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Soil Health and Ground Cover

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Local & Immigrant Farmer Education
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Promoting the use of Cover Crop Calculator for the Tropics as Nitrogen Management Tool and the Use of Cover Crops for Soil Health Management Guideline

Natural Resources Conservation Service
High soil degradation

In 1991, UN estimated that 38% of today’s global cultivated soil (552 mil ha) had been degraded to some degree by agricultural mismanagement since WWII (Gardner, 1987; Sugden et al., 2004).

http://www.fao.org/landandwater/agll/glasod/glasodmaps.jsp
Definition of Soil Health

- A simple definition of soil health is *the capacity of a soil to function*. How well is your soil functioning to infiltrate water and cycle nutrients to support growing plants? (NRCS, 2013)

- The capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Doran, 1996).
**Benefits of a healthy soil?**

1. Healthy soil holds more water
   - Organic matter holds 18-20 times its weight in water
   - 1% of organic matter in the top six inches of soil would hold ~ 27,000 gallons of water per acre!

2. Organic matter builds as tillage declines and plants and residue cover the soil.

3. Healthy soil recycles nutrients for plants to use.

The process of improving soil health is slow:
- Most farmers can increase their soil organic matter in 3 to 10 years if they are motivated about adopting conservation practices.
- Finding good soil health indicators would provide more incentive.
Healthy Soils are porous, allowing air and water to move freely, thus ensuring a suitable habitat for the myriad of soil organisms.

Increasing soil organic matter is critical to sustain soil functions.
Characteristics of a Healthy Soil

- High biological diversity
- Stability to disturbance or stress
- Maintenance of soil nutrient cycling
- Suppression of multiple pests and pathogens
- Improvement of plant health
Nematodes as Soil Health Indicators

Bacterivore  Fungivore  Herbivore  Omnivore  Predator

Free-living nematodes
Nematodes and Soil Nutrient Cycling

Detrital N, P

Inorganic N, P

Fungal N, P

Bacterial N, P

Plant N, P

Fungal-feeding Nematode

Bacterial-feeding Nematode

Omnivorous and Predatory Nematode

(modified from Ingham et al., 1985)
Benefits of Cover Cropping

1. Reduce fertilizer costs
2. Add organic matter
3. Improve yields by enhancing soil health
4. Reduce the need for herbicides and other pesticides (nematicide)
5. Prevent soil erosion
6. Conserve soil moisture
7. Protect water quality
8. Help safeguard personal health
9. Some cover crops offer harvest possibilities as forage, grazing or seed in multiple crop enterprises.
1. Cut Fertilizer Costs

1. Leguminous CC contributing N to cash crops
   - 30-60% of N that the legume produced can be available for the subsequent cash crop
   - We are developing cover crop calculator for different soil and farming systems in Hawaii
Non-Leguminous Cover Crop

Scavenging and mining soil nutrients

• Rye can took up 70 lb N/A when planted soon after last crop.
• Deep-rooted cover crops (such as oil radish) draw Ca and K that leach down the soil profile to upper soil surface.
• Although P doesn’t leach, it is not readily available for plant to uptake. Cover crops such as buckwheat and lupins, secrete acids into soil that put P into a more soluble form for plant to uptake.
• Cover crops could also enhance plant P uptake by hosting mycorrhizae fungi.
2. Adding Soil Organic Matter

- Soil organic matter contributes to improve soil structure, increase infiltration and water holding capacity, increase cation exchange capacity (help soil to store nutrients).
- Two portions of soil organic matter:
  - Active fraction -- rich in simple sugars, proteins, fresh residues, microbial cells (responsible for the release of most N, P, K from organic matter) – annual legumes
  - Stable fraction – rich in celluloses and lignins, tougher to break down, contribute to humus (responsible for real soil organic matter, dark content, water holding capacity, cation exchange capacity or CEC) – grassy covers and perennial legumes
How does cover crop improve soil structure?

- Leguminous cover crops enhance bacteria in the soil. **Bacteria** produced polysaccharides that ‘glue’ soil particle together.
- Grasses have a ‘fibrous’ root system that help aggregate the soil between roots.
- Most plant roots develop mutualistic relationships with mycorrhizae fungi that produce **glomalin**, which glues together organic matter, plant cells, bacteria and other fungi.
- Cover crops with deep roots (sorghum-sudangrass, rapeseed, yellow sweetclover) break up compacted soil.
5. Prevent soil erosion

- Cover crops reduce soil erosion by stabilizing field roads, inter-row areas, and borders when soil is wet.

- Topsoil is the most fertile portion of a field (contain the highest % of organic matter and nutrients.
6. Conserve Soil Moisture

- Organic **surface mulch** provided by cover crops increase water infiltration and reduces evaporation.

- Water-efficient legumes: lablab, pigeonpea, sunn hemp, jack bean in dryland areas.

Pigeonpea (*Cajanus cajan*)
How to manage cover crops profitably?

1. Undersown close to cash crop termination
2. Intercropping cover crops along with cash crop

3. Strip-till cover crop – extend the benefits of cover crop
4. Plant in section of your farm that is harden and nutrient depleted from long-term cropping.
5. Mix cover cropping
6. Row switching between cover crop and cash crop rows
7. Field borders, hedgerows/shrubs

Reducing time of no production

Attract natural enemies of insect pests/pollinators
1. Undersown close to crop termination

- Shade tolerant cover crops: white clover, rye, hairy vetch, crimson clover, red clover, sweet clover.

- Small seeded CC (clovers) don’t need a lot of moisture to germinate, while larger-seed CC need several days of moist condition to germinate.

Oil radish planted close to die back of corn
2. Intercropping cover crops along with cash crop = living mulch

- Plant some low but fast growing cover crops (buckwheat, millet, cowpea) throughout the field for one month.
- Strip-till alternate rows of cover crop to plant in cash crop.

Buckwheat & zucchini
3. **Row switching**

- Switch the cover crop rows the next year.
- Mow or clip the cover crop strip periodically and use as surface mulch for the cash crop rows.

I can not benefit from green manure if I plant cover crop as intercrop.
Strip-till Cover Cropping with sunn hemp (*Crotalaria juncea*)
Evaluation by Bioindicators
Good bugs from Burlese Funnels

These soil microarthropods also play important roles in breaking down soil organic matter. Cover crop treatments increased soil microarthropods as compared to the control.
Sunn hemp might have served as a trap crop for thrips and whiteflies to locate cucumber crop, thus reduce these insect pests from the crop.
Plant a biennial cover crop such as yellow sweetclover with a deep taproot and give plenty above ground biomass.

This allow tremendous soil improving benefits when allow to grow for years.

Yellow sweetclover is a legume, fixes N, and last for two years.

Deep taproot also bring up minerals from the subsoil.
6. Mix planting legume and grain cover crops

Sunn hemp and oat
(TAMU406)
A FARMER’S FAVORITE COCKTAIL
MAY NOT BE WHAT YOU THINK.

INNOVATIVE FARMERS ARE BREATHING NEW LIFE INTO THEIR SOIL BY SEEDING A “COCKTAIL MIX” OF 6-12 PLANTS TO GET DIVERSITY ABOVE-GROUND, WHICH CREATES MUCH-NEEDED DIVERSITY BELOW THE GROUND. THROUGH THAT DIVERSITY, FARMERS ARE MIMICKING THE SOIL-BUILDING AND MICROBIAL-FRIENDLY CONDITIONS OF THE DIVERSE NATIVE PRAIRIES.

WANT MORE SOIL SECRETS?

CHECK OUT
WWW.NRCS.USDA.GOV
How to select cover crops to fit your needs? (effects on organic matter)

- **Annual legumes**: Produce plant materials that are succulent and rich in proteins and sugars – leave little long-term organic matter.

- **Grain and grasses, non-legumes**: Produce plant materials that are woodier or more fibrous – promote more stable organic matter (humus), increase soil structure, CEC, but might tie up nutrients temporarily.

- **Perennial legumes** such as perennial peanut, white clover or sunn hemp (if let sunn hemp grown for months) may fall in both categories – leaves will break down quickly, but stems and root systems can contribute to humus accumulation.

Crimson clover
*Trifolium incarnatum*

*Oat*
*Avena sativa*

*White clover*
*Trifolium repens*
**Reference Links**

- Soil slake and soil infiltration test
  
  
  [http://www.youtube.com/watch?v=Rpl09XP_f-w](http://www.youtube.com/watch?v=Rpl09XP_f-w)
  
  [http://www.youtube.com/watch?v=9_ItEhCrLoQ](http://www.youtube.com/watch?v=9_ItEhCrLoQ)

- Insectary plants and other Sustainable Pest Management approaches:
  

- Cover crop:
  
  [http://www.ctahr.hawaii.edu/WangKH/cover-crop.html](http://www.ctahr.hawaii.edu/WangKH/cover-crop.html)

- CRATE website:
  
  [http://www.ctahr.hawaii.edu/WangKH/CRATE.html](http://www.ctahr.hawaii.edu/WangKH/CRATE.html)
Questions?