

## FUNCTIONS OF SOIL AND SOIL PROFILE

### DEFINITIONS

**soil** - the outer weathered layer of the earth's crust.

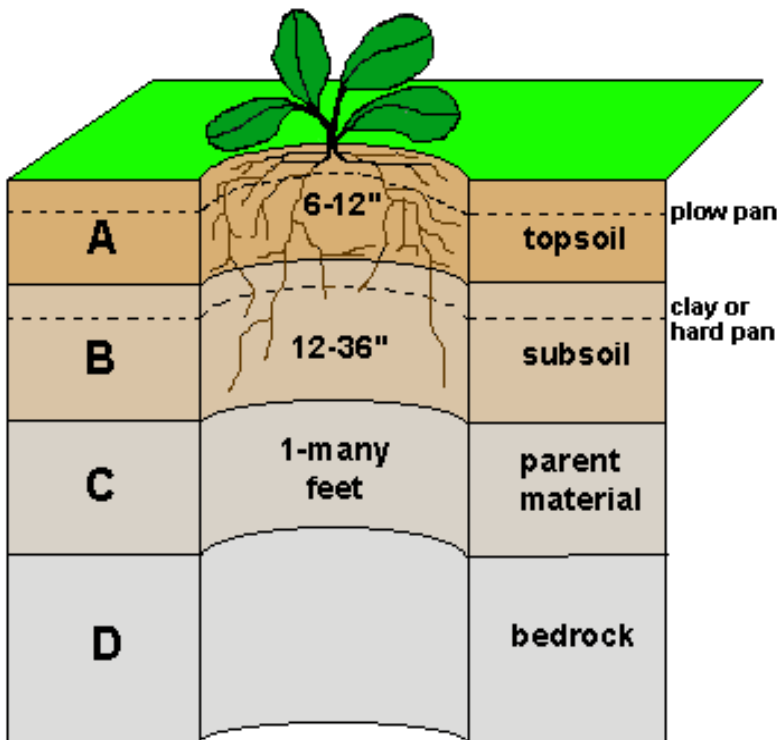
**growing medium** - the substrate in which plants grow. Usually applied to manufactured or synthetic soils, i.e. "potting soils", or highly amended soils, ex. landscape beds.

### FUNCTIONS OF WATER OR GROWING MEDIUM

- 1) **Support and anchorage**
- 2) **Supplies mineral nutrients**
- 3) **Supplies water**
- 4) **Allows gas exchange** - especially  $O_2$  and  $CO_2$ , but also ethylene

### SOIL ORGANIZATION

**soil profile** - morphology of horizons (layers) in a soil.



#### A Horizon or topsoil

- highly weathered
- abundant life, therefore, high in organic matter
- dark colored

**plow pan** - a compacted impermeable layer in the A horizon due to repeated plowing or tilling (approx. 6" deep)

#### B Horizon or subsoil

- less weathered; higher in clay
- less life, therefore, low in organic matter
- lighter colored

**clay pan** - impermeable layer high in clay.  
**hard pan** - impermeable layer high in iron.

#### C Horizon or parent material

- little weathered
- little life, except deep rooted plants and little to no organic matter

#### D Horizon or bedrock

- rock base

## SOIL COMPOSITION

### TYPES OF SOIL BASED ON COMPOSITION

A) **Organic soil** - contain 20% or more organic matter

#### 2 types

- 1) **peat soil** - contains greater than 65% organic matter
- 2) **muck soil** - contains 20-65% organic matter

B) **Mineral soil (field soil)** - contains less than 20% organic matter.

**4 Major Components** (in a well watered, but well drained loam soil)

- 1) **air** - approximately 25% of volume; in larger pores
- 2) **water** - approximately 25% of volume; in smaller pores
- 3) **mineral particles** - 44-49% of volume

Mineral Particle	Size
sand	0.05-2 mm
silt	0.002-0.05 mm
clay	<0.002 mm

4) **organic matter** - typically about 1% in nature

**litter** - partially decayed organic matter on the soil surface.

**humus** - highly decomposed, fine, amorphous organic matter in the soil.

#### Functions of Organic Matter:

- 1) stabilizes soil structure
- 2) increases water retention and availability
- 3) increases drainage and aeration
- 4) increases cation exchange capacity
- 5) supplies nutrients upon decay (only if low C:N ratio)
- 6) stabilizes pH
- 7) food source for microorganisms

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### PROPERTIES OF SAND Vs. SILT Vs. CLAY

#### SAND

- 1) **Physical** - structurally simple; relatively unweathered, physically broken down parent material
- 2) **Chemical** - relatively inert; results in:
  - a) little effect on soil chemistry and pH
  - b) poor nutrient holding capacity (i.e. CEC)
- 3) **Pore Space**
  - a) less total pore space
  - b) more large (macro) pores, fewer small (capillary) pores; thus sand causes:
    - 1) increased aeration
    - 2) increased drainage
    - 3) decreased water holding capacity

**SILT** - intermediate chemical and physical properties between sand and clay

#### CLAY

- 1) **Physical** - structurally complex
  - a) colloidal - sub-microscopic and held in suspension in solution
  - b) when wet - viscous and gelatinous, sticky; when dry - hard, packed and cohesive
  - c) composed of **micelles** = flat, sheet-like plates laminated into stacks
  - d) very large internal and external surface area
  - e) very small internal and external pores
- 2) **Chemical** - very complex; negatively charged
  - a) very high cation exchange capacity (CEC); hence, nutrient holding capacity
  - b) charge allows **flocculation** (aggregation) or **de-flocculation** (spread-out)
    - 1) **Ca<sup>+2</sup>** promotes **flocculation** of soil, and good soil structure
    - 2) **Na<sup>+</sup>** promotes **de-flocculation** of soil, and poor soil structure

**3) Pore Space**

- a) greater total pore space
- b) more small (capillary) pores; fewer large (macro) pores; thus clay causes:
  - 1) **decreased aeration**
  - 2) **decreased drainage**
  - 3) **increased water holding capacity**
  - 4) **but not all water is available**

**TYPICAL AGRICULTURAL SOIL**

An agriculturally productive soil is a balanced mixture of sand, silt, and clay. For example, a typical **loam soil** is composed of 40% sand, 40% silt, and 20% clay. This yields a balance between aeration vs. drainage vs. water holding capacity vs. fertility.

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**SOIL CHEMISTRY**

**cation exchange capacity (CEC)** - milliequivalents per 100 grams dry soil; meq/100 g.

Component	CEC (meq/100 g)
sand	2-4
silt	4-10
clay	10-100
organic matter	150-300

**percent base saturation** - % of total CEC occupied by basic nutrients, such as  $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{K}^{+}$  and/or  $\text{Na}^{+}$  (as opposed to acidic  $\text{H}^{+}$  and  $\text{Al}^{+3}$ )

**pH**- negative log of the hydrogen ion concentration; **pH =  $-\log [\text{H}^{+}] = \log 1/[\text{H}^{+}]$**

pH is a measure of the acidity of a solution. Below pH 7 is acid, pH 7 is neutral, and above pH 7 is basic. pH is seldom high or low enough to directly effect plants. Its major effect is on the solubility of nutrients in the soil solution, i.e. nutrient availability.

Nutrients That Are More Available at		
Low pH (below pH 5.5)	Intermediate pH (pH 6-7)	High pH (above pH 6.5 )
Fe, Zn, Cu, Mn, B	P	N, K, Mg, Ca, S, Mo

How to Increase or Decrease Soil or Growing Medium pH	
Chemicals that Increase pH	Chemicals that Decrease pH
<ul style="list-style-type: none"> <li>o <b>calcitic lime</b> - <math>\text{CaCO}_3</math></li> <li>o <b>dolomite</b> - <math>\text{CaCO}_3 / \text{MgCO}_3</math></li> <li>o <b>hydrated lime</b> - <math>\text{Ca}(\text{OH})_2</math></li> <li>o <b>burned lime</b> - <math>\text{CaO}</math></li> <li>o <b>basic fertilizers (nitrate)</b></li> </ul>	<ul style="list-style-type: none"> <li>o <b>elemental sulfur</b> - S</li> <li>o <b>aluminum sulfate</b> - <math>\text{Al}_2(\text{SO}_4)_3</math></li> <li>o <b>iron sulfate</b> - <math>\text{FeSO}_4</math></li> <li>o <b>acidic fertilizers (urea, ammonia, ammonium)</b></li> </ul>

**TYPE SOILS BASED ON CHEMICAL PROPERTIES**

A) **Acid Soils** - soils with acid pH; in regions of high rainfall

B) **Basic or Alkaline Soils** - soils with basic pH; in arid regions

**3 Types:**

- 1) **saline soil** - pH 7-8.5, and has greater than 2,000 ppm total soluble salts.
- 2) **sodic soil** - pH 8.5-10, low to moderate total salts, but 15% or more of CEC is occupied by Na.
- 3) **saline-sodic soil** - pH 8-8.5, greater than 2,000 ppm total soluble salts and 15% or more of CEC occupied by Na.

**How to improve saline, sodic or saline-sodic soils**

- a) **leach** - application of large volumes of water to removes excess soluble salts.
- b) **add elemental sulfur (S)** - acidifies the soil
- c) **add gypsum (CaSO<sub>4</sub>)** - Ca promotes good soil structure, drainage and Na leaching

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**GROWING MEDIA FOR CONTAINERS****WHY PURE FIELD SOILS ARE NOT USED IN CONTAINER PRODUCTION**

- 1) **packs too much**, which
  - a) decreases total pore space, esp. large pores
  - b) decreases aeration
  - c) decreases drainage
- 2) **must sterilize** for disease and weed seeds
- 3) **heavy** - increases shipping costs and heavy to manually handle
- 4) **hard to obtain** good supply in many areas

**GROWING MEDIA**

Most container production uses specially prepared mixes called **growing media**, **artificial media**, **soiless media** or **potting soils**, which are made from various organic and inorganic **growing medium amendments**. The highest quality peat moss is sphagnum peat moss. All the organic amendments, except peat moss, must be composted before use.

<b>Organic Amendments</b>	<b>Inorganic Amendments</b>
peat moss bark coir sawdust or wood shavings cedar chips rice hulls bagasse cotton gin trash municipal compost or processed sludge	sand vermiculite perlite styrofoam calcined clay or haydite rice hull ash rock wool

**Typical Growing Medium Should Contain:**

**50-75% organic amendments** - usually sphagnum peat moss, composted bark or coir

**25-50% inorganic amendments** - usually vermiculite, perlite, sand or styrofoam

**plus:** lime, starter fertilizer and sometimes a wetting agent and gypsum

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## SOIL MOISTURE

### FORMS OF SOIL MOISTURE (1 bar = 0.987 atm)

- 1) **chemically combined** - occurs as a water shell around compounds and particles in soil; plants cannot utilize.
- 2) **hygroscopic water** - water adsorbed onto soil particles, held at less than -31 bars of tension; plants cannot utilize.
- 3) **capillary water** - water held by capillary attraction in the capillary pores in soils; held at -1/3 to -31 bars; plants can extract water in the larger capillary pores down to approximately -15 bars.
- 4) **gravitational water** - water in large pores immediately after watering or a rain, which drains from the soil (within 24 hr.) by the force of gravity; held at greater than -1/3 bars (0 to -1/3 bars); plants can utilize when present.

### SOIL WATER TERMINOLOGY

**field capacity** - the amount of water a soil can hold against the force of gravity;  
- at field capacity, water is held -1/3 bars.

**wilting** - the loss of plant turgidity due to excessive water loss.

**incipient wilting** - when a plant wilts, but recovers when placed in a saturated atmosphere (100% R. H.), ex. overnight.

**incipient wilting point** - the soil moisture content when a plant wilts, but recovers when placed in a saturated atmosphere (100% R. H.), ex. overnight.

**permanent wilting** - when a plant wilts, but cannot recover when placed in a saturated atmosphere (100% R.H.).

**permanent wilting point** - the soil moisture content when a plant wilts, but cannot recover when placed in a saturated atmosphere (100% R.H.).

### HOW TO DETERMINE WHEN TO WATER PLANTS

#### 1) Based on soil

- a) experience - feel, looks, etc.
- b) measure soil water potential, usually use a **tensiometer** - an instrument that is inserted in the soil and measures the soil moisture tension.

#### 2) Based on plant

- a) experience - wilting, looks, etc.
- b) measure plant water potential

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## MULCHES

**mulch** - any material applied to the surface of the soil or growing medium

Mulches are almost always beneficial to use, and their use is highly recommended. In nature, the soil under plants is covered by a natural mulch of composting litter (leaves, twigs, etc.)

### TYPES OF MULCHES

- 1) **organic** - bark, leaves, sawdust, straw, hay, needles, paper
- 2) **inorganic** - plastic, gravel

### BENEFITS AND USES OF MULCHES

- 1) **stabilizes soil temperature** - cooler in summer; warmer in winter under a mulch
- 2) **conserves water** - decreases evaporation of water from soil surface
- 3) **better water infiltration** - more rain or irrigation water soaks-in due to slower runoff
- 4) **controls erosion** - due to slower runoff
- 5) **may add nutrients** - upon decomposition, if it is a) organic and b) has a low C:N ratio

6) **decreases weed growth** - decreases germination of weed seeds & growth of weed seedlings

7) **appearance** - used for decorative purposes

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