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ASAC 1101 : FUNDAMENTALS OF SOIL SCIENCE (2+1)

Level : B.Sc (Ag), I semester

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Topic

Soil Temperature

Importance of soil temperature:

It affects-

- **Plant and microorganism growth**
- **Evaporation**
- **Soil aeration**
- **Many important soil phenomena, from frost-damaged pipelines and pavements to the spring awakening of biological activity in soils**

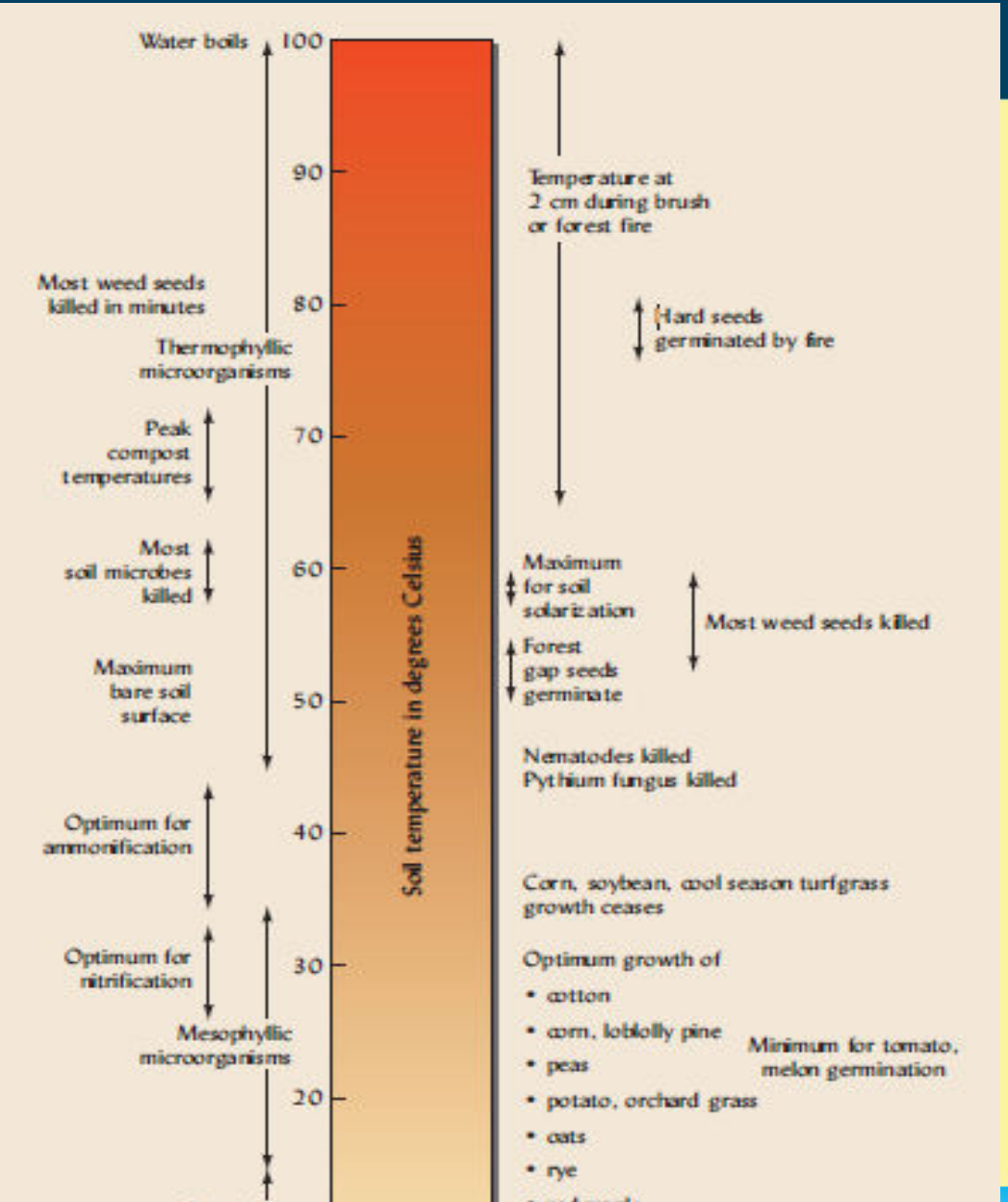
Pavement Interactive

Processes affected by soil temperature

The temperature of a soil greatly affects the physical, biological, and chemical processes occurring in that soil and in the plants growing on it.

- ❑Plant Processes
- ❑Microbial Processes
- ❑Freezing and Thawing
- ❑Permafrost
- ❑Soil heating by Fire

NRDC



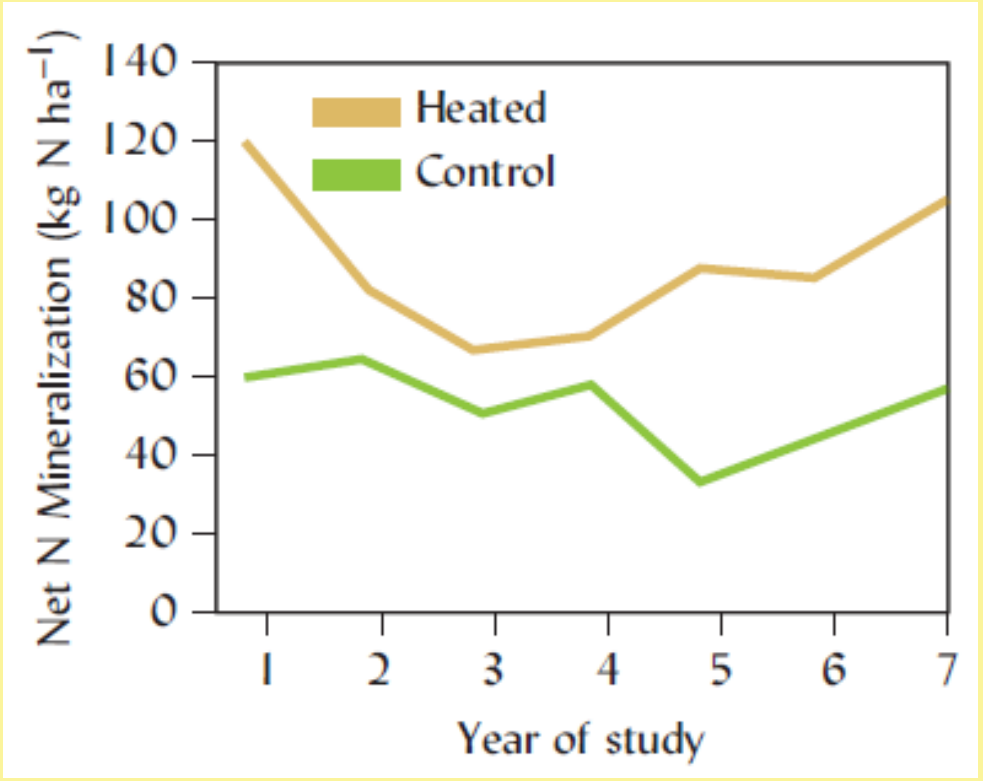
Soil temperature ranges associated with a variety of soil processes.

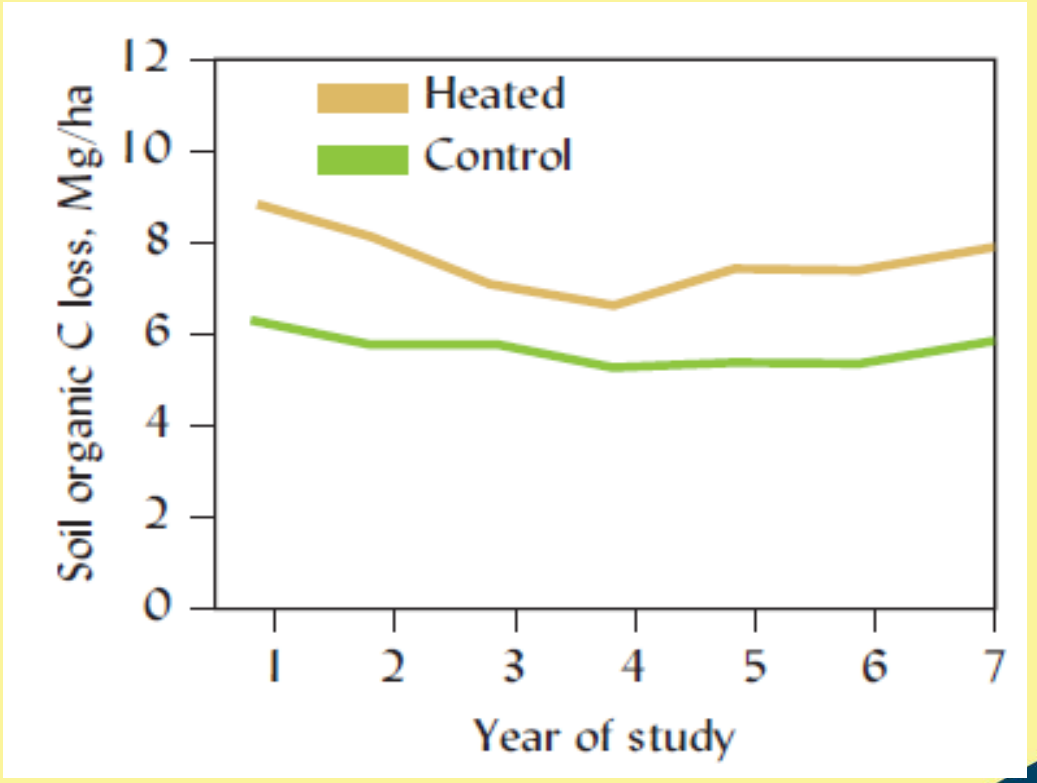
Plant processes

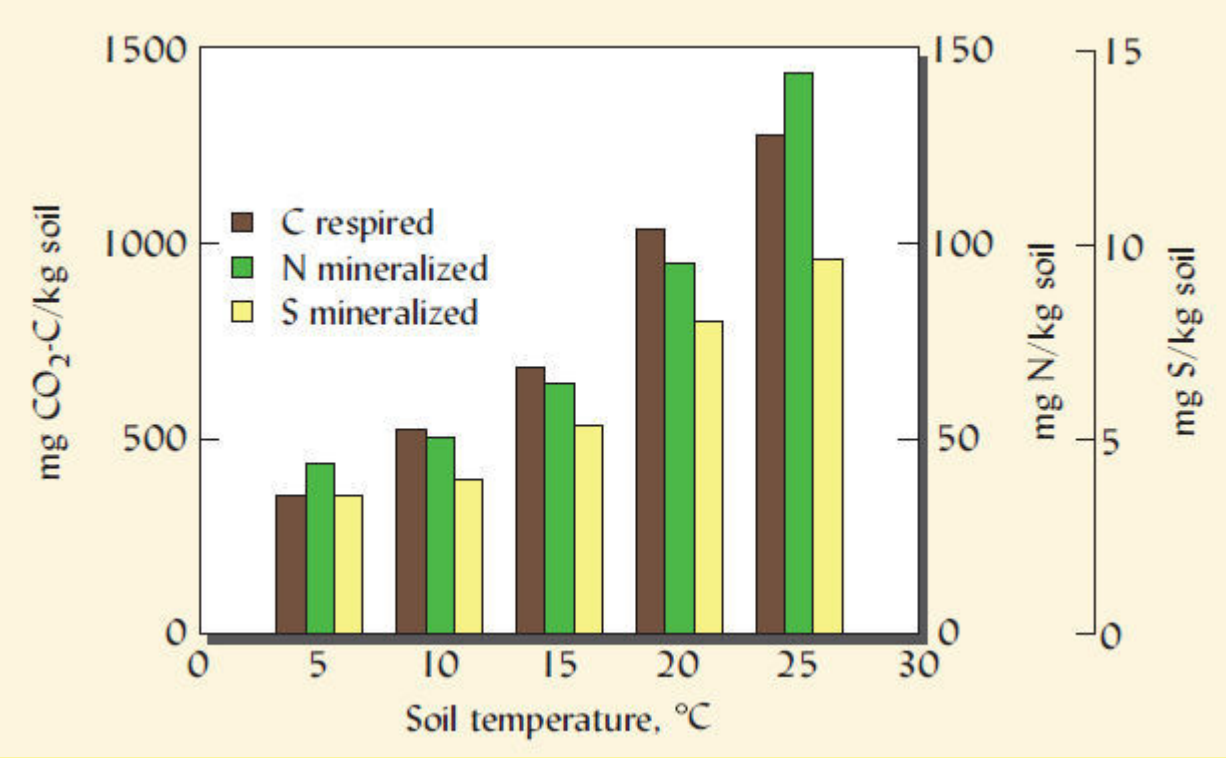
- Most of the plants are sensitive to soil temperature
- Soil temperature affects the seed germination and root growth
- Many plants require a specific temperature to trigger the seed germination
- The seeds of certain prairie grasses and grain crops require a period of cold soil temperatures (2–4 °C) to enable them to germinate the following spring, a process termed ***vernalization***.
- Root functions are sluggish in the winter months
- Nutrient movements are also slow in cool soils
- Excess temperature can also damage crops

Microbial processes

- Microbial activity ceases at temperatures that freeze water (<0 °C)
- Microbial activity is far greater at warm temperatures; the rates of microbial processes such as respiration typically more than double for every 10 °C rise in temperature
- The optimum temperature for microbial decomposition processes may be 35–40 °C
- In environments with hot, sunny summers a heating process called ***soil solarization*** can be used to control pests and diseases in some high-value crops


Net N Mineralization (kg N ha^{-1})
140
120
100
80
60
40
20
0
Heated
Control
1
2
3
4
5
6
7
Year of study


Soil organic C loss, Mg/ha
12
10
8
6
4
2
0
Heated
Control
1
2
3
4
5
6
7
Year of study



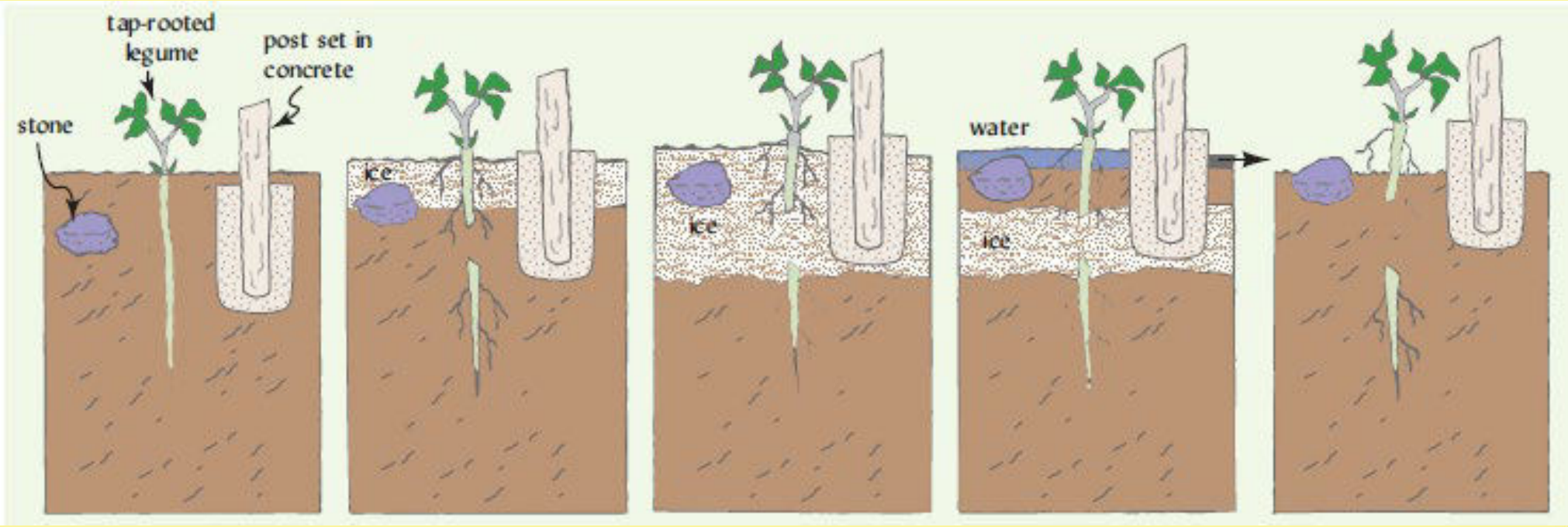
Effect of soil temperature on cumulative microbial respiration (CO_2 release) and net nitrogen and sulfur mineralization in surface soils

Freezing and thawing

- It increases the structural stability.
- In contrast, for soils with good aggregation to begin with, freeze–thaw action when the soil is very wet can lead to structural deterioration
- Alternate freezing and thawing can force objects upward in the soil, a process termed *frost heaving* which is most severe where the soil is silty in texture
- Freezing can also heave shallow foundations, roads, and runways that have fine material as a base. So, the foundation depth should be maintained (10 cm for subtropical, 200 cm for very cold region)

Nhpr

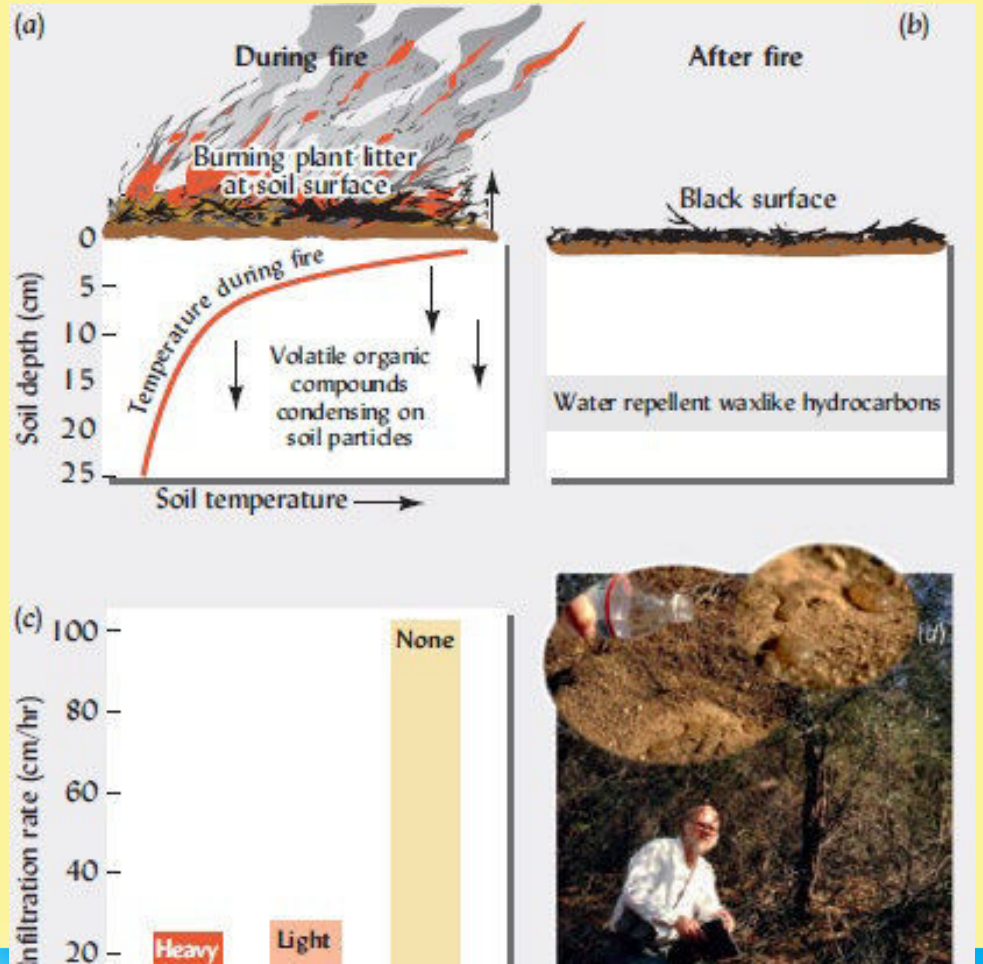
Frost Heaving



Permafrost

- The thawing of arctic permafrost is expected to further accelerate global warming, as decomposition of organic materials long trapped in the frozen layers of Histels releases vast quantities of carbon dioxide into the atmosphere.

Soil heating by fire



(a) Heating up the surface soil to remove the volatile organic component in sandy soil

(b) The volatile substances diffuse to the sub soil and again solidified. It will drastically reduce the infiltration of the water

The thermal properties of soil

- **Specific Heat of Soils**
- **It is the heat capacity per gram of soil (cal/g). It controls the degree to which the oils warm up**
- **The specific heat largely controls the degree to which soils warm up in the spring**
- **The specific heat of pure water is defined as 1.00 cal/g (or 4.18 joules per gram, J/g); that of dry soil is about 0.2 cal/g (0.8 J/g)**
- **Wetter soils warming more slowly than drier ones**

The thermal properties of soil

Heat of vaporization

- It requires a large amount of energy (540 Kcal) for every kilogram of water vaporized.
- This use of energy for evaporation cools the soil

The thermal properties of soil

Thermal conductivity of soil

- **The movement of heat in soil is analogous to the movement of water**
- **The rate of flow being determined by a driving force and by the ease with which heat flows through the soil. This can be expressed as Fourier's law:**
- $qh = -k \, dT/dx$
- **Where, *qh* is the *thermal flux*; k is the thermal conductivity of the soil; and d*T/dx* is the temperature gradient over distance *x* that serves as the driving force for the conduction of heat.**

Factors affecting thermal conductivity

Compaction

- The arrow shows the heat transfer
- The compacted soil will transfer more heat
- Compacted soil increases the particle-particle contact which helps in heat transfer

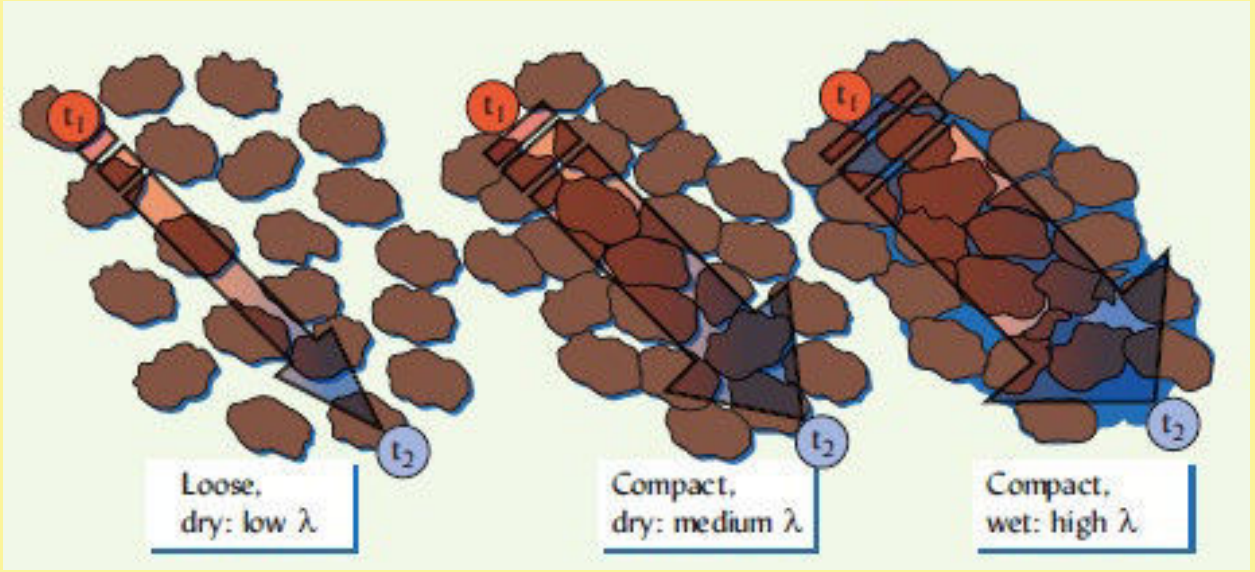
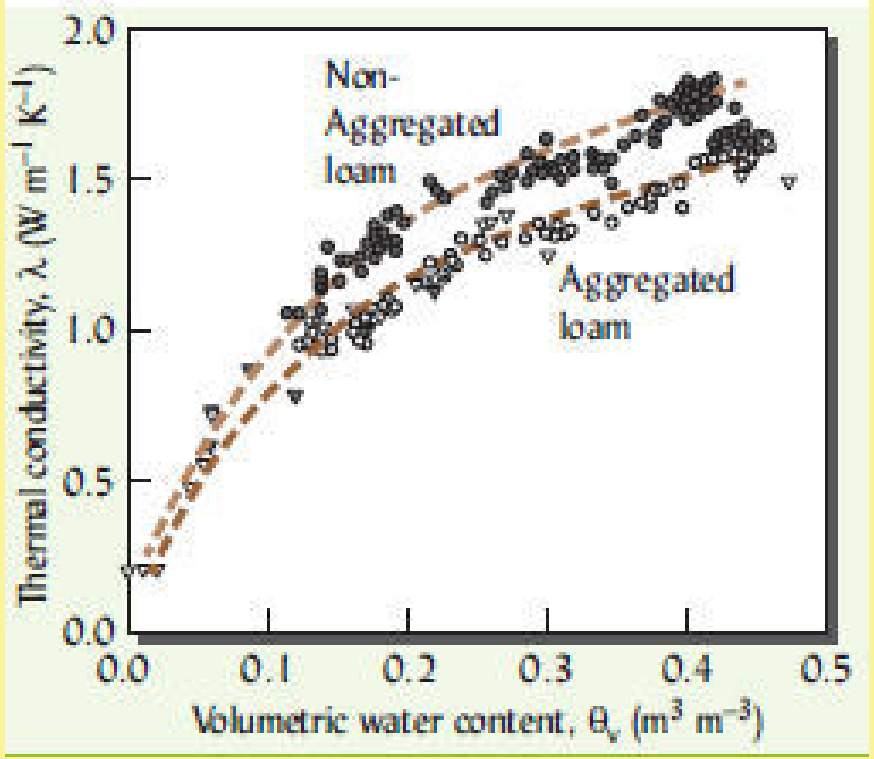


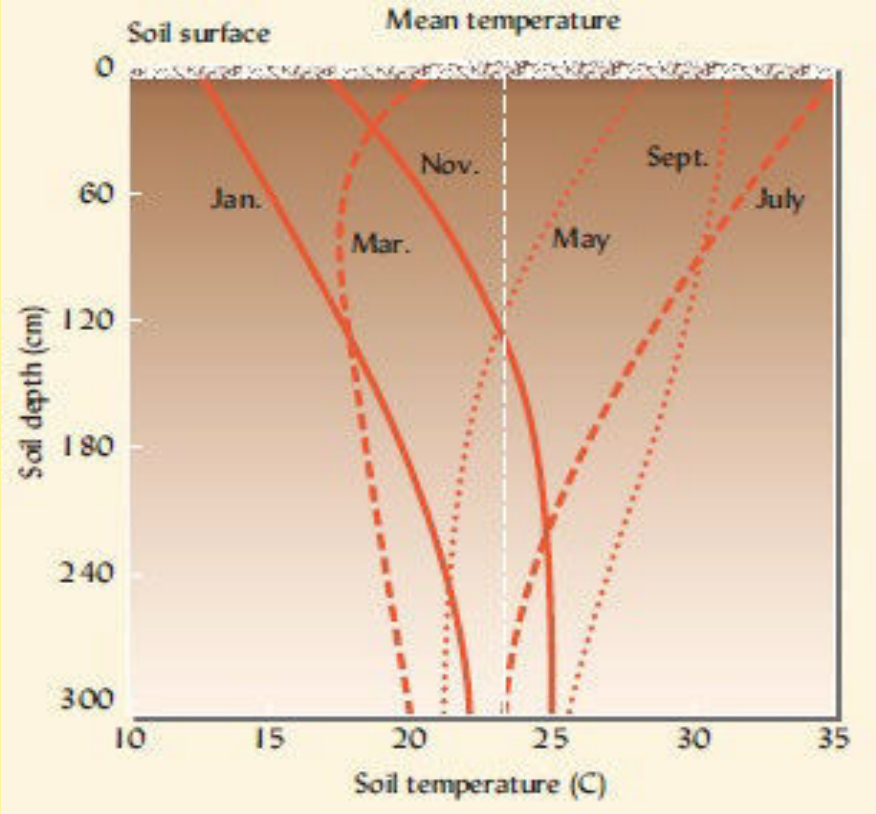
Diagram courtesy of Ray R. Weil

Factors affecting thermal conductivity

- If the water content of the soil is increased, it will also increase the heat transfer. The water has more thermal conductivity than the air.

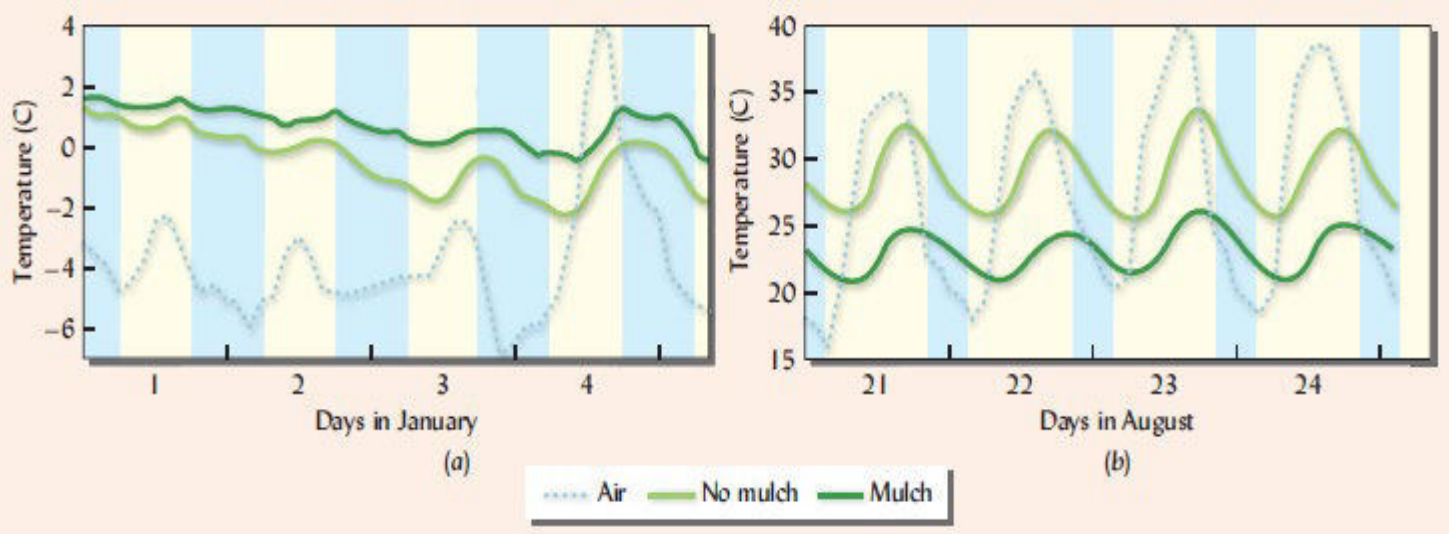


Variation with Time and Depth



- Soil surface temperature changes with the seasons.
- But the subsoil temperature changes very little with the season (4-5m depth).
- Subsoil temperature is less variable than the air and surface soil temperature.

Soil Temperature Control



- **Organic mulches and plant-residue management-**
  It is generally used to buffer the soil temperature.

- **Mulch from conservation tillage- Conservation tillage left the crop residues on the soil surface. So, it reduces the transportation cost**

- **Advantages in Warm Climates**

- **Plastic Mulches-**

➢ Plastic mulches are used to increase the soil temp.

➢ Two types- 1. Clear plastic 2. Black plastic

➢ Clear plastic has greater heating effect than the black plastic.

➢ Generally used in cool climates for growing crops or for pest management.

➢ The major disadvantage is that it is nonrenewable. But biodegradable plastic films can be used as a mulch

- **Biodegradable Plastic Mulches-**

Diagram courtesy of Ray R. Weil

- **Moisture Control-**

➢ **The soil with more water having 3-6^{0}C lower temperature than the dry soil.**

➢ **To get a warmer soil, drainage condition should be improved.**