Principles of Soil Science

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Introduction

What is soil?

- surface layer
- composed of
- complicated: chemical, biological and physical system

Why is soil so important?

- provides
- supports plants
- supports structures
- stores and purifies water
- serves as a biological filter

Our responsibility

Soil Profile – Side view of the soil

Horizon A – topsoil

- upper part
- area of
- plow/work/cultivate
- biological activity
- thickness varies
- weathered
- nutrients
- plant roots

Horizon B – subsoil

- thickness
- nutrients
- clay accumulates
- roots develop
- contains water

Horizon C – parent material

- similar to
- not affected by

Examine the Soil Profile

- rooting depth
- uniformity
- disturbance in texture
- compacted layers
- soil color:

dark soil – associated with organic matter
brown-red – adequate air and good drainage
yellow – imperfect drainage
mottling/streaking – seasonal/periodic water problems
blue-green/grey – continuously wet/saturated

MAJOR COMPONENTS OF A MINERAL SOIL (by volume)

Soil air (25%)

- required by
- aeration
- not continuous
- influenced by:

Soil water (25%)

- solvent for
- influences biological activity
- not always available
- affects soil temperature
- held by
- depends on:

Mineral matter (45%)

- solid fraction – made up of small rocks and fragments
- developed from parent material
- what properties?

Organic matter

- variable
- desirable
- source of:
- increases:

Soil organisms

small: bacteria, fungi, actinomycetes, algae

larger: earthworms, insects big: moles, gophers, mice

MICROBIAL ACTIVITY	MAJOR BENEFIT TO SOIL
Nutrient-cycling	Making nutrients available to plants Preventing nutrients from leaching
Organic matter degradation	Thatch maintenance Making nutrients available to plants Produce humates > stimulate plant growth Indirect effects on control of soil pests
Nitrogen fixation	Increased nitrogen nutrition
Production of polysaccharides	Improve soil structure
Production of antibiotic compounds	Pest resistance
Mycorrhizal symbioses	Improved phosphorus nutrition

UNDERSTANDING SOIL PHYSICAL AND CHEMICAL PROPERITIES

SOIL TEXTURE

indicates size and proportion of soil particles

largest	sand
↓	silt
smallest	clay

soil particles group by size > soil separates
used to names soils

TEXTURE AFFECTS

- drainage
- aeration
- water holding capacity
- nutrient holding ability

SANDY SOILS – coarse textured, light, easy to work

- structural backbone – supports weight with little compaction
- abundant macropores
- water moves quickly
- air replaced faster
- allow root penetration

SILTY SOILS

- poor drainage
- can be susceptible to compaction

CLAY SOILS – fine textured, heavy, difficult to work

- helps create structure
- abundant micropores, hold water
- store water and nutrients
- retain water after rain
- have large surface area

SURFACE AREA (cm)

very coarse sand — **clay**

$11cm^2$

COARSE TEXTURED SOILS: sands, loamy sands, sandy loams

- large particle size
- ≠ hold water and nutrients
- rapid infiltration and percolation
- slow release fertilizers beneficial

FINE TEXTURED SOILS: clays, sandy clays, silty clays

- small particle size
- low infiltration and percolation
- needs time to dry out
- holds water and nutrients
- season long fertilizer application

PHYSICAL AND CHEMICAL PROPERTIES

SOIL TEXTURE	DRAINAGE	SUSCEPTIBILITY TO COMPACTION	WATER & NUTRIENTS HOLDING CAPACITY
sand	excellent	little to none	limited
loamy sand	excellent	limited	limited
sandy loam	good	limited to moderate	moderate
loam	good to fair	moderate	moderated – substantial
silt loam	fair to poor	substantial	substantial
clay loam	fair to poor	substantial	substantial
clay	poor	substantial	substantial

SOIL STRUCTURE

- arrangement of soil particles
- particles grouped > aggregates

held: electrical and chemical bonds
gelatinous materials (excretion of microorganisms)
iron and aluminum hydroxides

aggregates: create pore space between particles and aggregates
fragile and easily compressed
silts and sands aggregate poorly

Decomposing organic matter:

aids in development of structure aids in stability of structure

Ideal soil structure: granular, open, loose

STRUCTURE INFLUENCES

- soil moisture: infiltration and drainage
- aeration
- availability of nutrients
- action of microorganisms

CAN BE DESTROYED BY:

- working soils when wet
- use heavy equipment
- increase traffic

COMPACTION

- reduces total pore space
- large pore space > compressed
- increase resistance to root penetration

Soil Bulk Density – measure of soil strength and resistance to crushing

$$\frac{\text{dry weight of soil solids}}{\text{total soil volume}} = g/cm^3$$

NATURAL ACTIVITIES IMPROVE SOIL STRUCTURE

- freezing and thawing
- root growth
- wetting and drying
- microbial activity

TO IMPROVE SOIL STRUCTURE → add Organic Matter

WHAT IS ORGANIC MATTER?

part of the soil that comes from living organisms + non-living fraction that comes from plant and animal residues (in various stages of decay)

ORGANIC RESIDUES

complex mixture of readily decomposable + resistant molecules
made up of carbon (50-55%) and nitrogen (7-8%)

HOW DOES ORGANIC MATTER IMPROVE THE SOIL?

OM affects physical, biological and chemical properties of the soil:

- increases aggregation which improves soil structure
- improved soil structure increases porosity which improves water infiltration and aeration
- increases biological activity: supplies nutrients, energy and habitat for beneficial organisms
- provides a nutrient reservoir: releases nutrients (N, P, S)
- retains nutrients that are in a form available to plants: the negatively charged surface of OM attracts cations (K^+, Ca^{++}, Mg^{++}, H^+)

SOIL ORGANIC MATTER AND SOIL TILTH

- OM helps bind soil particles together forming larger aggregates, improving soil structure
- microbes produce a gelatinous matrix that adheres to soil particles
- clay particles adhere to humic acids forming organo-mineral complexes

Some Common Organic Amendments used in Landscapes:

manures – some nutrients, best composed, may contain viable weed seeds, fresh manure has soluble salts

grass clippings – if clippings are left after mowing can reduce fertilizer rate 25-30%. Be sure to maintain proper mowing height

peat moss – expensive, acidic

leaf mold – compost, recycle natural wastes

sawdust – will take a long time to break down, high carbon: nitrogen ratio, cause temporary shortage of nitrogen

woodchips – will take a long time to break down, high carbon: nitrogen ratio, cause temporary shortage of nitrogen

COMPOST

ON THE SOIL

- serves as a mulch
- prevents cracking at soil surface
- slows water movement across the soil surface
- prevents soil erosion

IN THE SOIL

- improves soil quality, soil structure
- affects biological activity
- improves nutrient pool
- increases availability of nutrients

Characteristics of desirable compost:

- mature – stable
- no contaminants or toxic substances
- low weed seed content
- low soluble salt content

INORGANIC AMENDMENTS

- physically dilute soil
- not easily compressed
- require large amounts to make difference
- used to improve internal porosity
- stable won't decompose

ex:

TOPSOIL

- no legal definition – know what to look for
- determine source – one that does not contain persistent herbicides, noxious weeds
- request soil test – nutrients, pH and organic matter levels
- determine texture

SOIL NUTRIENTS

- major portion of nutrients in soil are not available to plants
- nutrients exist in complex structure – not soluble
- roots can absorb simple soluble forms dissolved in water
- nutrients held (tied up) and slowly released into the soil solution
- microorganisms help convert complex nutrients into simpler forms

CATION EXCHANGE CAPACITY

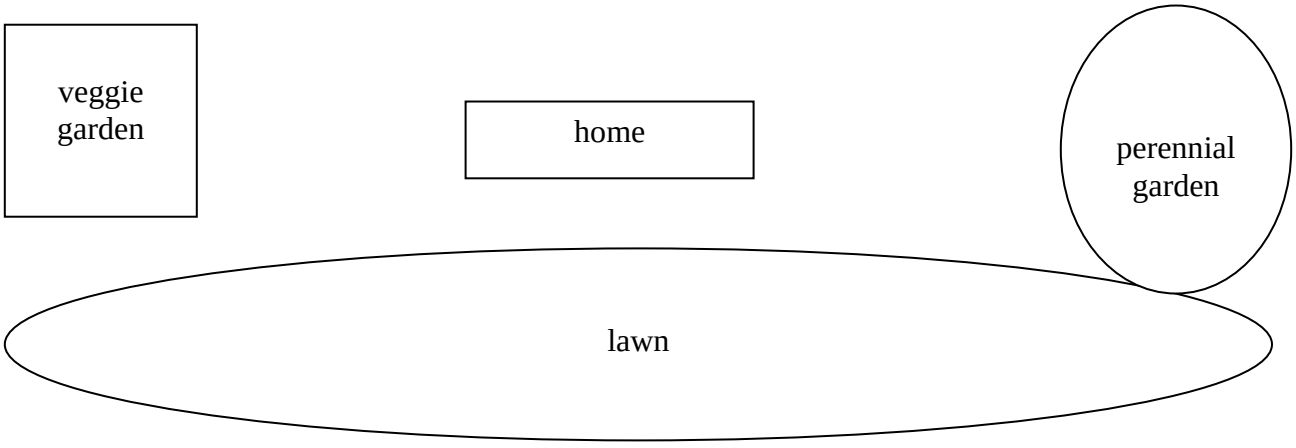
- ability of the soil to hold nutrients on soil surface (clay and organic matter)
- clays and organic matter have a high CEC
- nutrients held (tied up) and slowly released into the soil solution

SOIL SAMPLING

When? early enough to get soil test results back

How? 2-3" depth for turf, sample at same depth
4-6" depth for other plantings

Where? take many samples using a trowel or probe (remove turf, rocks, etc.)
mix in plastic container and submit a composite sample



SOIL REACTION – Soil pH

acidity or alkalinity measured in pH units

pH scale: 0----------7----------14
acidic ← neutral → alkaline

pH 5.0 is 10x more acidic than 6.0
5.0 is 100x more acidic than 7.0

- most soils in New York State
- plants have a preference
- there are exceptions
- pH influences nutrient availability

CHECKING pH

STANDARD pH KIT

Chloro Red	Bromo Blue
5.0 - 6.2	6.0 - 7.2

WIDE RANGE pH KIT

Bromo Green	Phenol Red
3.8 - 5.2	7.0 - 8.2

WHY DO SOILS HAVE A LOW pH

parent material, leaching, removal of calcium, use of fertilizers, erosion of topsoil

TO RAISE SOIL pH: add limestone

placement: must be in contact with soil — apply preplant
incorporate — finer > quicker reaction

materials: know the properties of different liming materials including:
strength, rate of reaction, ease of use, economics

timing: before planting is always better. If you apply lime to established turf no more than 50lbs/1000 sq ft/application.

LIMING MATERIALS

SOURCE	CALCIUM CARBONATE EQUIVALENT* %	RATE OF pH CHANGE
burned lime	180	very fast
hydrated lime	140	fast
ground or pulverized limestone	75-95	slow
dolomitic limestone**	75-95	slow
pelletized limestone	75-95	fast

* liming power of a material
** contains magnesium (recommended only if the pH is low and magnesium is low)

Work Problem:

If you test pH yourself, determine soil texture, use liming chart to determine amount of lime to apply.

Apply: 50# of ground limestone/1000 square feet

Available materials: Calcium carbonate equivalent is: 90 = Acme's ground limestone
140 = Sonic hydrated lime

$$\frac{50\#/1000 \text{ sq ft}}{90} \times 100 = \mathbf{55\#}$$ Acme's ground limestone

$$\frac{50\#/100\ 0\text{sq ft}}{140} \times 100 = \mathbf{36\#}$$ Sonic hydrated lime

TO LOWER SOIL pH - use acidifying materials

- note their rate of reaction
- cost varies
- check ease of handling

ACIDIFYING MATERIALS

sulfur – the recommended material (for turf do not apply more than 5#/1000 sq ft on established turf. Avoid summer applications)

aluminum sulfate – concern about over application

ammonium sulfate – contains nitrogen (21%)