Soil Management

Understanding How to Create & Maintain Healthy Soil

for your (general) growing needs

What is the most important physical component of a healthy soil?

Organic Matter

What is Organic Matter?

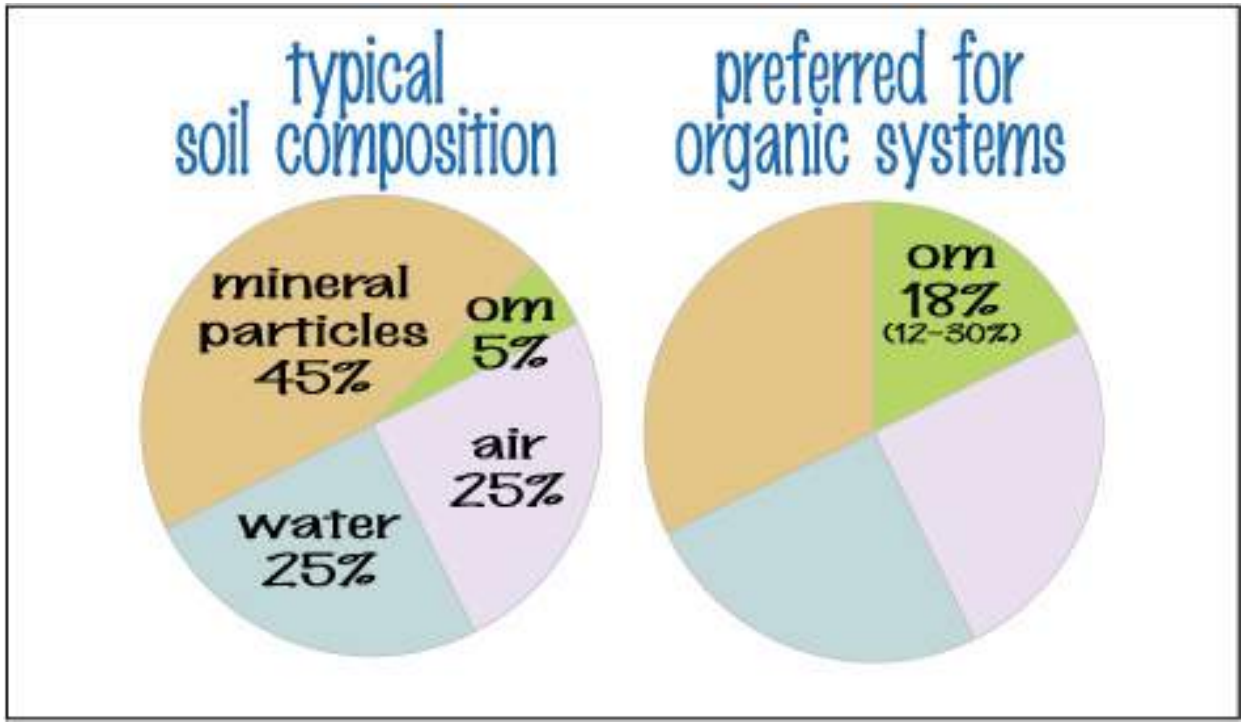
- It can be divided into three general categories:
  - living micro-organisms,
  - fresh and partially decomposed material,
  - Humus
- Dead and decaying plants or animals (including cells & tissues of soil organisms & substances synthesized by soil organisms).
- Animal manures
- Processed food by-products
- Materials decomposed to different stages exist simultaneously
- Manure, compost, and fresh plant debris are common OM additions to soil

What is the role of Organic matter in soil?

- Holds soil particles together; stabilizes soil
- Reduces erosion risk
- Increases soil's water holding and releasing ability
- Stores and supplies nutrients for plants & microbes
- Minimizes soil compaction – especially in clay soil
- Carbon sink
- Improves the effect of environmental pollutants, immobilizes them; reduces leaching

How much organic matter is usually in soil?

- typically 5-8% of soil
- could be as high 30% or more in organic soils
- 12 – 20% or more desired in organic growing systems
- classify soils as "organic soils" if there is between 12-18% OM

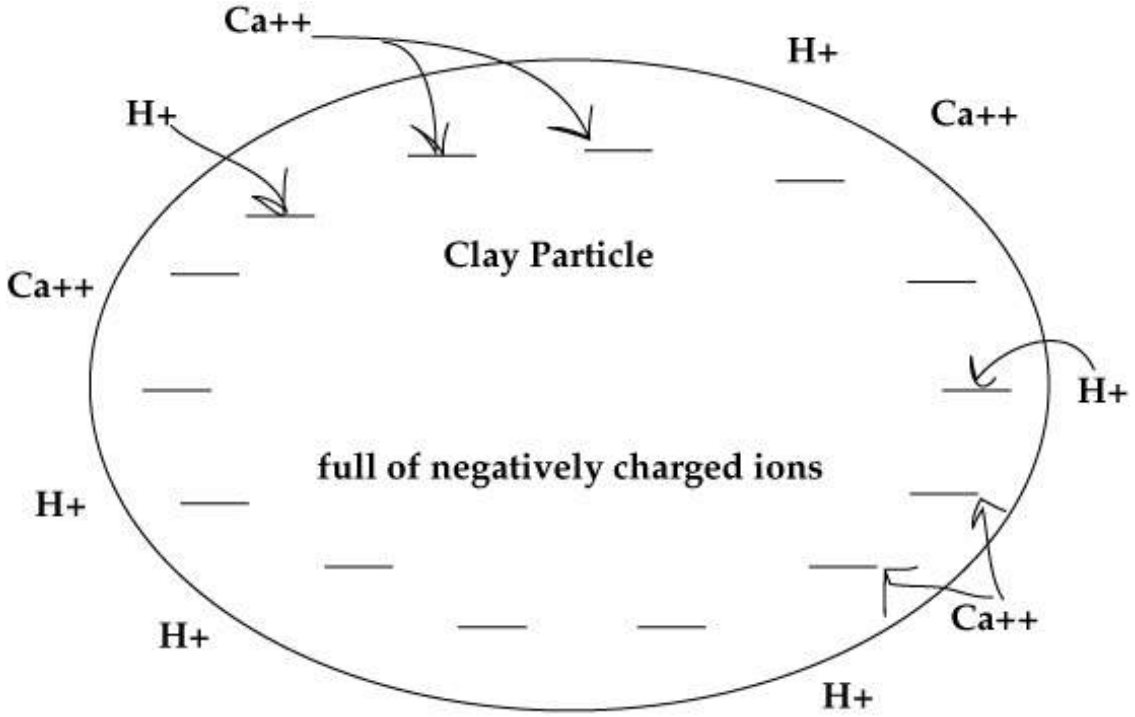


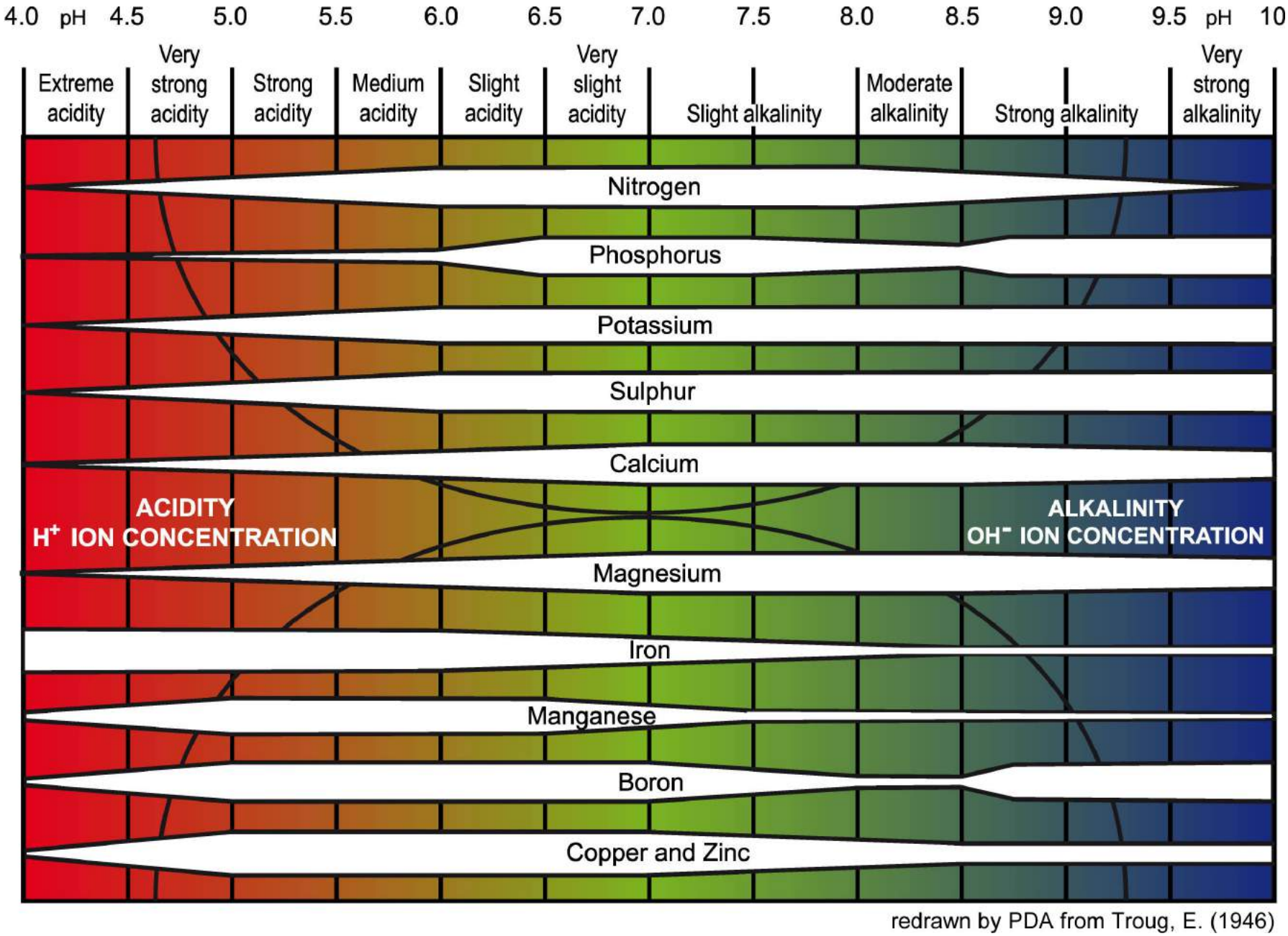
What are the characteristics of Organic Matter in soil?

- High Cation & Anion Exchange Capacity (CEC)
  - **What is CEC, cation-exchange-capacity?**
    - An ion is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving the atom a net positive or negative electrical charge.
    - Ions can be created by both chemical and physical means. In chemical terms, if a neutral atom loses one or more electrons, it has a net positive charge and is known as a cation. If an atom gains electrons, it has a net negative charge and is known as an anion.
    - Since the electric charge on a proton is equal in magnitude to the charge on an electron, the net electric charge on an ion is equal to the number of protons in the ion minus the number of electrons.
    - An anion (-) is an ion with more electrons than protons, giving it a net negative charge (since electrons are negatively charged and protons are positively charged).
    - A cation (+) is an ion with fewer electrons than protons, giving it a positive charge

Key points about Cation Exchange Capacity:

- CEC = measurement of the holding capacity of your soil.
- When you receive your soil test results, one of the most important things is the CEC because it tells you how much fertilizer you can apply. (How much N can soil soil absorb?)
- Ex: If your test showed CEC of 12, multiple by 10 (for N holding capacity) to know you can add 120 lbs of N per acre.
- CEC 0-10 = sandy soils
- CEC 11-20 = loamy
- CEC 21+ = clay (heavy)
- CEC is also a measurement of how much clay you have, type of clay, and how much OM in the soil.
- You cannot change the type or amount of clay you have (CEC doesn't change much, test 5-10 years), BUT you can change the type and amount of OM, which does change the texture and nutrients in the soil.





redrawn by PDA from Troug, E. (1946)

(cont'd) What are the characteristics of Organic Matter in soil?

- Soil's ability to hold + and - charged nutrients
- High in Carbon
- Buffer against pH changes in soil
- C:N ratio - indicator of Nitrogen (N) availability
- Nutrient concentration
- Holds water better than mineral soils
- Compost Characteristics: Carboxyl and Hydroxyl Groups
    - Carboxylic acid are proton (H+) donors. They are the most common type of organic acid.
    - Hydroxyl group of compounds found in bases, (some acids, alcohols) - (Ca++, Mg++, K+, and Na+) These basic **cations** will come from the weathering of rocks and minerals, from dust blown on soils, from irrigation water or runoff water. When basic cations dissociate in the soil solution, they will produce hydroxyl ions (OH-). This will raise the pH of the soil.
    - The "pH of the soil" refers to the concentration of hydrogen ions in the soil solution.
    - pH stands for "power of Hydrogen" - The pH scale is a logarithmic scale that usually runs from 1 to 14. Each whole pH value below 7 (the pH of pure water) is ten times more acidic than the higher value and each whole pH value above 7 is ten times less acidic than the one below it. For example, a pH of 3 is ten times more acidic than a pH of 4 and 100 times (10 times 10) more acidic than a pH value of 5. So, a strong acid may have a pH of 1-2, while a strong base may have a pH of 13-14. A pH near 7 is considered to be neutral.
    - Lower the pH, the more Hydrogen

What types of organic matter are there?

Humic & non-humic.

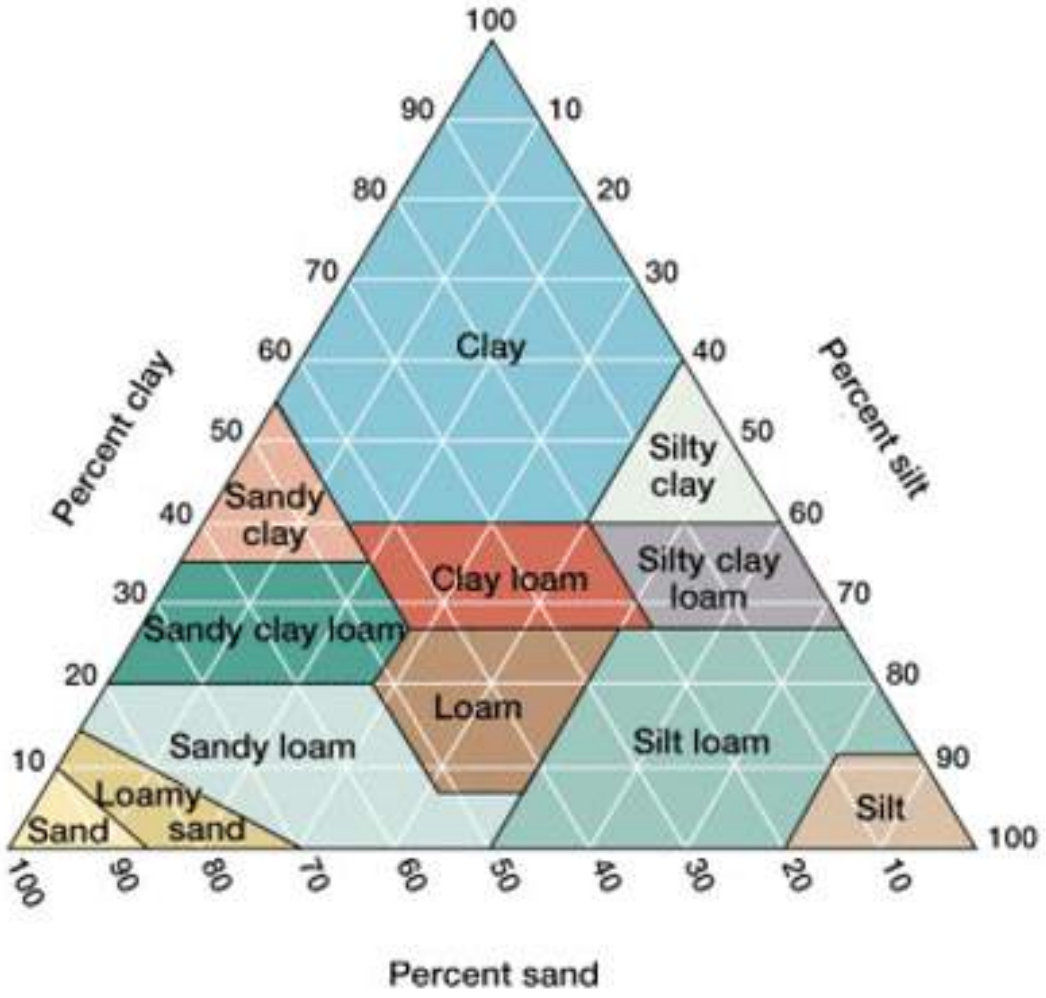
Non-humic:

- Primary components from fresh animal and plant waste
- Easily decomposed by microbes (when present)
- Comprise 20-30% of Soil OM
- Decompose to: Carbohydrates (several types), Amino Acids, Lipids, Lignin
- Have the ability to bind to inorganic soil particles into stable aggregates. Some sugars may stimulate seed germination and root elongation. Other soil properties affected by polysaccharides include cation exchange capacity (attributed to -COOH groups of uronic acids) , anion retention (occurrence of -NH2 groups), and biological activity (energy source for micro-organisms)

Humic:

- Biochemical decomposition of non-humic materials
- Resistant to further decomposition
- Accumulate in soil
- Dark in colour – give soil dark characteristic
- 60-80% of soil OM
- 3 types:
    - Humins: larger particles; low number of carboxyl groups, inactive.
    - Humic acids: smaller than humins (approximately colloid sized), more carboxyl groups than humins.
    - Fulvic acids: smallest humic substances; large number of carboxyl groups; most active among humic substances

Soil Texture - diagram



What role does Organic Matter play in soil texture?

Organic Matter and Sandy Soil:

- Sand does not hold water or nutrients, but drains very well
- Organic matter binds sandy soil particles together:
  - Gives sand water-holding potential
  - Acts as a nutrient storage and release
  - Still allows for good drainage
  - Promotes and sustains microbial life
- This does not change the texture of a sandy soil, rather it changes the soil's characteristics

What role does Organic Matter play in soil texture?

Organic Matter and Clay Soil:

- Clay soil holds water and nutrients very well, but is dense, poor draining, and susceptible to
- compaction
- Organic matter separates clay particles:
    - Increasing drainage ability
    - Increasing air flow for roots and microbes
    - Reducing (but not eliminating) susceptibility to compaction

How and when we use organic matter, and what type of OM we use, depends on many factors…

- What organic materials are readily available?
- How close are those materials to our farm?
- What is our budget?
- How big is our space?
- How long is our growing season?
- What are current soil OM levels?

Great Urban Sources of OM:

- Fallen leaves (Be careful of contaminants)
- Grass Clippings (pesticide free)
- Coffee grounds (acidic)
- Okara (tofu bi-product)
- Horse Manure (careful of feed & straw)

Great Rural Sources of OM:

- Horse, cow, or chicken manure
- Straw
- Spoiled hay
- Fallen leaves

How does soil 'use' Organic Matter?

- Soil OM is decomposed by microbes - a process called **mineralization**
  - Once mineralized, soil organic matter can be carried into soil solution & absorbed by plants – this depletes soil OM levels
  - It is our job to ensure our soil's organic matter levels are maintained
  - Higher temperatures, air, and nitrogen, increase soil microbial activity and thus mineralization
- Warmer temperature = more microbial activity = more growth in summer!
- Air is most often introduced through cultivation
  - This releases more nutrients, but also makes them susceptible to leaching
- Nitrogen is needed by plants and microbes
  - Reducing cultivation slows down mineralization

How can we introduce Organic Matter to soil?

1. Crop growth
2. Additions of compost
3. Additions of fresh or decomposed manure
4. Additions of fresh or dried plant materials, mulching and sheet mulching
5. Cover cropping

1. Crop Growth

- Plants add OM to soil from debris drop and root sloughing
- Root sloughing adds OM to soil at lower depths without disturbing the soil

2. Compost Additions

- Compost nutrients are available to plants quickly
- Great addition at start of season
    - Dig into soil
    - Mulch soil
    - Covering seeded rows
    - Use for transplanting and transplant mixes
    - Double digging
- Use throughout the season
    - Side dress plants
    - Continue mulching
    - Compost tea

(Cont'd)How can we introduce Organic Matter to soil?

3. Manure Additions

- Can be raw or decomposed
    - Raw manure can be applied in winter
    - Raw may be better side dressing – if too much in soil can kill plants
- Decomposed or rotted manure can be used like compost
- Raw manure is also a great compost activator
- Can also make manure teas for foliar feeds
- If using mushroom manure in organic farming (cost is expensive) and most likely contains pesticides, fungicides etc unless certified organic

4. Mulching: Additions of plant debris to the soil surface

- Plant Trimming Mulch
- Straw or other high carbon materials
- Compost/Leaf Mulching
- Sheet Mulching

(Cont'd) How can we introduce Organic Matter to soil? (4 - Mulching)

More about Mulches:

- Addition of OM to soil at surface
  - Slowly incorporated into soil by macro-organisms
  - Can be incorporated by cultivation
- Can be any type of OM or even synthetic
- Reduce soil evaporation
- Reduce impact of rain on soil aggregates
- Regulate soil temperature
- Promotes biological activity near soil surface
- Keep away from base of plants

A. Plant Trimming Mulch

- When trimming leaves off plants they can be dropped onto the soil surface as a mulch
- Easier than moving to compost bin
- Do not use diseased leaves!

B. Straw and High Carbon Materials

- Good for long season crops (e.g., garlic, kales)
- Can be reused
- Also used for perennials (Sawdust and blueberries)
- Wait until very decomposed if incorporating into soil to maintain proper C:N ratio

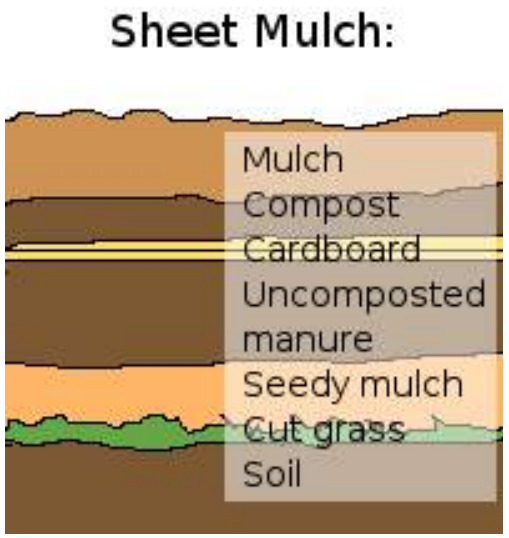
(Cont'd) How can we introduce Organic Matter to soil? (4 - Mulching) More about Mulches:

C. Compost/Leaf Mulching

- Compost is a great mulch and should be used frequently
- Nutrients leach into soil when watering
- Leaf Mulch
    - Can often be acquired easily and for free
    - Tree leaves have good nutrient profile
    - Leaf mold (aged leaves) good for mulch and incorporating into soil
    - Can be reused

D. Sheet Mulching

- Permaculture methods frequently use sheet mulch
- Great for:
    - Improving poor, compacted soils with additions of OM
    - Quickly adding life & nutrients to depleted soil
    - Reusing urban waste products
    - Suppressing noxious weed growth
    - Sheet mulching can be done anytime, but spring and summer are best



- Alternating layers of carbon and nitrogen materials
- Often starting with thick layers of cardboard or newspaper
- Fresh manure or other high N materials at bottom helps suppress and decompose unwanted plant growth
- Topped with leaves or compost
- Give lots of water!
- Can plant into soil pockets in new mulch

(Cont'd) How can we introduce Organic Matter to soil?

5. Cover Cropping

- The practice of growing a crop for the main purpose of improving soil quality
- Usually not harvested for sale
- Can be planted at anytime of the year, but usually over winter on the coast

Cover Crops can be used to:

- Increase organic matter content of soil
- Fix atmospheric nitrogen
- Protect soil from impact of rain
- Suppress weeds
- Suppress insect pests
- Provide pollen for bees
- Increase crop diversity

(cont'd - Cover crops:) Increasing organic matter content

- Growing organic matter is one of the easiest ways to increase it in our soil
    - Important in rural and isolated areas
    - Important in closing the farm 'loop"
- Importing seeds for cover crops is easier than importing organic matter
- Cover crops contribute OM through growth above and below the soil
- Capture and store nitrogen in leaves
    - Crops for increasing OM:
- Winter Rye and Wheat
    - Leaf and root growth
- Buckwheat (spring and summer)
    - Also accumulates Phosphorus
- Oats (fall)
    - Winter kills as mulch
- Sunflowers (summer)
- Phacelia (summer)
    - Also great for attracting beneficial insects
- Calendula – Pretty, too!
- Leafy Greens – Tasty, too!
- Squash – Lots of OM!

(cont'd - Cover crops:) Fixing Nitrogen

- Legumes can extract nitrogen from the atmosphere to make it available to plants
- Nitrogen is one of the most important plant nutrients but is difficult to maintain in soils
- Leguminous cover crops include:
  - Beans and peas
  - Winter Peas or Field Peas
  - Fava beans
  - Vetch
  - Clover
  - Alfalfa
- Legumes will not fix nitrogen if:
  - Soil is high in N already
  - Soil is saturated with water
- Some soils may need to be inoculated with proper organisms to form root associations
- Roots develop small nodes which are red when actively fixing nitrogen

(cont'd - Cover crops:)

Protect soil from impact of rain

- Winter rains can damage soil structure and promote soil erosion
- Cover crops protect the soil
  - Must be planted early enough to get established
  - Can be tough to balance with cash crops
- Winter-killed crops may mulch the soil (oats)

Suppress Weeds

- Many cover crops are allelopathic – they suppress the growth of other crops
  - Fall rye
  - Sunflowers
  - Mustards
  - Buckwheat
- Grows fast to out-compete weeds

Suppress Insect Pests

- Some crops suppress insect pests
  - Mustards
  - Buckwheat

Provide pollen for bees

- Buckwheat
- Phacelia

Cover Crop Management Summary:

- Can be planted in spring, summer or fall
- Most plantings in fall or late summer for over-wintering
    - Earlier planting gets crop better established for winter soil cover
    - Crop has more time to absorb soil nitrogen
- Do not over seed! Crop will compete with itself
- Crops can be mixed
- Cut crop and incorporate crop into soil before it flowers (unless you want flowers to attract bees)
- Incorporate in time to allow for decomposition before next crop is planted
- If smothering cover crops allow for a much longer period of decomposition
- Crop rotation planning needs to consider cover crops
- Cover crop needs are different in small and large scale systems
    - More important in large scale systems
    - Can take a way precious growing time in smaller systems
    - Cover crops are a vital piece of a sustainable, closed-loop agro-ecosystem

About Raised Beds:

- Benefits of raised beds:
    - They improve soil drainage, allowing soil to dry and warm faster in the spring, and provide a better environment for growing perennial crops (such as raspberries) that need well-drained soils.
    - They allow gardening in areas with little or no soil, unsuitable soil, or contaminated soil.
    - They can fit neatly into small spaces, a boon to gardeners with limited land.
    - They can raise the height of the garden, increasing accessibility for people who have difficulty bending and stooping.
    - They can contain garden soil in areas prone to runoff or close to storm drains, such as steeply sloped lots or parking strip gardens, which reduces runoff of soils and contaminants into waterways.
- Drawbacks of raised beds:
    - Imported soil used in raised beds is often of lower quality than many native coastal soils.
    - Soils in raised beds dry out faster than native soils, making diligence in summertime irrigation essential.
    - The time and cost of building materials, construction, and maintenance can sometimes be a barrier to using raised beds.

Fertilizing for crops & raised beds (Comparing Types of Manure):

Manure Type	N	P	K	Pros	Cons
Chicken	1	1.5	0.5	No weeds Best used as additive for compost pile	Faeces & urine, high in N, too strong for direct application, needs to be composted
Cow	0.8	0.5	0.5	Most balanced of animal manures, manure breaks down fast due to digestion of cellulose/nature of cow stomach. Moist, which helps in composting.	Not strong in terms of nutrients
Horse	0.5	0.3	0.4	Well balanced, rich in organic matter due to poor digestion than cows. Urine soaked bedding, is high in nitrogen.	Lots of weeds, unknown materials which may contain contaminants
Pig	0.6	0.4	0.3	If organic, it is excellent and needs to be completely finished.	Needs to be composted completely or else it's noxious. If from intensive meat production facility, will be very high in copper
Sheep & llama	0.4	0.3	0.8	Similar to cow & rich in potassium	Not readily available - but if you had a farm, they are useful
Rabbit	2	1.4	0.6	High in N & P Safest to compost it.	You could dry pellets and scatter around plants, but use with caution due to the high ammonia content from urine.
Mushroom	0.7	0.3	0.3	Outstanding ONLY if organic	It is the residual waste of mushroom growing industry, comprised of straw, horse manure, dried blood, chalk, and often traces of pesticides used to control fungus gnats.
Green manure				Cover crops. Add carbon, other nutrients, improve drainage & structure. Legumes fix N creating a symbiotic relationship with the bacteria.	So many types & variations
Slurry, Tea				Dairy cow manure collected in concrete basin and water added, then a machine spreads on a field Tea can be made in a similar way on a small scale with steeping OM in water , straining, using as a foliar or crop fertilizer	Decomposition is anaerobic, & can be terribly stinky!
Human				Many parts of the world, it's used because it's too rich & valuable to waste by polluting rivers etc. very high in nitrogen.	Not allowed in organic growing of food for human consumption.

Fertilizing for gardens & raised beds (Comparing uses for NPK):

Gaia Garden organic fertilizers

Fertilizer	N	P	K	Uses
All Purpose	4	4	4	Good for lawn, all landscape and garden plants, including trees, shrubs, all fruit and vegetables.
Power Bloom	2	8	4	Excellent for all flowering plants. Good for increasing production of tomatoes, potatoes, and peppers.
Blood & Bone Plus	9	5	5	Use where major nutrient deficiencies are present to stimulate rapid growth.
High P Bat Guano	0	13	1	Excellent for increasing the number and size of buds in flowering plants.
Turf Essentials	5	2	2	Use this slow release fertilizer to produce a healthy, vibrant lawn
Fertilizing Soil Conditioner	4	2	2	Provides a slow release fertilizer that promotes healthy growth in vegetable gardens, lawns, flower beds, and on shrubs.
Steamed Bone Meal	2	11	2	Good for flower and root development. Apply when planting perennials, trees and shrubs.
Vegetative Blend	5	2	2	Great for green leafy vegetables like lettuce, kale, spinach, chard, etc., also corn and any other rapidly growing plants.
Liquid tomato Supreme	4	3	3	Contains the specific nutrients to produce abundant, nutritious tomatoes naturally
Glacial Rock Dust				Best source of natural minerals & trace elements which feeds soil micro-organisms. Beneficial for all plants! (add to compost) lets the soil re-create the colloids (minerals and humus) which are needed to improve soil structure, moisture holding properties, nutrient availability and bacterial action.
Worm castings				Provides beneficial micro-organisms and available nitrogen. High in beneficial bacteria, organic matter, humus, nitrogen, calcium, magnesium, phosphorus and potassium in an easily absorbable form. Nutrients for vigorous plant growth. This odourless material provides good aeration, moisture-retaining capabilities, and will not leach from the soil.