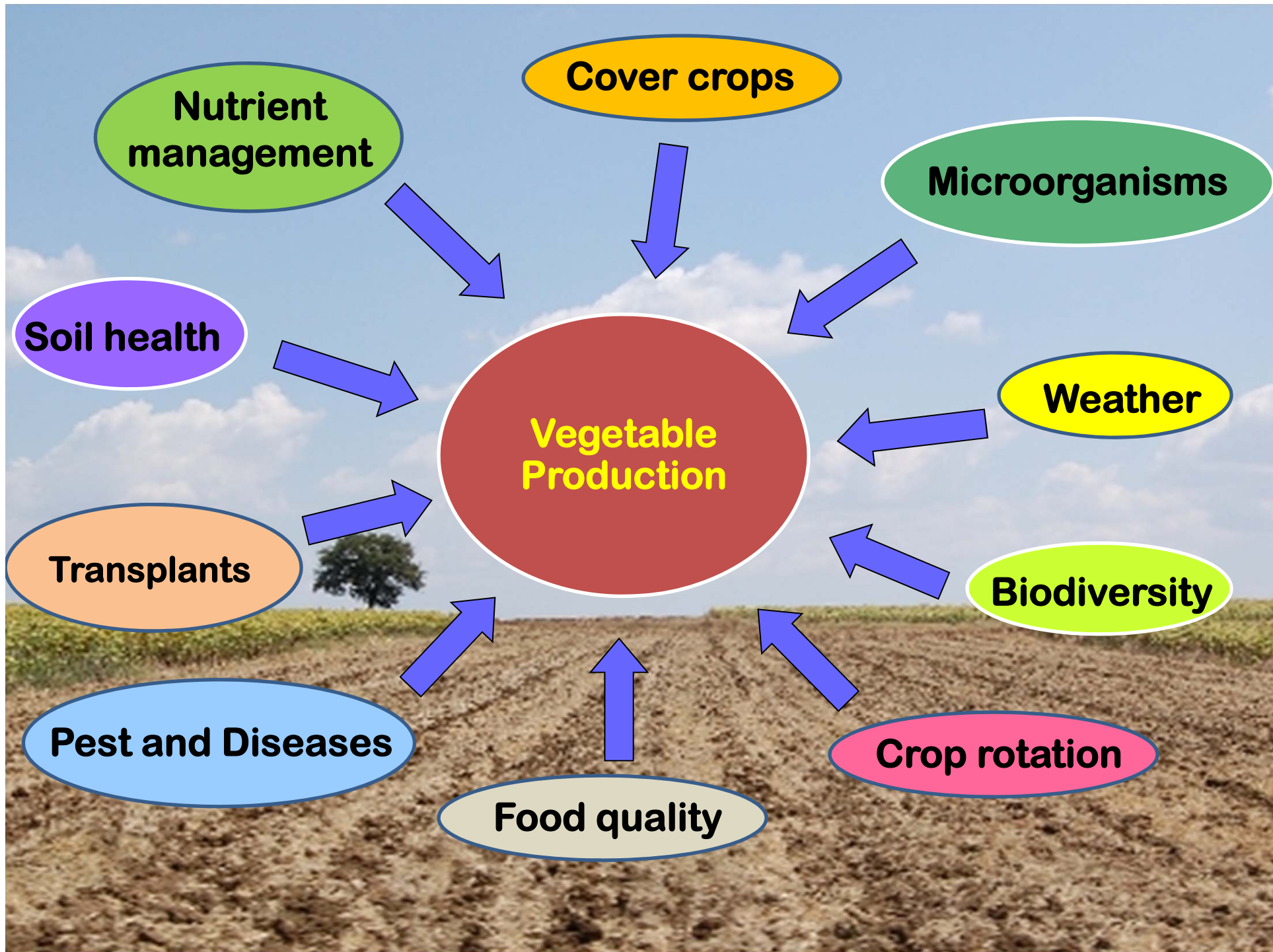


Cover crops and how they impact vegetable production systems

Dr. Ajay Nair
Department of Horticulture
Iowa State University



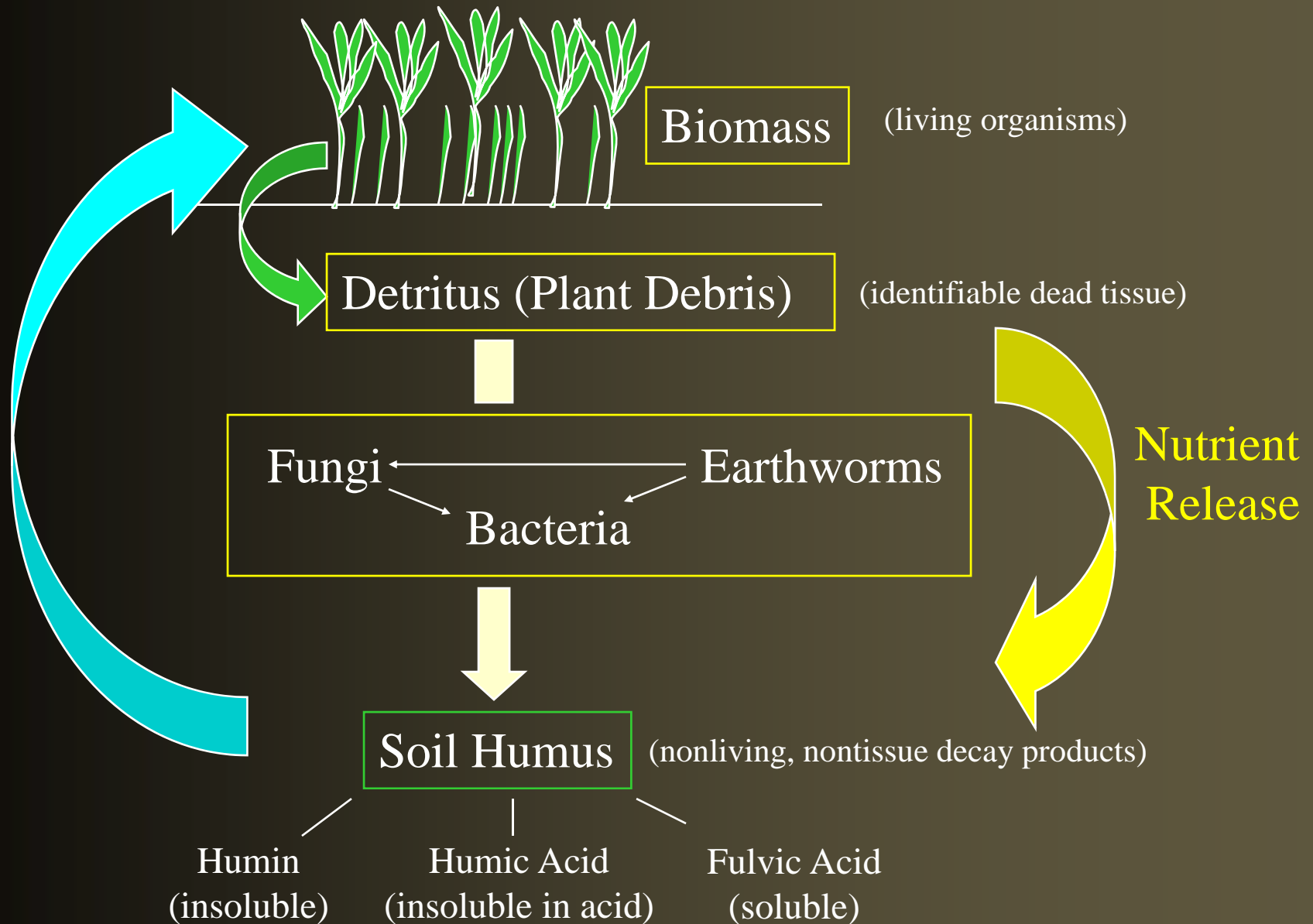


Some key questions



- **How to develop a biodiverse system**
- **How can we feed our soil using organic inputs**
- **How to build up a soil that is self sustaining and productive**
- **Enhance yield and profits**
- **Efficient nutrient cycling**

Organic Matter



Cover crop benefits

- Add organic matter
- Reduce soil erosion
- Windbreaks
- Supply N to subsequent crops if legume
- Reduce soil compaction
- Improve nutrient recycling (catch crops)
- Pest effects?

Cover crop problems

- Seed costs
- Management costs
 - Planting
 - Killing
 - Incorporating
- Sometimes interfere with crop
- Pest effects?

Commonly used cover crops

- Winter (winter annuals)
 - Rye, wheat, hairy vetch
- Early spring or fall (cool season)
 - Oats, peas, red clover, mustards
- Summer (warm season)
 - Sorghum-sudangrass, buckwheat, soybean
 - Oats, peas, mustards
- Biennial/Perennial
 - Alfalfa
 - Clover

Non-legumes

Seeding :70-90lb/A

Winter rye

A wide-angle photograph of a lush green winter rye field. The plants are densely packed and appear to be in the early stages of growth. In the background, there is a line of trees and a utility pole. A small blue tarp is visible on the right side of the field. The sky is overcast and grey.

Seeding :100-120lb/A

Oats

A photograph of a field with rows of green oat plants in the foreground and yellow-flowered plants in the background. The word 'Oats' is overlaid in white text on the oat plants. The field is divided into sections, with the oat plants in the foreground and yellow-flowered plants in the background. The sky is overcast, and there are trees in the distance.

Brassica Cover Crops



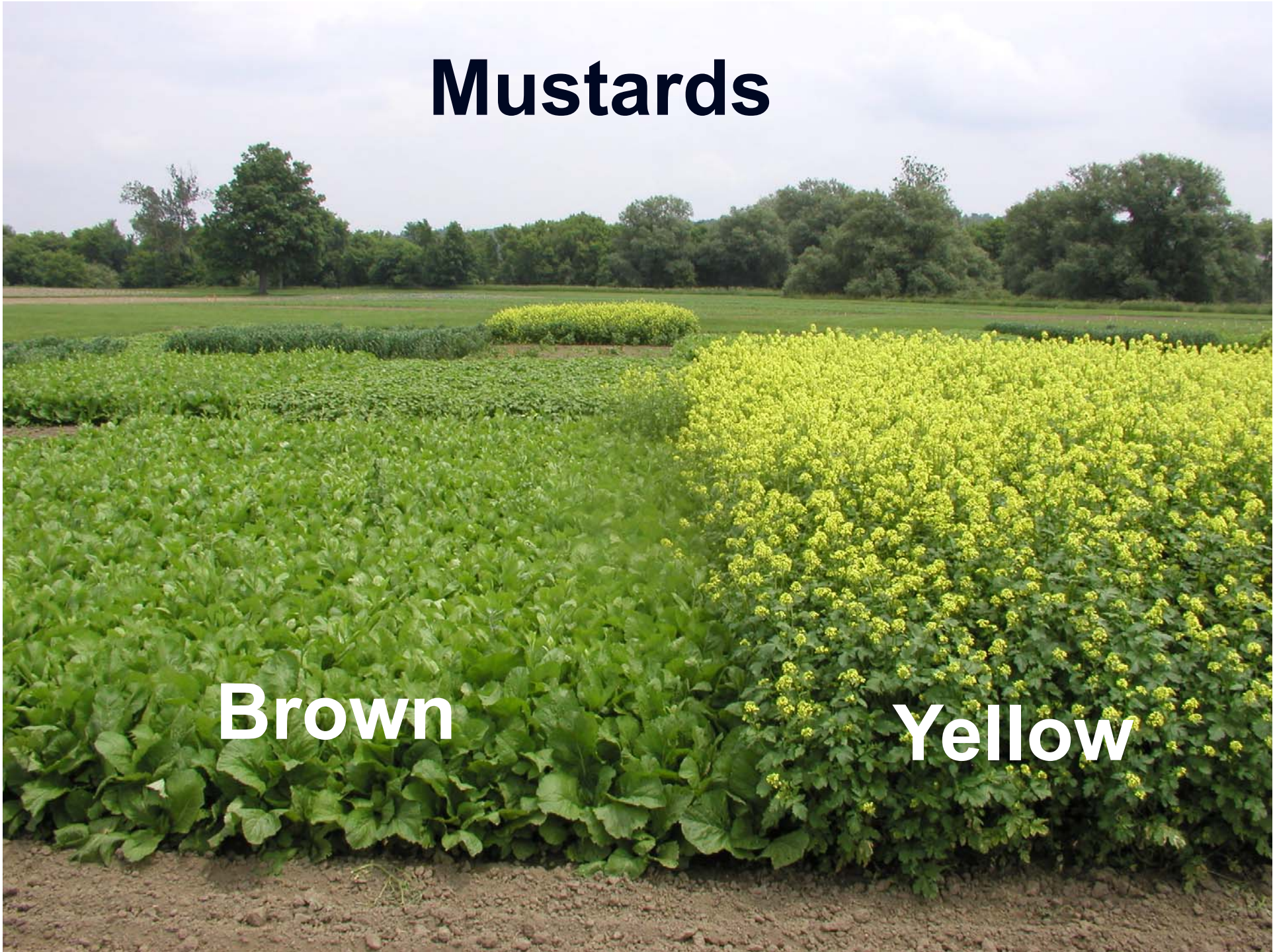
Yellow mustard
Brown mustard
Oilseed radish

- **Fall planted**
- **Erosion control and nutrient scavenging**
- **Biofumigants**
- **Nematode suppression**
- **Reduce compaction**
- **No-till option with mustards**

Mustards

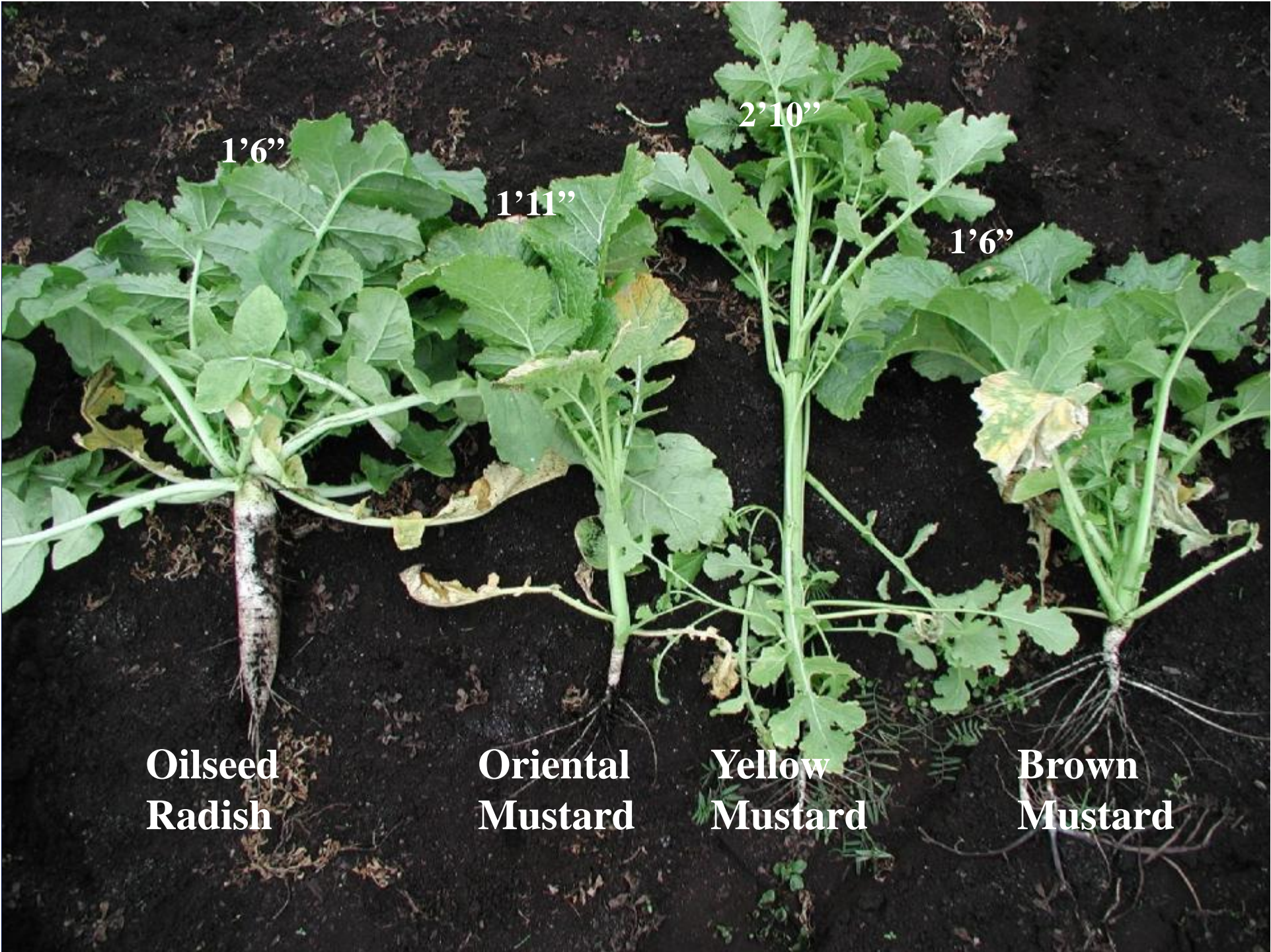
Brown

Yellow



The Methyl Bromide saga !

- Soil fumigant and structural fumigant to control pests across a wide range of agricultural sectors.
- Because MeBr depletes the stratospheric ozone layer, it was phased out in January 1, 2005,
- Critical Use Exemption (CUE): for agricultural users with no technically or economically feasible alternatives



1'6"

1'11"

2'10"

1'6"

**Oilseed
Radish**

**Oriental
Mustard**

**Yellow
Mustard**

**Brown
Mustard**

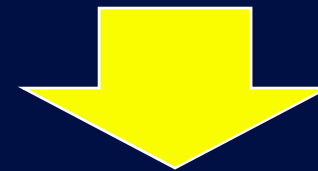
A wide-angle photograph of a commercial farm showing a vast field of green oilseed radish plants. The plants are densely packed and appear to be in the early stages of growth. In the background, there is a line of trees and utility poles under a clear sky. A semi-transparent yellow banner with a grid pattern is overlaid on the top portion of the image, containing the main title text.

**Successful establishment of oilseed radish
on a 25 acre commercial farm**

Source: Mathieu Ngouajio



- *Excellent biomass production*
- *Large taproot good for soil aeration*

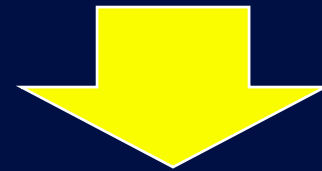


***Cultivar
'Daikon'***

Source: Mathieu Ngouajio

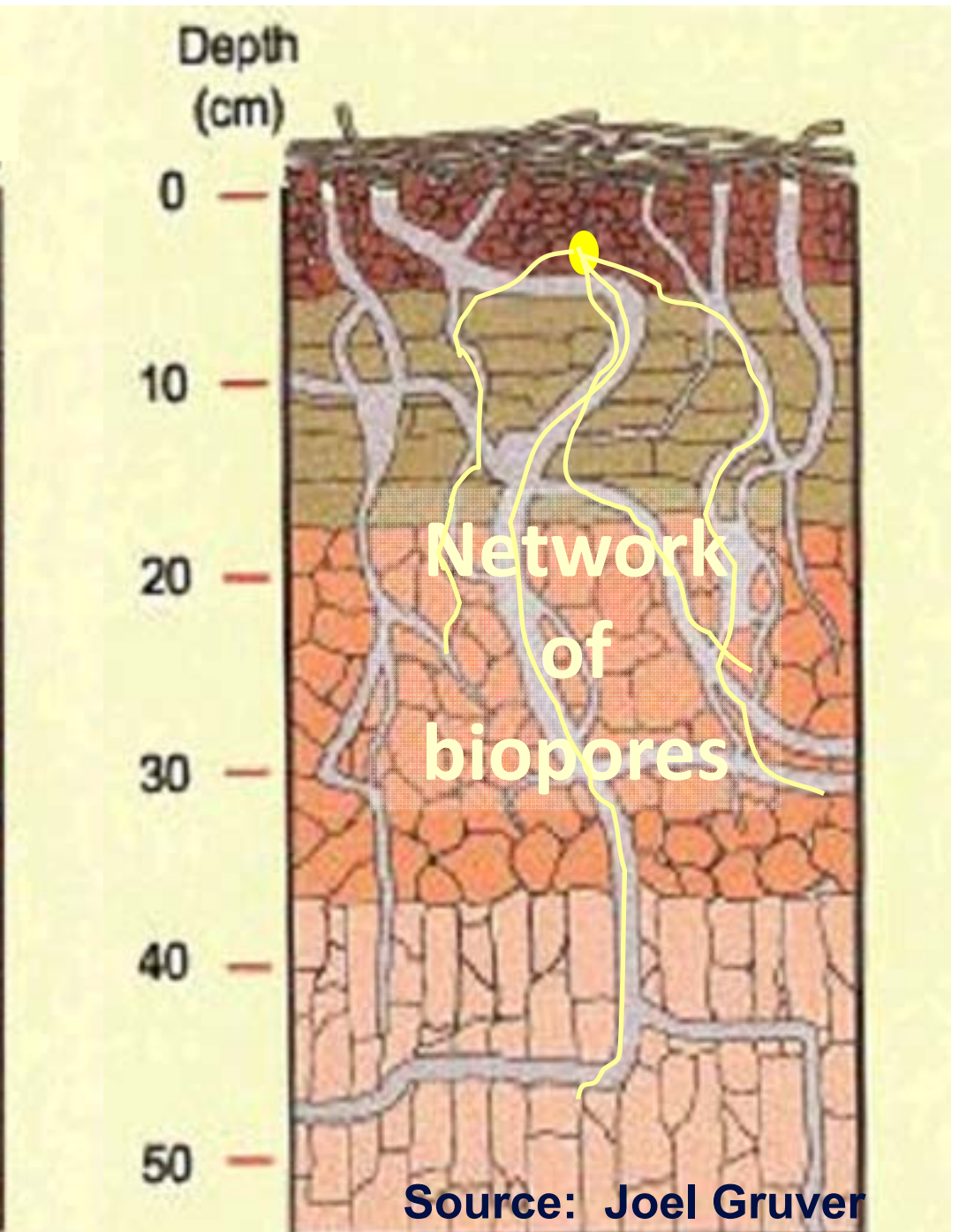
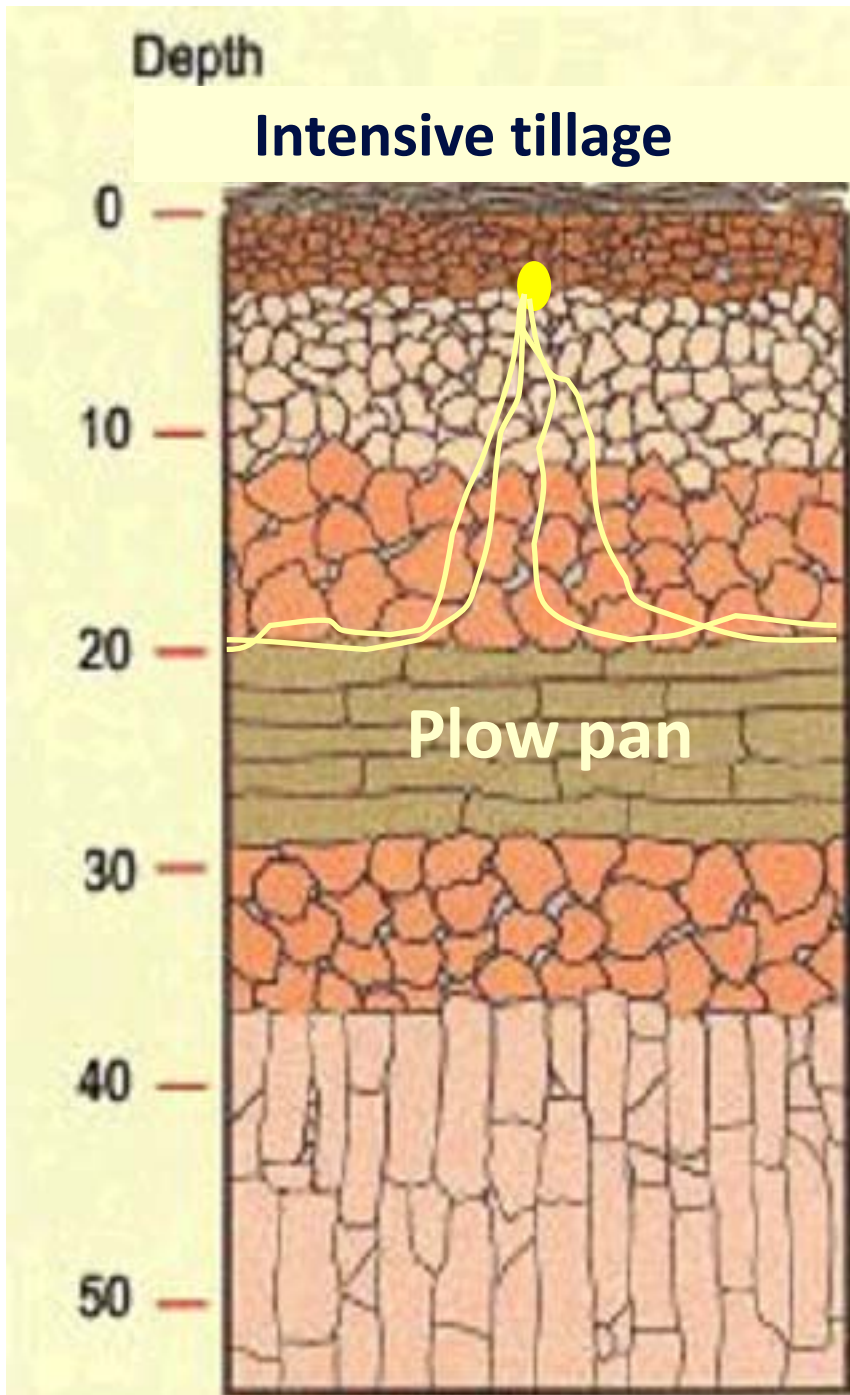


□ *Huge tap roots if allowed adequate time to grow*



***Cultivar
‘Defender’***

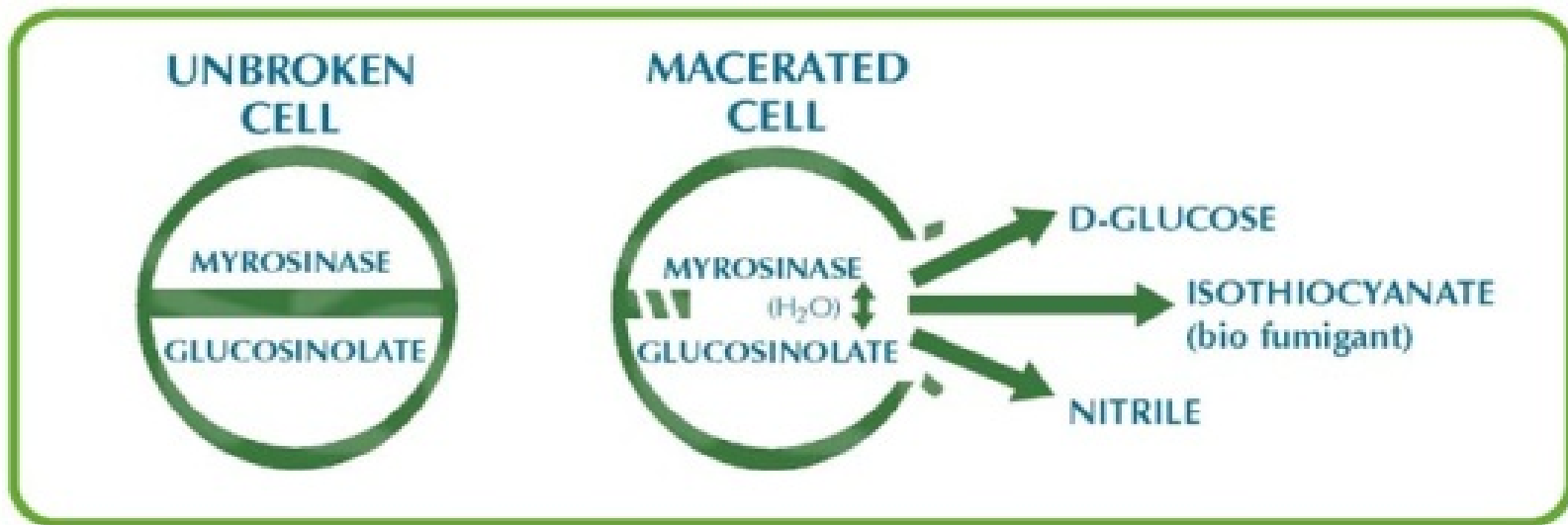
Source: Mathieu Ngouajio



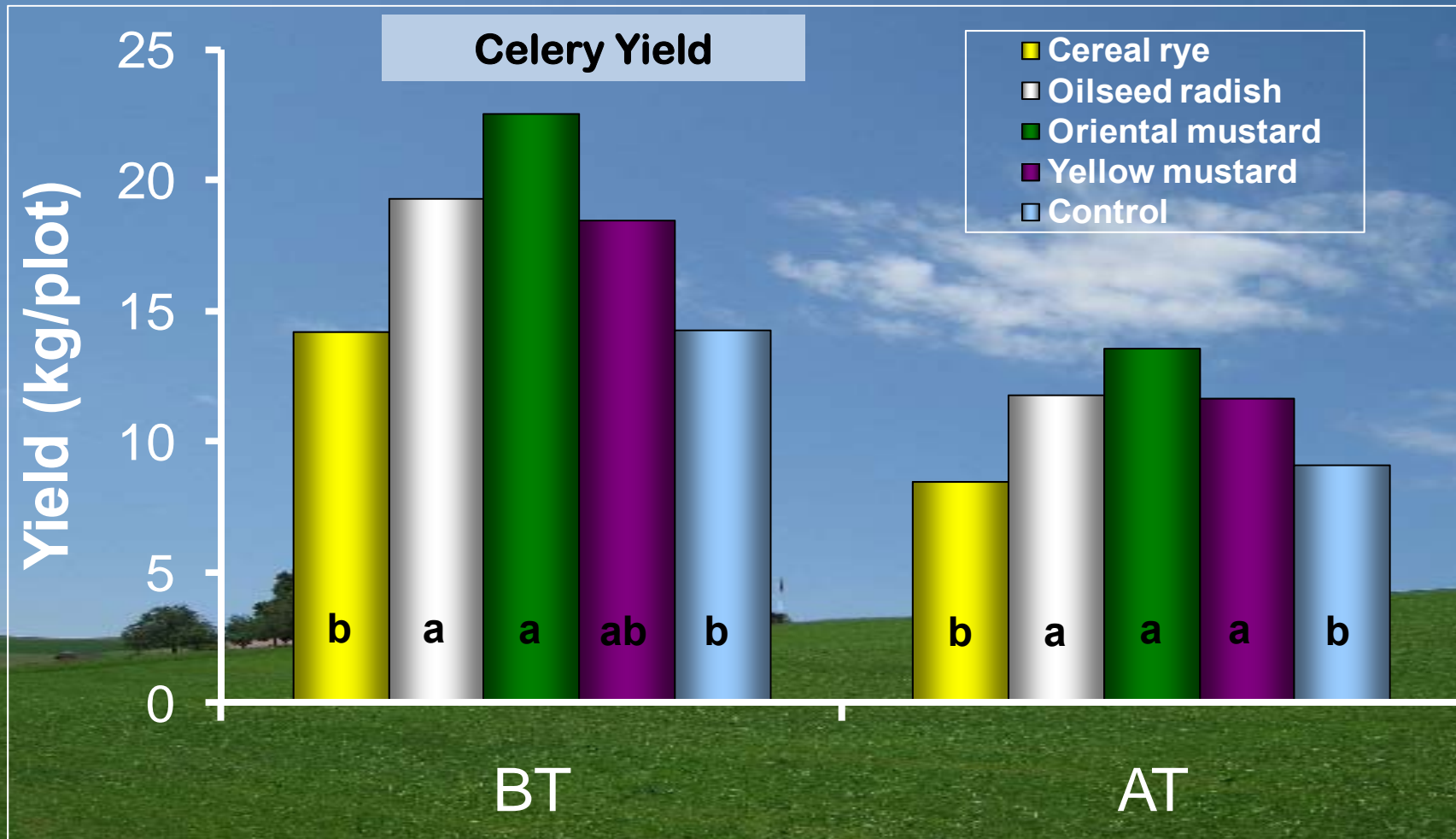
Brassica cover crops as Biofumigants



The biofumigation process.

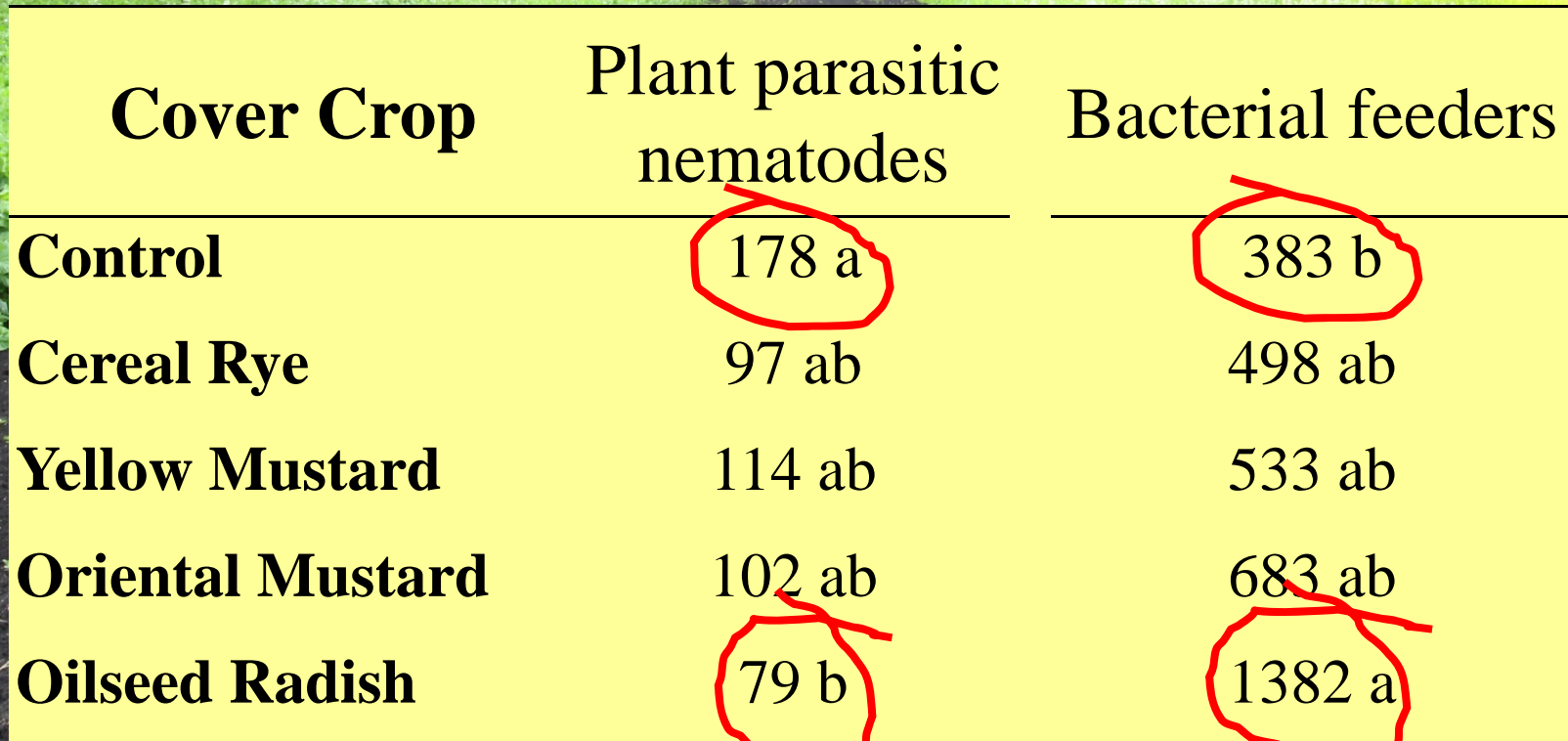


Brassica cover crops in celery production



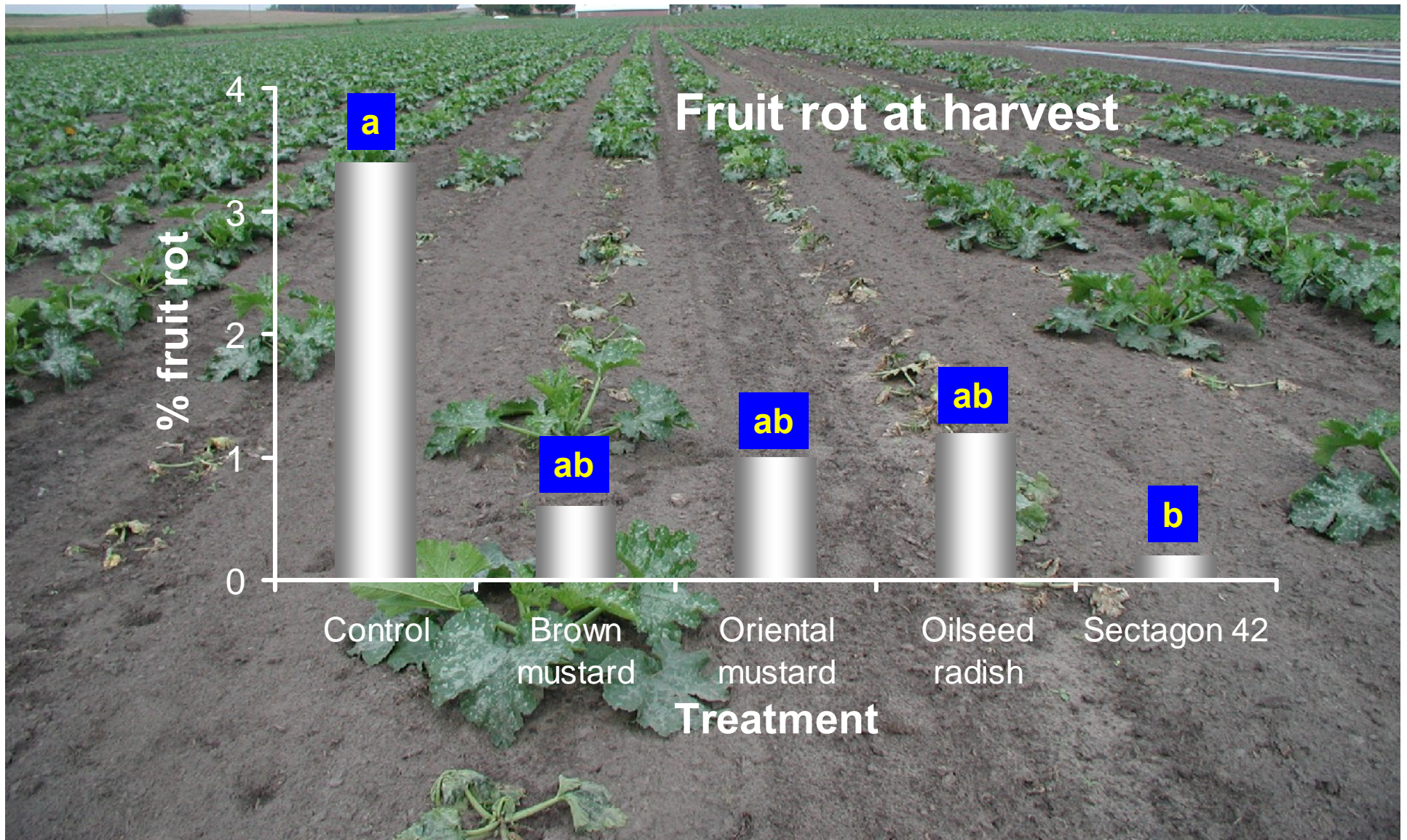
Yield was lowest in the rye plots followed by control plots

Impact of cover crops on Nematode community



Cover Crop	Plant parasitic nematodes	Bacterial feeders
Control	178 a	383 b
Cereal Rye	97 ab	498 ab
Yellow Mustard	114 ab	533 ab
Oriental Mustard	102 ab	683 ab
Oilseed Radish	79 b	1382 a

On-Farm Study testing the impact of Brassica cover crops on *Phytophthora capsici* in vine crops



50-90lb/A

Buckwheat

2000-4000 lb/A



40-50lb/A



Sorghum-sudangrass

8000-10,000 lb/A

Legumes

Nitrogen Fixation

- * Symbiotic relation between bacteria and plants:
 - e.g., legumes + *Rhizobium*
 - bacteria require plant for growth; plant gains 'free' source of available N

- * Grasses-*Azospirillum/Azobactor*

N contribution of legumes

N% (from analysis) x biomass gives rough estimate.

Not all N in legumes is fixed

About 40-60% of N content of legume is available in yr 1

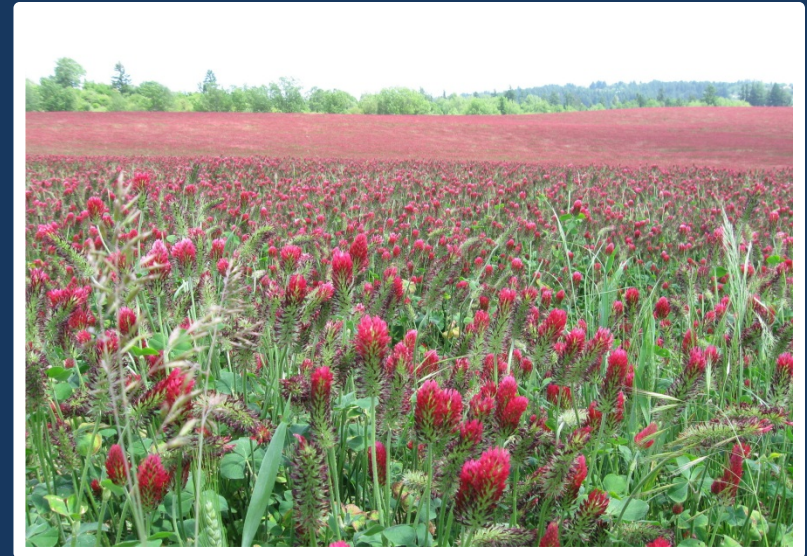


Rhizobia are host specific

GENUS	SPECIES	PLANT
<i>Rhizobium</i>	<i>meliloti</i>	Alfalfa (Medicago, Melilotus)
	<i>leguminosarum</i>	Peas (<i>Pisum</i>)
		Vetches (<i>Vicia</i>)
		Clover (<i>Trifolium</i>)
		Beans (<i>Phaseolus</i>)
	<i>loti</i>	Trefoil (<i>Lotus</i>)
	<i>fredii</i>	Soyabean (<i>Glycine</i>)
<i>Bradyrhizobium</i>	<i>japonicum</i>	Soyabeans, Tropical legumes (<i>Arachis, Leucaena</i>)
<i>Azorhizobium</i>	<i>caulinodans</i>	Stem nodules (Sesbania)
		Non-legumes (Parasponia)

Crimson Clover

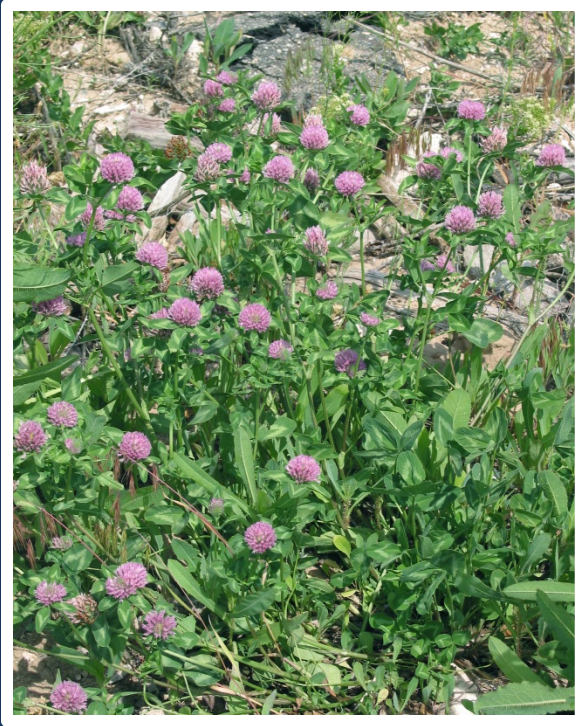
- Does not OVERWINTER
- 3-5 ton/A biomass
- Can fix close to 70-130lb/A
- Seed 6 weeks before the killing frost
- Seeding: 20-30lb/A (broadcast)
- Companion planted with rye
- Can attract root-knot nematodes



Berseem Clover

- Does not **OVERWINTER**
- 6-8 ton/A biomass
- Can fix close to 70-150lb/A
- Seeding: 15-20lb/A (broadcast)
- Plant early spring or early fall
- Can attract root-knot nematodes





Red Clover

- Biennial
- Easy to establish
- 3-4 ton/A biomass
- Can fix close to 70-150lb/A
- Seeding: 10-12lb/A (broadcast)
- Plant early spring/late summer



White Clover

- Perennial
- 3-5 ton/A biomass
- Can fix close to 70-150lb/A
- Seeding: 5-10lb/A (broadcast)
- Plant late fall or early spring

Hairy vetch

Winter annual





Soybean

N contribution of legumes

<i>Cover crop</i>	<i>N (Lb/A)</i>
Red Clover	50-120
<i>Crimson clover</i>	30-60
<i>Hairy vetch</i>	50-100
Austrian Winter Peas	30-70
Cowpea/Soybean	40-100

□ *Numbers vary with location and total biomass production*

Cover crop mixtures

Grass-legume mixtures



Grass legume mixtures

Nitrogen benefits?

	Cowpea	Soybean
	-----lbs/A-----	
Alone	45.0	105.0
With Japanese Millet	71.8	41.8
With Sorghum-sudangrass	31.1	33.2

Drinkwater and Brainard, unpublished

Rye-Vetch in tomato production





Cover crops

The image is a side-by-side comparison of two cover crop species. On the left, a clump of cereal rye is shown with its roots and soil pulled out, revealing a dense network of fibrous roots and a thick, reddish-brown rhizome system. The leaves are long, narrow, and green. On the right, a clump of hairy vetch is shown, characterized by its upright, branching habit and dense, feathery foliage. The leaves are smaller and more intricate than those of the cereal rye.

Cereal rye

Hairy vetch

Legume-Cereal Mixture 2 : 3 ratio

Cereal Rye
70lb/A
35lb/A



Hairy Vetch
25lb/A



- Adds organic matter
- Improvement in soil structure
- Weed and erosion control
- Recycling of nutrients

- Nitrogen fixation
- Recycling of nutrients
- Companion crop with rye

Dairy compost

MSU Compost Facility

Why did I take this
summer job ?

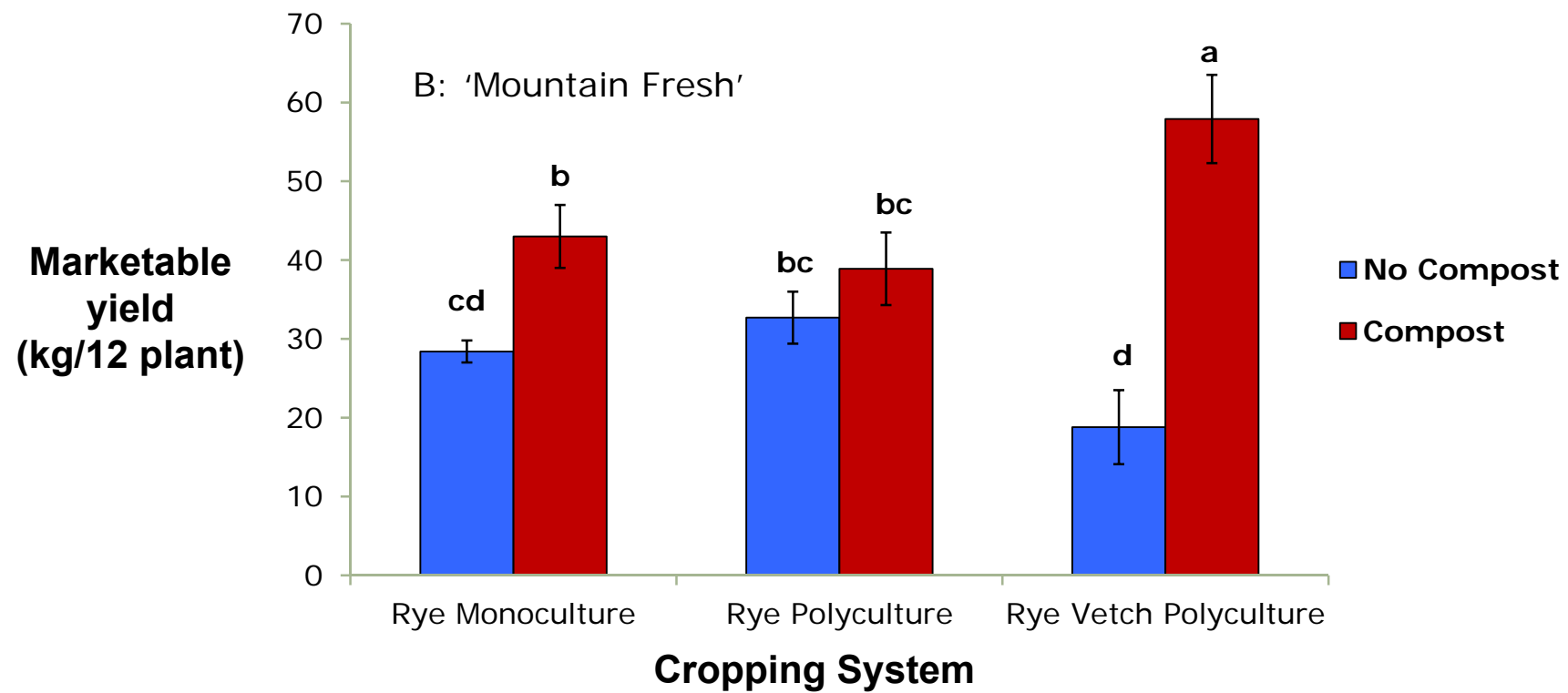
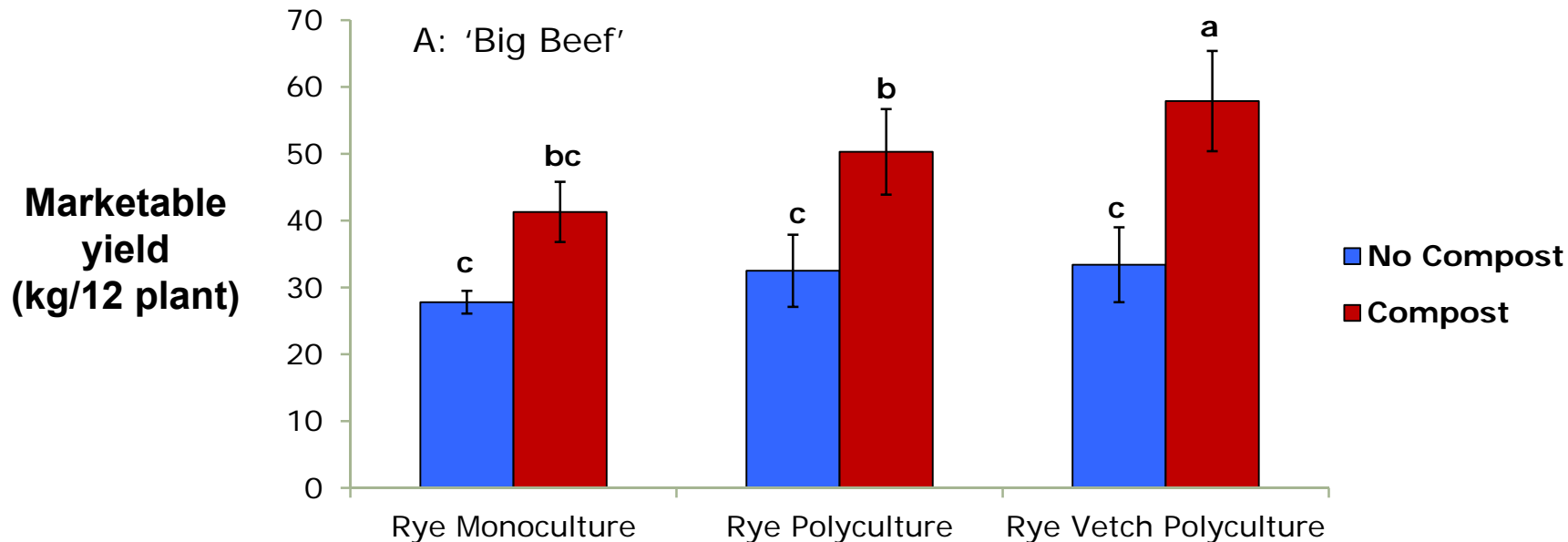




**Black plastic mulch
with drip irrigation**

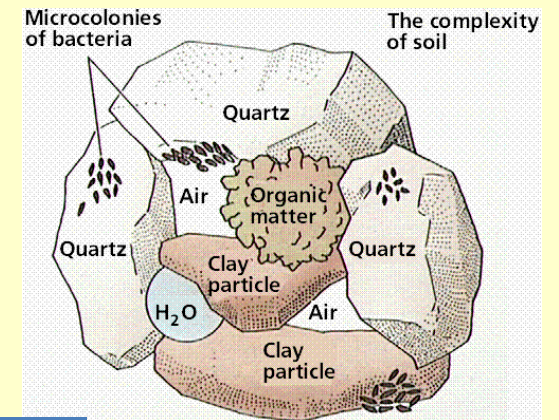
Transplanting

**Staking and other
cultural operations**



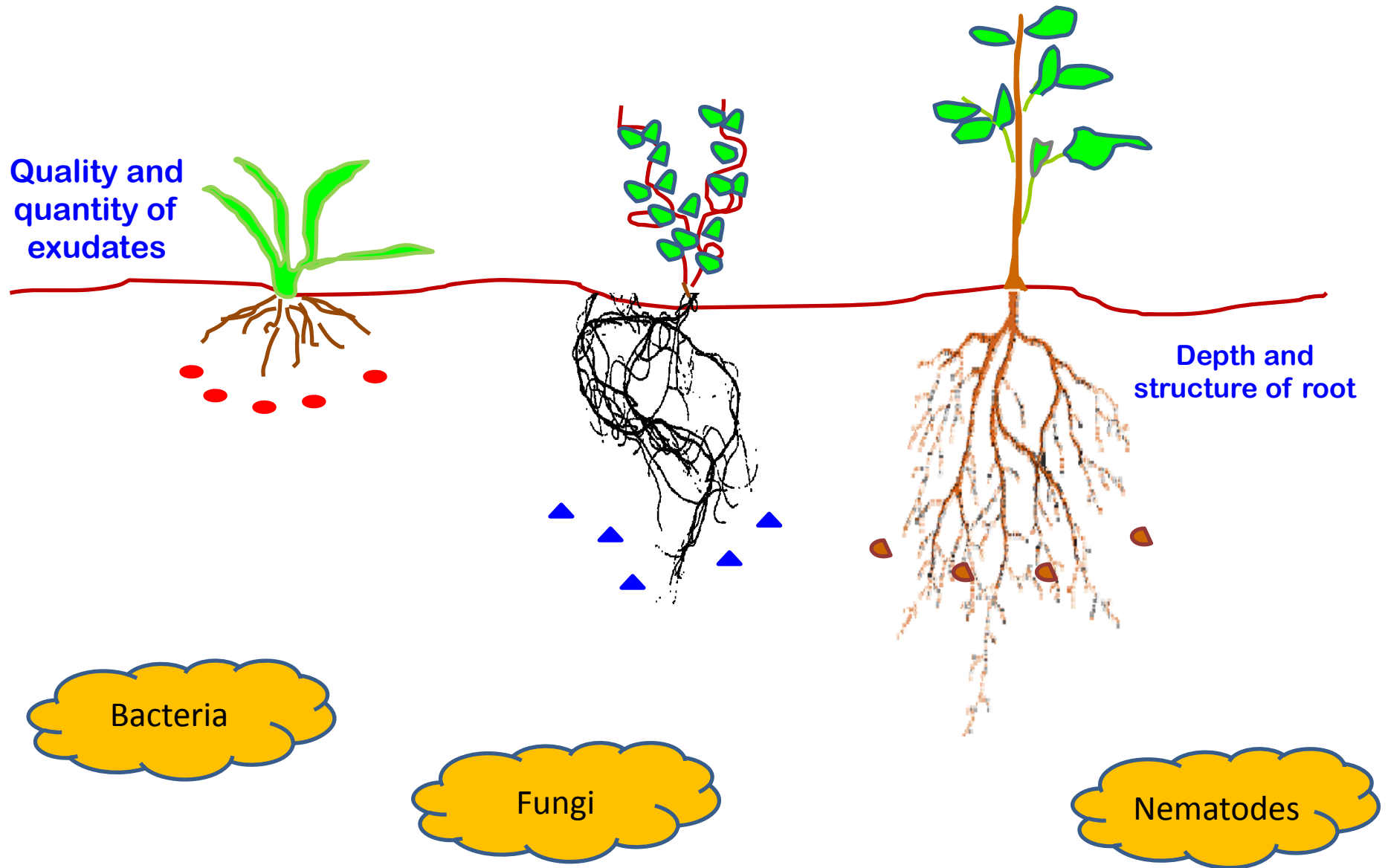
Carbon and Soil Organic matter

2010



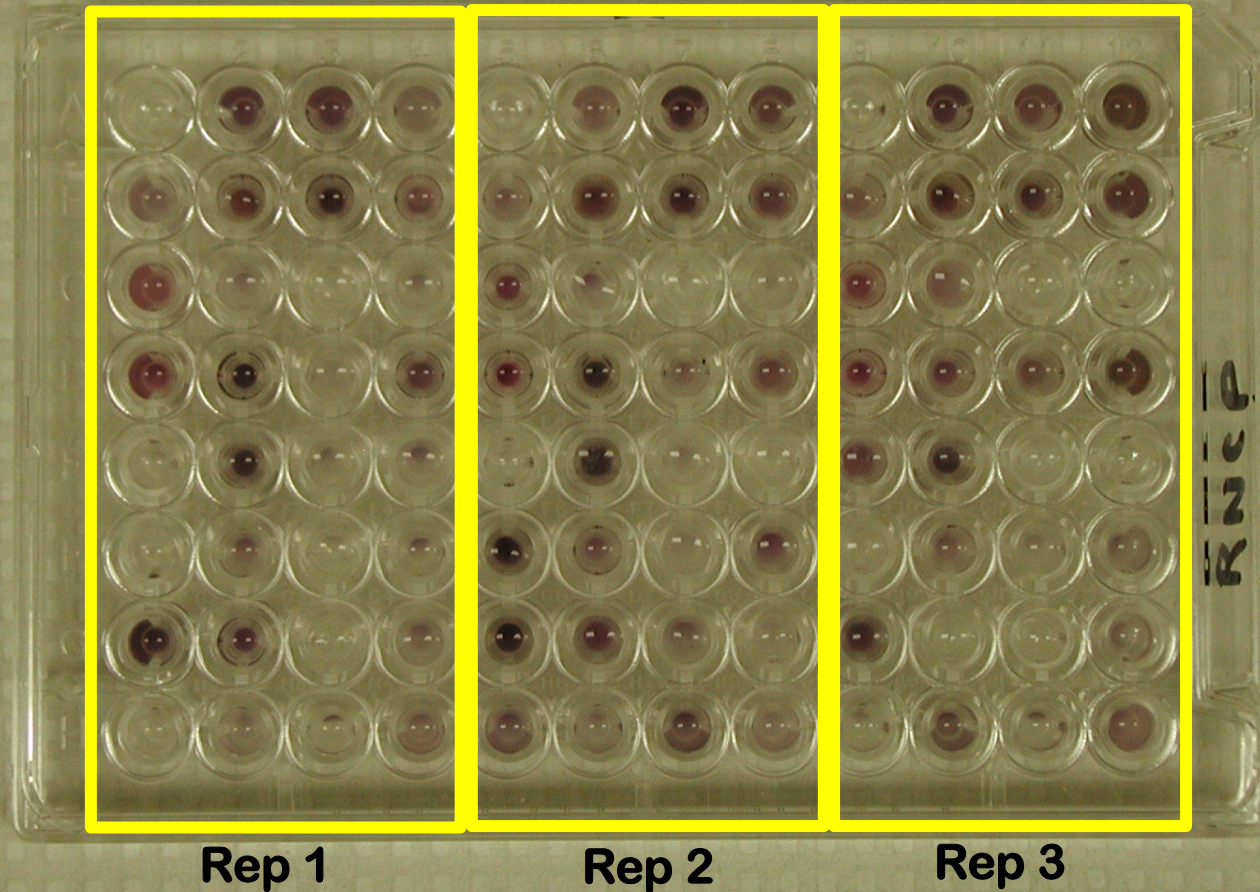
Treatment	Carbon (%)	SOM (%)	2005 (SOM %)
Rye	2.4	4.1	2.7
Rye + compost	2.8	4.8	2.7
Rye + Vetch	1.9	3.3	2.4
Rye + Vetch + compost	2.4	4.2	2.4

Crop diversity can influence soil biology



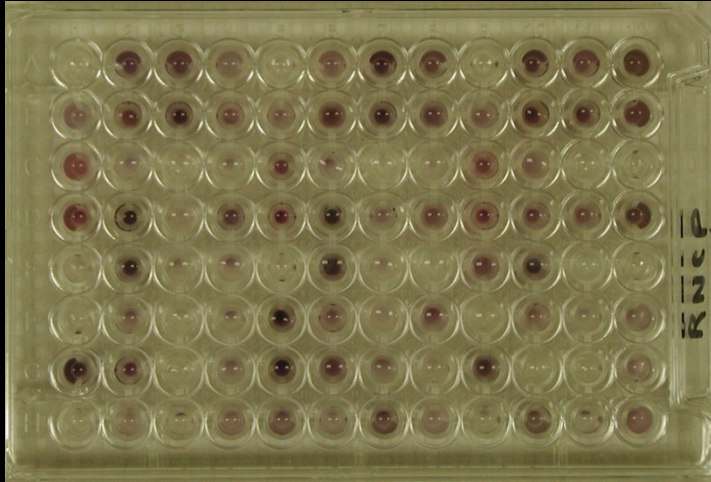
Community level physiological profile

Patterns of potential C source utilization

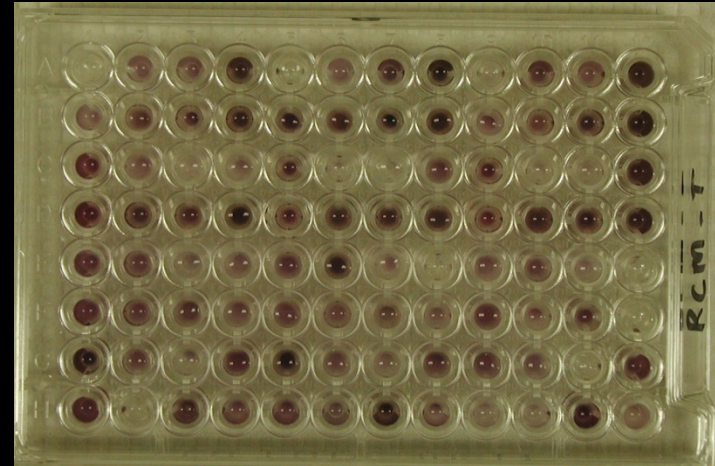


○ 31 carbon substrates

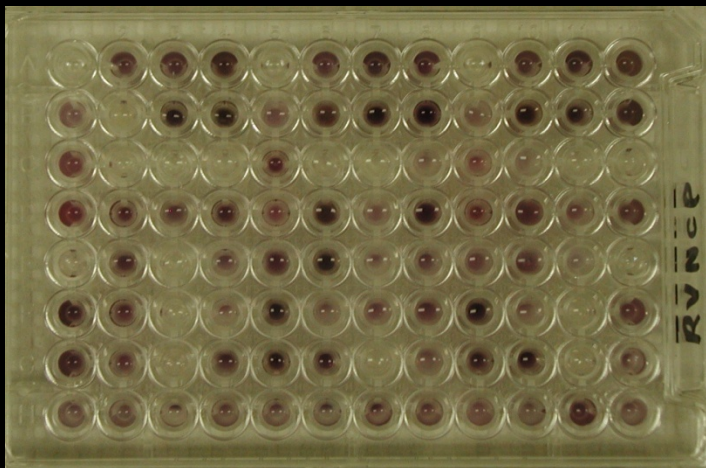
Microbial Diversity



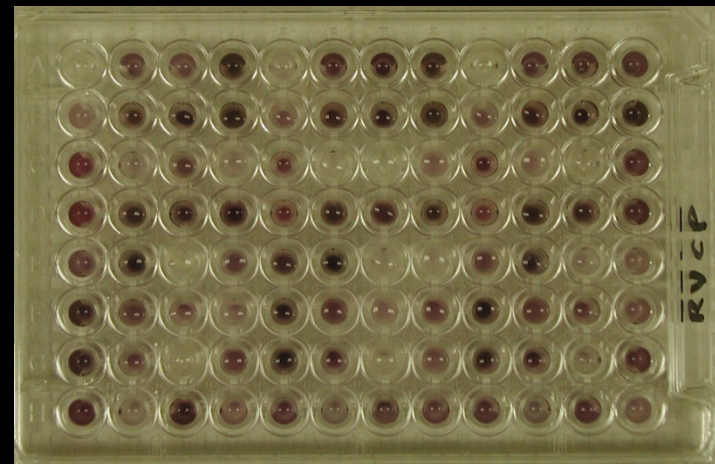
Rye – No Compost



Rye - Compost



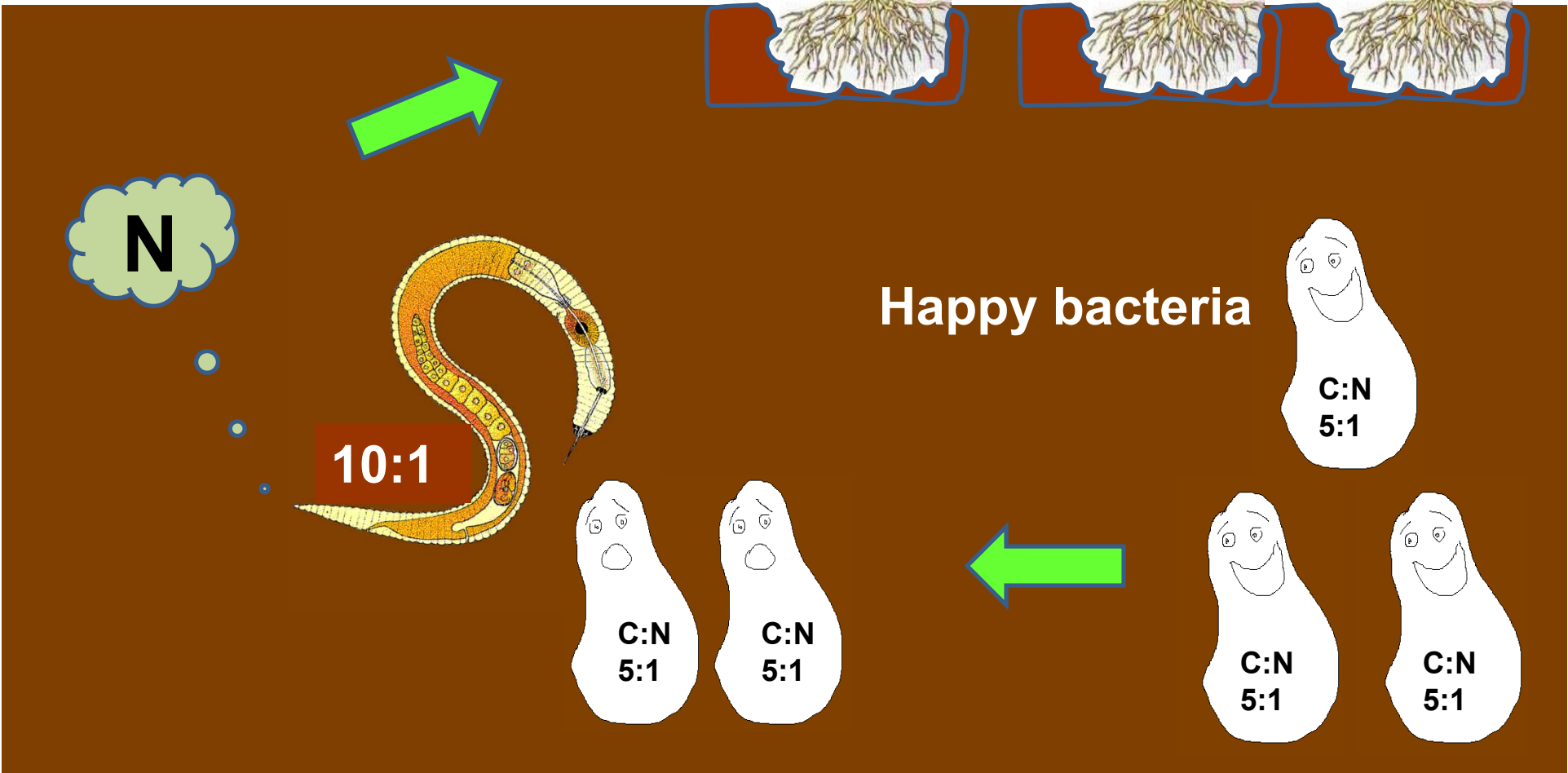
Rye Vetch – No Compost



Rye Vetch - Compost

What do
nematodes do in
the soil ?

Nutrient Cycling



N

10:1

Happy bacteria

C:N
5:1

C:N
5:1

C:N
5:1

C:N
5:1

C:N
5:1

Nematode Classification

Herbivore

Fungivore

Bacteriovore

Tylench
Tylenchs

Spiral
Apilyschs

Stunt
Dorylaims

Pin
Bacteriovore

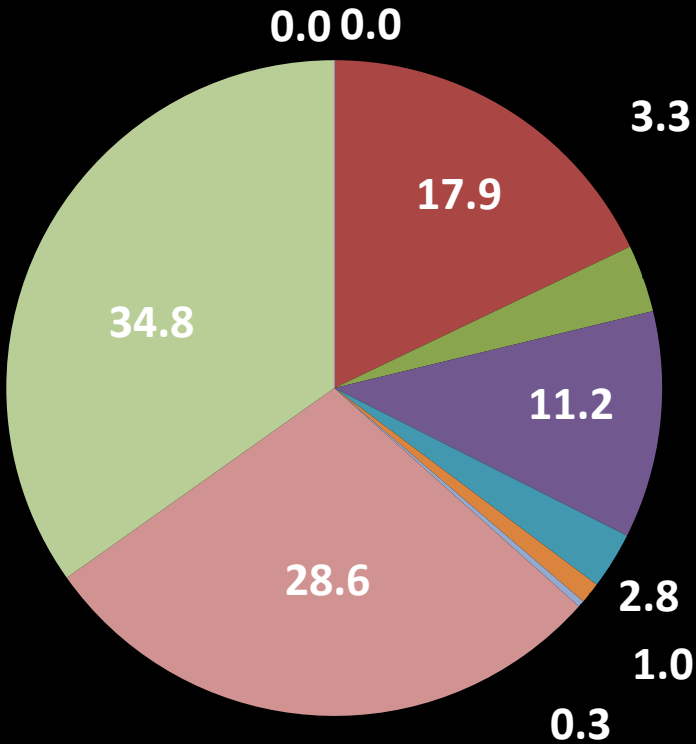
Nematode community analysis

Treatment	Nematode Counts		
	Herbivores	Fungivores	Bacteriovores
Rye	193	57	23 b
Rye + compost	142	43	66 b
Rye + Vetch	255	48	164 b
Rye + Vetch + compost	223	38	365 a
Significance	NS	NS	**

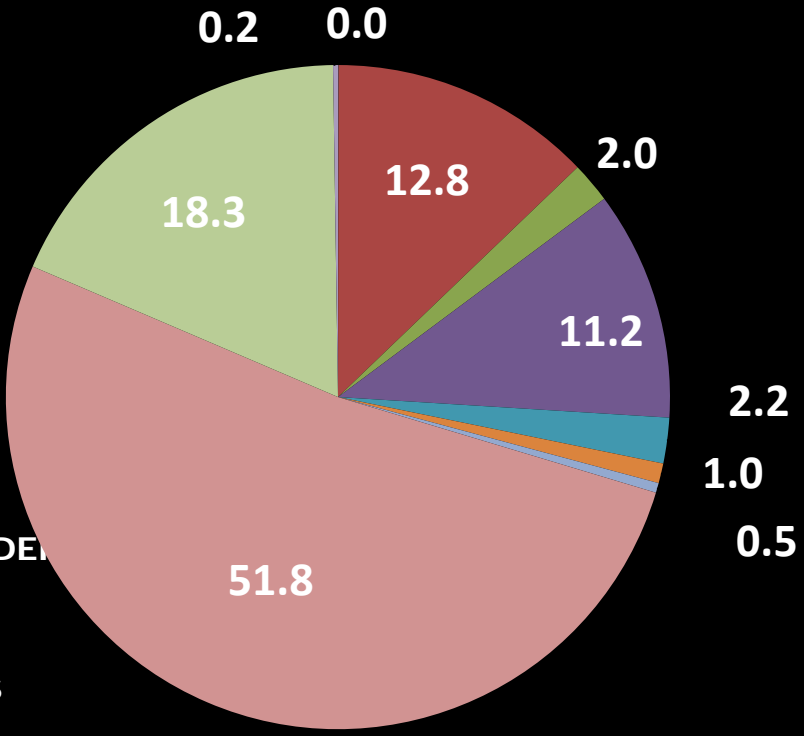
**** Amendment significant ($\alpha=0.01$)**

Relative proportion of nematode population

No compost



Compost



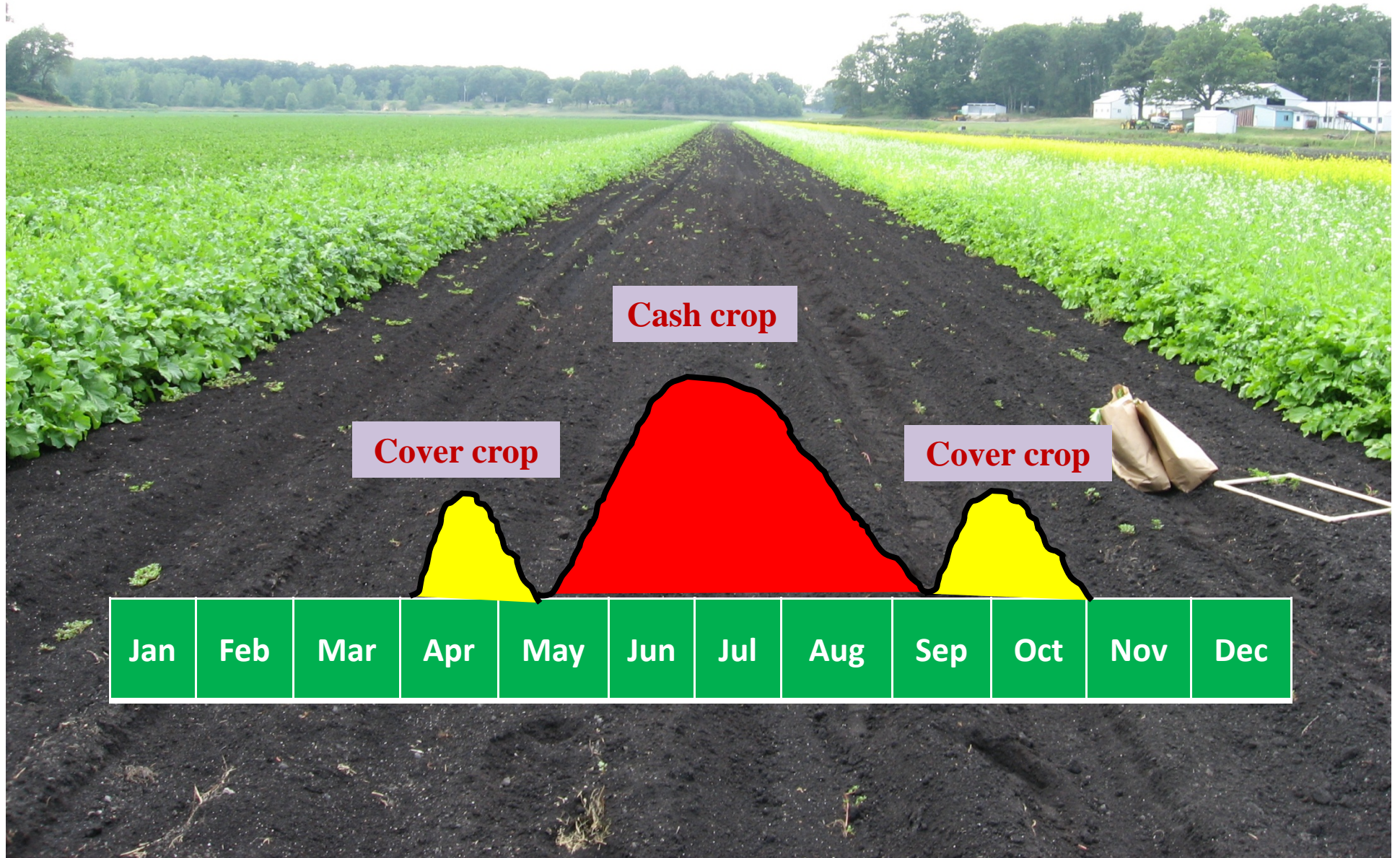
- LESION
- SPIRAL
- STUNT
- TYLENCHS
- APHELENCHS
- DORYLAIMS
- MONONCHS
- BACTERIALFEEDER
- MYCOFUNGI
- OLIGOCHAETES

Things to consider

- Soil Biology : A vital constituent of any production system
- Cover crops : Cereal rye is definitely a good choice for biomass production and recycling of nutrients.
- Hairy vetch is an excellent addition as a legume cover crop, however, northern latitudes pose a challenge. Early flowering and short growing cultivars should be incorporated
- “Cover crop rotation” would also be an important aspect to consider. This would ensure “microbial population diversity”

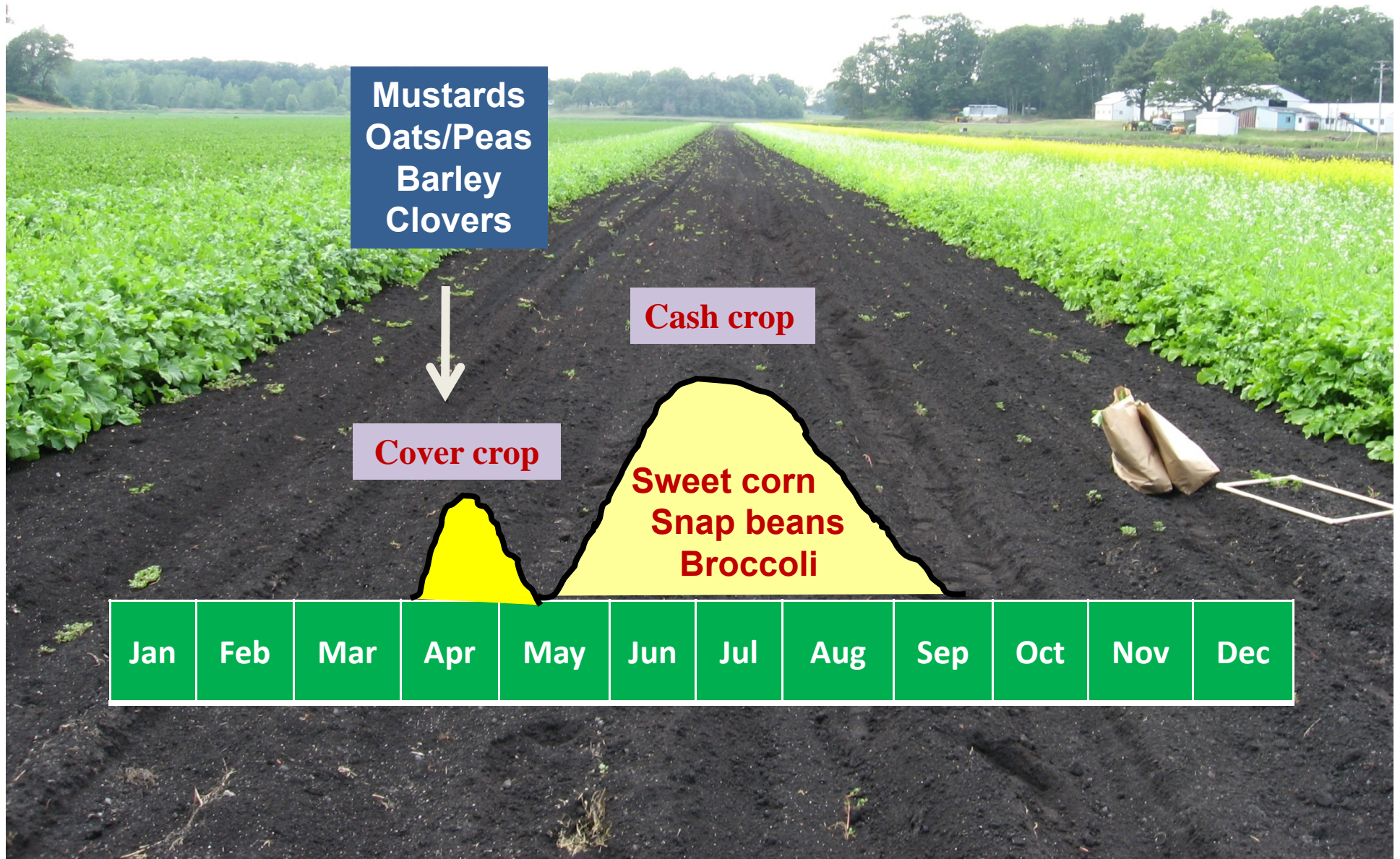
Cover crop integration in vegetable systems

Cover cropping window: Spring and Fall

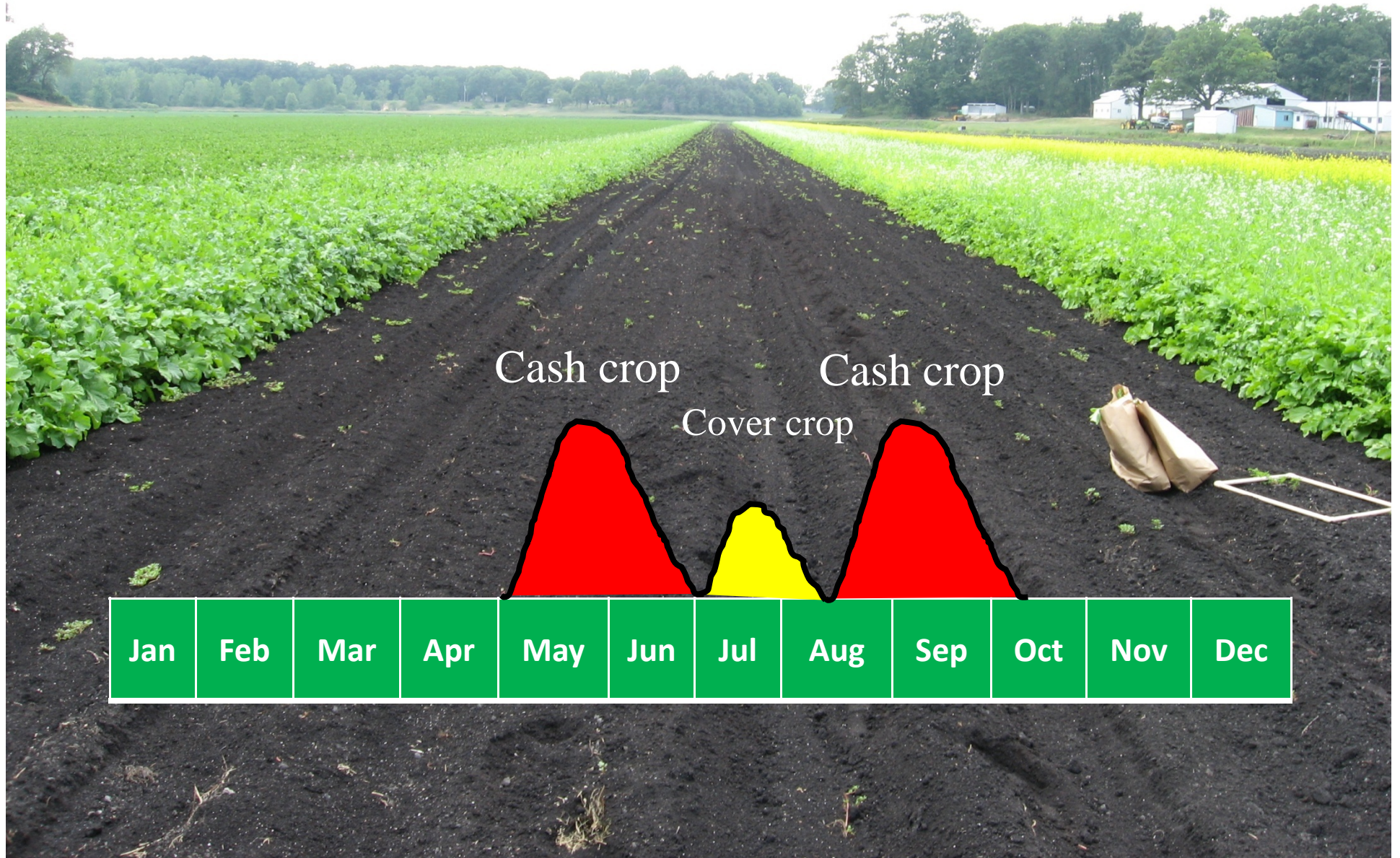


Cover cropping window: Spring

Before late planted vegetable

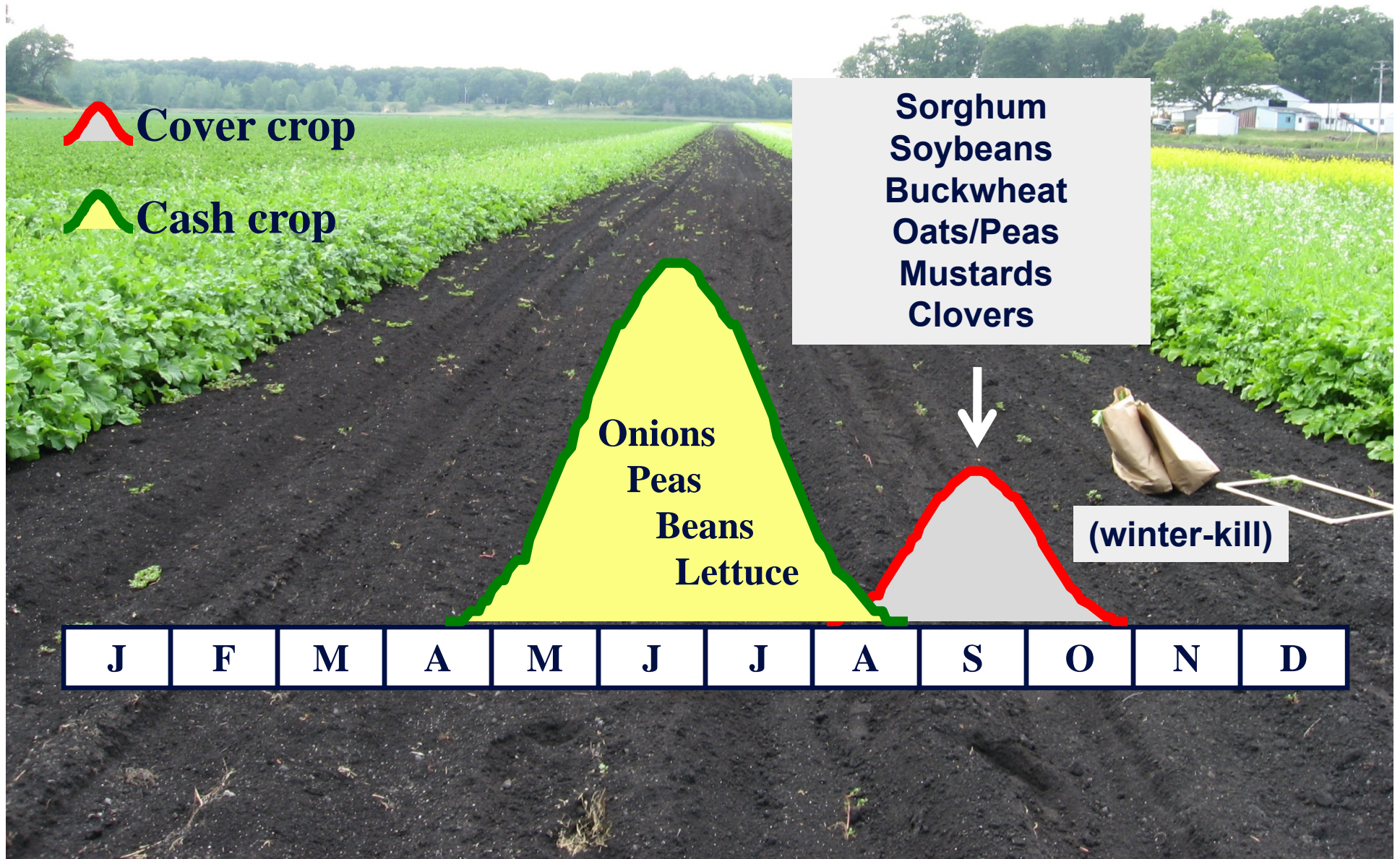


Cover cropping window: summer



Cover crop windows: **Summer or Fall**

After early harvested vegetables



Brassica in Onion Production

Cover crops

Or

**No cover
crops**

Planting density



Yellow Mustard

Oilseed Radish



- 259, 000/Acre
- 225K/A
- 205K/A
- 172K/A
- 140K/A



Low density



High density



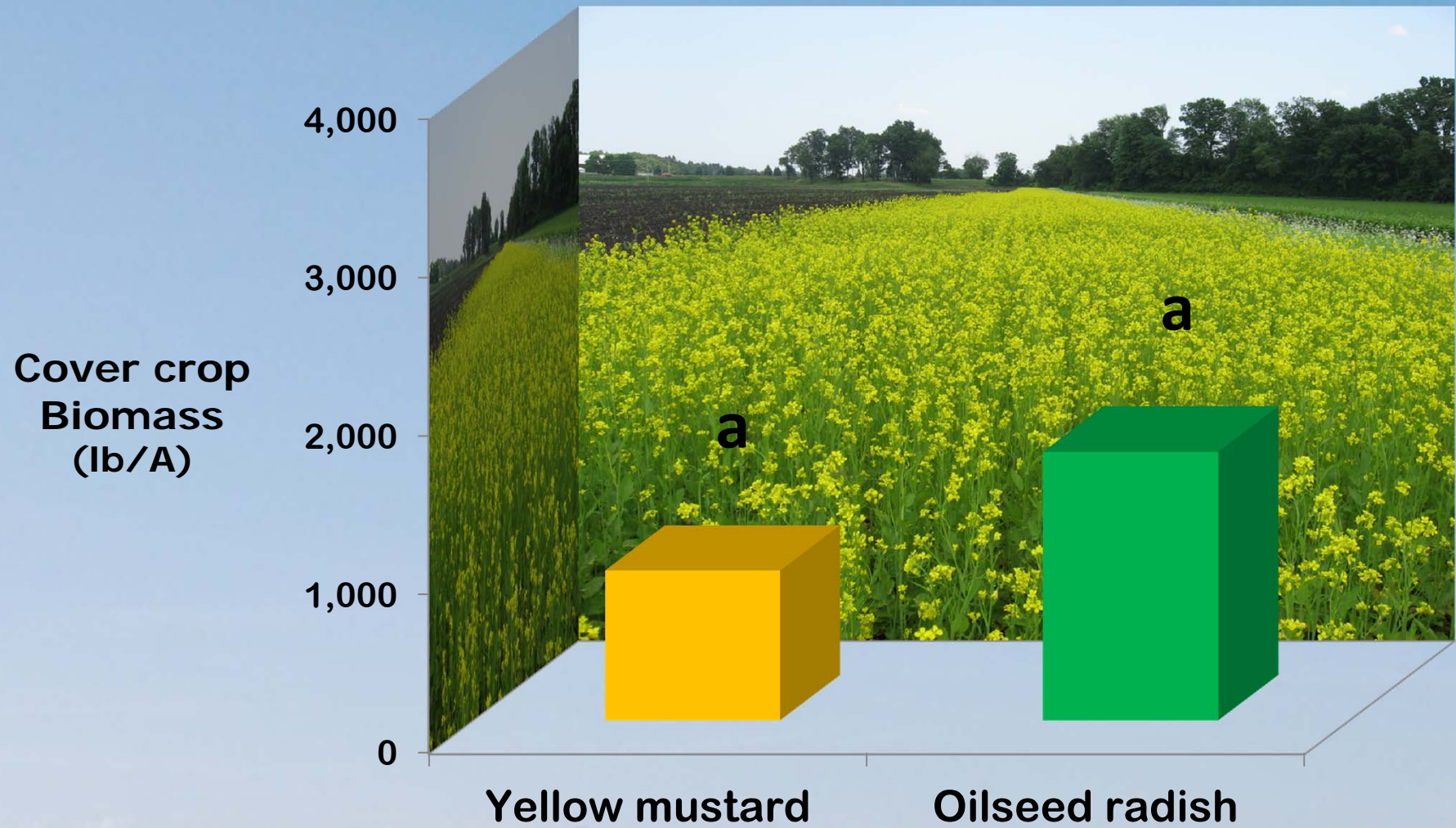
Oilseed radish



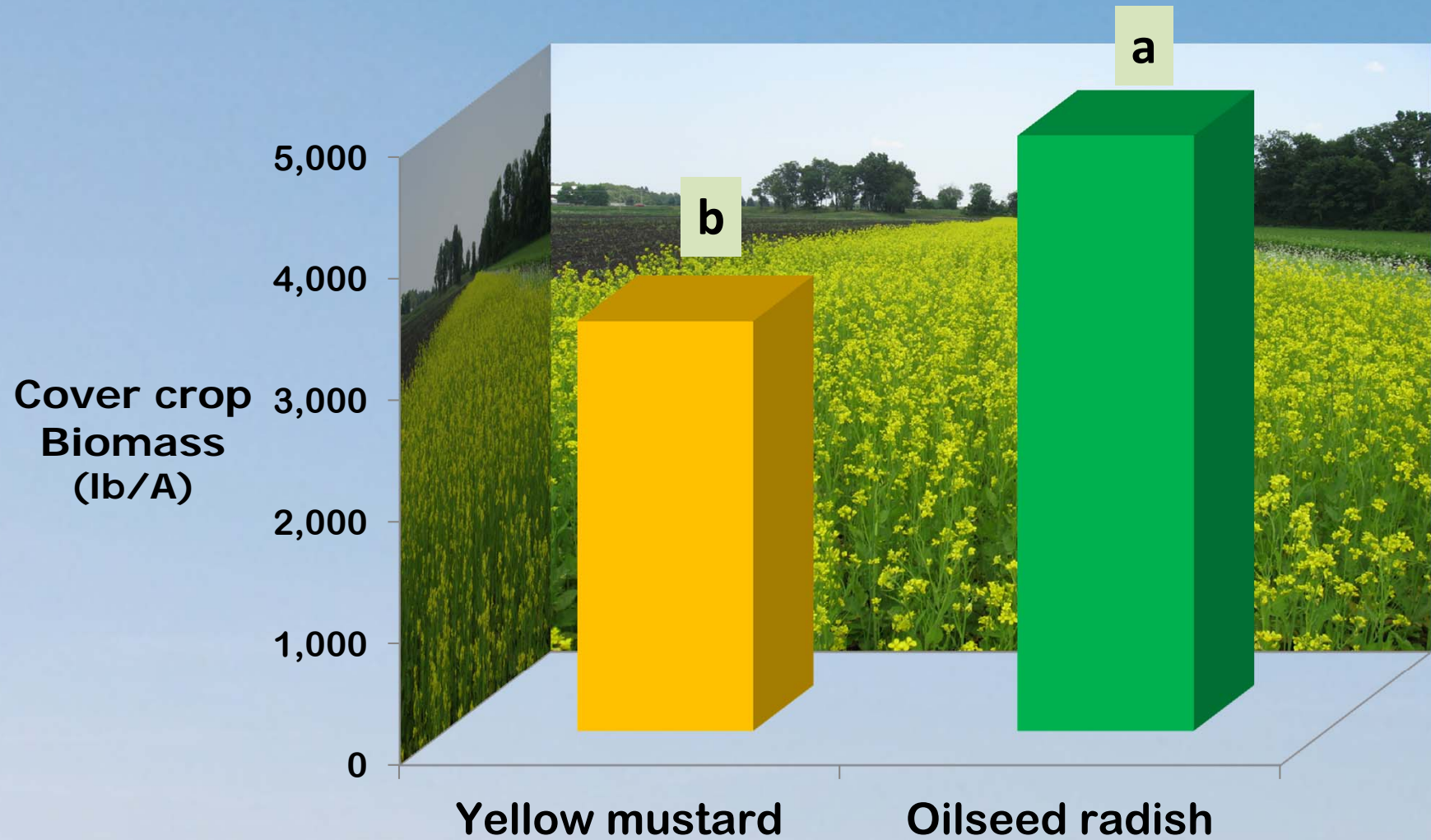
Yellow Mustard



COVER CROP BIOMASS (YEAR 1)



COVER CROP BIOMASS (YEAR 2)



Cover Crop	Stand count		Biomass evaluation	
	6 Jun	1 Jul	Plant count	Plant weight (g)
Control	166 b	156.8 b	11 b	11.6 b
Oilseed Radish	235 a	223.1 a	14 a	19.9 a
Yellow Mustard	230 a	225.0 a	14 a	18.8 a

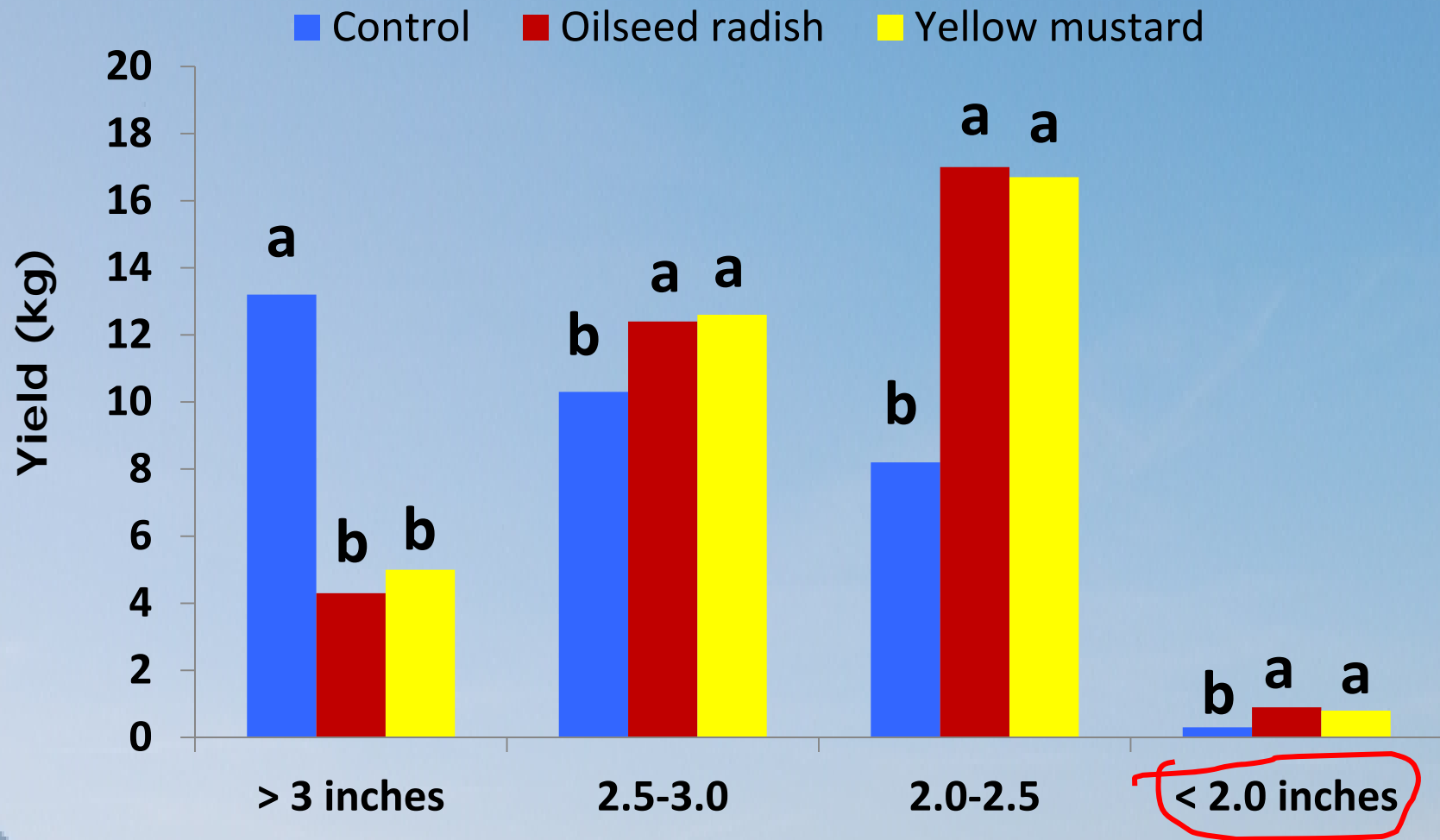
Plant density	Stand count		Biomass evaluation	
	6 Jun	1 Jul	Plant count	Plant weight (g)
259,000	280 a	275.5 a	17.3 a	23.3 a
225,000	244 b	231.3 b	14.2 b	19.9 ab
205,000	209 c	199.1 c	13.8 b	16.2 b
172,000	187 d	175.8 d	11.8 c	13.5 bc
140,000	132 e	126.4 e	8.3 d	10.8 c





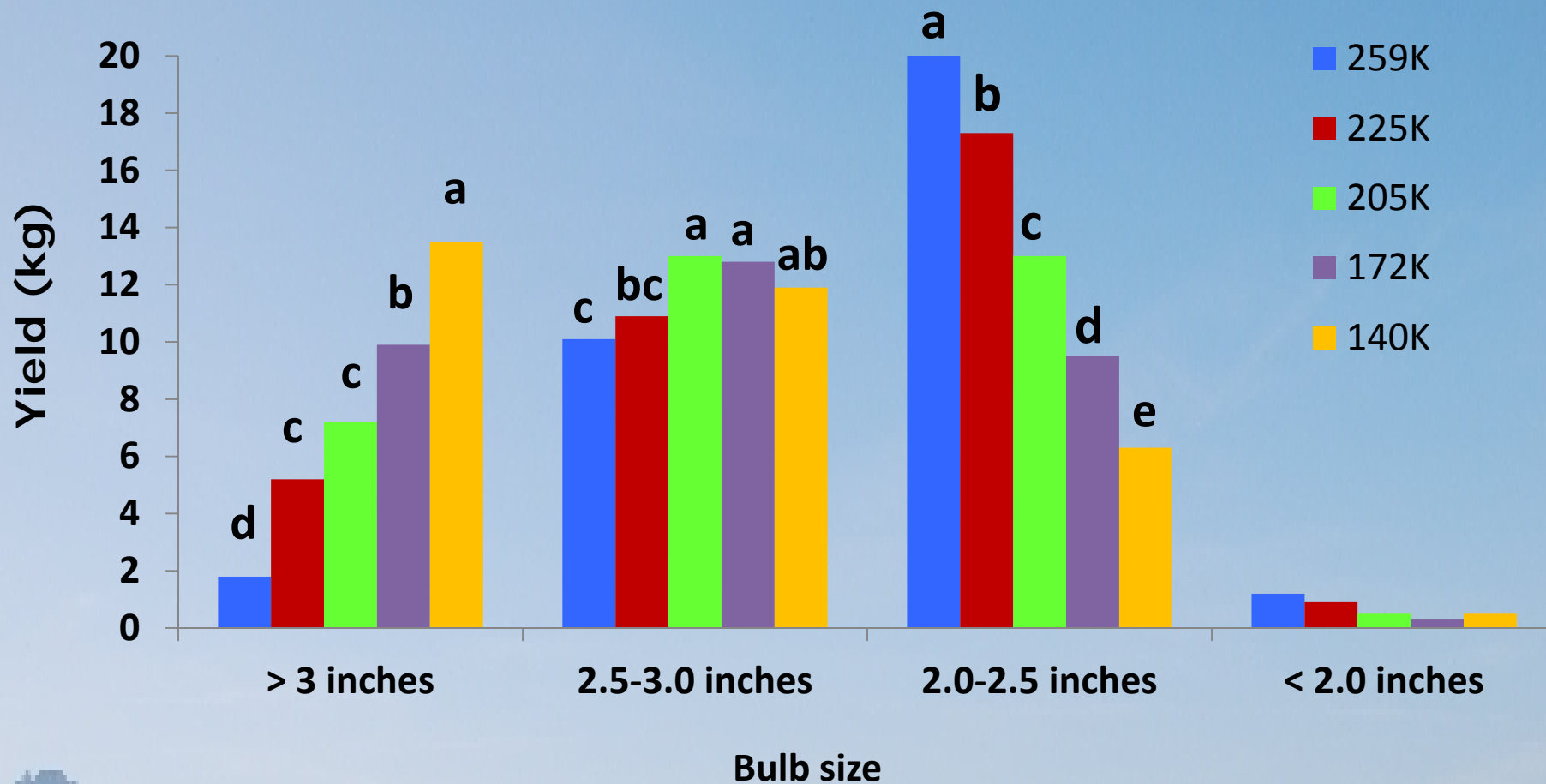
10-foot section harvested

Onion yield: Cover crop effect



Non-marketable

Grade distribution



Yield change as a result of the use of cover crops

2008

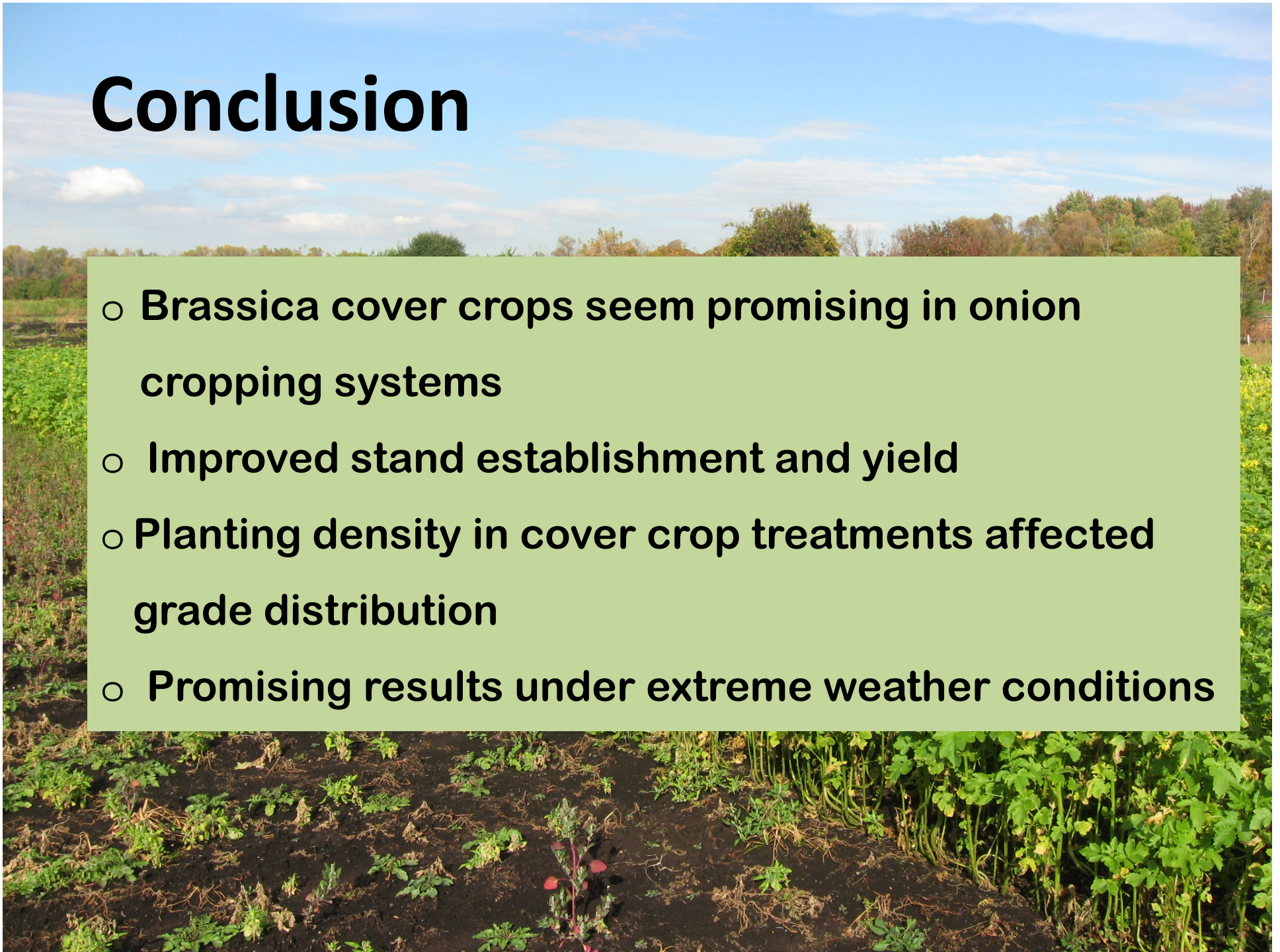
Cover crop	Yield increase (% of control)
Control	0.0%
Oilseed Radish	6.0%
Yellow Mustard	8.5%

2009

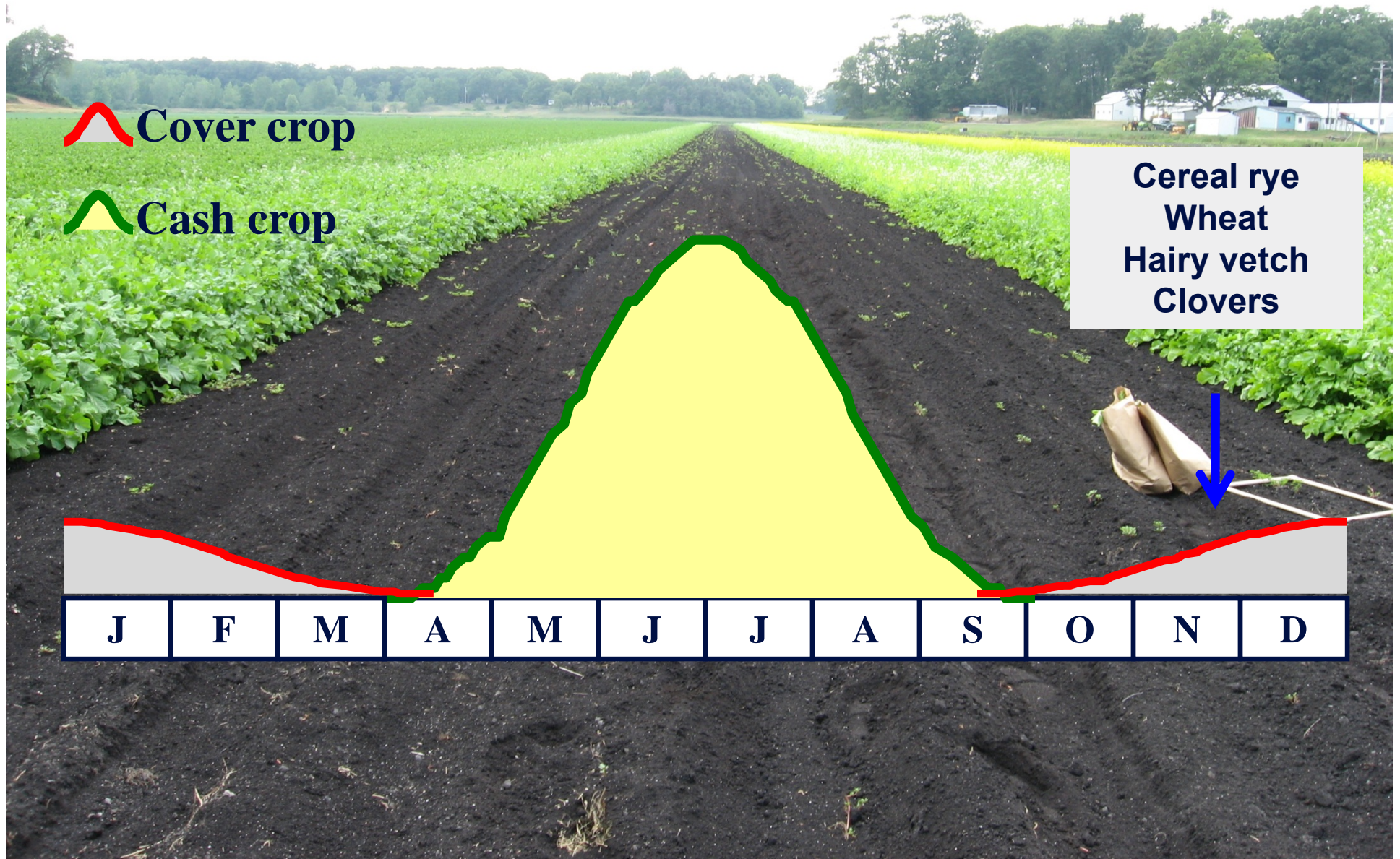
Cover crop	Yield increase (% of control)
Control	0.0%
Oilseed Radish	71.0%
Yellow Mustard	74.2%

Conclusion

- **Brassica cover crops seem promising in onion cropping systems**
- **Improved stand establishment and yield**
- **Planting density in cover crop treatments affected grade distribution**
- **Promising results under extreme weather conditions**



Cover crop windows: **Winter** **Off-season**



Undersowing/Interseeding



Cover crop windows

Interseeding/Undersowing Example
Broccoli- cereal rye

 Cover crop

 Cash crop



Broccoli with winter rye

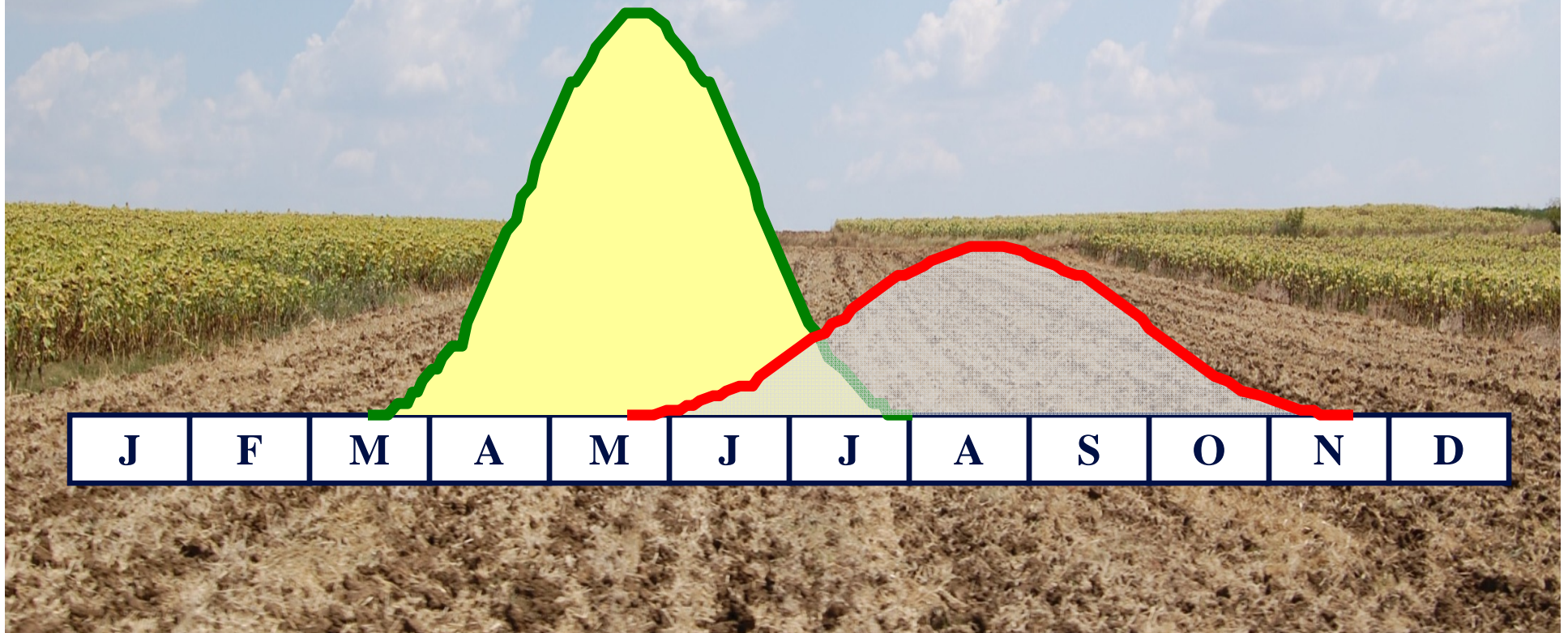


Cover crop windows

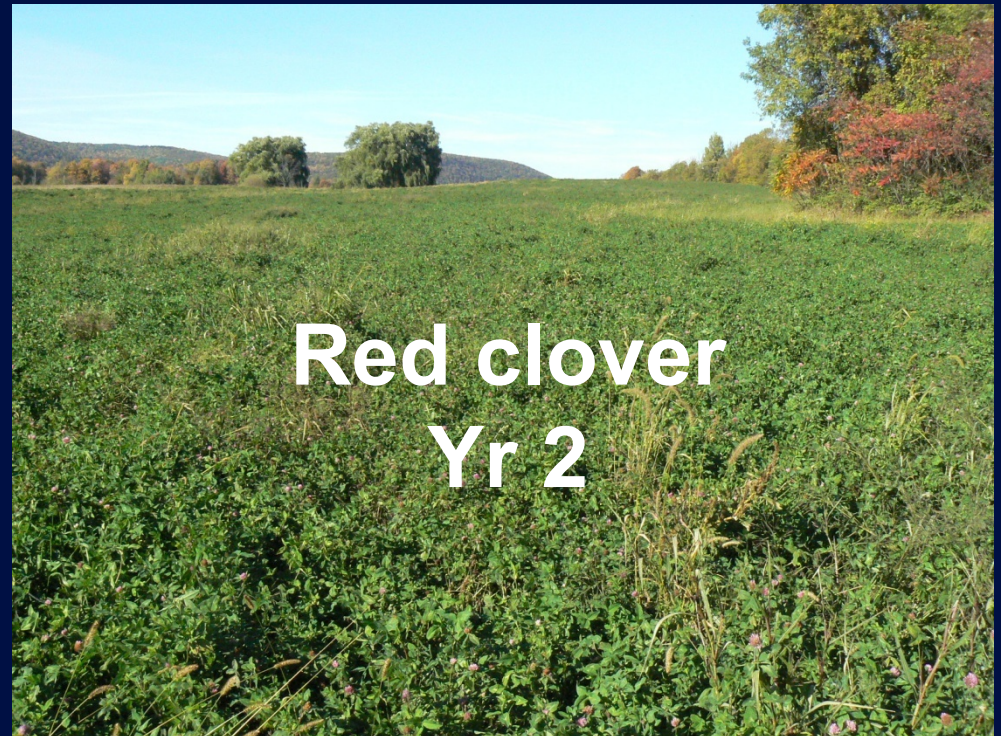
Interseeding/Undersowing Example
Peas/Red Clover

 Cover crop

 Cash crop



Relay cropping and Interseeding



Windbreaks



Cover crop windows

Windbreak Example
Carrots or Onions with Barley

 Cover crop

 Cash crop





Cover crop establishment: Weed pressure









Plot treated with Dual II Magnum

Irrigating cover crops

- Better germination and establishment
- Higher biomass



Greg Rinehart, Boone IA



Combining reduced tillage and
cover cropping:
Some examples

Strip-tillage

- Till strips
- Plant into strips
- Leave area between strips undisturbed



Strip-tillage in carrots



Diversity may be important in response to management

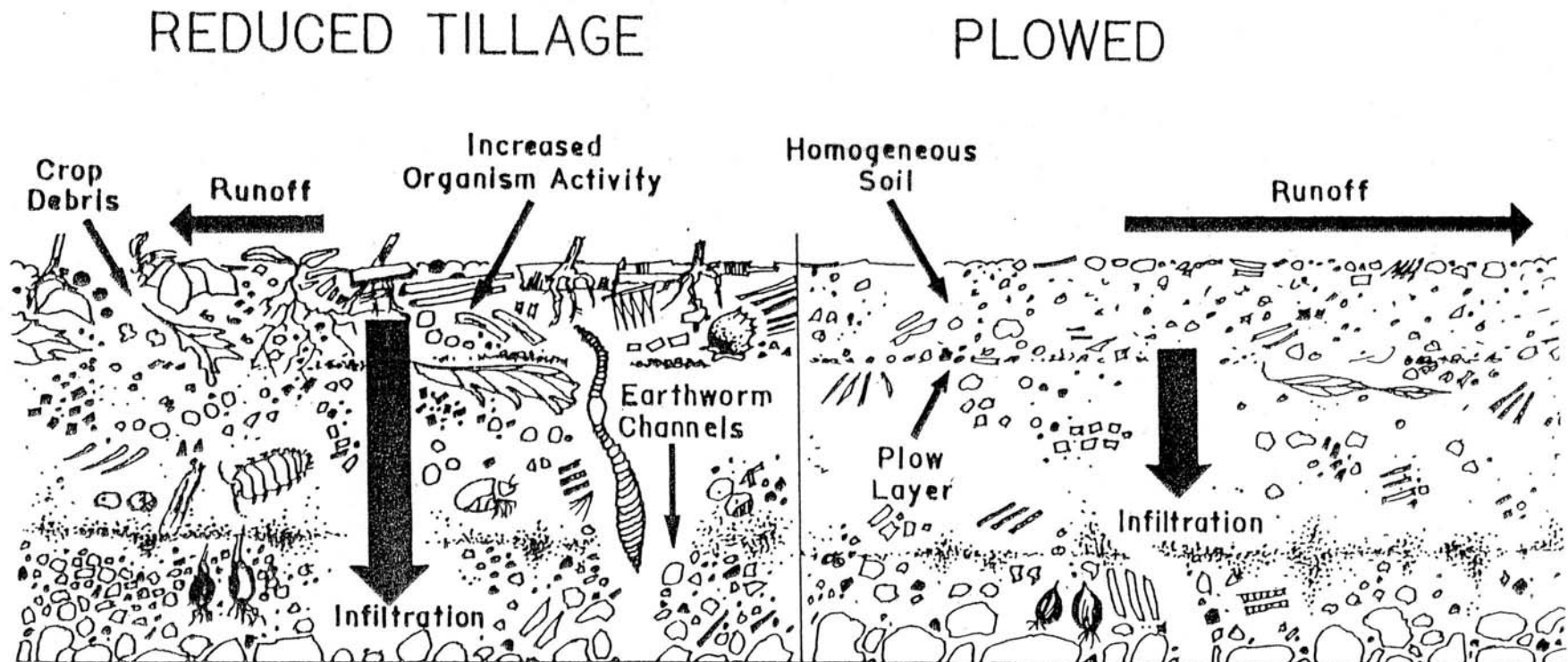


Figure 2. A comparison of biological, physical, and chemical properties of minimum tillage and plowed soils (from Stinner and Stinner, 1989).

Permanent Beds Controlled traffic



Conventional tillage no cover crop



Rye in strip-till pumpkins



Potential Problems with Strip-till

- Weed management more complicated
- Nutrient management different
- Pest issues
 - Garden symphalan
 - Slugs
 - Diseases?

Need for systems approach; integration with crop rotation, fertility management, cover crops etc.

Why soil biology is important for vegetable cropping systems?

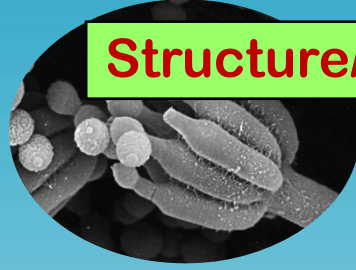


- Annual, short duration crops
- Soil nutrient status critical
- Timely supply of nutrients
- Soil pest and pathogens
- Water holding capacity
- Soil structure

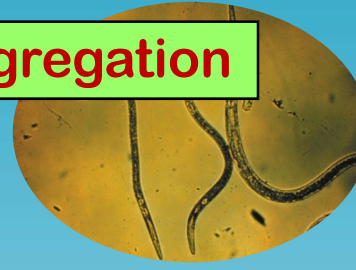
Process Controllers



Happy bacteria



Funny fungi



Nomadic nematode



Pristine Protozoans

Structure/Aggregation

Humification

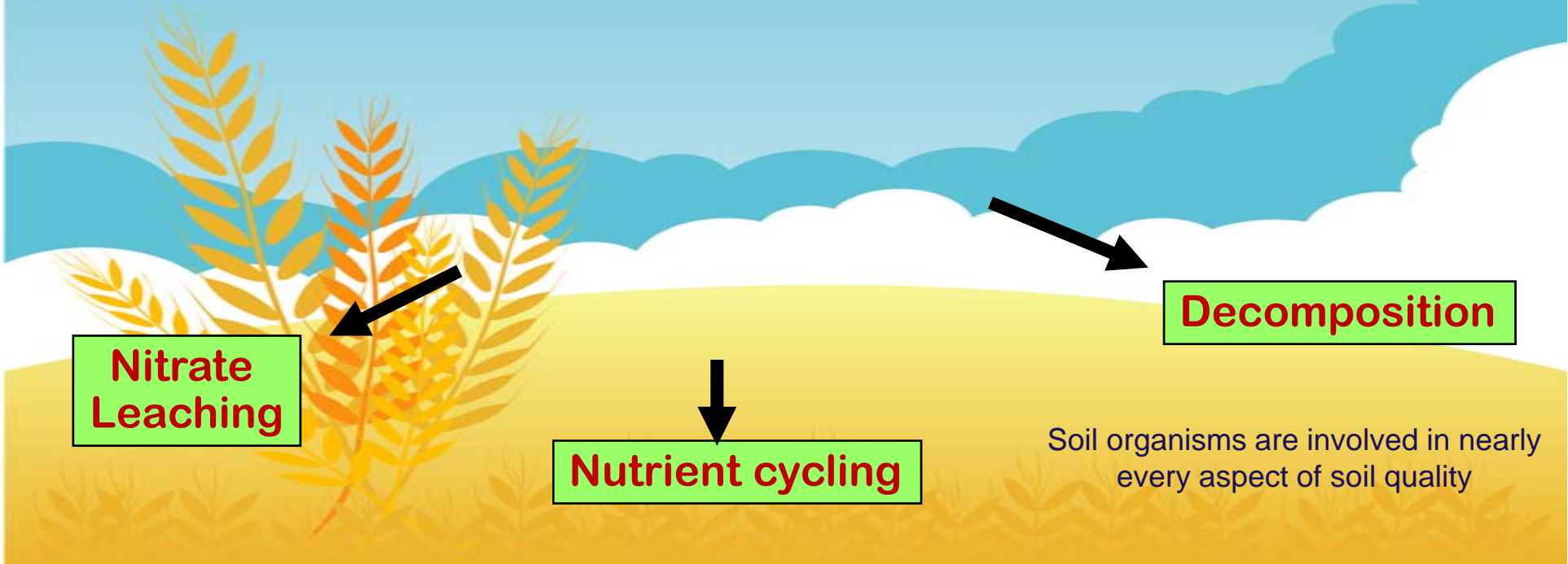
Organic matter

Decomposition

Nitrate Leaching

Nutrient cycling

Soil organisms are involved in nearly every aspect of soil quality



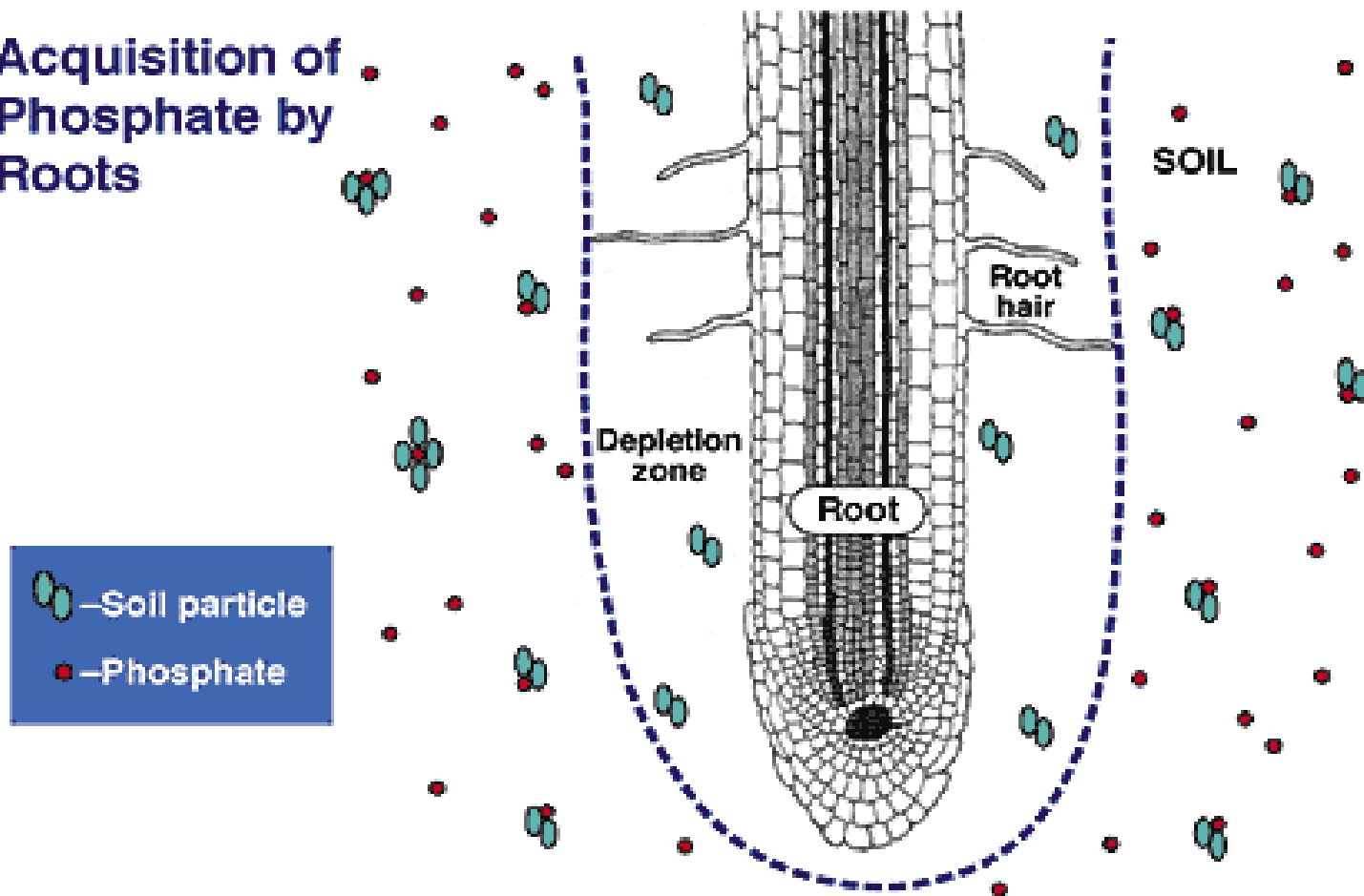
Significance of soil microflora and fauna

- Breakdown complex molecules and compounds
- Pathogen suppression
- Stabilization of soil aggregates
- Nutrient cycling



Bacteria
Fungi
Nematode
Mycorrhizae

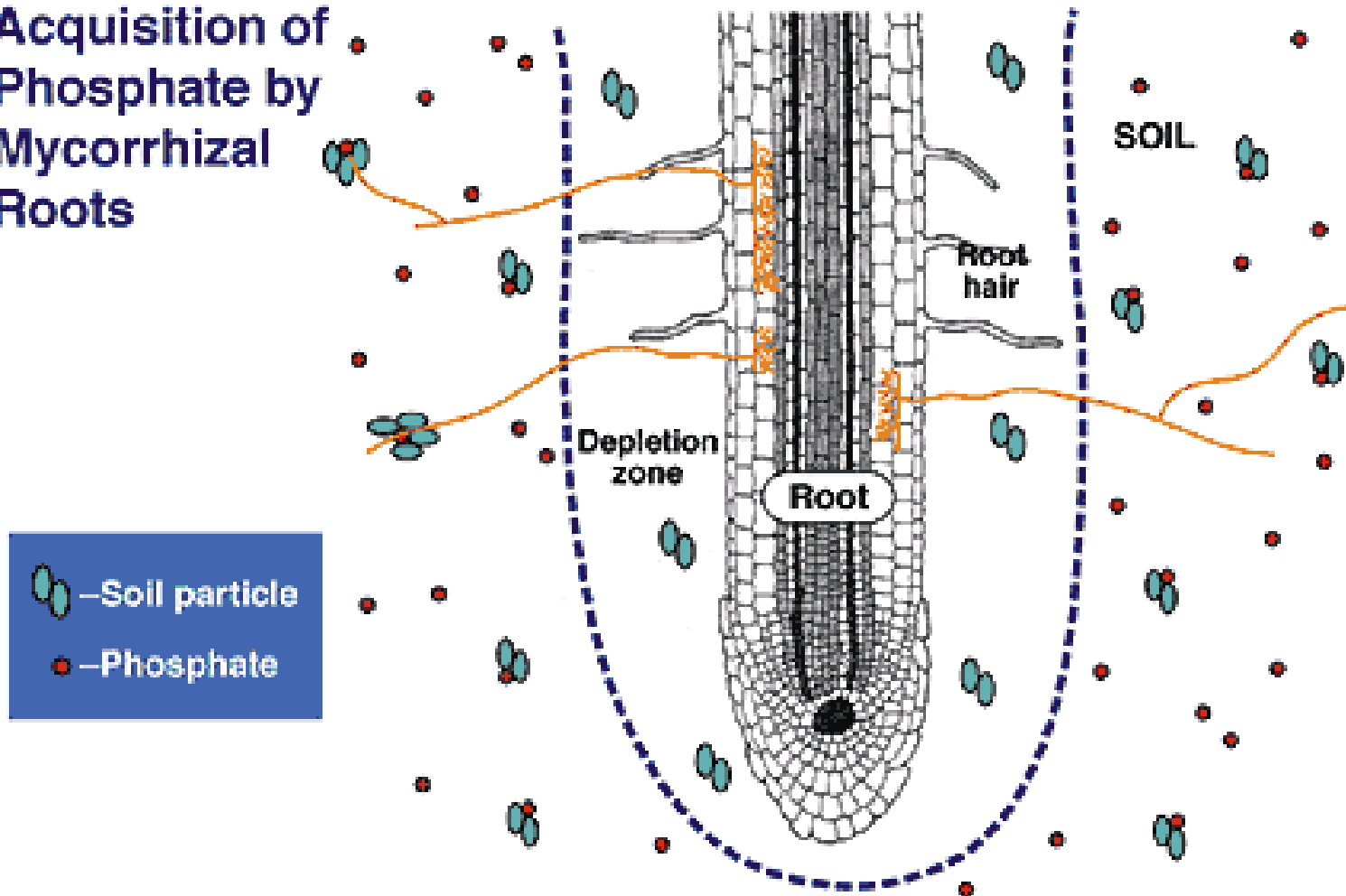
Acquisition of Phosphate by Roots



Roots without mycorrhizae

Source: Harrison et al. 1999

Acquisition of Phosphate by Mycorrhizal Roots



Roots with mycorrhizae

Source: Harrison et al 1999

Soil Building Processes

Cover Crops

Compost

Why biologically active ?

Crop rotation

• *Initiate decomposition reactions*

No-till

• *Release of nutrients for plant*

uptake
Irrigation

• *Development of humus and other*

growth promoting substances

Management

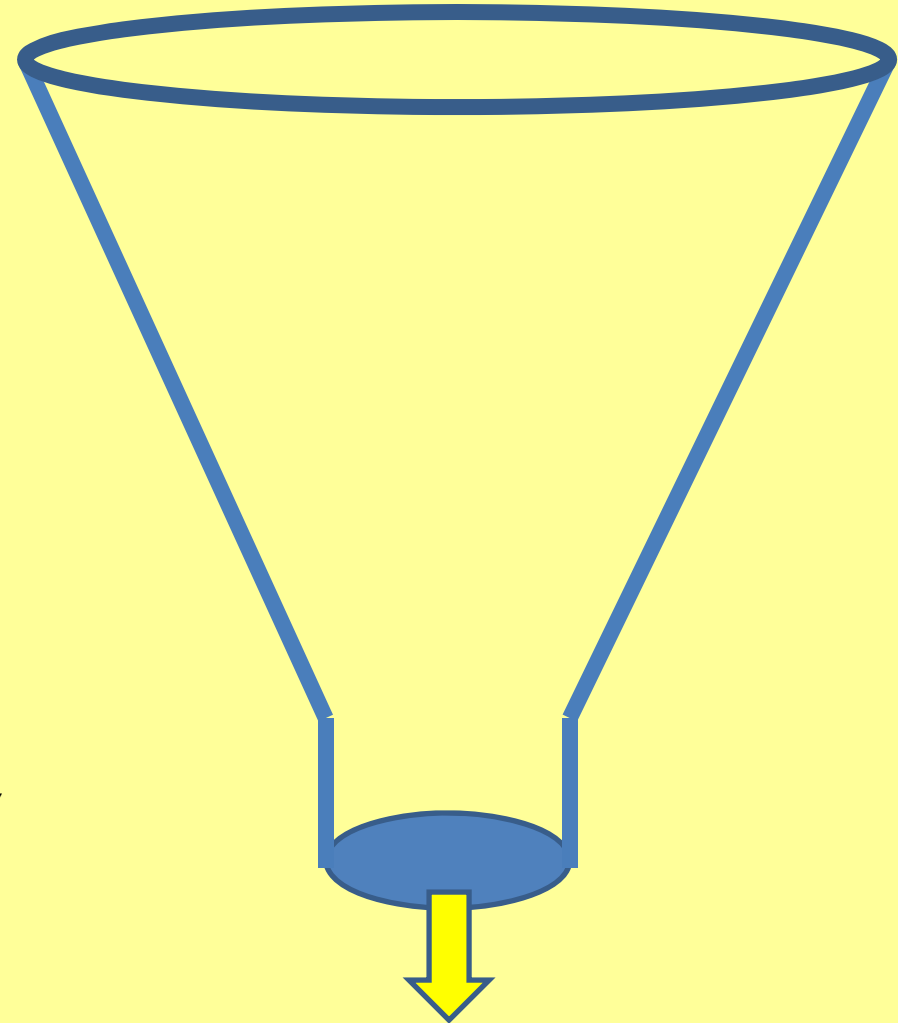
• *Improvement in soil structure and*

physical properties

• *Suppress soil-borne pathogens by*

occupying the niche

• *Drive nature's C and N cycles*



Biologically Active Soil

Value addition



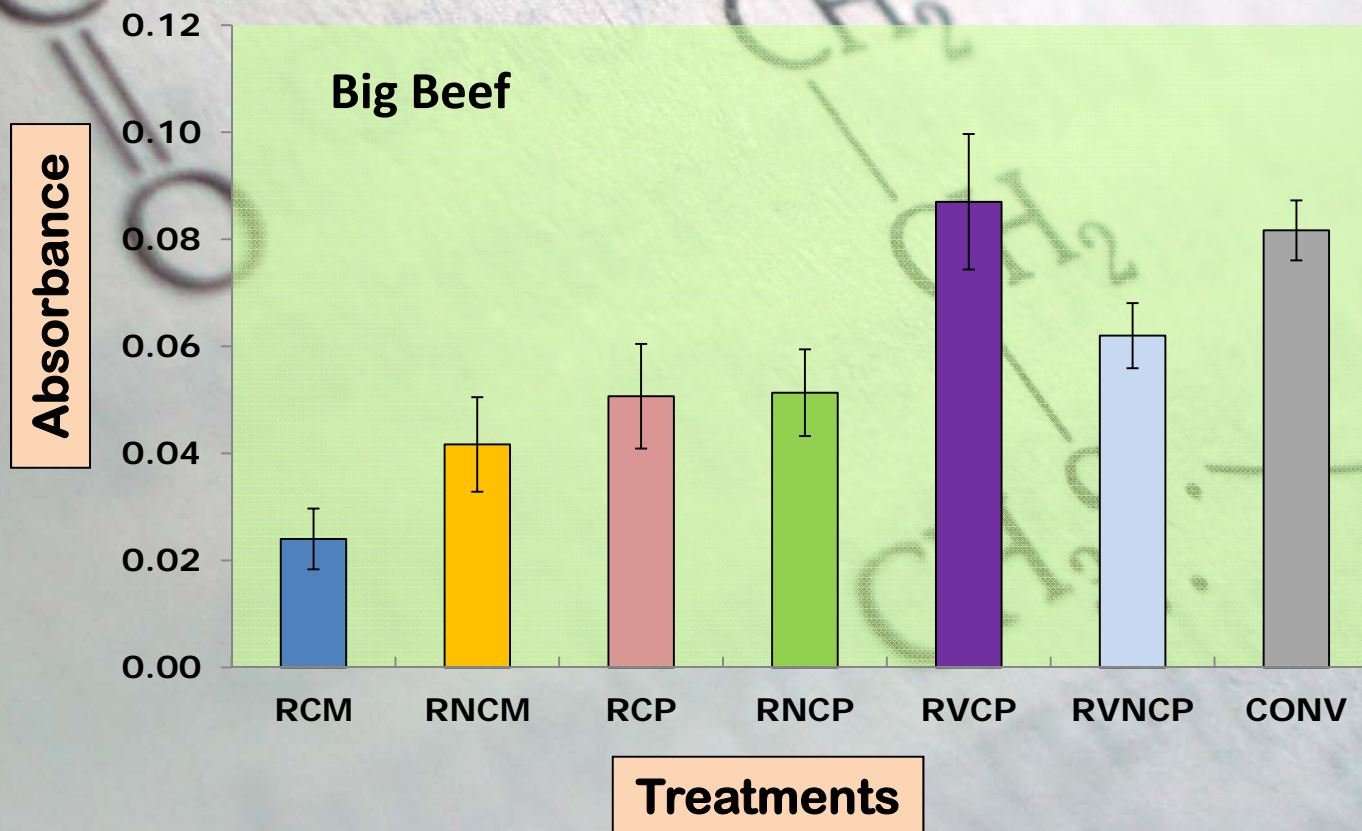
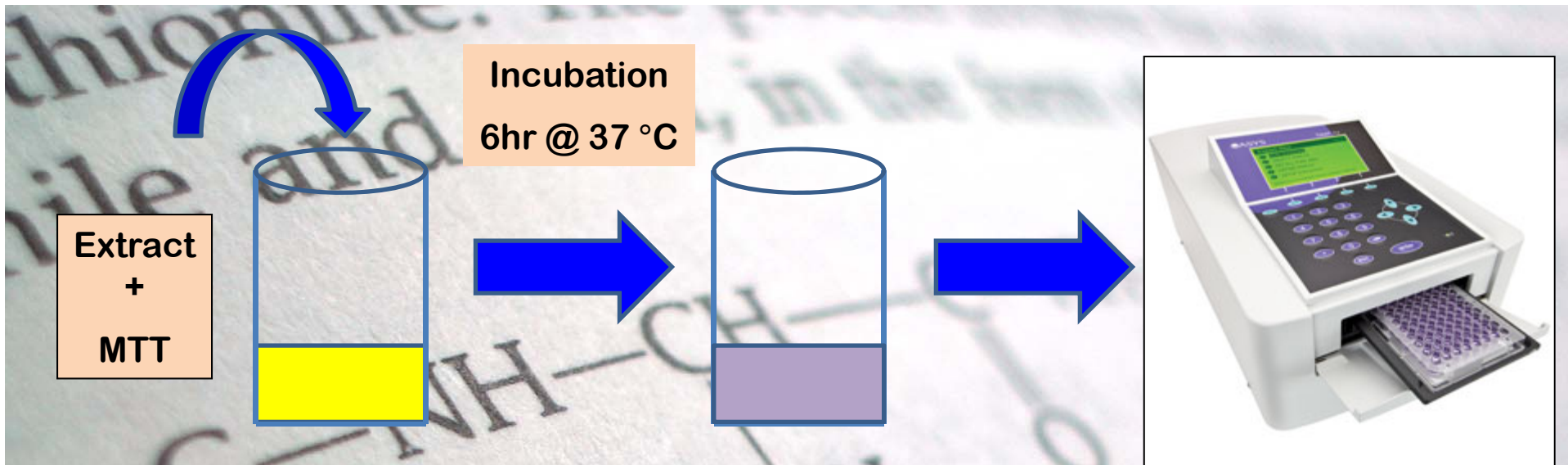
- **Biological activity**
- **Consumer demand**
- **Example: marketing of berries for antioxidants**



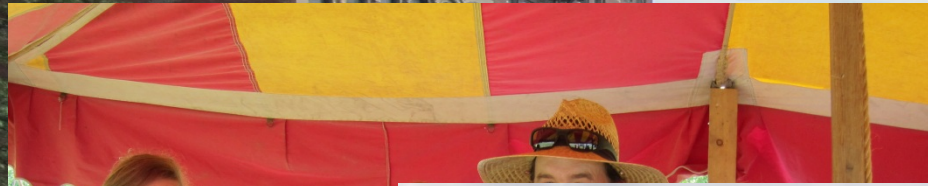
**Help establish and expand
agricultural-related businesses
in Iowa**







Promising !!!



**Geisler,
Bondurant**

**Bob Vanous,
Cedar Rapids**



Moines Farmers Mkt



**Mike Vonweih
Phil Hackett,
Carson**



Wilbers, Boone

THANKS



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Moriah Bilenky
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