

## Lecture 6 Tropical Soils

In general, tropical soils are unproductive in terms of crop yields.



Tropical soils are now known as:

Oxisols (most weathered, typical tropical soils, high in iron & aluminum oxides)

Ultisols (highly leached)

Alfisols (least weathered, younger soils, aluminum & iron soils, temperate soils)

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### Productive Tropical Soils

Alluvial soils (Entisols):

Young, recently deposited soils carried by water.

Volcanic ash soils (Inceptisols):

Derived from volcanic eruptions.

Basaltic soils:

Basaltic rocks are high in iron, aluminum, calcium, and magnesium. Both volcanic and basaltic soils contain some ferromagnesian minerals and source of bases.

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### Terms Used in Tropical Soils

Deep weathering: Physical and chemical breakdown of soils.

Chemical weathering is very active in the tropics.

Hydrous oxide clays: Residues from highly leached tropical soils.

Combination of oxygen, aluminum, and iron.

The term hydrous refers to water molecules attached to oxides.

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## Tropical horticulture: Lecture 6

**Laterite (Plinthite):** Later derives from a word meaning "brick."

The hardened tropical soils are due to loss of water in hydrous oxide clays.

May be overrated as tropical problem. Soils widely used as building material.

**Laterization:** Soil development process in the tropics.

Silica is removed and hydrous oxide clays are left. Trace elements are removed.

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**Latosol (Oxisol):** Any tropical soil largely composed of hydrous oxide clays, low pH, infertile.

**Leaching:** Net removal of soluble material by water.

**Plant nutrients:**

O, H, C Derived from air and water.

N, Ca, Mg, K, P, S Macronutrients derived from soil.

Cl, B, Mo, Zn, Fe, Mn, Cu Micronutrients derived from soil.

**Red and yellow tropical soils (Latosols):**

Soils based on iron oxide.

**Silica:** Mineral composed of silicon and oxygen.

**Tropical Soil Characteristics:**

Low cation exchange.

Low base saturation.

Low pH.

Good structure.

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**Tropical soils tend to be old soils that stood above oceans for many millennia**

**Older soils are:**

Deeply weathered.

Highly acid (pH 4.2–5.0), so chemical reactions differ from ideal.

High leaching by rain (net removal of soluble material).

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# Tropical horticulture: Lecture 6

## Clays

Clays are the “life blood” of the soil due to the active exchange mechanism of bases.

Clays differ in tropics and temperate climates

Temperate clays: Montmorillonite (2:1 layer)  
Tropical clays: Kaolinite (1:1 layer)

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### Montmorillonite (temperate clay, 2:1 layers)



Each micelle consists of an alumina layer sandwiched between two layers of silica (2:1 layers)  
These clays are not bound together tightly.  
Swell when wet because hygroscopic surfaces between layers adsorb water and force the layers apart.  
All surfaces adsorb water and minerals.  
Temperate clays tend to be sticky (poor structure) but have good exchange capacity.

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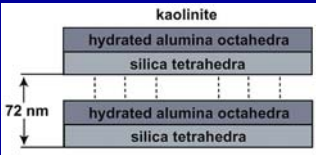
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### Kaolinite (tropical clays, 1:1 layers)



Each micelle consists of two different layers one of silica and the other of alumina.  
Micelles are relatively large and bound together tightly.  
Distance between layers is relatively fixed.  
Micelles do not increase when water is adsorbed.  
Internal space unavailable for surface reaction.  
Micelles do not shrink greatly when dry or expand much when hydrated.

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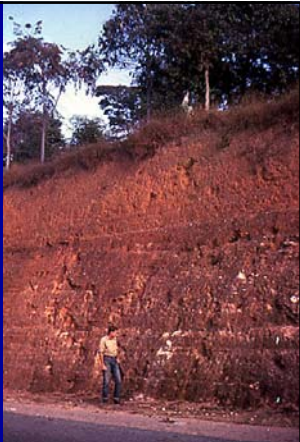
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# Tropical horticulture: Lecture 6

**Tropical Soils Summary**

- Good structure
- Good drainage
- Do not remain sticky very long when wet
- Reduced fertility



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**Soil Formation**

Soil formation processes depend on climate.

The soil forming processes in cold humid temperate climates is called podzolization and produce podzolic soils.

Podzols (spodosols) is the extreme type and derives from a Russian word meaning “ash beneath” and refers to the color of the A2 horizon.

Podzolization is characterized by:

- Deep accumulation of litter and humus, originating in cold soils.
- Strongly acid due to litter.
- Iron and aluminum is leached form upper horizon; color is ashy in A2 horizon.
- Fungi are the main soil forming organisms.

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The soil forming process in the humid tropics and subtropics is called laterization.

The extreme type is called laterites (formerly latosols but now oxisols).

Characterized by:

- Shallow accumulation of liter and humus (due to high temperature and high moisture).
- Bacteria are the main soil forming organism.
- Soils are neutral to acidic.
- Silica, normally very resistant, is broken down and leached out leaving a residue of oxide clays.
- Accumulation of iron and aluminum in the upper horizons (thus are red in color).
- Complete and deep weathering.
- Intense leaching.
- Low cation exchange capacity (CEC); low fertility.

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# Tropical horticulture: Lecture 6

Soil Summary		
Variables	Podzolization	Laterization
Climate	Cold	Warm to hot
Natural vegetation	Conifers	Tropical rainforest
Soil forming microorganism	Fungi	Bacteria
Humus	Abundant	Sparse
Soil reaction	Acid (pH 4.5–5.0)	Neutral (pH 6.5–7.0)
Earthworms	Scarce	Abundant
Solubility of silica	Low	High
Iron and aluminum	Leached out of A horizon	Accumulate in A horizon
Hydrolysis	Weak	Intense

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### Arid Soils

In arid regions, carbonates accumulate in the upper surface and produce alkaline soils which are characteristic of desert and steppe (aridosols in desert; mollisol in steppes).

Trickle irrigation was developed to leach salts from upper layers.




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### Advantages of Tropical Soils

Good structure.

Temperate clays are sticky when wet while tropical clays:

- Do not form permanent clods
- Not so sticky when wet
- Tend to be loose and friable.

Moisture supply is dependable (due to climate) which is not true in many temperate regions.

In Savanna climate irrigation may be required in winter dry period.

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## Tropical horticulture: Lecture 6

### Paradox of Exuberant Vegetation and Poor Soils

Soils under rainforest do not contain many nutrients, and these are tied up in the complex interactive system of soil and forest.

Nutrient recycling refers to the decomposition of litter and the very rapid mineralization of released nutrients which are absorbed by plant roots. The nutrients in the system are basically stored in living vegetation. The soil simply serves as a transfer between living and decaying vegetative matter.

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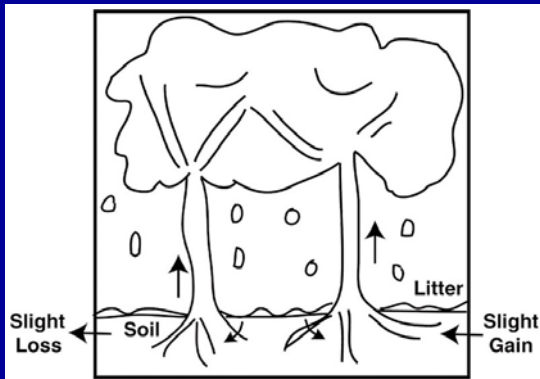
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### Nutrient Recycling



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### However, if trees of tropical rainforest are removed

Organic matter is mineralized and leached away.

Soil is exposed to sun directly and chemical decomposition increases.

Net loss of minerals by crop removal.

No pumping by shallow rooted crop plants.

Soil flora and fauna is disturbed and soil fertility is reduced.

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## Tropical horticulture: Lecture 6

### Soil structure deterioration.

Structure may be changed for the worse.

Friable soil is removed and only oxide clays are left.

Structure is less friable.

More important soil structure is exposed to direct force of raindrops which may be severe.

### Soil compaction increases.

Increasing density reduces pore space and limits soil oxygen.

### Soil loses fertility and productivity.

After third year of crop removal there is an increase in pests such as weeds, diseases, insects, and rodents.

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Soil after forest destruction and removal is in a "pioneer" condition and will be colonized by aggressive weedy plants which compete with new crop for available nutrients.

Erosion ensues—may be an advantage if there is a movement toward unweathered mineral rich rock; but this is slow.

Gullying is a more severe and an immediate problem with heavy rainfall.

The inherent low soil fertility is a severe limitation to tropical soils.

Fertilization is an agricultural necessity with crop production.

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### Fertility of tropical soil is fragile

Under undisturbed conditions there is a slight loss by leaching with nutrient gains by rainfall and lightning, dust, nitrogen fixation by bacteria, "pumping" action of deep roots in partially weathered submaterial, and slight release of additional minerals from soil weathering.

The balanced equilibrium found in the rainforest is disturbed by felling the forest and burning the residue. The first year of crop production on the "virgin" soil may be good because the 3" of humus in rain forest is turned into ash and is available to fertilize the new crop.

However in the second year yields are lower and in the third year yields may be uneconomical.

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# Tropical horticulture: Lecture 6

### Decreasing Rice Yields

Malaysia, Upland Rice	Yield (lb/acre)
Virgin soil	800-1000
Second year	600-800
Third year	400-600

British Honduras, Maize	Yield (lb/acre)
Virgin soil	1500-2000
Second year	1200
Third year	800

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### Tropical Soils and Topography

In the Amazon valley productive soils do not lie in the high "terra firme" rainforest but rather in the Amazon flood plain (*varesea*).

Varesea is renewed by flooding.

Silt is low in minerals but is renewed each year.

10-50 miles

Rainforest      Amazon      Terra Firma

Seasonally Flooded      Seasonally Flooded

Varsea (flood plain)

10% of Amazon Basin

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Amazon Rainforest (*Af*) represents 40% of the area of Brazil and is mostly forested.

It contains only 3-4% of the population concentrated along rivers in a few towns but is increasing by movement of colonists from arid areas.

Most of the population is involved in subsistence agriculture, a low level of economic development.

Much of the population is involved in a collection economy (natural rubber, Brazil nuts, native palm nuts) an even lower level of economic development.

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## Tropical horticulture: Lecture 6

### Why is this economic level so low?

Soils in the Amazon are senile (old tropical soils).  
They were derived from a previous lake bed and are very sandy and leached.  
Nutrients are impoverished.  
Only 10% of the Amazon consists of the more fertile flood plain.

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Agriculture is increasing but most of the area is being developed for cattle (ecologists claim McDonald's need for cheap beef is ruining the Amazon).  
In the 1920s a huge area (Fordlandia and later Belleterra) was developed for rubber production by the Ford Motor Company in their drive for vertical integration of their manufacturing process.  
*Hevea* rubber is native to this area but pest pressures made this project a failure.

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Some believe this activity was just a ruse to reduce the price of Malaysian rubber.  
A few years ago American billionaire Daniel K. Ludwig attempted to develop a pulp industry but this collapsed.  
At the present time the colonization system in the Amazon is causing severe economic, ecological, and social problems.

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