Effects of Surface Mulch on Soil Health Conditions in Conservation-Tillage Systems

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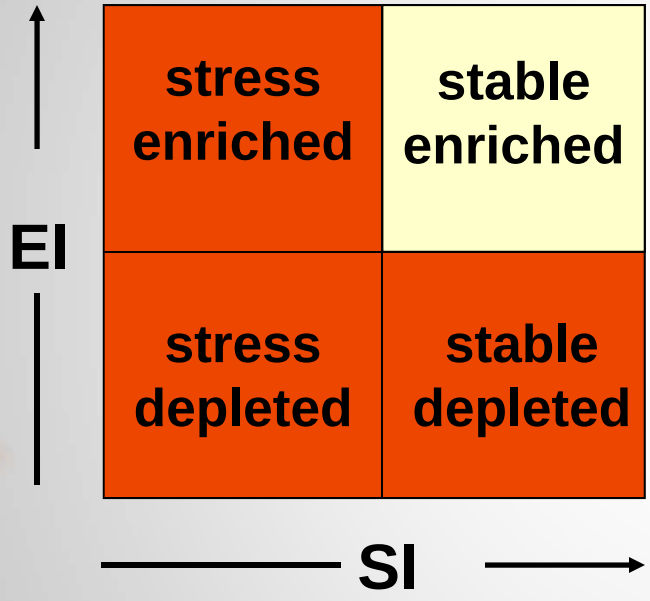
Outline

- Are we keep re-inventing the wheel?
- Comparing tilled, no-tilled, and synthetic mulch to bare ground system
- Integrating no-till cover cropping with natural farming

Goals of maintaining soil health



(Ferris et al., 2000)

- Maintaining high soil nutrient enrichment throughout a cropping cycle
- Sustain a stable soil food web structure

Different Approaches of Conservation Tillage

- Strip-till
- Ridge till
- No till
- Natural farming

Impact of previous conservation tillage practices on nematode communities

Conservation tillage increase bacterivores and fungivores, between cover cropping ar ear study	DuPonte et al., 2009
Failed to sh l web structure following tv	Hanel, 2003; Minoshima et al., 2007
Failed to sh l web structure following tv	Marahatta et al, 2010;
Increase SI em.	Okada and Harada, 2007
Amending soil with green manure clearly increase omnivorous and predatory nematodes in soil under greenhouse pot experiments.	Wang, McSorley et al, 2004
Strip-till of sunn hemp cover crop followed by mulching soil surface periodically with sunn hemp residues enhanced SI within 2 cropping cycles.	Wang, et al., 2011

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- ✓ Comparing tilled, no-tilled, and synthetic mulch to bare ground system
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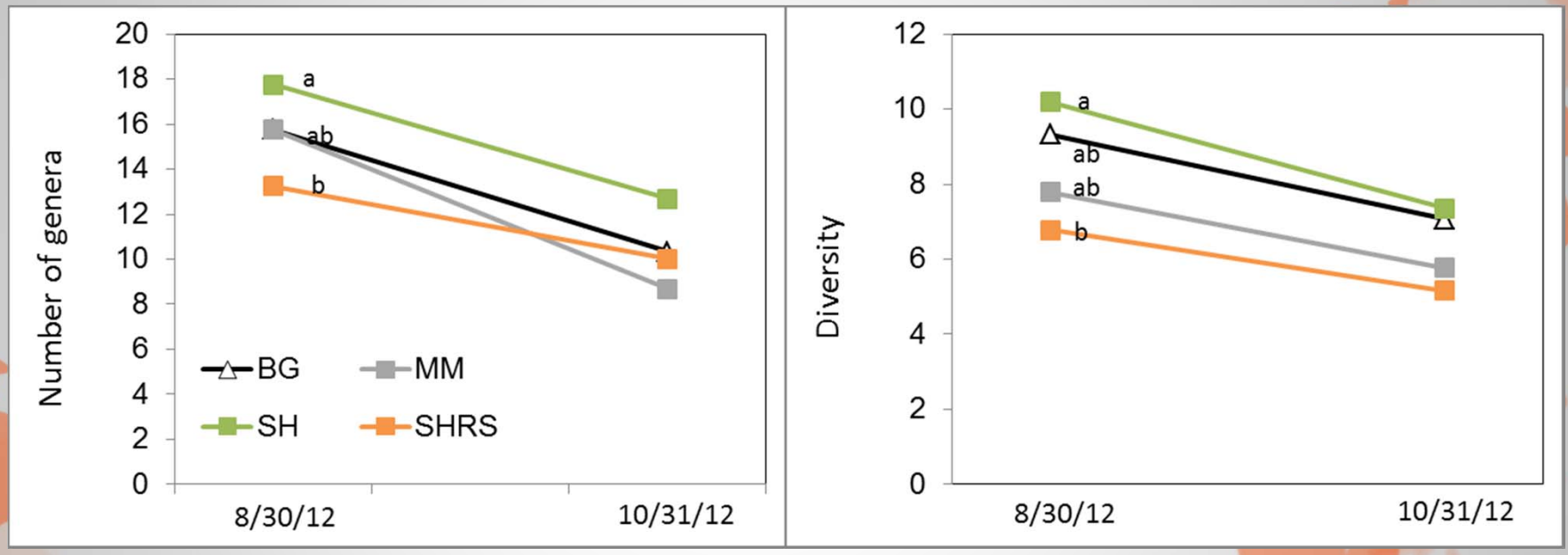
Comparing Tilled, No-tilled, Synthetic mulch to Bare Ground system

SH=Sunn hemp
RS = Rapeseed
BG = Bare ground
MM = Metalic mulch

Comparing Tilled, No-tilled, Synthetic mulch to Bare Ground System



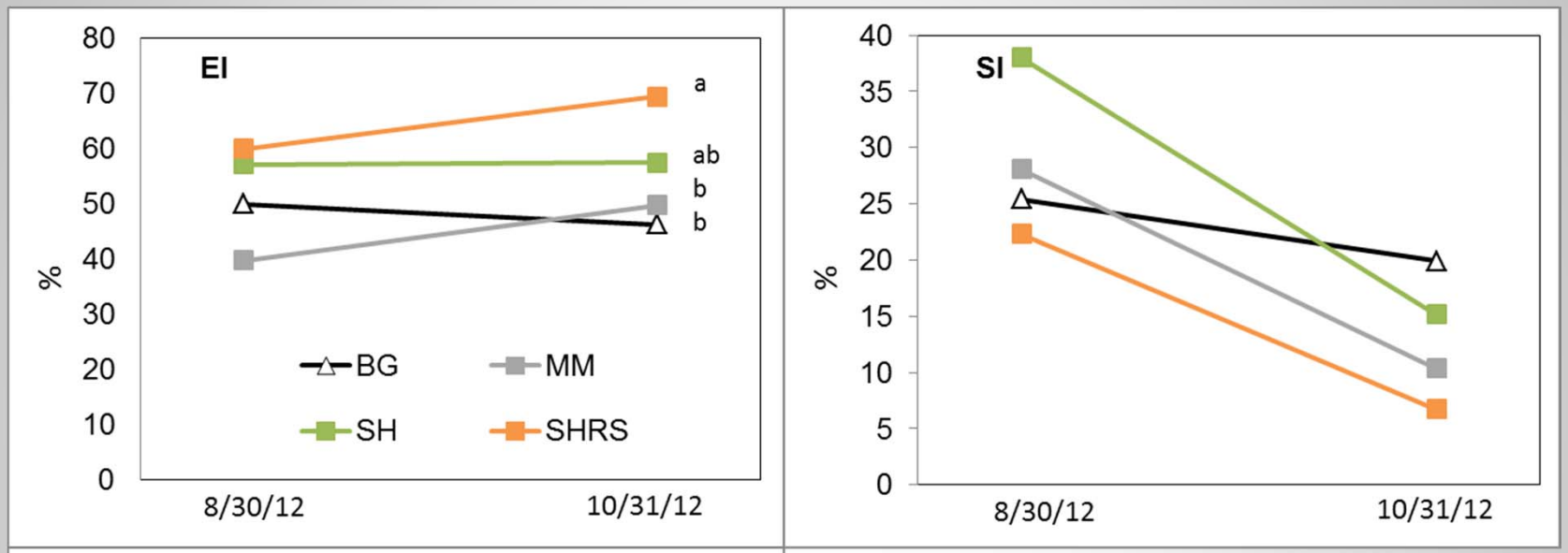
8/30/12 = termination of cover crop
10/31/12 = termination of zucchini crop

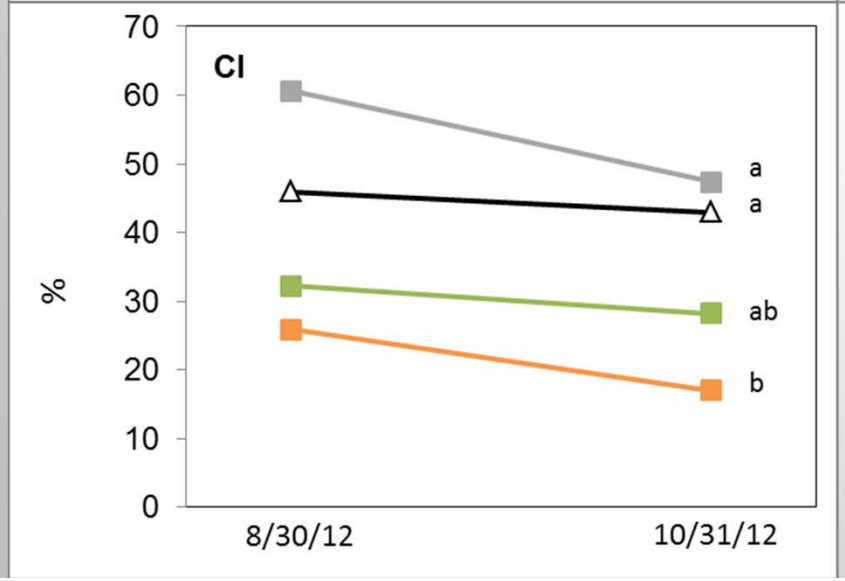
BG = till once
MM = till once + metalic mulch
SHRS = sunn hemp & rapeseed till twice
SH = No-till + SH organic mulch

At end of cover crop:

- SH no-till supported highest richness and diversity.
- SHRS tilled twice has lowest richness and diversity.

Comparing Tilled, No-tilled, Synthetic Mulch to Bare Ground System





At end of zucchini crop:

- SHRS tilled twice has highest EI, MM & BG has lowest EI.
- Reversed is true for CI.
- None affect SI.

Summary

- Incorporation of cover crop residues improved soil enrichment rapidly, resulted in less stressful soil condition (low CI) but did not improve SI.
- SH no-till cover cropping system did not improve nematode community structure within one cropping cycle of zucchini.

✓ *Thus, more work is needed to speed up soil health improvement process.*

Outline

- Are we keep re-inventing the wheel?
- Comparing tilled, no-tilled, and synthetic mulch to bare ground system
- ✓ Integrating no-till cover cropping with natural farming

Principles of Natural Farming

- Avoidance of manufactured inputs and equipment,
- Exploits the complexity of living organisms that shape each ecosystem, about "building the system",
- "the cultivation and perfection of human beings",
- Close observation of local conditions,
- Demands no inputs and mimics nature.

Building the system

Biodiversity in Natural area vs Monoculture

Enriched with indigenous micoorganisms

Disturbed agroecosystem with less biodiversity

Basic Theories of Korean Natural Farming

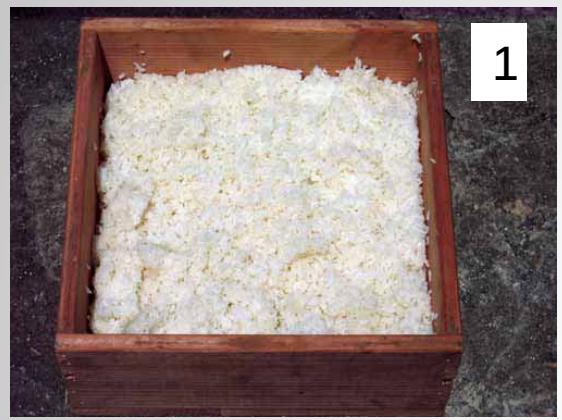
IMO

- Introduce indigenous microorganisms (IMOs)
- Reduce soil disturbance through no-till
- Increase production with on-farm inputs

Masanobu Fukuoka

Master Cho (Han-Yu Cho)

Culturing IMO Using Different Substrates



2/3 full steam rice in a box

Cover the rice box and scattered with bamboo leaves

Check the box in 4-5 days for white mold

Add brown sugar 1:1 (w/w)

Seal with paper towel.
Container 2/3 full.
Ferment for 7 days

Culturing IMO Using Different Substrates

6

2 oz IMO2 + 60 lb mill run + 5 gal water (with 120 ml of SES)

Compost for 7 days, < 110°F

8

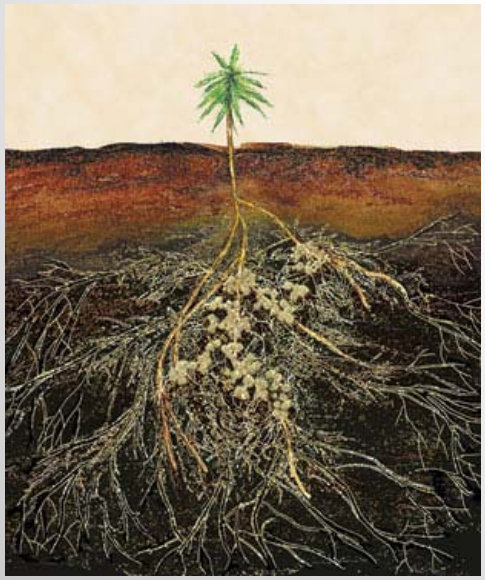
7

IMO3 + field soil + soil from natural area (2: 1: 1) + 5 gal water (with 120 ml of SES), cover and composted for ~7 days.

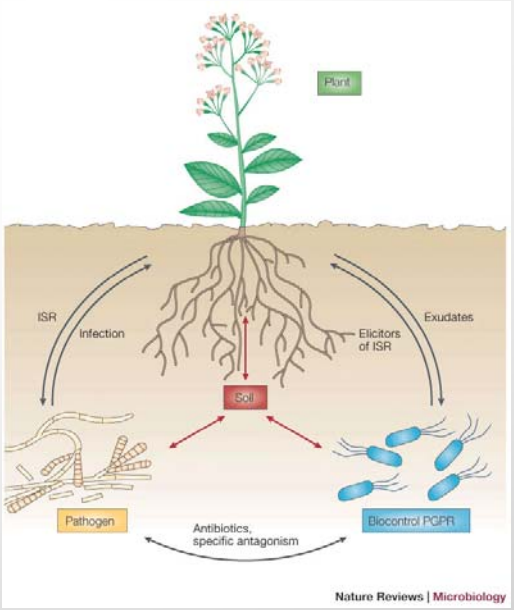
9

What does IMO do?

1) Increase soil nutrient cycling organisms?
2) Increase soil dwelling mesofauna?
3) Increase root mycorrhizae?
4) Increase plant growth promoting rhizobacteria (PGPR)?

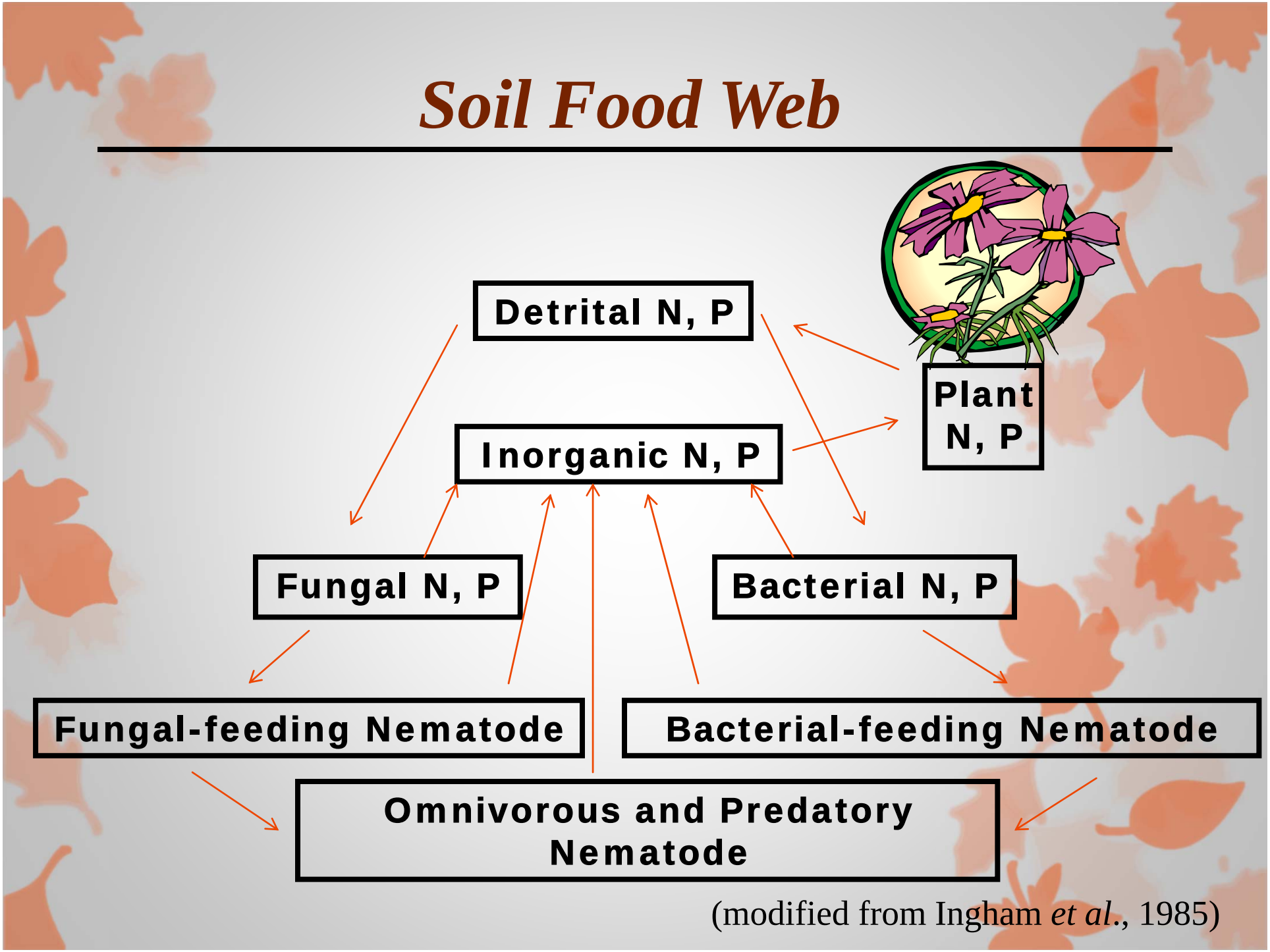


Mycorrhizae



PGPR

Soil Food Web



(modified from Ingham *et al*., 1985)

Anticipated Soil health indication

Bacterivore Fungivore Herbivore Omnivore Predator

EI = Enrichment index

CI = Channel index

SI = Structure index

+ richness, diversity

Foliar Spray (Nutrient inputs)

- BRV: brown rice vinegar
- FPJ: fermented plant juice
- LAB: lactic acid bacteria
- FAA: fish amino acid
- OHN: oriental herb nutrients
- WCAP: water soluble Ca-Phosphate
- WCA: water soluble Ca
- MA: Mineral A, B, C, D
- SW: sea water

Korean Natural Farming

- Korean Natural Farming = a practice to deliberately culture and reintroduced naturally occurring soil microorganisms into no-till agroecosystem, followed by foliar nutrients inputs of various fermented or nutrient extracted farm waste.

+

Scatter IMO4, cover with mulch (7 days)

Evaluating Benefits of KNF using Nematodes as Soil Health Indicators

- Four farm trials comparing KNF to either conventional (CONV) or organic (ORG) farming.

Farm	Crop(s)	Plot size (# plots/treatment)	Surface mulch
✓ Poamoho	Grape tomato	8 × 30 ft^2 (3/treatment)	Sunn hemp no-till farming
Farm #1	soybean	8 × 20 ft^2 (4/treatment)	Sunn hemp cover crop
Farm #2	kabocha squash	2 × 2 ft^2 (10/treatment)	Wood chips
Permaculture Farm	kale, beet, broccoli, onion, leek	4 × 100 ft^2 (2/treatment)	Macadamia nut husks

Poamoho Trial (Grape Tomato)

1. KNF+ SH
2. KNF + WM
3. CONV + SH
4. CONV + WM

Conv = Organic fertilizer (Chicken pellets fertilizer 180 lb/acre)

Sunn hemp (SH)
Weed Mat (WM)

Poamoho Trial (Grape Tomato)

Sunn hemp grown from May-July, 2012 produced 14.7 tons/acre of biomass.

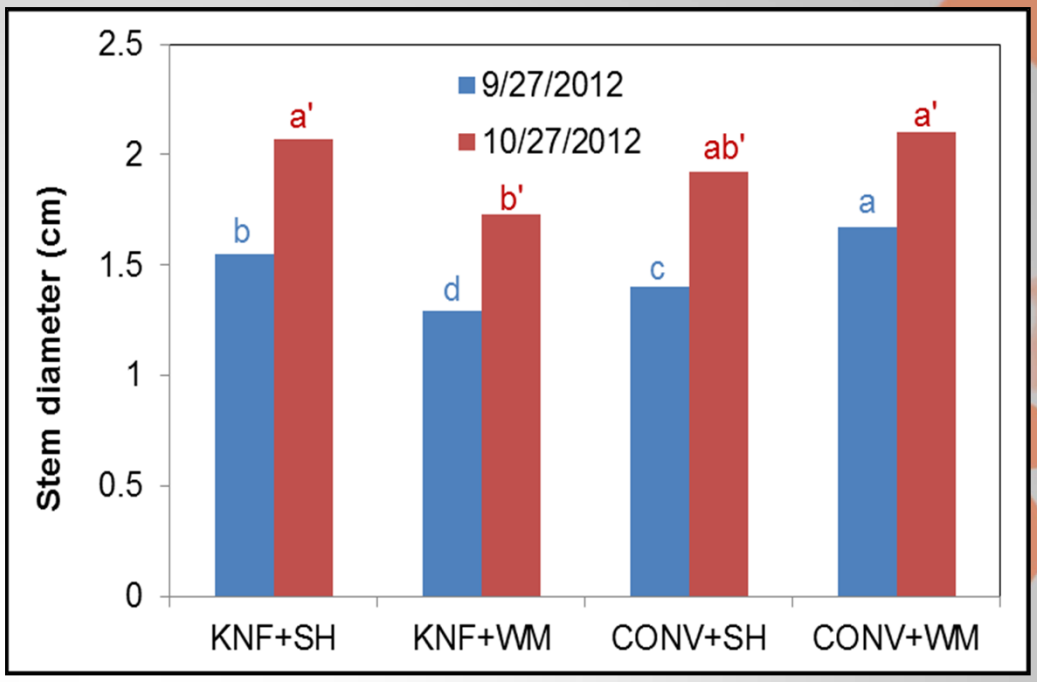
Roller crimper = no-till equipment for organic farming

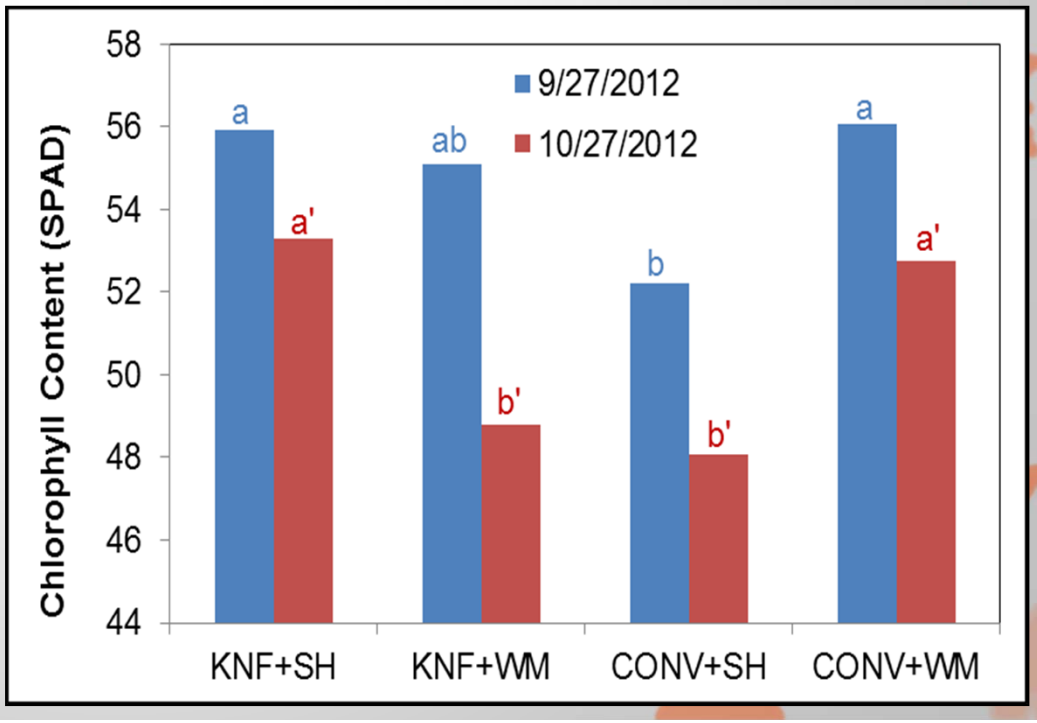
Poamoho Trial

Plant health

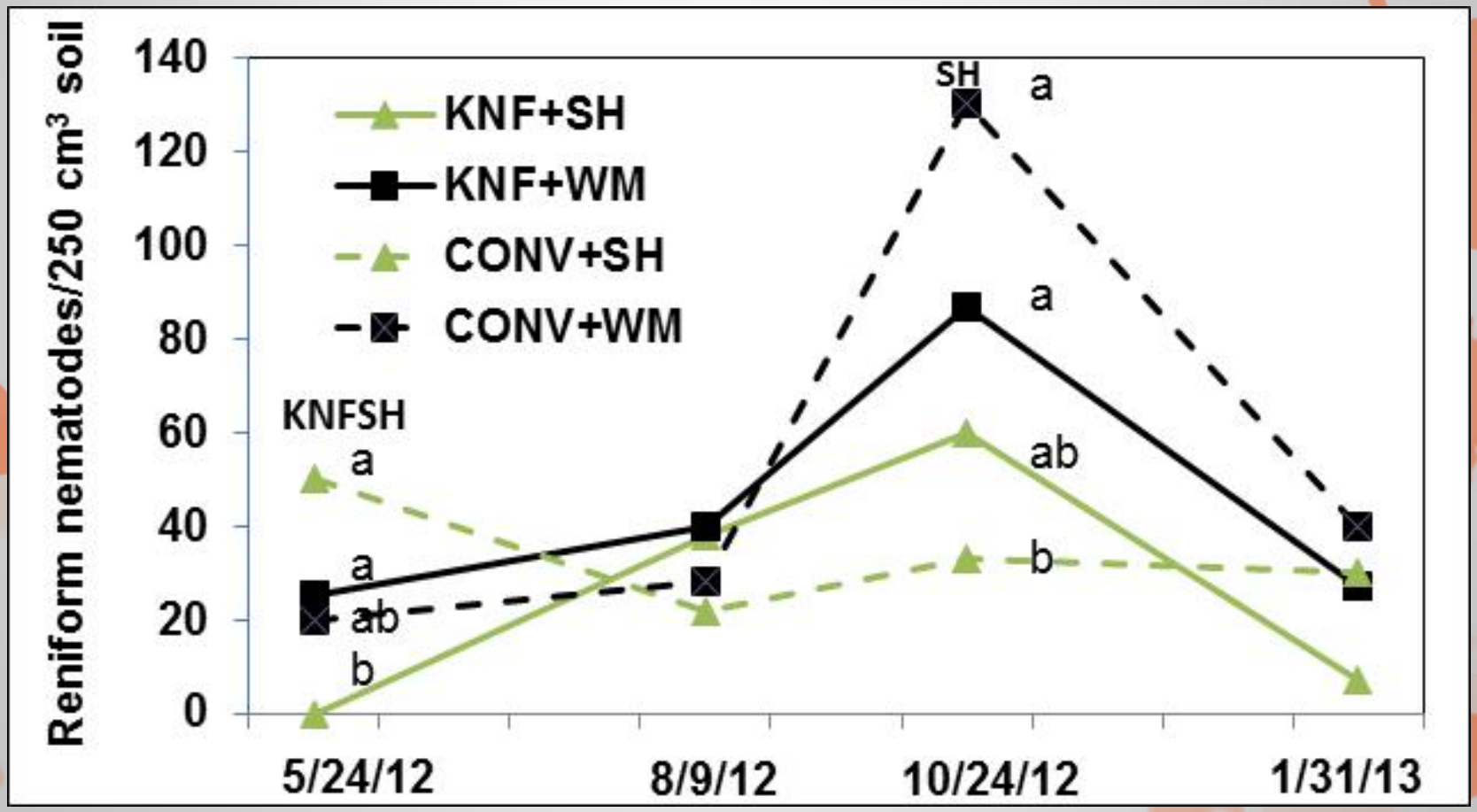
- **KNF works well with SH mulch; org fert (Conv) works well with WM.**
- KN+SH was comparable to Conv+WM.

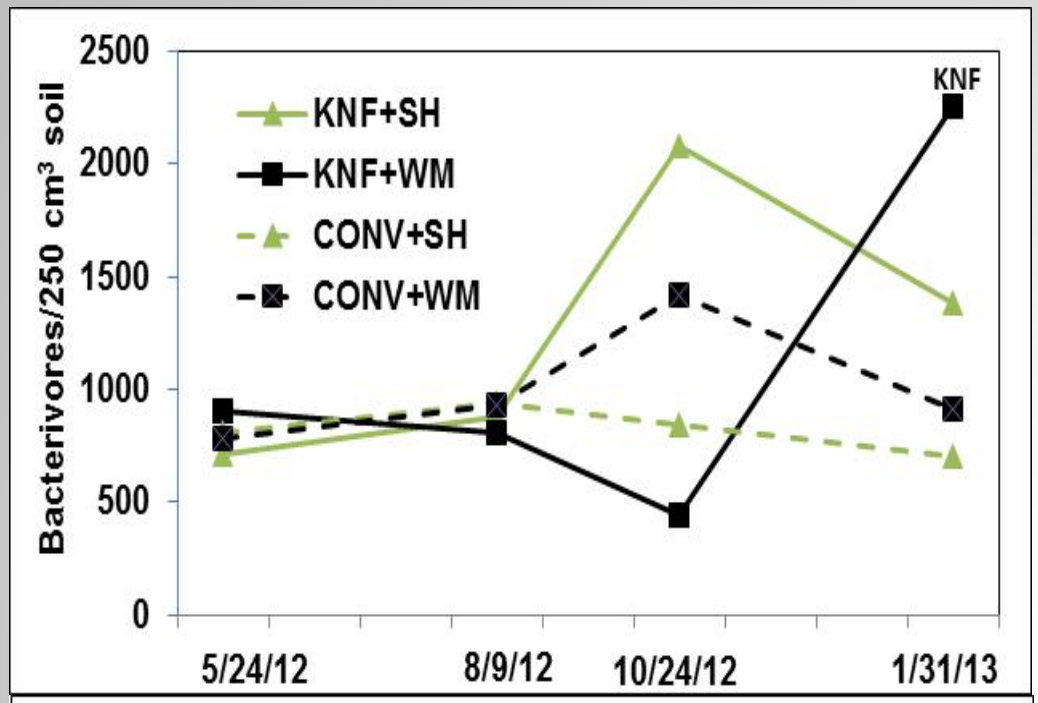
SPAD Chlorophyll meter

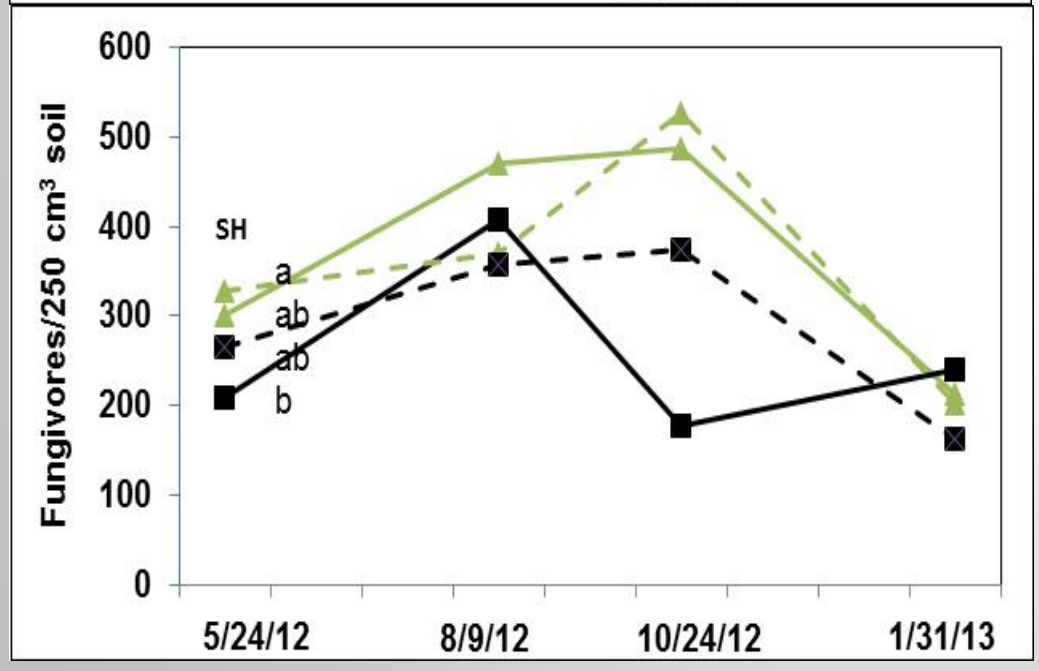




Sunn Hemp Suppress Plant-parasitic nematodes but not KNF



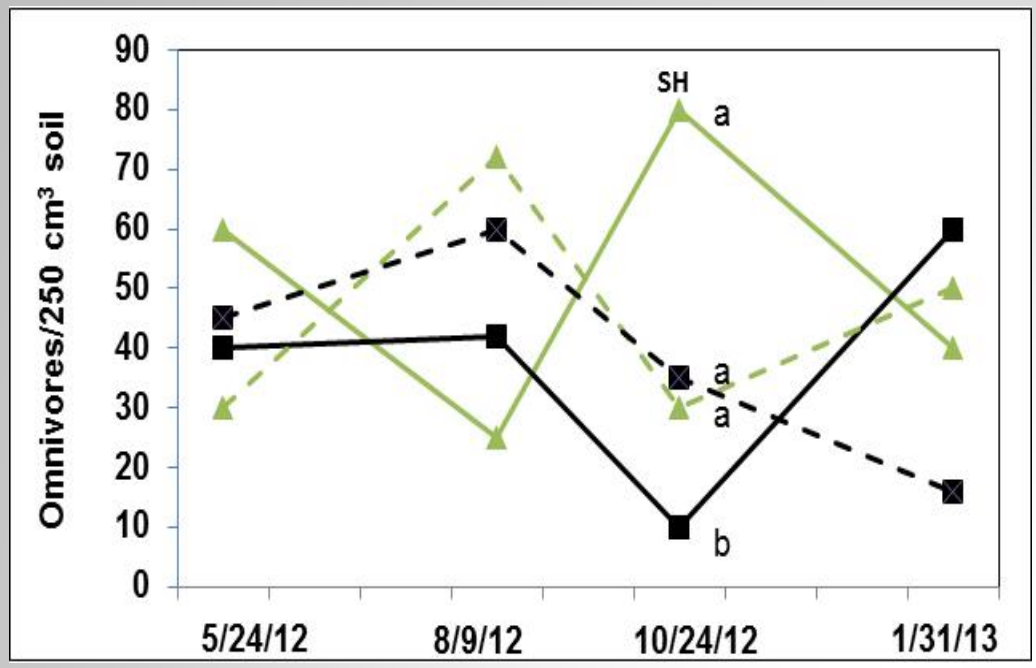


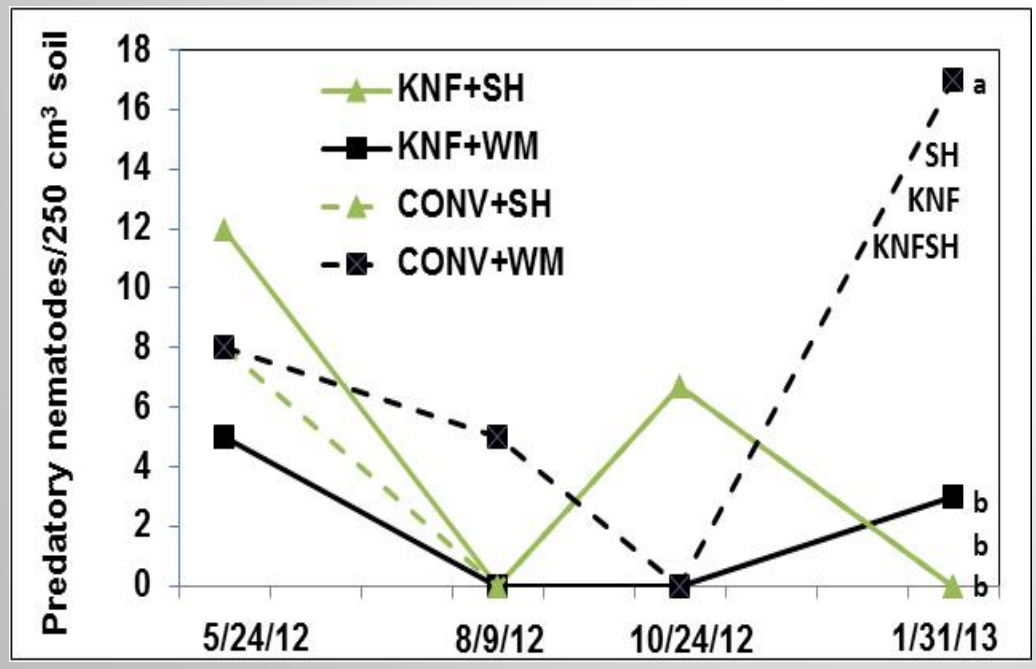


Poamoho Trial

Soil health

- KNF+SH has better bacterial decomposition than KNF+WM < 3 months after tomato planting.
- KNF resulted in more bacterial decomposition at the end of experiment.
- SH increased fungal decomposition up to ~ 3months.





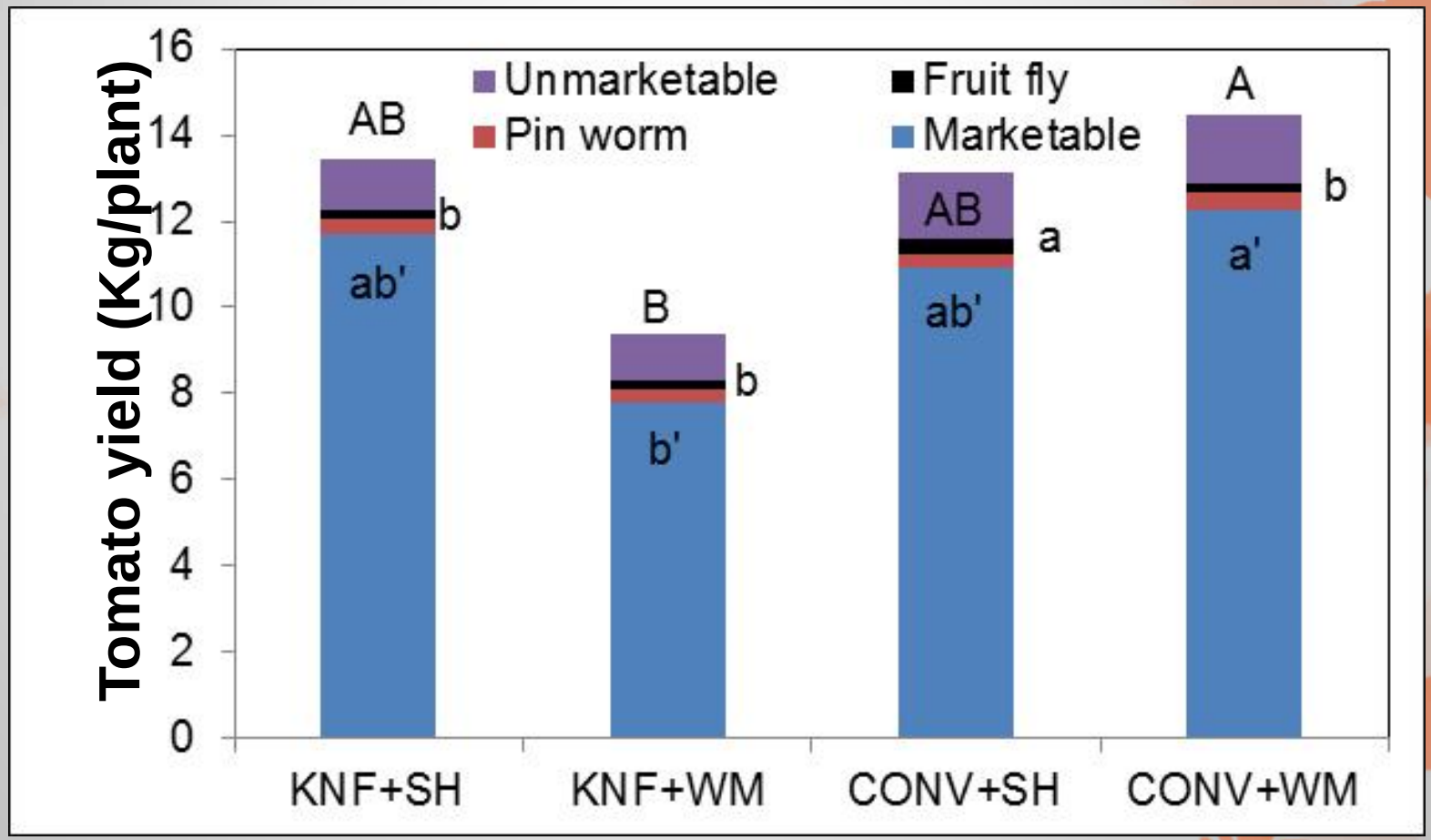
Soil Health

- KNF+SH increased omnivorous and predatory nematodes (< 3 months).
- Indicating reduced disturbance, improve in soil community structure, more stable soil food web.
- It took 2 years to reach this conditions in strip-till SH cover cropping system (Wang et al, 2011).

Poamoho Trial (Grape Tomato)

KNF + SH at 3 months after planting

Tomato Yield in KNF+SH is Comparable to CONV+WM



Nutrient Analysis of IMO4

			mg/dm^3
pH	8.3	Mn	523
N	0.67 %	Fe	12
P	825 ppm	Cu	8.1
K	1900 ppm	Zn	36
Ca	1361 ppm		

Summary

- Nutrient source from IMO4 is minimal, yet KNF practice produced comparable tomato yield as chicken pellets fertilized crop.
- IMO4 treatment resulted in more bacterial dominated decomposition in KNF plots especially when integrated with organic mulch (e.g. SH).
- KNF+SH had highest omnivorous and predatory nematodes ~ 3 months after planting, indicating stable soil food web structure, though WM treatment catch up later.

Materials and Methods

- Four farm trials comparing KNF to either conventional (CONV) or organic (ORG) farming.

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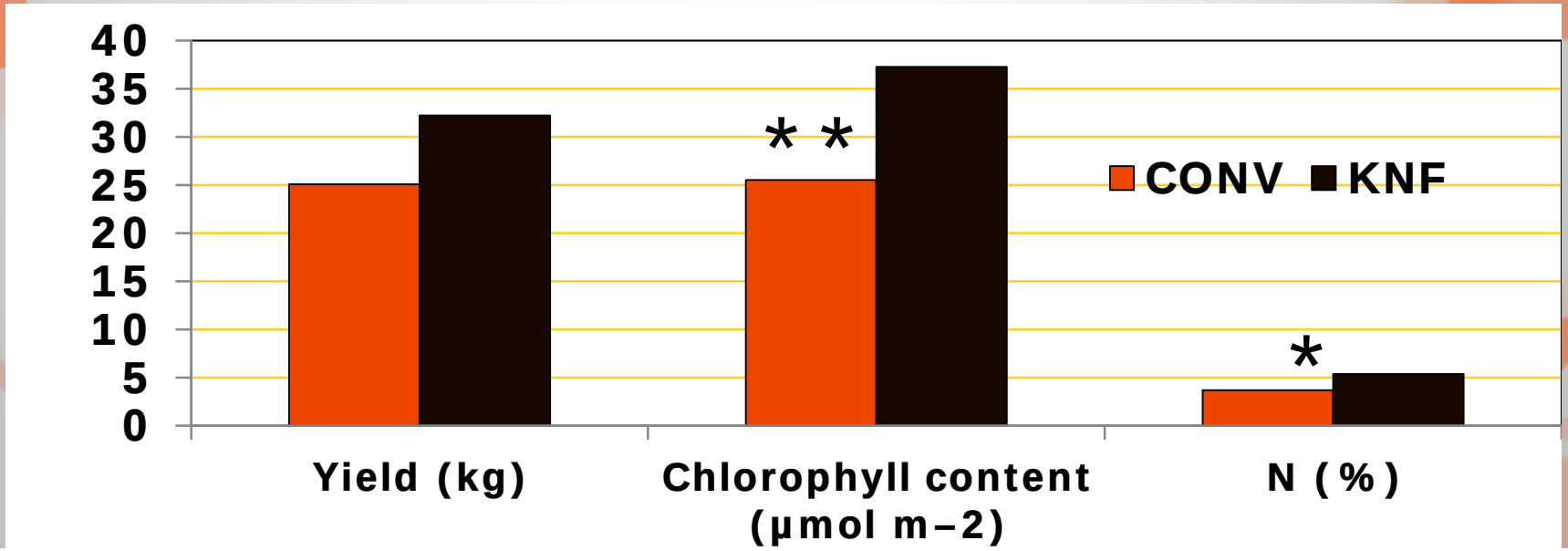
Farm #1 (Soybean)

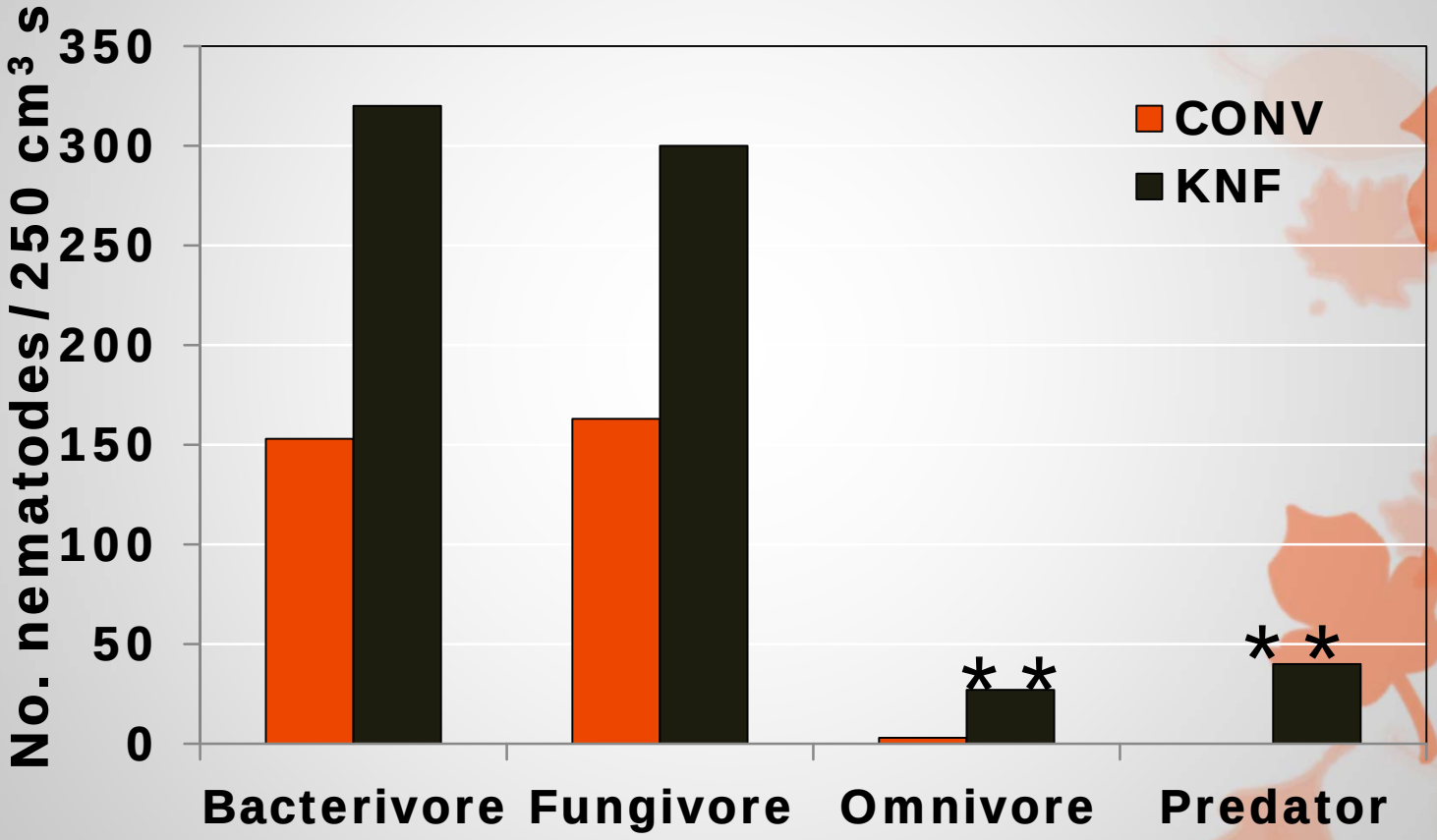
KNF improve Plant Health

Conv = Ammonium sulfate



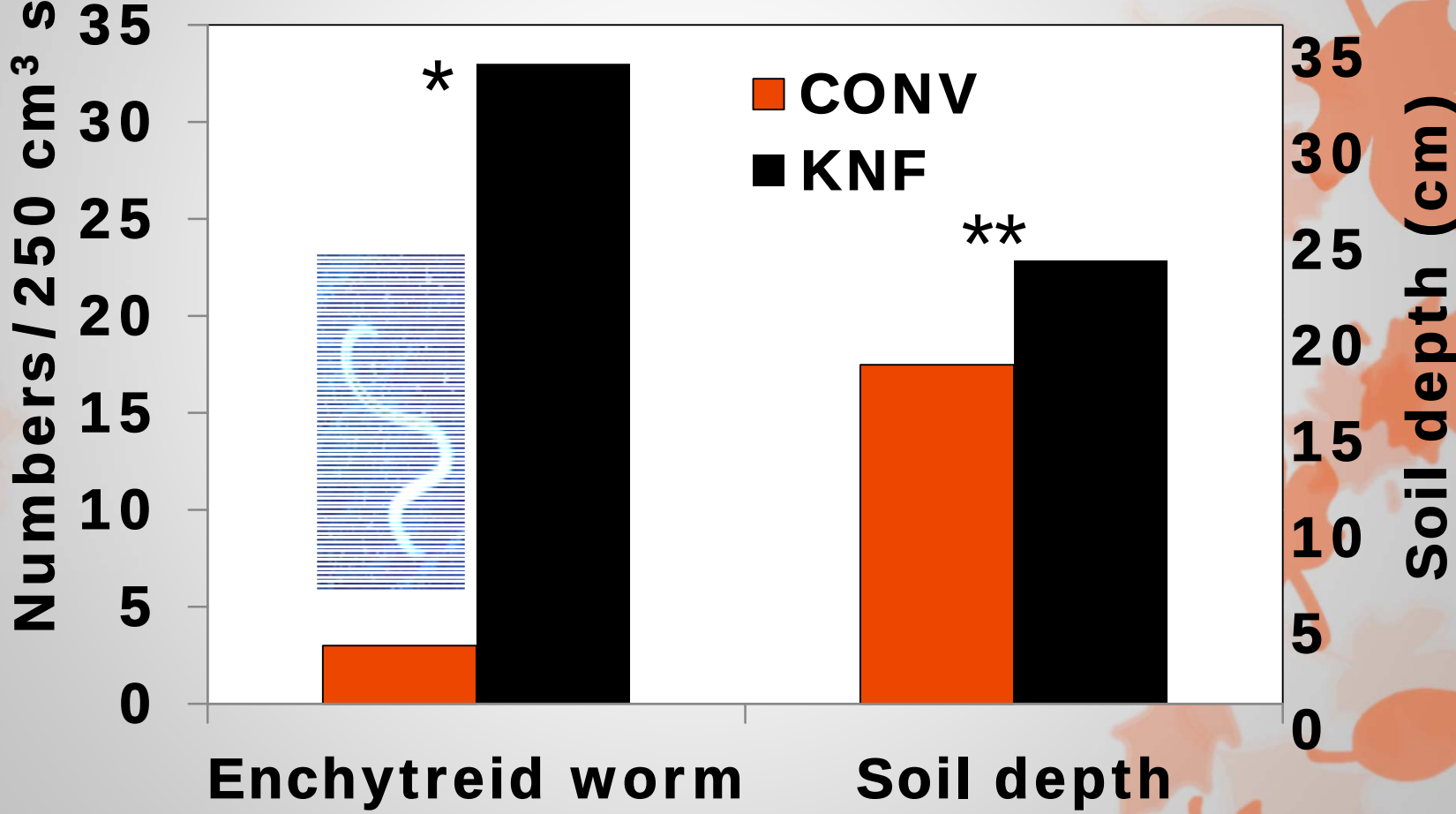
Farm #1 (Soybean)

KNF improve soil health



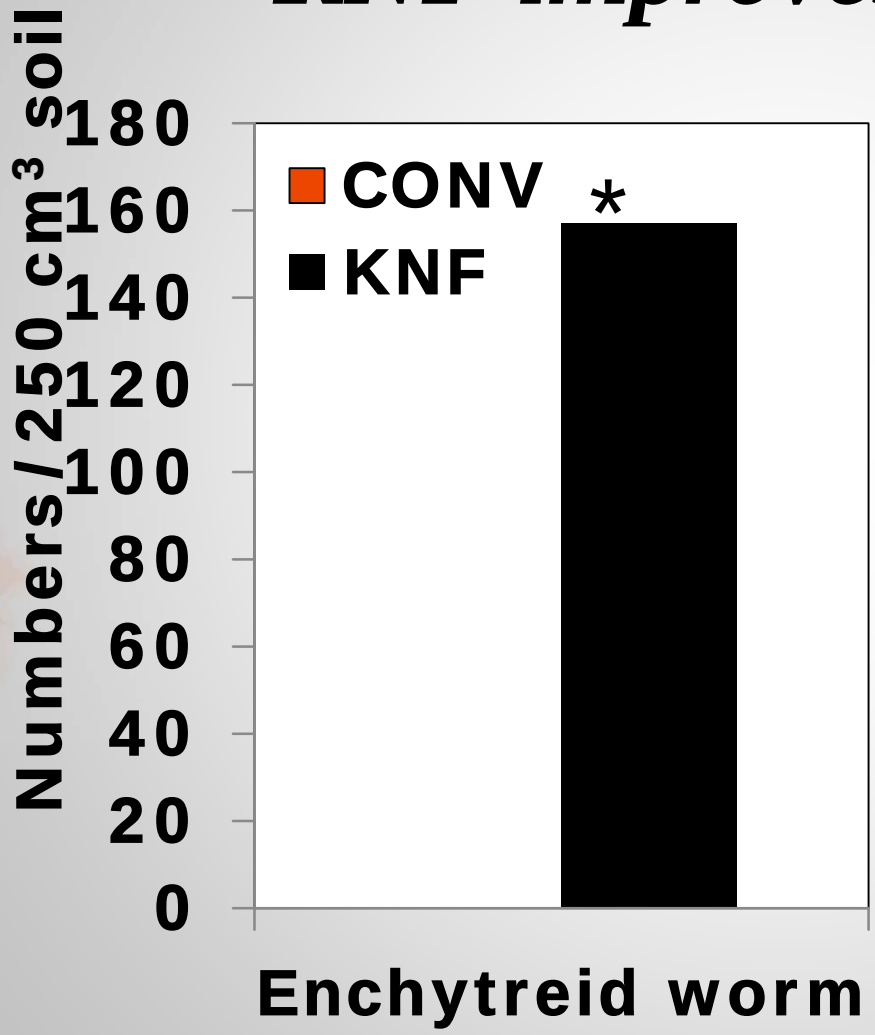
Farm #1 (Soybean)

KNF reduced soil compaction



Farm #2

KNF improves Soil Tilth



KNF did increased enchytreid worm that could contribute to better soil tilth in Farm #2.

Materials and Methods

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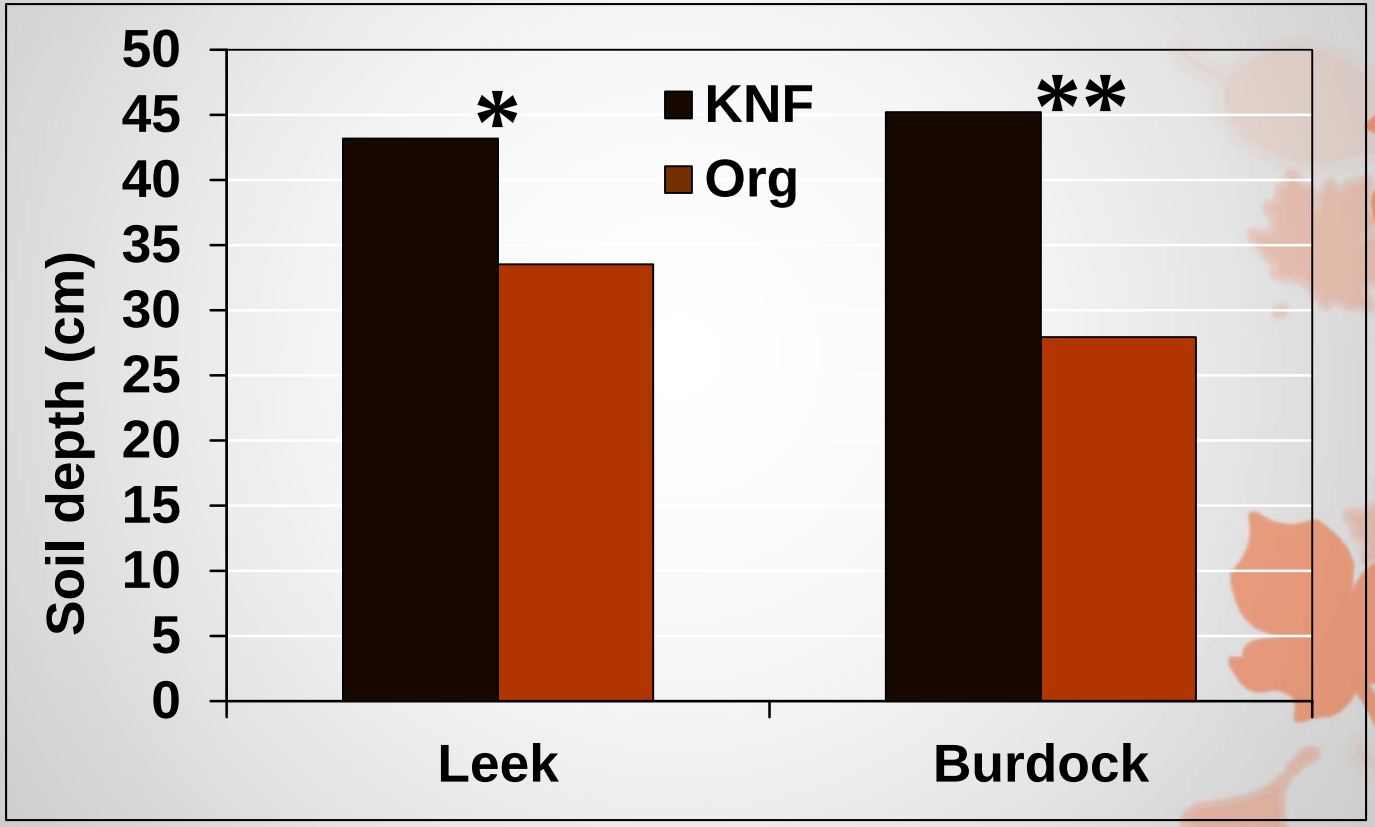
Farm #3

Results (Soil Compaction)



Summary

- Incorporating cover crop residues increased soil nutrient enrichment (EI) transiently, but it did not improve community structure (SI).
- No-till cover cropping did not increase EI and SI within one zucchini cropping cycle.
- Adding IMO4 compost to no-till SH increased bacterivores, fungivores, and resulted in higher omnivorous and predatory nematodes within 3 months after tomato planting.
- Thus, introducing IMO could speed up soil health improvement process in a no-till cover cropping practice.

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