients
- Low or very low pH

Conclusion:

- Organic matter is of crucial importance.
- High water and nutrient retention
- High CEC
- Reservoir of nutrients
- Buffer effect against acidity
- No P fixation



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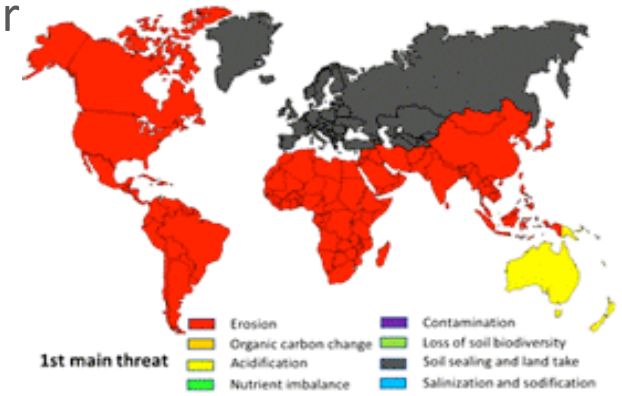
THE DANGERS FOR AFRICAN SOILS

- Main danger: loss of organic matter
- Difficult task, mainly linked to hot and humid climate (strong decomposition) and to rainfall (erosion, leaching)
- In the absence of primary forest, during cultivation, measures must be taken to protect, and constant inputs of organic manure must be amended to compensate for losses.

MAJOR RISKS FOR SUB-SAHARAN AFRICAN SOILS

The major risks to these soils are as follows (Montanarella et al., 2016):

- Mineralization of organic matter
- Erosion and leaching
- Nutrient mining
- Acidification



DANGERS FOR AFRICAN SOILS

MINERALIZATION OF ORGANIC MATTER

- Hot and humid climate
- Lack of organic fertilization (uncompensated losses)
- Soil exposed to the air (bare soil)
- Soil turned over (ploughing, tuber harvesting) → exposed to air
- Mineral fertilization : Priming effect
- Burning
- No or insufficient fertilization.
- Nutrient mining

DANGERS TO AFRICAN SOILS

EROSION AND LEACHING

DANGERS TO AFRICAN SOILS

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DANGERS TO AFRICAN SOILS

EROSION AND LEACHING

- Intensive rainfall
- Low soil cover, bare soil
- Soil turned over → soil structure destroyed → loose particles are carried away by water
- Lack of anti-erosion measures (ridges, hedges, stone barriers, drains)
- Insufficient SOM
- Burning

THE DANGERS FOR AFRICAN SOILS

ACIDIFICATION

- Natural (rain, lack of soil buffering capacity, secretion of acid root exudates from plants)
- Rotation with too many legumes (secretion of acid root exudates)
- Ammonium or triple phosphate mineral fertilization (acid fertilizer)
- Lack of use of lime or chicken droppings to raise the pH
- Loss of organic matter (buffering capacity)
- Burning

BURNING

During fire:

- Mineralization of SOM
- Volatilization of nutrients
  - 75 % N
  - 50 % P

After the fire:

- Bare and exposed soil
- Erosion
- Leaching
- Mineralization of SOM

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SOIL PROTECTION MEASURES

5 objectives to protect the soil:

1. Protect the soil and its OM from rain (leaching, erosion)
2. Protect the soil and its OM from the air (mineralization, loss of nitrogen by volatilization)
3. Add organic matter to compensate for losses
4. Add nutrients to compensate for losses/exports
5. Increase or stabilize the pH to avoid acidification

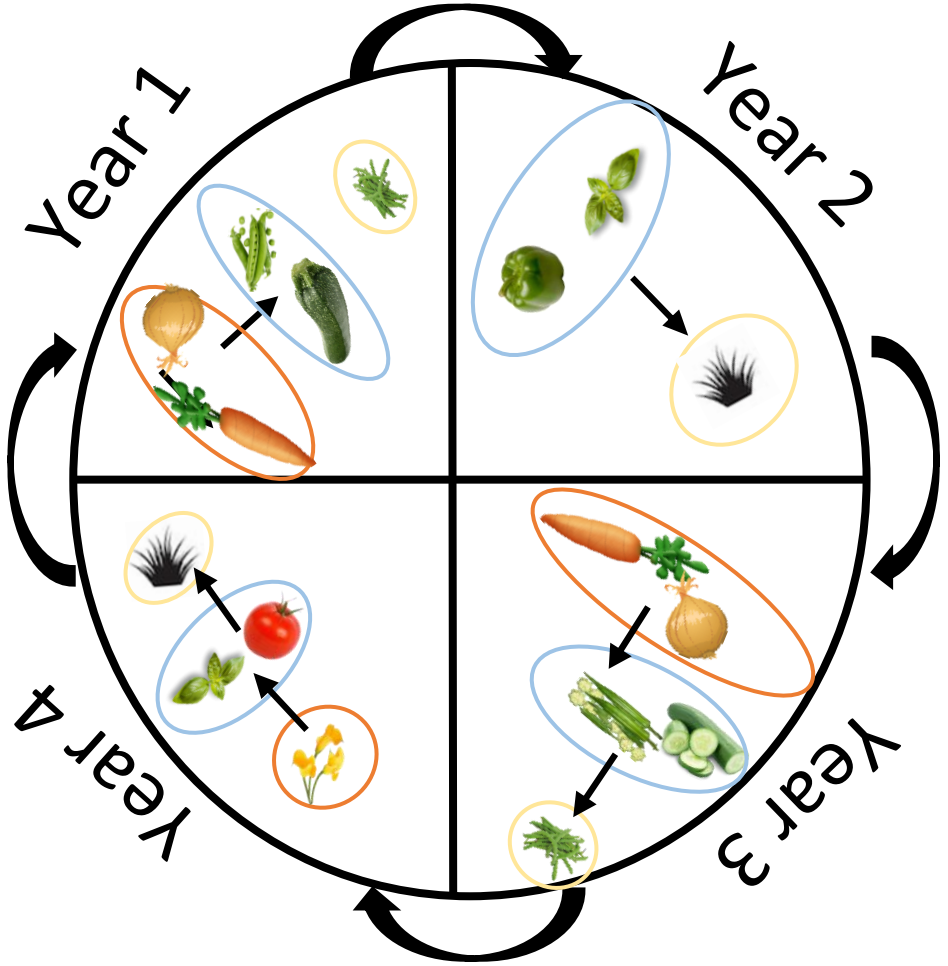
Different measures to meet one or more of the objectives

SOIL PROTECTION MEASURES - CROP ASSOCIATIONS

- Optimization of space → Better soil coverage
- Fills gaps between rows of a slow starting crop
- Cultivation of trees helps intercept raindrops
- Combine destructive crops with protective or regenerative crops

SOIL PROTECTION MEASURES - CROP ROTATIONS

- Cover the soil at all times
- Allow to alternate greedy and less greedy crops
- Allow to alternate destructive crops with regenerative crops
- Allow to alternate crops with different nutritive needs
- Avoid leaving bare soil!
- Between 2 crops, sow a green manure
- Mulching



RECOMMENDATIONS FOR AN EFFICIENT ROTATION

- Cultivate species of the same family in decreasing order of requirement and sensitivity
- Always cover the soil: protection against erosion, leaching and loss of organic matter.
  - If no crop is planned, sow a green manure.
- In dry season, provide a green manure or mulch, or leave the crop after harvesting the seeds.
- Provide a green manure every 4 years minimum

GRASSES

- Demanding in nitrogen (N) and phosphorus (P)
- Recycles nutrients from the deepest layers
- Enriches the soil with organic matter
- Deep and powerful root system
- High biomass production
- Possible green manure

LEGUMES

- Not very demanding, except in phosphorus (P)
- Fix nitrogen and mobilize soil P
- Used to enrich the soil in nitrogen
- Green manure

UNDERGROUND CROPS

- Involves intensive soil turnover and low soil cover
- Risks of erosion, leaching and loss of organic matter.
- They are destructive crops (except sweet potato)
- Alternate them with regenerative crops (legumes or green manures)
- Cultivate them maximum 1 year out of 4
- In case of cultivation with soil protection measures (mulching, associated crops, agroforestry), they can be cultivated 1 year out of 2
- Respect also the necessary breaks for the families to which they belong.

SOIL PROTECTION MEASURES

MULCHING

- Soil cover between crop rows
- Can be covered in the dry season
- Maintains humidity
- Limits weed growth
- Serves as a refuge for many beneficial organisms

SOIL PROTECTION MEASURES

GREEN MANURES

- A green manure is a crop that is grown to protect/regenerate the soil
- Produce a large amount of biomass
- Mobilize soil nutrients
- Nitrogen input (if legumes)
- The organic matter produced and the nutrients mobilized can be returned to the soil as :
  - Mulching, compost or manure after feeding the animals

  --> Contribution of organic matter and nutrients

SOIL PROTECTION MEASURES

AN ADAPTED FERTILIZATION

- Must match crop needs to avoid nutrient mining
- Insufficient mineral fertilization only:
  - Does not compensate for OM losses
  - Causes a priming effect and a loss of MOS

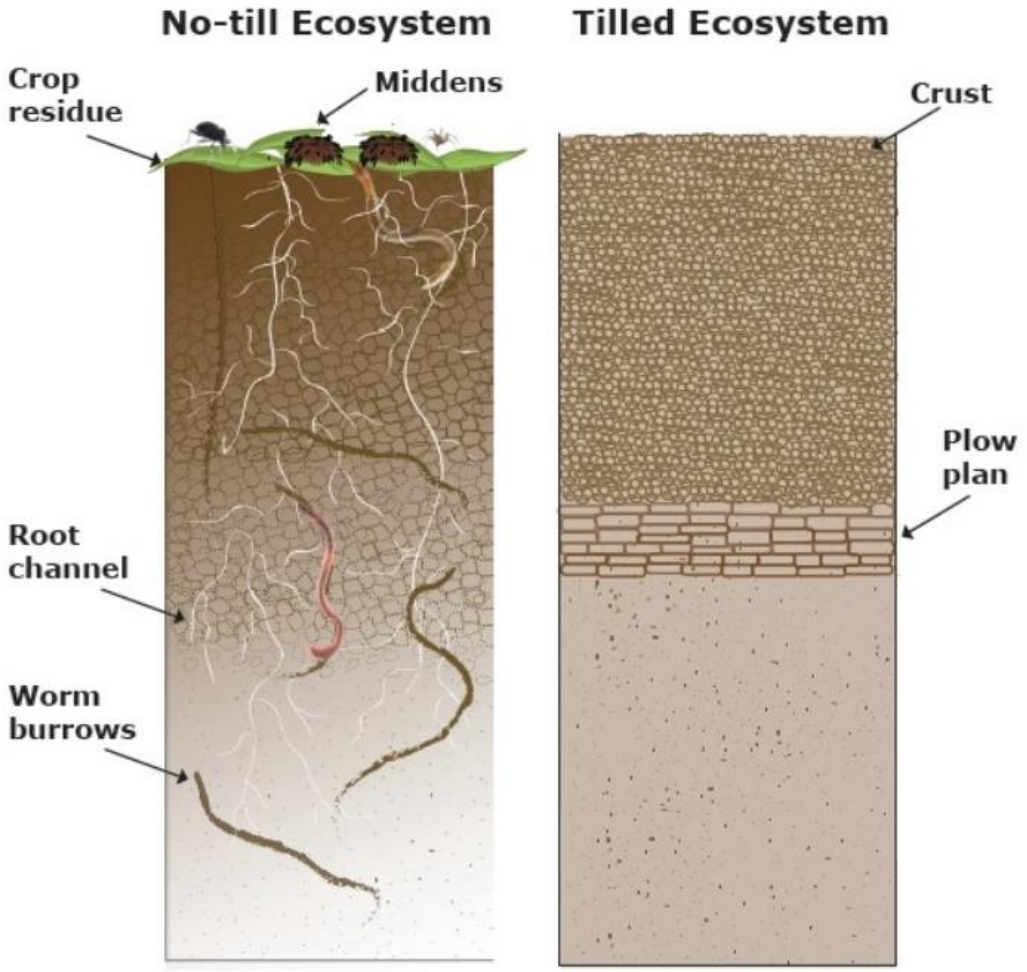
SOIL PROTECTION MEASURES

CONSERVATIVE TILLAGE

- Working the soil superficially and locally in the place where the seed or seedling will be planted
- Facilitated by a soil without hardened crust
- To protect the soil from erosion and prevent the creation of a crust:
  - A permanent cover of the soil is done by cultivation or by a mulch
- In a no-till organic production:
  - Limit the intensity of tillage to a minimum.
  - Must be done superficially (10-20cm) by hand or by animal traction
- Ridges and/or partitioned ridges can be added to reduce runoff

SOIL PROTECTION MEASURES

CONSERVATIVE TILLAGE



SOIL PROTECTION MEASURES

HEDGES

- Limit runoff and erosion
- Recycle leached water and nutrients
- Recommended around plots to keep water and soil in the plot
- Must be placed perpendicular to the slope following the contour lines
- Other advantages...
  - Biodiversity, forage production, barrier against pests and climatic hazards

SOIL PROTECTION MEASURES
STONE WALLS

- Limit runoff and erosion
- Recommended around plots to keep water and soil in the plot
- Must be placed perpendicular to the slope following the contour lines
- Other advantages...
  - Refuge for the beneficiaries

SOIL PROTECTION MEASURES

ACIDITY CONTROL

- When using synthetic nitrogen fertilizers, prefer nitrate (NO_3^-) or urea ($CO(NH_2)_2$) fertilizers
- Avoid the use of ammonium fertilizer (NH_4^+), an acid
- Limit the use of synthetic phosphorus fertilizers
- Prefer organic fertilizers, especially chicken manure
- Protect or increase MOS
- Apply lime
- Do not overload rotations with legumes

QUESTIONS?