UNIVERSITY OF MINNESOTA
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Connecting High Tunnels to Soil Health

USDA United States Department of Agriculture
Natural Resources Conservation Service

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325
High Tunnel System

NRCS Conservation Practice Standard (CPS)

https://efotg.sc.egov.usda.gov/#/state/MN

1. Provides:
   - Definition,
   - Purpose,
   - Conditions where practice applies,
   - Technical Criteria,
   - Considerations
   - Plans and Specifications,
   - Operation and Maintenance.

2. Located within Section IV of the Field Office Technical Guide (FOTG)

Test your knowledge

What is the correct Purpose statement for the High Tunnel System Conservation Practice Standard?

Test your Knowledge

What is not a statement for conditions where the 325 High Tunnel System practice applies?

A. This practice applies to land capable of producing crops. This practice applies were sun or wind intensity may damage crops, or where an extension of the growing season is needed due to climatic conditions.
B. An enclosed polyethylene, polycarbonate, plastic, or fabric covered structure that is used to cover and protect crops from sun, wind, excessive rainfall, or cold, to extend the growing season in an environmentally safe manner
C. The practice does not apply to crops not grown in the natural soil profile (i.e. tables/benches, portablepots, hydroponically, etc.).

Addressing all the General Criteria is required to meet the 325 Conservation Practice Standard.

True

False

Test your knowledge

Is this Statement True or False?

Addressing all the General Criteria is required to meet the 325 Conservation Practice Standard.

CRITERIA

General Criteria Applicable to All Purposes

Plan supportive conservation practices to address all environmental concerns associated with the installation and use of the high tunnel systems such as erosion, irrigation, and runoff.

Crops must be grown in the natural soil profile. Raised beds may be installed to improve soil condition, fertility, and access. Raised beds are a maximum of 12 inches in depth.

The practice does not include greenhouses or low tunnel systems.

The practice cannot be used to provide shelter or housing for any livestock, or to store supplies or equipment.

Locate structures to avoid buried public utilities.

Locate the structure near a viable water source for irrigation.

The high tunnel structure must be planned, designed, and constructed from a manufactured kit in accordance with manufacturers' recommendations. The high tunnel frame must be constructed of metal, wood, or durable plastic; and be at least 6 feet in height at the peak of the structure. If required for enclosure, end wall covering may be greenhouse-grade plastic, polycarbonate, wood, or other. Use structures with the entry/exit point sized to facilitate movement of equipment and supplies needed for the production of planned crops.

Answer: True

Test your knowledge

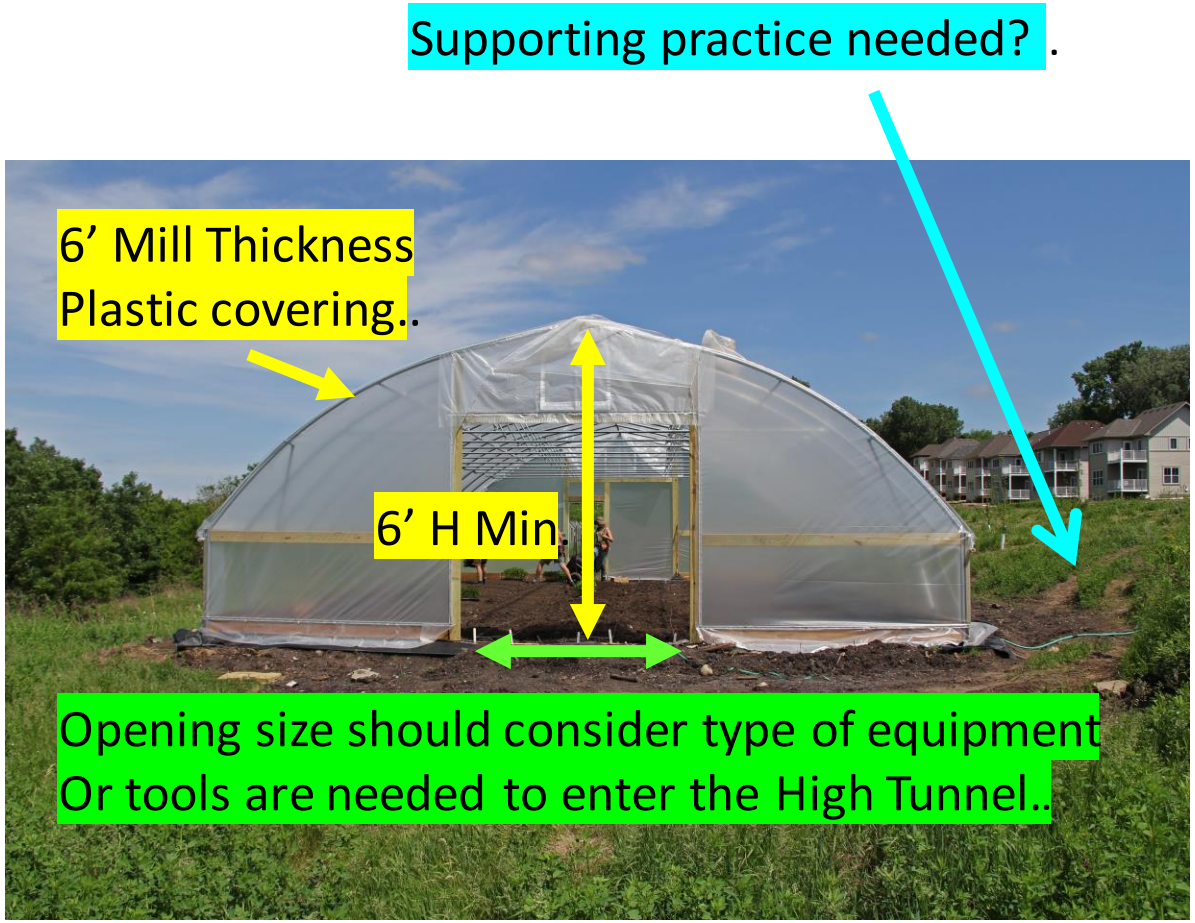
Is this Statement True or False?

325 High Tunnel Systems Conservation Practice Standard (CPS) Highlights

- ✓For organic producers, it will be the responsibility of the producer to make sure that all permissible activities, design, material used, and material specifications are consistent with the USDA Agricultural Marketing Service National Organic Program, National Standards on Organic Agricultural Production and Handling.
- ✓Crops must be grown in the natural soil profile.
- ✓The high tunnel structure must be planned, designed, and constructed from a manufactured kit in accordance with manufacturers' recommendations.
- ✓The high tunnel frame must be constructed of metal,wood, or durable plastic; and be at least 6 feet in height at the peak of the structure

325 CPS Highlights

- ✓ For polyethylene covers, use a minimum 6-mil greenhouse grade, UV-resistant material.
- ✓Construct high tunnel structures on level grade or the naturally occurring slope if the slope does not exceed five percent.



325 CPS Highlights

- Plan supportive conservation practices to address all environmental concerns associated with the installation and use of the high tunnel systems such as erosion, irrigation, and runoff.

325 CPS Highlights

- ✓The practice does not include greenhouses or low tunnel systems.
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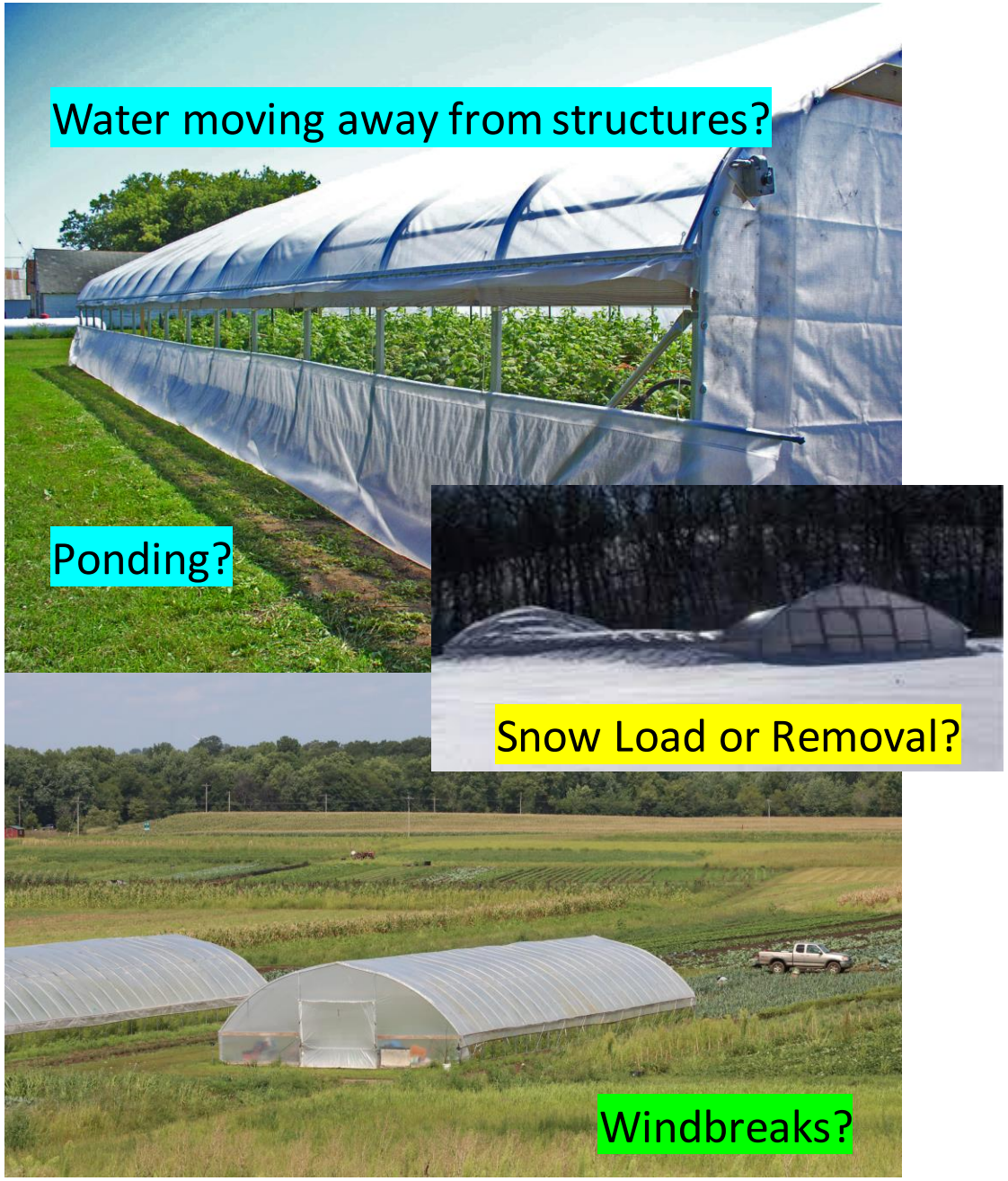
- ✓Locate structures to avoid buried public utilities.



Types of High Tunnels

GrowSpan Round Cold Frames

GrowSpan Gothic Cold Frames

GrowSpan Straight Sided Cold Frames

Photo's from FarmTek website.

Bells and Whistles: Doors

Bells and Whistles: venting

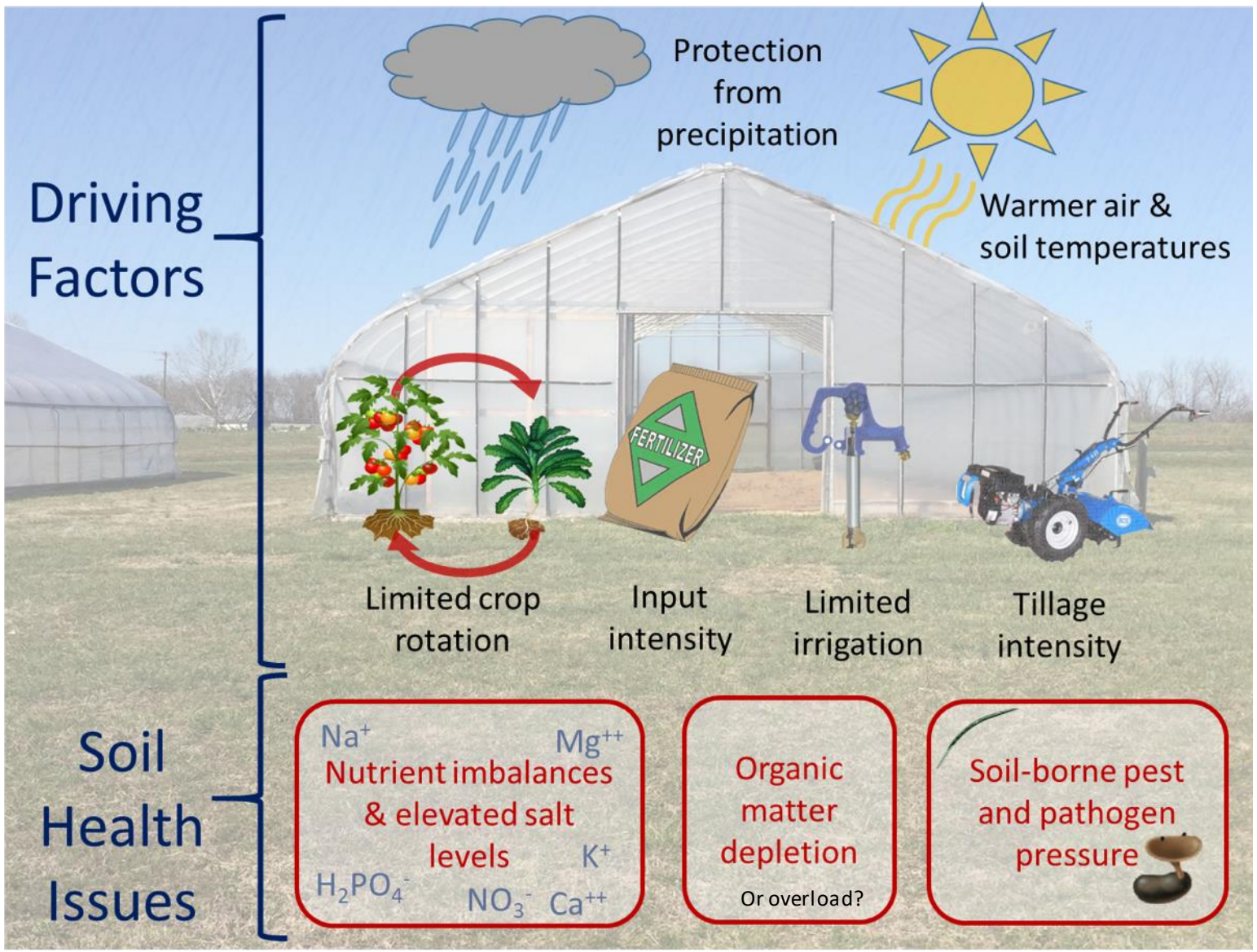
Or shutters and fans?

PVC quonset tunnel collapsed under ice and snow load. Vinland Valley Nursery, Baldwin City, KS. Photo Credit: Dan Nagengast, hightunnels.org

And now the risks…

Multi-bay quonset tunnels damaged in severe thunderstorm in August of 2004. Photo credit: Ted Carey, Kansas State University

Why is Soil Health important in High Tunnels? What Resource Concerns are popping up?



Controlled environments like high tunnels and greenhouses are very different systems from the open field.

Image source: K. Jacobson, Univ Kentucky

Possible high tunnel resource concerns

NUTRIENT TRANSPORTED TO GROUND WATER

COMPACTION

INEFFICIENT IRRIGATION WATER USE

SOIL ORGANISM HABITAT LOSS OR DEGRADATION

AGGREGATE INSTABILITY

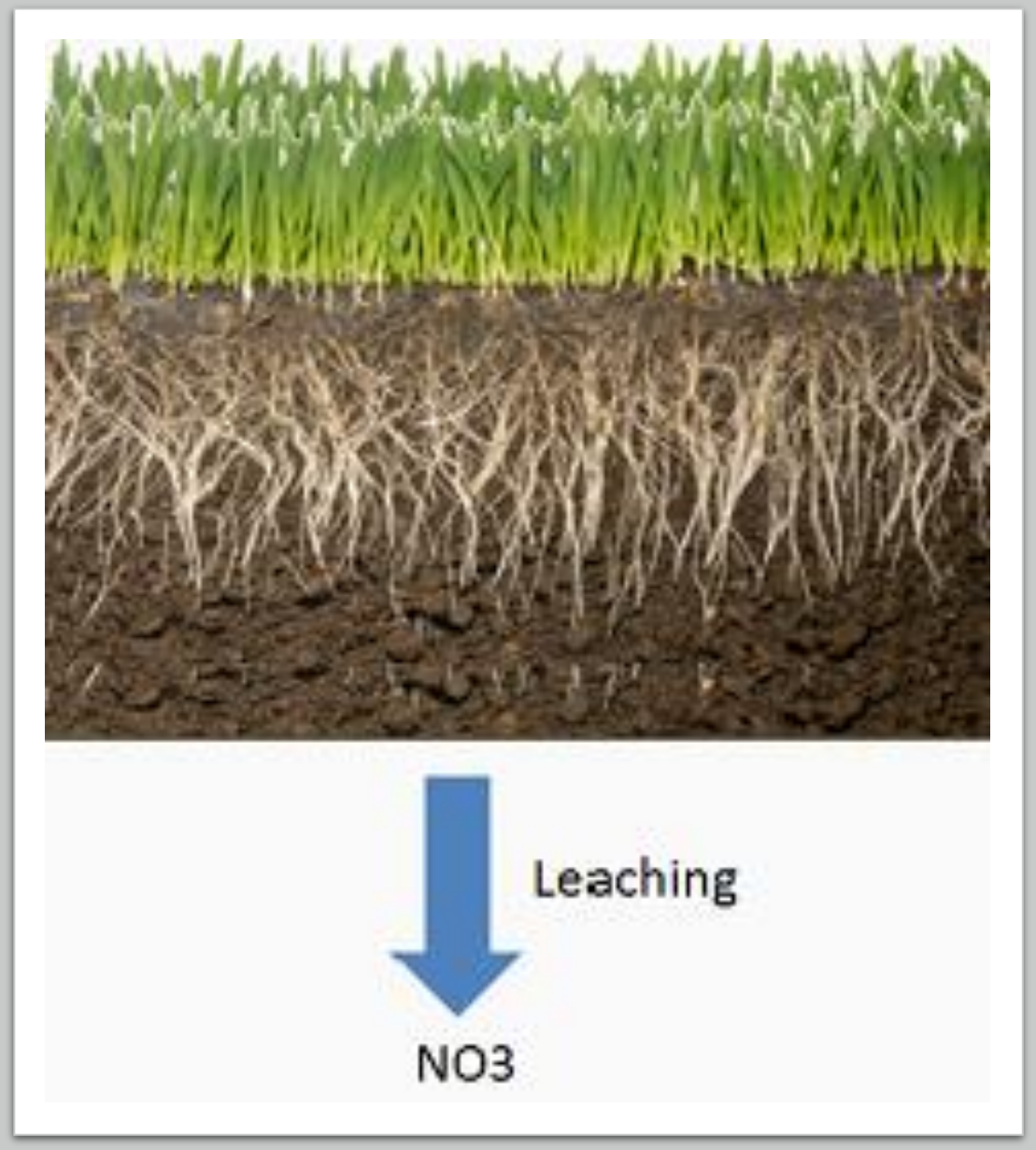
PLANT PRODUCTIVITY AND PLANT HEALTH

PLANT PEST PRESSURE – DISEASE AND INSECT

NRCS Resource Concern Fact Sheets: https://efotg.sc.egov.usda.gov/references/public/MN/Resource_Concern_Fact_Sheets.pdf

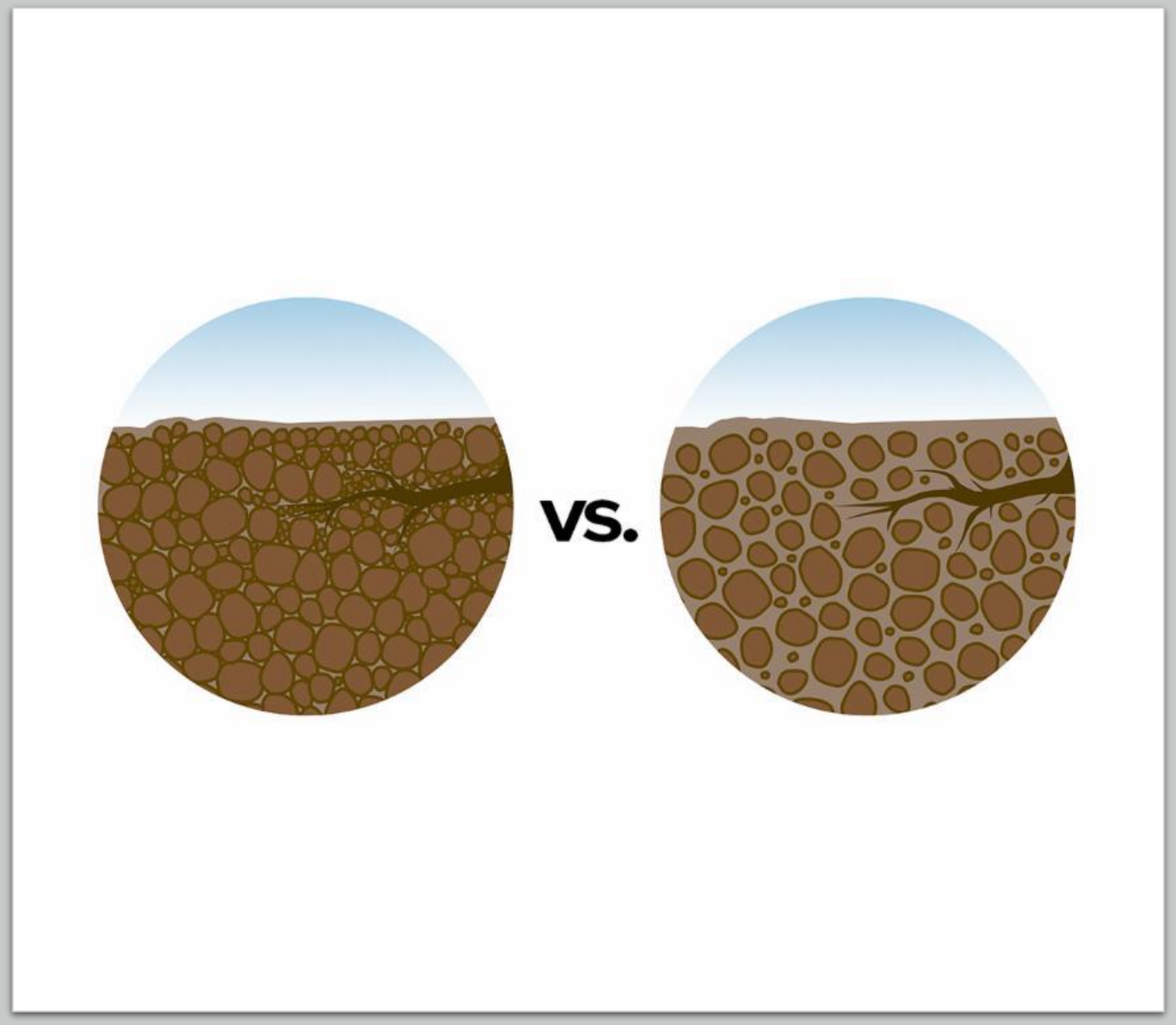
1. Nutrient transport to ground water - *possible*

- High levels of nutrients and salinity in top few inches due to fertigation practices
- Nutrient recommendations increased in tunnels
- Evidence that nutrients not in drip line are not solubilizing – not getting wet, which stimulates microbial activity.
- What happens to these nutrients when plastic is removed and system is ‘flushed’?



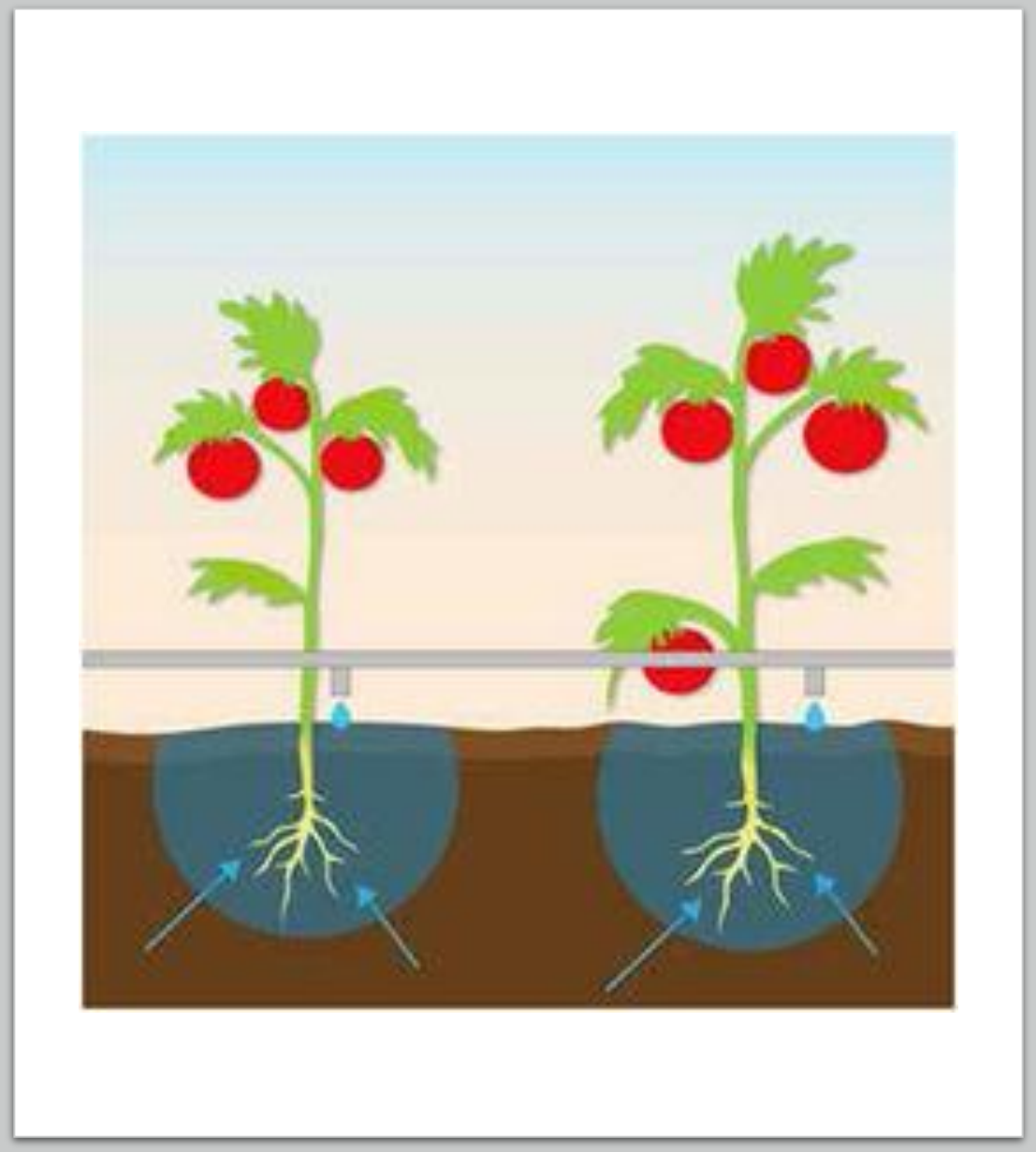
2. Compaction - *likely*

- Compaction appears to increase over time in high tunnels
- Intense management and heavy tillage in first few inches contributor



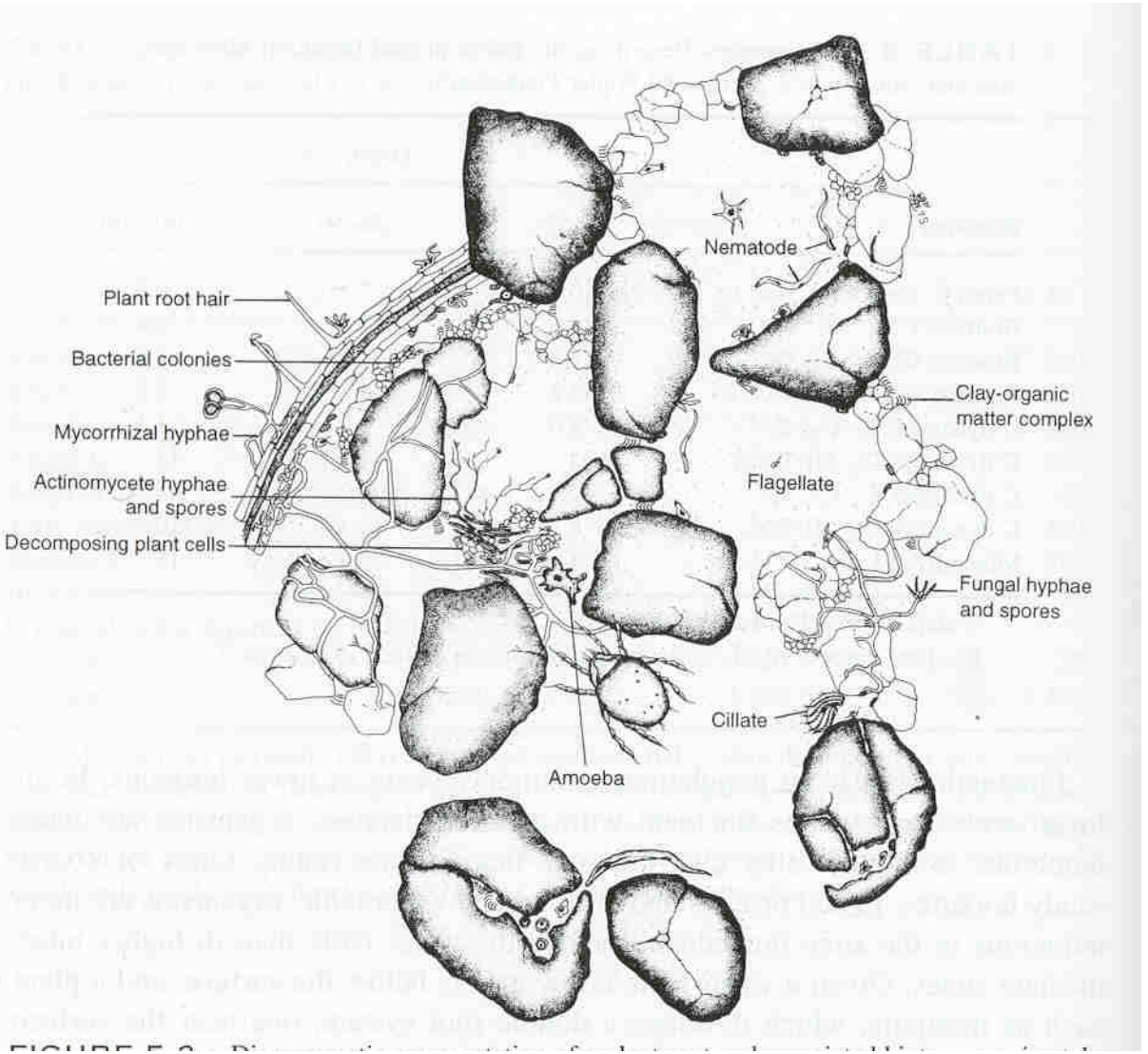
3. Inefficient irrigation and water use - *possible*

- On one hand, water is used efficiently when it is delivered via drip lines
- On the other hand, we don’t understand what the lack of natural rainfall is doing to soil organisms, decomposition and nutrient delivery

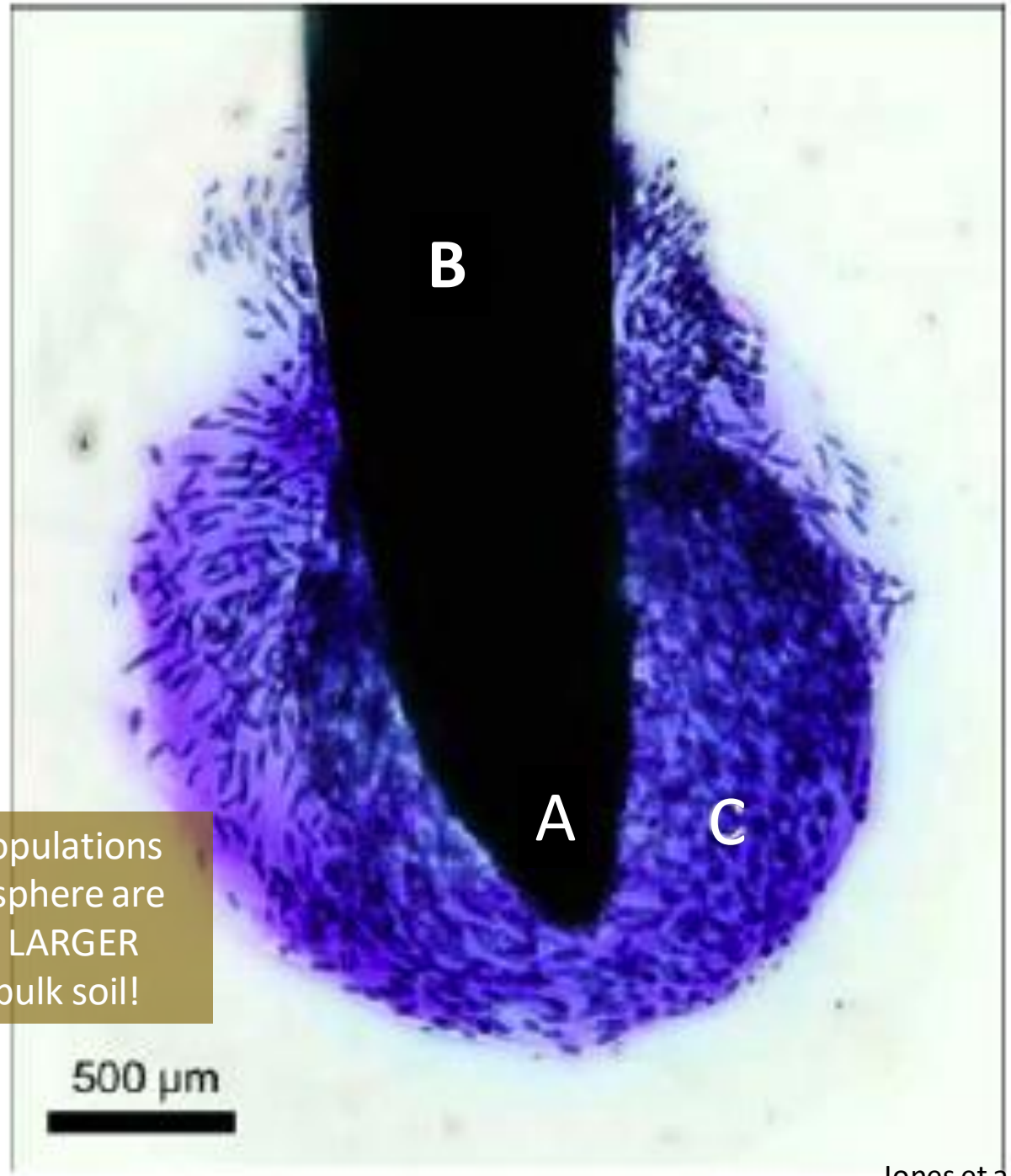


4. Soil organism habitat loss and reduced aggregate stability - *likely*

- High tunnels are irrigated deserts – hot, lack of moisture.
- Some farmers report loss of organisms, such as earthworms
- Organisms help to create stable aggregates through their activity.
- how do tunnels modify natural aggregation practices in unknown



. . . and roots exude organic material that microbes can feed on



microbial populations in the rhizosphere are 20-30 times LARGER than in the bulk soil!

Jones et al., 2009

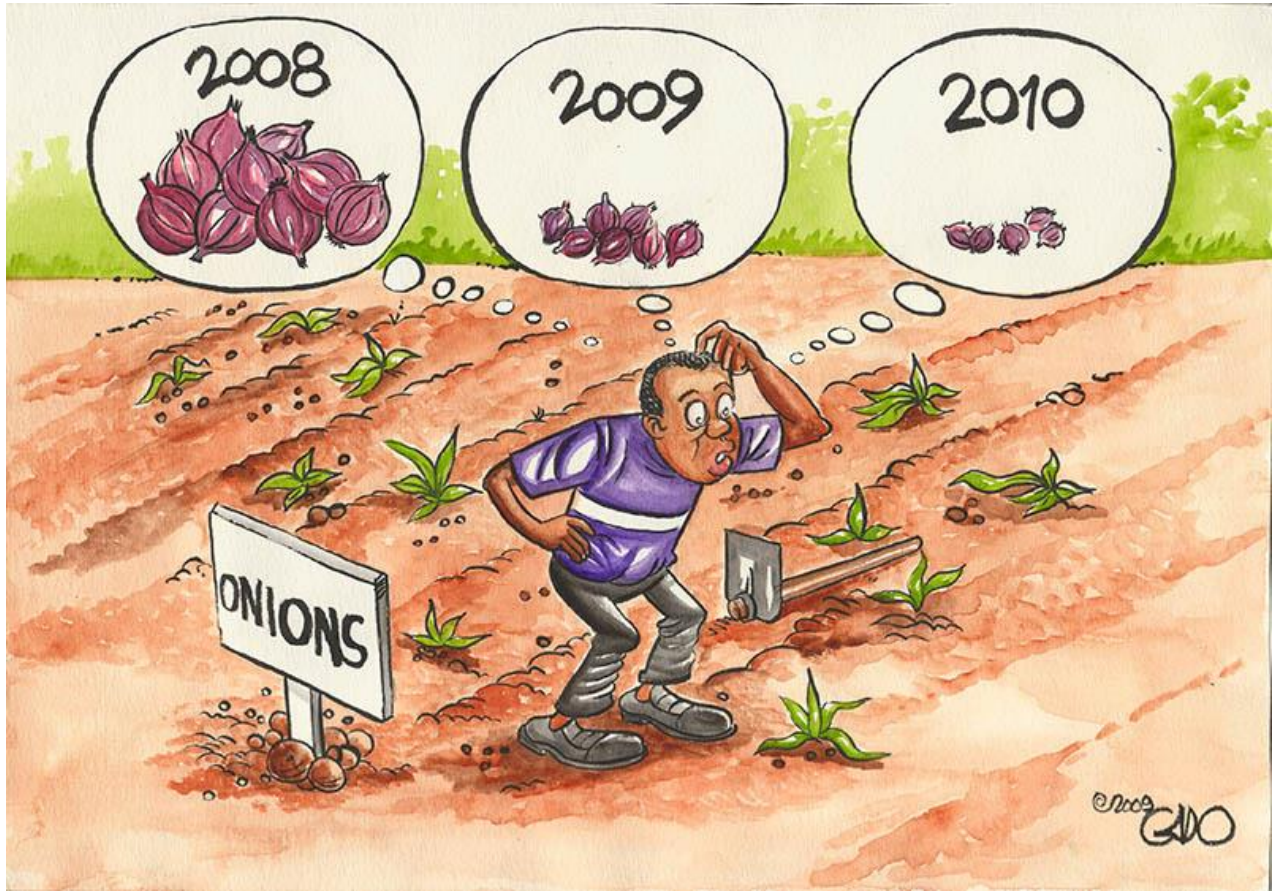
Soil biology is critical!

It drives functions related to nutrient cycling and availability in organic systems.

It also helps form aggregates via the sticky ‘glue’ released through their natural activity

5. Plant pest pressure – disease and insects - *likely*

- High moisture conditions (if overhead watered) combined with lack of ventilation can lead to disease
- Disease strikes upon stressed plants.
- Evidence that insects (both beneficial and problematic) differ inside v outside of tunnels
- Pest Management 595 CPS. – Prevention, Avoidance, Monitoring and Suppression (PAMS)

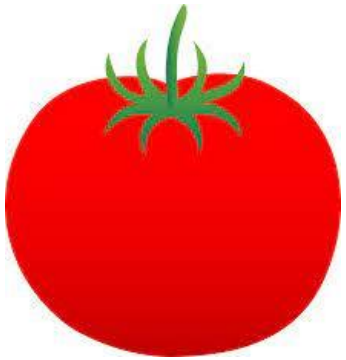


Producer focus groups in four regions revealed common challenges

Fertility and physical properties	Water management	Soilborne diseases
Compost management – including high P challenges	Winter irrigation challenging in far north	Downy mildew
Older tunnels with fertility issues	Need for water quality testing before HT install	Fusarium and bacterial wilt (tomatoes)
Salinity – especially over time	Still learning water and soil depth relationships by soil type	Sclerotinia – lettuces, and other crops
Soil compaction over 5-10 years		Rhizoctonia (NE)
Inconsistency of soil testing labs specific to HT		Southern blight (SE)

Survey of 20 tomato high tunnels in Northeast

Higher nutrient demand → increased yield = increased nutrient removal in crop



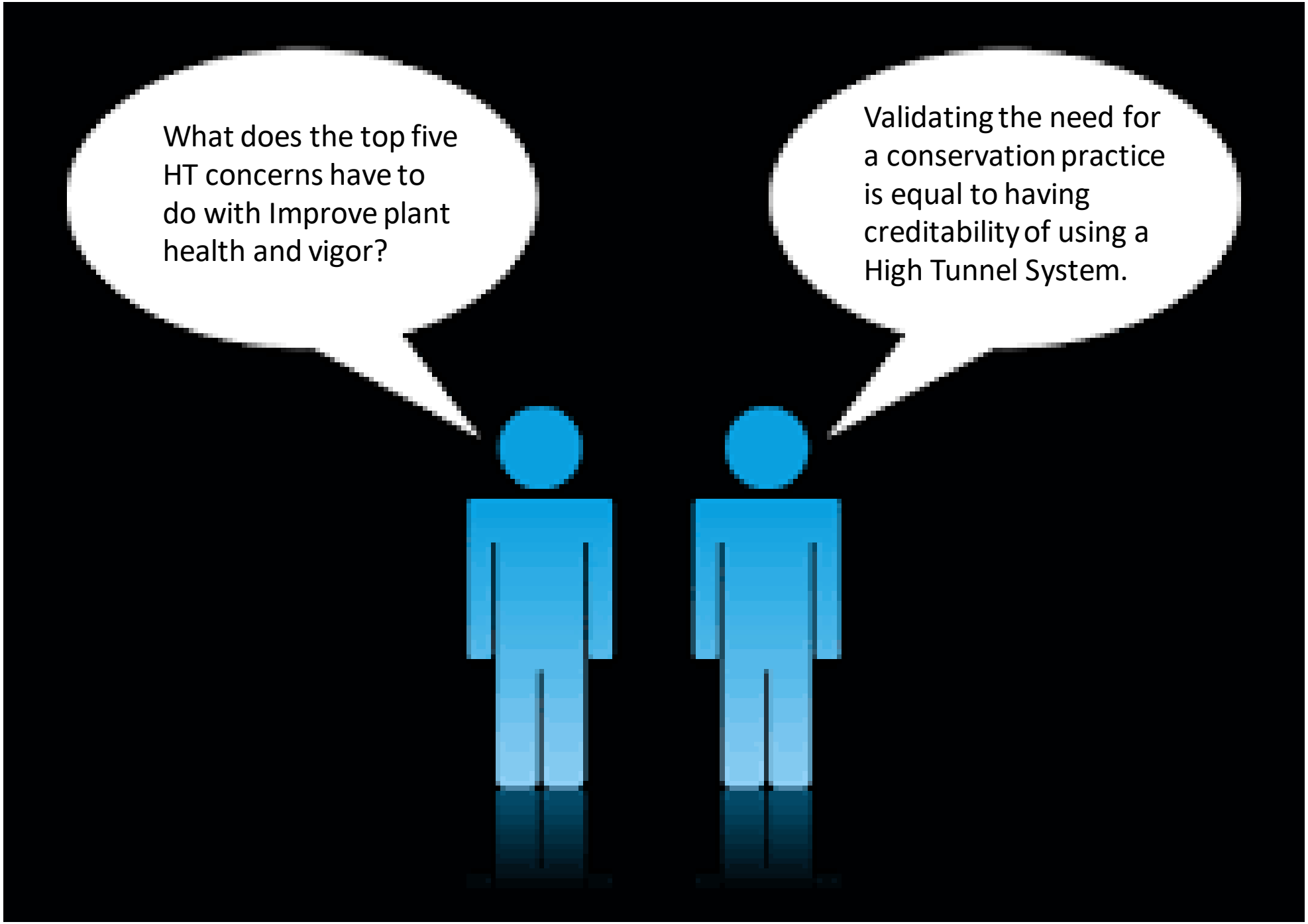
Potassium is removed in large quantities by tomatoes. Ensure availability as fruits form

Nitrogen is also removed in large quantities, provide sufficient available N for biomass production through the entire growing season.

Monitor available AND reserve soil nutrients! Take leaf samples monthly for additional guidance.

Fertilizer application should be based on soil test results, otherwise you are guessing!

Grubinger et al., 2019


What does the top five HT concerns have to do with Improve plant health and vigor?
Validating the need for a conservation practice is equal to having creditability of using a High Tunnel System.

What Conservation Practices assist a producer in achieving better soil health?

What Conservation Practices may solve the identified resource concerns?

Nutrient Management

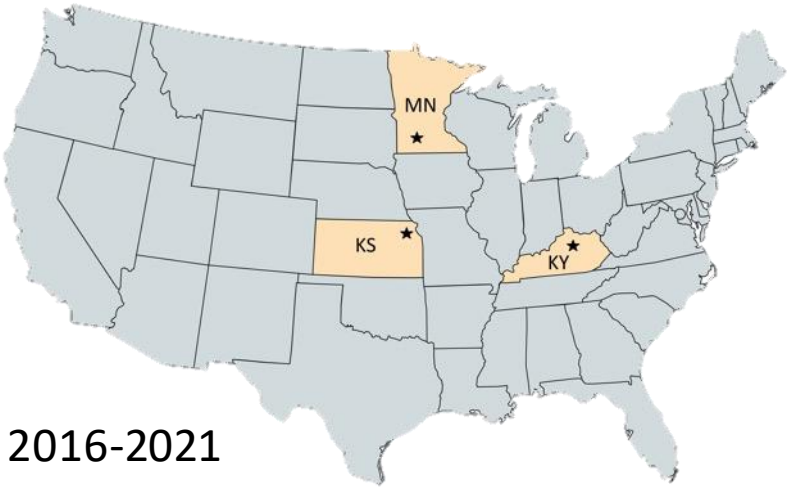
- Matching soil test reports with fertility strategies
  - Manure / compost may not always be the best bet due to P loading
- Choosing fertilizers with low salt content
- Increased awareness of the degree to which moisture management impacts nutrient release, and nutrient movement, in tunnels
- Evidence that soil organic matter may be increasing in high tunnels, not decreasing, due to compost use

What Conservation Practices may solve the identified resource concerns?

Cover crops

- Exploration of cover crops in (some) high tunnel environments
- TBD

How do we squeeze in cover crops? Where is the time?



USDA-OREI, 2016-2021

Winter	Spring	Summer	Fall	Winter
Jan Feb Mar	Apr May	Jun Jul Aug	Sep Oct	Nov Dec

…Fall-seeded, winter hardy

Cover crop

Summer crop

Fall-seeded…

Fall-seeded, winter kill

Cover crop

Spring cool season crop

Summer

Cover crop

Fall cool season crop

Species and systems we evaluated

Summer planted
(provide fall N)

- 1. cowpea
  2. cowpea + sorghum sudan grass
- spring kale (Starbor), fall spinach (Corvair)

Fall planted –
Winter-killed
(conserve and scavenge N)

- 1. Japanese millet
  2. cowpea + millet
- Early spring greens
  Summer tomato
  (BHN-589)

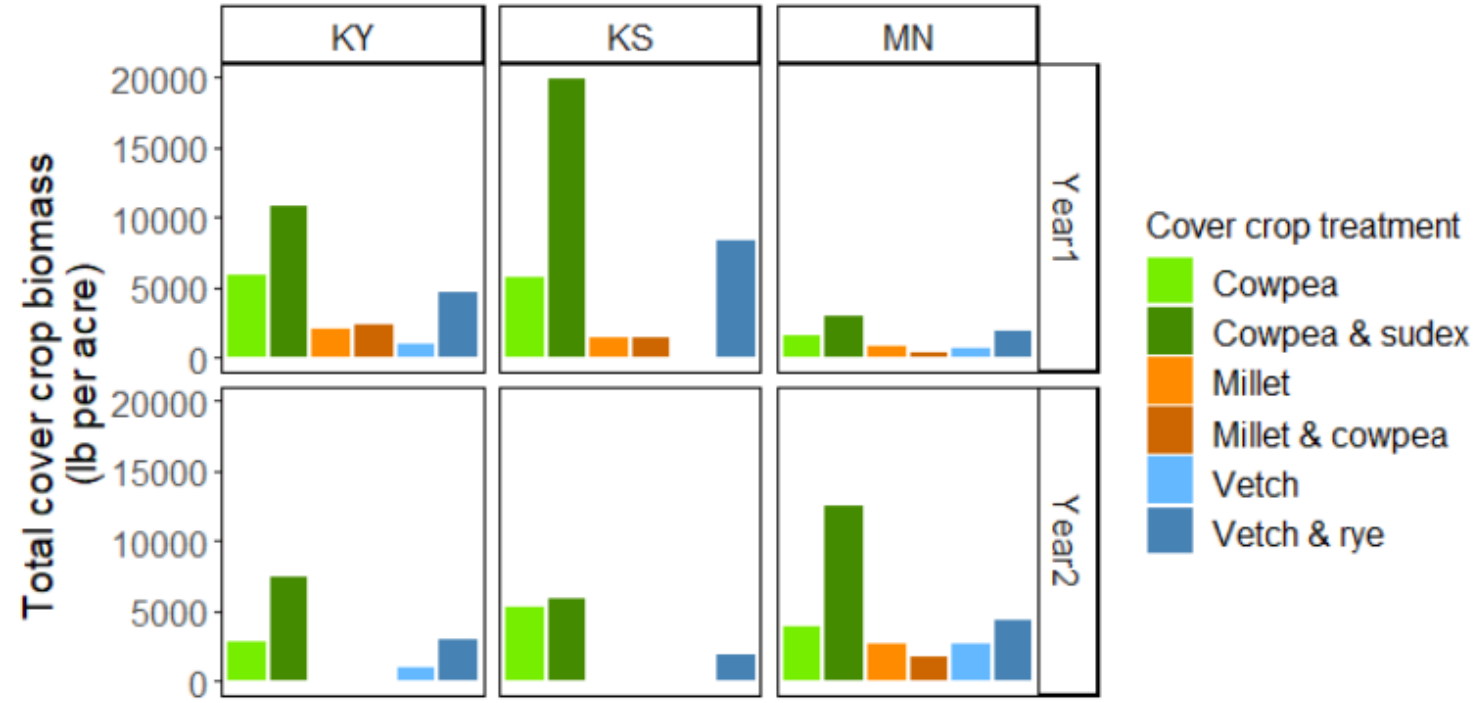
Fall planted - overwintered
(provide spring N)

- 1. Vetch
  2. Vetch + winter rye
- Bell peppers (Declaration)

Bare ground control

- No cover
- Bell peppers (Declaration)
  same schedule as over winter treatment

Total cover crop biomass

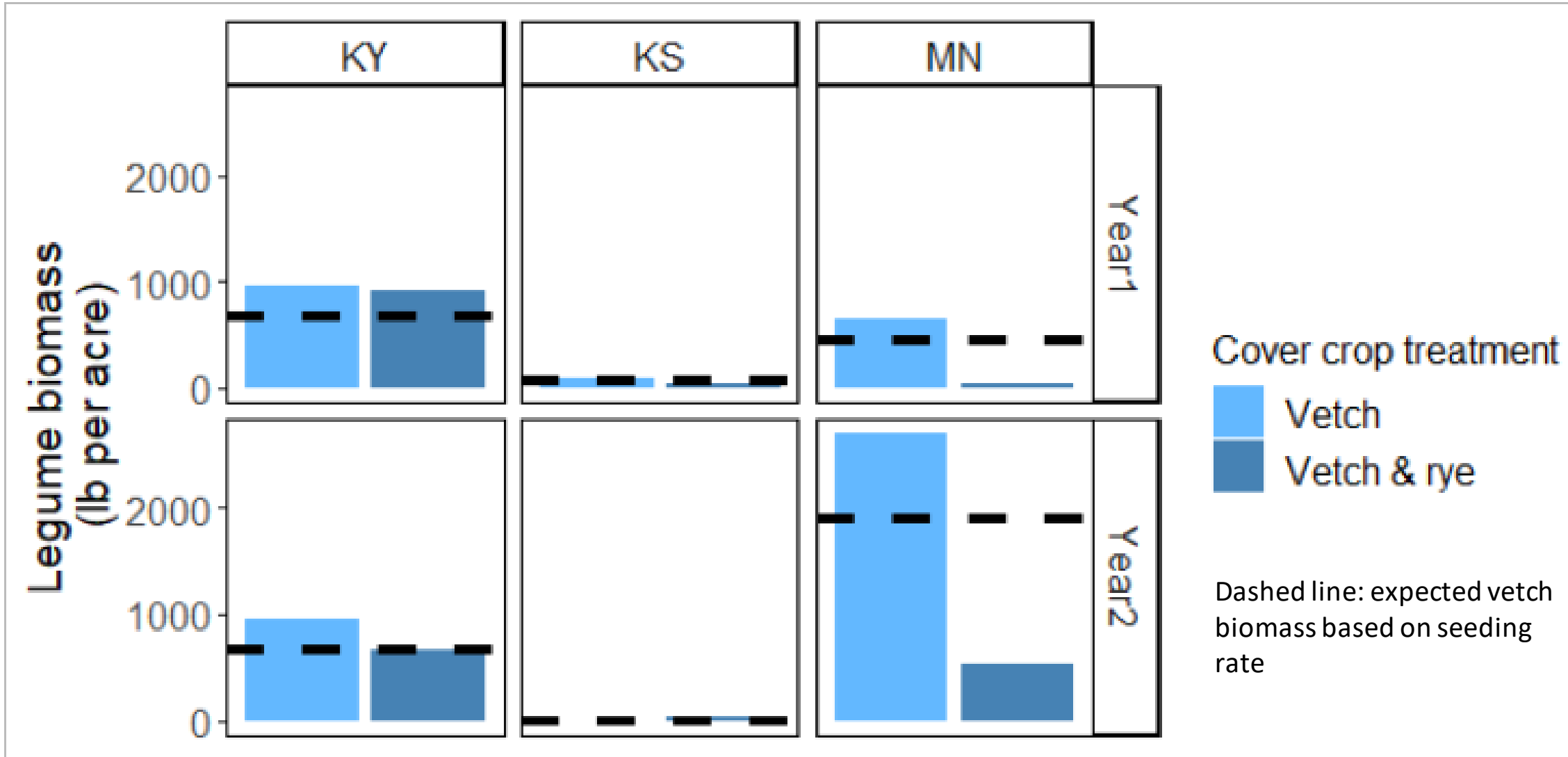


Overwintering cover crop biomass
Legume-grass mixtures usually produce more biomass than legume

Summer: Residue remaining following cowpea and sorghum mix mowing was substantial

Overwintered legume biomass

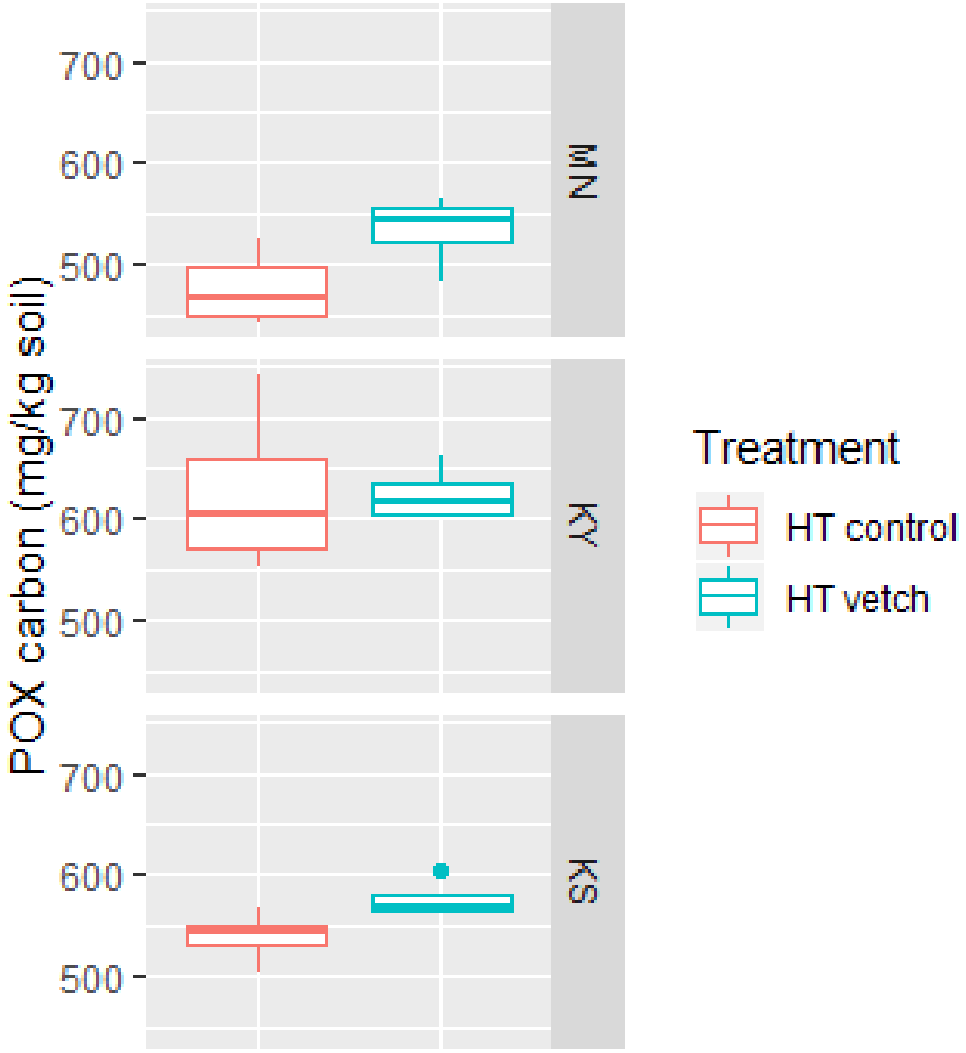
In cold climates (MN) legumes struggled when mixed with competitive grasses



After three years of winter vetch, evidence that soil organic matter is building

Vetch tended to increase soil carbon where it grew well

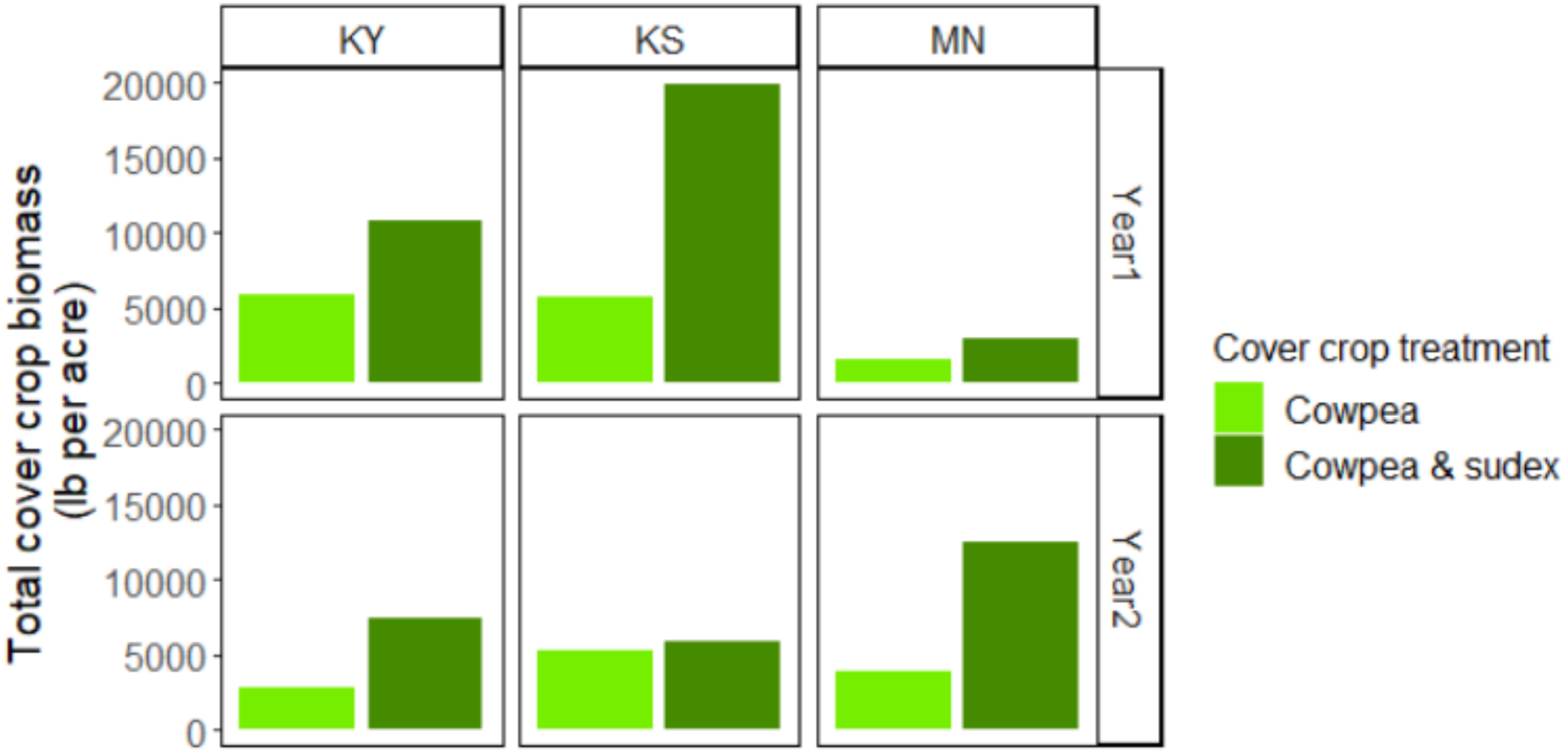
- MN: vetch > control
- KY: No difference, but vetch did not perform well in KY winters
- KS: vetch > control



In Minnesota, winter annual cover crops were covered with a second layer of row cover; looked pretty good in the dead of winter.

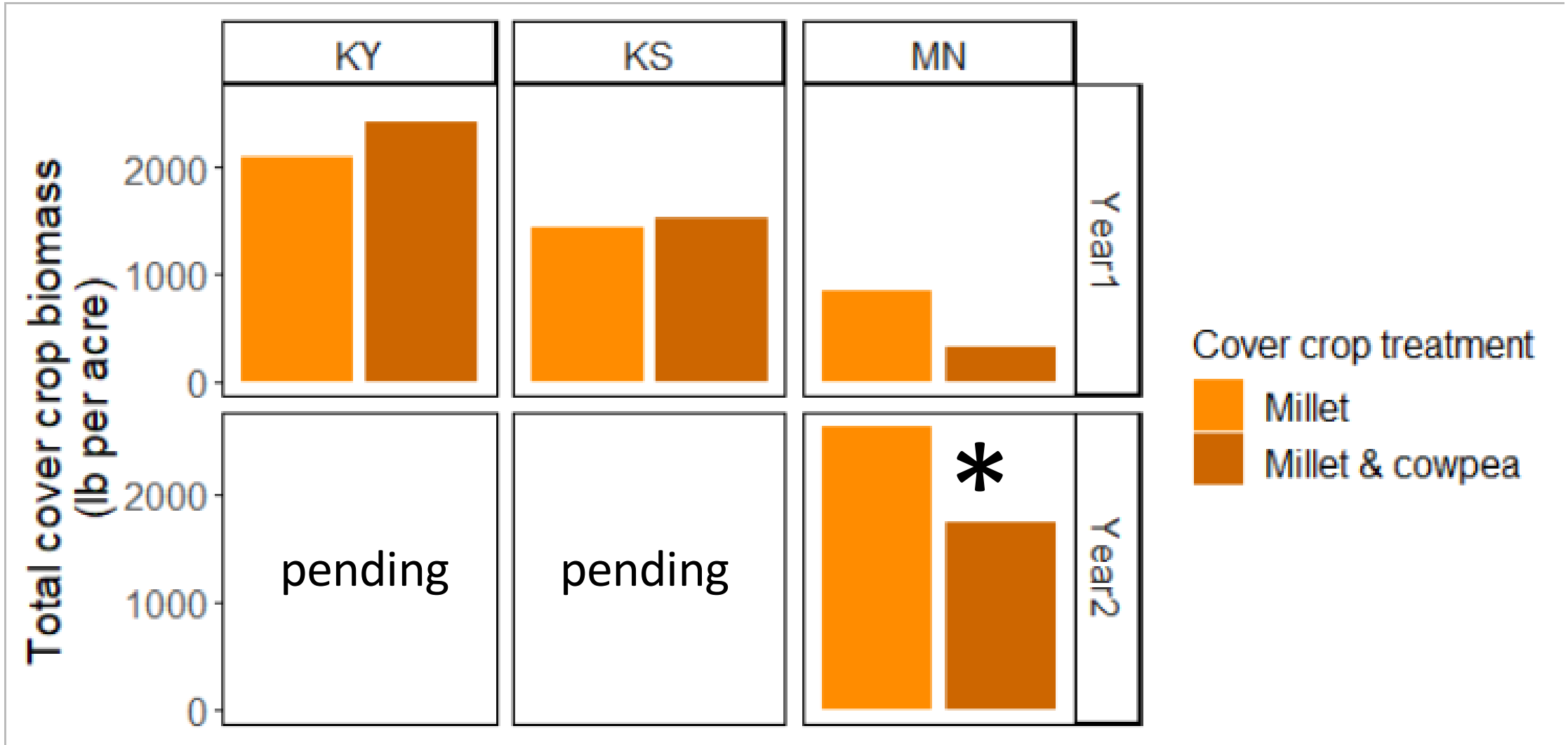
Vetch (and many weeds) were alive and well under the row cover in sub-zero temperatures

Summer cover crop biomass



Cowpea & sudex consistently had higher biomass than cowpea alone

Winterkilled cover crop biomass



What did you learn?

What do you still want to learn more about?

Thank you!

USDA United States Department of Agriculture

Natural Resources Conservation Service

NIFA

MINNESOTA DEPARTMENT OF AGRICULTURE

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