Cover cropping practices that enhance soil fertility

Joel Gruver
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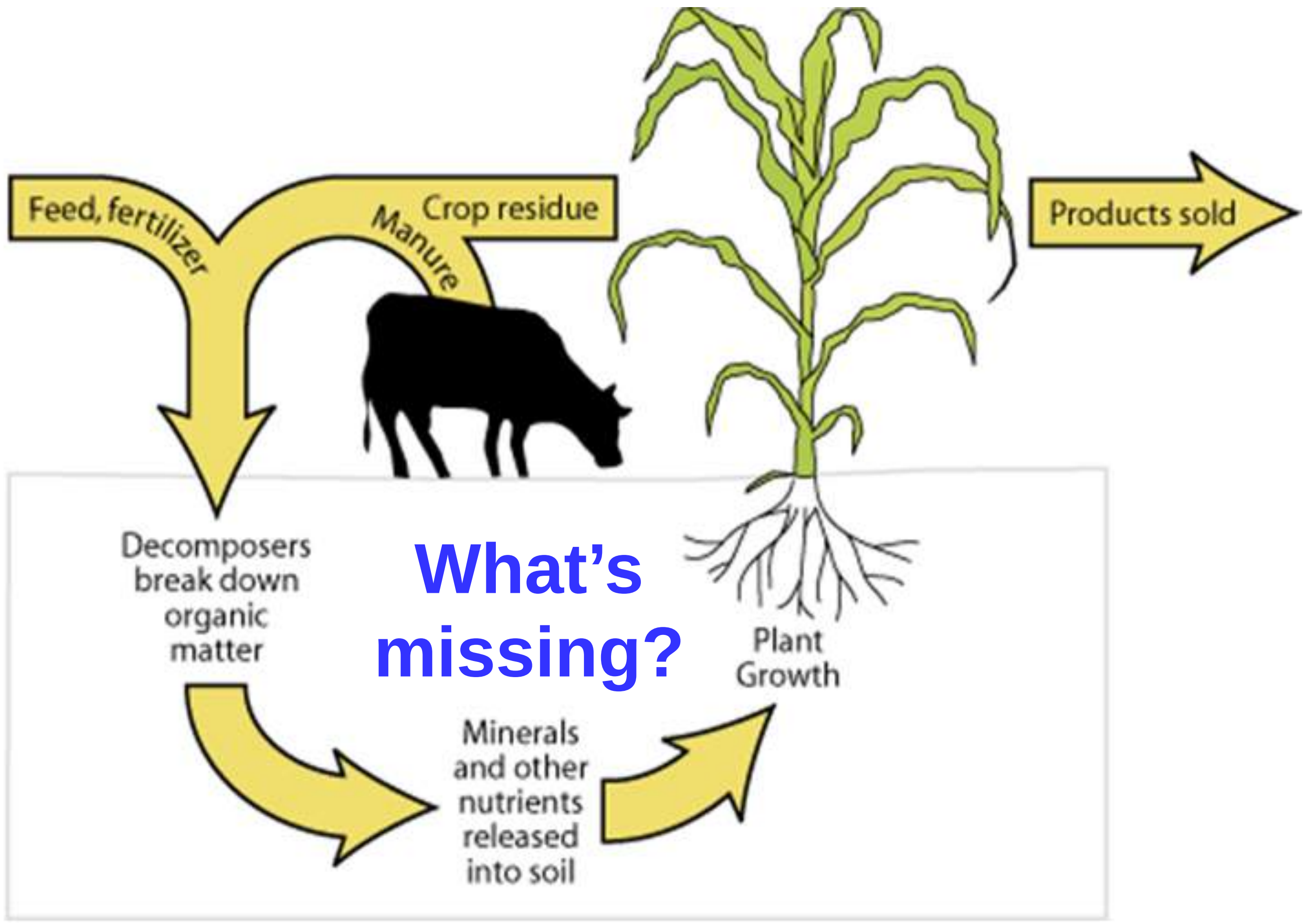
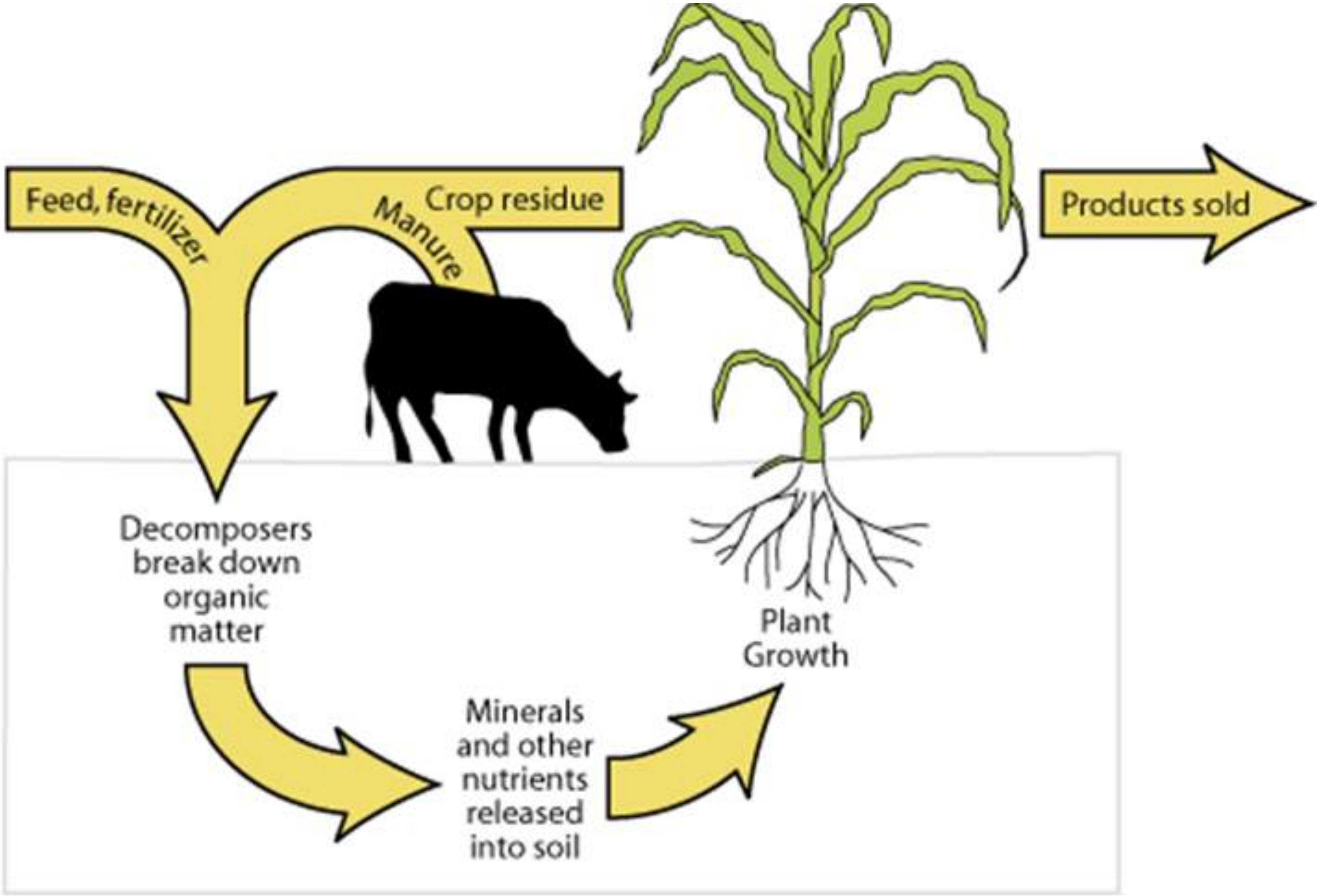
Nutrient dynamics in agroecosystems

Nutrient inputs



Nutrient outputs



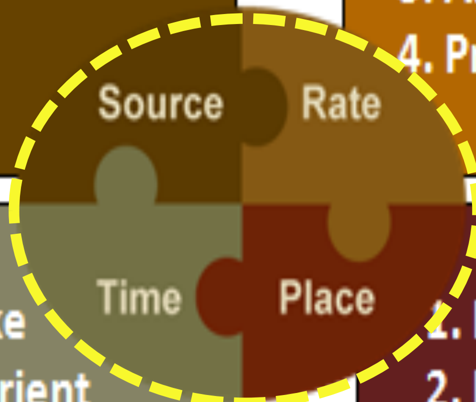
Nutrient losses to the surrounding environment …

sometimes exceed nutrient removal by harvest

How many of you are familiar with the 4R concept?

1. Supply in plant available forms
2. Suit soil properties
3. Recognize synergisms among elements
4. Blend compatibility

1. Appropriately assess soil nutrient supply
2. Assess all available indigenous nutrient sources
3. Assess plant demand
4. Predict fertilizer use efficiency

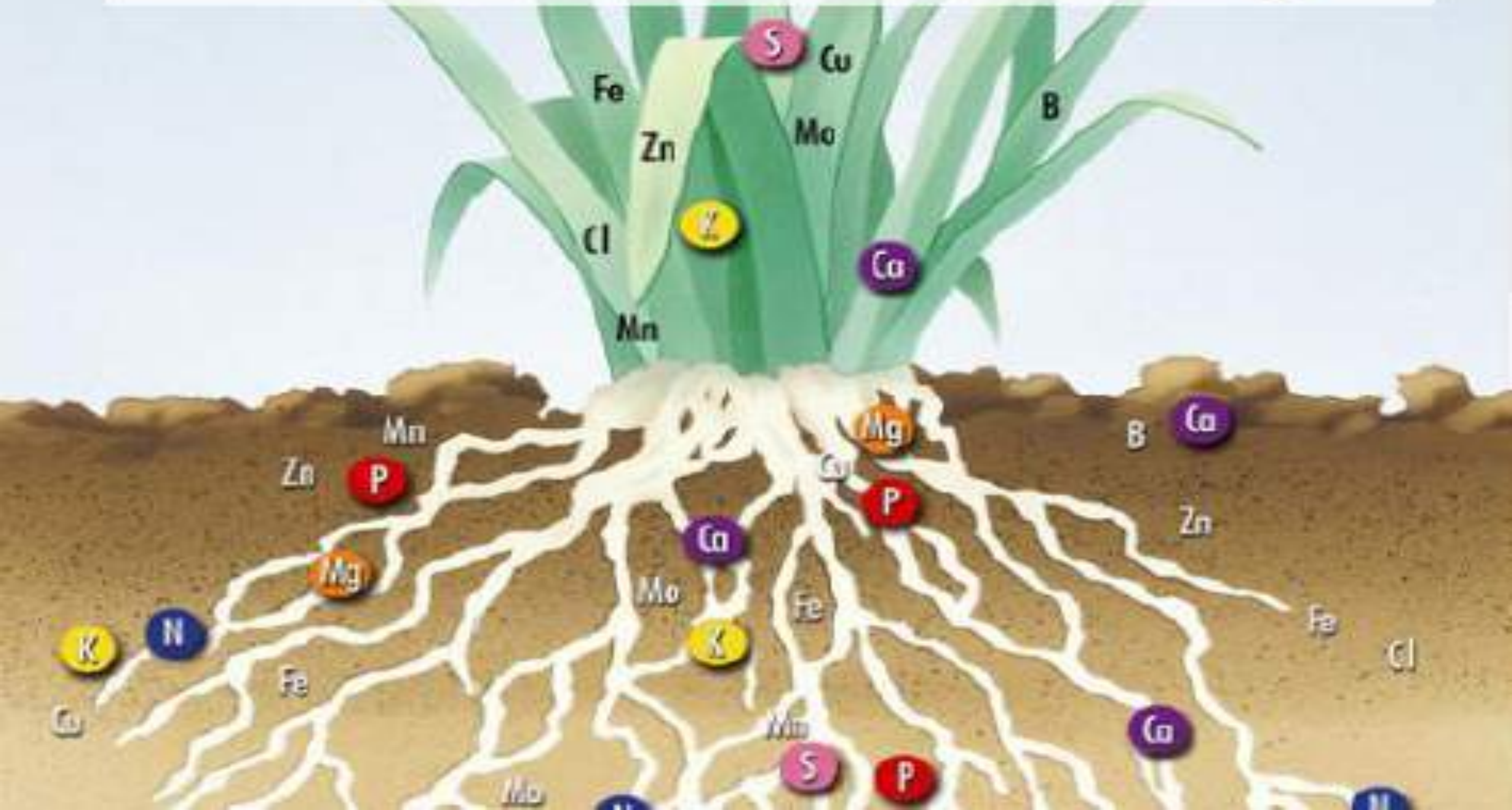


1. Assess timing of crop uptake
2. Assess dynamics of soil nutrient supply
3. Recognize timing of weather factors
4. Evaluate logistics of operations

1. Recognize root-soil dynamics
2. Manage spatial variability
3. Fit needs of tillage system
4. Limit potential off-field transport


Every
RECIPE STARTS
with the
SAME ESSENTIAL
INGREDIENT.
Plants don’t
know the
difference
fertilizer
LIFE'S MAIN INGREDIENT

Soil fertility is >> chemical fertility



Soil

Biological Fertility

+

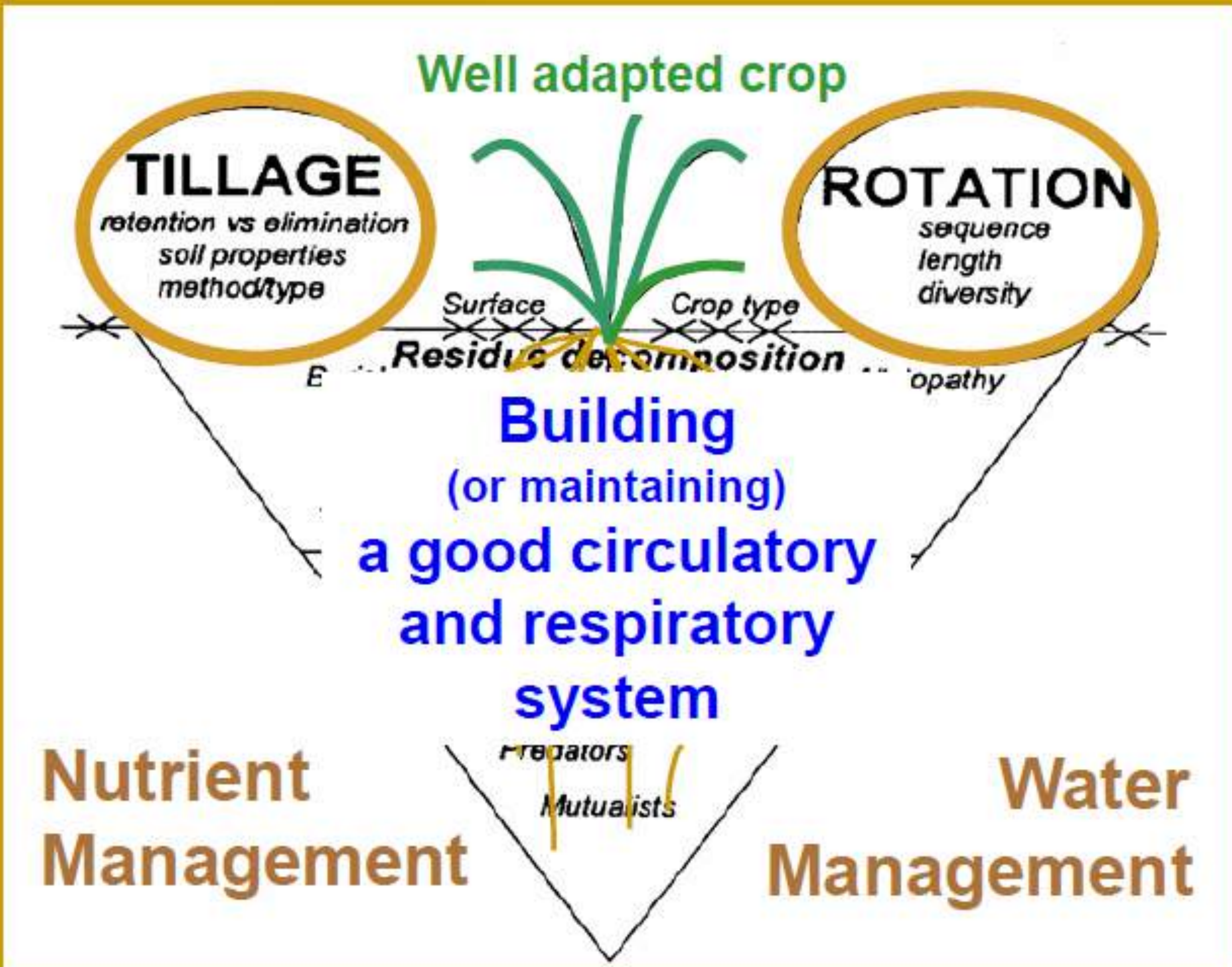
Chemical Fertility

+

Physical Fertility

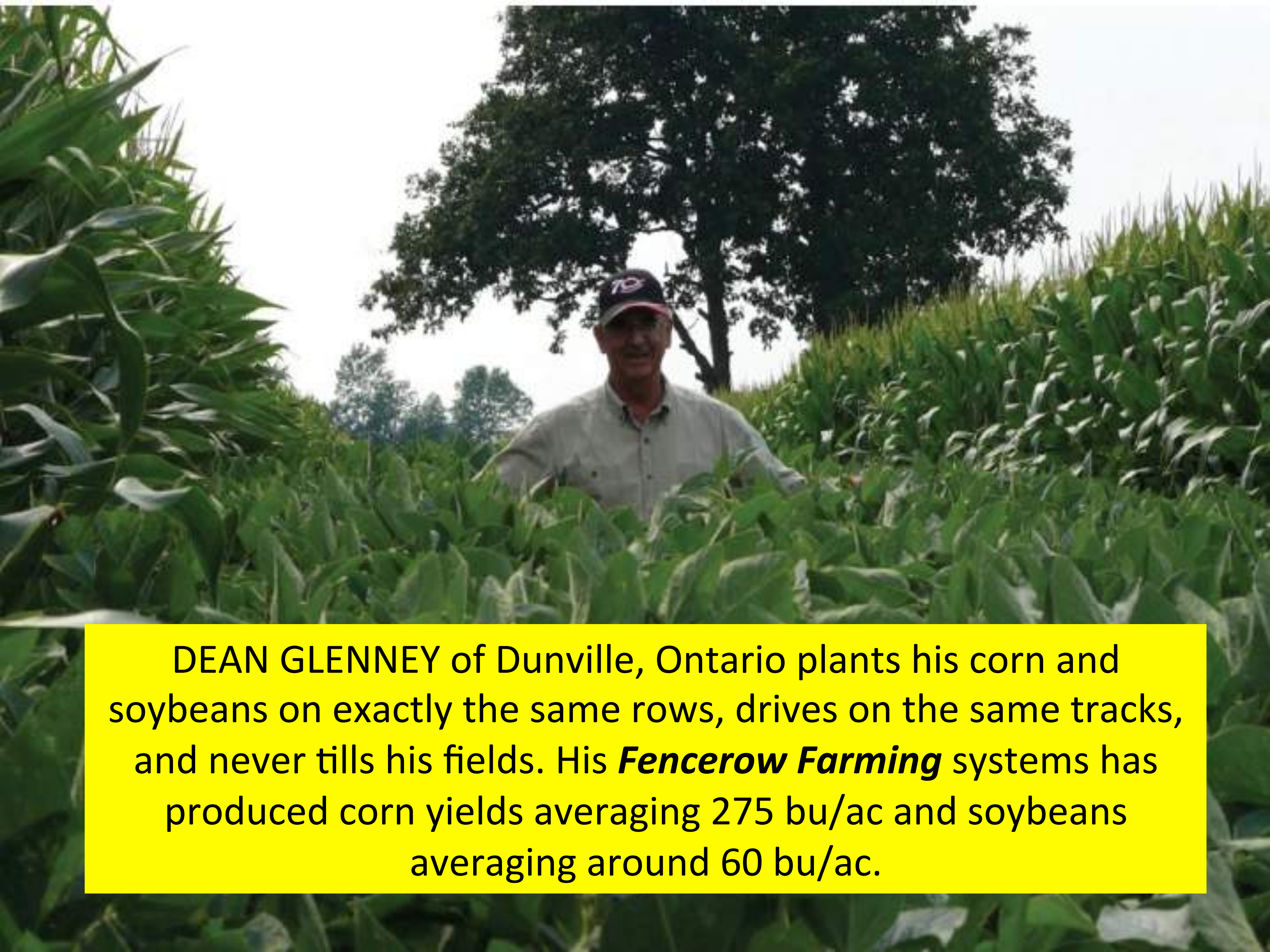
Fertility

A balanced approach to soil management



Adapted from Bailey and Lazarovits (2003)


Small increases in OM can improve crumb structure
Superior air/water relationships
Healthier root growth and function

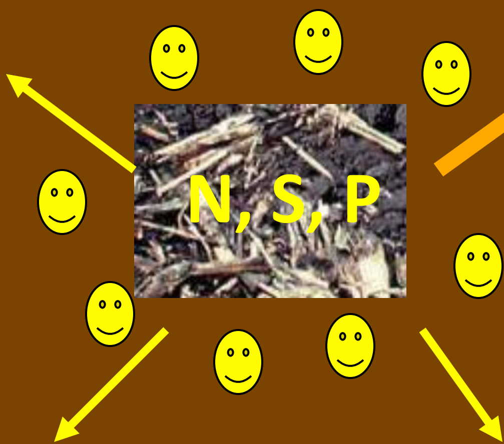


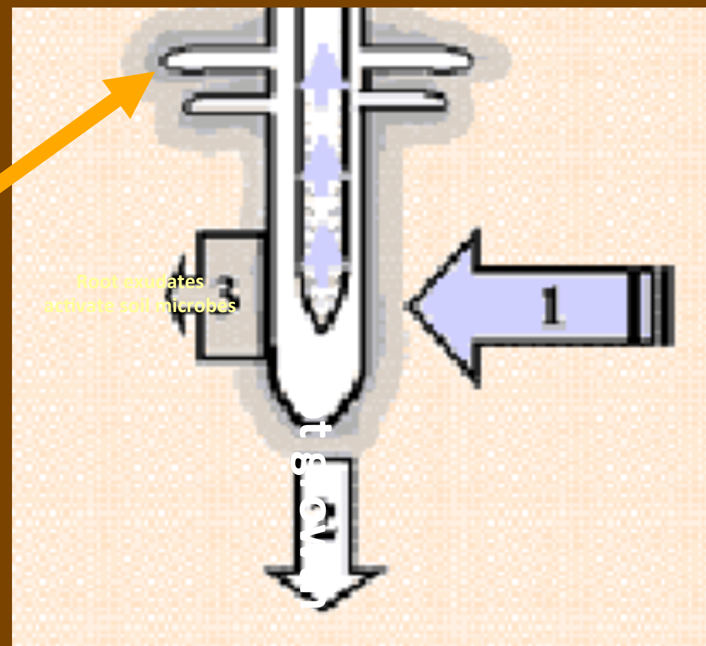
DEAN GLENNEY of Dunville, Ontario plants his corn and soybeans on exactly the same rows, drives on the same tracks, and never tills his fields. His ***Fencerow Farming*** systems has produced corn yields averaging 275 bu/ac and soybeans averaging around 60 bu/ac.

"One of the things that pops up immediately in our analysis is that Mr. Glenney's plants use up all of the fertilizer almost within 70 days after planting. So some way this plant is sucking up all of the nutrients, but we're not sure why yet" "The other field still has quite a lot of fertilizer remaining even at the end of the season. It just doesn't get used. One of the fundamental things that's happening is in one field the root system must be more efficient in taking up the nutrients."

Dr. George Lazarovits

The ins and outs of root function





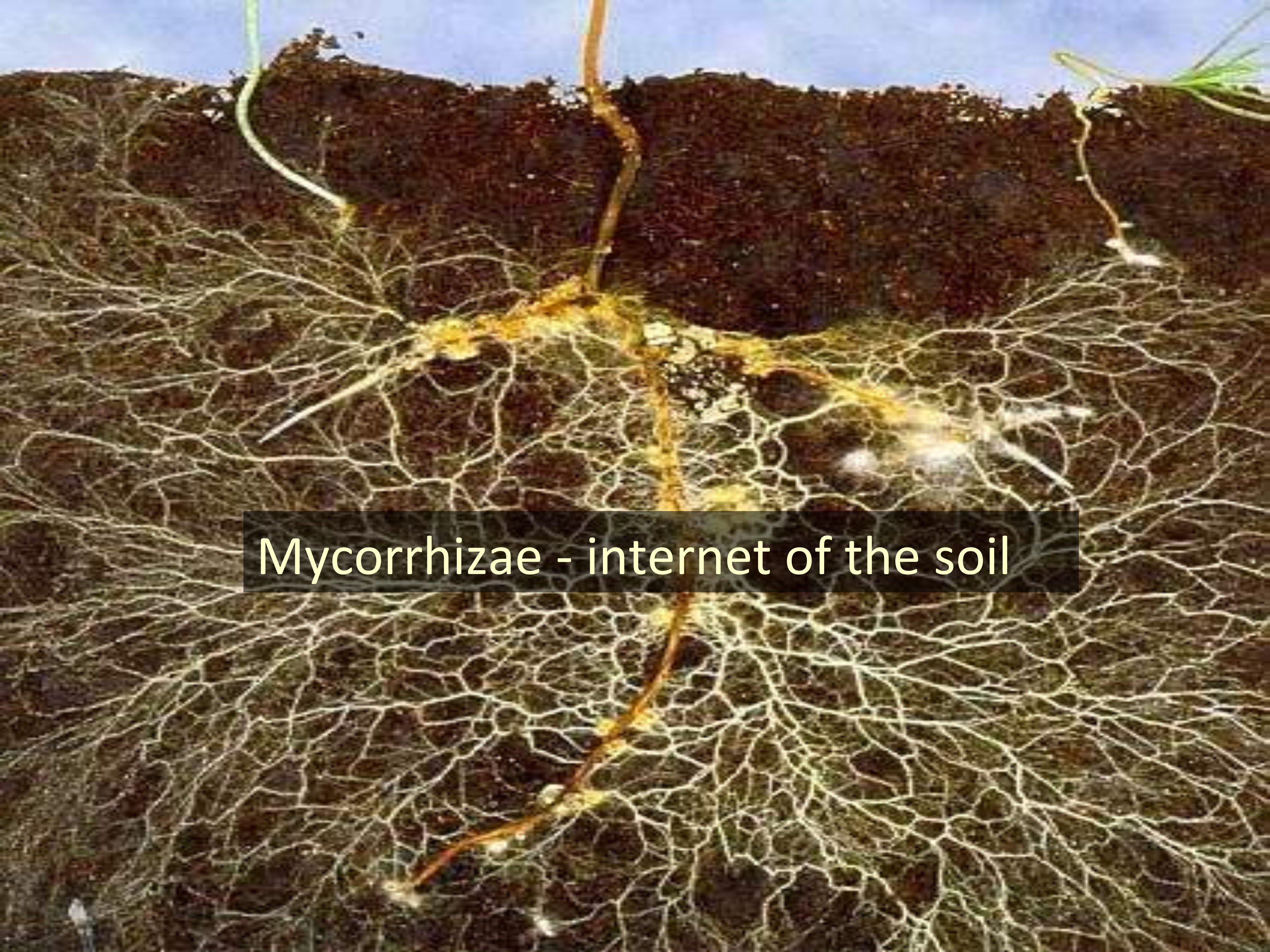
H_2O

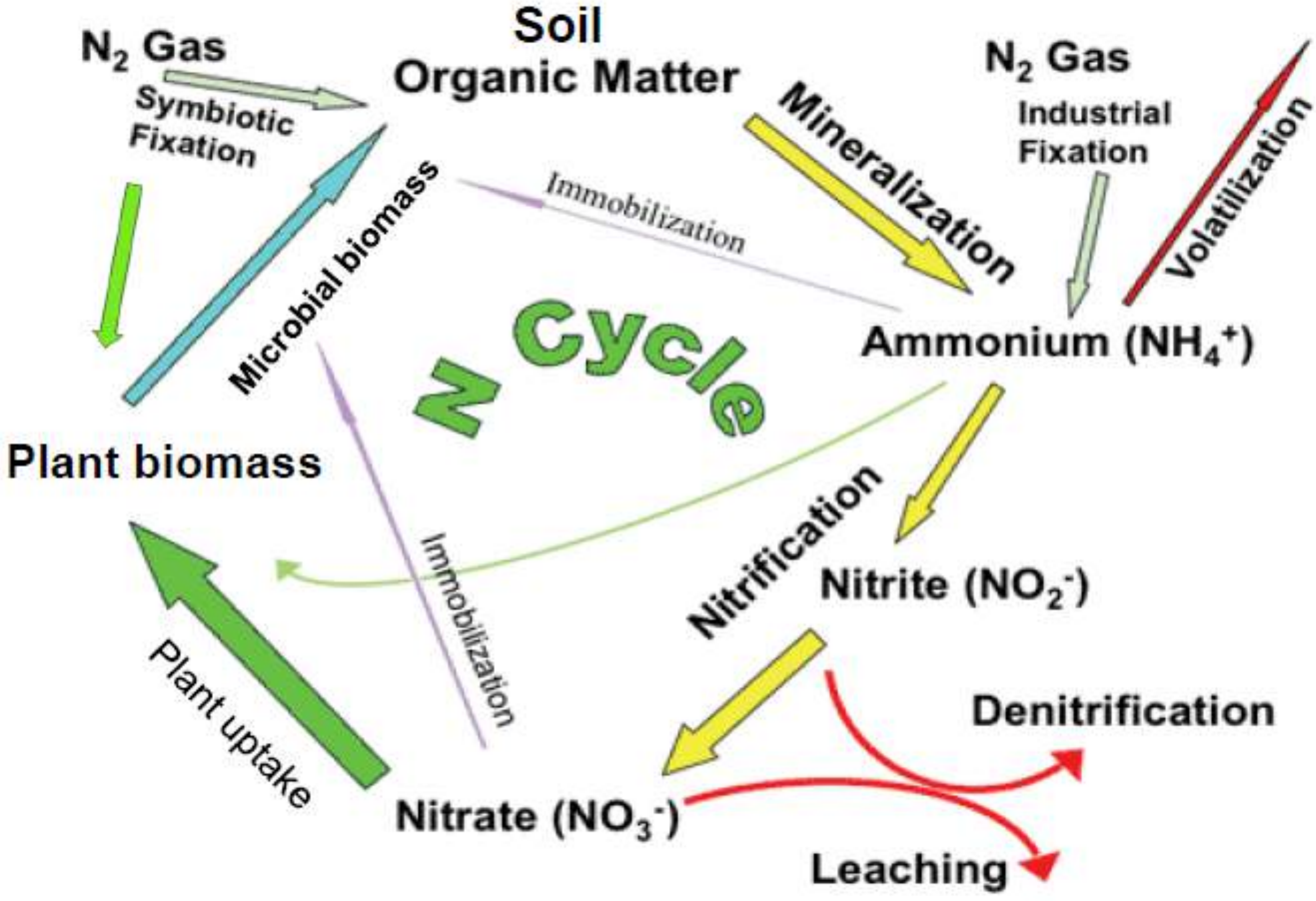
Transpirational stream

H_2O

Diffusion

Microorganisms produce most but not all of the enzymes need to digest OM

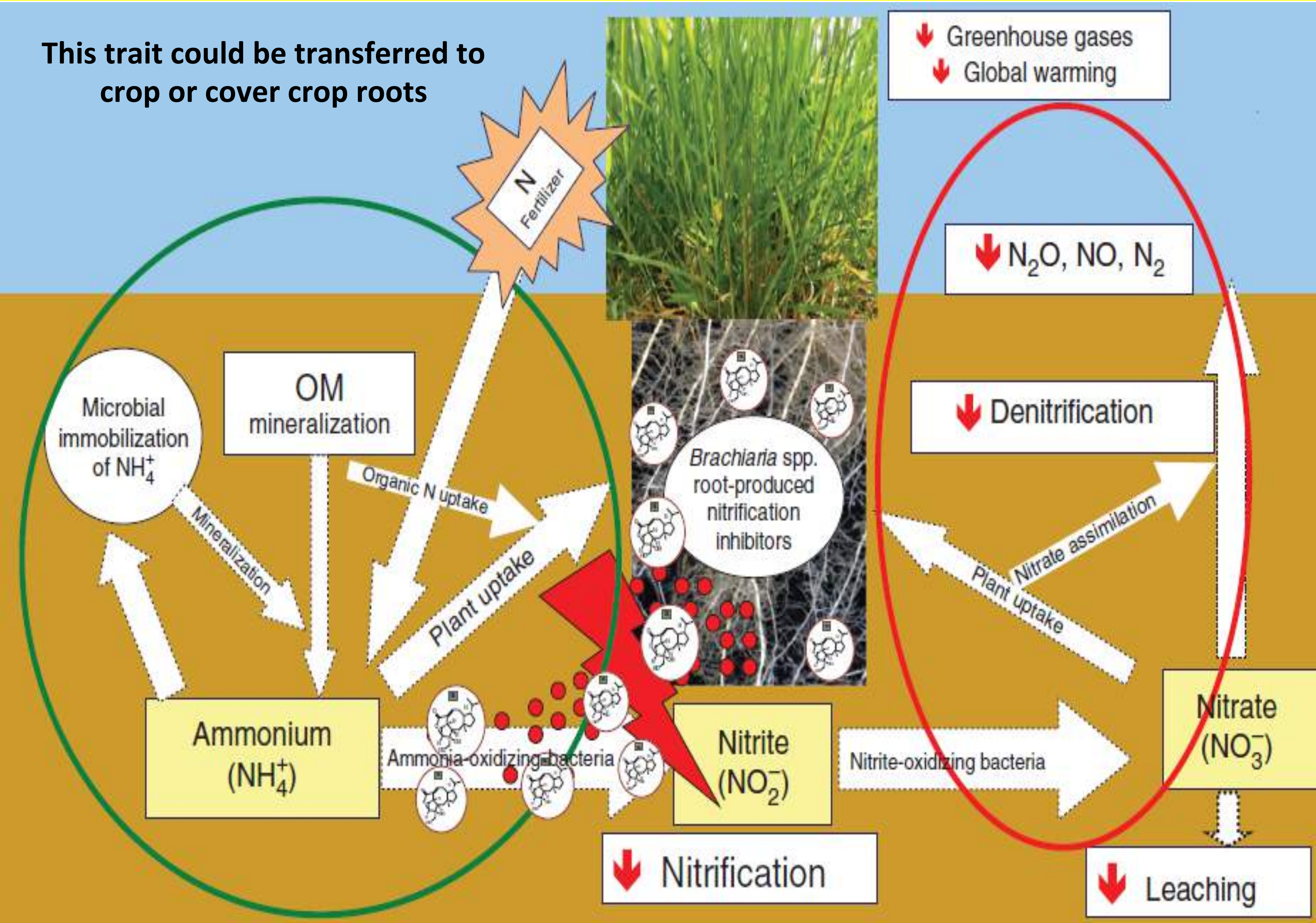

Mycorrhizae - internet of the soil

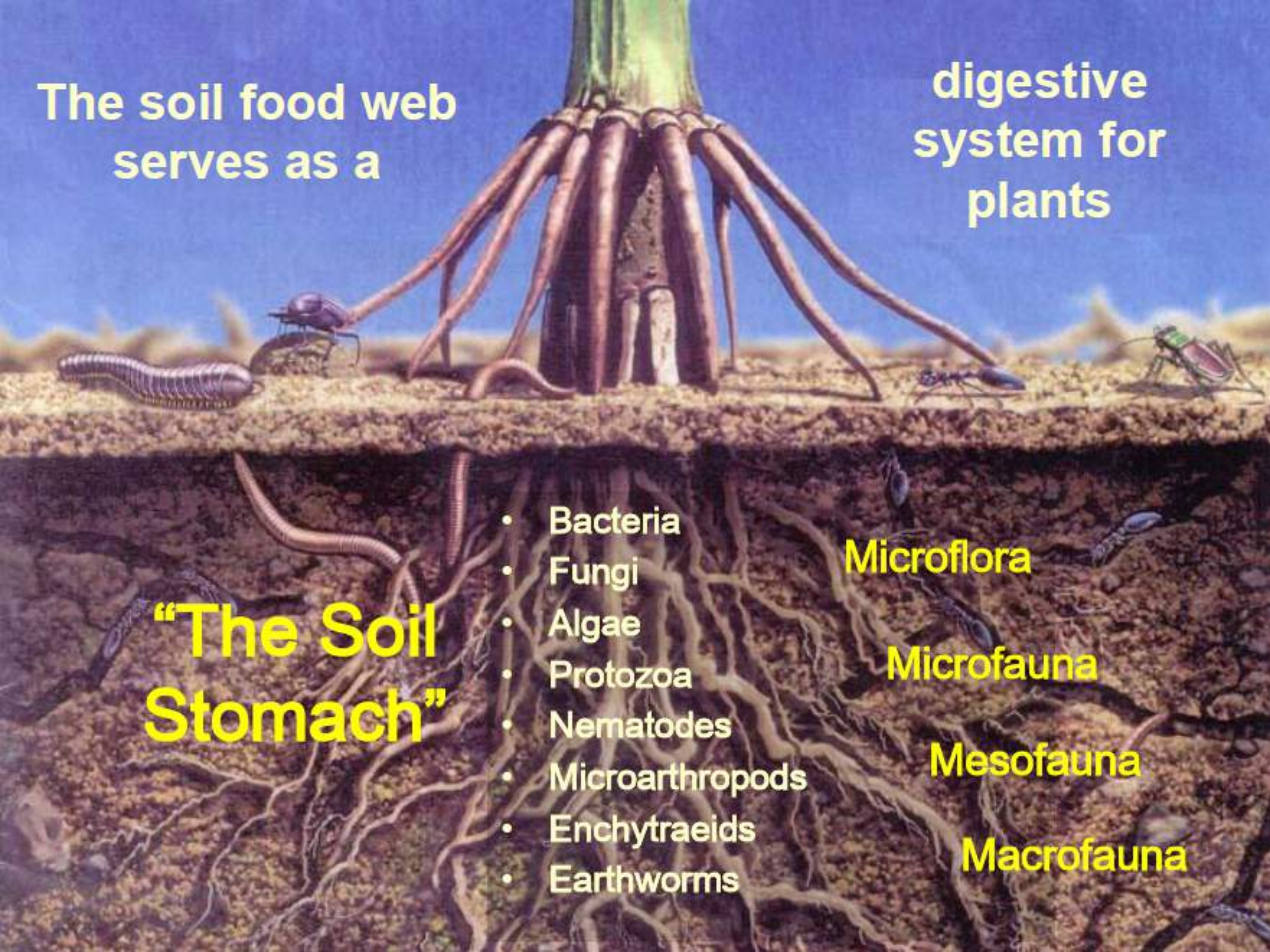


N$_2$ Gas
Symbiotic Fixation
Soil Organic Matter
Microbial biomass
Immobilization
Mineralization
N$_2$ Gas
Industrial Fixation
Volatilization
N Cycle
Ammonium (NH_4^+)
Plant biomass
Nitrification
Nitrite (NO_2^-)
Immobilization
Plant uptake
Denitrification
Nitrate (NO_3^-)
Leaching

The root systems of natural vegetation often inhibit nitrification

This trait could be transferred to crop or cover crop roots




The soil food web serves as a
digestive system for plants
"The Soil Stomach"
• Bacteria
• Fungi
• Algae
• Protozoa
• Nematodes
• Microarthropods
• Enchytraeids
• Earthworms
Microflora
Microfauna
Mesofauna
Macrofauna

Direct effects of cover crops on nutrient cycling

- Trap nutrients that would otherwise "leak out" during fallow periods
    - leaching <u>through</u> soil
    - losses as eroded soil or runoff

- Release nutrients later—potentially at the time needed by the next crop

- Fix N from atmosphere (legumes)

- Translocate nutrients from deeper in subsoil, to near surface after cover crop death

Indirect effects of cover crops on nutrient cycling

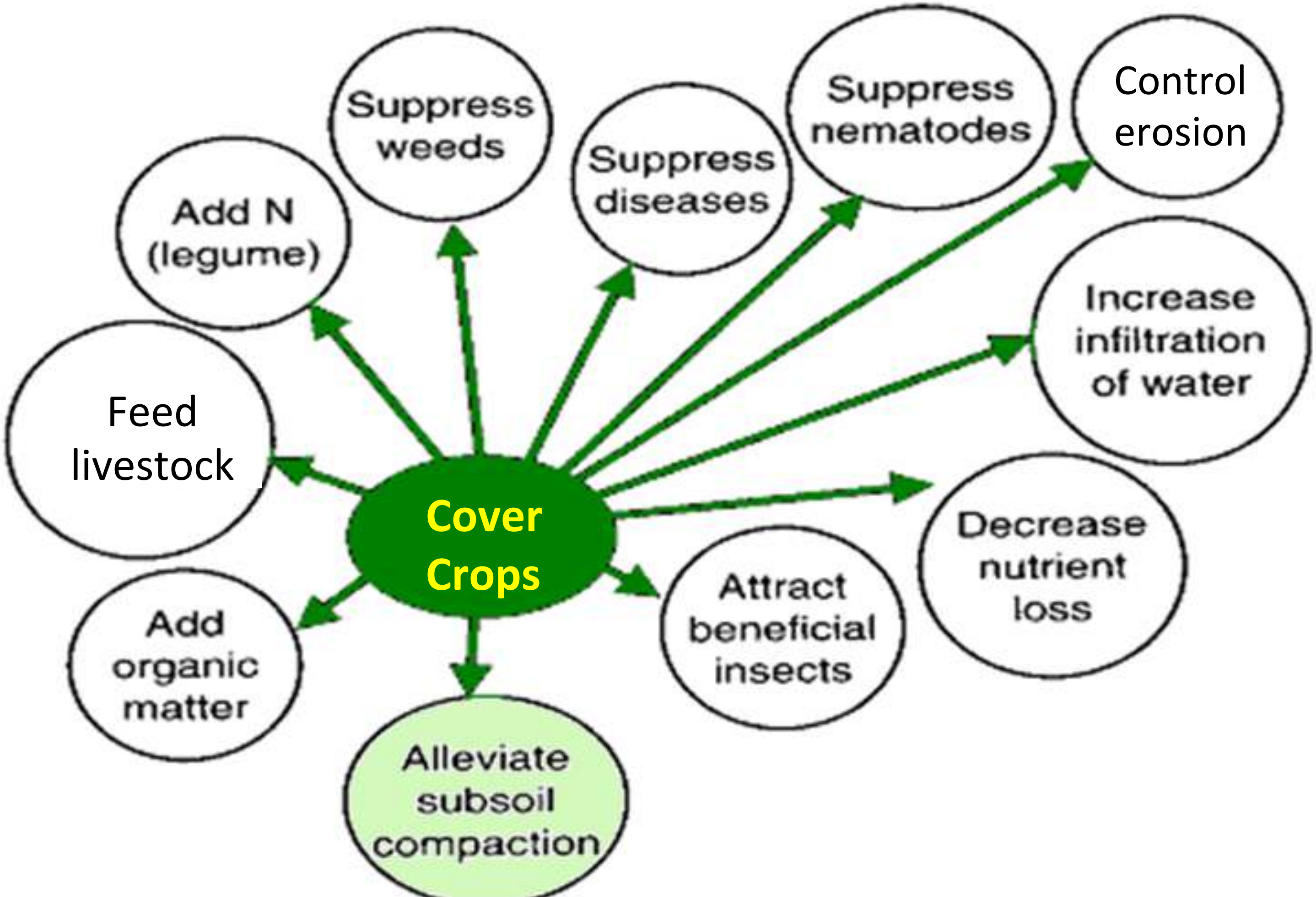
- Increase overall soil biological activity accelerating cycling of nutrients of soil organic matter and soil minerals

- Increase populations of specific root symbionts (e.g. mycorrhiza)

- Create biopores enhancing air and water movement and root growth and function in subsequent crops

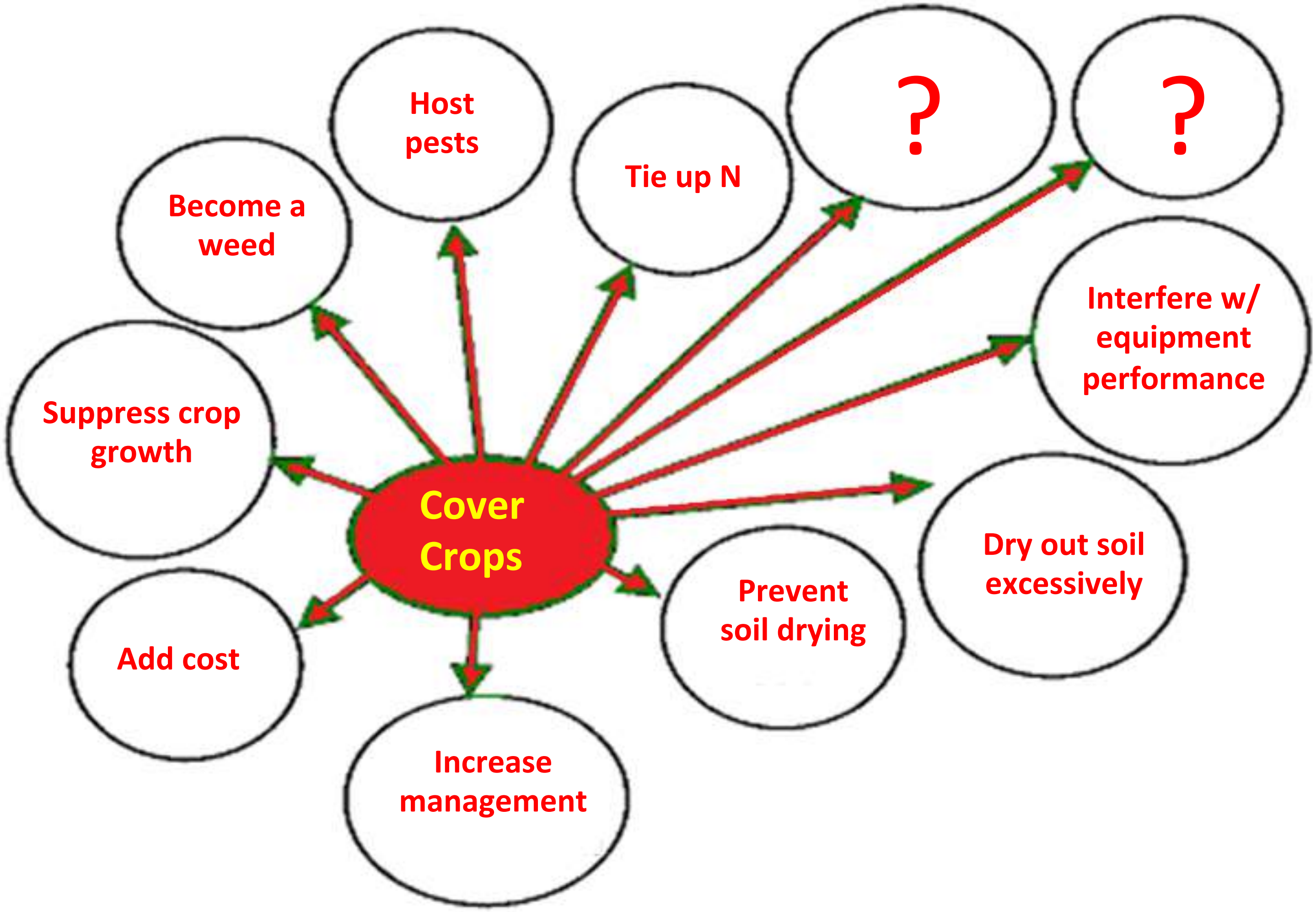
- Build soil organic matter at soil surface and throughout soil profile

CCs affect many agronomic factors simultaneously



Adapted from Magdoff and Weil (2004)

Not all effects are positive



Adapted from Magdoff and Weil (2004)

Match CC objectives with species

GRAZING = #1 way to make cover crops pay!

brassicas, clovers, small grains, a. ryegrass, sorghum-sudan

Nutrient scavenging/cycling

brassicas, small grains, annual ryegrass

Bio-drilling

brassicas, sugarbeet, sunflower,
sorghum-sudan **sweet clover, alfalfa**

N-fixation

clovers, vetches, lentil, winter pea, chickling vetch, sun hemp, cowpea, soybean

Bio-activation/fumigation

brassicas, sorghum-sudan, sun hemp, sesame

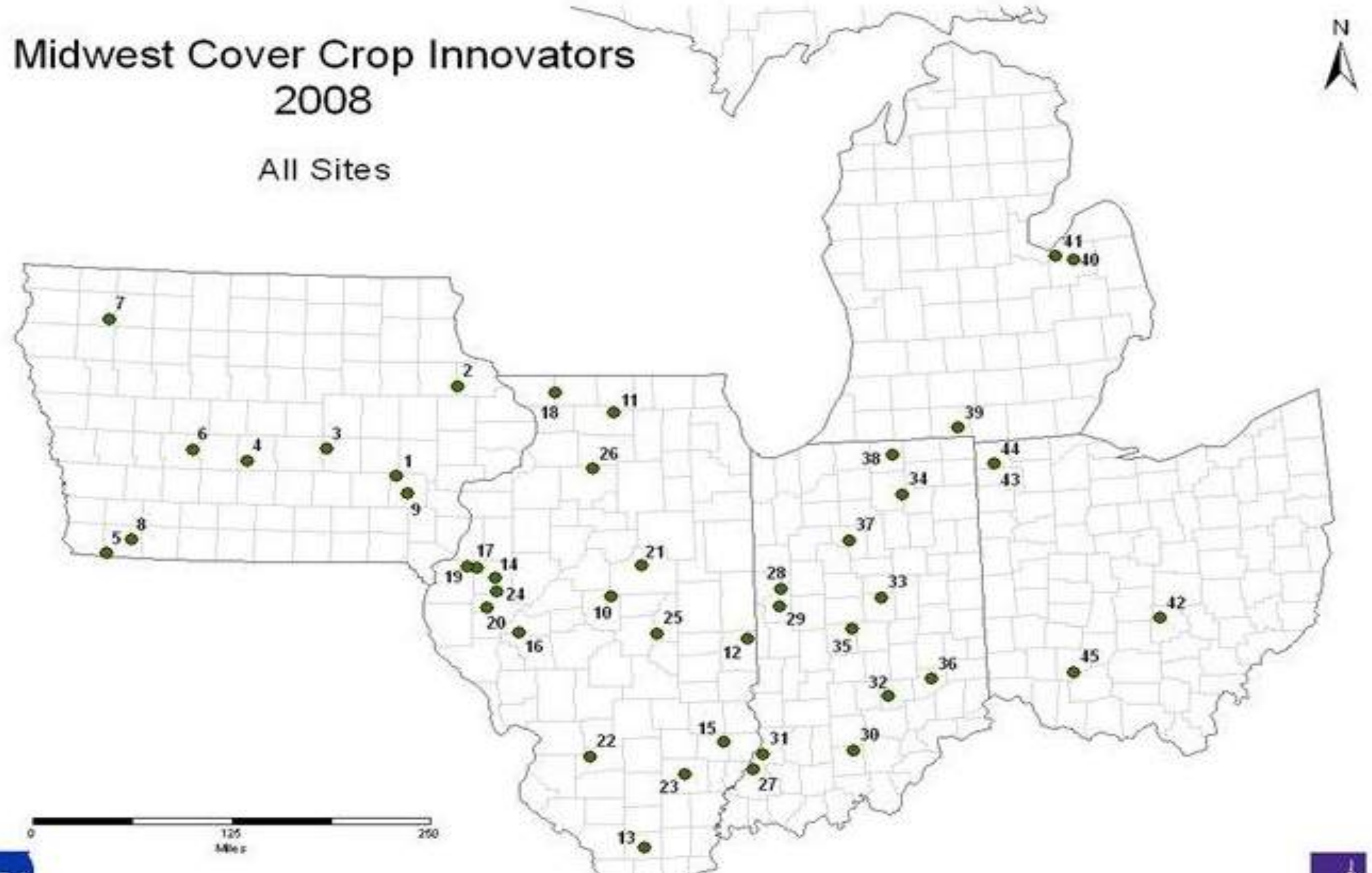
Weed suppression

brassicas, sorghum-sudan, cereal rye, buckwheat

Reduce Risk

- Enroll in programs that pay you to plant CCs
- Use time tested CC methods
- Use more than one method of planting CCs
- Plant mixtures/cocktails
- Grow some crops e.g. small grains, vegetables, corn silage, shorter season hybrids/varieties that are harvested early
- Plan residual herbicide programs carefully
- Scout for insect pests that are attracted to residue
- Irrigate/fertilizer CC
- Capture CC value by grazing
- Adjust cropping system to improve CC performance
- Reduce fertilizer inputs modestly on an experimental basis

> 160 CC INNOVATOR PROFILES



Nutrient Management for Super High Yields

Wayne Tomhave
Jacksonville, IL

Reply New Post Forums List -> Crop Talk

Message format: Threaded Go

Jim

N IL - W WI etc

Posted 10/11/2010 12:35 (#1391385)

Subject: Fall fertilizer, spring strip till, tillage radishes & rocks (pics) - evolution of a system?

Quote Reply Alert

~ 12000 views

Wheat was harvested and then on August 4th he came back with his 24 row 30" Kinze planter equipped with our Dawn 1572 coulter combo and milo seed plates. He filled 12 boxes on one side of the planter with tillage radish seed and the other 12 boxes with Austrian winter peas.

He doubled back on 15" centers with RTK guidance on his Cat tractor and ended up with no-tilled alternating rows of tillage radishes and Austrian winter peas into wheat stubble. No fertilizer was used and glypho was sprayed right after the August 4th planting to kill any volunteer wheat. Radish was planted at 2.5 lb/acre and peas at 15 lb/acre

The stand was amazing! The pit showed these huge radishes breaking up the very hard top soil down to about 24" and into the subsoil. The tillage needed without bring up the rocks and with low (zero) hp required!

“This customer will strip till into these radishes for corn about the first of May with his 24 row Pluribus system on a Bauer 60 ft bar, banding P,K and 1/3 of his N as dry fertilizer with a Montag cart into the strip. Then come back and side dress the remaining 2/3 of his N with our 6000 on the same Bauer toolbar as liquid 28 or 32%. 30" beans will get fall fertilizer into corn stalks and spring strip till to give a warm, cleared, fertilized seedbed.

The system these folks are evolving finally came into focus for me - the parts all fit together: A Wheat-Corn-Bean rotation with "tillage" done via RADISHES (!!) into the wheat stubble every third year! All done with a single 60 ft 30" planter, RTK and one 60ft toolbar

I came away from there thinking I have seen the future of production agriculture, at least in some areas”


Precision radishes w/o peas
Precision planted radishes w/ peas from 5 ft of row
Radishes with peas were ~20% larger


What are these roots doing that is
NOT accomplished by a steel shank?
Steve Carruther's farm
in Ontario, Canada

Impact of winter-killed cover crops on *in-row* soil test P and K

Mustard

Inter-row soil test P - 56

In-row soil test P - 60

Inter-row soil test K - 482

In-row soil test K - 1014

Tillage Radish

Inter-row soil test P - 62

In-row soil test P - 78

Inter-row soil test K - 372

In-row soil test K - 948

Oat

Inter-row soil test P - 60

In-row soil test P - 72

Inter-row soil test K - 384

In-row soil test K - 538

Phacelia

Inter-row soil test P - 72

In-row soil test P - 84

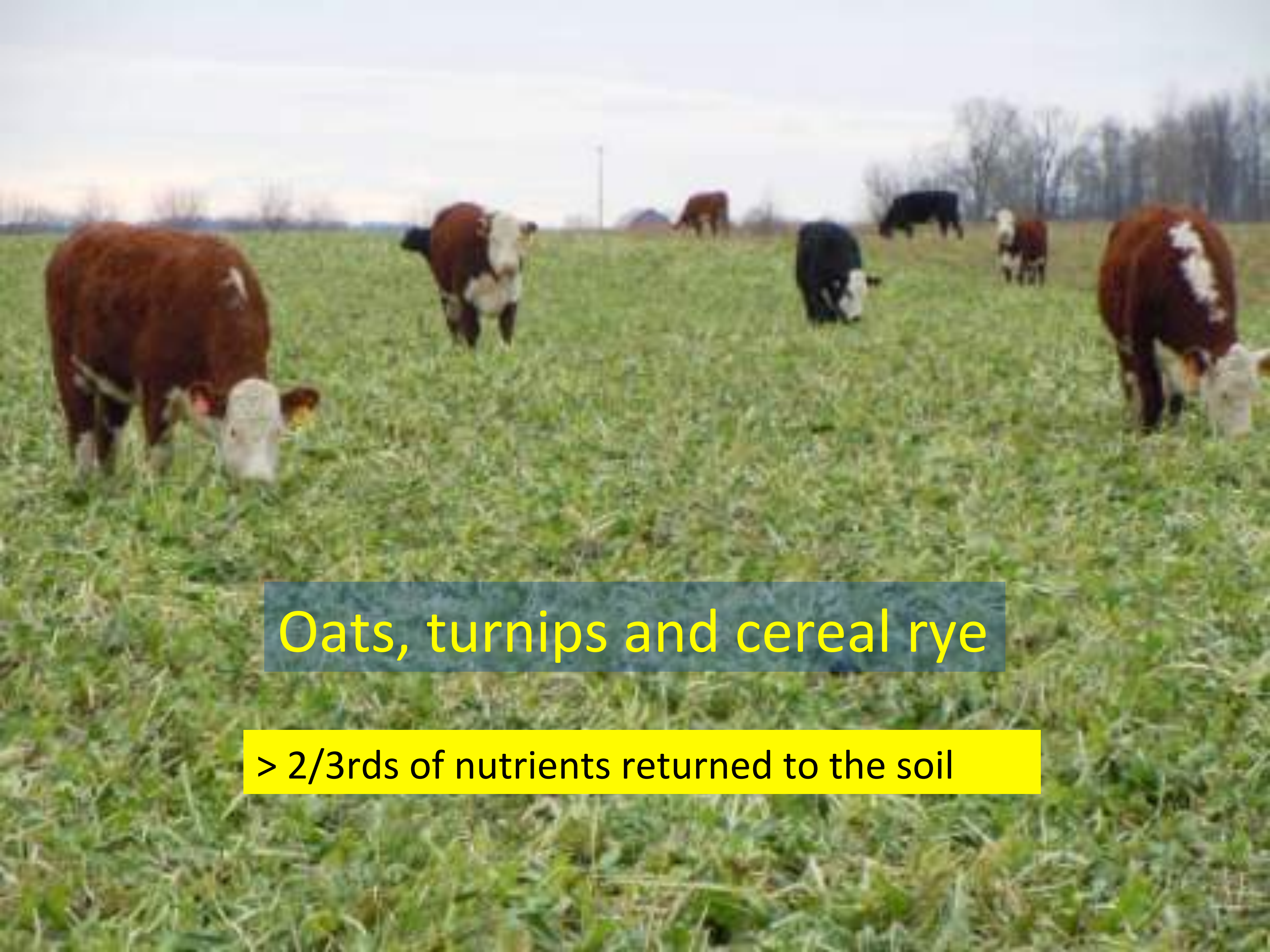
Inter-row soil test K - 454

In-row soil test K - 506

All #s are lbs/a Mehlich 3 extractable nutrients as reported by Key Agricultural Services here in Macomb, IL


Crimson clover
Chick peas
We are using small plots to identify cover crops that play well together
Green lentils
Fava beans

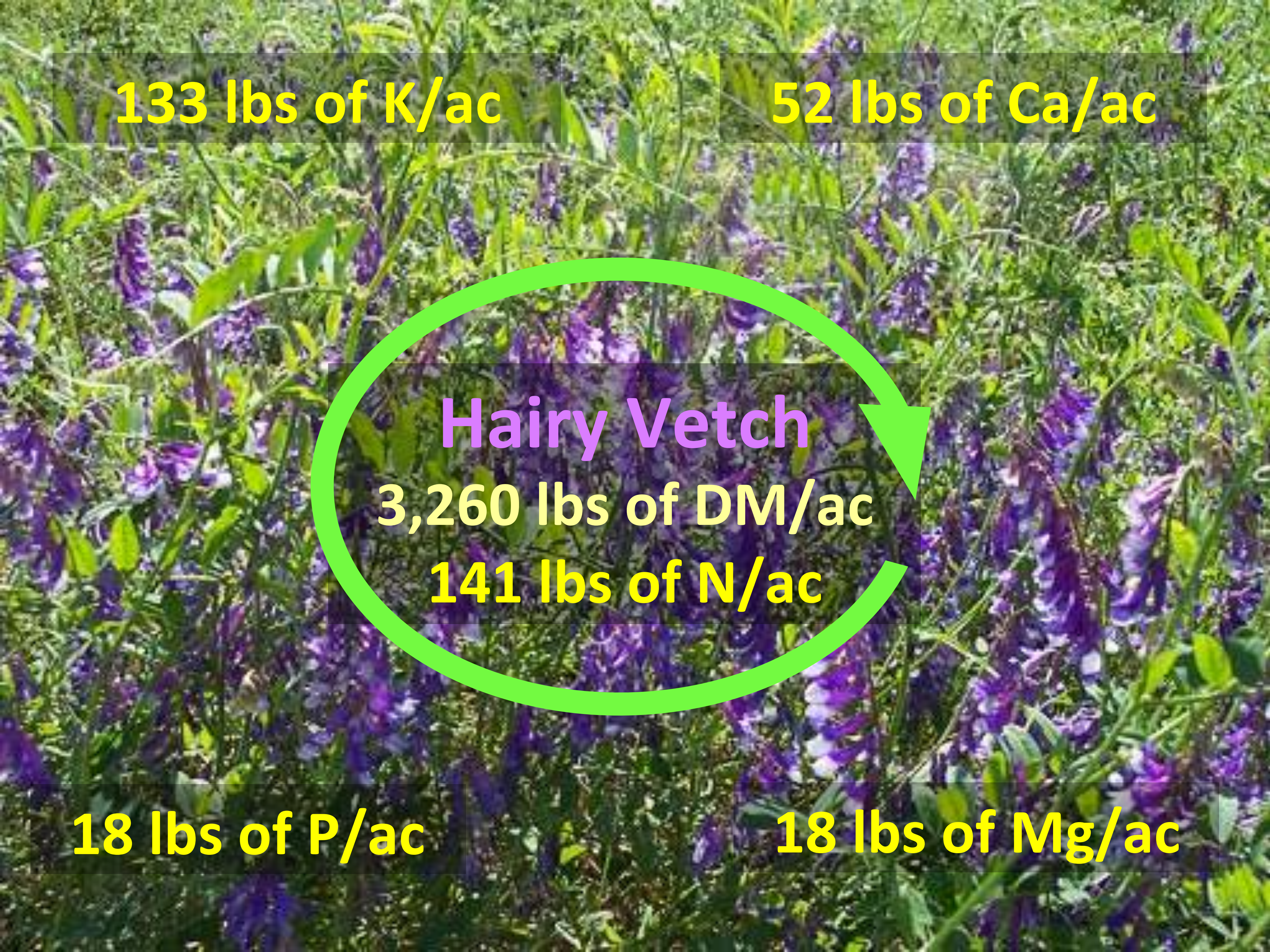

Do you want
both species to
winter kill?


Oats, turnips and cereal rye
> 2/3rds of nutrients returned to the soil

Optimizing fertility for CC

- Inoculate legumes
- Inoculate non-legumes?
- Fertilize cover crops when residual fertility is low


HIGHEST OUTPUT
COMFORT GRIP


133 lbs of K/ac
52 lbs of Ca/ac
Hairy Vetch
3,260 lbs of DM/ac
141 lbs of N/ac
18 lbs of P/ac
18 lbs of Mg/ac


+20 lbs N/a

Fall cover crop biomass production as influenced by manure N application rate

	Manure N application rate (kg N ha^{-1})		
Cover crop species	0	134	266
	Cover crop biomass (kg ha^{-1})		
Red clover*	2180 a[+]	1965 a	2355 a
Oilseed radish	565 a	1085 ab	1290 b
Perennial ryegrass	1180 a	2250 b	2700 b
Oats	1340 a	2390 b	2520 b

* Average of fall and spring control plots

[+] Values with different letters are significantly different ($P < 0.05$)

"Weil's Law" of root/shoot ratio effects

1. If conditions above ground are limiting, the roots will suffer most.

e.g. late planting or crowding (above ground limit) decreases root/shoot ratio.

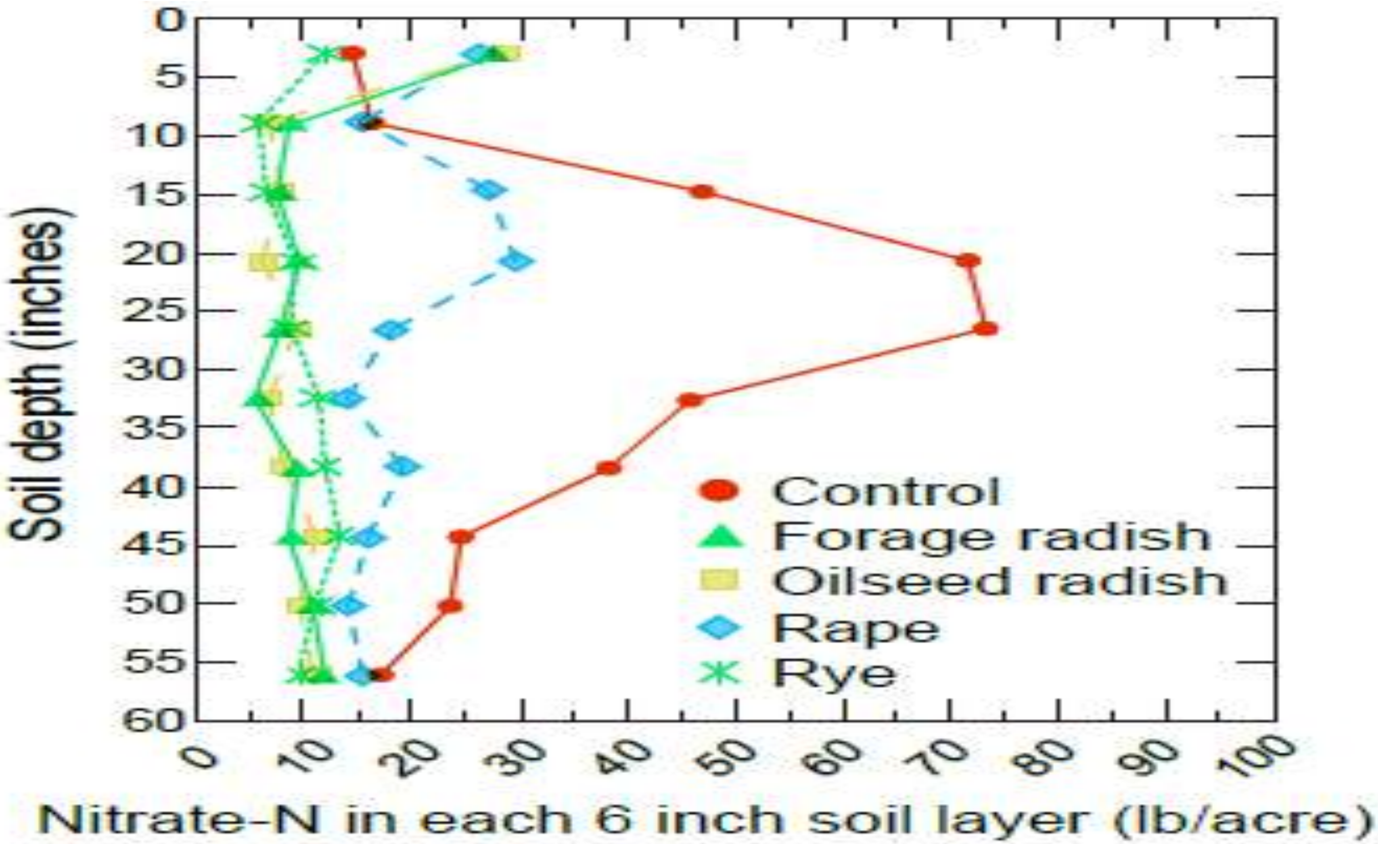
2. If conditions below ground are limiting, the shoots will suffer most.

e.g. N deficiency or drought (soil limit) increases root/shoot ratio

Because of their deep root system, rapid root extension, and heavy N feeding, radishes are excellent scavengers of residual N following summer crops . Radishes take up N from both the topsoil and from deeper soil layers, storing the N in their shoot and root biomass. With favorable fall growing conditions, radishes typically take up more than 100 lb/ac of N.

Without available N, radishes grow very poorly

Early planting of radish promotes high biomass production and associated nutrient accumulation but research at the University of Maryland has shown that **late planted radishes can still take up substantial quantities of N despite low biomass production due to shifts in plant C:N ratio** (Dean and Weil, 2009).



Forage radish and other cover crops clean up nitrate from a sandy soil profile by mid-November. Control soil had no cover crop, only winter weeds. (Data from Dean and Weil, 2009)

Unlike cereal rye and other small grains whose residues decompose slowly and continue to immobilize N for an extended period, radish residues decompose and release N rapidly.

Timely crop establishment following radishes can result in an early boost in growth and N uptake similar to following a legume cover crop or N fertilizer application.

In contrast, if planting is delayed and weather/soil conditions are conducive to leaching or denitrification, the availability of N scavenged by radishes to subsequent crops may be limited.

Pat Sheridan (Fairgrove, Michigan)

http://talk.newagtalk.com/forums/thread-view.asp?tid=73097&mid=521773#M521773

We've done some PSNT tests with and w/o fall seeded radish. **Kind of a moving target (year to year) in N credits, but I will say that we've always had a bigger credit following radish than what we had without.** That could be for a lot reasons. Weather, soil types, temp, etc. I've had an increase of almost 80#s of N using radish vs none, and I've had an increase of 20# vs none.

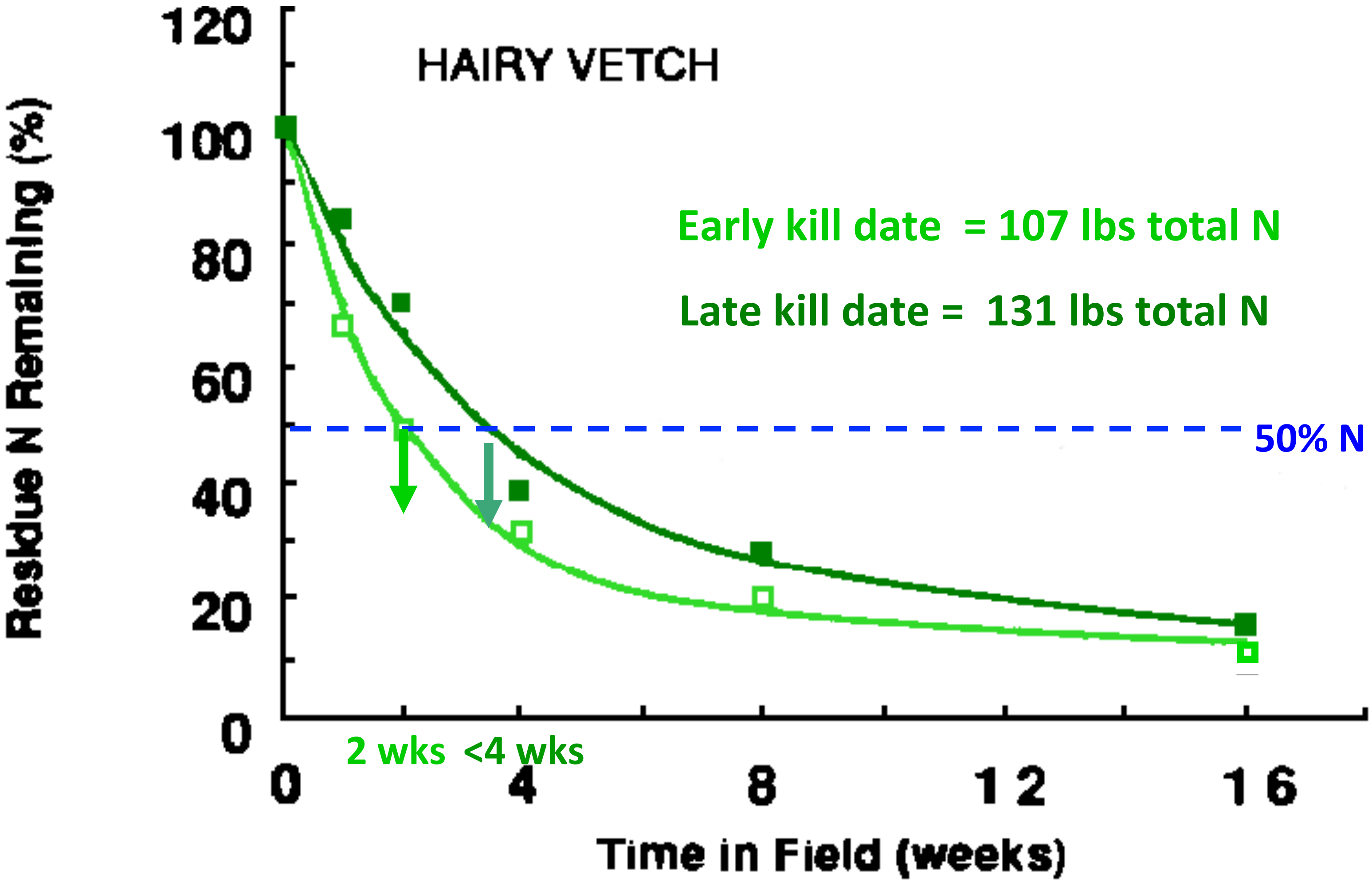
N credit is a very nice benefit of using a cover like radish, but I also like the other benefits from radish we've observed.

Radish effects on Soil Phosphorus and Potassium

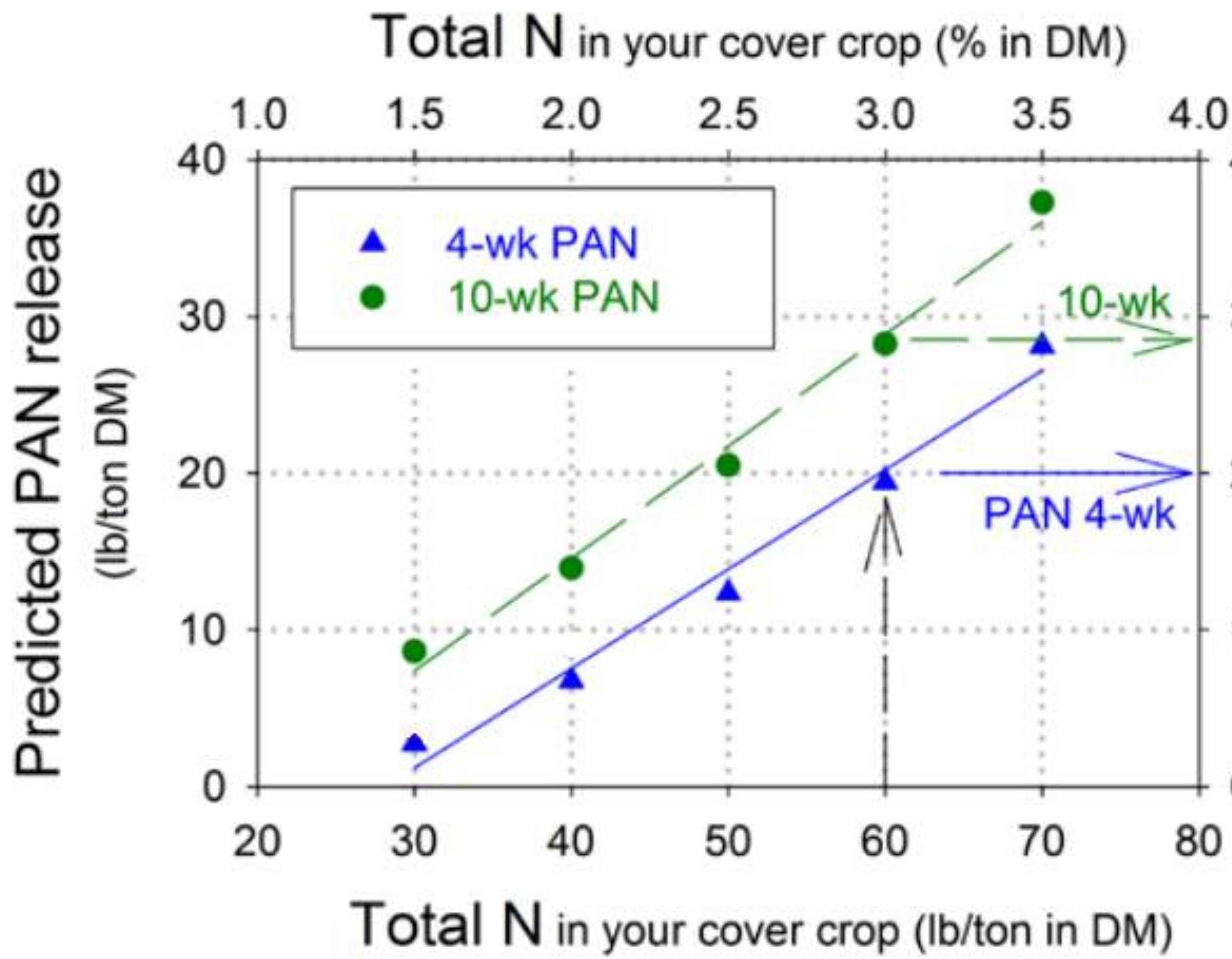
Radishes are excellent accumulators of P and K (root dry matter commonly contains more than 0.5% P and 4% K), and elevated levels of soil test P have been measured following radish cover cropping, particularly within 1–1.5 inches of radish root holes.

Despite radish being a non-host of mycorrhizal fungi, mycorrhizal colonization of corn following radish does not appear to be suppressed.

Understanding cover crops as nutrient sources

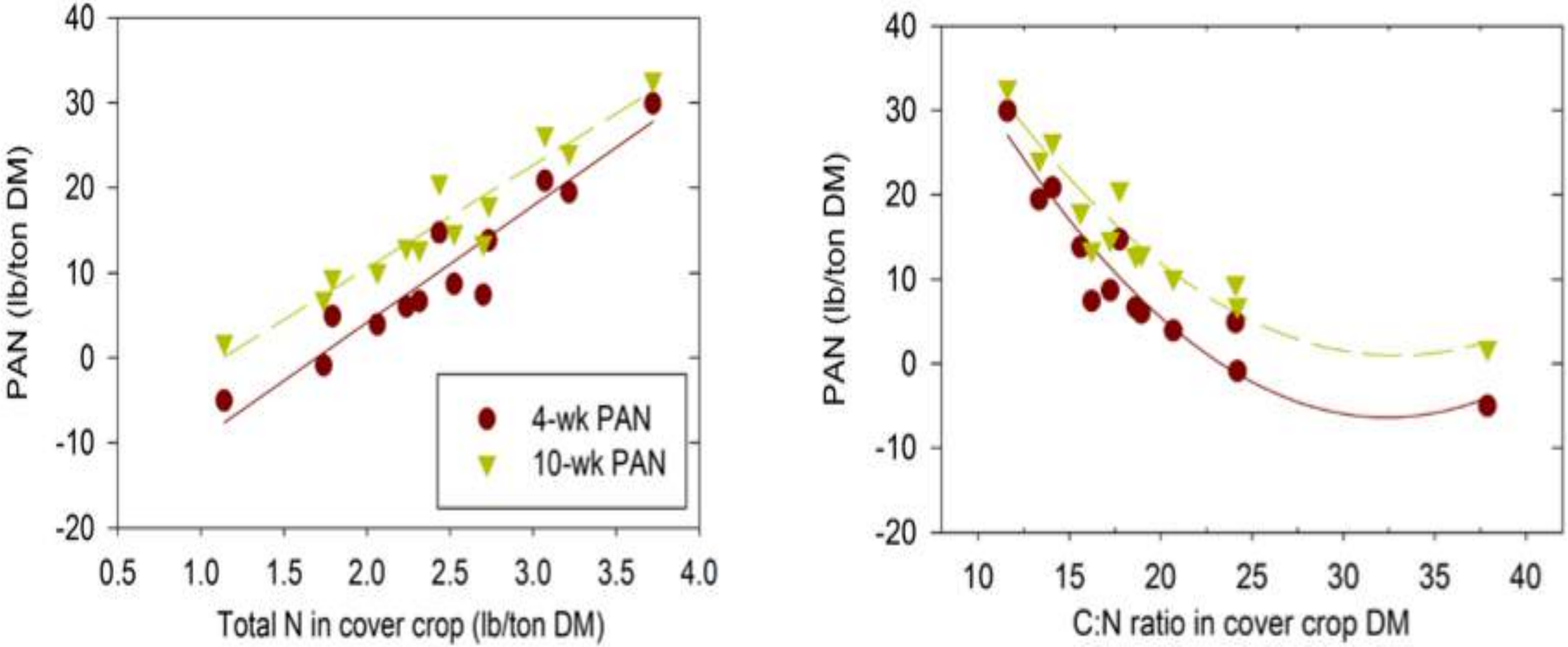


Wagger (1989)



Total N in your cover crop (% in DM)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Predicted PAN release
(lb/ton DM)
0
10
20
30
40
4-wk PAN
10-wk PAN
10-wk
PAN 4-wk
20
30
40
50
60
70
80
Total N in your cover crop (lb/ton in DM)

Higher N content = lower C:N ratio



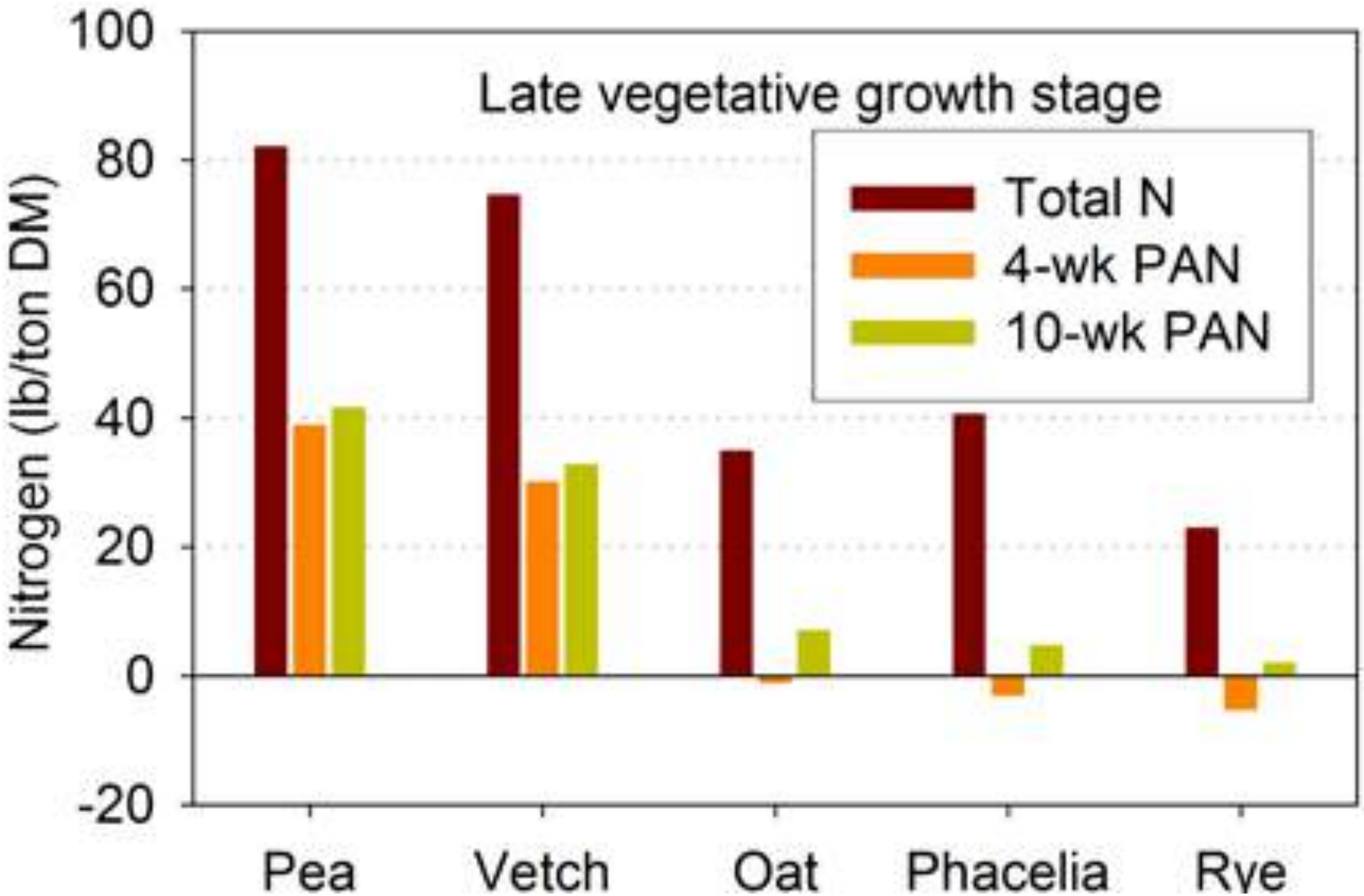

Late vegetative growth stage
Total N
4-wk PAN
10-wk PAN
Nitrogen (lb/ton DM)
100
80
60
40
20
0
-20
Pea
Vetch
Oat
Phacelia
Rye

Table 5.– Dry matter and N accumulation by winter cover crops in the mid-Willamette Valley, 1992–1995.[1,2]

Cover crop	4-year average		
	Dry matter	N uptake	N concentration
	ton DM/a	lb/a	% in DM
Non-legume			
Micah barley	1.6	50	1.6
Annual ryegrass[3]	2.6	40	0.8
Monida oats	2.7	50	0.9
Stephens winter wheat	2.7	60	1.1
Wheeler cereal rye	3.3	70	1.1
Juan triticale	3.6	60	0.8
Legume			
Fava bell bean	1.4	60	2.1
Austrian winter pea	2.0	120	3.0
Kenland red clover	2.1	100	2.4
Woolypod Lana vetch	2.2	150	3.4
Karridale subclover[3]	2.4	120	2.5
Hairy vetch	2.5	150	3.0
Common Dixie crimson clover	3.2	120	1.9

[1]Adapted from: Sattell et al., 1999, OSU Extension Service publication EM 8739.

[2]Cover crops were seeded in mid-September and irrigated after seeding. Dry matter and crop N uptake were measured in mid-April of the following year.

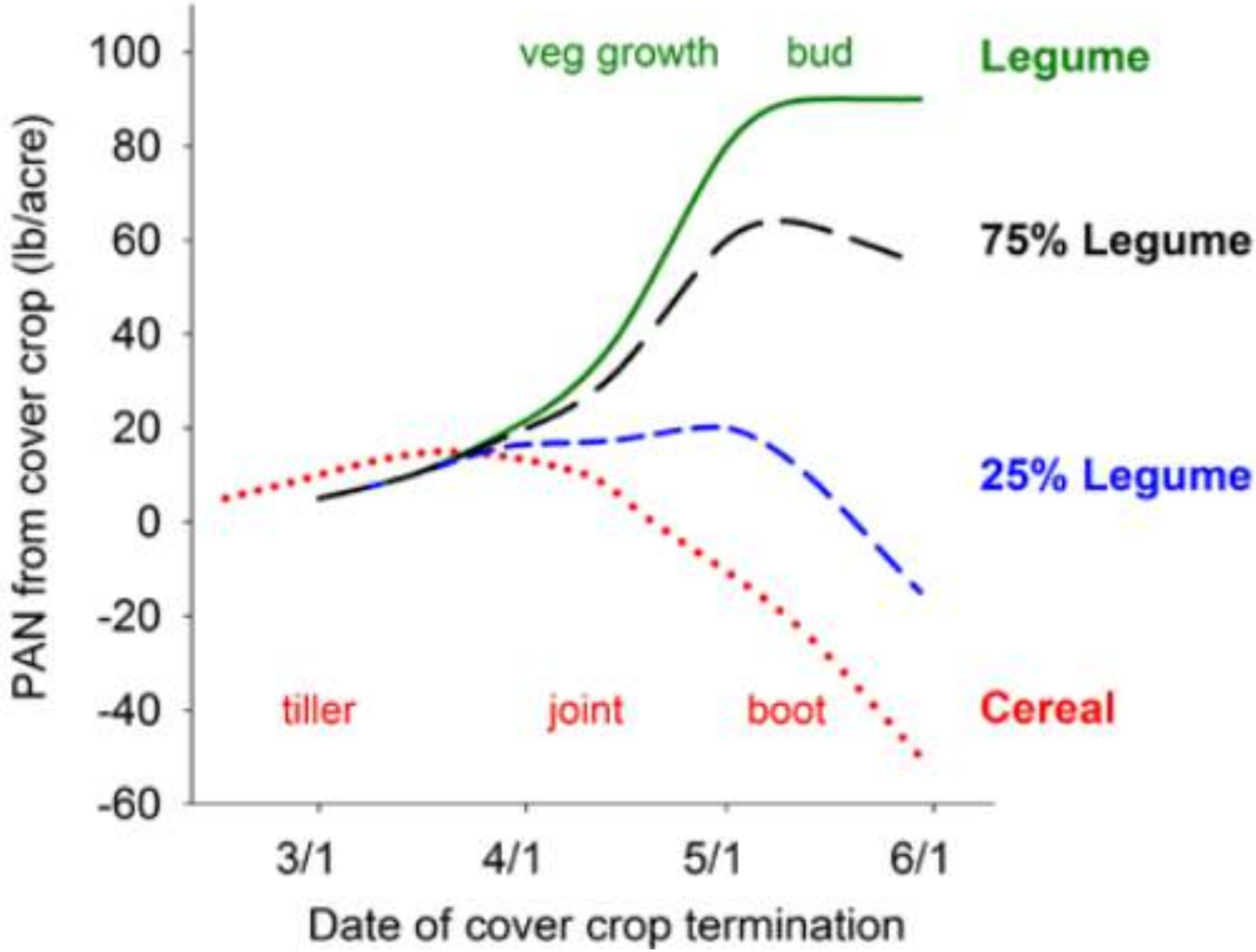
U of I on-farm covercrop research

(grain yields = bu/acre)

Location	Cover Crop	Grain Crop	0 lb N/ac	60 lb N/ac	180 lb N/ ac	240 lb N/ ac
Hortin	Hairy Vetch	Corn	169	184	180	184
Hortin	Fallow	Corn	105	142	162	164
Hortin	Rye	Corn	65	102	119	120
Hortin	Hairy Vetch	Sorghum	90	97	99	100
Hortin	Fallow	Sorghum	74	87	94	92
Hortin	Rye	Sorghum	54	72	77	74

http://frec.cropsci.uiuc.edu/1993/report13/table10.htm

Cereal rye often suppresses corn and sorghum yields



Effect of kill date on typical plant available N (PAN) release from cereal, legume, or mixed stands. Based on compilation of field data from Willamette Valley cover crop trials. Source: D. Sullivan


Have you ever collected CC biomass samples?

Measuring, monitoring and managing

JANUARY 1, 2008 GRAZING MANAGEMENT

Charles Fletcher uses pasture probe to improve bottom line

Purdy, Missouri — Especially when you're feeding the stuff, most of you closely monitor the bunker, silo, bin, mow, bag, baleage line or whatever else holds the stored feed. Probably you aren't quite as intense in keeping track of your inventory of growing pasture. With any experience you just know what's out there, and do fine without making things more complicated.

Charles Fletcher isn't out to convince you that you're wrong, but he's sure that what he's doing these days is right for him. Thousands of dollars in extra annual profit right.

A couple of years ago, Charles spent $475 on a New Zealand-made electronic plate meter that estimates pasture forage dry matter. His wife, Melissa, allocates three hours each week during the grazing season for taking dry matter readings on 46 paddocks at his 240-acre dairy here, one of two operated by the KBC Dairy partnership.

GrassMaster II Drymatter Instrument - Novel Ways Products

The GrassMaster II is a single-handed highly accurate and reliable electronic dry matter meter in the shape of a lightweight pasture wand.

The Grass Master II records the dry matter (DM) in kg/ha (or lb/acre) for up to 200 paddocks. It does this using the capacitance method. A low voltage electric field spreads out into the grass or growing material near the base of the probe, and changes in this field are strongly related to the water mass nearby, and by difference to the dry matter of the material.

There is a selection of grassland equations available, backed up by Tru-Test research. You can also use your own equation for specific crops, calculated using the cut-weigh-dry method. Novel Ways staff are working on a universal equation.

Results can be sent directly to your computer spreadsheet or feedbudget program. Visit our Downloads Page for some free trials.

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N Distribution of Legume Cover Crops

Crop	Tops (%N)	Roots (%N)
Peas	89	11
Clovers	68	32
Alfalfa	58	42

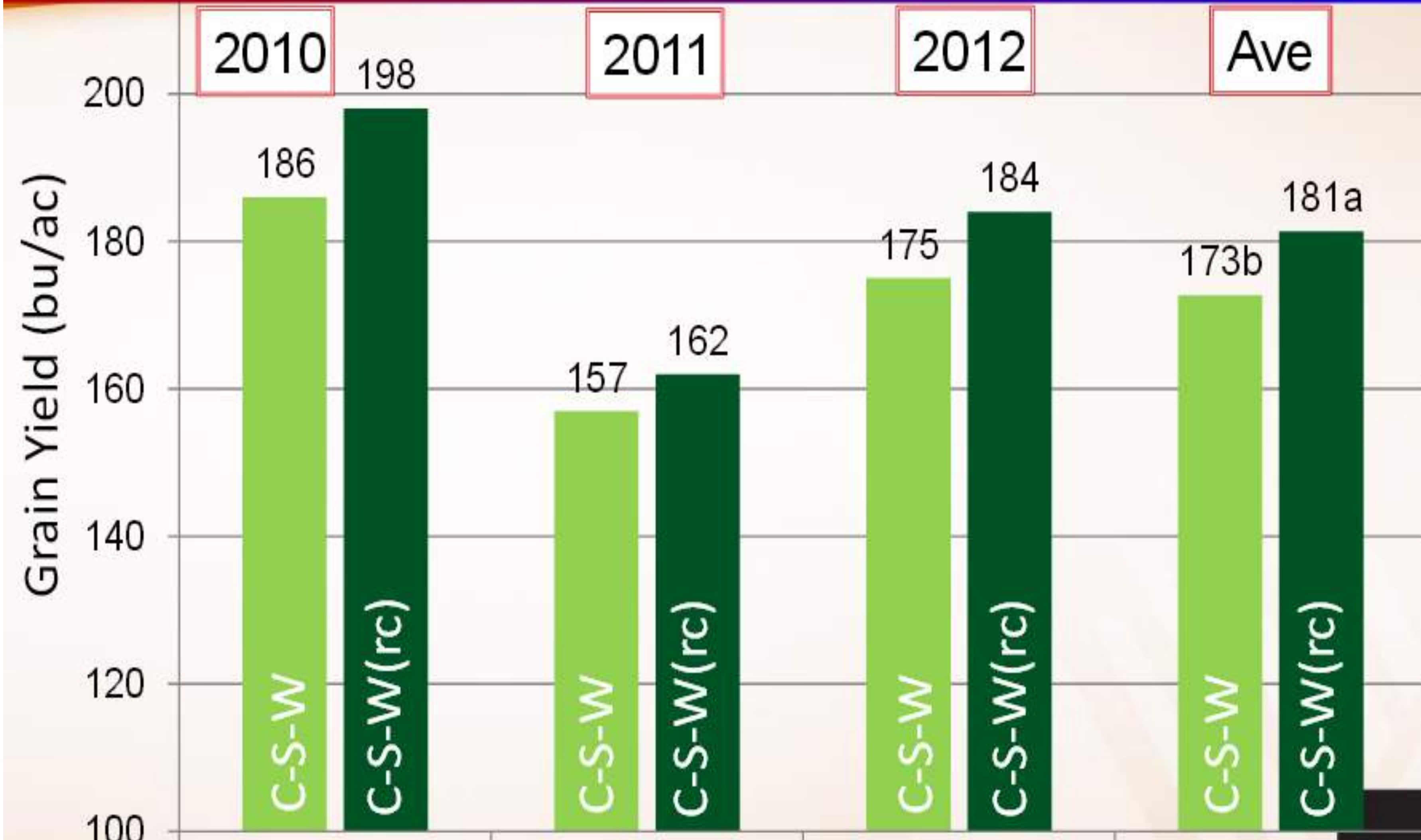
Adapted from MCCP

How much N can frost seeded red clover fix ??

Year	Legume	Lbs. DM/a	Total lbs. N/a
1991	Red clover	4456	128
1992	Red clover	3918	110
1993	Red clover	4125	119
1994	Hairy vetch	4459	146
1995	Red clover	3407	100
1996	Red clover	5049	147
1997	Hairy vetch	2110	84
1998	Red clover	4458	109
1999	Red clover	7607*	265
Mean		4399	134

Corn Yields after Wheat +/- Red Clover,

Ridgetown 2010-12



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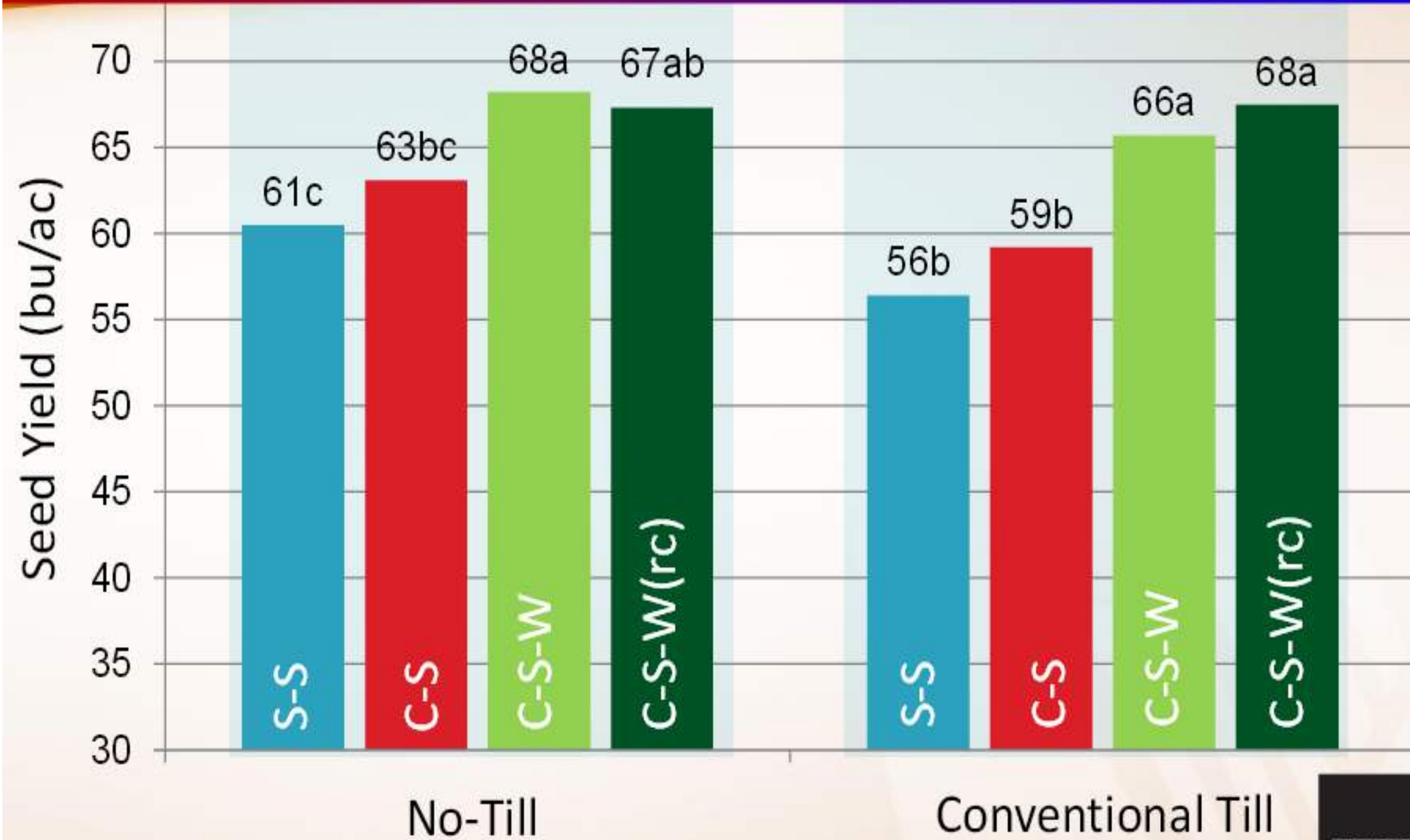
Soybean Yields with Wheat +/- Red Clover,
Ridgetown 2010-12



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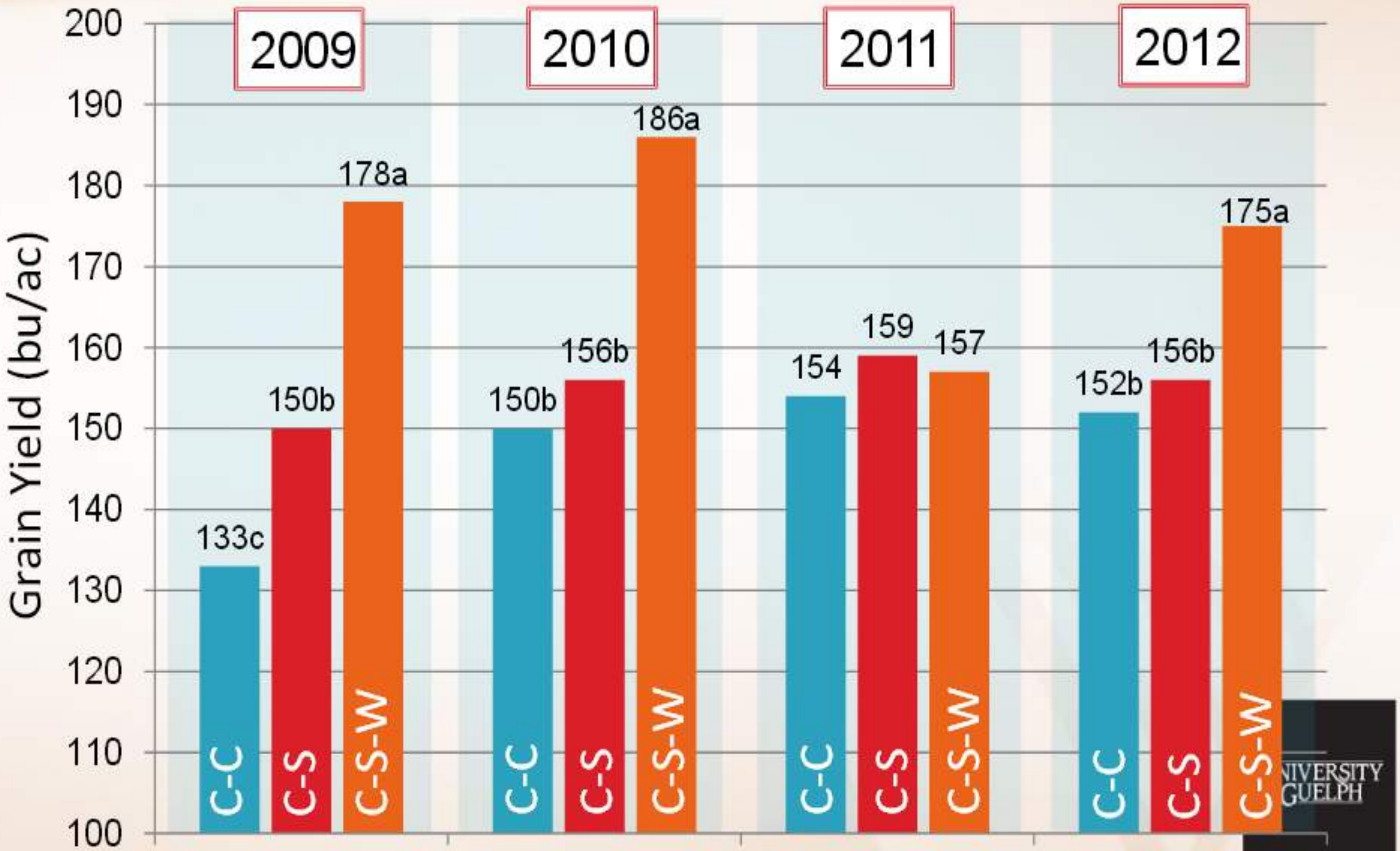
1. The "Rotation Effect"
Wheat on Corn Yields Ridgetown 2009-12



1. The "Rotation Effect"
Wheat on Soybean Yields Ridgetown 2009-12

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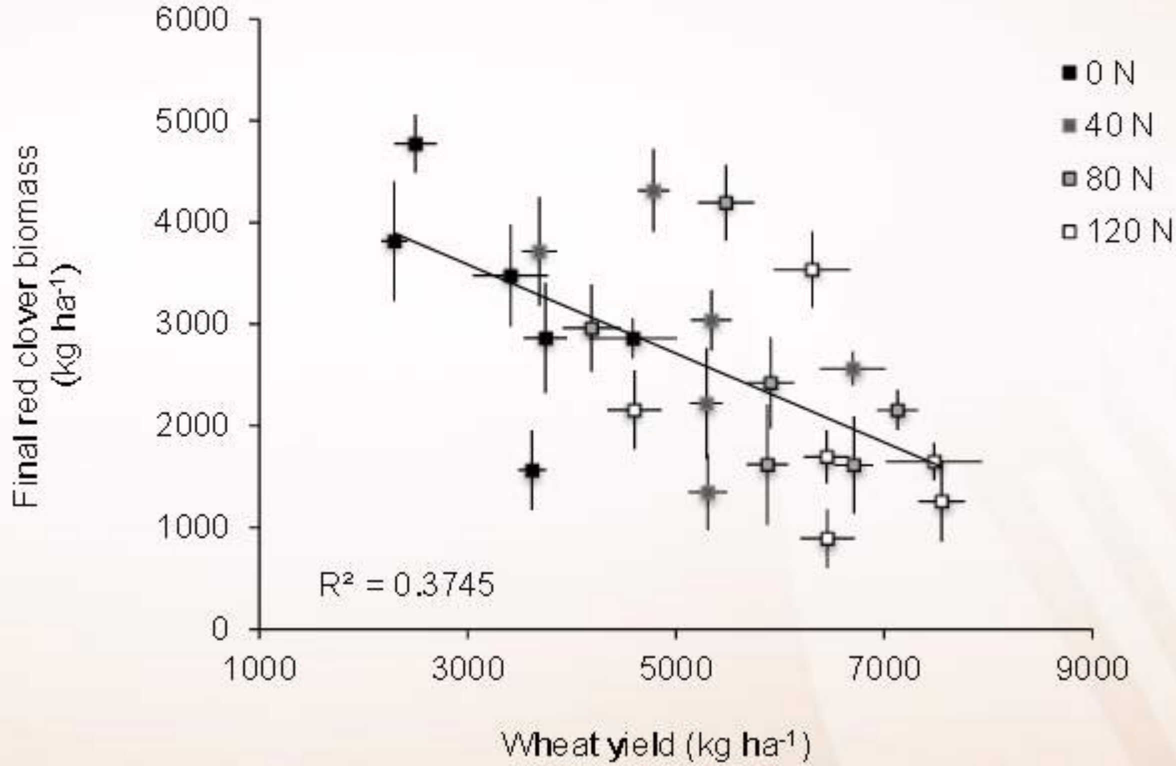
http://www.mccc.msu.edu/meetings/2013/Reports&Presentations2013/9Reconsidering%20red%20Clover%20B%20Deen.pdf

Plant Agriculture

Effect of wheat yield on red clover biomass



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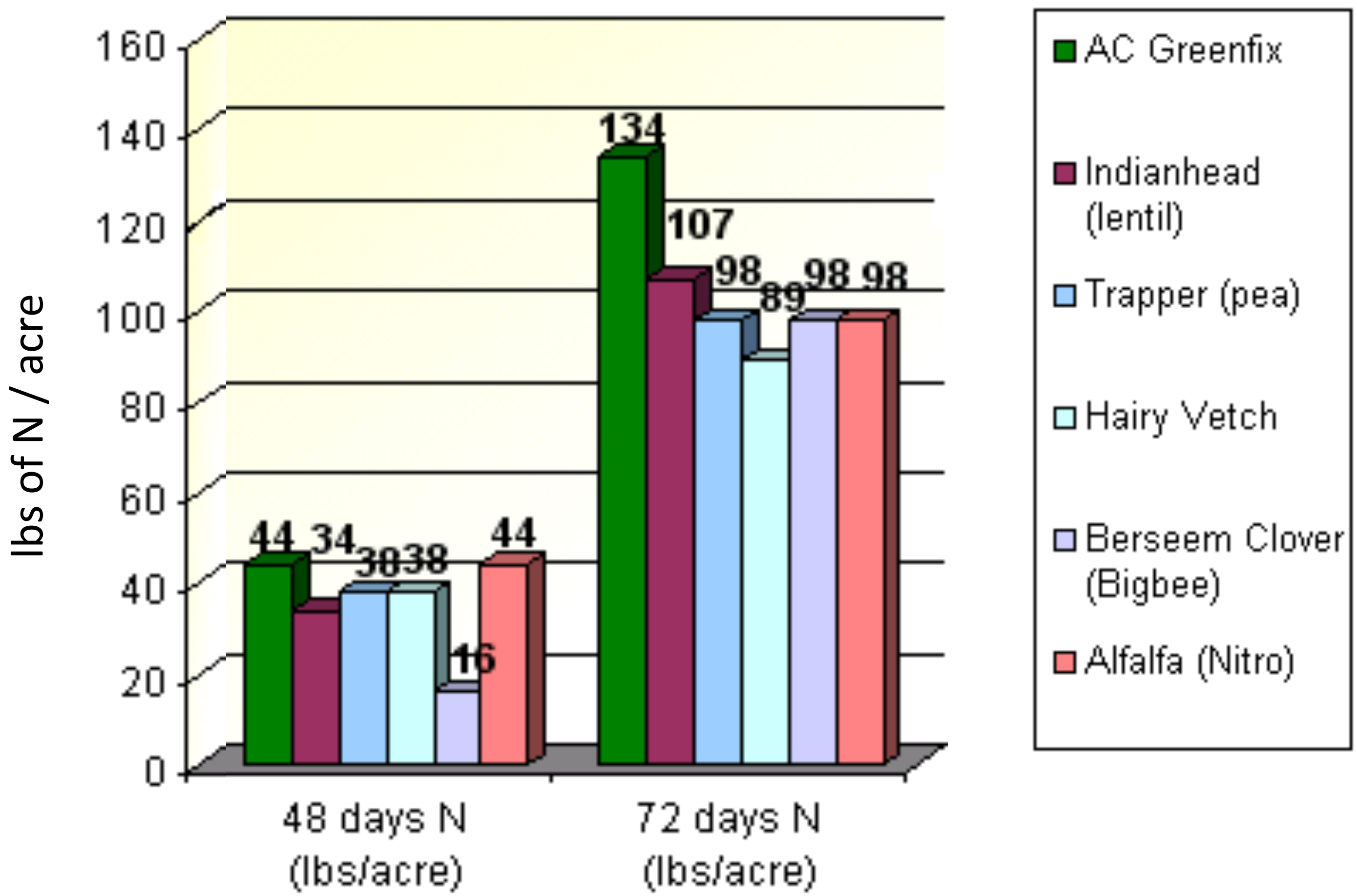
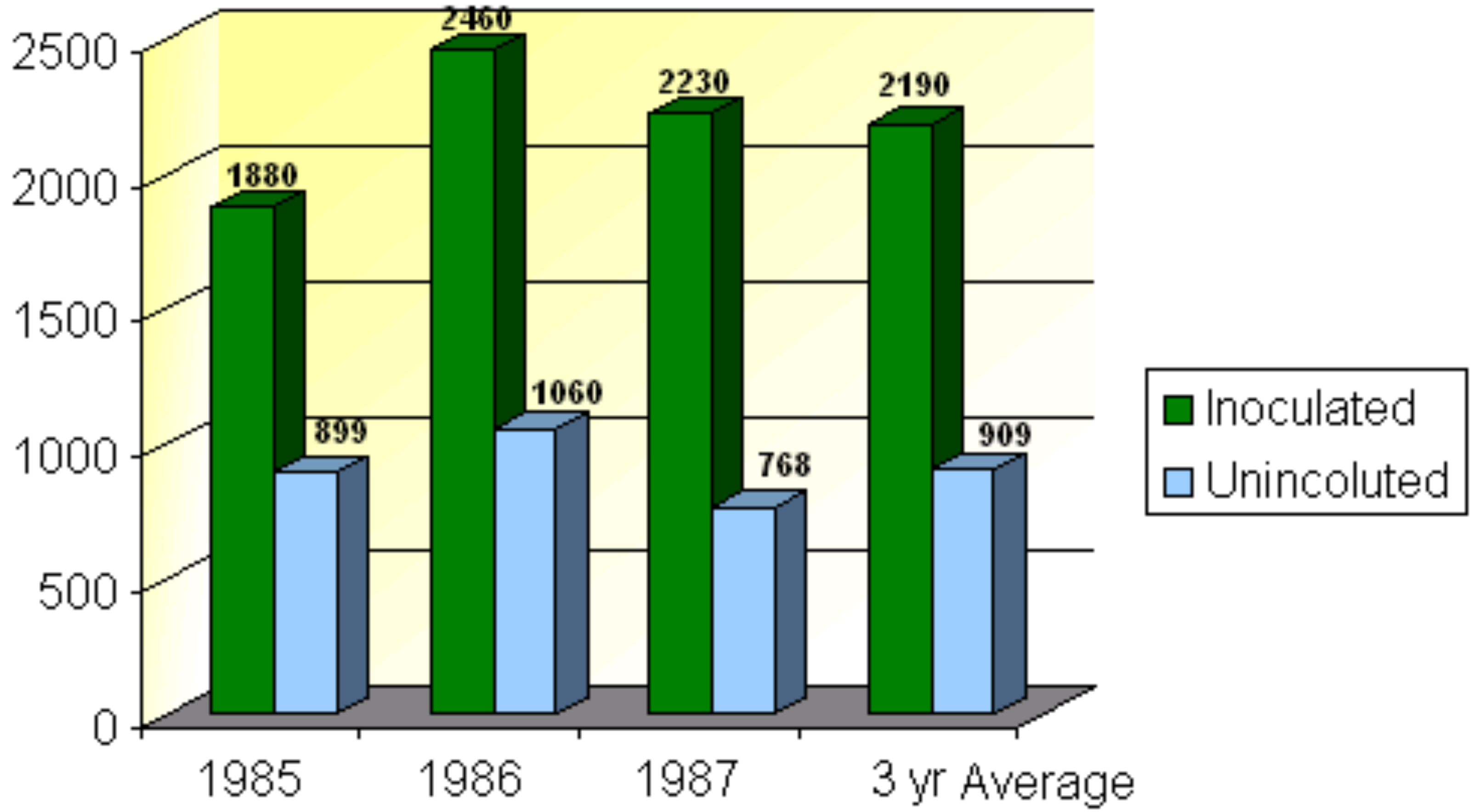
CHANGING LIVES IMPROVING LIFE


Anyone recognize this CC species?

AC Greenfix was the top N fixer in a recent study





Effect of seed Inoculation on dry matter produced up to full bloom by AC Greenfix seeded into wheat stubble at Swift Current in 1985, 1986 and 1987.

Can Cover Crops Improve the Efficiency of Fall Applied Nitrogen within Conventional Midwestern Cropping Systems?

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Methodology-N Fertilization Practices

- Fall N fertilizer application was applied to standing cover crops in November as anhydrous ammonium (200 kg ha^{-1}).

What did we learn?

Objective 1

- Tillage Radish and Cereal Rye were the only cover crops species that were able to absorbed the full rate of fall applied N.

- Fall application of N into a standing cover crop significantly reduces nitrate leaching. Cereal Rye>Tillage Radish>Crimson Clover

- Cover crops had no impact on corn silage production in the 2011/2012 growing season.

Objective 2

- Tillage Radish releases more fall applied N at planting relative Cereal Rye and Crimson clover.

- Extreme climatic conditions effect rate by which cover crops release fall applied N in the spring.