Soils and How They Affect Plants

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Topics

- Basic soil properties
- Problem solving
  - compaction
  - salt damage
  - high pH soils
  - soil damage during construction
  - flooding

Soil Physical Properties

Result from the combination of texture and structure:

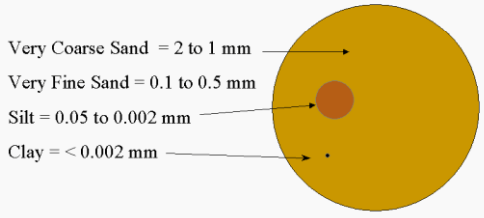
Texture; the size and proportion of soil particles
"What you inherit"

Structure; the arrangement of soil particles
"What you can change"

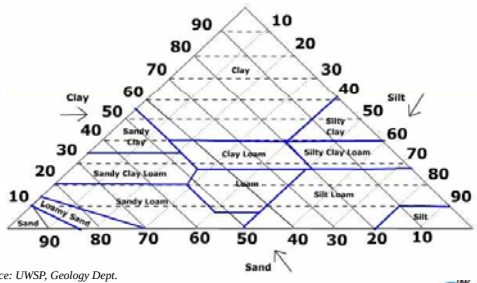
Soil physical problems are either inherent (texture) or created (change in structure)

Soil Properties: Texture

Soil Texture: The relative proportions of sand, silt, and clay particles in a mass of soil (material less than 2mm in size).



Soil texture classified based on ratios of sand, silt and clay



Source: UWSP, Geology Dept.

Soil Texture: Functional Generalities

Soil characteristics influenced by texture

- Infiltration
- Permeability
- Available water holding capacity
- Porosity
- Shrink-swell potential
- Erodibility

Soil Structure

Aggregation of primary particles into compound particles or clusters

- referred to as peds, crumbs or aggregates

Key Point

"structure modifies the influence of texture in regard to moisture and air relationships, availability of plant nutrients, action of microorganisms and root growth" (Foth)

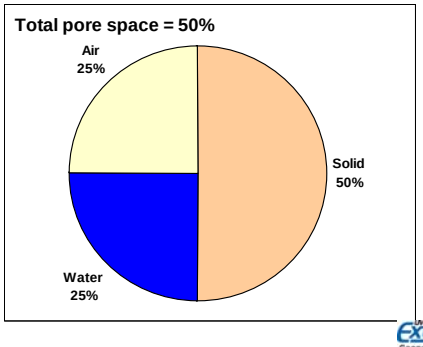
How?

The size of aggregates results in spaces much larger than could exist between adjacent sand, silt and clay particles

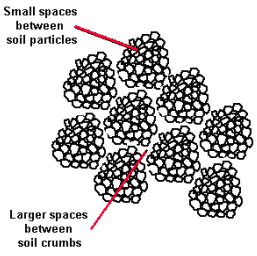
Pore size relationships facilitate:

- movement of air and water
- channels for root penetration
- habitat for microorganisms

An Ideal Soil



Physical arrangement and pore distribution



Factors affecting aggregates

Formation

- OM decomposition (microbial gums)
- Mycorrhiza (glomalin)
- Physical/chemical interactions with colloids and water
  - freezing
  - drying

Destruction

- Wetting
- Mechanical disruption
  - tillage
  - traffic

Soil Physical Properties

Problems

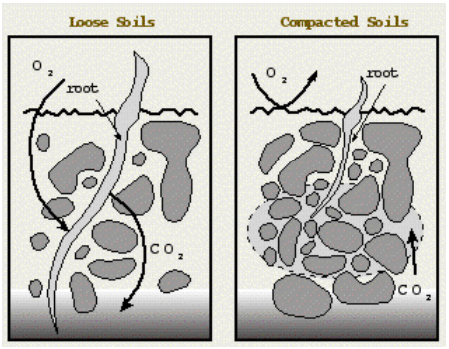
Related to texture

- excessive drainage (sand)
- poor drainage (clay)

Related to structure

- compaction
  - surface
  - layer
- crusting
- disturbance

Compaction



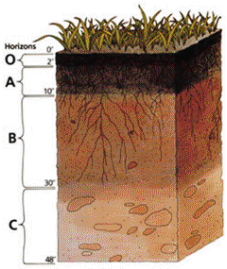
Source: The Ohio State University

Disturbance

Undisturbed soil

Soil "functionallity" formed over several thousand years

- Clay leached to illuvial zone
- Structure formed
- Macropore system developed
  - freeze fracturing
  - root channels
  - earthworm channels



Tips to avoid physical problems

Stay off wet soil

- wet soil compacts easily

Don't work wet soil

- soil should "freely crumble" in hand

Don't use excessive tillage

- perform major tillage in fall
- use the roto-tiller judiciously

Amendments to address physical problems

Organic amendments

- immediate and long-term benefit
  - physical bulking agent
  - breakdown results in gums which "glue" particles together
- majority of mass will decompose in first year ~ 90%
  - should be added on an annual basis

Amendments (cont.)

Organic amendments

- A2305 "Organic soil conditioners"
- fall applications should be incorporated
- be careful of nutrient implications, especially Nitrogen
  - predict based on C:N ratio
  - < 30:1, nitrogen released
  - >30:1, nitrogen tied-up

Amendments (cont.)

Inorganic amendments

examples: perlite, vermiculite, ground tires

- bulking agent only
  - increase pore space
- don't solve true structural problems
  - no effect on aggregation
- not recommended
- DO NOT MIX SAND WITH CLAY

What about commercial additives?

"Clay Buster"

- processed pine bark
- Canadian sphagnum peat moss
- limestone
- Gypsum
- with extended-release fertilizer to support healthy plant growth.

Soil pH

A measure of soil acidity

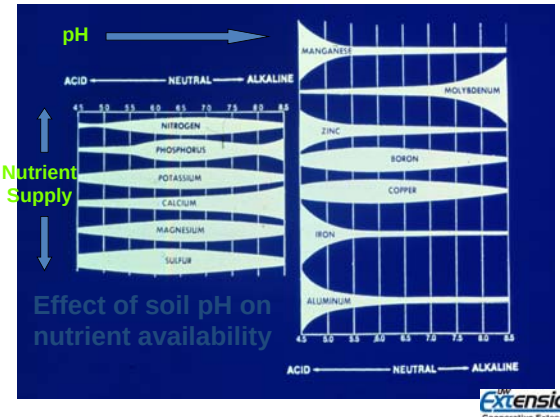
scale: 1-14

less than 7, acidic

7, neutral

greater than 7, basic

Soil pH determines what chemical form a nutrient will take and therefore, it's availability



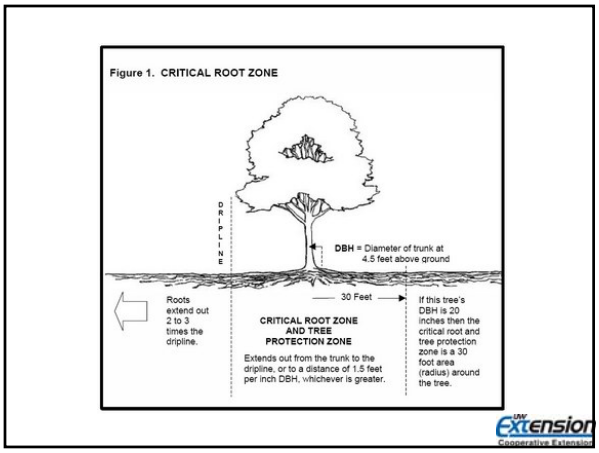
Effect of soil pH on nutrient availability

Soil and Site Problems

- Root related problems difficult to diagnose **WHY?**
- Symptoms typically appear on trunk and canopy
- Typically abiotic, chronic, primary stress
  - Compacted soil
  - Salt usage
  - Soil pH
  - Soil water holding capacity
  - Grade changes and soil layering

Soil and Site Problems

- Soil compaction is extremely difficult, expensive, and often impractical to correct once it has occurred
- Avoid grade changes and soil compaction in the Critical Root Zone (CRZ) or Radius (CRZ)
  - DBH x 1.5 = __ft of radius



Compaction

Reduces pore space affecting:
- Infiltration
- Drainage
- Gas exchange
- Soil microbes/ activity

Reduces nutrient availability
- Especially potassium

May physically damage roots
- Compromised roots an entry point for pathogens
- Pythium and phytophthora excel in low oxygen environments

Compaction

Prevention:

Stay off wet soil
- Foot traffic
- Lawn mowers
- Other equipment, esp. heavy construction
- Stockpiled materials

Keep heavy traffic areas away from CRZ
- Establish paths, walkways
- Heavy traffic will compact soil even under ideal conditions

Compaction

Remediation:

Tillage will damage feeder roots, not an option in CRZ
- Most (~85%) of roots in top 18 inches

Freeze- thaw cycles
- Slow, will take years

Core aeration

Vertical mulching

Compaction

Vertical mulching:
- 2 inch diameter holes, 12 to 18 inches deep
- 18 to 24 inch grid in CRZ
- Fill with compost, aggregate/ compost mix
- DO NOT plug hole
- Stop drilling if a root is encountered

Functions
- Improve gas exchange
- Increase infiltration and drainage
- Allows root penetration, growth
- Improved habitat for microorganisms, benefits

Salt damage

Foliar and soil effects

In soil, chemical and physical effects

Chemical:
- Salt accumulation
- Chloride toxicity
- pH increases
- May take years to develop
- Symptoms appear in late summer or during hot, dry spells
  - Abnormal color
  - Needle tip burn
  - Marginal leaf burn
  - General decline

Salt damage

Physical:

Sodium destroys soil structure
- Loss of pore space
- Reduced water infiltration and retention
- Soils easier to compact

Detrimental to mycorrhizal fungi
- Reduces nutrient uptake
- Makes plants more prone to stresses

Salt damage

Prevention:

Avoid deicing salt if possible

Use substitute products, not NaCl (rock salt)
- calcium chloride
- calcium magnesium acetate (CMA)

Divert runoff water to avoid salt build up

Salt damage

Remediation:

Improve structure and drainage of poorly drained soils

Add organic matter to maintain structure
- Vertical mulching

Add gypsum (calcium sulfate)
- Calcium displaces sodium allowing structure to reform
- Broadcast, 2 lb/ 100 square foot

Leach
- Both Na and Cl are water soluble
- Must have adequate drainage

High pH soils

Caused by calcareous soil parent material
- $CaCO_3$
- Eastern Wisconsin

High pH limits micronutrient availability
- Usually iron, may be others

Causes chlorosis (yellowing)

Species dependant
- Oaks (pin and white): Fe, Mn, Cu, Zn
- Maples and Birches: Mn

BUT: other causes, compaction and injury may cause chlorosis even if Fe is available

High pH soils - chlorosis

Iron chlorosis on Pin Oak

High pH soils - chlorosis

Prevention:

Do not plant susceptible species
- pH > 7.0
- Low organic matter soils

Protect susceptible species during construction

Watch P and K applications
- Apply only if required
- Excess can exacerbate problem

Avoid these materials:
- Nitrate containing fertilizers
- Limestone and lime containing materials
- Hard water (use rainwater for watering)

High pH soils - chlorosis

Remediation:

<u>Soil acidifiers</u>

Ammonium sulfate
- 3 lb/ 100 square feet, spring
- Will stimulate grass growth

Elemental sulfur
- 5 to 6 lb/ 100 square feet, broadcast and incorporated
- Soil pH must be below 7.5
- Slow

Sulfuric acid
- Not recommended
- BE CAREFULL!

High pH soils - chlorosis

Remediation:

Iron Fertilizers

Iron sulfate (also aluminum sulfate)
- Rapid but may lead to toxicity
- 2 to 3 lb/ inch of trunk diameter
- Apply to 12 – 18" holes around the drip line, follow directions

Chelates
- "Protected micronutrients"
- Commercially available
- For mild cases only
- Apply to holes drilled within the CRZ, follow package directions
- Effectiveness?

Soil damage during construction

Problems

Mixing of soil horizons
- Loss of natural soil – water relationships
  - Excessive drainage
  - Poor drainage
- Loss of fertility

Deep compaction
- Excavation often done under less than Ideal conditions
- Barrier to drainage, root penetration

Soil damage during construction

Remediation:

Correct soil problems before establishment of landscaping
- Tillage to relieve compaction
- Organic matter addition
- Soil testing

Do not add OM to transplant holes
- Creates a "zone of comfort"
- Use "vertical mulching" to improve soil and encourage root growth

"Soften" transition zone
- Loosen sidewalls, remediate topsoil surrounding hole

Flooding

Standing water reduces gas exchange

Damage, mortality depends on plant health and duration of standing water

Prevention:
- Do not plant susceptible species in flood prone areas
- Divert runoff water, create surface drainage
- Vertical mulch to aid infiltration, gas exchange