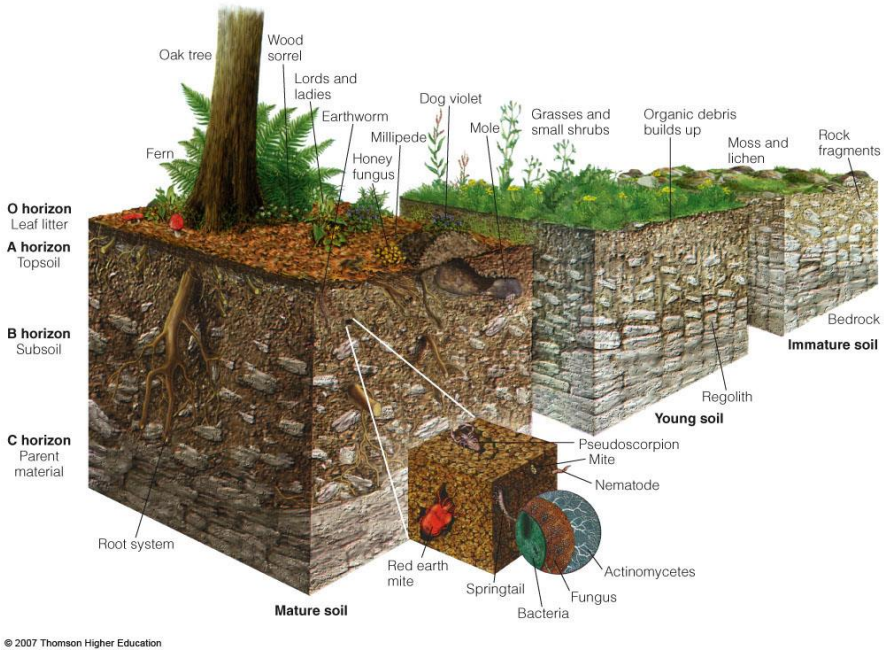
Problem soils and their management



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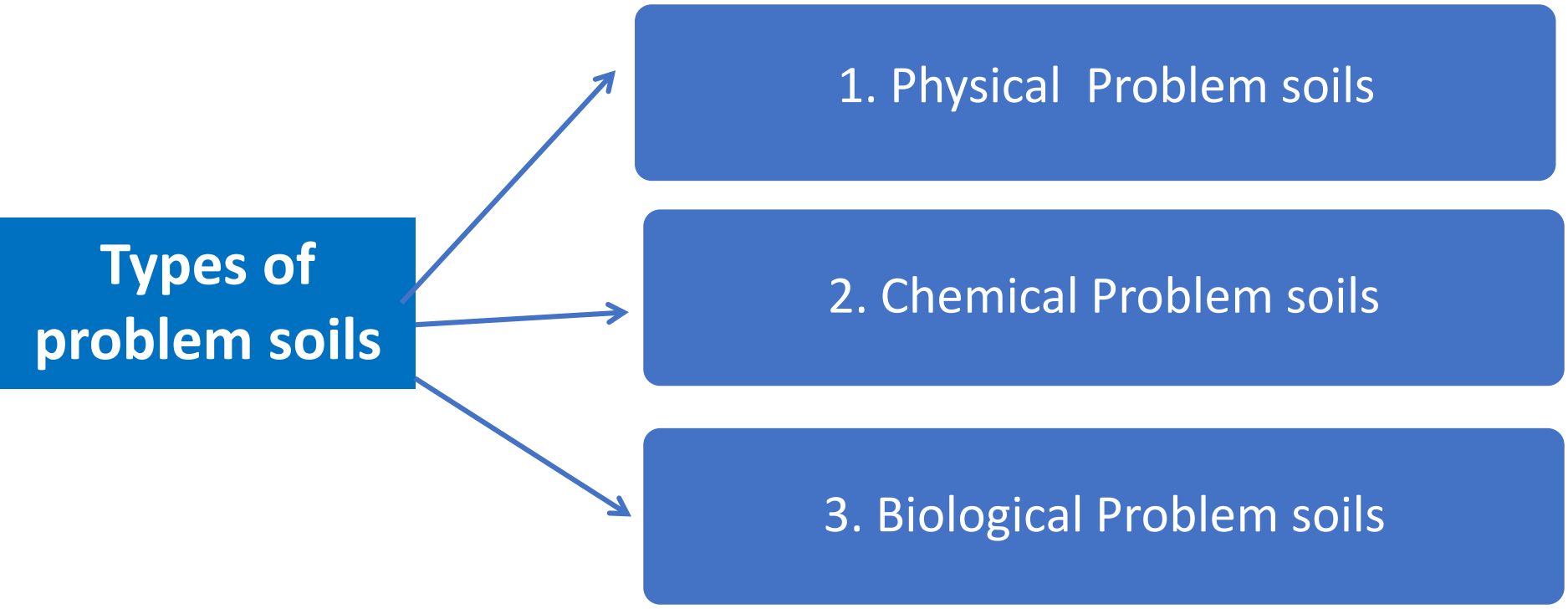
Department of Agriculture (Land use division)

The problem soil

- Soil that has **agricultural problems** due to the soil's unsuitable physical and chemical properties, or less suitable for cultivation.
- Productivity – lower (due to inherent unfavorable soil condition)


Types of problem soils
1. Physical Problem soils
2. Chemical Problem soils
3. Biological Problem soils

1. Physical Problem soils

1.1. High permeable soils & Slow permeable soils

Why is permeability important for soil?

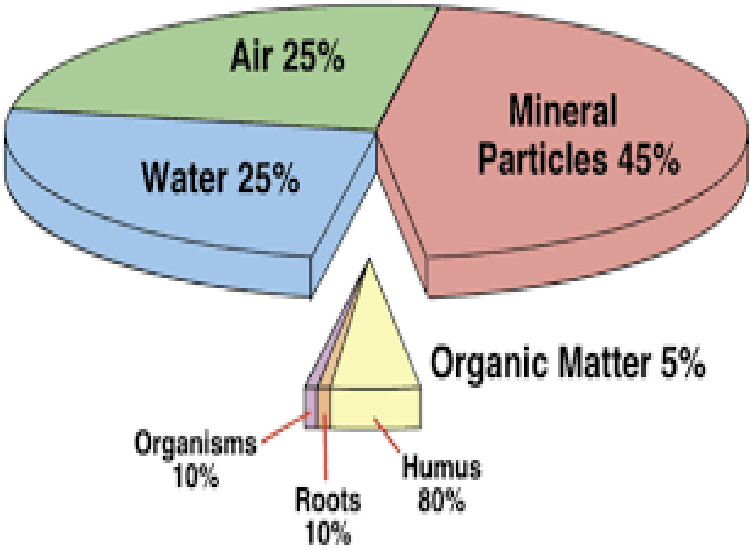
- **Permeability - movement of air and water through the soil**

  - the property of the soil to transmit water and air

- It is important because it affects the supply of root-zone air, moisture & nutrients available for plant uptake

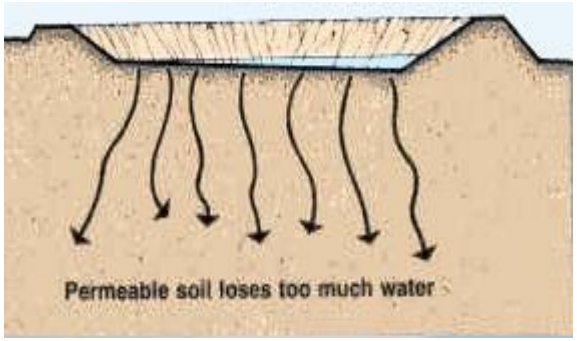
Good arable soil,

- ✓ possible for plant roots to obtain both air and water



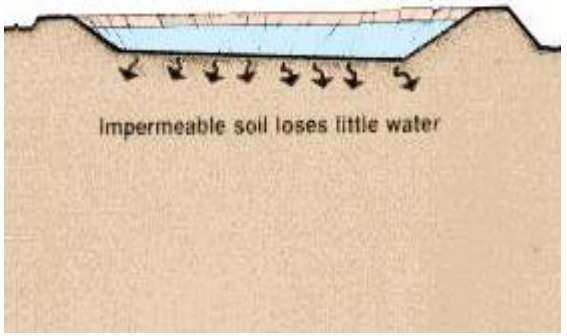
Sand

- ➢ drains too fast (high permeable)



Clay

- ➢ doesn't infiltrate & drain fast enough (slow permeable)



မြေဆီသြစာ
ကောင်းမွန်သောမြေ

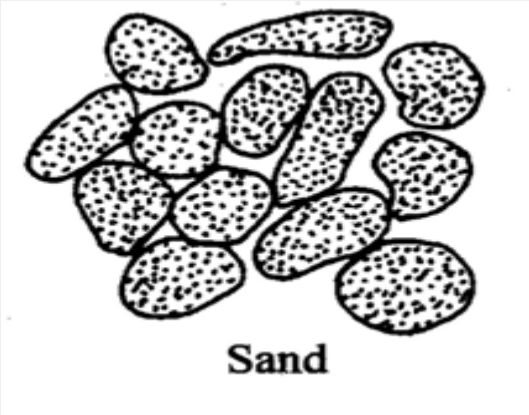
- အပင်အတွက်မရှိမဖြစ်လိုအပ်သော အများလို၊ အနည်းလို အဟာရဓာတ်များပေါများ
- မြေဆွေးဓာတ်လုံလောက်စွာပါဝင်
- မြေချဉ်ငံကိန်းသင့်တင့်မျှတ
- မြေပြုပြင်ခြင်းလုပ်ငန်းများလုပ်ဆောင်ရန်လွယ်ကူ
- ရေထိန်းစွမ်းအားကောင်းမွန်
- မြေဆီလွှာတိုက်စားခံရမှု နည်းပါး
- အကျိုးပြု အဏုဇီဝ သက်ရှိများ ကြွယ်ဝ ပေါများ

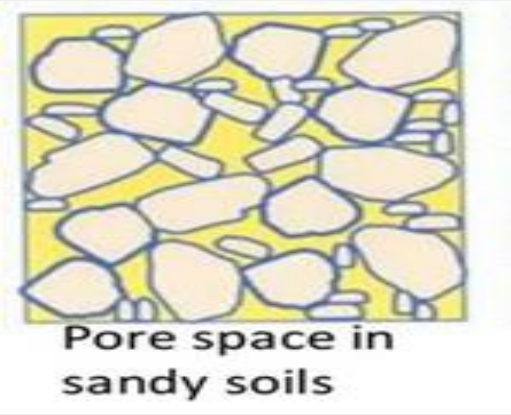
High permeable soil (Sandy Soil)

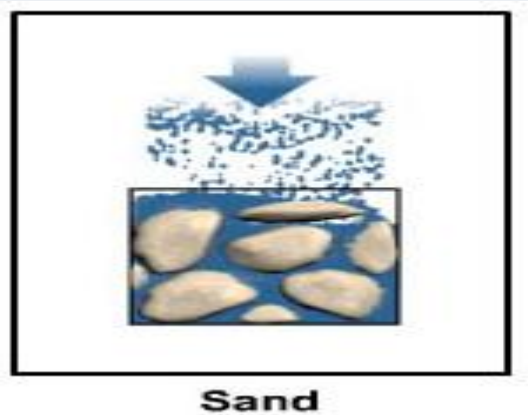
- Generally clay < 10 %, Sand > 65 % soils
- Sand particles - large, irregularly shaped bits of rock
- Large air spaces between the sand particles allow water to drain very quickly
- Nutrients tend to drain away with the water, often before plants have a chance to absorb them
- Thus, sandy soils are usually nutrient-poor

High permeable soil (Sandy Soil)

- Sandy soil has so much air in it that microbes consume organic matter very quickly
- Sandy soils contain very little clay or organic matter, they don't have much of a crumb structure
- The soil particles don't stick together, even when they're wet







Sandy soil constraints

- Poor soil structure
- Low water holding capacity & high infiltration rate
- Subsoil constraints / hard pans
- Poor establishment (poor root anchorage to the crops grown)

- Poor fertility/ low N supply / low organic matter
- Low biological activity - root disease/herbicide residues
- Wilting symptoms in plants appear frequently

Management of high permeable soil

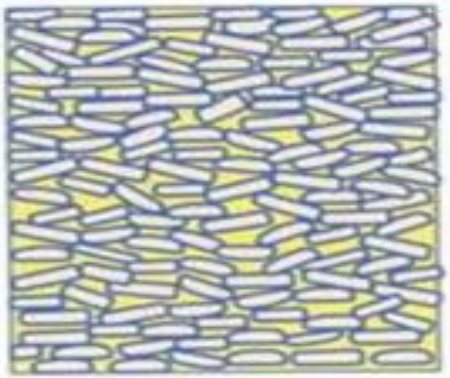
- Add well-rotted manure or finished compost
- Mulch the plants with leaves, wood chips, bark, straw mulch
- Add at least 2 inches of organic matter each year
- Grow cover crops or green manures

Management of high permeable soil

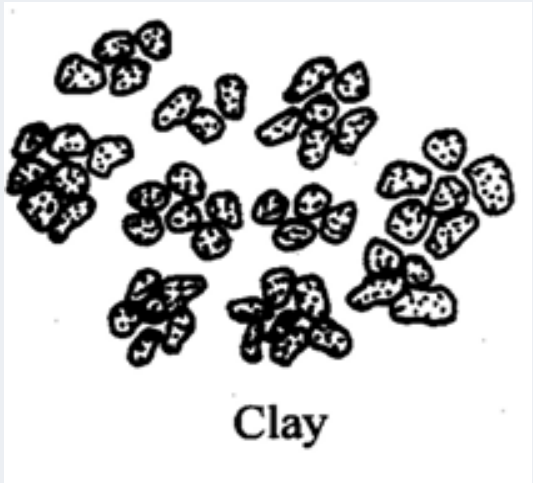
- Application of clay soil up to a level 100 t ha^{-1} based on the severity of the problem and availability of clay materials
- Providing polythene sheets below the soil surface to reduce infiltration rate
- Frequent irrigation of water
- Frequent split application of fertilizers and use slow release fertilizers

Low permeable soil (Clay soil)

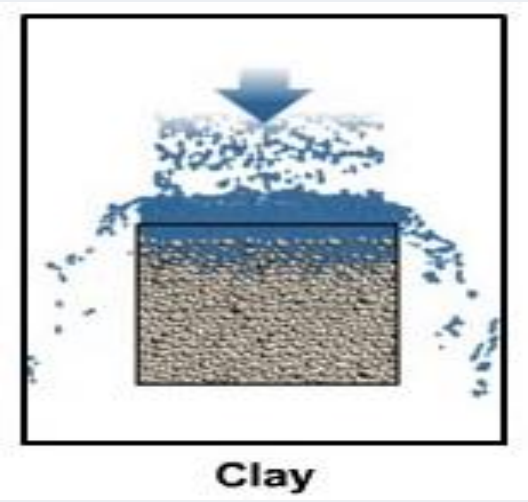
- Clay - heavy soils & slow permeable soils
- Generally, Clay contents > 30 % in 20” of top soils
- Clay particles are small, flat & pack together so tightly that there is hardly any pore space at all
- When clay soils are wet, they are sticky and practically unworkable



Pore space in clay soils



Clay



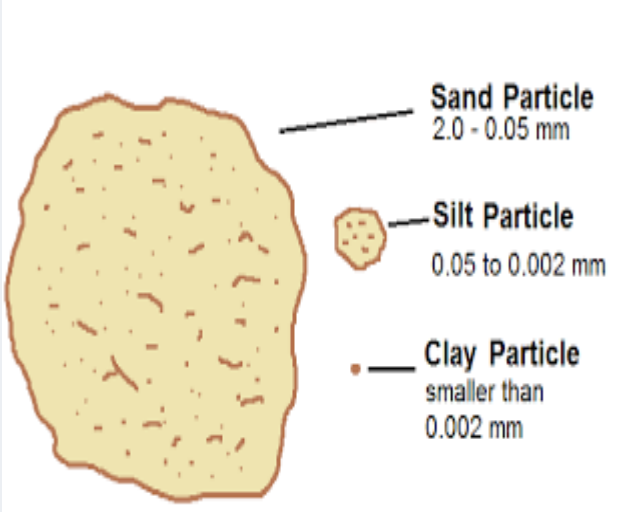
Clay

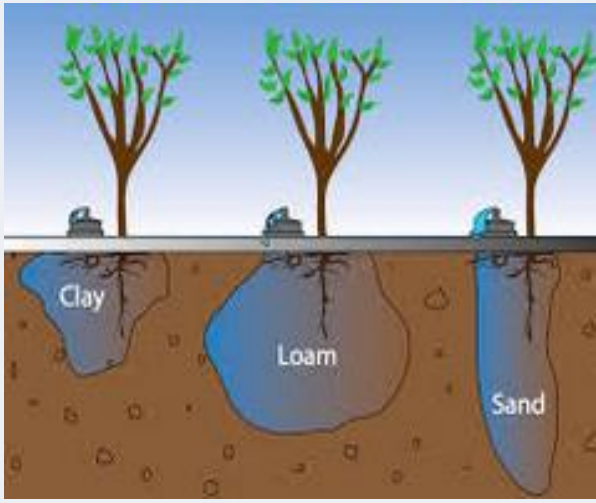
Clay Soil

- When dry they become hard and cloddy, and the surface cracks into flat plates
- Low in both organic matter & microbial activity
- Plant roots are stunted because it is too hard to push through the soil

Clay soil constraints

- Infiltration rate - low
- Increases - runoff (which removes more nutrients)
- Poor aeration
- Erosion of surface soils
- Impeded drainage leads to water logging





Management of slow permeable soil

- Application of organic matter
- Formation of ridges and furrows
- Providing open/ subsurface drainage
- Huge quantity of sand /red soil application to change the texture
- Contour /compartmental bunding to increase infiltration
- Deep ploughing during summer to enhance infiltration

1.2. Hard pan

- Hardpans, hard layers, or compacted horizons, either surface or subsurface, are widespread problems that limit crop production.
- **a dense layer of soil, usually found below the uppermost topsoil layer**.

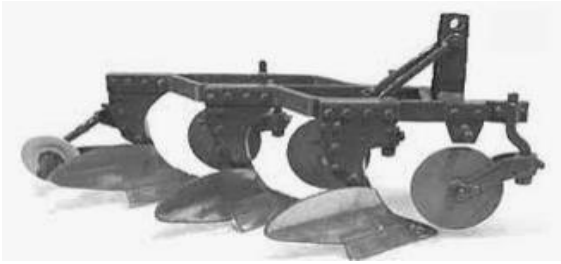
Formation:

1) Due to continuous tillage to a constant depth(5–10 cm).

2) Due to deposition of $CaCO_3$, iron and silicate materials in subsoil

Types of Hardpan

- ***Caliche*** — lime-cemented hardpan found in arid area. It is white or light in color, soil over it is usually alkaline.
- ***Claypan*** — layer of clay soil. The clay may be hard when dry and softer when wet, but always impedes flow of water, causing drainage problems.
- ***Fragipan*** — layer of dense, compact cemented silt & fine sand. It is hard when dry, but brittle & fragile when wet.
- ***Plowpan*** — formed by action of moldboard plows.



- ***Traffic pan*** — compacted by foot traffic.

Impacts

- High bulk density (>1.8) (penetration resistances that limit root growth, reduce water & airflow)
- Lowers water holding capacity, available water, movement of air & nutrients
- Limited root growth leads to limited crop water & nutrient uptake.
- Reduced water flow prevents rainfall or irrigation water from filtering into the soil profile

chisel plough

Technology to overcome the sub soil hard pan

- The field is to be ploughed with chisel plough (loosen and aerate soil)
- Farm yard manure at 12.5 t ha^{-1} is to be spread evenly on surface.
- Addition of organic compost & manure to soil - The bacteria can help reduce hardpan.
- Adding organic matter - the key to loosening hard soils

1.3 fluffy paddy soil

major characteristics

Low bulk density of the topsoil resulting in the sinking of farm animal, labourers & poor anchorage to paddy seedlings

Causes

- due to the continuous rice-rice cropping sequence
- The traditional method of preparing soil for transplanting rice consists of puddling which results in substantial break down of soil aggregates into a uniform structureless mass
- Solid and liquid phases of the soil - changed
- Under continuous submergence of soil for rice cultivation in a cropping sequence of rice-rice-rice, soil particles are always in a state of flux and the soil strength is lost leading to fluffiness of the soils

Constraints of fluffy paddy soil

- This type of soil has high clay content.
- Animals or tractors may sink in the soil while working
- During puddling operations, an invisible drain of finance for the farmers due to high pulling power needed for the bullocks and slow movement of labourers
- The transplanting operation becomes difficult in these soils

Management of fluffy paddy soil

- 8-10 times passing of 400 kg stone roller or oil drum with sand inside
- Sand can be applied if necessary
- When the soil is in semi dry condition along with addition of lime 2t ha^{-1} once in three years
- Growing of garden land or irrigated upland crops after rice – rice cropping system


400 kg stone roller

2.2. Acid soil

- ✓ Soil with low pH
- ✓ contain relatively high amounts of exchangeable **H^+ & Al $^{3+}$**
- ✓ occupy approximately 60 % of the Earth

Formation

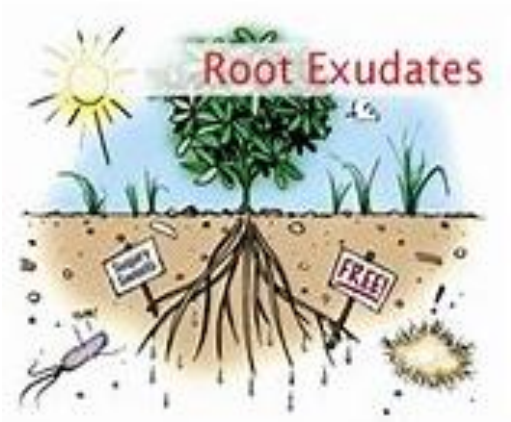
- ➢ areas of high rainfall, poor drainage, heavy nitrogen fertilizer use
- ➢ Humus decomposition
- ➢ Application of elemental sulphur (formation of H_2SO_4)

Properties of acid soil

- Low CEC
- Intermediate texture (Sandy loam to Loam)
- Low organic matter content (except hilly region & forest soils, peat soil)
- Low P content but N is variable
- High amount of Fe and Al in soil solution

Different sources for formation acid soil

- Rain fall
- Parent materials
- Fertilizer application
- Plant root activity
- Decomposition of organic matter
- Export of farm product
- Vegetation cover

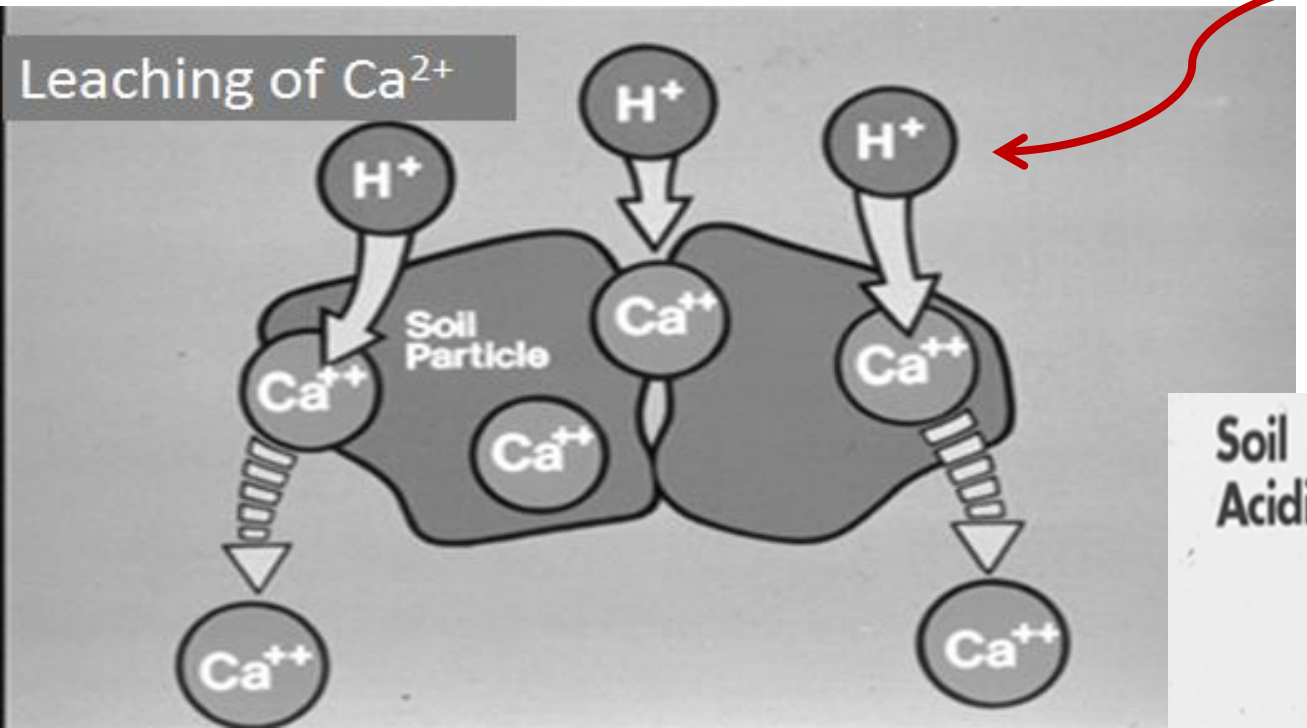


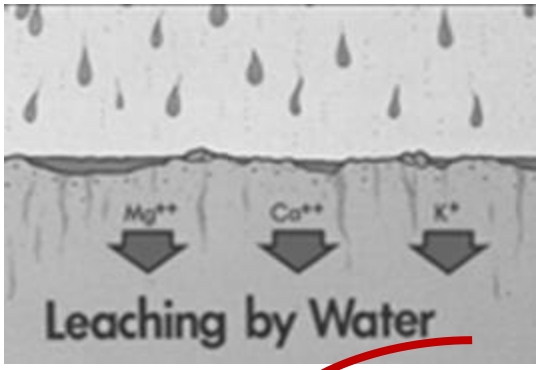
Rain fall

- Mostly found in excess rain fall areas
- Excess rain fall leaches base cation from the soil (Na, K, Ca & Mg)
- Additionally rain water has a slightly acidic

✓ $H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

- Increase the percentage of H^+ in soil





Soil Acidification

၂၀၂၃ ခုနှစ် ဇန်နဝါရီလအတွင်း ရွာသွန်းခဲ့သောမိုးရေများတွင် အက်စစ်ဖြစ်ထွန်းမှု အခြေအနေ

နေပြည်တော် ဖေဖော်ဝါရီ ၇

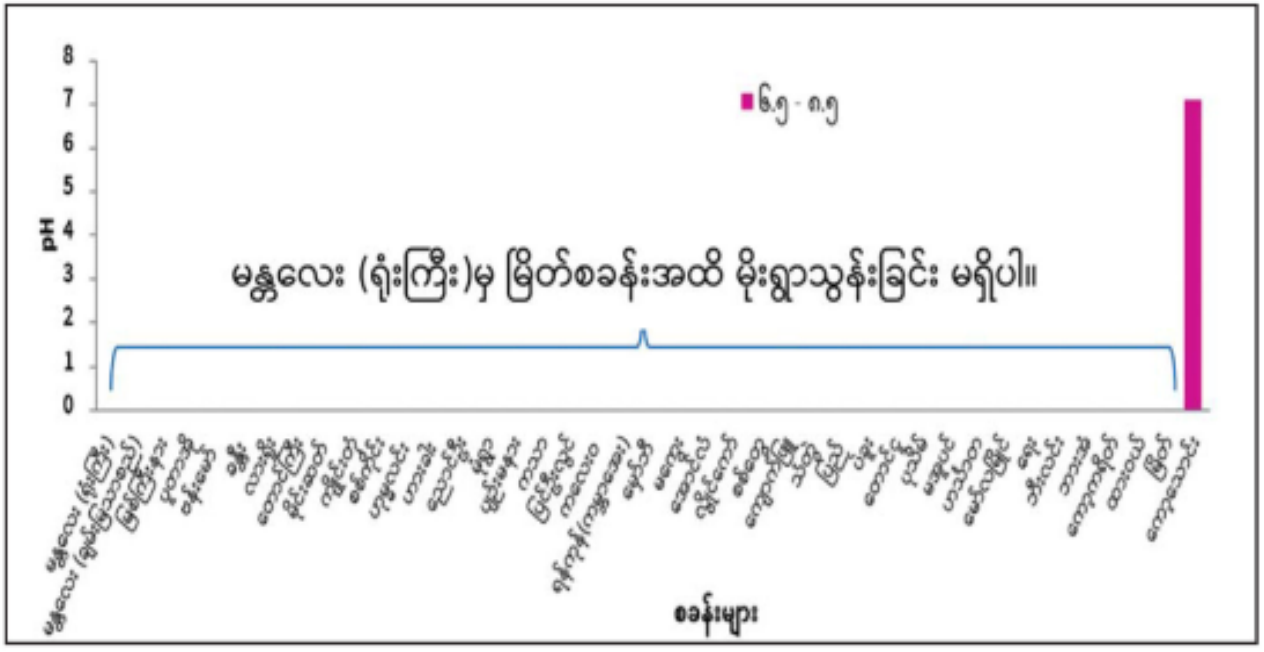
ပို့ဆောင်ရေးနှင့် ဆက်သွယ်ရေးဝန်ကြီးဌာန မိုးလေဝသနှင့် ဇလဗေဒညွှန်ကြားမှုဦးစီးဌာနသည် အရှေ့အာရှအက်စစ်ဖြစ်ထွန်းမှုစောင့်ကြည့်တိုင်းတာရေးကွန်ရက် (Acid Deposition Monitoring Network in East Asia– EANET) အဖွဲ့အစည်းတွင် အဖွဲ့ဝင်အဖြစ် ၂၀၀၅ ခုနှစ် နိုဝင်ဘာလမှ စတင်ဆောင်ရွက်ခဲ့ပြီး တိုင်းဒေသကြီးနှင့်ပြည်နယ်များ၏ မြို့ကြီး ၄၁ မြို့ရှိ မိုးလေဝသနှင့် ဇလဗေဒစခန်း ၄၁ ခု (ပုံ-၁)တွင် ရွာသွန်းသောမိုးရေများကို စုဆောင်းကာ မိုးရေတွင် အက်စစ်ဖြစ်ထွန်းမှုအခြေအနေကိုသိရှိရန် မိုးရေ၏ pH တန်ဖိုးများ တိုင်းတာခြင်းလုပ်ငန်းများကို လစဉ်ဆောင်ရွက်လျက်ရှိသည်။

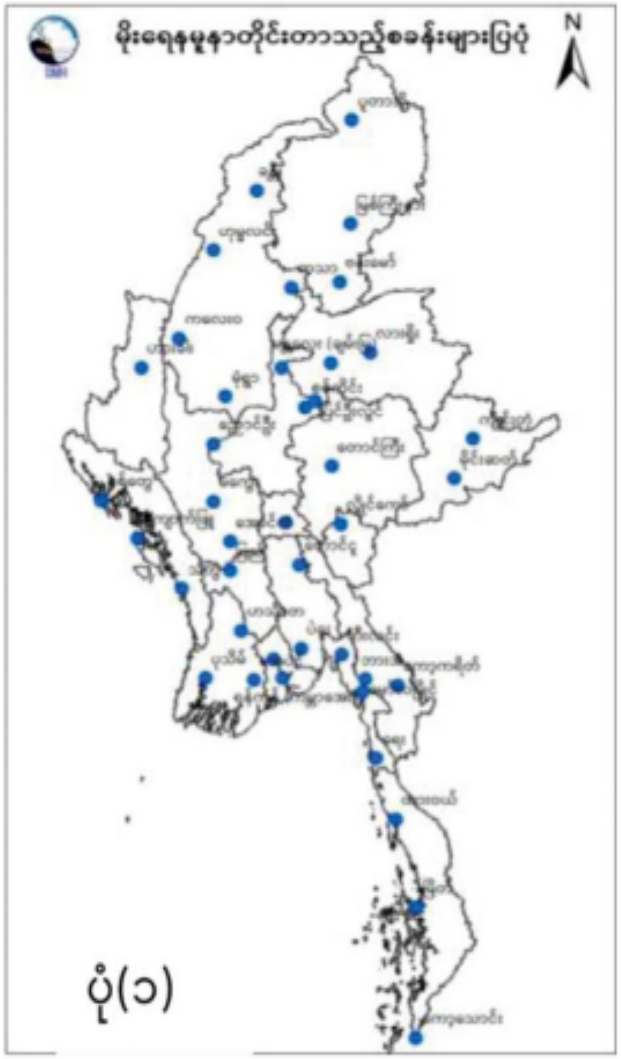
၂၀၂၃ ခုနှစ် ဇန်နဝါရီလအတွင်း ရွာသွန်းခဲ့သော မိုးရေများ၏ pH တန်ဖိုးနှင့် မိုးရေ၏ Electric Conductivity – EC များကို တိုင်းတာသည့် စခန်း ၄၁ ခုအနက် ကော့သောင်းစခန်းတွင်သာ မိုးရွာသွန်းခဲ့ပြီး ကျန်စခန်းများတွင် မိုးရွာသွန်းခဲ့ခြင်းမရှိဘဲ ကော့သောင်းစခန်းတွင် ရွာသွန်းခဲ့သောမိုးရေ၏ pH တန်ဖိုးသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့ (WHO) မှ စံသတ်မှတ်ထားသည့် သောက်သုံးရေအတွက် pH တန်ဖိုးနှင့် ကျန်းမာရေးဝန်ကြီးဌာနမှ စံသတ်မှတ်ထားသည့် သောက်သုံးရေအတွက် pH တန်ဖိုး (6.5 – 8.5) အတွင်းတွင်ရှိကြောင်း တိုင်းတာရရှိခဲ့သည်။

မိုးရေ၏ pH တန်ဖိုးသည် 5.6 အောက်ရောက်ရှိမှသာ အက်စစ်ဂုဏ်သတ္တိရှိသောကြောင့် ၂၀၂၃ ခုနှစ် ဇန်နဝါရီလအတွင်း မိုးရေနမူနာတိုင်းတာရရှိခဲ့သည့် ကော့သောင်းစခန်း၌ ရွာသွန်းခဲ့သော မိုးရေတွင် အက်စစ်ဖြစ်ထွန်းမှုအခြေအနေမရှိကြောင်း တွေ့ရှိရသည်။ (ပုံ-၂)

သတင်းစဉ်

ပုံ(၂)။ ၂၀၂၃ ခုနှစ်၊ ဇန်နဝါရီလအတွင်း ရွာသွန်းခဲ့သော မိုးရေ၏ pH တန်ဖိုးပြပုံ





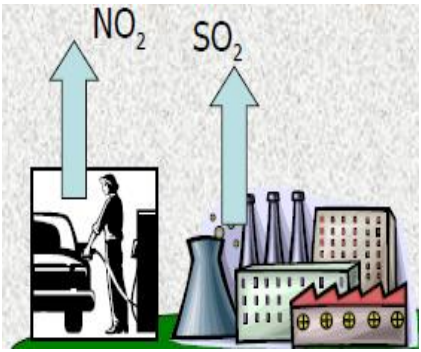
ရွာသွန်းခဲ့သော မိုးရေနမူနာ၏ pH တန်ဖိုး

စဉ်	စခန်းအမည်	pH
၁။	ကော့သောင်း	၇.၁

Humid region, soil acidification increase on global scale (acid precipitation)

Burning of fossil fuels lead to the formation of acid

eg. H_2SO_4, HNO_3



Contact with soil these acid rain rapidly break down soil minerals as well as depressing soil pH (serious ecological hazard)

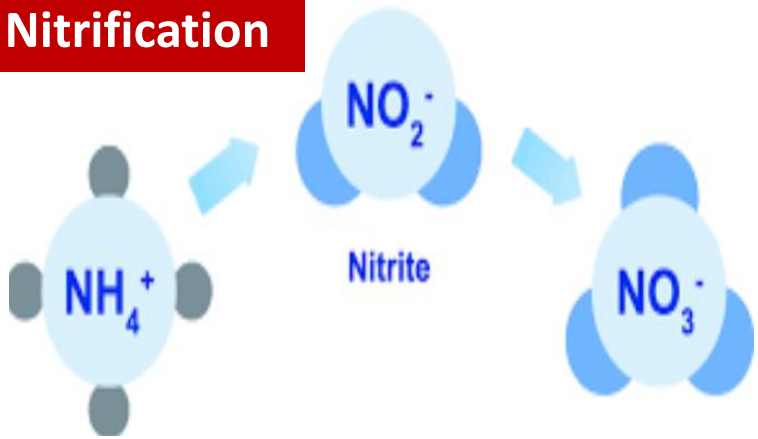
Parent materials

- Many soils of the world are acidic (parent material weathering)
- The development of acid soil on acidic rocks like Granite, Gneiss, quartz, silica
- Materials eg. shale, sandstone & granite generally produce more acidic soils
- Overtime soils have a general tendency to become more acidic

Fertilizer use

- Repeated application of N fertilizer
- Most acidifying are ammonium sulfate, monoammonium phosphate (MAP) & diammonium phosphate (DAP)
- Less acidifying are urea, ammonium nitrate & anhydrous ammonia

Nitrification



Nitrification produce H^+

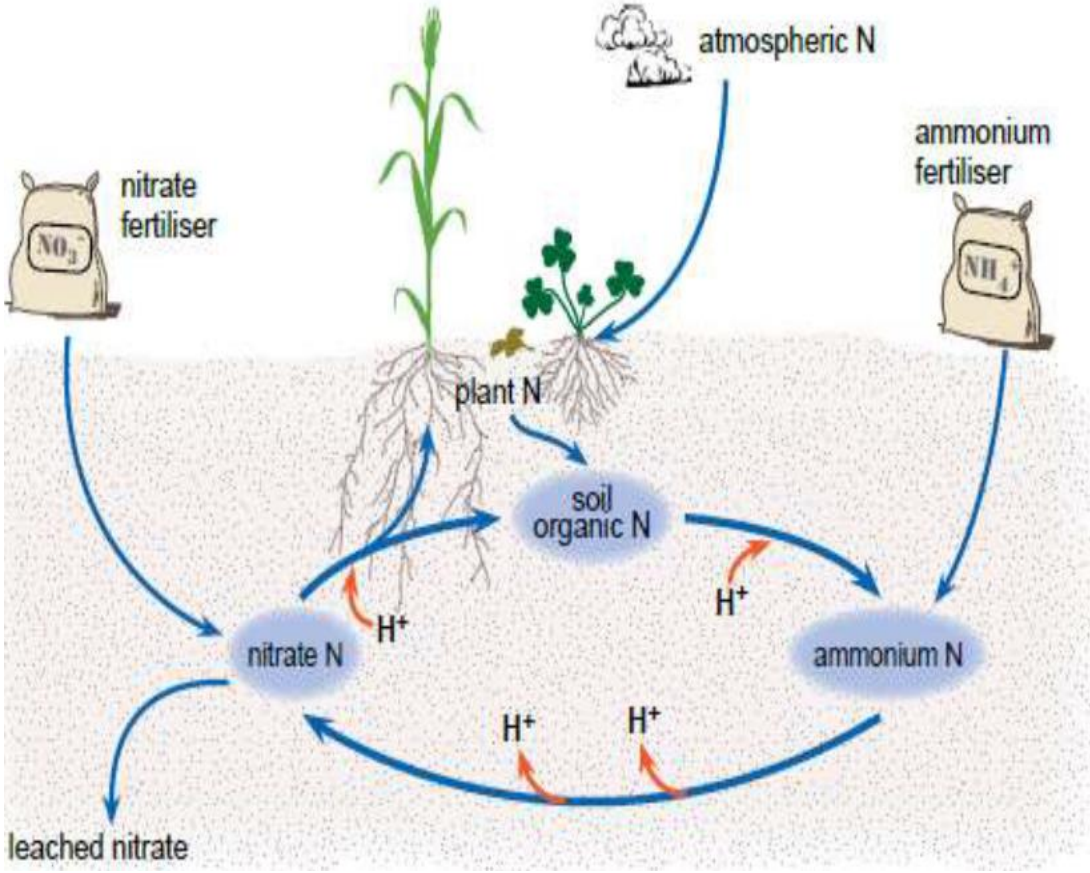
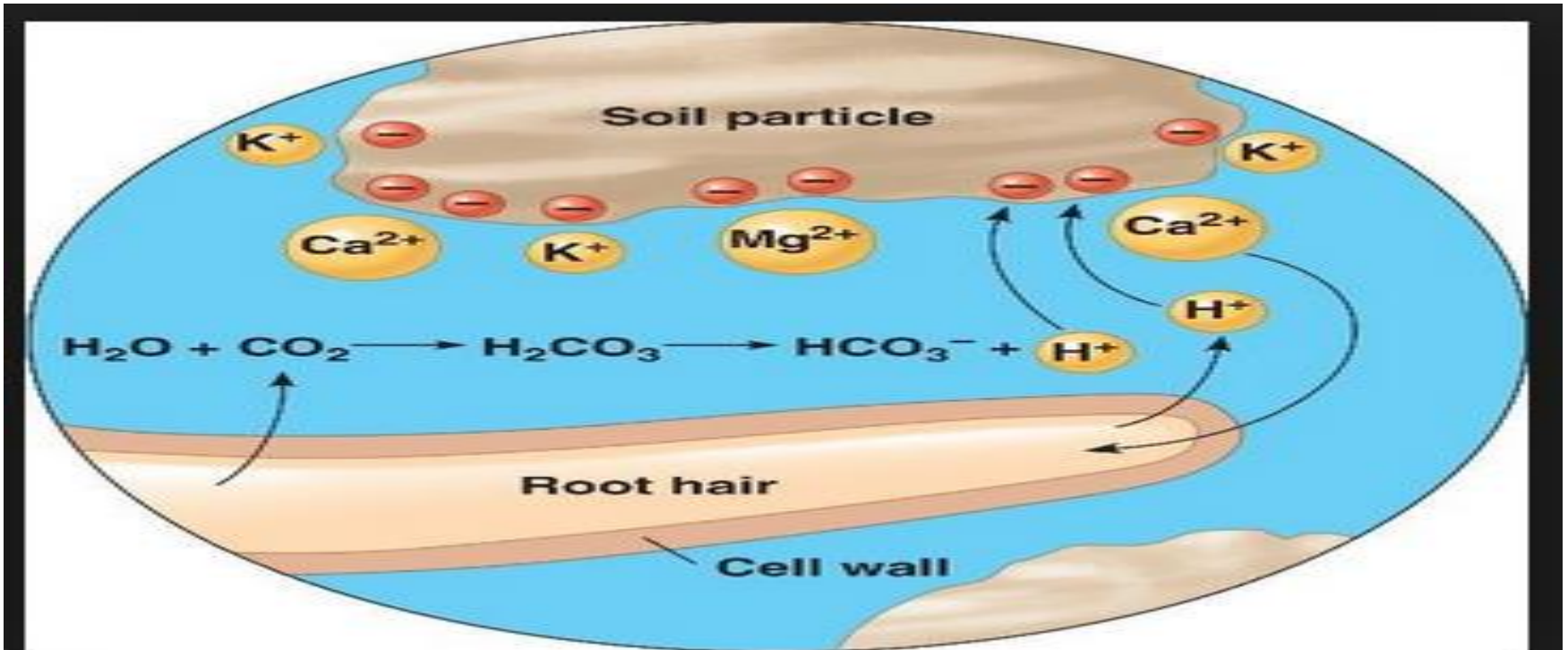


Figure. The main pathways showing the involment of N fertilizers in soil acidification

Plant root activity

- Plant uptake nutrients- both anion and cation
- Plant must maintain a neutral charge in their roots
- In order to compensate the extra positive charge they release the H^+ ions
- Some plants roots produce the organic acid – acid soil



Export of farm product

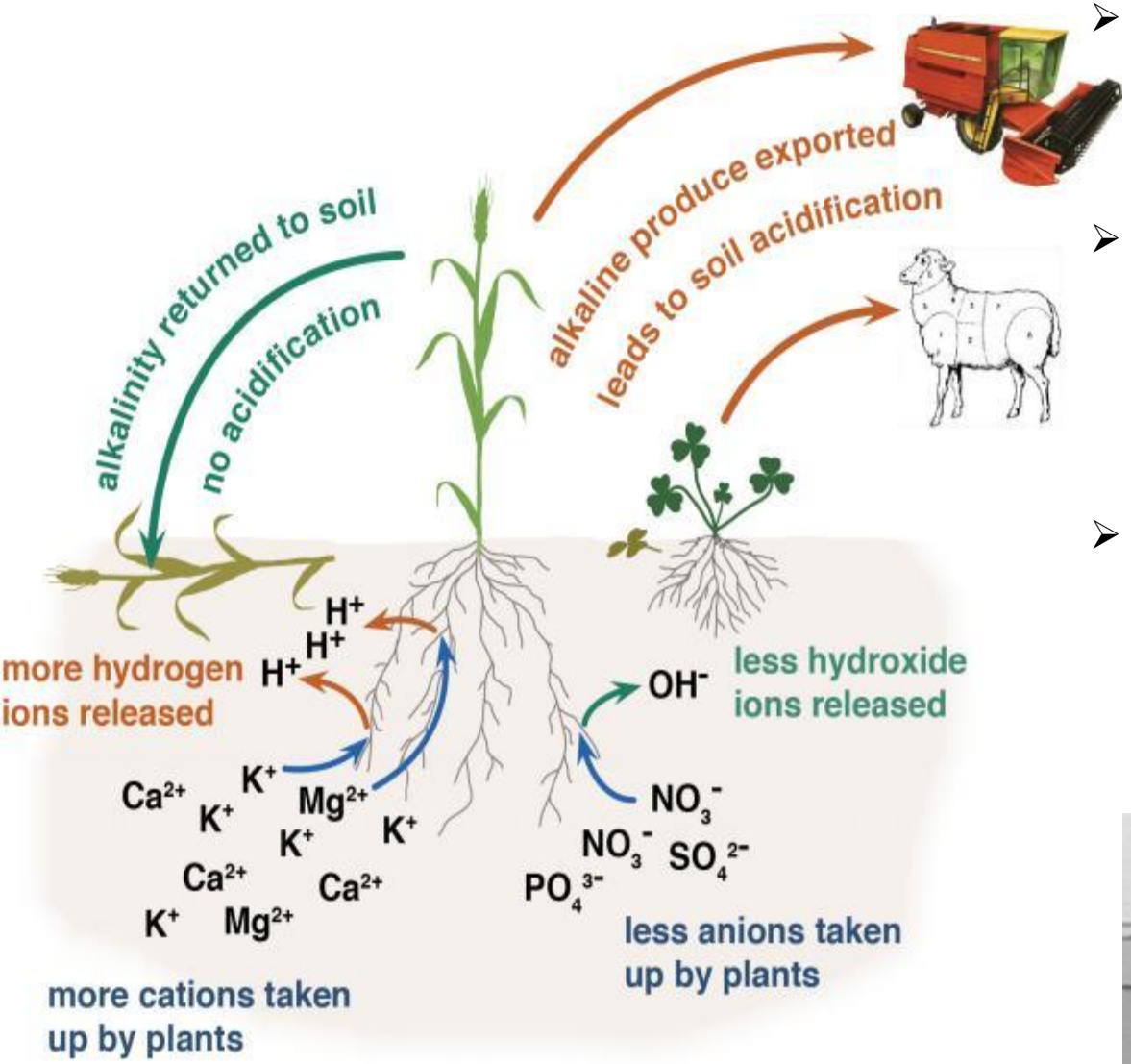
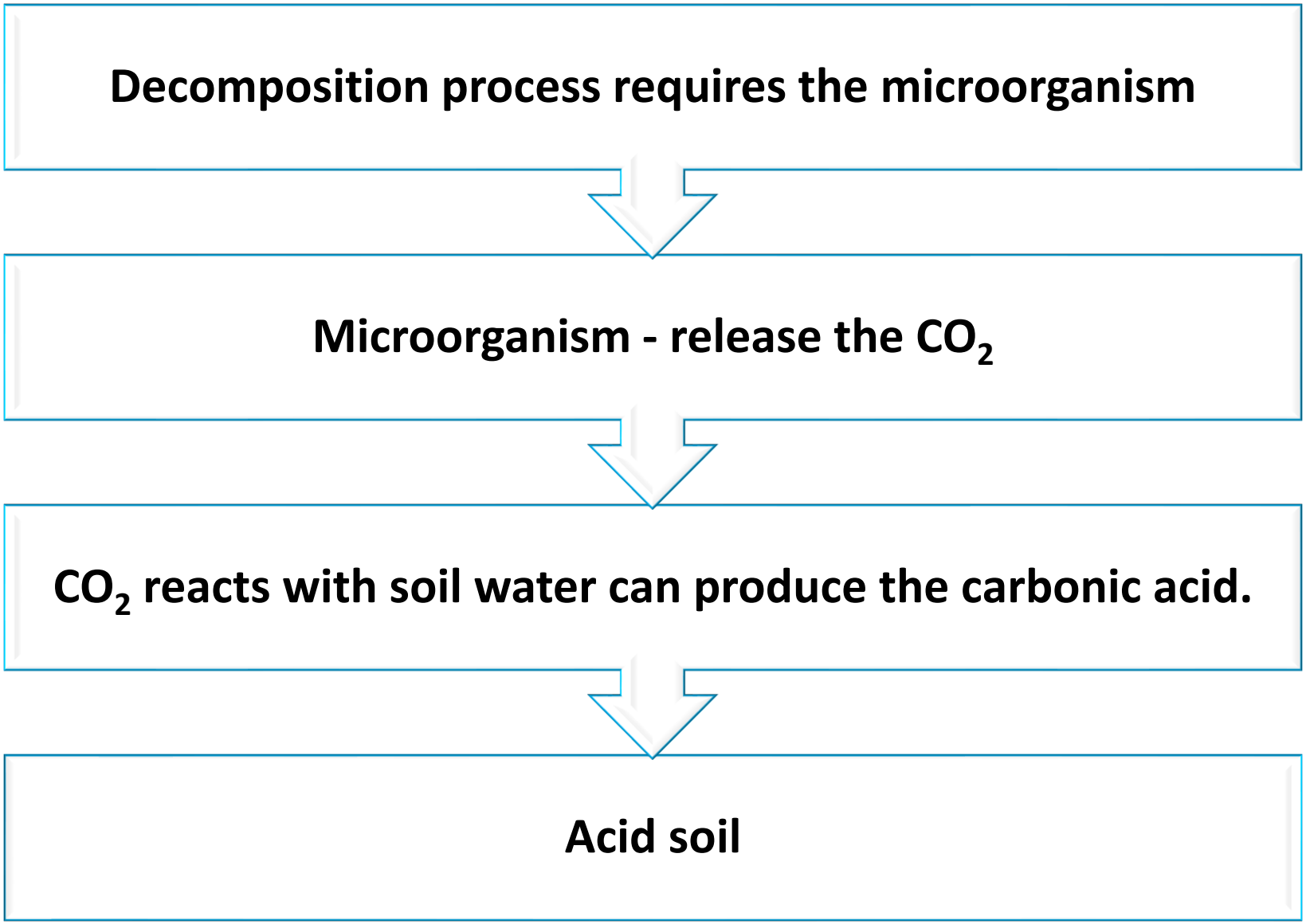


Figure H^+ added in the carbon cycle contribute to soil acidification

- Plants absorb more cations than anions (most plant material is slightly alkaline)
- In natural system, when plants die they are decomposed and returned to soil, balancing acidity caused by H^+
- In agriculture, if plant material is removed there is a net export of alkalinity and residual H^+ remain in soil causing soil acidity
- Over time, as this process is repeated, soil becomes acidic

Decomposition of organic matter



Vegetation cover

- Temperate region areas covered with conifers (acid soil develop easily)
- Foliage of conifers lacks alkali substances
- Leaf-litter on ground is degraded, organic acids are released (make the soil acid)
- Coastal region & marshy places, plants after the death & decay produce acid which render the acidic soil

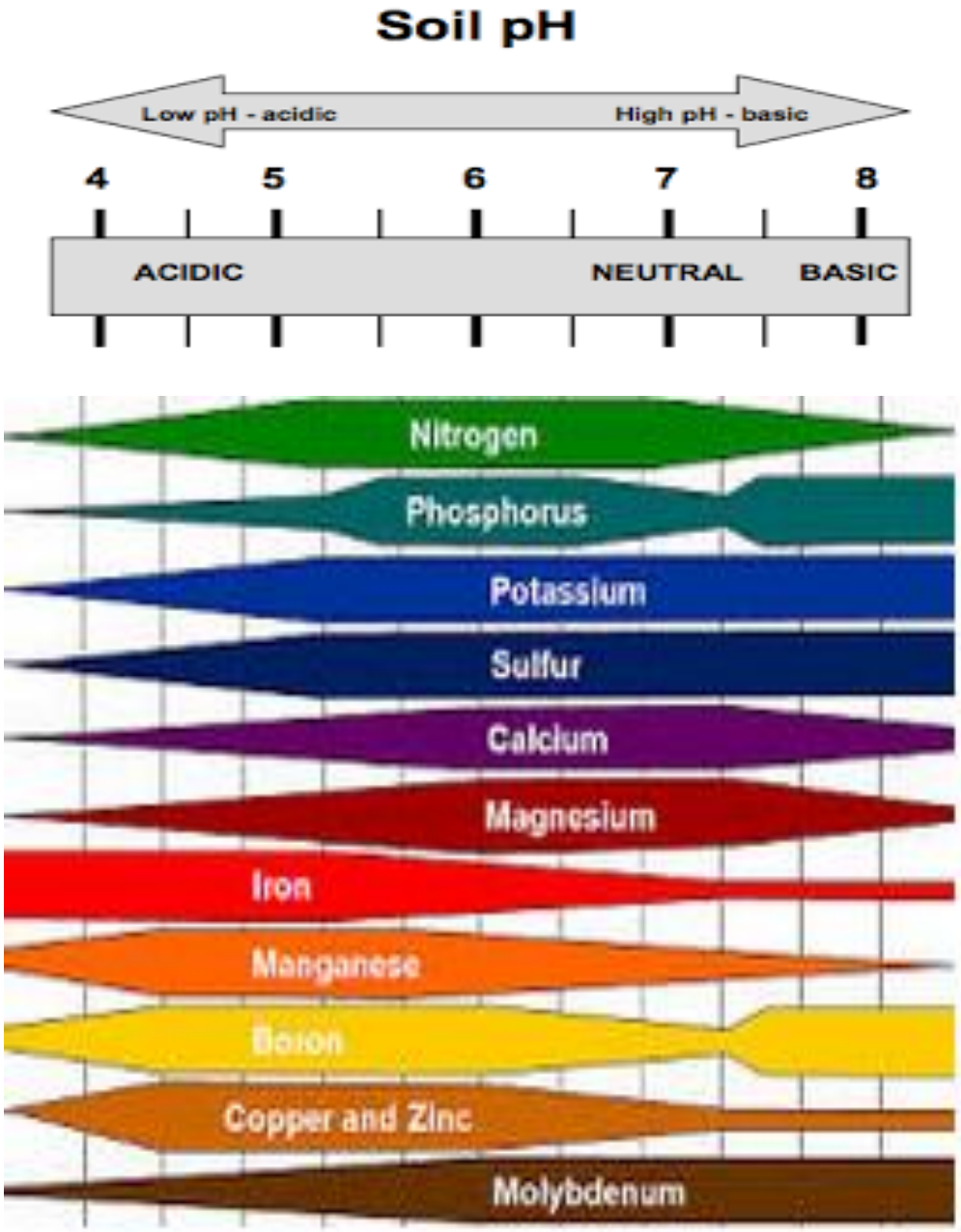
Impact on soil properties

Physical

- Strongly acid soils - potential for reduced vegetation
- High permeability
- Poor water holding capacity
- Low pH soils are more loosely held together
- Soil losses due to water & wind erosion
- Degraded through external influences such as high rainfall events, drought

Chemical

- Low pH
- More anion fixing capacity
- Decrease the availability of P
- High % of base unsaturation (low % of sum of base cations)
- Al toxicity is more
- Ca, Mg levels decrease (deficiency)
- Mo level decrease (deficiency)
- Restriction of nitrogen fixation in legumes



Biological

- Low pH reduced growth of beneficial organisms
- Change in the microbial decomposition processes
- Fungi population is more than that of bacteria
- Fungi cause root disease
- Decreasing the survival of native vegetation
- Earthworms are unable to tolerate low pH (poorer soil structure & reduced organic matter decomposition)

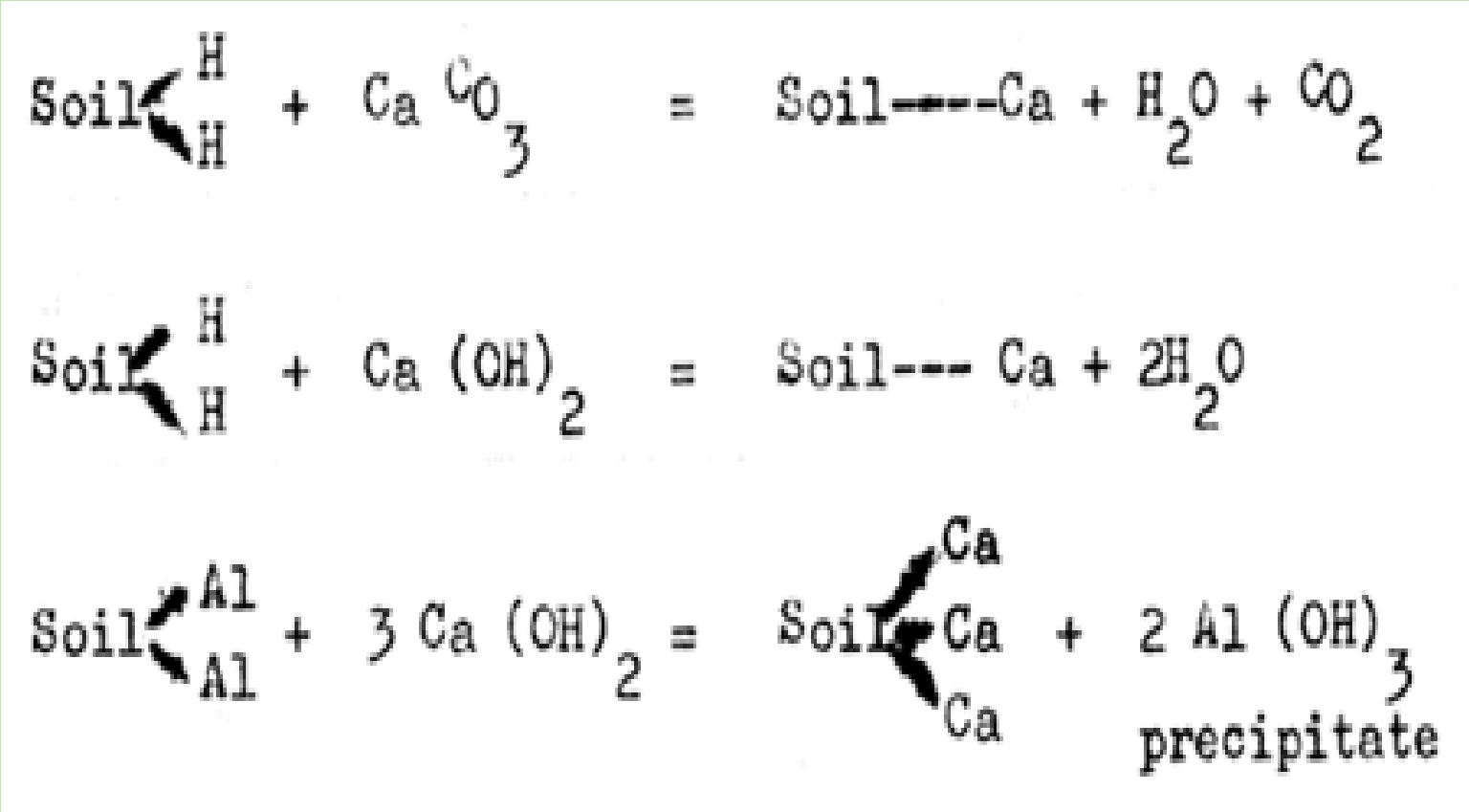
Management of acid soil

1. Application of liming materials (To neutralise soil acidity and increases activity of soil bacteria)

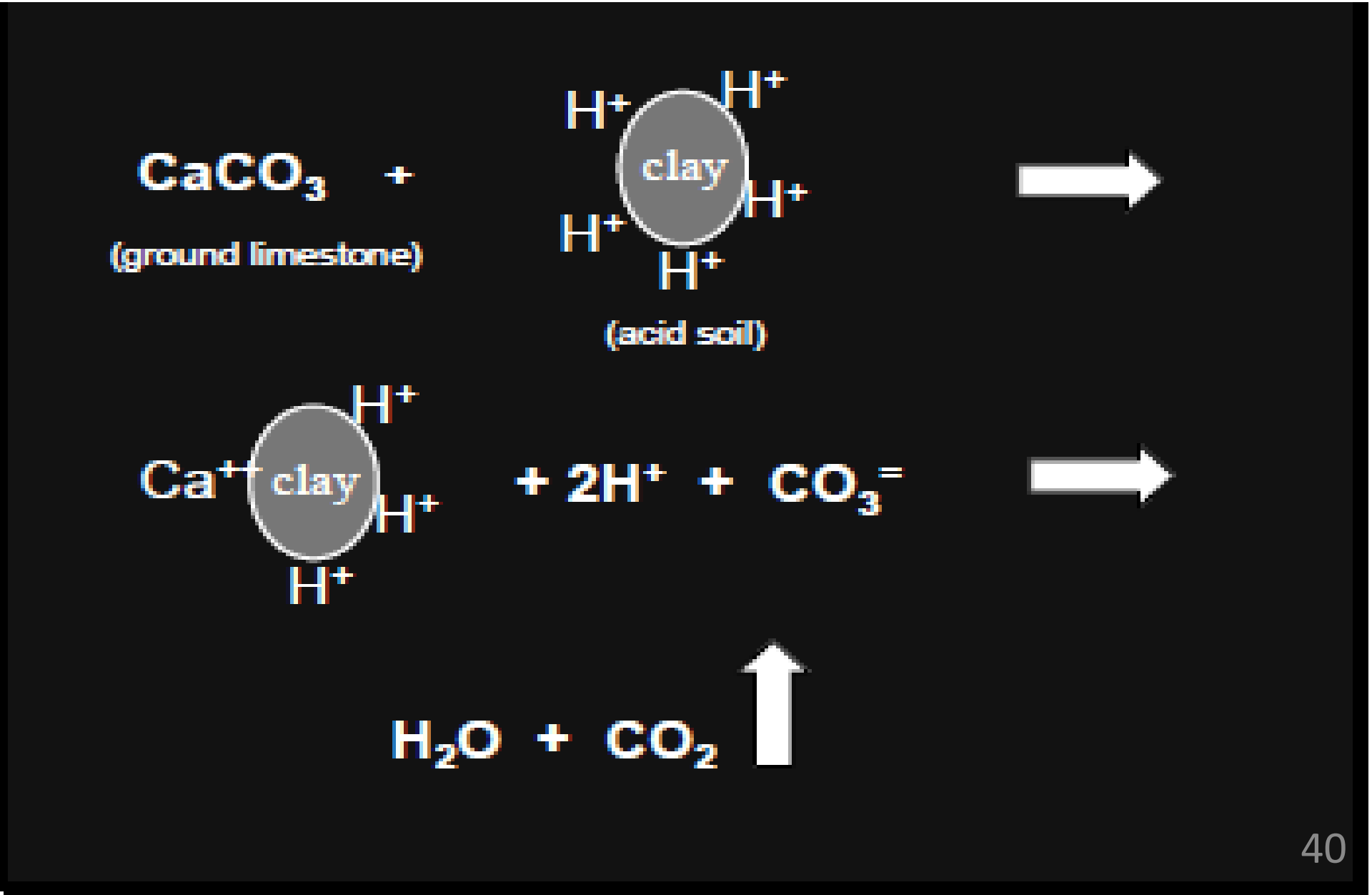
Different liming material to reclamation of acid soil

- Carbonates - $CaCO_3$ (ထုံးကျောက်)
- Oxides - CaO (မဖောက်ထုံး)
- Hydroxides - $Ca(OH)_2$ (ဖောက်ထုံး)
- Silicate of calcium - $CaSiO_3$

The reaction of lime with acidic soil is represented by the following equations



❖ lime should be mixed with the soil well ahead of planting



Solubility and qualities of lime

- Lime is slowly soluble in water
- Effectiveness depends on purity of the liming material & how finely it is ground

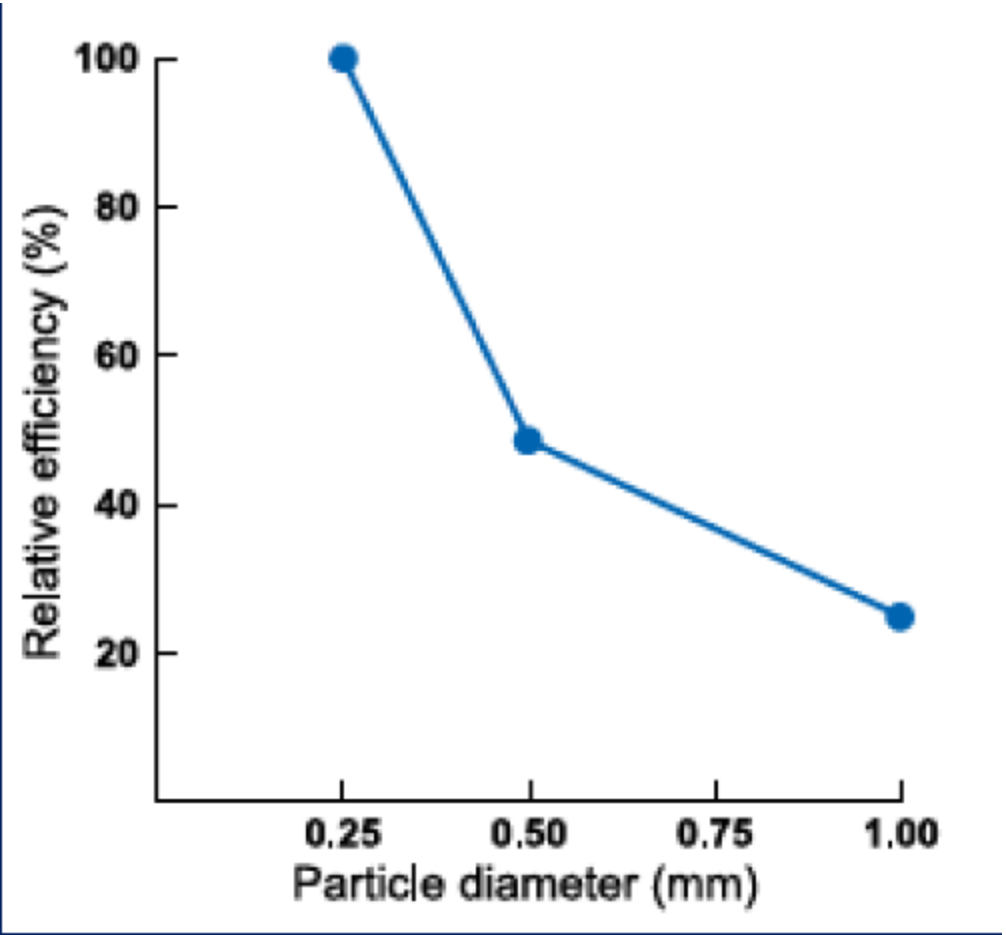
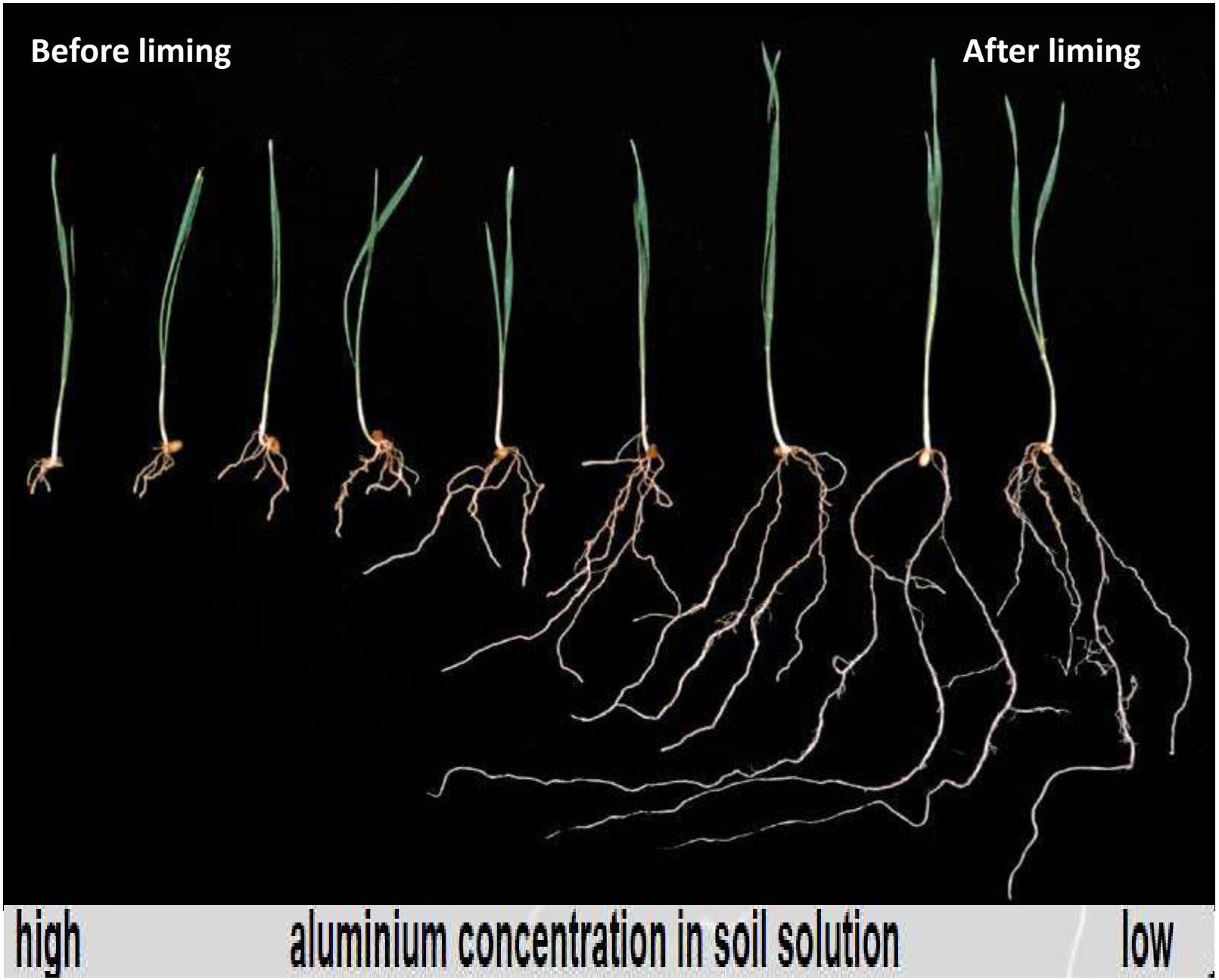


Figure. Particle size distribution & efficiency

Benefits

- liming eliminates toxic Al^{3+} & H^{+}
- lime will raise the soil pH
- supply Ca^{2+} & Mg^{2+}
- formation of soil aggregates (improving soil structure)
- Crop yield improvement
- Nutrient availability
- Improved microbial activity
- Improved legume fixation

Figure. Distinct growth rate on same acid soil upon liming


Before liming
After liming
high
aluminium concentration in soil solution
low

LIME REQUIREMENT(LR)

- LR of an acid soil is the amount of a liming material that must be added to raise the soil pH to a desired level. (usually in the range of 6.0 to 7.0)
- LR ranges from 3.5 to 15 t/ha.

Lime requirement (ton/ha) $=[(Al^{3+} + H^{+}) – (CEC * 0.01)] * 2 = X$

Lime Requirement (ton/ac) = X / 2.471

(1 ha = 2.471 ac)

Effects of over liming

- Deficiency of Fe, Cu, Zn, P, K
- Increment of OH^- activity may cause root injury
- Over liming Boron deficiency occur
- Too much application of lime increase the pore space in the soil, soil dries up, efficiency of water use is low

2. Application of Crop residues

- Basic cations which are released during decomposition of crop residuces increase the pH
- Soil pH changes after the addition of chickpea residues
- The greatest increase in soil pH occurred after chickpea addition as it is easily mineralized
- Chickpea has a potential alkalinity

3. Application of animal manures

Swine manure

Goat manure

Poultry manure

Cow manure

Reactions

- ✓ Organic manures mineralize, Ca ions are released into soil solution
- ✓ Ca ions get hydrolysis process
- ✓ CaOH formed reacts with soluble Al ions in the soil solution to give insoluble $Al(OH)_3$

Chemical composition of animal manure

Animal manure	Ca	Mg
Swine	1.37	1.30
Goat	1.37	0.83
Goat	1.24	0.89
Cow	1.12	1.94

Ano *et al* 2007

Other approach to acid soil management

- use of acid-tolerant species
- efficient use of fertilizers
- suitable crop rotations
- crop diversification

Acid Soil Crops: prefer a pH of 4 to 5.5:

Tea (4.0 – 5.5)

Blackberry (5.0-6.0)

Blueberry (4.5-5.0)

Cranberry (4.0-5.5)

Peanut (5.0-7.5)

Potato (4.5-6.0)

Raspberry (5.5-6.5)

Somewhat Acid Soil Crops: tolerate a pH of 5.5 to 6.5:

Apple (5.0-6.5)

Basil ပင်စိမ်း (5.5-6.5)

Carrot (5.5-7.0)

Cauliflower (5.5-7.5)

Corn (5.5-7.5.)

Cucumber (5.5-7.0)

Dill ဧယာ (5.5-6.5)

Eggplant (5.5-6.5)

Garlic (5.5-7.5)

Melon (5.5-6.5)

Parsley နံနံ (5.0-7.0)

Pepper ငရုတ်ကောင်း (5.5-7.0)

Pumpkin (6.0-6.5)

Radish (6.0-7.0)

Sweet potato (5.5-6.0)

Tomato (5.5-7.5)

Turnip မုန်လာဥ (5.5-7.0)

Selection of crops

Highly tolerant

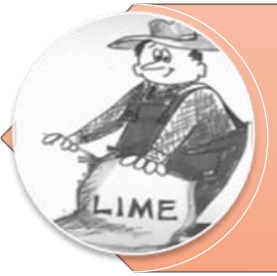
- Strawberry
- Plum
- Radish
- Sweat potato
- Pepper
- Beans
- Cabbage
- Carrot

Moderately tolerant

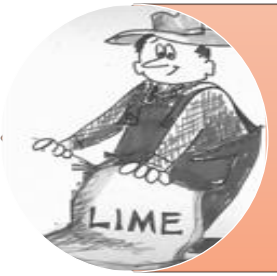
- Pineapple
- Orange
- Litchi
- Jack fruit
- Onion
- Tomato

Slightly tolerant

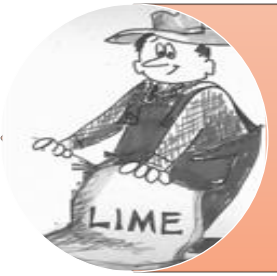
- Mango
- Guava
- Cashew



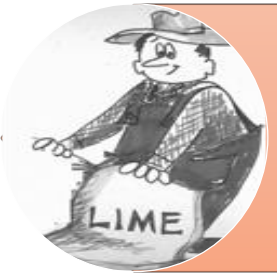
Soil acidity is a serious problem in agricultural land



improve soil health (various management practices)



Based on soil test value recommend the fertilizer



Judicious application of nitrogenous fertilizer

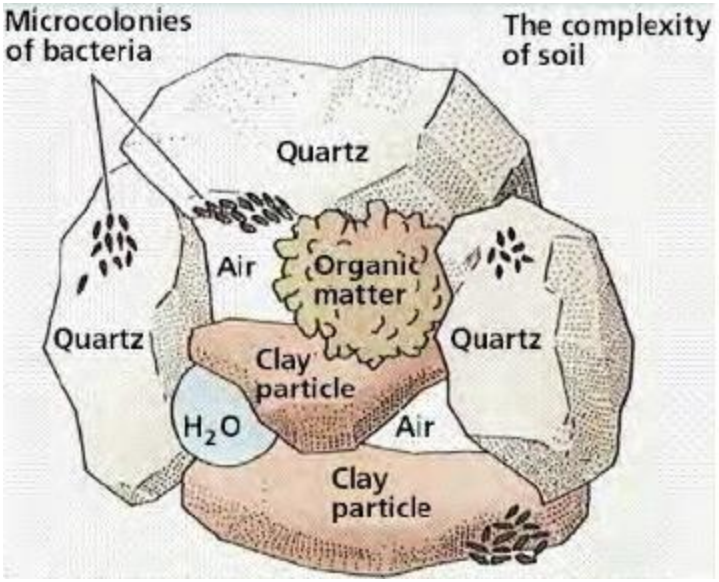
3. Biological Problem soils

3.1. Soil organic carbon (*SOC) and microbial population*

- SOC - main source of energy for soil microorganisms
- Humus participates in aggregate stability, and nutrient & water holding capacity.
- Organic acids (e.g., oxalic acid), commonly released from decomposing organic residues and manures
- Poor SOC - reduced microbial biomass activity & nutrient mineralization due to a shortage of energy sources.
- Low SOC results in less diversity in soil biota, which can cause disturbance in soil environment (e.g., plant pest and disease increase, accumulation of toxic substances).

Improving Carbon Levels

- Zero or minimum tillage
- Continuous application of manure and compost
- Use of summer and/or winter cover crops
- Avoid burning of crop residues



3.2. Earthworms

- Key role - **modifying physical structure of soils** by producing new aggregates and pores, which improves aeration, infiltration, and drainage.
- Produce **binding agents** responsible for the formation of water-stable macro-aggregates.
- **Improve soil porosity** by burrowing and mixing soil.
- As they **feed**, earthworms participate in plant residue decomposition, nutrient cycling and redistribution of nutrients in the soil profile.
- Dead or decaying earthworms, are a source of nutrients.

Problems

- Low or absent earthworm populations - indicator of little or no organic residues in soil
- **High** soil **temperature** and **low** soil **moisture** that are **stressful** not only to **earthworms**, but also for sustainable crop production.
- Earthworms stimulate organic matter decomposition.

Lack of earthworms

- ✓ Reduce nutrient cycling and availability for plant uptake.
- ✓ Reduce natural drainage and aggregate stability.

Improving Populations

- Tillage Management (no-till, strip till, ridge till)
- Crop Rotation (with legumes)
- Cover Crops,
- Manure and Organic By-product Application
- Soil Reaction (pH) Management (**neutral pH is ideal, earthworms can adjust to pH 5–8** with some species tolerating even more acidic soils)
- Proper irrigation or drainage

3.3. Soil Respiration (carbon mineralization)

- ✓ It is a measure of carbon dioxide (CO_2) release from soil
- ✓ plays a critical role in the regulation of carbon cycling
- ✓ provides an indication of the soil's ability to sustain plant growth
- ✓ measure biological activity and decomposition.

This CO_2 results from several sources,

- ❖ decomposition of soil organic matter and plant litter by soil microbes (microbial respiration)
- ❖ plant root respiration,
- ❖ the dissolution of carbonates in soil solution.

Problems

Reduced soil respiration rates

- ✓ little or no microbial activity in soil.
- ✓ nutrients are not released from SOM to feed plants and soil organisms.
- ✓ This affects plant root respiration, which can result in the death of the plants.

- Incomplete mineralization of SOM often occurs in saturated or flooded soils, resulting in formation of compounds that are harmful to plant roots (e.g. methane and alcohol).
- In such anaerobic environments, denitrification and sulphur volatilization usually occur, contributing to greenhouse gas emissions and acid deposition.

Improving Soil Respiration

- ❖ Under favorable temperature and moisture conditions, rate of soil respiration is generally limited by supply of SOM.
- ❖ Agricultural practices that increase SOM usually enhance soil respiration.


Thankyou very much