

# College of Agricultural, Consumer and Environmental Sciences

Basics of Soil Building & Health  
NM Farm & Ranch Heritage Museum  
Las Cruces, NM  
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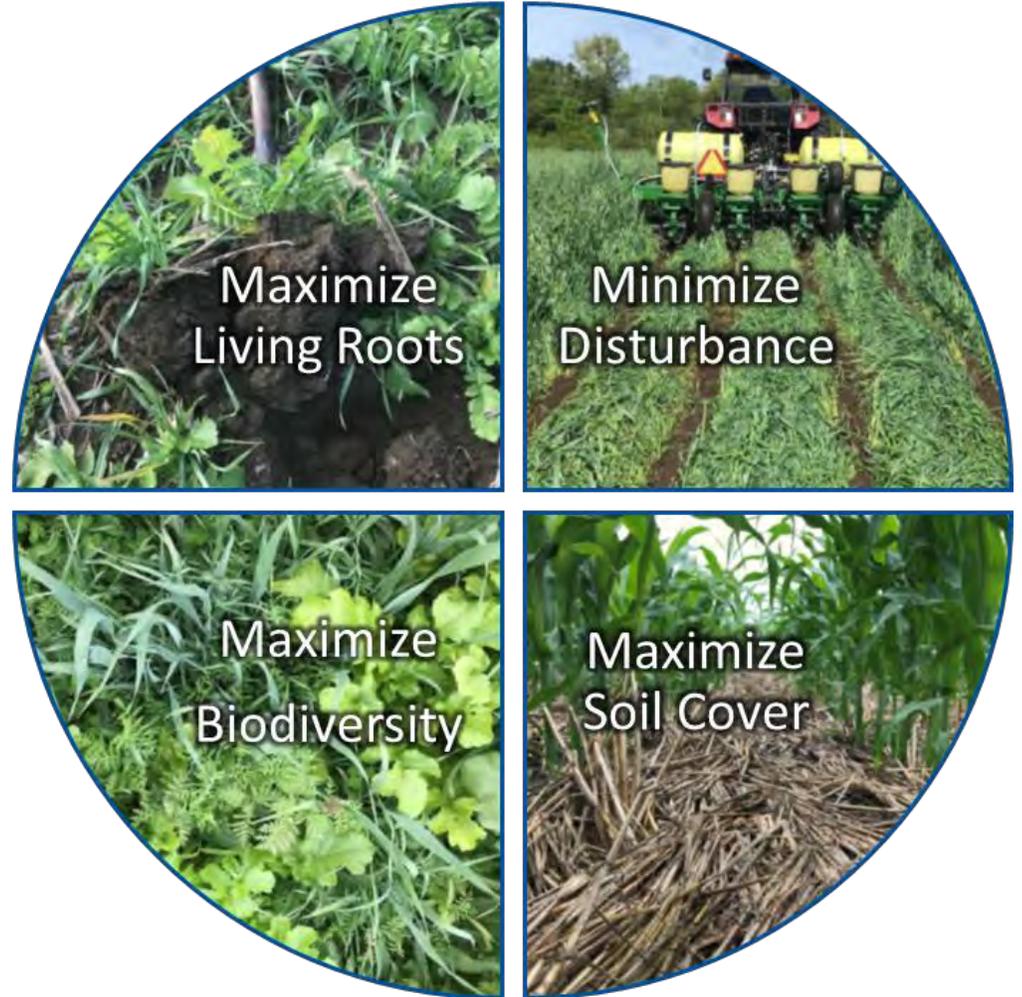
# What is Soil Health?

Soil health is defined as the continued capacity of soil to function as a vital living system, sustaining biological productivity, maintaining the quality of air and water, and promoting the health of plants, animals, and humans.



# Soil Health Principles

- Minimize Disturbance
- Maximize Cover
- Maximize Biodiversity and Incorporate Grazing
- Maximize Living Roots



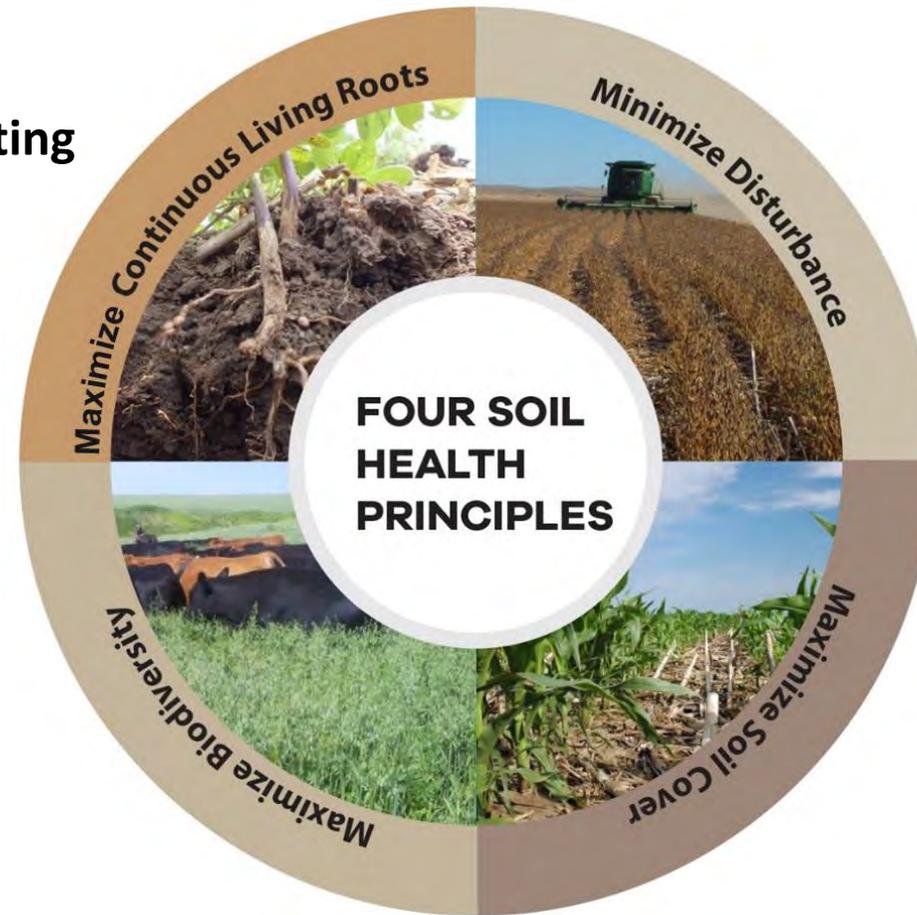
**These principles are common to all soils**

# Key Roles: Feed and Protect the Soil



# SYSTEM APPROACH IN SOIL HEALTH MANAGEMENT

- Crop rotation
- Cover crop relay crops
- Forage & biomass planting
- Perennial Crops/  
pasture crop



- Cover crop
- Crop rotation
- Rotational grazing
- Pollinator plantings
- Organic fertilizers
- Legumes in mix

- Reduced tillage
- Controlled traffic
- Avoid tillage in wet soil
- No-tillage/disturbance

- Cover crop
- Mulching
- Forage & biomass  
planting
- Plant residue

# Benefits of Minimizing Disturbance

- Protection of soil carbon
- Protection of soil microbes especially soil fungi
- Protection of soil structure
- Increased earthworms' activities
- Reduced compaction
- Better water infiltration into the soil

# Minimizing Disturbance



No-Till, Reduced or Minimum Tillage

# Reduced Tillage Goals

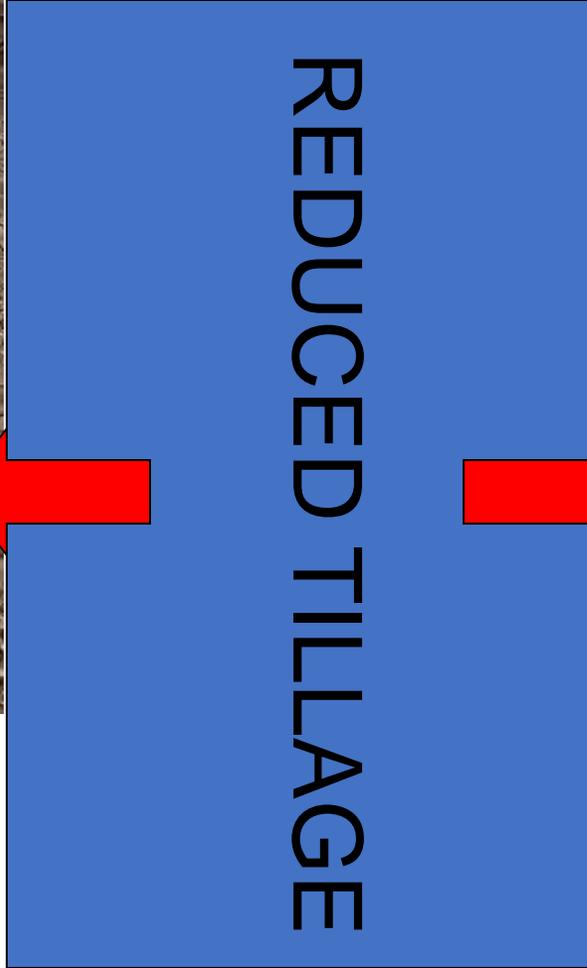
- Enhance soil quality
  - Conserve soil organic matter
  - Conserve soil moisture
- Reduce erosion
- Reduce fuel use
- Optimize weed control
- Maintain yields





Conventional tillage

- Primary, secondary tillage, seedbed preparation
- 2-4 field tillage passes
- 'Clean Field'



Permanent No-till

- No tillage passes
- Residue minimally disturbed
- Maximize protection against erosion and crusting

- Zone tillage (single pass)
- Strip tillage
- Permanent beds
- Plastic mulch cover
- Reduced freq. of plow till
- .....and so on

# STRIP TILLAGE



## Strip tillage

- ❖ Land preparation in strips
- ❖ Tillage width depends on the system
- ❖ Only 1 field pass before seeding

# Reduced Tillage Facts

- Depends on equipment (capital intensive)
- Depends on crop (works better for large seeds)
- Little difference between full-width tillage and reduced tillage in terms of yield (short-term)
- Labor savings during early-season field prep.
- Investment in long-term soil health

# Benefits of Maximizing Cover

- A shield from rain splash (erosion) and compaction
- Allow infiltration of water
- Provide protection from direct solar radiation
  - Reduce soil temperature at the surface
  - Prevent rapid soil evaporation
- Act as weed barrier

# Maximizing cover

- **Plant residue**

- What is left after the cash crop harvest
- Decomposes over time
- Adds organic matter and stimulates microbial activities
- Can help with earthworm multiplication

- **Mulches**

- Hard to decompose material spread on the soil surface.
- Prevents erosion, rapid water evaporation, and weed infestation
- Examples of mulches: grass clippings, wood chips, nut shells, straw, etc.

- **Cover Crops**



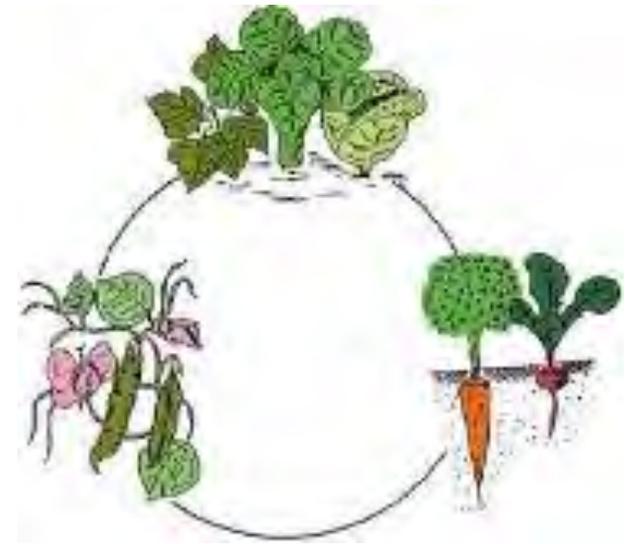
# Maximize Biodiversity

Examples:

- **Crop rotation**
- **Livestock Integration:** Supercharges a soil health system
- **Inter-seeding cover crops with cash crops** (living mulch)
- **Adding organic amendments**
- **Single and multispecies cover crops**

# Crop Rotation

- Good crop rotation can break the disease cycle
- Decrease pest pressure from insects, weeds, and diseases
- Enhances soil biological diversity
- Enhances sustainable cropping systems



# Livestock Integration

## Benefits of livestock-integrated cropping systems

- More efficient utilization of farm resources
- Manure, urine, saliva, hair, and skin - introduce and distribute microbes
- Incorporation of microbes and biomass through trampling
- Reduce the amount of chemical fertilizer per unit of land and minimize the consequent environmental risks
- Increases soil organic matter, microbial growth, and supports crop productivity



# Examples of Living Mulches

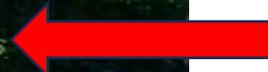
Los Lunas



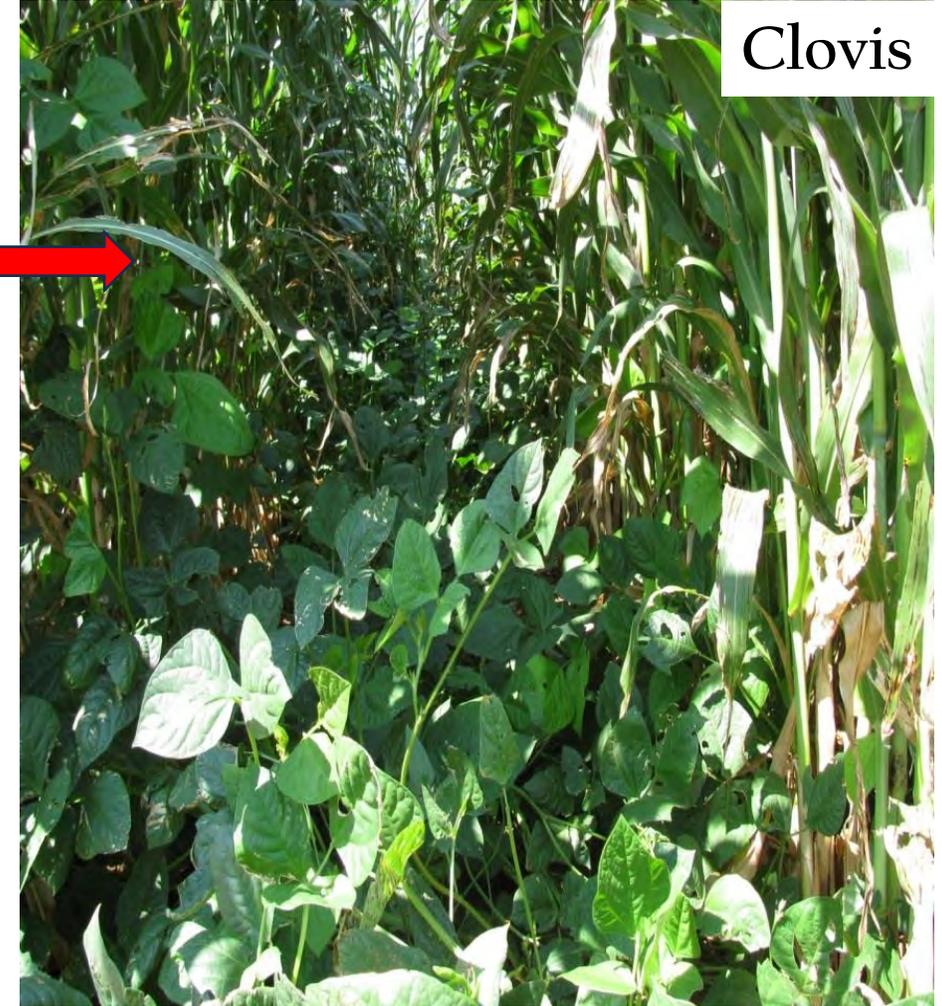
Corn Inter-seeded  
with Lablab



Dutch White  
Clover in  
Peach  
Orchard



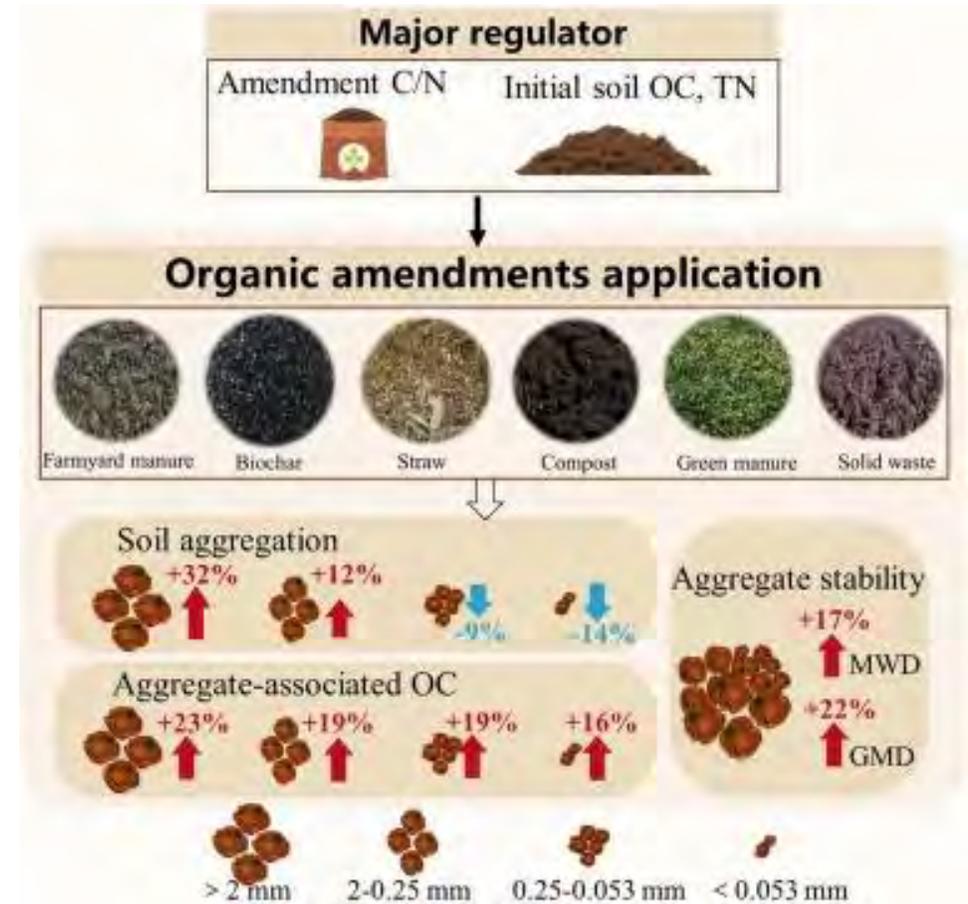
Clovis



# Adding Organic Amendments

Examples:

- Compost
- Vermicompost
- Manure (different types)
- Composted manure
- Biochar
- Different blends  
(for example, compost-biochar blend)



# Animal Manures

- Cow manure
  - Good general nutrient source (especially K)
  - OM benefit depends on amount of bedding
  - Can carry weed seed
- Poultry manure
  - Potent source N, P, Zn, and lime
  - Organic matter addition is relatively low
  - Best if composted
- Horse manure
  - Heavily bedded with wood shavings
  - Nitrogen availability can be a problem in the first year



# Peat Moss

- Improves soil moisture retention
- Minor improvement to nutrient holding capacity
- Provides negligible nutrient benefit
- High proportions may make soil hydrophobic



# Materials to Avoid

- Sawdust, wood shavings, wood chips
  - very high carbon/nitrogen ratio
  - will tie up all available N during breakdown (immobilization)
- Worst when tilled in
  - minor detrimental effect if used as mulch
- Composting the materials before soil application



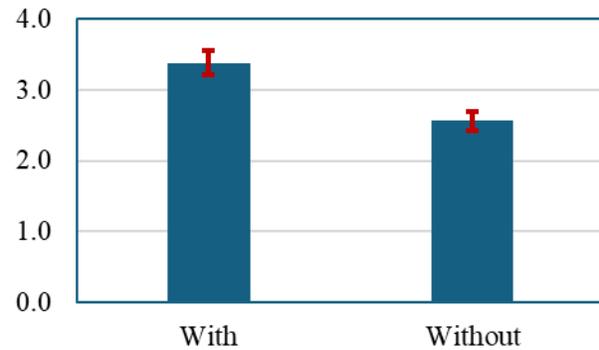
# Biochar

- Made by burning biomass under little oxygen or in the absence of oxygen
- It gives rise to a material that is rich in carbon
- The carbon in biochar is very resistant to decomposition
- Biochar properties depend on the feedstock and how it is made
- Some of them can be saline or with high pH (check the properties)
- It can help improve soil health through
  - Improved soil moisture, especially in sandy soil
  - Improved microbial abundance and activity
  - Improved nutrient use efficiency
- It works best if it is charged before use (mixed with a nutrient source)



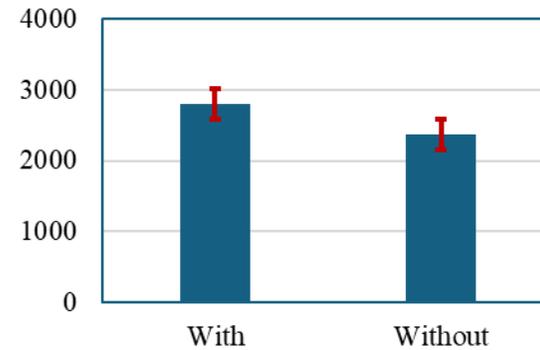
# Effect of Compost-biochar Blend on Soil Health and Crop Yield – 2 years After Application (15 t/ac)

**Organic Matter (%)**



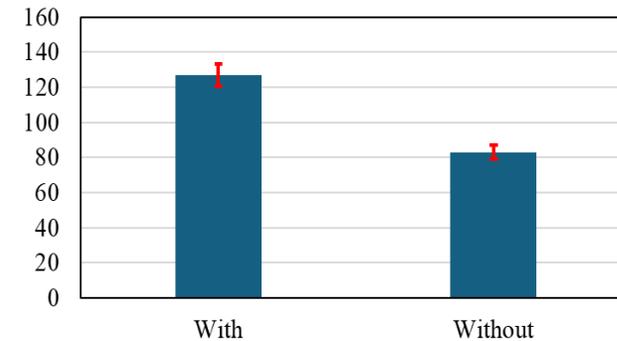
> 32%

**Microbial Biomass (ng/g)**



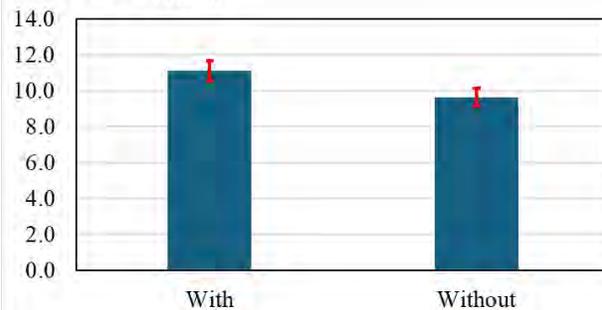
> 18%

**Arbuscular Mycorrhizal ng/g**



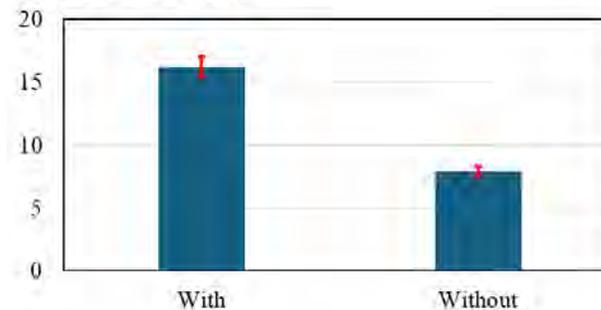
> 53%

**Nitrate-N mg/kg**



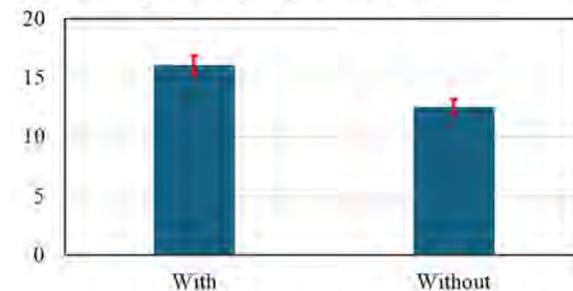
> 15%

**Phosphorus mg/kg**



> 105%

**Corn Silage Yield @ 65% MC (t/ac)**



> 28%

# Maximizing Living Roots

- Regular Cover Cropping
- Never living soil bare as much as possible
- Keep something growing in the soil



# What is a Cover Crop?

- Grown between cash crop cycles
- Intercropped with cash crops to cover bare ground
- Planted in the absence of a normal crop
- Grown primarily to add organic matter and nutrients to the soil

NOT HARVESTED OR PARTIALLY HARVESTED

# Purpose:

1. Erosion Control
2. Nitrogen Fixation
3. Biomass for soil health improvement
4. Supply nutrients, for example nitrogen in legumes
5. Reduce Soil Compaction
6. Weeds/Insects/Diseases Suppression
7. Habitat for beneficial organisms (birds, insects, etc.)

# General Considerations for Cover Crops

Think about:

- |                   |   |   |
|-------------------|---|---|
| Soil Conditions   | ➔ | What is the texture? Do you have high salinity? |
| Drainage          | ➔ | Do you have slow or fast-draining soil?)        |
| Rotational Period | ➔ | Does the cover crop fit into rotation?          |
| Season            | ➔ | When do I want to grow CC – winter or summer?   |
| Soil Preparation  | ➔ | Is there special soil preparation needed?       |
| Irrigation        | ➔ | Do I have enough water to raise the cover crop? |
| Termination       | ➔ | How do I terminate the cover crop?              |

# Classification of Cover Crops

Cover crops can be classified based on:

- i. The way the cover crop is used (catch crop, green manure, living mulches, etc.)
- ii. The type of crop planted (grasses, legumes, brassica, etc.)
- iii. When they are planted (summer, winter)
- iv. How long they last (Annual, Biennial, Perennial)

# Winter Cover Crops

- Planted in late summer or fall
- Provide ground cover during the late fall/winter/early spring
- Winter covers must be cold-tolerant crops
- Critical to plant on time before the temperature becomes too low
- Examples of winter hardy crops are triticale (hybrid of wheat and rye), hairy vetch, and cereal rye
- Cool season legumes include several clovers, vetches, medics, and field peas

# Warm Season Cover Crops

- Normally planted in summer as green manure
- Can provide an opportunity for crop rotation
- Improve poor soils
- Prepare land for perennial crops
- Provide nitrogen for the following winter cash crop
- Many species can be used for this purpose
- Examples of summer legumes
  - Cowpeas, Sweet clover, Sesbania, Guar, Crotalaria, Sunn Hemp, etc.

# How Cover Crops Affect the Soil

- Add Soil Organic Matter
- Breaking Soil Compaction
- Conservation of Soil Moisture
- Protection of the Soil From Water and Wind Erosion
- Supply Nitrogen/Nutrients to the Soil
- Weeds and Diseases Suppression

# Selection of Cover Crops

## Decisions to Make

- 1) What is your goal?
- 2) What cover crop options are available?
- 3) When is the seeding time?
- 4) What are the management practices?
- 5) Are there other important details to know?



# Performance in Relation to Set Goals

## Popular and Useful Choices of Cover Crops

| Crop                      | Over-winter ability | Biomass amount | Soil structure improvement | Comments   |
|---------------------------|---------------------|----------------|----------------------------|--|
| <b>Annual Ryegrass</b>    | NO                  | **             | ***                        | Overall, an easy crop to establish                                   |
| <b>Perennial Ryegrass</b> | ***                 | **             | **                         | Faster establishment than other perennials.<br>Extensive root system |
| <b>Winter Rye</b>         | ***                 | ***            | **                         | Can grow at low pH and at cool temperatures                          |
| <b>Winter Wheat</b>       | ***                 | ***            | **                         | Requires fertile soil; avoid wet or low pH soil.                     |
| <b>Sweet Clover</b>       | ***                 | ***            | **                         | Better with high pH than other clovers                               |
| <b>White Clover</b>       | ***                 | *              | **                         | Good for low pH soil, treat with inoculants                          |
| <b>Tall Fescue</b>        | ***                 | *              | **                         | Persistent, may become weed-like.                                    |
| <b>Buckwheat</b>          | NO                  | **             | *                          | Do not allow to mature, or reseeding will occur                      |

\*\*\* = Relatively High; \*\* = Moderate; \* = Relatively Low

# Cool Season Cover Crops

Late Sept – Nov (Fall planted CC) in some cases early spring

- Triticale/ wheat/ barley/ Rye
- Annual Ryegrass
- Clover
- Vetch
- Austrian Winter Peas
- Forage Radish (Tillage Radish)



# Warm Season Cover Crops:

Planted: March – July

- Cowpeas
- Lablab
- Pigeon Pea
- Buckwheat
- Pearl Millet
- Sorghum – Sudan
- Sesbania

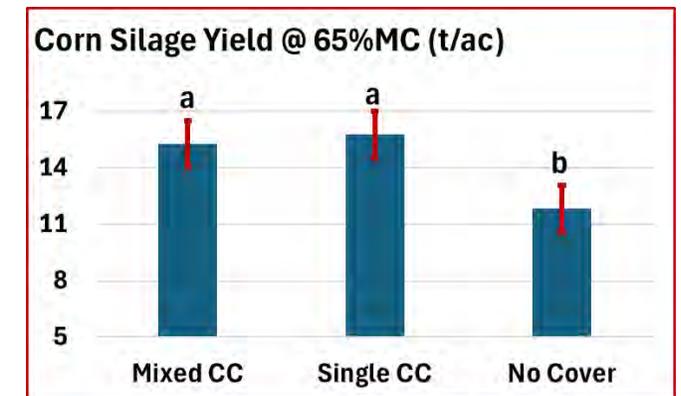
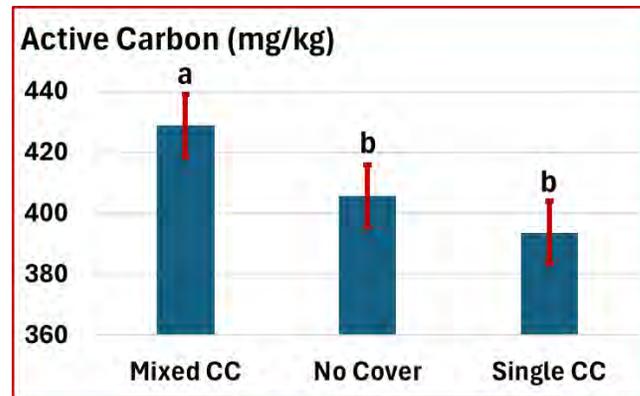
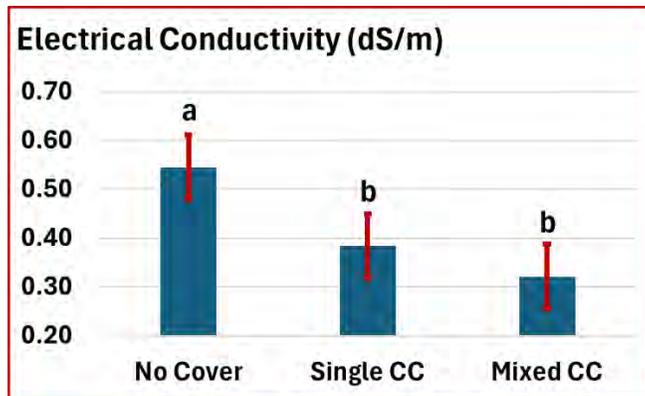
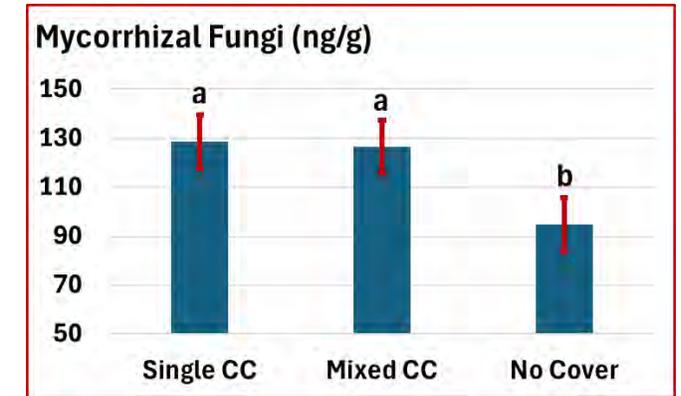
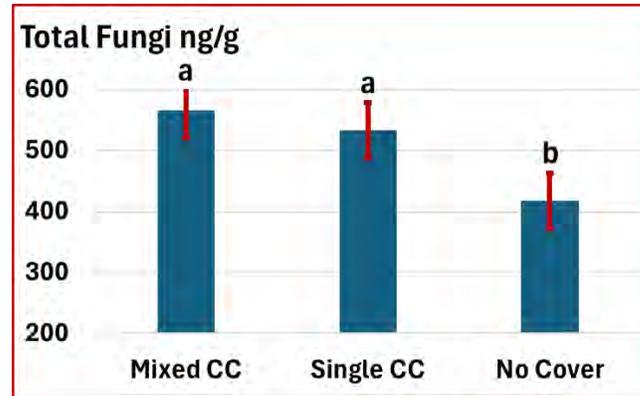
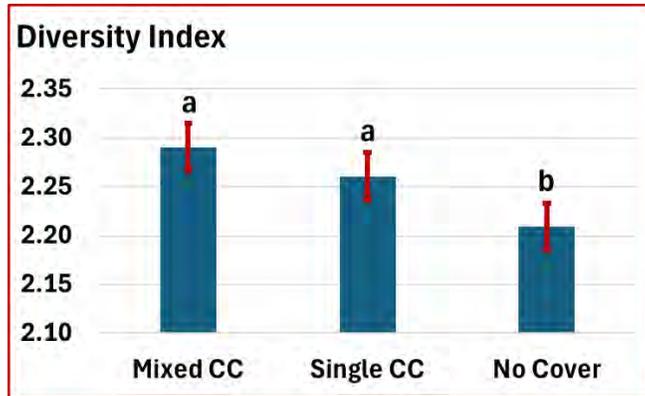


# Cover Crops and Soil Health – Long-term Soil Health Site in Las Cruces

## Results After 2 Years of Cover Crops

Single CC – Triticale;

Mixed CC – Triticale, Barley, Austrian Winter Peas, Diakon Radish



> 31%  
Yield  
Increase

# Perennial Cover Crops - Grasses

# Tall Fescue (cool season) – 20 lb./ac

- Tall Fescue (cool season) – 20 lb./ac
- Bunch grass,
- Cold-, heat-, shade-, and drought-tolerant.
- Disease tolerant
- A good soil health builder
- It has moderate to high salinity tolerance.
- Adapted to a wide range of soil conditions



# Perennial Ryegrass (cool season) – 25 lb./ac

- Bunch grass
- Cold and drought-tolerant
- Can suppress weeds
- Fast-growing
- It can struggle in hot, humid summers
- It is shade-intolerant
- Susceptible to certain fungal diseases



# Tall Wheatgrass (cool season) – 10 lb./ac

- Bunch grass,
- Cold-tolerant
- Late-maturing
- Produces high biomass yields
- Good for grazing
- Excellent seedling vigor
- Thrives in poor, high pH soils
- It is salt-tolerant



# Orchard grass (cool season) – 20 lb./ac

- Bunch grass
- Early maturing
- Moderate winter hardiness
- Moderate drought tolerance
- Good for grazing
- Palatable pasture for livestock and wildlife
- Produces high biomass when fertilized and irrigated





# Cover Crop Cocktail/Mixes

# Cover Crop Cocktails/Mixes

- Insurance against cover crop failure – if one species fail, others in the mix may survive.
  - for example, in LC, we planted 4 species (triticale, barley, AWP, radish) and 2 of them (barley and radish) failed because of irrigation problems. We still had a strong performance of two species (triticale and AWP).
- Multiple benefits from different species in the mix – you can achieve multiple goals i.e., organic matter addition, compaction alleviation, and nitrogen addition to the soil
- Enhancement of microbial diversity – different microbes associate with different crops.

# Cover Crop Chart

Google USDA Cover Crop Chart

| GROWTH CYCLE |             | PLANT ARCHITECTURE |                     | RELATIVE WATER USE |          |
|--------------|-------------|--------------------|---------------------|--------------------|----------|
| A            | = Annual    | γ                  | = Upright           | ●                  | = Low    |
| B            | = Biennial  | *                  | = Upright-Spreading | ●●                 | = Medium |
| P            | = Perennial | ≍                  | = Prostrate         | ●●●                | = High   |

| COOL      |                 |           |          | WARM   |         |     |                |           |                   |                 |              |     |               |     |              |   |           |   |               |
|-----------|-----------------|-----------|----------|--------|---------|-----|----------------|-----------|-------------------|-----------------|--------------|-----|---------------|-----|--------------|---|-----------|---|---------------|
| --GRASS-- |                 | BROADLEAF |          |        |         |     |                | --GRASS-- |                   |                 |              |     |               |     |              |   |           |   |               |
| A         | ANNUAL FESCUE   |           |          |        |         |     |                |           | A                 | BROWNTOP MILLET |              |     |               |     |              |   |           |   |               |
| A         | BARLEY          |           |          |        |         |     |                |           | A                 | FOXTAIL MILLET  |              |     |               |     |              |   |           |   |               |
|           |                 |           |          | LEGUME |         |     |                |           |                   |                 |              |     |               |     |              |   |           |   |               |
| A         | OAT             | A/B       | CAMELINA | A/P    | MUSTARD | A   | BALANSA CLOVER | A         | CHICKPEA          | A/P             | MEDIC        | A   | COWPEA        | A   | CLUSTER BEAN | A | AMARANTH  | A | PEARL MILLET  |
| A         | WHEAT           | A         | PHACELIA | A/B    | CANOLA  | A   | BERSEEM CLOVER | A         | PEA               | A               | LUPIN        | A/P | LABLAB        | A/P | JACK BEAN    | A | BUCKWHEAT | A | PROSO MILLET  |
| A/B       | ANNUAL RYEGRASS | A         | FLAX     | A      | RADISH  | A   | CRIMSON CLOVER | A         | LENTIL            | A               | FABA BEAN    | A/P | FENUGREEK     | A   | VELVET BEAN  | P | CHICORY   | A | GRAIN SORGHUM |
| A         | CEREAL RYE      | A         | KALE     | B      | TURNIP  | B/P | RED CLOVER     | A/P       | LESPEDEZA         | A/B             | SWEET CLOVER | A/P | PIGEONPEA     | A   | MUNG BEAN    | A | CUCURBITA | A | SUDAN GRASS   |
| A         | TRITICALE       | A         | SPINACH  | B      | BEET    | P   | WHITE CLOVER   | P         | BIRDSFOOT TREFOIL | P               | ALFALFA      | A   | PARTRIDGE PEA | A   | SOYBEAN      | A | SAFFLOWER | A | TEFF          |
| P         | SALINE TOLERANT | A/B       | CHARD    | A/B    | CARROT  | P   | KURA CLOVER    | A/B       | VETCH             | P               | SAINFOIN     | A   | SUNNHEMP      | A/P | PEANUT       | A | SUNFLOWER | A | CORN          |

# Limitations

- Management of cover crops is key to success
- Cost of seed and application needs to be justified
- Water consumption of cover crop growth may reduce soil moisture and harm the following cash crop
- May reduce soil temperature and cause slow growth in cooler regions
- Does nutrient value exceed the cost of cover crop production
- May harbor certain insects and disease that affect surrounding plants and vegetation



# Thanks

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