Class 2: Soil Organic Matter, Cover Cropping, and Related Management Strategies

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Today’s Outline

- What is Organic Matter?
- Organic Matter Roles in Soil
- Characteristics and Types of OM
- OM’s Effects on Texture
- Source of Organic Matter
- Incorporating OM into Soil
- Cover Cropping and OM
Organic Matter

- Soil organic matter is the most important physical component of a healthy soil.
- Organic matter brings life to soils.
- It changes the characteristics of different textured soils without changing the texture itself.
Soil organic materials are made up of:

- Dead and decaying plants or animals
- 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
Organic Matter

Organic matter’s role 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
- Ameliorates the effect of environmental pollutants
  - Immobilizes them; reduces leaching
Organic Matter

- Organic matter...

- Usually 5-8% of soil; 30% or more in org. soils.

- 12 – 20% or more desired in organic growing systems
Soil Organic Matter Characteristics

- High Cation & Anion Exchange Capacity (CEC)
  - 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 and ratios variable
- Particle density: 900-1300 kg/m$^3$
- Bulk density: 180-200 kg/m$^3$ - 130 kg/m$^3$
- Holds water better than mineral soils
Organic Matter

- Compost Characteristics:
  - Carboxyl and Hydroxyl Groups

Model structure of fulvic acid by Buffle
Two Types of Organic Matter

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
  - Very resistant to decay
  - Other compounds
Two Types of Organic Matter

**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.
Organic Matter

FRACTIONATION OF SOIL HUMIC SUBSTANCES

NON-HUMIC SUBSTANCES
e.g. recognizable plant debris; plus polysaccharides, proteins, lignins, etc. in their natural or transformed states.

SOIL ORGANIC MATTER

HUMIC SUBSTANCES
fractionation on the basis of solubility

soluble in acid
soluble in alkali
FULVIC ACID

insoluble in acid
soluble in alkali
HUMIC ACID

insoluble in acid
insoluble in alkali
HUMIN

Decreasing molecular weight
Decreasing carbon content
Increasing oxygen content
Increasing acidity and CEC
Decreasing nitrogen content
Decreasing resemblance to lignin
This process is driven by plant growth and biological decomposition; decomposition comes mostly from soil bacteria and fungi.
Organic Matter and Texture

What role does OM play in texture?
Organic Matter and Sandy Soil

- Sand does not hold water or nutrients, but drains very well (perhaps too 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
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
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 as soil stewards to ensure our soil 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
  • What are benefits and costs of this?
Maintaining Soil Organic Matter

- Slowing mineralization helps maintain organic matter levels
  - Slows down loss of OM

- Slowing mineralization also slows the rate at which nutrients are available to plants
  - Can be disadvantage for fast-growing crops
  - Can be supplemented through foliar and liquid fertilization
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?
Introducing Organic Matter to Soil

Great Urban Sources of OM:
- Fallen leaves
  - Be careful of contaminants
- Grass Clippings (pesticide free)
- Coffee grounds (acidic)
- Okara (tofu bi-product)
- Horse Manure
Introducing Organic Matter to Soil

- **Great Rural Sources of OM:**
  - Horse, cow, or chicken manure
  - Straw
  - Spoiled hay
  - Fallen leaves
We can introduce OM to soil with:

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
Introducing Organic Matter to Soil

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
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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 growing season
  - Side dress plants
  - Continue mulching
  - Compost tea
Introducing Organic Matter to Soil
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Introducing Organic Matter to Soil
3. Manure Additions

- Can be raw or decomposed
  - Raw manure cannot 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
4. Mulching: Additions of plant debris to the soil surface

1. Plant Trimming Mulch
2. Straw or other high carbon materials
3. Compost/Leaf Mulching
4. Sheet Mulching
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A Word or Two on 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
1. 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!
2. 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
3. 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
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4. Sheet Mulching

- Permaculture folks love to 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
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Sheet Mulching:
- 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
- Given lots of water!
- Can plant into soil pockets in new mulch
### Seed Free Organic Matter Mulch
9. Add 1-2” of straw, fine bark, wood shavings or landscape mulch.

### Compost or Soil
8. Add 1-2” of compost or soil. You can add manure if not for immediate use.

### Bulk Mulch
7. Lay down 8-12” of bulk material like hay, wood shavings or straw. Seeds are not a big concern because they will rot in this layer. For best composting, add some nitrogen to this layer. As you build this layer, spray on water to make damp, but not wet.

### Nitrogen Material
6. Lay down a thin layer of manure, meal or fresh grass clippings to entice worms through the decomposing sheet mulch layer.

### Sheet Mulch
5. Layer newspaper or cardboard to smother existing plants. Overlap edges by 6” and apply newspaper about ¼” thick. Water down paper to keep in place. Try not to walk on wet paper.

### High Nitrogen Material
4. Poke holes in the soil with a spade fork and add a thin layer of high nitrogen material to attract worms and burrowing beetles.

### Soil Amendments
3. Next day, add any soil amendments to adjust soil pH or add trace minerals on the basis of soil test results.

### Existing Vegetation
2. Next day, slash down the day of mulching and leave in place. Remove woody material.

### Existing Soil
1. Water well the night before.
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8 in. straw
compost
weed barrier
manure
grass
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- Synthetic Mulches:
6. 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 overwinter on the coast
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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
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- **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!
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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
Fixing Nitrogen

- Legumes will not fix nitrogen if:
  - Soil is high in N already
  - Soil is saturated with water or overly dry
- 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
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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
  - e.g., Oats
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- **Suppress Weeds**
  - Many cover crops are allelopathic – they suppress the growth of other crops
    - Fall rye
    - Sunflowers
    - Mustards
    - Buckwheat
      - Grows fast to outcompete weeds
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Suppress Insect Pests

- Some crops suppress insect pests
  - Mustards
  - Buckwheat
    - Wireworms
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- Provide pollen for bees
  - Buckwheat
  - Phacelia
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Introducing Organic Matter to Soil

Cover Crop Management Points

- Can be planted in spring, summer or fall
- Most plantings in fall or late summer for overwintering
  - 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 to gain more benefit
  - OM and N-fixing
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Cover Crop Management Points

- 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
Cover Crop Management Points

- 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 away precious growing time in smaller systems
- Cover crops are a vital piece of a sustainable, closed-loop agroecosystem