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# Acid Soil and Their Management

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## Acid soil

- Soil with low pH contain relatively high amounts of exchangeable  $H^+$  &  $Al^{3+}$  considered as the acid soil.
- Ultra acidic : 3.3
- Extremely acidic : 3.5 to 4.5
- Very strong acidic: 4.5 to 5.0
- Strong acidic : 5.1 to 5.5
- Moderately acidic: 5.6 to 6.0
- Slightly acidic : 6.1 to 6.5



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## Occurrence

- 157 M ha cultivable land in India **49 M ha** of land are acidic
- pH >5.6= 26 M ha
- pH 6.5= 23 M ha
- Acid soil occupies only **8%** of total geographical area in India.
- ✓ Arunachal Pradesh - 6.79 M ha
- ✓ Assam - 4.66 M ha
- ✓ Manipur - 2.19 M ha
- ✓ Meghalaya - 2.24 M ha
- ✓ Mizoram - 2.05 M ha
- ✓ Tripura - 1.05 M ha



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# Sources of acid soil formation



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## Different sources for formation acid soil

- Rain fall
- Parent materials
- Fertilizer application
- Plant root activity
- Decomposition of organic matter
- Climate
- Vegetation cover
- Topography
- Human interference



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## Rain fall



- Mostly found in excess rain fall areas (Hilly areas).
- Excess rain fall leaches **base cation** from the soil.
- Additionally rain water has a slightly acidic **pH is 5**
- Creates base unsaturation.
- Increase the percentage of Hydrogen and Aluminium ion in soil



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## Parent materials

- ✓ The development of acid soil on acidic rocks like Granite, Gneiss, quartz silica.
- ✓ When these rocks lack bases, produce acidity in soil after decomposition by weathering
- ✓ Silicic acid- Orthosilicic acid & trisilicic acid

### **Reason for development of acid soil from parent material**

- ✓ Parental rock with simple composition.
- ✓ Less adsorbed cation.
- ✓ Poor buffering capacity.
- ✓ Quick percolation of water through them.







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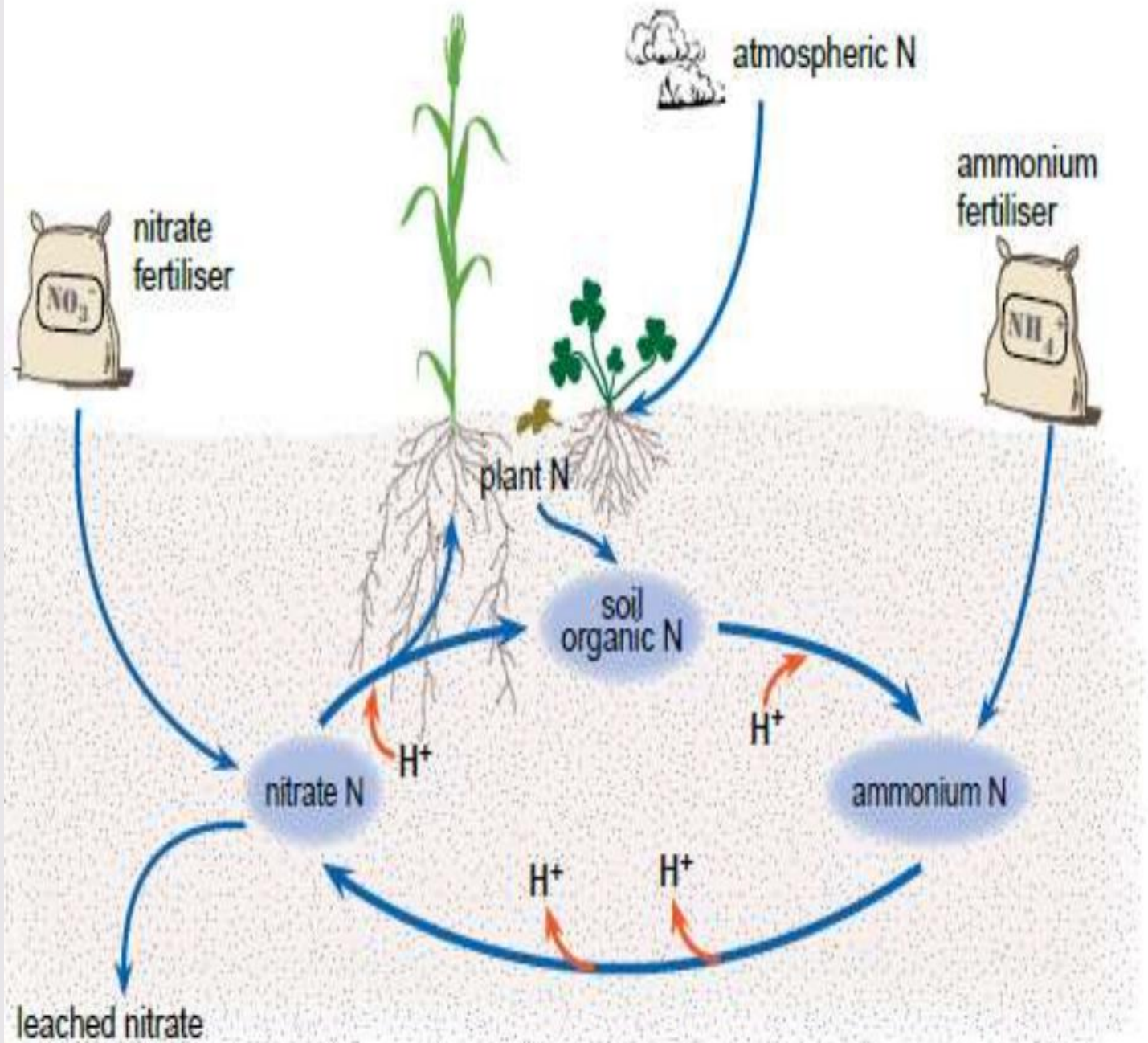
## Fertilizer use

- Repeated application of ammoniacal fertilizer leads to formation of acid soil.
- Ammonium sulphate & Ammonium nitrate fertilizer reacts in the soil process is called nitrification to form a nitrate.
- This process release the Hydrogen ions.



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34 The main pathways showing the involvement of nitrogen (N) fertilisers in soil acidification



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## Plant root activity

- Plant uptake nutrients in the forms of 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.



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# Decomposition of organic matter

Decomposition process requires the microorganism



Microorganism - release the  $\text{CO}_2$



$\text{CO}_2$  reacts with soil water can produce the carbonic acid.



Acid soil



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# Climate

- **Humid region** development of acid soil good because where evaporation is less than precipitation
- Acid soil must receive more than **750 mm** annual rainfall.
- Temperate region the acid soil can develop even if rain fall scanty.
- Hilly region evaporation is very slow due to very low temperature.



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## 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 (fulvic acid) produced its makes soil become acidic.
- Coastal region & marshy places plants after the death & decay produce acid which render the acidic



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## Topography

- Sloppy places with good drainage condition are supposed to be development of acid soil.
- Development of acid soil is very easy in hill slope
- In plains with good drainage condition enhance the acid soil.



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## Human interferences

- Improving drainage in submerged lands
- In Cauvery delta region acid soil is formed due to application ammoniacal fertilizer.
- Regular use of nitrogen fertilizers.
- Industrial wastes containing sulphur / Sulphur dioxide contribute acid soil.





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**Process**

**Laterization**

**Podzolisation**



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## Laterization

- Occurs in tropical and sub tropical.
- Laterites are formed from the leaching of parent rocks (Granite, Basalts, schist, sandstone).
- Laterites soils are rich in Al & Fe- Acidic in nature.
- Aluminium ore exist in clay minerals.
- Due to leaching acid dissolving the parent mineral lattice.
- Easily leached ions of Ca, Mg, Na, K.



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## Podzolisation

- Process of soil formation especially in humid region.
- It involves mobilization and precipitation of dissolved organic material and soluble mineral like Al & Fe are leached from A horizon to B horizon.
- Its formed under moist, cool & acidic condition.
- Especially where the parent material such as quartz.
- Siliceous material creates strong acidic



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# Characteristics of Acid so



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## Physical

- Light texture soil
- High permeability
- Poor water holding capacity
- Poor cation exchange capacity
- Poor organic matter content



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## Chemical

- Base unsaturated soil
- More anions than cations.
- Active and potential soil acidity.
- Toxic effects of Al concentration more.
- At low pH - Al, Fe, Mn, Zn, Cu, Co availability is more
- P, Ca, Mg is less



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## Biological

- Fungi population is more than that of bacteria
- Fungi cause root disease.
- Rate of decomposition of biological material and rate of mineralization and nitrification are reduced when acidity is increased.



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## Kinds of acidity

**Active acidity**

**Exchange acidity**

**Residual acidity**

**Total acidity**





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# Impact on soil properties

Physical

Chemical

Biological



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## Physical

- In strongly acid soils the potential for reduced vegetation - soil losses due to water & wind erosion are also increased.
- low pH soils are more loosely held together - degraded through external influences such as high rainfall events, drought.



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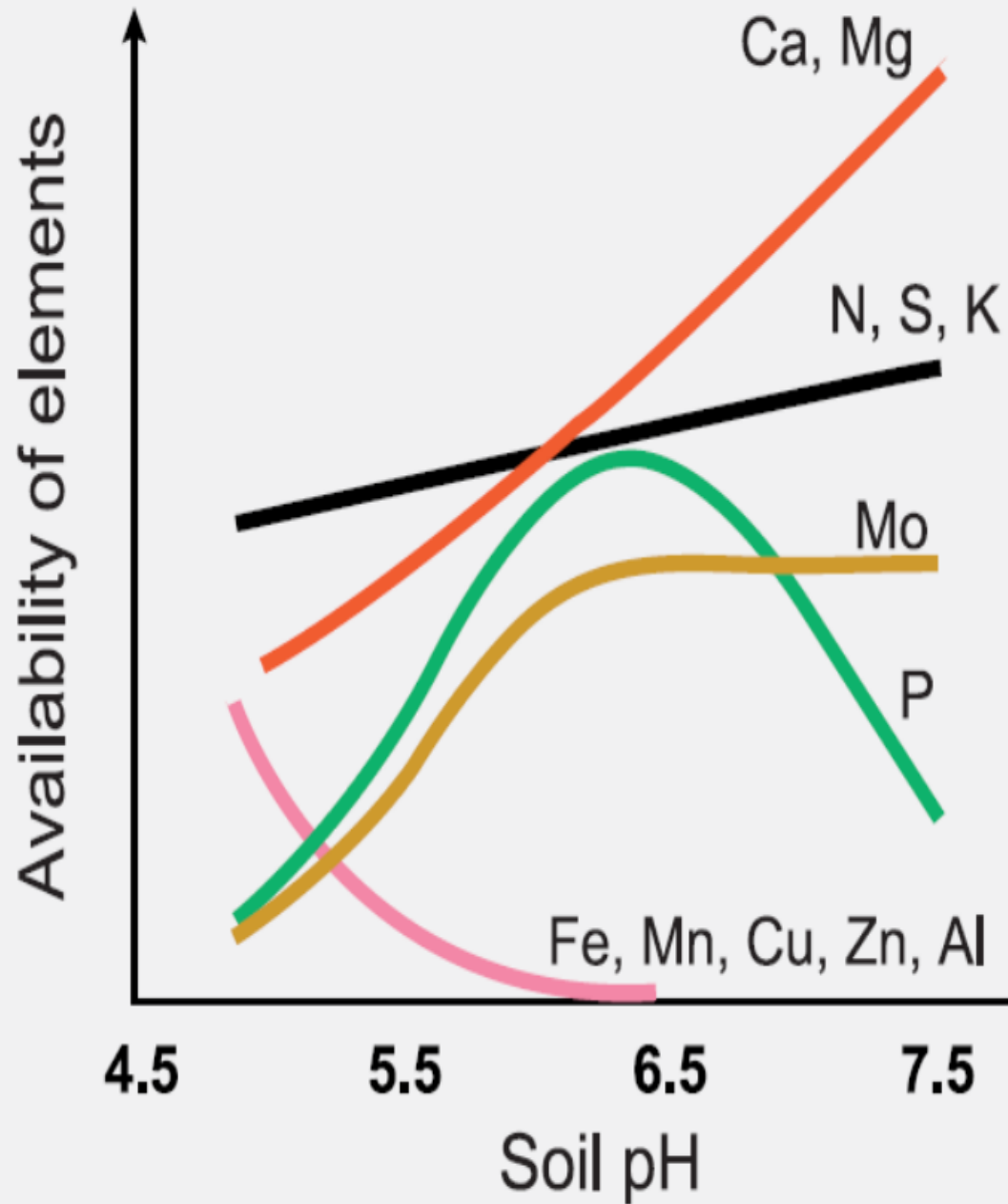
## Chemical

- Low pH
- More anion fixing capacity
- High percentage of base unsaturation
- Decrease the availability of P
- Aluminium toxicity is more
- Ca, Mg levels are decreased – deficiency occur
- Mo level decreased – deficiency occur
- Restriction of nitrogen fixation in legumes



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## Biological

- Low soil pH leads to reduced growth of beneficial organisms.
- Low pH results in a change in the microbial decomposition processes (essential for the release of nutrients from organic matter).
- Symbiotic relationships between native vegetation and soil organisms
- Decreasing the survival of native vegetation.
- Earthworms and some insects are unable to tolerate low -lead to poorer soil structure and reduced organic matter decomposition



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# Management of acid soil



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# Application of liming materials

Different liming material to reclamation of acid soil

- Oxides -  $\text{CaO}$
- Hydroxides -  $\text{Ca(OH)}_2$
- Carbonates -  $\text{CaCO}_3$
- Silicate of calcium -  $\text{CaSiO}_3$



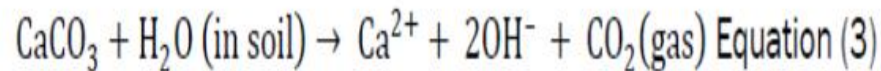


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## Calcium carbonate $\text{CaCO}_3$

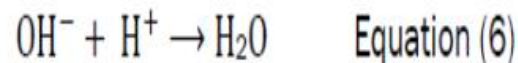
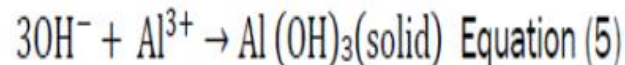
Lime is dissolved (slowly) by moisture in the soil to produce  $\text{Ca}^{2+}$  and hydroxide ( $\text{OH}^-$ ):



Newly produced  $\text{Ca}^{2+}$  will exchange with  $\text{Al}^{3+}$  and  $\text{H}^+$  on the surface of acid soils:



Lime produced  $\text{OH}^-$  will react with  $\text{Al}^{3+}$  to form solid  $\text{Al}(\text{OH})_3$ , or it will react with  $\text{H}^+$  to form  $\text{H}_2\text{O}$  as shown in equations 5 and 6.





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## Oxides of lime



## Hydroxides of lime



## Silicates of Calcium





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## *Solubility and qualities of lime*

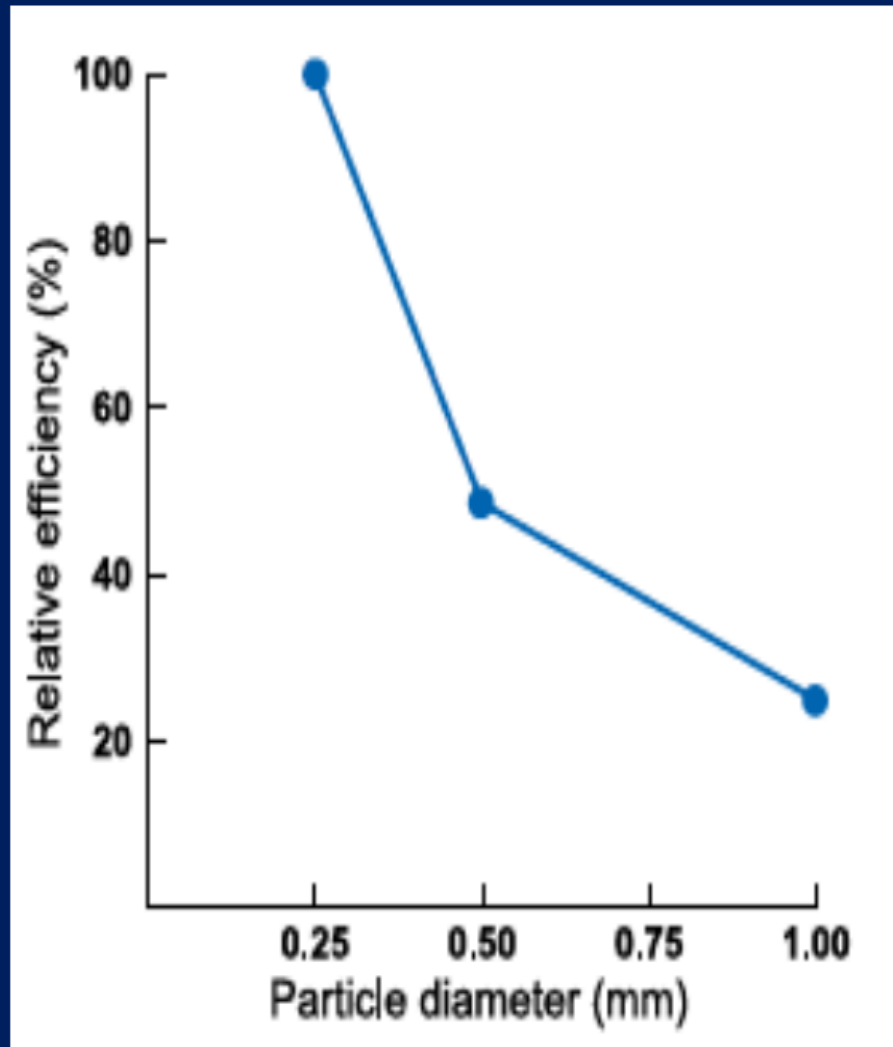
- Lime is lowly soluble in water- particles must be finely ground to neutralize soil acidity.
- Very small changes in the sizes of the particles have a major effect on the time required to dissolve them.
- Effectiveness depends - Purity of the liming material & how finely it is ground.
- The lower the CCE value, the more lime you will need to neutralize the soil's acidity



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# Particle size distribution & efficiency





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- liming eliminates toxic  $\text{Al}^{3+}$  and  $\text{H}^+$  through the reactions with  $\text{OH}^-$ .
- Excess  $\text{OH}^-$  from lime will raise the soil pH, which is the most recognizable effect of liming.
- Another benefit of liming is the added supply of  $\text{Ca}^{2+}$ , as well as  $\text{Mg}^{2+}$

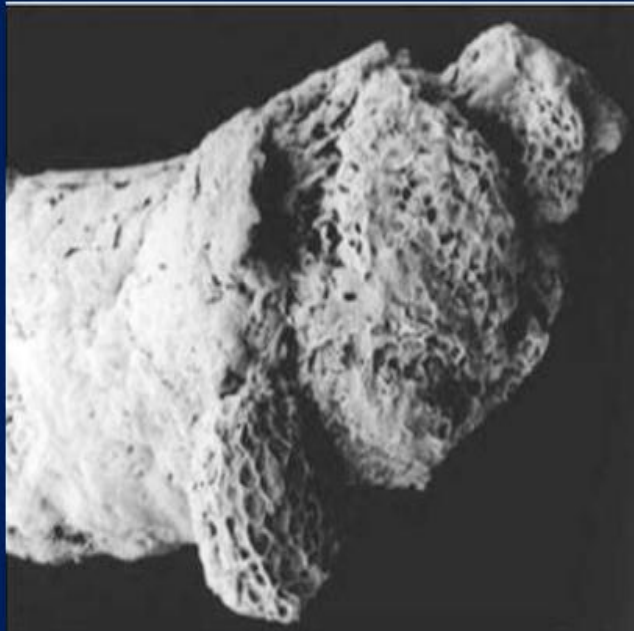


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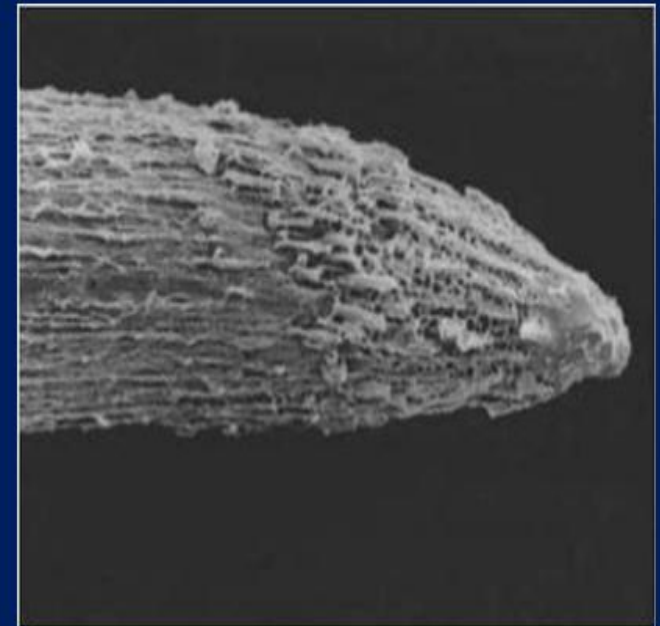
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## Benefits

**Root**



**Before liming**



**After liming**



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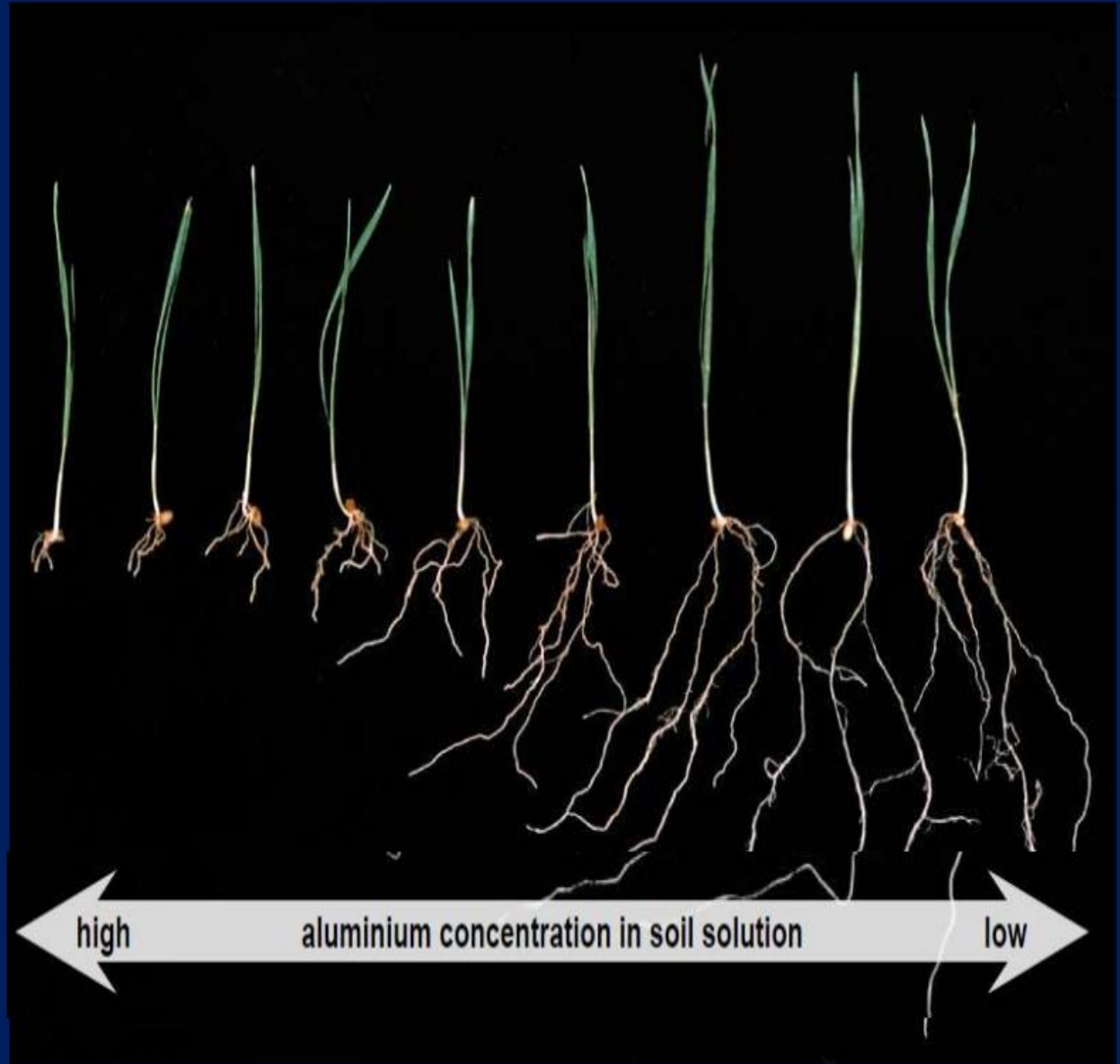
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## *Effects of over liming*

- Deficiency of Fe, Cu, Zn, P, K
- Increment of  $\text{OH}^-$  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



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## Crop residues

- Soil pH changes after the addition of chickpea & canola residues.
- The greatest increase in soil pH occurred after chickpea addition as it is easily mineralized.
- Chickpea has a potential alkalinity.
- The soluble fraction was the main source of alkalinity within the first 2 days.

**Kochian LV, Hoekenga OA, Pineros MA (2004)**



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- Basic cations which are released during decomposition of crop residues increase the pH (**Noble and Randall, 1999**).
- The excess cation content, indicative of ash alkalinity, represents the liming potential of residues (**Noble *et al.*, 1996**).

**Table 1. Chemical properties of the residues.**

Residue	C:N ratio	Ash Alkalinity (cmol/kg)
Chickpea	21:1	150
Canola	40:1	130
Wheat	64:1	45

**(Rukshana *et al.*, 2009).**



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# Effects of unburned Lime on Soil pH and Acidic Soil

- The lime materials used were agricultural burned lime and 3 unburned lime materials
  - ✓ Karongi
  - ✓ Musanze
  - ✓ Rusizi
- Fineness of agricultural burned and Musanze unburned lime were higher (70.57 and 63.03%, resp.).

**C. Yamoah *etal* 1996**



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- The increase of Mg saturation was observed only with Karongi unburned lime application.
- Use of 2.8 t/ha of Rusizi or Musanze unburned lime as alternative to the agricultural burned lime – decrease soil acidity.

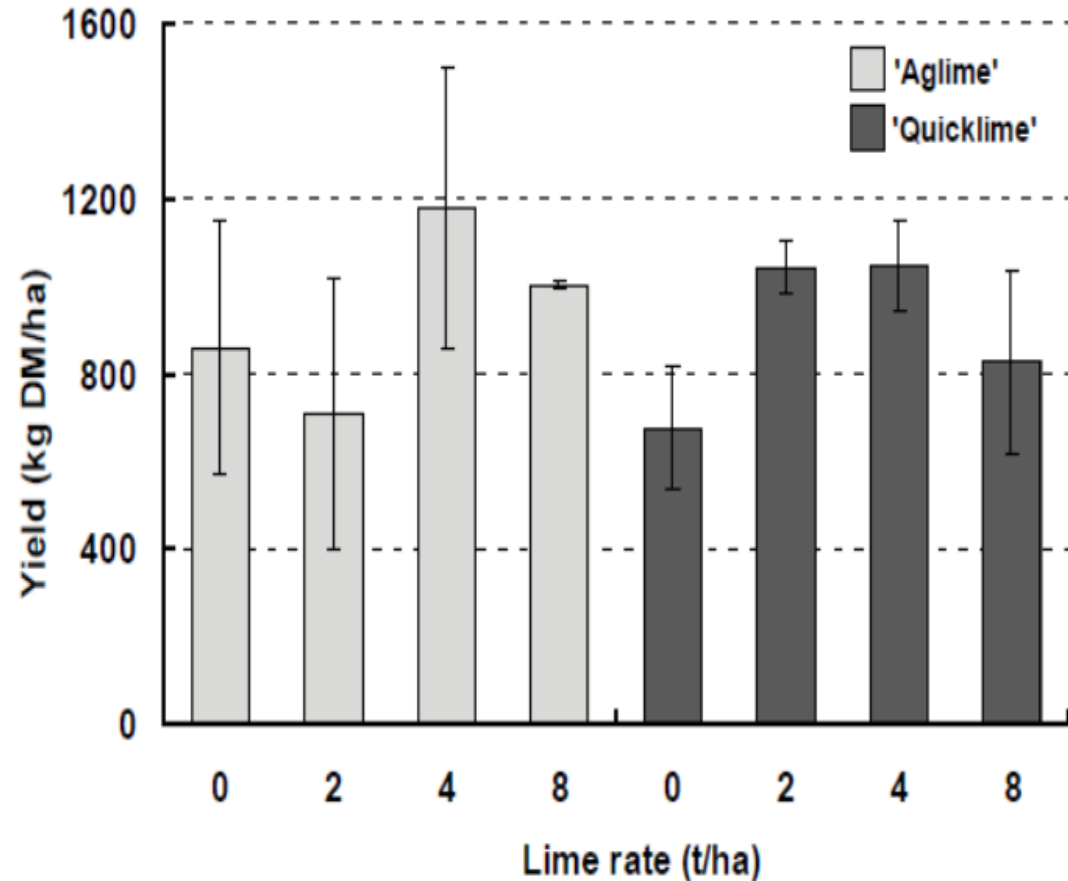
**C. Yamoah *etal* 1996**



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# Comparison of agricultural lime and quick lime



**Moir et al 2009**

Crop: **Lucerne**

Agriculture lime : Increased pH from **5.3 to 5.6**

Reduced Al level from **2 to 1.3 me/100g**



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# Neutralization of soil acidity by animal manures & Comparison

Five animal manures

- Rabbit manure
- Swine manure
- Goat manure
- Poultry manure
- Cow manure

**Hue et al. (1986),**





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## Reactions

- Organic manures mineralize- Ca ions are released into the soil solution.
- Ca ions get hydrolysis process.
- Calcium hydroxide formed reacts with soluble aluminum ions in the soil solution to give insoluble  $\text{Al(OH)}_3$ .

Hue et al. (1986),



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# Chemical composition of animal manure

<u>Animal manure</u>	<u>Ca</u>	<u>Mg</u>
Rabbit manure	1.37	2.16
Swine manure	1.37	1.30
Goat manure	1.37	0.83
Poultry manure	1.24	0.89
Cow manure	1.12	1.94

*Ano et al 2007*



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## Acidity under successive pig slurry applications

- Pig slurry application as soil manure can alter the chemical properties of the soil and affect its acidity, modifying the environment for crop growth and development.
- Decreased the acidity to a depth of 8cm.

**Cledimar Rogério Lourenzi et al. 2008**



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- The application of pig slurry increased soil pH
- The applications also resulted in accumulation of Ca and Mg exchangeable levels in the surface layers, increasing base saturation and reducing Al<sup>3+</sup> saturation.

**Cledimar *et al.* 2008**



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## Natural resources

- **Nitrate leaching** considered to be the dominant mechanism for accelerated acidification
- The growing of deep-rooted perennial pastures (lucerne) is seen as an answer to slowing the acidification process (**Ridley *et al.* 1998**).
- This could be achieved by perennial plants using available nitrogen more efficiently thereby reducing nitrate leaching.
- The native eucalypts increase the surface soil pH (**Wilson 2002**)



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## Selection of crops

### Highly tolerant

- Strawberry
- Goose berry
- Plum
- Radish
- Sweet potato
- Pepper
- Beans
- Cabbage
- Carrot

### Moderately tolerant

- Pineapple
- Orange
- Litchi
- Jack fruit
- onion
- Tomato

### Slightly tolerant

Mango  
Banana  
Guava  
Cashew



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## *Conclusion*

- Soil acidity is a serious problem in agricultural land
- We improve soil health – practice various management practices
- Based on soil test value recommend the fertilizer
- Judicious application of nitrogenous fertilizer
- To advice the farmer should know about soil test technology