Managing Soil Microbial Communities and Functionality in Your Orchard

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THANK YOU!

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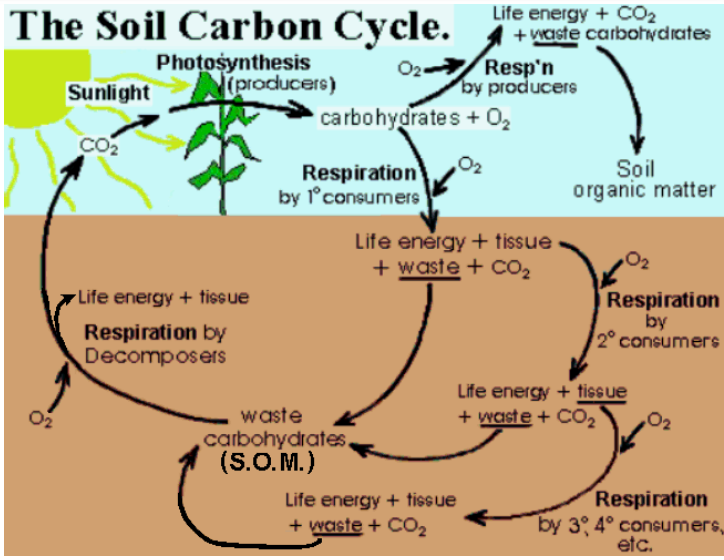
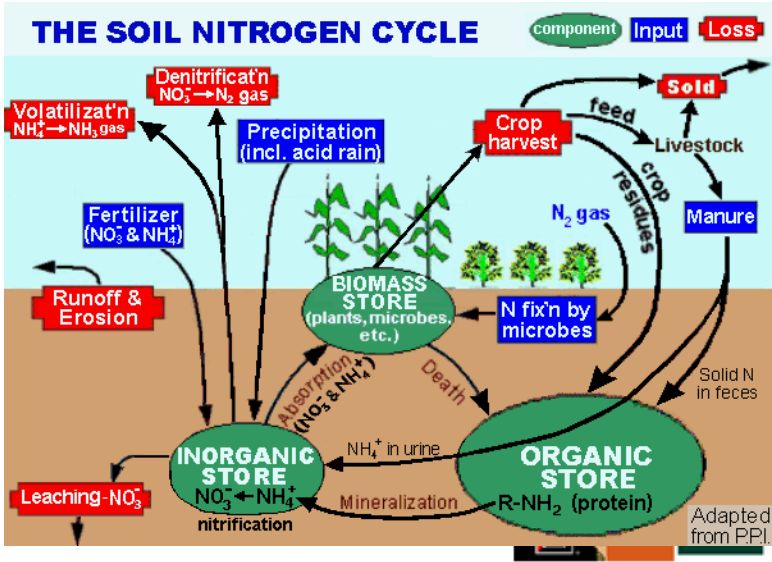
Overview



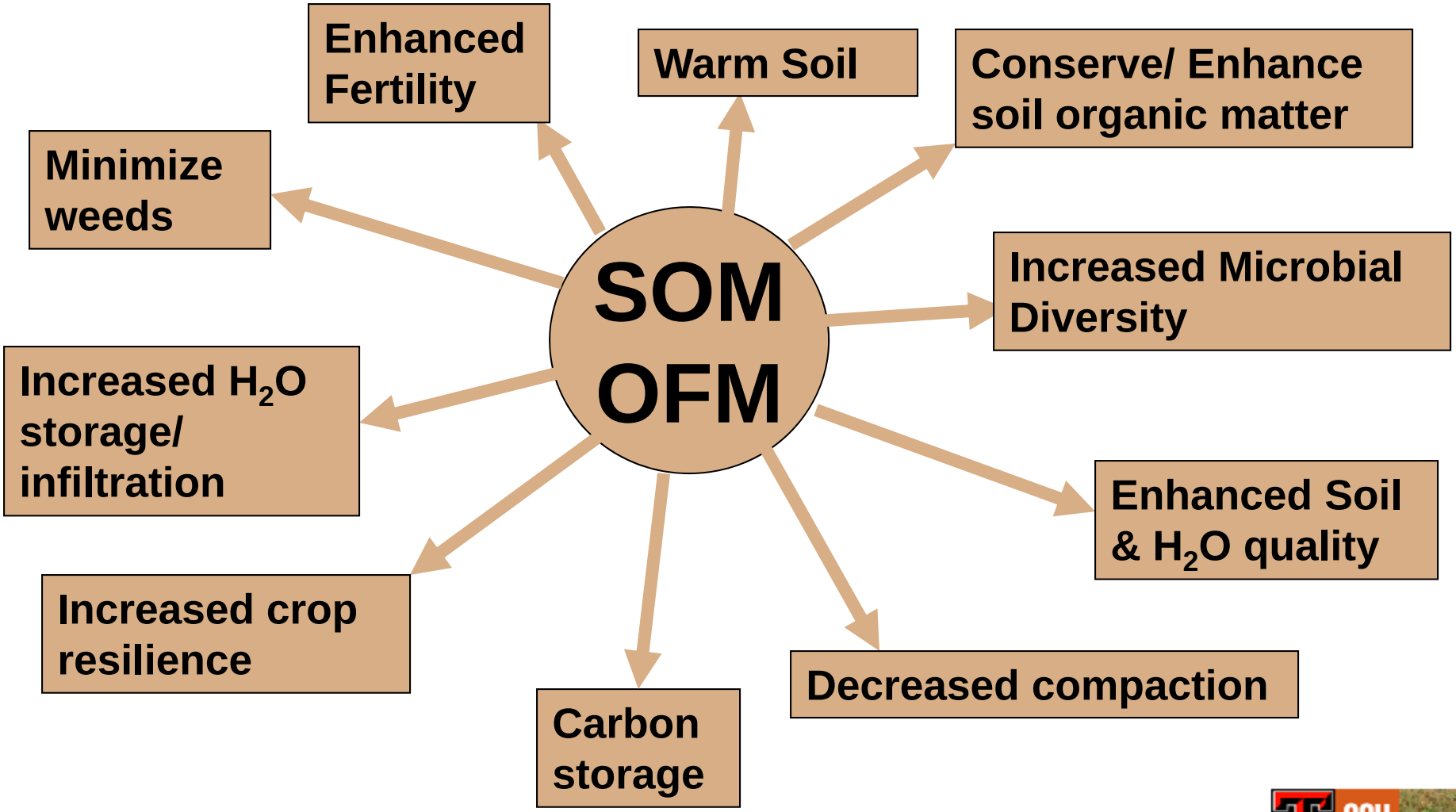

- Why are soil (micro-)organisms important in orchard systems?
- Orchard Floor Management is key
- Strategies to enhance microbial functioning
- Future directions





Microbe pics: www.nrel.colostate.edu/projects/glide16
Soil cycle pics: http://nsac.ca/pas/staff/cmi/soil3001/c_cycle.htm

Orchard Floor Management Objectives ≈ SOM Management



Soil Biological Indicators of Enhanced Nutrient Cycling

- Particulate Organic Matter…POM
- Soil Microbial Community Composition
- Potentially Mineralizable Nitrogen (Organic N → Inorganic N)
- Soil Enzyme Activities

Managing for Soil Health must begin by changing the way you think about Soil.

Soil Organisms

Soil Organic Matter

OFM Management









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Soil Organisms

Soil Organic Matter

OFM Management

OFM Strategies (not comprehensive)

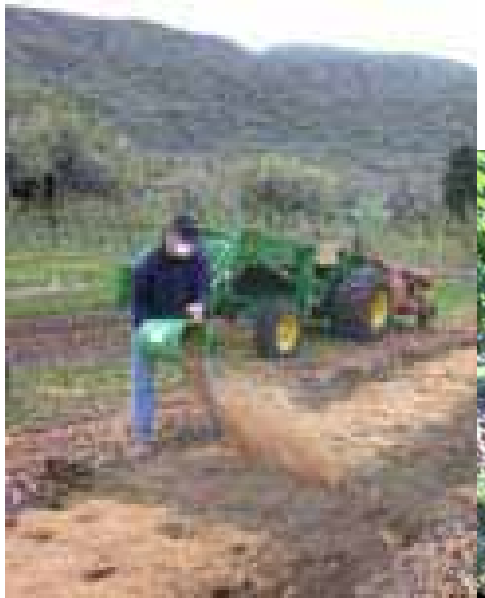
OFM Strategy	PROS	CONS
Herbicide strip	↑ Weed control ↔ disturbance to roots, irrigation	↔ soil organic matter (SOM) ↑↓ Organic herbicides effectiveness, ↑ cost; multiple apps
Cultivation	↑ Weed control; ↓ cost	↑ Tree/ irrigation damage; ↓ SOM
Organic Mulches	↑ SOM, Microbes, Nutrient cycling; ↑ water conservation & soil temps	↓ Weed control; ↑ cost (transportation) ↓ soil N, Ca; ↑ rodents
Landscape cloth	↑ Weed control; ↓ evaporation	↔ ↓ SOM; ↑ cost ↑ maintenance
Biodegradable films	↑ Weed control; Degradable; ↓ evaporation	↔ ↓ soil organic matter (SOM); ↑ cost ↑ maintenance
'Living' mulches	↑ SOM, Microbes, Nutrient cycling (N?);↑ water conservation	↑ competition for water & nutrients;↑ rodents
Combinations	↑ SOM; ↑ Weed control	? Costs?

TRADEOFFS

Managing for Soil Health must begin by changing the way you think about Soil.

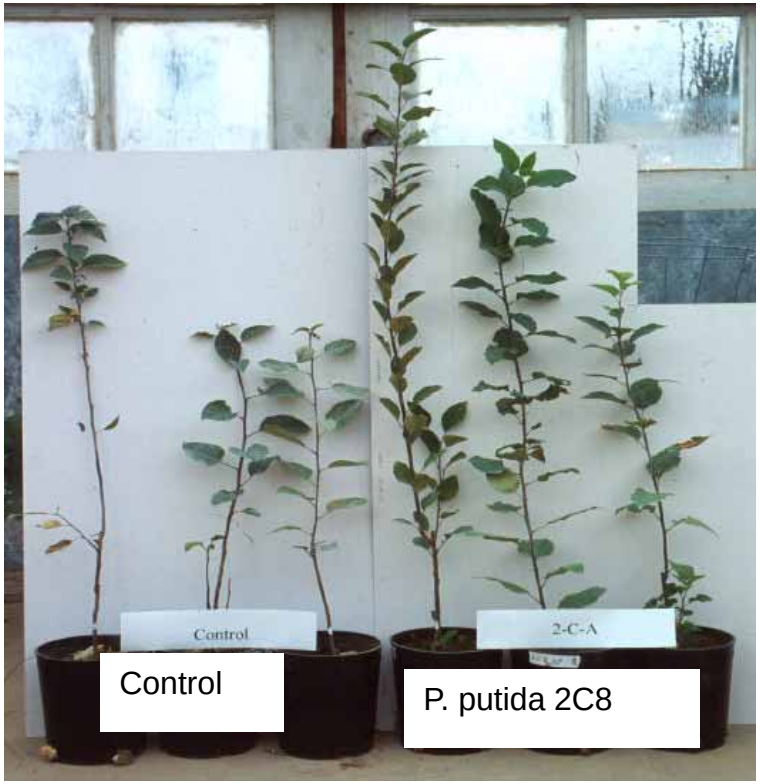
Goal: Pathogen resistance (ARD)

- Fumigate
- Add microbes
- Phyto-management
- Add organic materials



Photos courtesy of David Granatstein and Mark Mazzola

Inundation Effects Only Last So Long (and not so consistently)



Recovery of Specific Microorganisms from Cameo/M.26Grown at WVC-Sunnyslope

Treatment	#*P. penetrans*/g	% *Pythium* root infection
Control	121	27.5
B. napus Seed meal	18	9.3
MeBr	4	6.2

Figures courtesy of Mark Mazzola

Previous research in OFM

- At OSU: compost + herbicide → ↑ SOM, inorganic N, P, and K vs. compost + cultivated.
- At Cornell & WSU: bark mulch ↑ soil quality and tree performance (in established orchard).
- Landscape cloth:

  In BC: ↑ soil [illegible] weeds ↑ tree vigor and yield ([illegible] et al. 2003).

  In [illegible]: ↑ Fruit yield ↑ leaf N BUT ↓leaf P, Ca, and Mg (Yin et al. 2007). ↑ yield earlier & maintained higher yields, ↑ economic return (Tomashini et al. 2007)
- At MSU: Effect of OFM was rootstock dependent!

TRADEOFFS

Mulch Trial results

8-yr ‘Gala’/M.26 – Wenatchee, WA

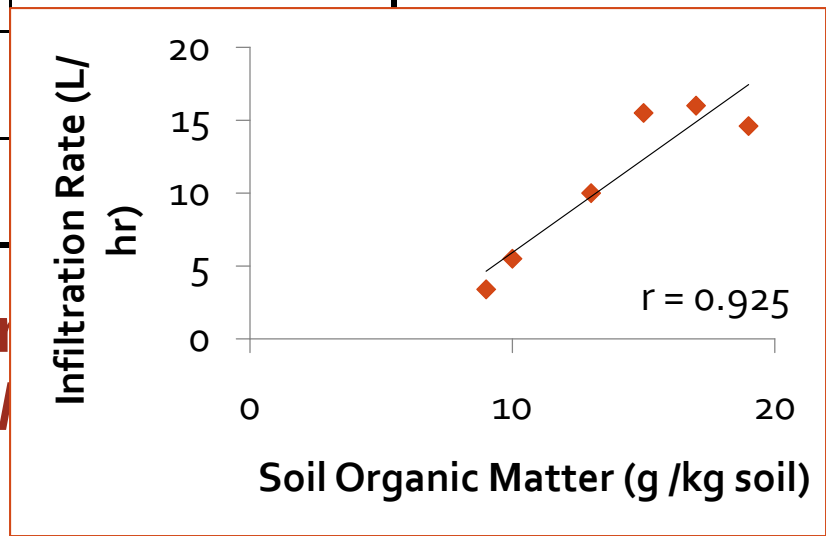
TRT	2005			2006				
	Fruit yield	Fruit Size 80-88	Gross Fruit Value*	Fruit Yield	Fruit Size 80-88	Gross Fruit Value*	TCSA increase	Canopy volume
	kg/tree	%	$/ha	kg/tree	%	$/ha	cm^2	m^3 /5 trees
Wood chip	22.4	15.5 a	35,454	14.7	39.0	27,249	3.7 a	56.7 a
Control mow	20.4	6.6 b	29,647	14.3	33.5	24,077	3.0 b	47.6 ab
Cultivator Z 3x	17.6	7.0 b	23,603	13.3	22.0	25,100	2.3 c	39.2 b
p=	0.150	0.014		0.805	0.076		0.001	0.008

Slide courtesy of David Granatstein

Soil Organic Matter Change

Treatment	Soil C (g/kg soil)	Infiltration (L/hr)
Herb. Strip (check)	10 d	5.5 cd
Biosolids	19 a	14.6 ab
Shredded Paper Mulch	13 cd	10.0 bc
Alfalfa Mulch	15 bc	15.5 ab
SPM + Biosolids	17 ab	
Black Plastic Mulch	9 d	

7-yr study, Summerland, BC; sa
loam soil, high density 'Spartan'/



Slide courtesy of David Granatstein

OFM Research at OSU 2005-2007

Cloth vs. Organic Amendments

Bark Mulch
Leaf Compost

Landscape Cloth

Living Mulch

Wheat Straw Mulch

Living Mulch

Herbicide Strip vs.Org. Amendments

Wheat Straw Mulch

Herbicide Strip

Alfalfa Straw Mulch

Site characteristics

CLOTH VS. ORGANIC MULCH

Corvallis site:

- Regina/ G6 2005
- Single line drip
- High SOM (4%)
- Silty clay loam
- Avg ppt. 104 cm
- Bark June 05, 06, Leaf Oct 06

HR site:

- Regina/ G6 2005
- Single line drip
- High SOM (3%)
- Sandy loam
- Avg ppt. 76 cm
- Straw mulch Jun 05, 06

HERBICIDE VS. ORGANIC MULCH

Alfalfa site:

- Sweetheart/ Mazzard 1999
- Micro-sprinklers
- Silt loam
- Avg ppt. (37 cm)
- Wheat Aug 05, Alfalfa Jun 07

- Wheat site:
  - Tieton/G6 2004
  - Micro-sprinklers
  - Loam
  - Avg ppt. (37 cm)
  - Wheat Nov 2005 (reseeded)

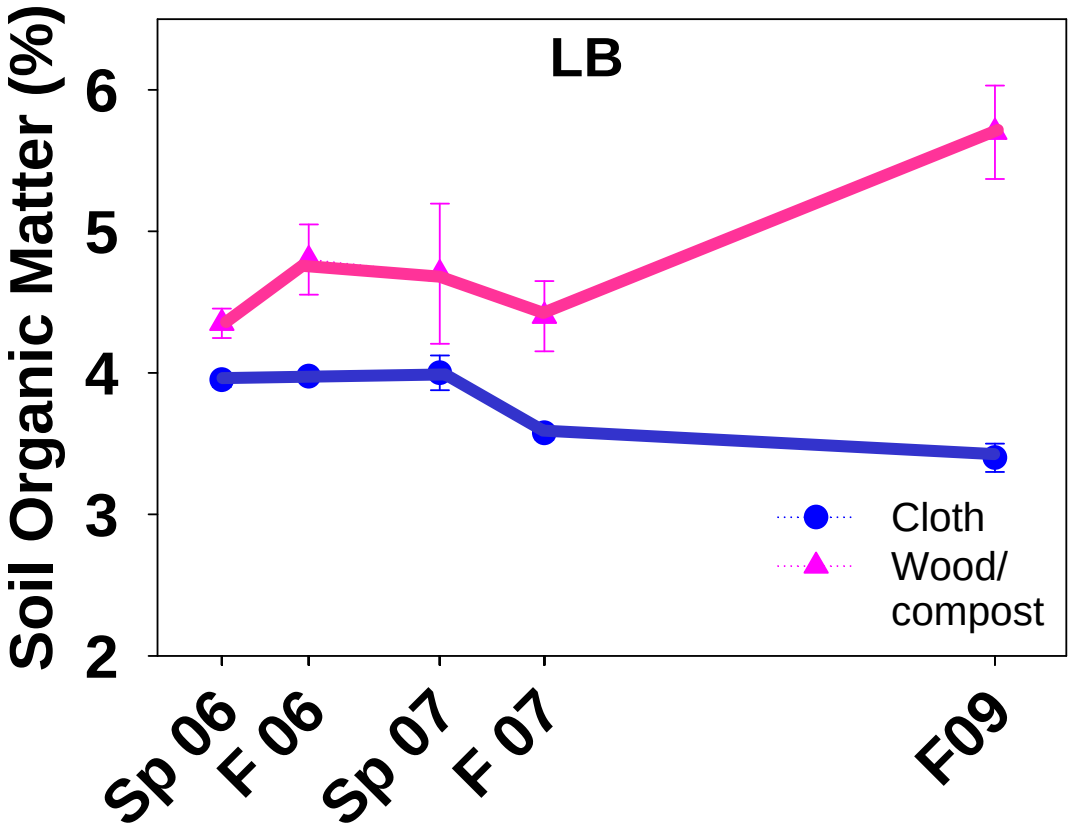
Soils: 0-6 in collected in October 2007; Leaves collected in Aug 2007

Effect of OFM on Soil Chem. Props

Soil Property	Bark Mulch Compost + Cultivation	Wheat Straw + Cultivation	Wheat Straw + Herbicide	Alfalfa Straw + Herbicide
SOM	↑(4.0% to 4.6%)	↔	↑ (2.0 - 2.7%)	↔
POM-C	**↑ (> 300%)**	↑ (39%)	↔	↑ (33%)
Soil inorganic N	↓ (49%)	↑ (11.5%)	↑ (27%)	↑ (42%)
N mineralization	↑ (25%)	↑ (21%)	↑ (48%)	↑ (22%)
Soil P	↑ (19%)	↔	↔	↓ (25%)
Soil K	↔	↔	↑ (40.6%)	↑ (60%)
Soil Ca	↓ (14.5%)	↔	↔	↔
Soil Mg	↓ (15%)	↔	↔	↔
Soil Mn	↑ (47%)	↔	↑ (11%)	↔
Soil Zn	↑ (27%)	↓ (32%)	↑(32%)	↔
Soil B	↑ (39%)	↓ (20%)	↔	↑ (13%)
Soil Cu	↓ (12.5%)	↔	↑ (37%)	↔
Soil sulfate	↓ (30%)	↔ (9%)	↔	↔

Initial SOM = 4.0%
SOM increased 10% in Sp 2006, 15% after leaf compost in Fall 2007 and 42.5% in Fall 2009 (last app was April 2009)

Bark mulch in Jun 05 & 06
Leaf compost Oct 06 & 07 & April 2009



Initial SOM = 4.0%
SOM held steady from 2005 to Sp 2007 but declined 11% in Fall 2007 and 15% in Fall 2009

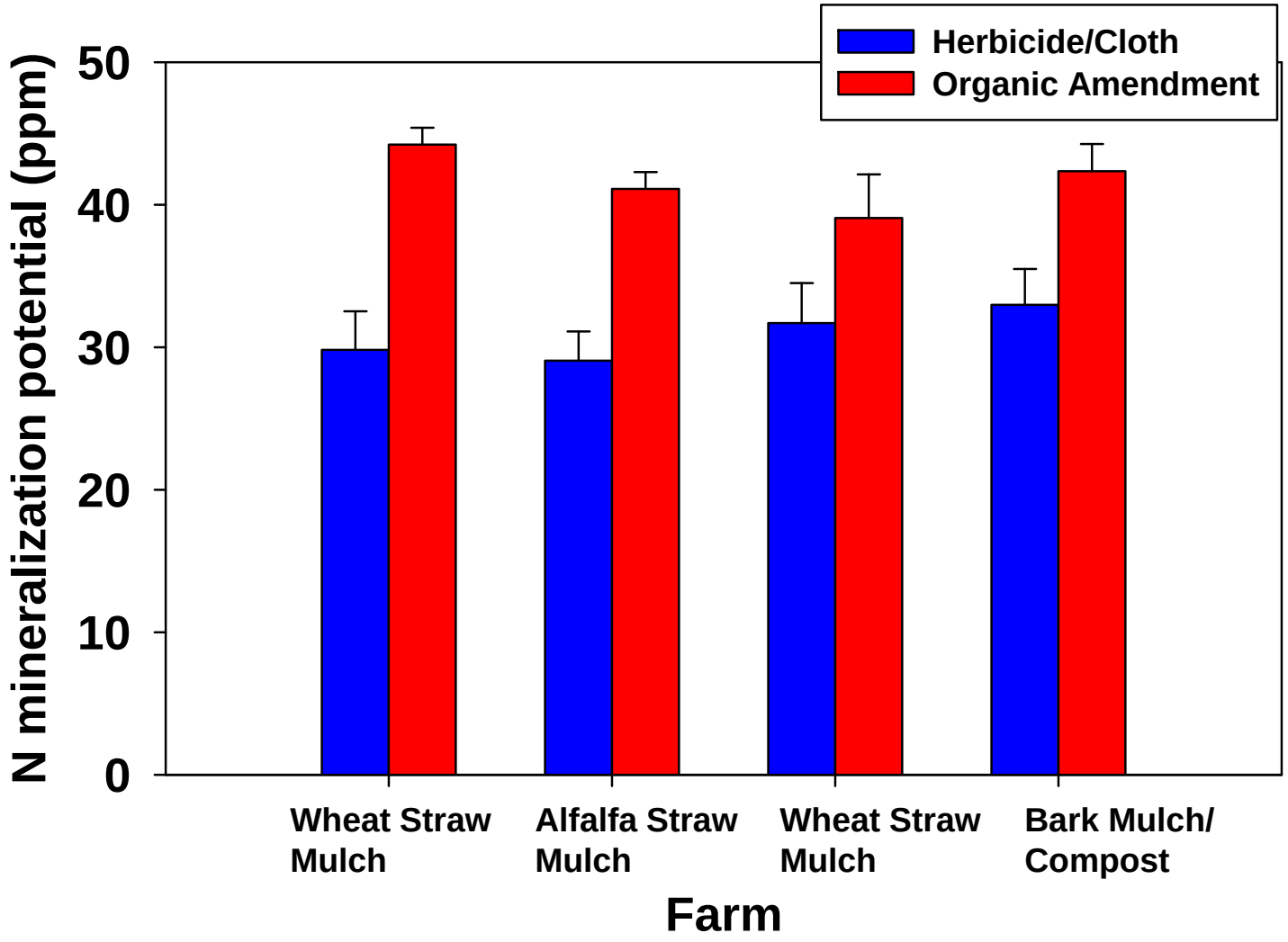
Impacts of OFM on Soil Enzymes & Biology

Cloth

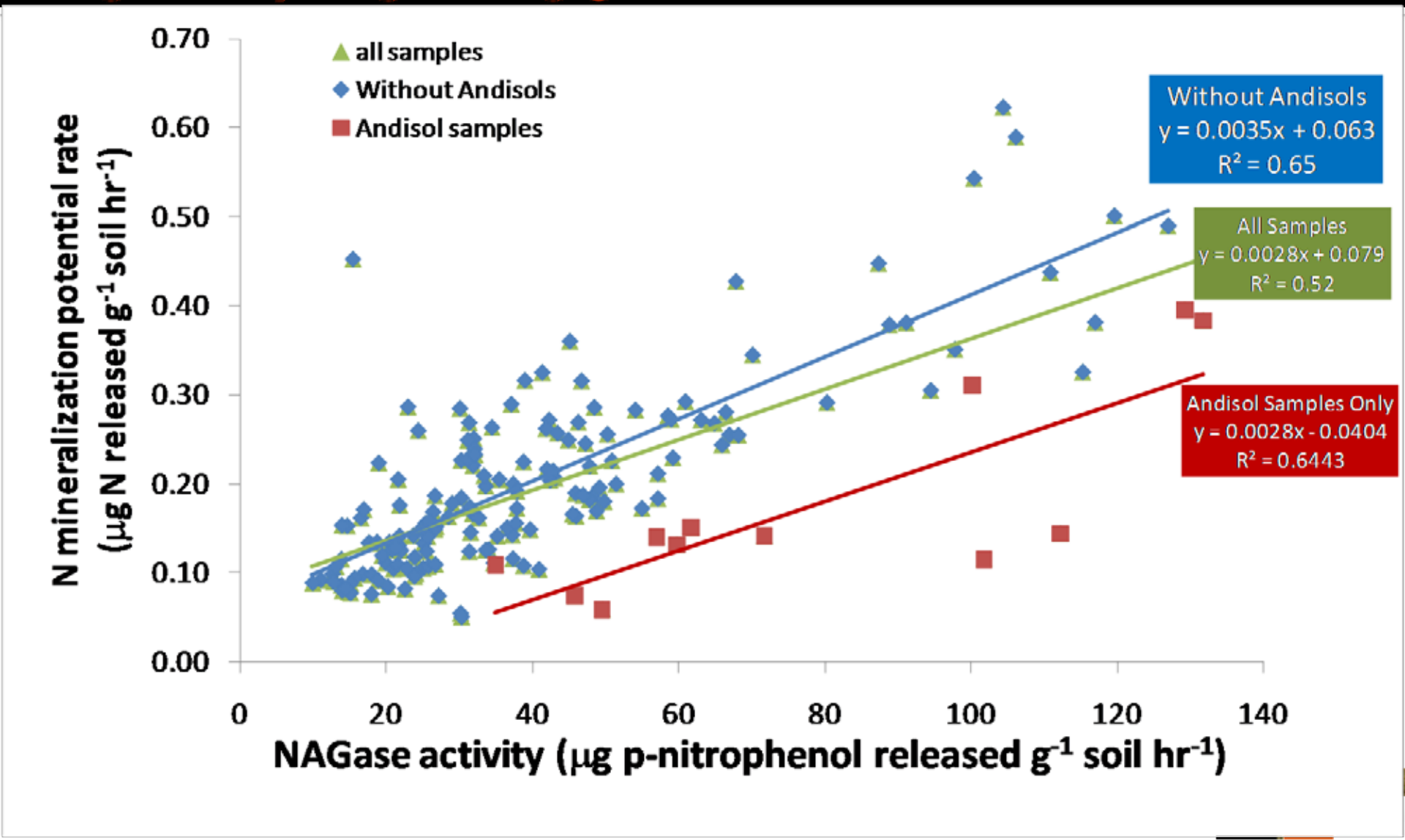
Herbicide

Soil Property	Bark Mulch + Compost + Cultivation	Wheat Straw + Cultivation	Wheat Straw + Herbicide	Alfalfa Straw + Herbicide
N mineralization	↑ (25%)	↑ (21%)	↑ (48%)	↑ (22%)
C enzyme	↔	↔	**↑ (58%)**	↑ (15%)
N enzyme	**↑ (up to 75%)**	↔	**↑ (57%)**	↑ (47%)
P enzyme	↔	↔ ↑	**↑ (15-83%)**	↔
S enzyme	↔	↑ (17%)	**↑ (96%)**	**↑ (74%)**
Microbial Biomass	↑ (10.3%)	↔ (6.6%)	↑ (22%)	↑ (40%)
Total Bac	↔	↔ (9%)	↑ (23%)	↑ (27%)
Total Fungi	↑ (17%)	↑ (46%)	↑ (20%)	**↑ (52%)**
AMF	↓ (39%)	↑ (31%)	**↑ (57%)**	**↑ (133%)**
F1:B	↑ (32%)	↑ (72%)	↑ (22%)	**↑ (59%)**
Soil H2O	↑ (up to 7% greater)	↓***	↑ (~9% greater)	↔***
Soil Temp	↑ (up to 2°F greater)			

Effect of OFM on N mineralization potential (Organic N → Inorganic N)

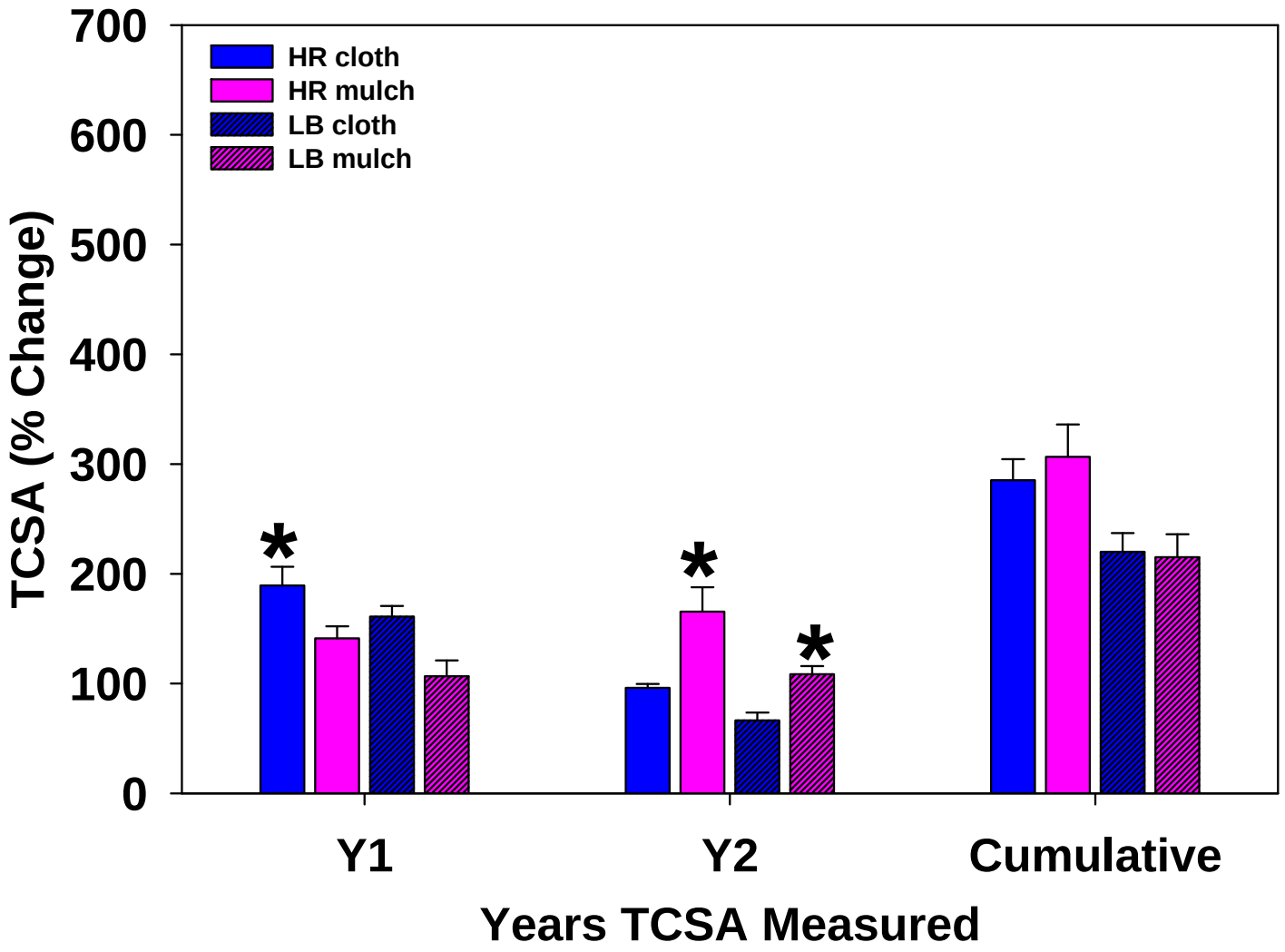


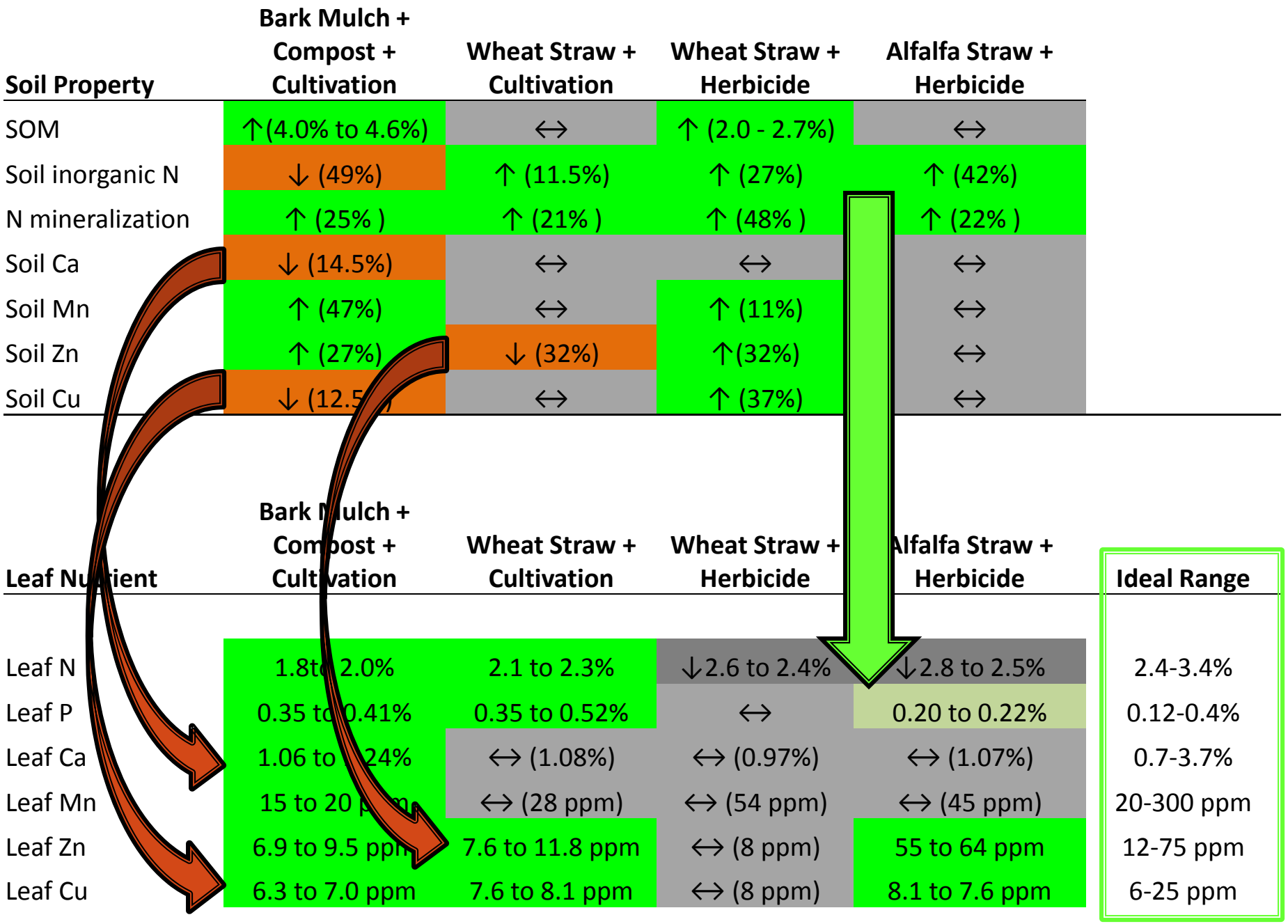
Relationship between NAGase activity (chitin → NH_4^+) and N mineralization potential (Org N → NH_4^+) (9 farms, 0-15 and 15-30 cm)



OFM Impact on % TCSA

(OSU organic farms planted 2005)




Soil Property
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↔
Soil Zn
↑ (27%)
↓ (32%)
↑(32%)
↔
Soil Cu
↓ (12.5
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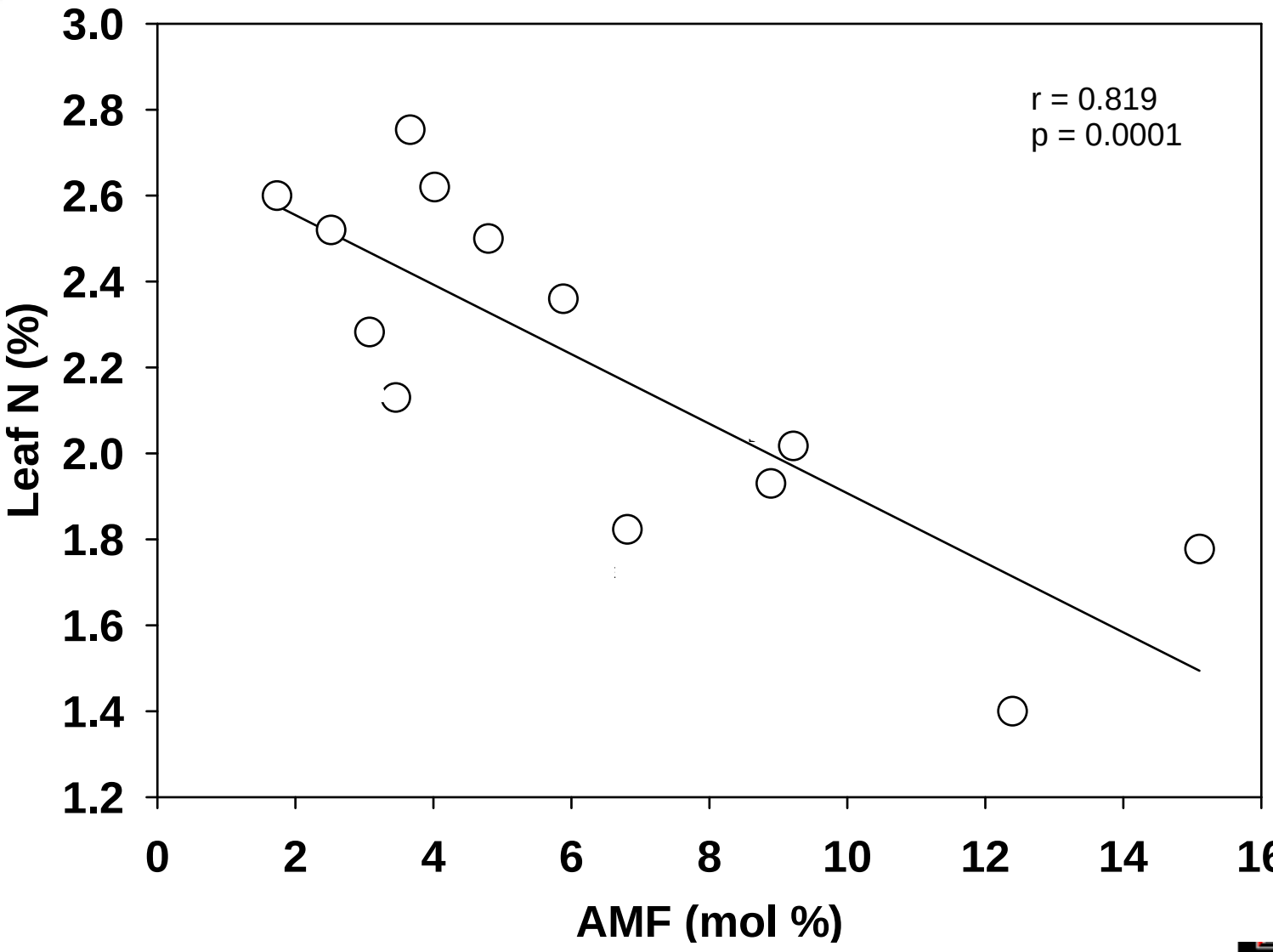
Leaf Nutrient
Bark Mulch + Compost + Cultivation
Wheat Straw + Cultivation
Wheat Straw + Herbicide
Alfalfa Straw + Herbicide
Ideal Range
Leaf N
1.8to 2.0%
2.1 to 2.3%
↓2.6 to 2.4%
↓2.8 to 2.5%
2.4-3.4%
Leaf P
0.35 to 0.41%
0.35 to 0.52%
↔
0.20 to 0.22%
0.12-0.4%
Leaf Ca
1.06 to 24%
↔ (1.08%)
↔ (0.97%)
↔ (1.07%)
0.7-3.7%
Leaf Mn
15 to 20 p m
↔ (28 ppm)
↔ (54 ppm)
↔ (45 ppm)
20-300 ppm
Leaf Zn
6.9 to 9.5 ppm
7.6 to 11.8 ppm
↔ (8 ppm)
55 to 64 ppm
12-75 ppm
Leaf Cu
6.3 to 7.0 ppm
7.6 to 8.1 ppm
↔ (8 ppm)
8.1 to 7.6 ppm
6-25 ppm

AMF vs. Leaf N Concentration (9 Ore Farms)



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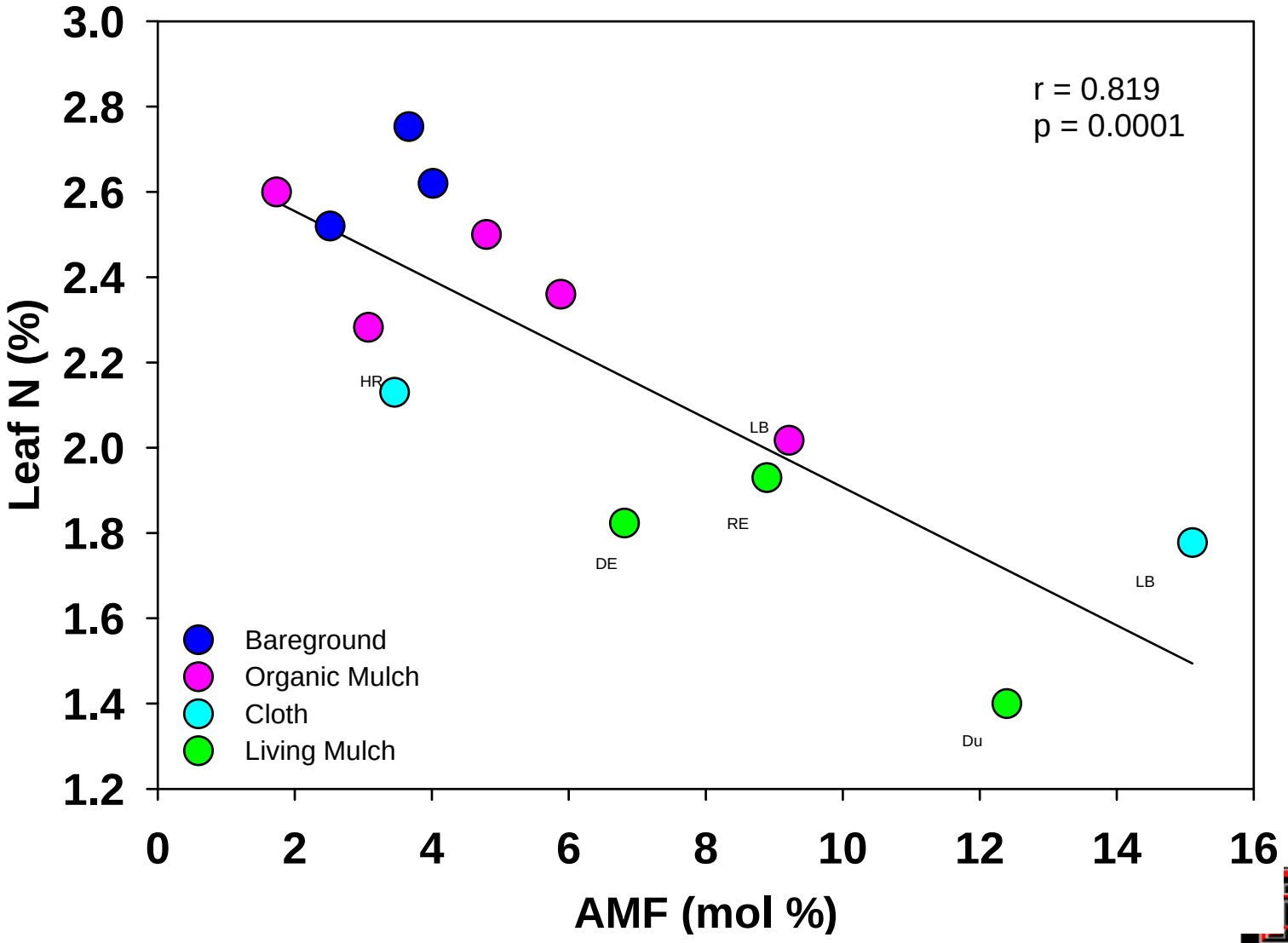
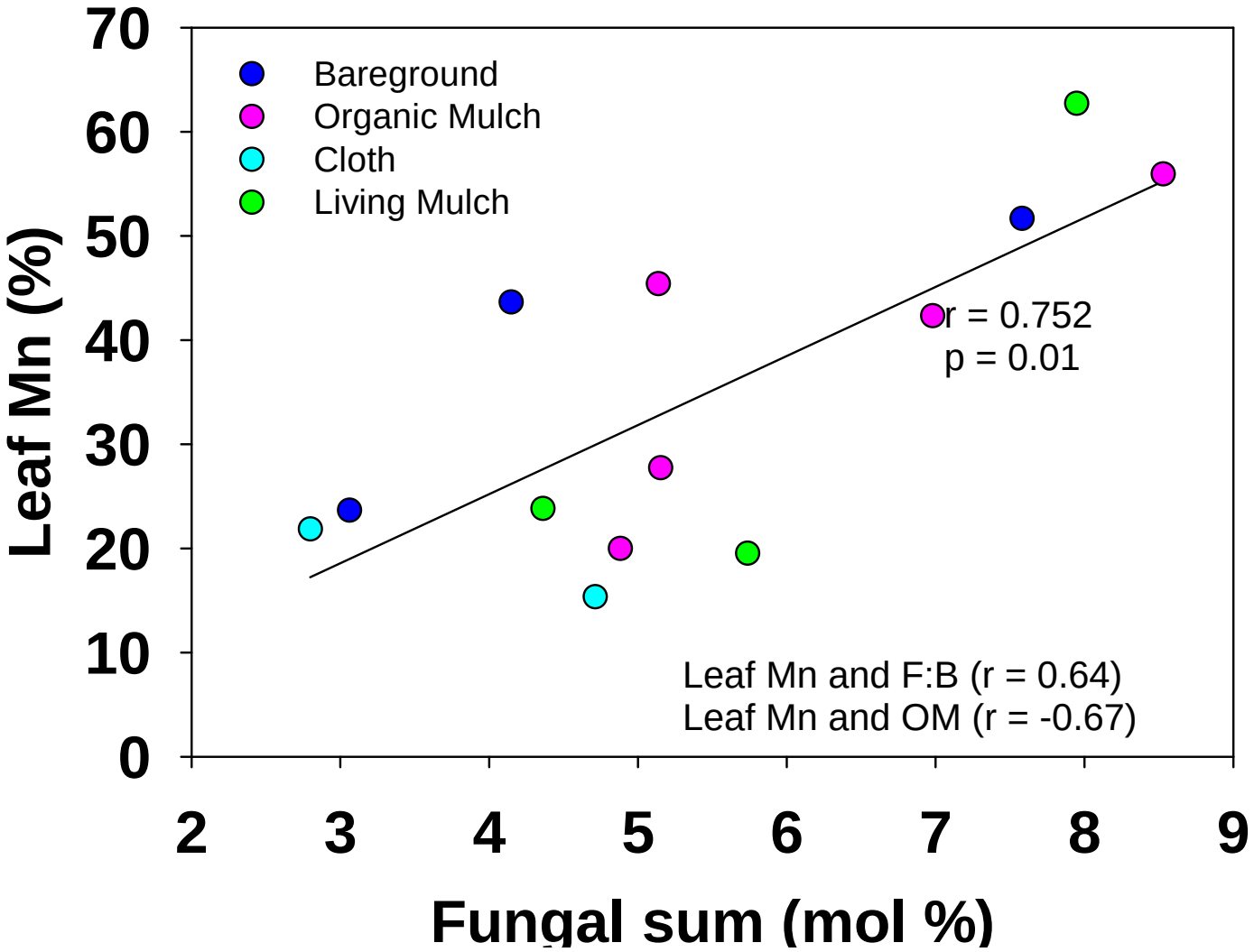


Fungi vs. Leaf Mn (9 Ore Farms)



CLOTH VS. ORGANIC MULCH
New orchards, High SOM

Bark/ Leaf Compost (4 apps)

- ↑ SOM, POM, Nmin, Soil Mn, Zn, B
- ↓ Inorganic N, Ca, Mg, Cu, SO_4^{2-}
- ↑ NAG, SMB, Total fungi, F:B
- ↓ AMF
- ↑ Leaf nutrients

Wheat straw (2 apps; last '06)

- ↔ SOM, ↑POM, Nmin, inorganic N
- ↓ Soil Zn, B
- ↑ S enzyme, AMF, Total Fungi, F:B
- ↑ Leaf N, P, Zn, and Cu

HERBICIDE VS. ORGANIC MULCH
Est. Orchards, Low SOM

Wheat straw (newer orchard)

- ↑ SOM, Soil inorganic N, Zn, Cu
- ↑ all microbial indicators
- ↔ Leaf nutrients

Alfalfa straw (old orchard)

- ↔ SOM, ↑inorganic N & B
- ↓ Soil P
- ↑ all microbial indicators
- ↑ Leaf Zn, Cu
- ↓ Leaf N

Managing for Soil Health must begin by changing the way you think about Soil.

TRADEOFFS

- Allow soil to work for you.
- C as your fertilizer
- Site characteristics/history important
- Established orchards may have altered tree responses
- Integrate research on pathogens/ SOM/ Nutrients
- Breeders aimed at organics!
- Other benefits? (water, temp, resiliency, C credits, greenhouse gases?)
- Diversify OFMs
- Buy local, Think global

Questions?

Wishing you a festive holiday season!