Soil Health: Balancing Benefits and Challenges

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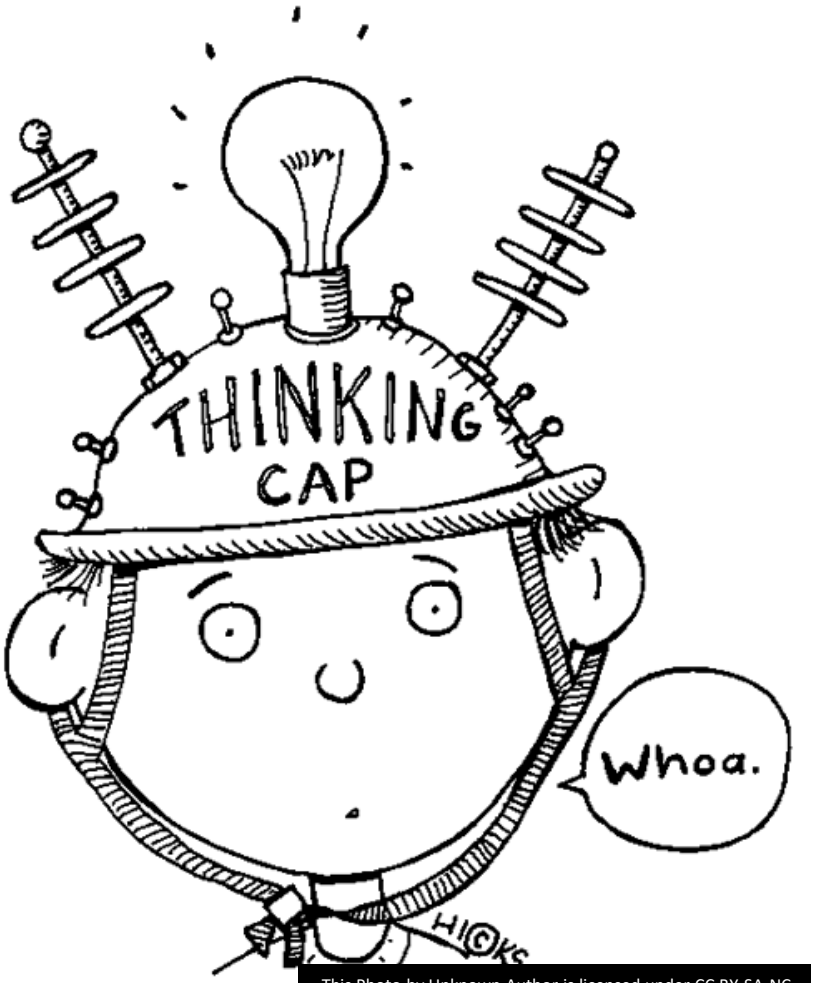
POLL

How many producers have you worked with that have used these as arguments to not improve soil health?:

- It costs too much
- Yields will decrease
- Don’t want any extra weeds in my field
- Uses too much water
- Mixes are too complicated

How do we change the way producers think about their soil?



Source: hammer.org

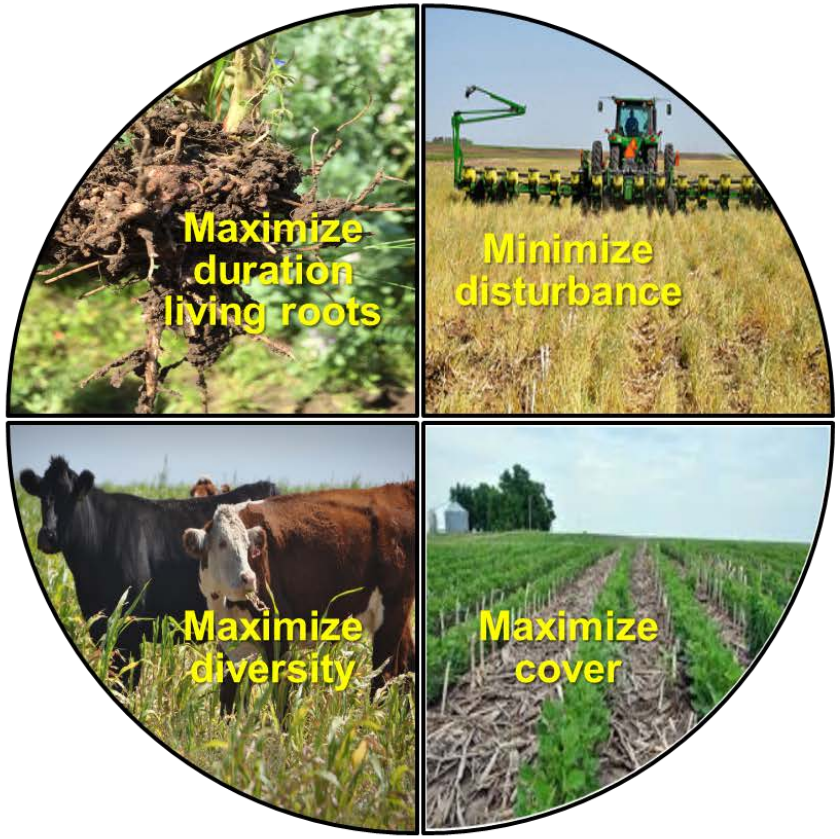
Goals

At the end of this lesson you will be able to:

- Determine and evaluate benefits and challenges of improving soil health
  - Economic impacts
  - Reduced risk
  - Increased production efficiencies
  - More resilient soils
- Discuss these issues with your producers to encourage adoption of soil health practices

Soil Function & Soil Health Benefits

- Reduced Erosion
- Increased Soil Organic Matter
- Increased Nutrient Cycling
- Increased Drought Resilience
- Improved Filtering and Buffering
- Reduced Pest and Disease incidence



Benefits Of Heathy Soil

- Benefits of Healthy Soils
  - Higher Soil Organic Matter
  - Increased nutrient cycling
  - More available water
- Economic Results
  - Increased land values
  - Reduced risk
  - Higher profits

How much is soil worth?

Economic impacts of NOT building Soil Health

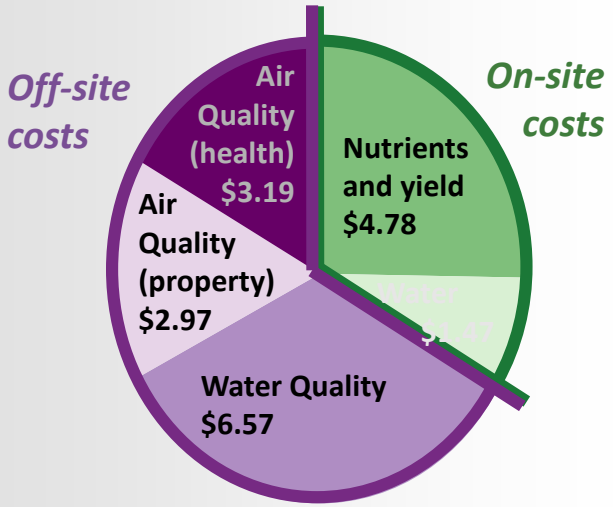
Water & wind erosion at 7.6 t/ac/yr costs:

- $40/acre/year to replace lost fertilizer nutrients
- ~ $17/acre/year to pump well irrigation water to replace lost soil and soil water holding capacity
- Total cost of soil and water lost annually from U.S. cropland amounts to on-site productivity loss of **> $27 billion/year**
- World-wide costs are more than **$400 billion/year**

Erosion costs on one field

Degrades organic matter levels and other fines first

Affects soil, air & water quality *AND THE BOTTOM LINE $$$*



$19 per ton soil

Soil Quality Inst., 2003

Value of Ton of Topsoil

- Most Biological activity occurs in top 3 inches.
- One million pounds or 500 ton of topsoil in top 3 inches.
- Average Value of Cropland = $10,000/Acre
- Soil Productivity Value: $5,000/500 = $10/Ton
- Soil Lost at T value = 4-5 ton/acre
- Lost value per acre = $10/ton soil loss * 4-5 tons
- Losing $40 to $50 per acre

Value of Soil Organic Matter

Assumptions: 2,000,000 pounds soil in top 6 inches
1% organic matter = 20,000#

Nutrients:

Nitrogen: 1000# * $0.50/#N = $500
Phosphorous: 100# * $0.70/#P = $ 70
Potassium: 100# * $0.50/#K = $ 50
Sulfur: 100# * $0.50/#S = $ 50
Carbon: 10,000# or 5 ton * $?/Ton = $ 0

Value of 1% SOM Nutrients/Acre = $670

Original Jim Kinsella/Terry Taylor(2006)/revised Jim Hoorman (2011)

What does it take to convince a farmer?

- Reduce inputs
- Increase Production
- Combination of both

Three Questions:

? Soil Organic Matter: what's it worth?

? Improve nutrient cycling: is it believable?

? Increase water efficiency: can it be done?

Question

When discussing the benefits of improving soil, should it all be in monetary terms?

a. Yes

b. No

Soil Health Increases N Efficiency

Nitrogen Efficiency:

- Conventional: 30-50%
- Cover Crop & No-till: Goal is to Increase to 80%+

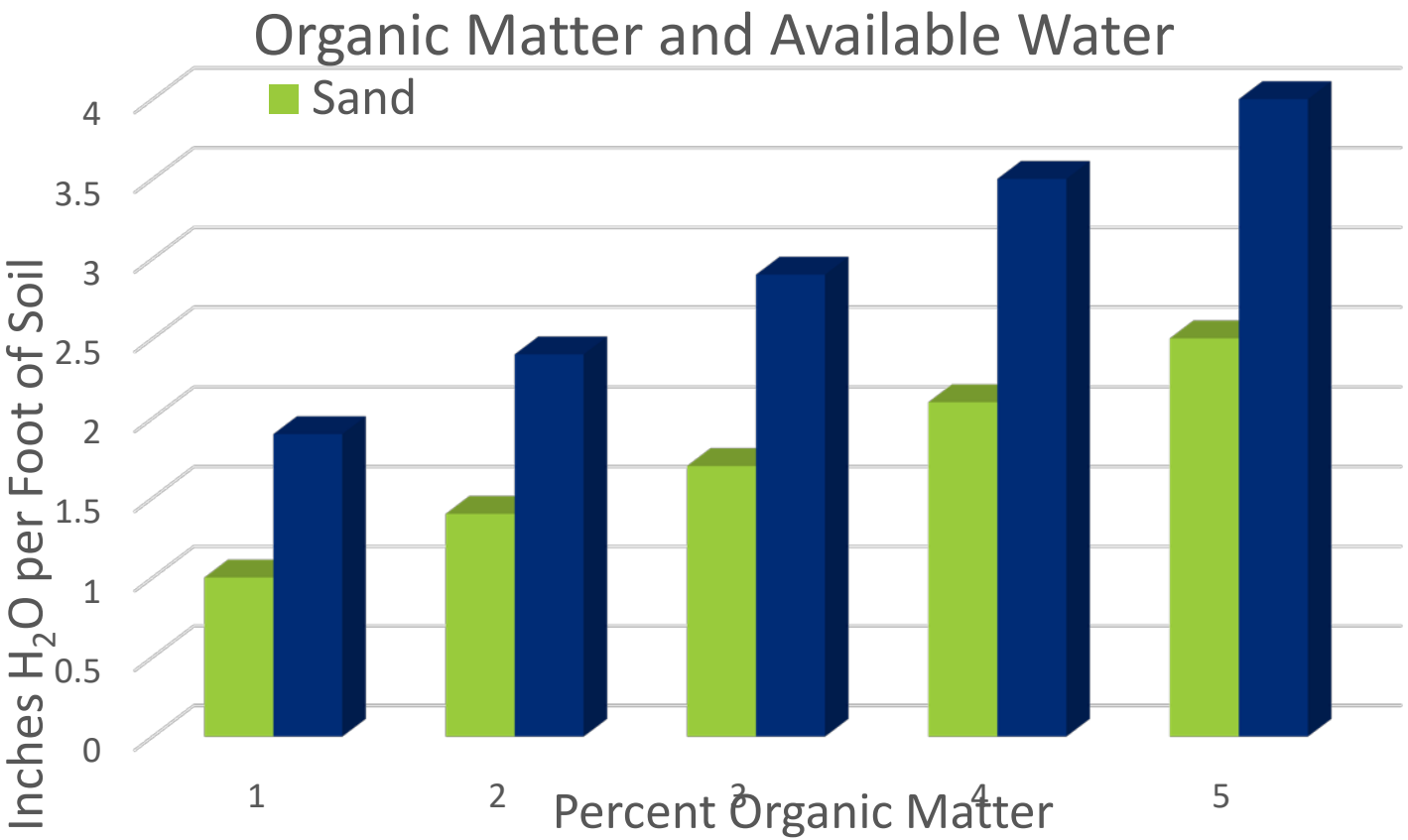
Phosphorus Efficiency:

- Conventional: 10-50%
- Cover Crop & No-till: Goal is to Increase to 80%+

Healthy Soils are FERITILE Soils


healthy soil is bio-powered...
Natural biological processes in the soil are responsible for about 60% of the available nitrogen and 50% of the available phosphorus in soil.
did you know?
Many nutrients taken up by plant roots are first cycled through a soil organism before becoming available to the plant.
We're learning that the soil/plant interchange of nutrients and water is far more dynamic and elegant than we had ever imagined.
unlock the SECRETS IN THE SOIL

SOM & Available H_2O Capacity/Foot Soil



Hudson, 1994

Soil Health Impact on Reducing Weeds

- Farmers promote weed seed production by tilling the soil and burying the seed.
- Ways to fight weed
  - Hoe or pull them out
  - Kill with herbicides
  - **Compete for sunlight and nutrients by growing cover crops to reduce weed seed production.**
- Mycorrhizae fungi reduce weed pressure in healthy soils by keeping plants healthy and growing faster.

Rinaudo, 2010; Vatover et al. 2005; Atierie et al, 2005; Jordan and Heuerd, 2001


the green mile...
separate strands
of mycorrhizal fungi
can total more than
1 mile
in just a handful
of healthy soil.
did you know?
Arbuscular mycorrhizal fungi (abundant in healthy soils) have a symbiotic relationship with many plants.
They attach themselves either on or inside plant roots to tap into the carbohydrates transported from the plant leaves. In turn, the fungal hyphae (filaments) grow out from the roots and bring water and soil nutrients back to the plant.
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SECRETS
IN THE SOIL

Spring 2008 Weed Suppression

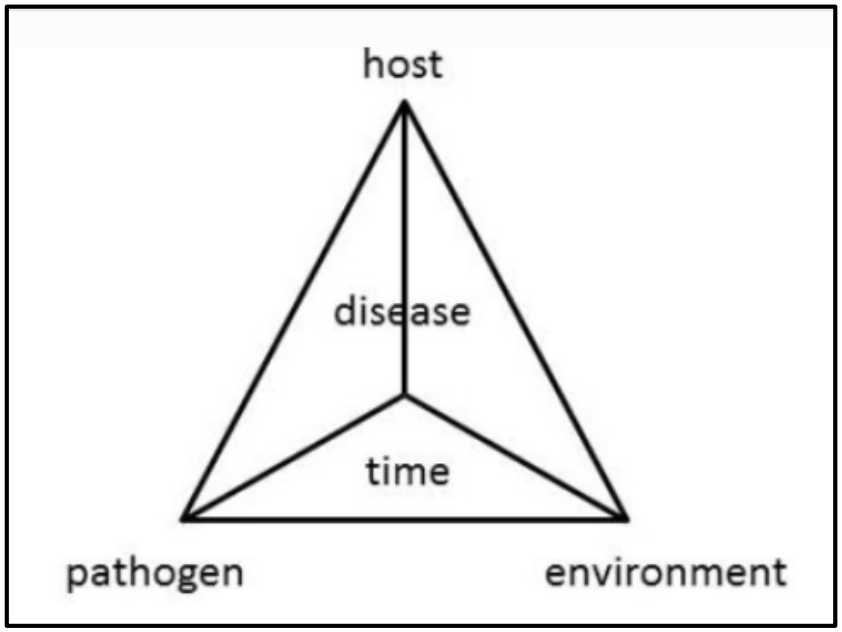
Long term no-tillers who use cover crops report cutting herbicide costs

by 33%

Effects of cover crops on Disease

- Improved water infiltration
- Reduced compaction
- Improved soil structure

Lead to better drainage: which improves the soil environment for less disease incidence and higher number of predators of disease carrying insects.



Soil Health Mechanisms for increased resistance/tolerance to soil born diseases

- Increased nutrient uptake → More vigorous plants
- Competitive exclusion of pathogens
- Changes in root exudation
- Enhanced P uptake may inhibit spore germination/infection
- Microbial shifts that enhance soil health
- Lignification of root cells that limit pathogen penetration.

E. Barrios, 2007. Soil biota, ecosystem services, and land productivity. Ecological Economics 64. Science Direct.com

Disease Soil Ecology Research

Conclusions:

"Soil borne diseases are most damaging when soil conditions are poor as a result of inadequate drainage, poor soil structure, low SOM, low soil fertility, and high soil compaction."

G.S. Abawi, T.L. Widmer, 2000. Impact of soil health management practices on soil borne pathogens, nematodes, and root diseases of vegetable crops. Applied Soil Ecology.

Reduce Compaction

- Deep ripping may cost $30+/ac
- Deep rooted and/or fibrous rooted cover crops break up compaction
  - Annual Ryegrass $17/ac.
  - Rapeseed $8/ac.
  - Sunn Hemp $26.80
- Advantage of deep roots

  vs tillage??? Increase SOM

Cover Crop Water Quality Benefits

- Reduces nutrient and pesticide runoff by 50% or more.
- Decreases Soil Erosion by 90%
- Reduces Sediment Loading by 75%
- Reduces Pathogen Loading by 60%
- May decrease flooding potential by increasing water infiltration

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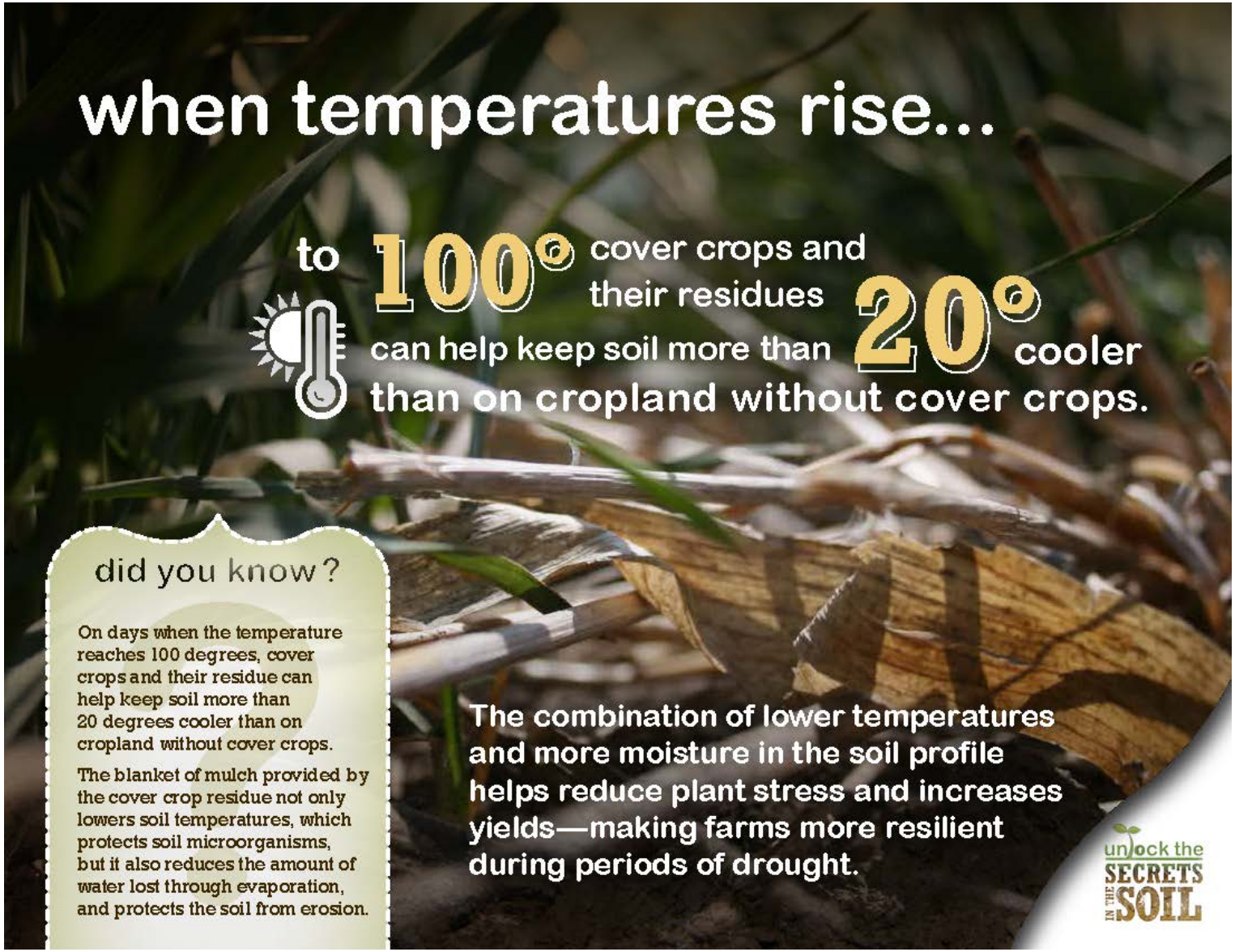
Cover Crop Benefits: Climate

- **Soil temperature is *cooler* under cover!**
  - Increase pest resistance
  - Increase crop resiliency to extreme climate shifts
    - Drought
    - Heavy rainfall events
    - Hotter temperatures
  - Increase soil moisture
  - Protect soil organisms


when temperatures rise...
to 100° cover crops and their residues can help keep soil more than 20° cooler than on cropland without cover crops.
did you know?
On days when the temperature reaches 100 degrees, cover crops and their residue can help keep soil more than 20 degrees cooler than on cropland without cover crops.
The blanket of mulch provided by the cover crop residue not only lowers soil temperatures, which protects soil microorganisms, but it also reduces the amount of water lost through evaporation, and protects the soil from erosion.
The combination of lower temperatures and more moisture in the soil profile helps reduce plant stress and increases yields—making farms more resilient during periods of drought.
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Summary

- Soil health practices are essential
  - Reduced/No-till
  - Cover crops or live plants/roots
  - Conservation cover
- Farmers can reduce their input costs by planting cover crops.
- How we manage the soil impacts soil temperature, water storage, & crop yields.
- Soil health also impacts weeds, insects, diseases, weather and climate.

What's next for PIA?

Soil Health in PIA: Challenges

- BUT…"PIA is different"
  - Year round growing season
  - Unique tropical and volcanic soils
  - Limitations on seed sources
  - Limited to approved varieties
  - Pest pressure
  - Cost of equipment
  - Others?

Soil Health in PIA: Accomplishments

- Soil Health training for NRCS and partners
- PMC cover crop trials
- Revive PIA Soil Health Team
- Collaborate with partners to conduct soil health workshops and field days
- Work directly with farmers and ranchers to promote soil health practices

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www.pia.nrcs.usda.gov

Soil Health in PIA: Partnerships

- UH-Manoa, CTAHR, HARC, Oahu RC&D, PREL
- Soil Health training for NRCS and partners
- PMC cover crop trials
- Revive PIA Soil Health Team
- Collaborate with partners to conduct soil health workshops and field days
- Work directly with farmers and ranchers to promote soil health practices

Soil Health in PIA: Future Directions

- Collaboration is KEY!
- Conduct soil workshops & outreach events
- Promote soil health practices
- Share success stories – and challenges
- TEAMWORK!

Questions?