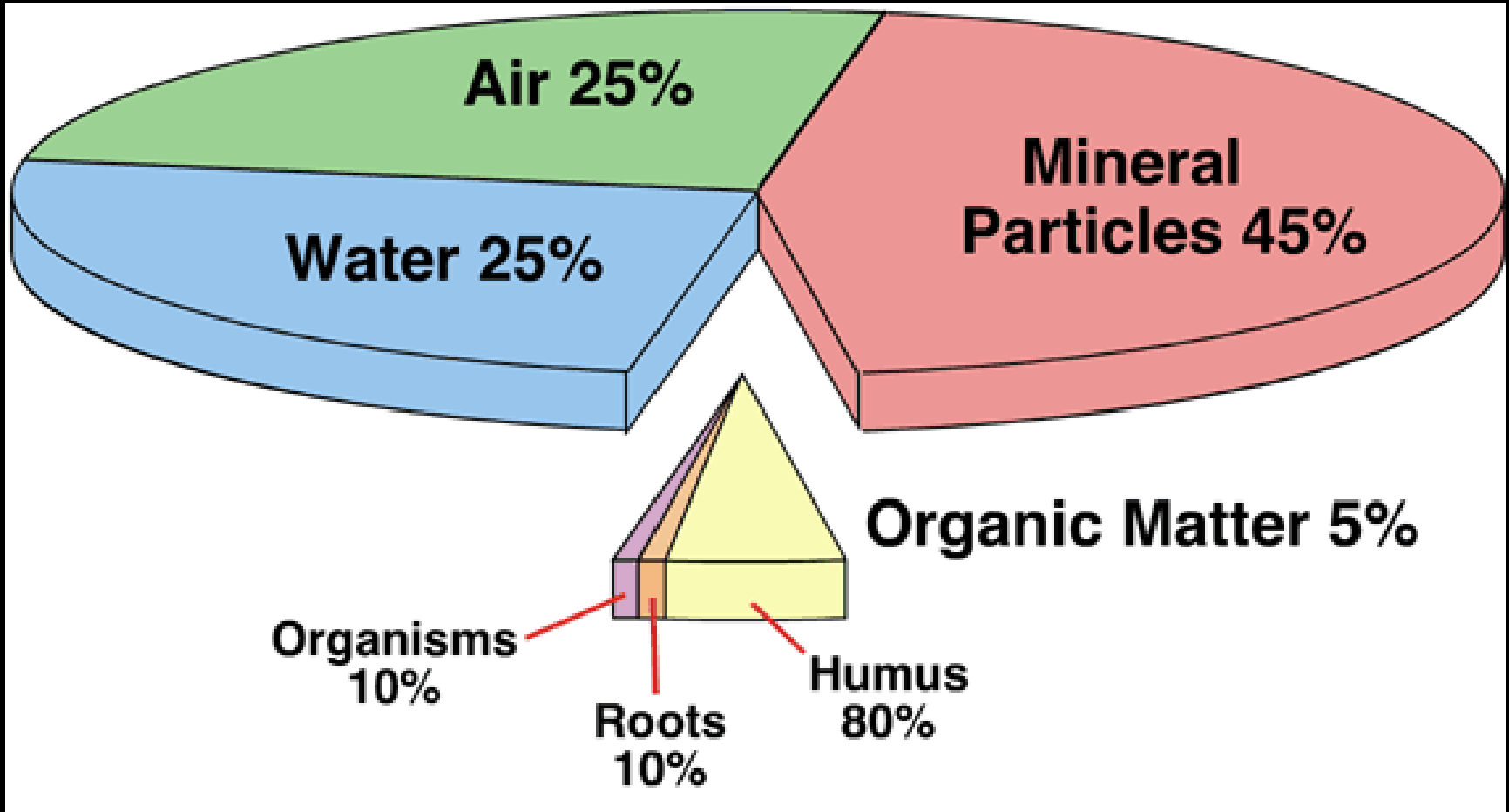


# IT ALL STARTS WITH HEALTHY SOIL

Cary L. Rivard, Ph.D.  
Dept of Horticulture  
Kansas State University



# What is Soil?

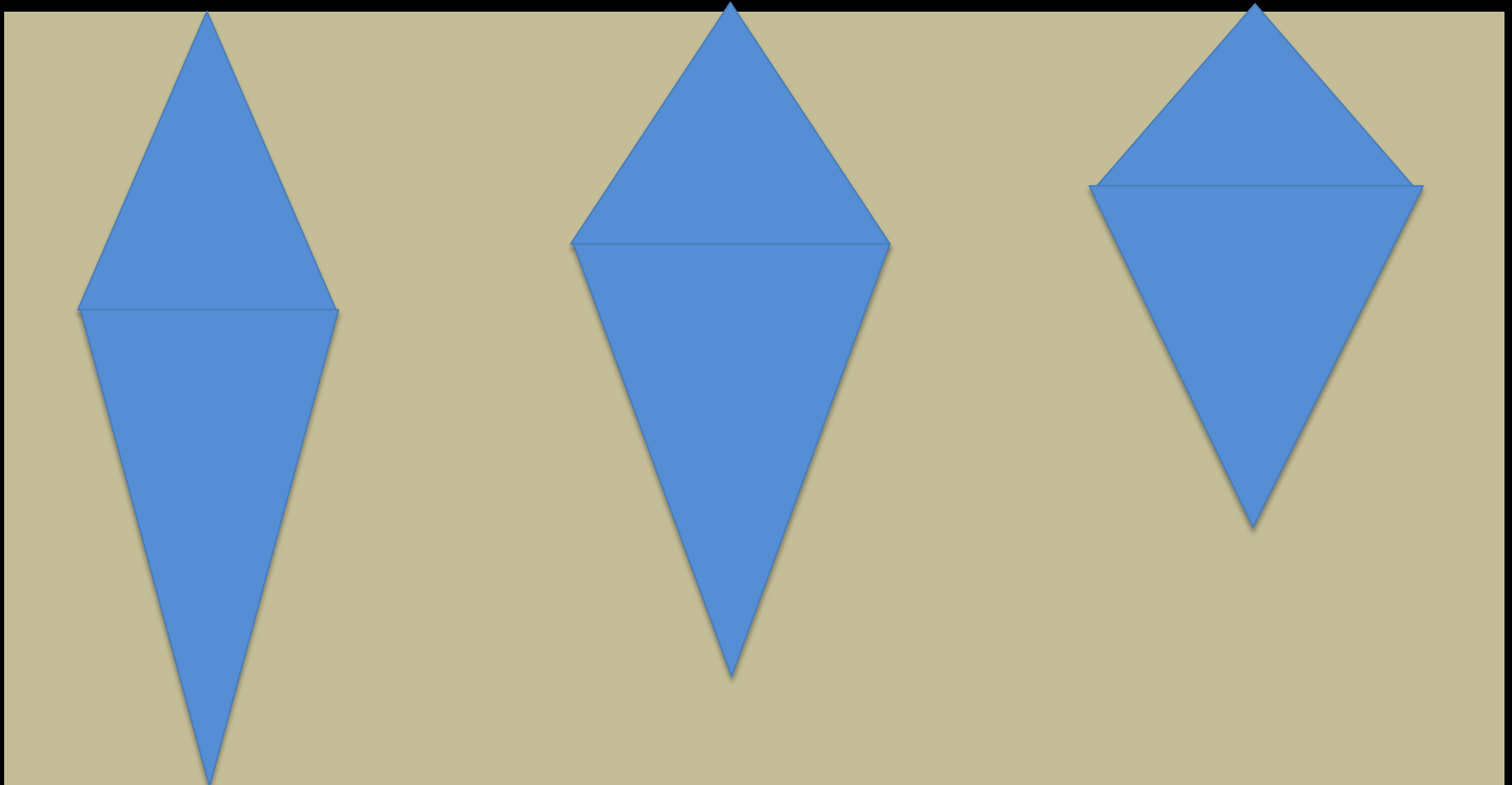


**Soil Health = Plant Performance**

# Soil Physical Properties

Water distribution is dependent on soil type

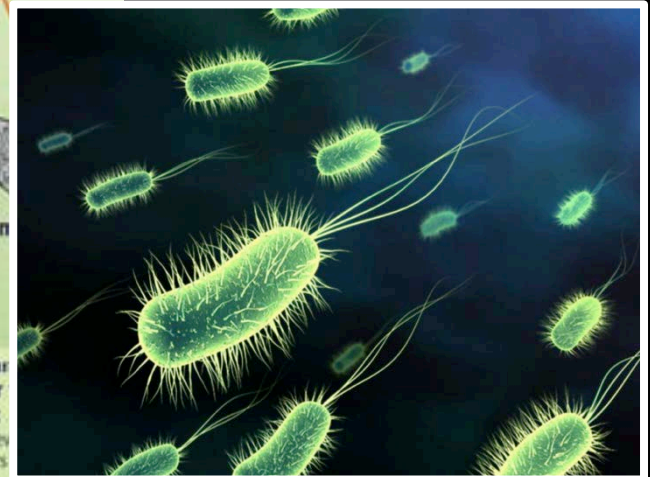
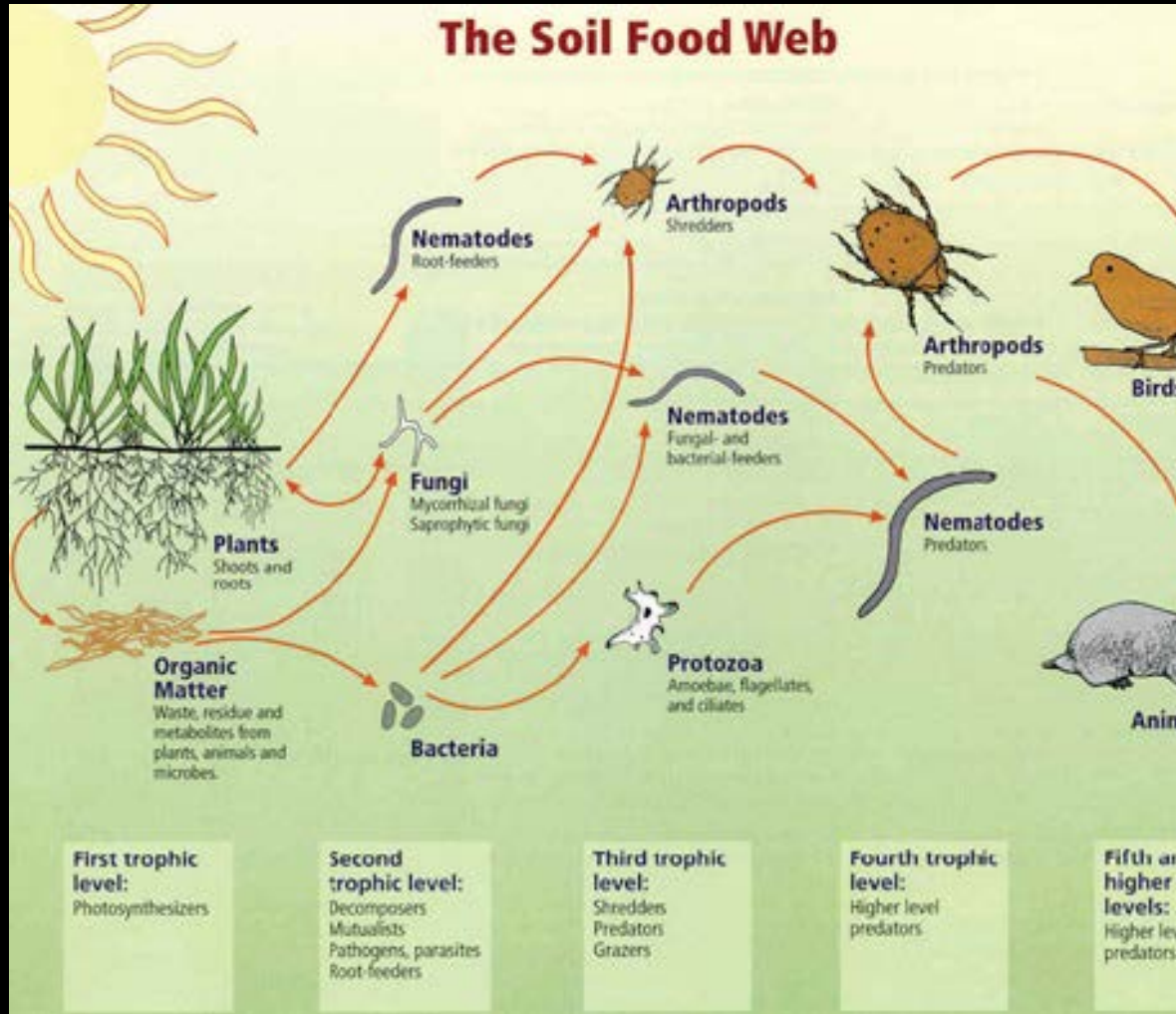
Sand ← → Loam ← → Clay





# Soil Health and Biology

## The Soil Community is DIVERSE





# Soil Health and Biology

The Soil Community is DIVERSE



# Soil Improvement

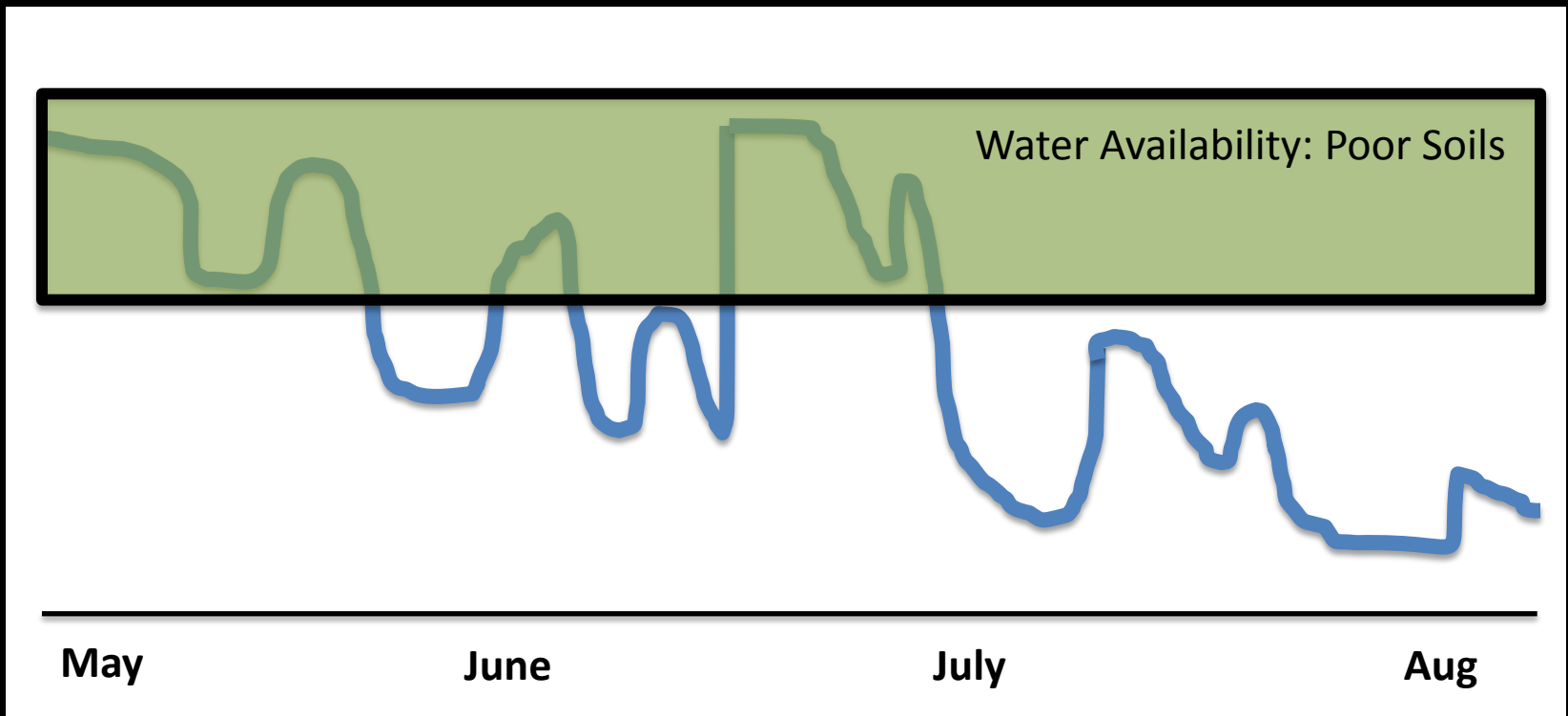
## Adding Organic Matter

- Organic matter (OM) improves soil in a number of ways
  - Loosens tight clays
  - Increases water-holding capacity
  - Increases cation exchange capacity
  - Soil “aggregates” and tilth
- How OM can be added
  - Compost
    - Pre-plant or side-dressing
  - Degradable mulch
  - Crop residues
  - Cover crops / green manures



# Soil Quality/Health

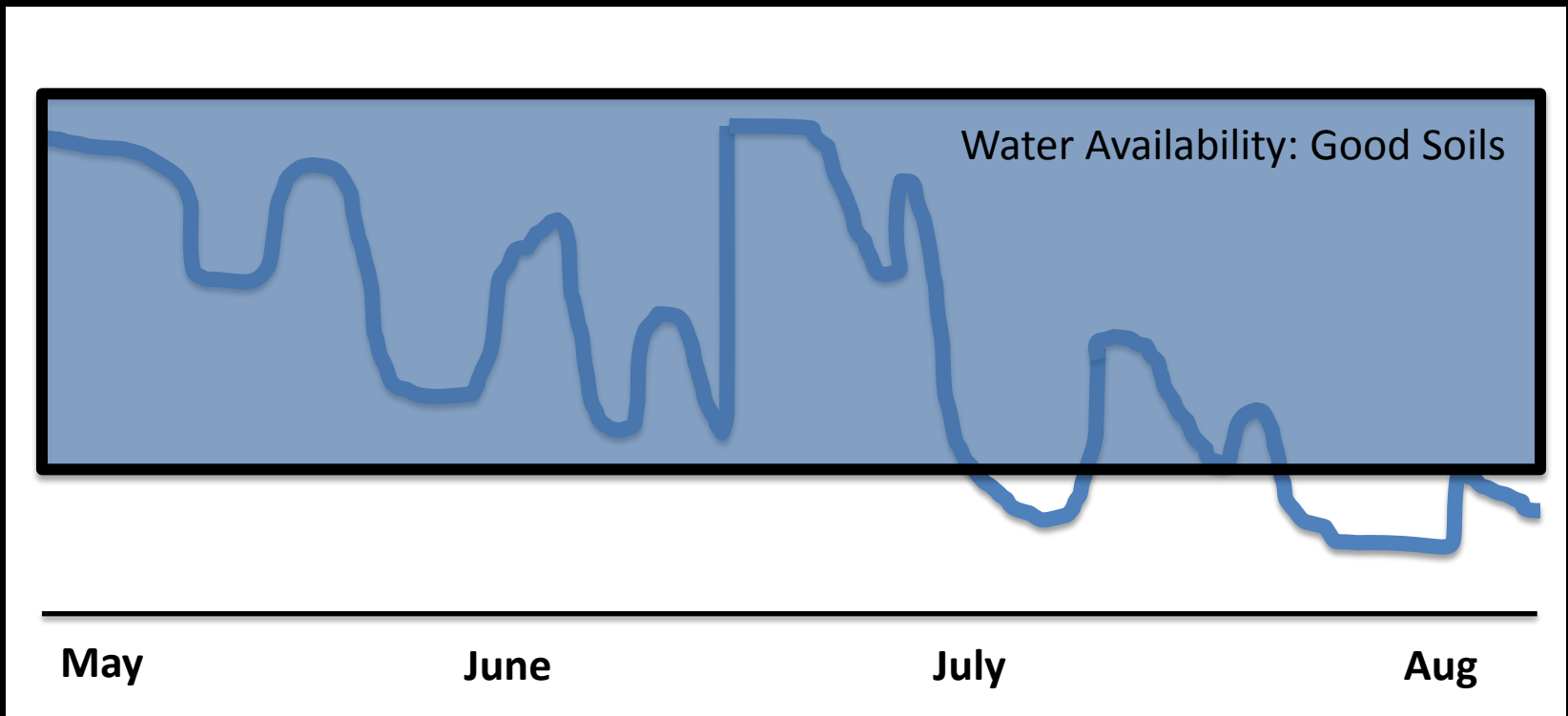
## Good Soil Protects Crops from Drought

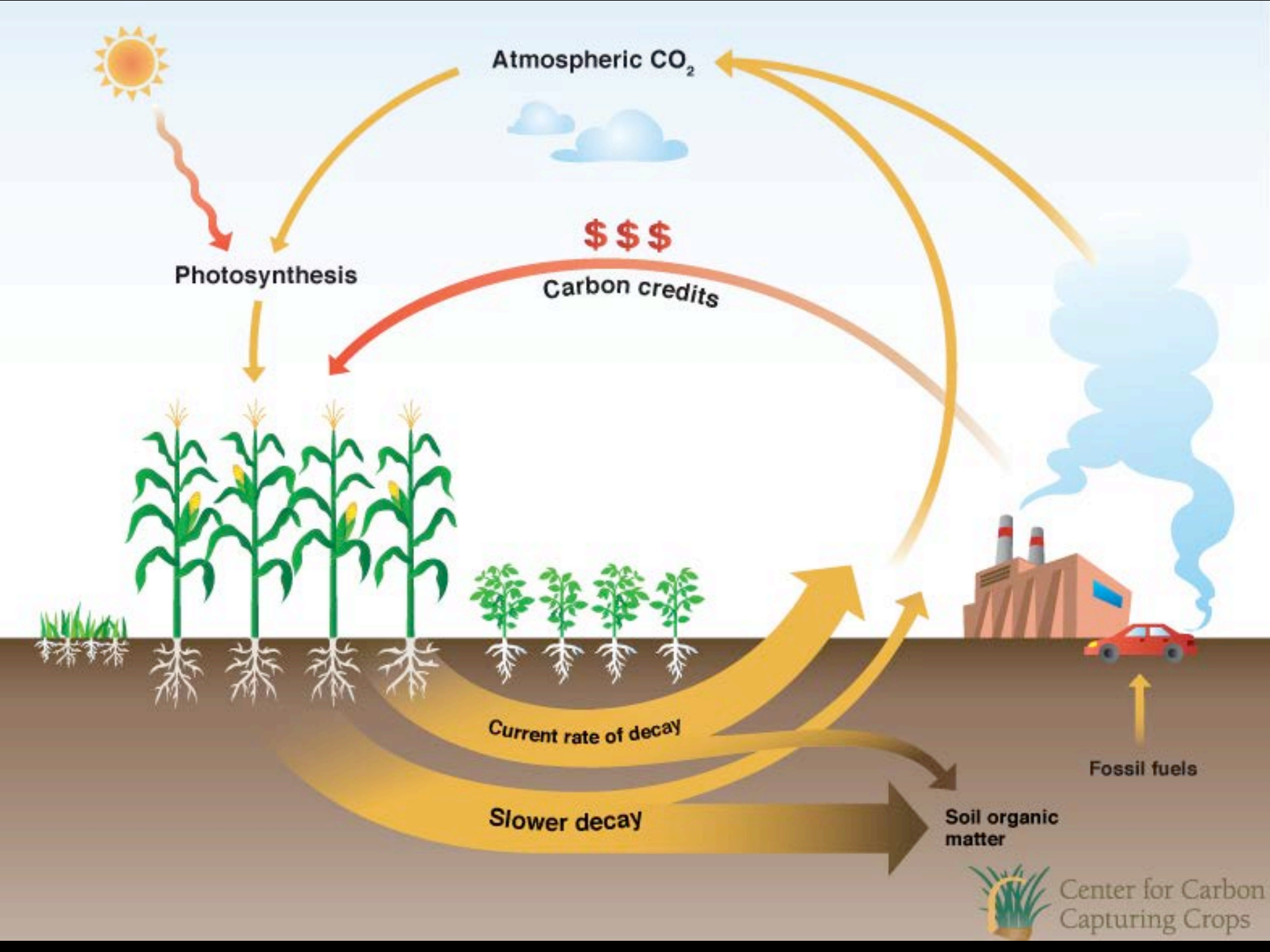




# Soil Quality/Health

## Good Soil Protects Crops from Drought





Center for Carbon  
Capturing Crops

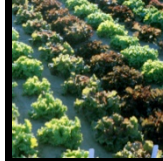
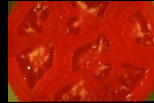
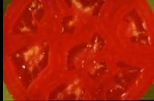
# Crop Rotation

## Designing a Crop Rotation

| <b><u>Alliaceae</u></b>             | <b><u>Brassicaceae</u></b>   | <b><u>Cucurbitaceae</u></b>  | <b><u>Fabaceae</u></b>                     | <b><u>Solanaceae</u></b>                    |
|-------------------------------------|--|--|--|---|
| Chives<br>Garlic<br>Leeks<br>Onions | Broccoli<br>Brussel sprouts<br>Cabbage<br>Cauliflower<br>Collards<br>Lettuce<br>Mustard<br>Radish<br>Rutabaga<br>Spinach<br>Turnip | Cantaloupe<br>Cucumbers<br>Honeydew melons<br>Pumpkins<br>Squash<br>Watermelon | All beans<br>English peas<br>Southern peas | Eggplant<br>Peppers<br>Potatoes<br>Tomatoes |
| <b><u>Asteraceae</u></b>            | <b><u>Poaceae</u></b>  | <b><u>Malvaceae</u></b>  | <b><u>Chenopodiaceae</u></b>               | <b><u>Apiaceae</u></b>                      |
| Lettuce                             | Corn   | Okra   | Spinach                                    | Carrot                                      |



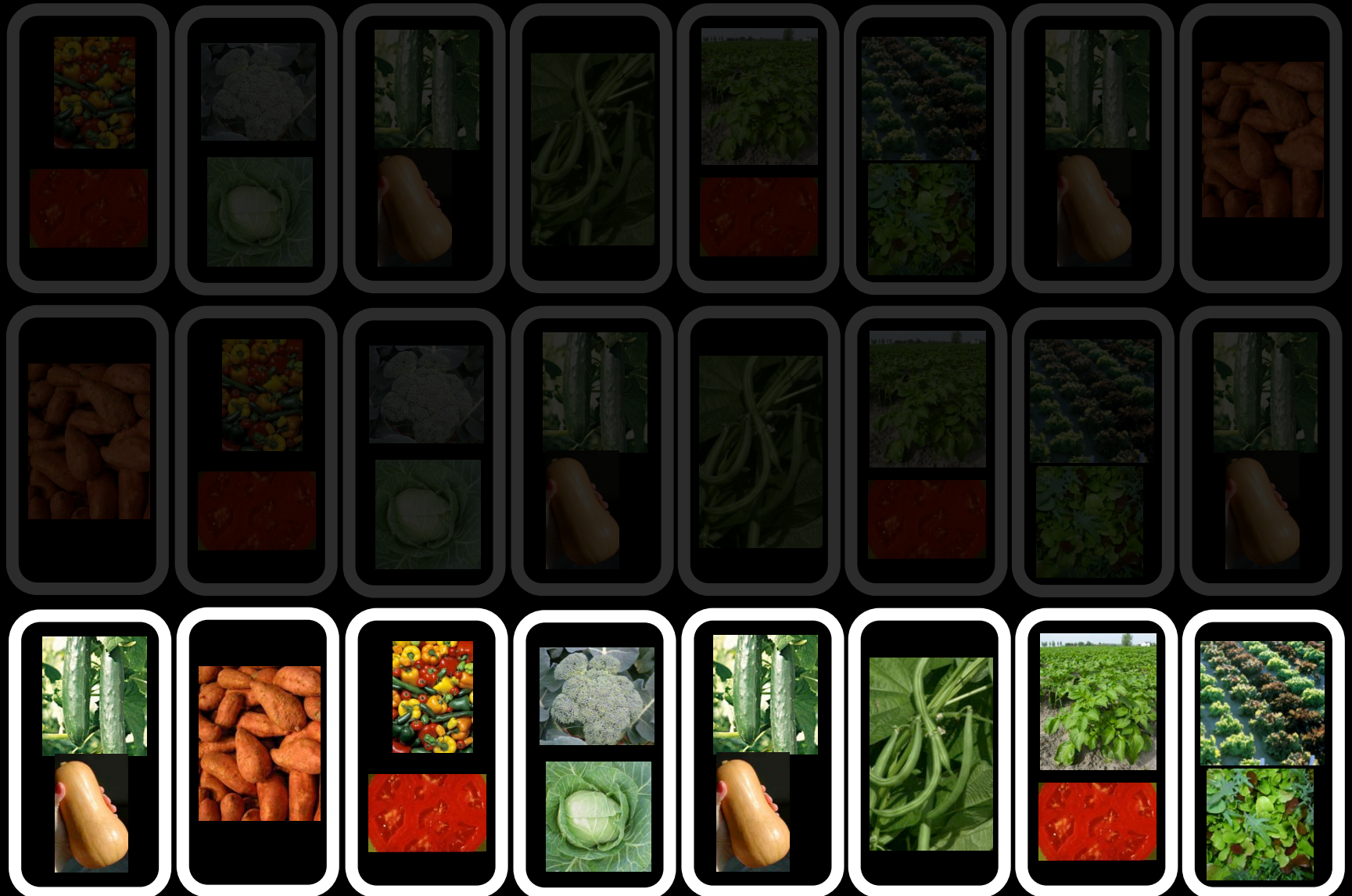
# Crop Rotation



# Crop Rotation



# Crop Rotation





# Crop Rotation



Fallow / Perennial Grasses

Fallow / Perennial Grasses

Fallow / Perennial Grasses

# Compost

## Using Compost: Pros



- Benefits
  - Plant nutrients (macro and micro)
  - Soil improvement (CEC, WHC)
  - Improve drainage
  - Disease suppression (beneficial microbes)
- Prior to planting (spring or fall)
- As mulch
  - High C:N ratio (mature)
- In potting mix (transplants)
- Prior to cover crop planting





# Compost

**Compost can provide disease suppression**



Recipe: 30 % Dairy manure  
30% Waste Hay  
30% Waste Silage  
5% Finished compost  
5% Clay soil



# Compost

## Using Compost: Cons

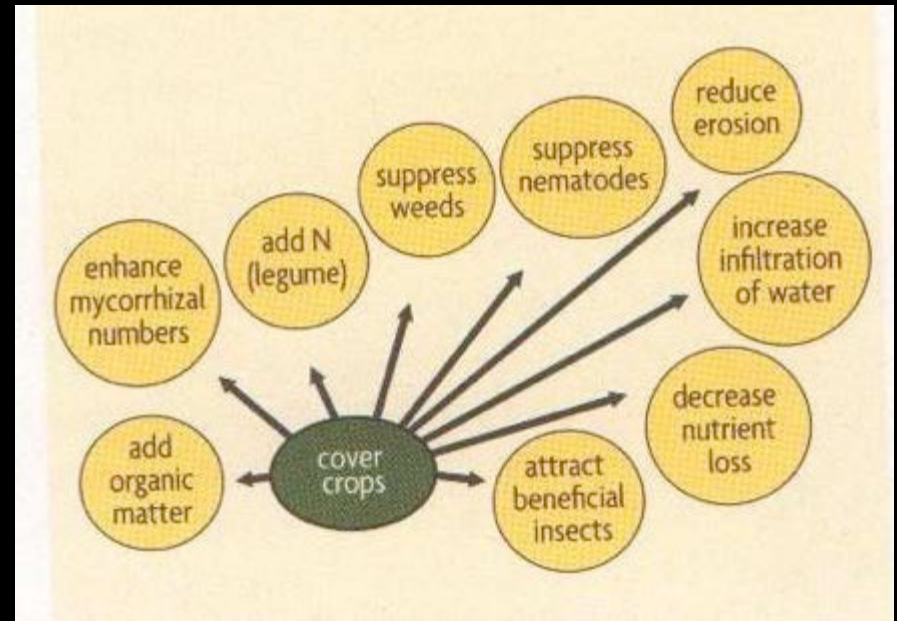
- Poorly made or immature compost can be a source of pathogens, weed seeds, and insects.
- Be sure that compost is mature
- Careful with transplants
- Excessive plant nutrients
  - Avoid crop burn
- Soil salinity (over time)
  - Repeated use
- Animal waste
  - Human pathogens
  - Heavy metals



# Cover Crops

## Cover Crops

- Also known as “green manures”, cover crops are extremely important for soil health
  - Organic matter
  - Soil microbial health
- Suppress Weeds
- Add / Recover nitrogen
  - Highly-leachable  $\text{NO}_3$
  - Legume cover crops fix N
- Can be used as mulch
  - No-till or strip-tillage
- Can reduce excess nutrients (P)
- Reduce soil erosion





# Benefits of Cover Crops

## Reduced Weed Seed Bank

- Weed seed germination
  - Light
  - Soil disturbance
- Cover crops
  - Competition
- Life cycle interruption
  - Reduced seed bank





# Benefits of Cover Crops

## Grow Your Own Mulch

- Cover crop residues serve as mulch
- Source of soil carbon
- Source of nitrogen







**Utilize Cover Crops to Attract Beneficials and Pollinators**





Cover Crop used as wind breaks





Clover Cover Crop used as “living mulch”





Annual Rye in Row Middles (Fall-Spring)







# Challenges of Cover Crops

## Challenges exist with cover crops

- Managing cover crop biomass
- Equipment
- Disease and pest pressure
- Production logistics
  - Have a CC plan!







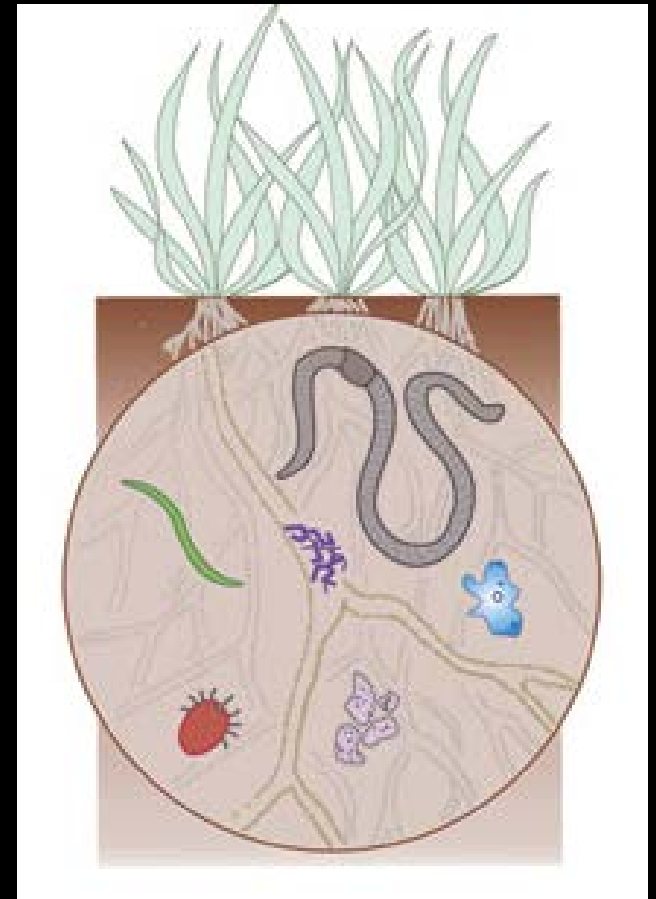
Re-growth



# Cover Crops in Tunnels

**Cover Crops are important in high tunnels**

- Need to retain soil quality
- Challenges
  - Irrigation
  - Real Estate
- “Short-window” crops
- Mowing down the crop
- Moveable tunnels





























# Planning for Cover Crops

## A few scenarios for planning your rotation

- Warm-Season Vegetables

Winter CC

Cash (Vegetable) Crops

Winter CC

- Cool-Season Vegetables

Fall Cash Crops

Summer Cover Crops

Fall Cash Crops

- Fall Cover Crops

Winter CC


























Cash (short) Crops


































Fall CC

Winter CC



# Planning for Cover Crops

| PLOT | YEAR 1  |     |     |     |     |  |  |     |     |     |   |   | YEAR 2 |     |     |     |
|------|---|-----|-----|-----|-----|--|--|-----|-----|-----|---|---|--------|-----|-----|-----|
|      | Jan   | Feb | Mar | Apr | May | Jun  | Jul  | Aug | Sep | Oct | Nov   | Dec   | Jan    | Feb | Mar | Apr |
| 1    |   |     |     |     |     | beans           |  |     |     |     |   |   |        |     |     |     |
|      | white clover   |     |     |     |     |  | vetch           |     |     |     |   | vetch  |        |     |     |     |
| 2    |   |     |     |     |     | roots           |  |     |     |     |   |   |        |     |     |     |
|      | sweet clover   |     |     |     |     |  | white clover    |     |     |     |   |   |        |     |     |     |
| 3    |   |     |     |     |     | squash          |  |     |     |     |   |   |        |     |     |     |
|      | f. rye         |     |     |     |     |  | sweet clover    |     |     |     |   |   |        |     |     |     |
| 4    |   |     |     |     |     | potatoes        |  |     |     |     |   |   |        |     |     |     |
|      | soy beans      |     |     |     |     |  |  |     |     |     | rye  |   |        |     |     |     |
| 5    |   |     |     |     |     | corn            |  |     |     |     |   |   |        |     |     |     |
|      | white clover   |     |     |     |     |  | soy beans       |     |     |     |   |   |        |     |     |     |
| 6    |   |     |     |     |     | cabbage family  |  |     |     |     |   |   |        |     |     |     |
|      | vetch        |     |     |     |     |  | white clover  |     |     |     |   |   |        |     |     |     |
| 7    |   |     |     |     |     | peas          |  |     |     |     |   |   |        |     |     |     |
|      | Oat stubble  |     |     |     |     |  | clovers       |     |     |     |   |   |        |     |     |     |
| 8    |   |     |     |     |     | tomatoes      |  |     |     |     |   |   |        |     |     |     |
|      | vetch        |     |     |     |     |  | oats          |     |     |     |   |   |        |     |     |     |

| YEAR 2   |     |      |     |   |     |     |     |     |     |     |     | YEAR 3   |     |     |     |       |     |     |     |  |  |  |  |
|--|-----|------|-----|---|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-------|-----|-----|-----|--|--|--|--|
| May  | Jun | July | Aug | Sep   | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May  | Jun | Jul | Aug | Sep   | Oct | Nov | Dec |  |  |  |  |
|  |     |      |     | ○ tomatoes ○  |     |     |     |     |     |     |     | peas    |     |     |     |       |     |     |     |  |  |  |  |
|  |     |      |     | ↙ oats ↘  |     |     |     |     |     |     |     | clovers   |     |     |     |       |     |     |     |  |  |  |  |
| ○ beans   |     |      |     |   |     |     |     |     |     |     |     | tomatoes ○   |     |     |     |       |     |     |     |  |  |  |  |
| vetch   |     |      |     | vetch  |     |     |     |     |     |     |     | oats ↘   |     |     |     |       |     |     |     |  |  |  |  |
| ☺ roots   |     |      |     |   |     |     |     |     |     |     |     | ☺ beans   |     |     |     |       |     |     |     |  |  |  |  |
|  white clover      |     |      |     |   |     |     |     |     |     |     |     |  vetch   |     |     |     |       |     |     |     |  |  |  |  |
| ☺ squash    |     |      |     |   |     |     |     |     |     |     |     |  roots   |     |     |     |       |     |     |     |  |  |  |  |
|  sweet clover      |     |      |     |   |     |     |     |     |     |     |     |  white clover   |     |     |     |       |     |     |     |  |  |  |  |
| ☺ potatoes ○   |     |      |     |   |     |     |     |     |     |     |     |  squash  |     |     |     |       |     |     |     |  |  |  |  |
|  |     |      |     | ↙ rye ↘ ↘   |     |     |     |     |     |     |     | sweet clover    |     |     |     |       |     |     |     |  |  |  |  |
| corn    |     |      |     |   |     |     |     |     |     |     |     | ☺ potatoes ☺   |     |     |     |       |     |     |     |  |  |  |  |
|  soybeans      |     |      |     |   |     |     |     |     |     |     |     |  |     |     |     | rye ↘ |     |     |     |  |  |  |  |
| cabbage family    |     |      |     |   |     |     |     |     |     |     |     | corn    |     |     |     |       |     |     |     |  |  |  |  |
|  white clover  |     |      |     |   |     |     |     |     |     |     |     |  soybeans   |     |     |     |       |     |     |     |  |  |  |  |
| peas    |     |      |     |   |     |     |     |     |     |     |     | cabbage family    |     |     |     |       |     |     |     |  |  |  |  |
|  clovers       |     |      |     |   |     |     |     |     |     |     |     |  white clover   |     |     |     |       |     |     |     |  |  |  |  |

Taken from: *The New Organic Grower*, Eliot Coleman

# Winter Cover Crops

## Annual Grasses - Rye, Wheat, Oats, etc.



Crop Winter Rye

- High biomass
  - Rye is highest
  - Straw production
- Nitrogen recovery
- Weed competition
  - Allelopathy (Rye)
- Killing the crop
  - Early crops
- Plant Sept 1 – Nov 15



# Winter Cover Crops



Oats



Winter Wheat

# Winter Cover Crops

## Annual Legumes

- Fix Nitrogen
  - Inoculant
- Clovers
- Vetch
- Winter peas
- Easier to kill
- Less biomass (straw)



Crimson Clover (Annual)



# Winter Cover Crops



Hairy Vetch



Austrian Winter Pea



# Fall Cover Crops

## Tillage Radish and Other Brassicas



Tillage Radish





# Summer Cover Crops

## Annual Grasses – Sorghum, Millet, Spring Oats



Foxtail Millet

- High Biomass
  - Nitrogen recovery
  - Weed competition
  - Mulch / OM production
- Short duration
  - Millet (45 days)
- Can be particularly difficult to kill
  - Sorghum-Sudan

# Summer Cover Crops



Japanese Millet



Sorghum-Sudan Grass







# Summer Cover Crops

## Annual Summer Legumes

- Fix Nitrogen
  - Inoculant
- Soybean
- Forage soybean
  - Biomass
- Sunn Hemp
  - Peanut inoculant
- Cowpea
  - Very drought tolerant



Cowpeas



# Summer Cover Crops

## Other Annual Summer Cover Crops



Buckwheat



Sunn Hemp

# No-Till Veggie Crops

## Characteristics of Crops that Do Well in No-Till

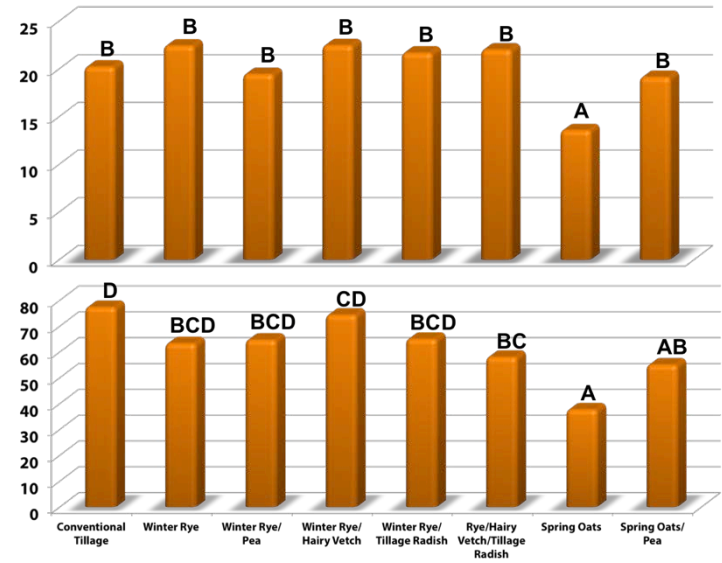


- **Competitive** crops do best
  - Canopy development
  - Water and nutrients
- Planting date
  - Late (summer crops)
- Crops that do well under mulch
- Transplants
- Crops that require intensive weed management





2013 No-till Pumpkin Trial Avg Weight & Count Per Treatment Wichita





# Challenges of No-Till

## Challenges exist in No-Till Systems

- Soil temperature
  - Early crops
  - Seed germination
- Managing cover crops
- Nutrient tie-up
  - Fertigation/foliar feeding
- Disease and pest pressure
- Organic CC termination



Southern Blight on Tomato





No-till and/or strip-till methods with fabric







# Take-home Message

## Soil Health = Plant Performance

- Soil and water are our most valuable resources as growers
  - Conservation is key
- Protect soil
- Feed the soil
- Water quality



# Take-home Message

## Soil Health = Plant Performance

- USE COVER CROPS!!!
- Reduce tillage
- Manage water -> erosion
- Utilize crop rotations
- Increase OM
- Use mulches and drip
- Be realistic in your expectations

