Turning the soil: The dirt on tillage and no-till

Sam Corcoran
Concord Ag Com, Spring Forum
April 26, 2023

University of Massachusetts Amherst

This work supported in part by NE SARE, SNE20-004-MA

What is tillage?

- **A soil management practice that turns and mixes the soil.** The goals are:
  - Seeding or converting pasture/hayfields/sod
  - Aerating the soil
  - Loosening the soil
  - Controlling weeds

Pictured: A moldboard plow. Alan Joseph Franzluebbers, in Principles and Applications of Soil Microbiology (Third Edition), 2021.

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Pictured: Steam rising from a tilled field, 4/25/23

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  - Incorporating manure
    - Prevents ammonia (NH_3) volatilization
    - Limits manure runoff
  - Incorporating lime
    - Increases pH to the depth of incorporation instead of just the top 2 inches

Iowa State Extension

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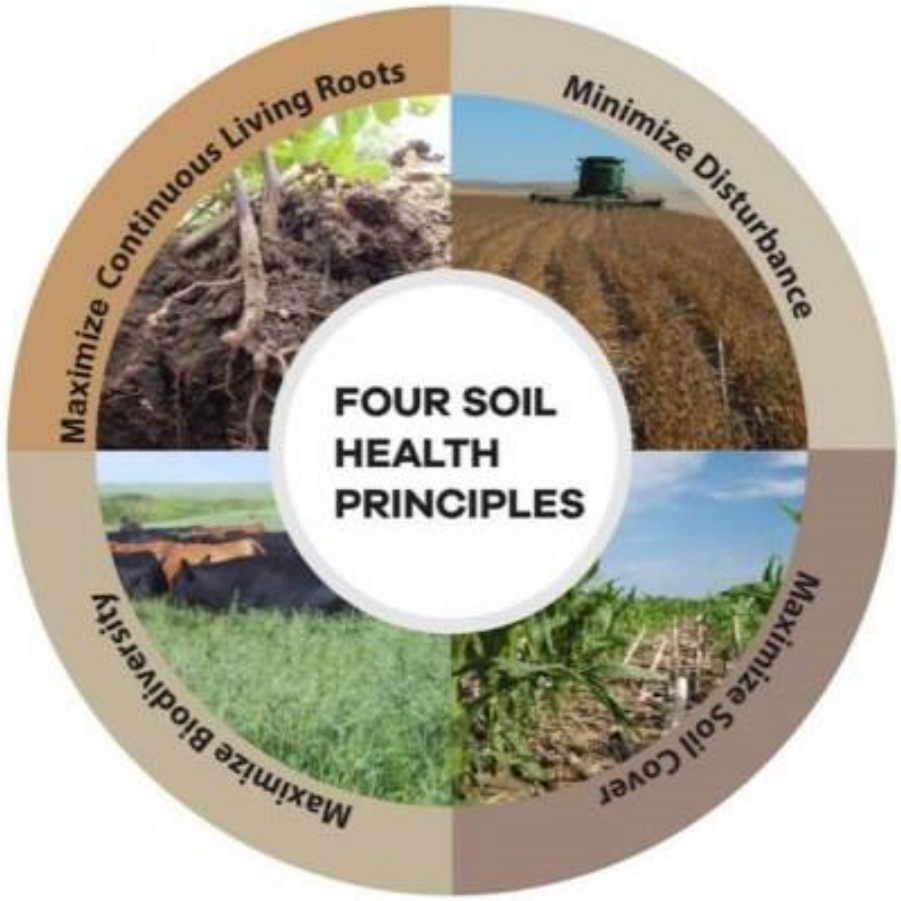
  - Incorporating lime
    - Increases pH to the depth of incorporation instead of just the top 2 inches
  - Managing crop residues
    - Incorporating cover crop residue into the soil as a soil health practice
    - Incorporating crop residue into the soil for plant pathogen and insect management

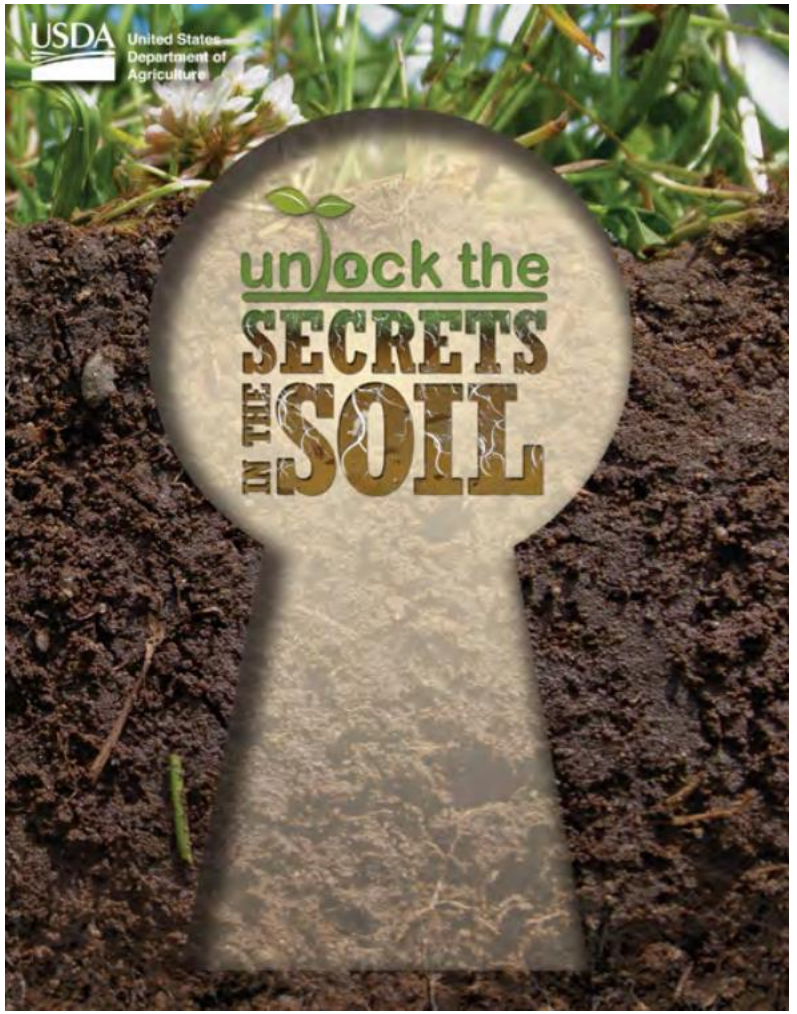
Why All the Fuss About No-Till?

https://www.britannica.com/place/Dust-Bowl

Natural Resource Conservation Service (then Soil Conservation Service) was founded in 1935 in response to the Dust Bowl and SOIL EROSION.

Why All the Fuss About No-Till?





2012, NRCS (Natural Resource Conservation Service) launched, "Unlock the Secrets in the Soil" Program

Why All the Fuss About No-Till?

Cover crops maximize living roots AND soil cover AND biodiversity. Prevent erosion, add carbon.

Why All the Fuss About No-Till?

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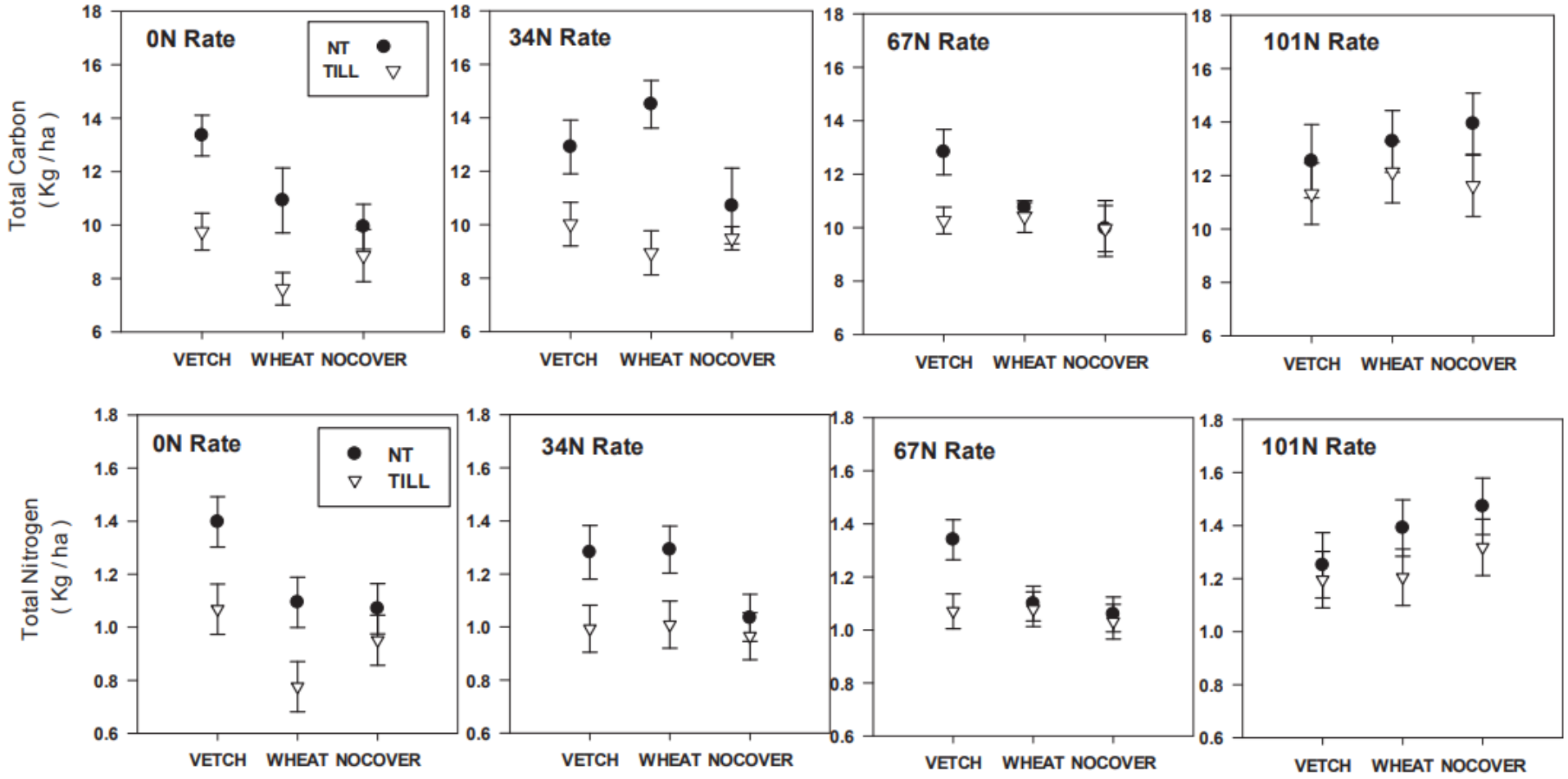

To incorporate or not to incorporate...31-year study

Mbuthia, L. W., Acosta-Martínez, V., DeBruyn, J., Schaeffer, S., Tyler, D., Odoi, E., ... & Eash, N. (2015). Long term tillage, cover crop, and fertilization effects on microbial community structure, activity: Implications for soil quality. *Soil Biology and Biochemistry*, *89*, 24-34.

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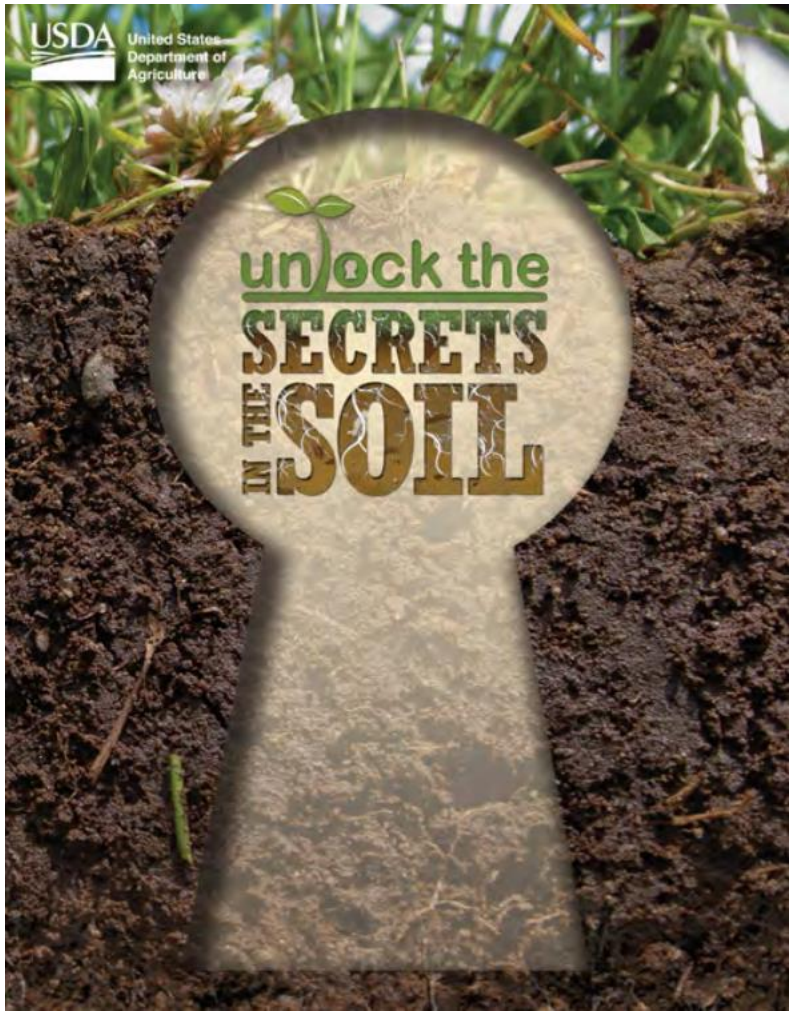

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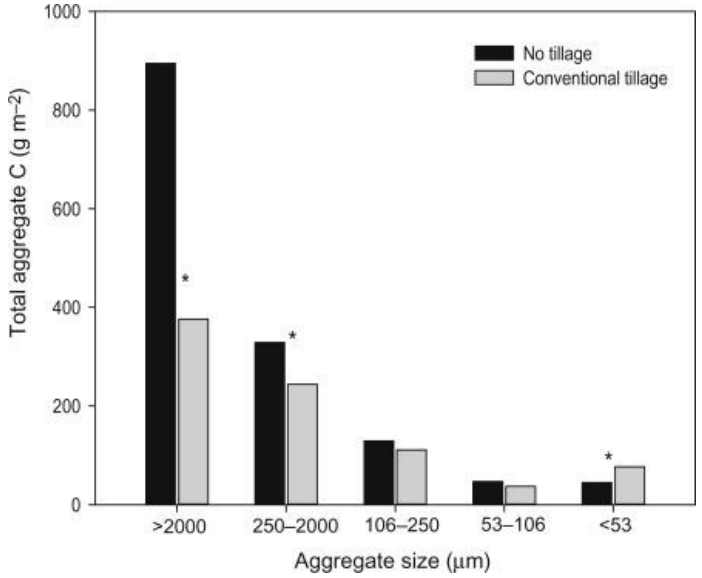
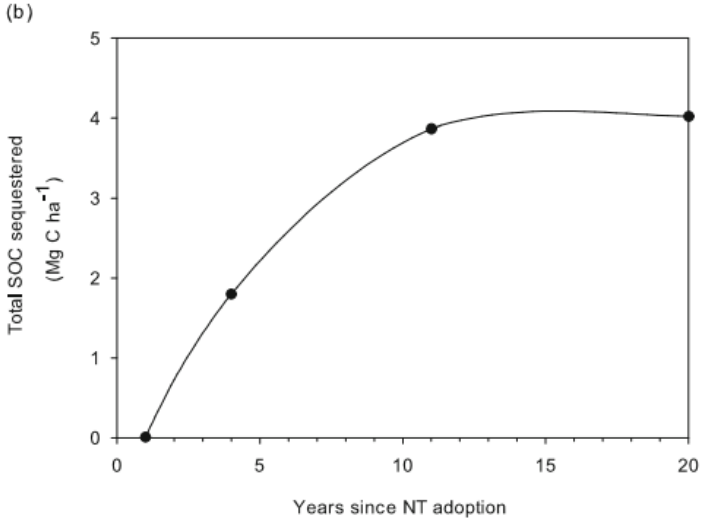
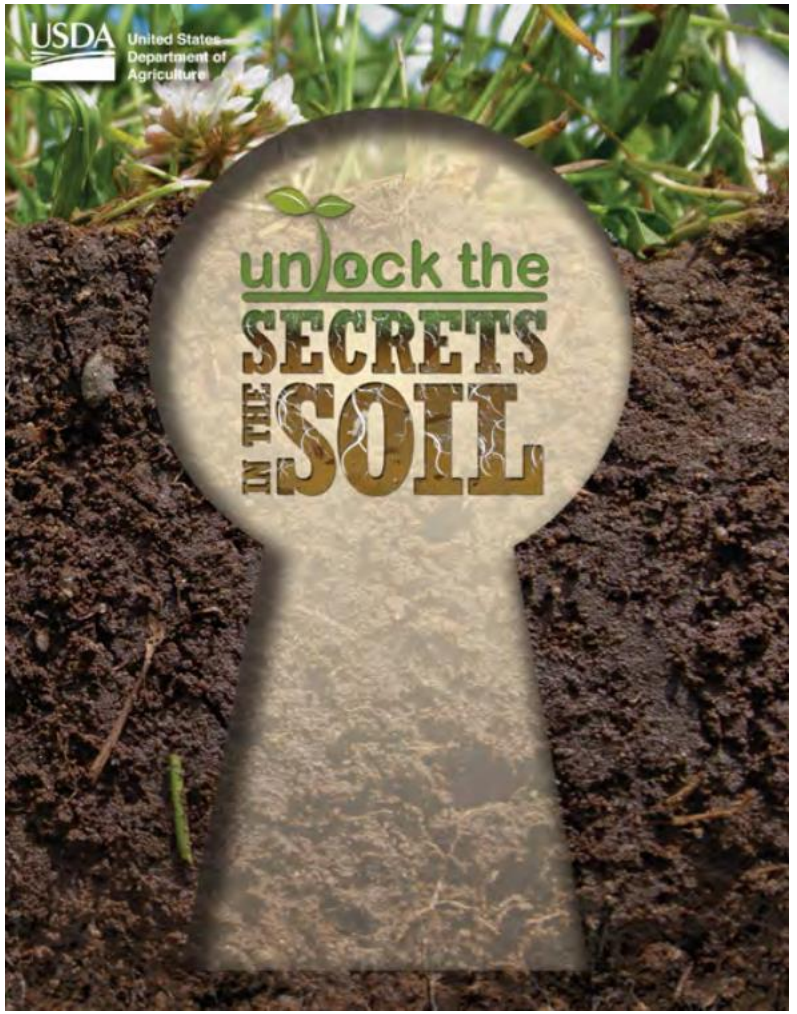


Singh, B. P., Setia, R., Wiesmeier, M., & Kunhikrishnan, A. (2018). Agricultural management practices and soil organic carbon storage. In *Soil carbon storage* (pp. 207-244). Academic Press.



Álvaro-Fuentes, J., Plaza-Bonilla, D., Arrúe, J.L. *et al.* Soil organic carbon storage in a no-tillage chronosequence under Mediterranean conditions. *Plant Soil* **376**, 31–41 (2014). https://doi.org/10.1007/s11104-012-1167-x



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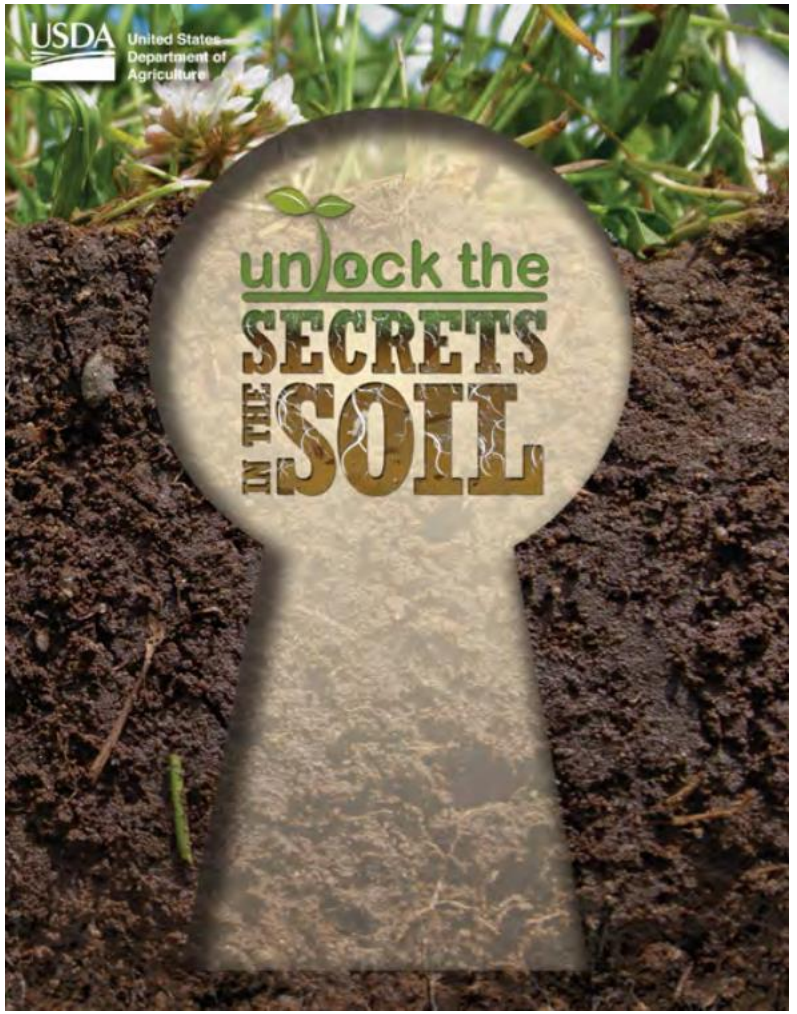

Top: Limon-Ortega, A. (2011). Planting system on permanent beds; a conservation agriculture alternative for crop production in the Mexican Plateau. In *Soil Erosion Issues in Agriculture*. IntechOpen. Bottom: Wolfgang Sturny, 10 year No-Till Switzerland

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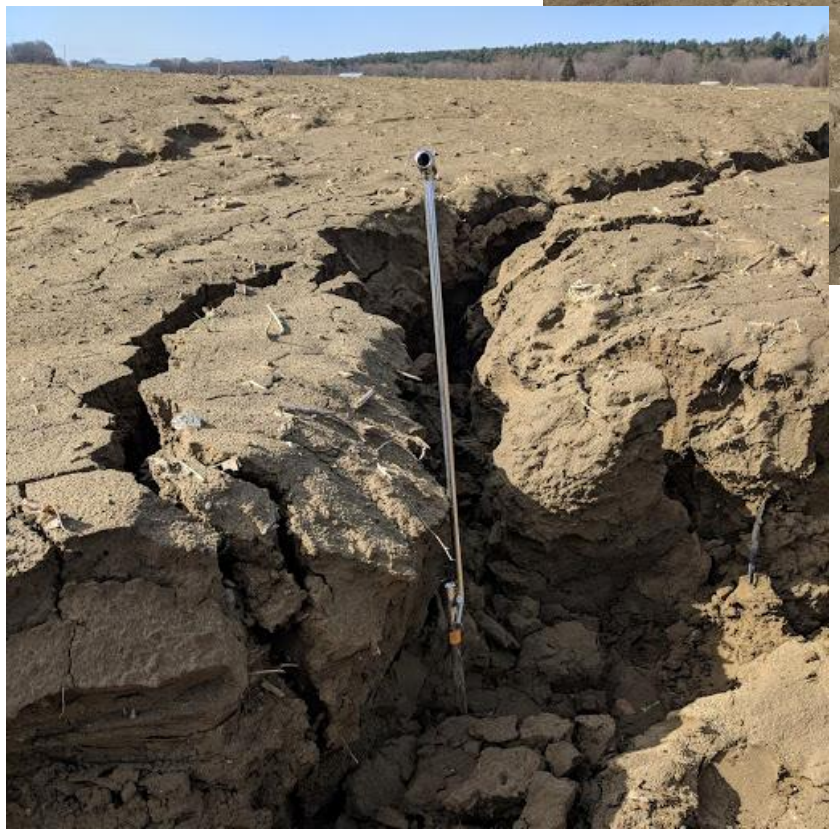
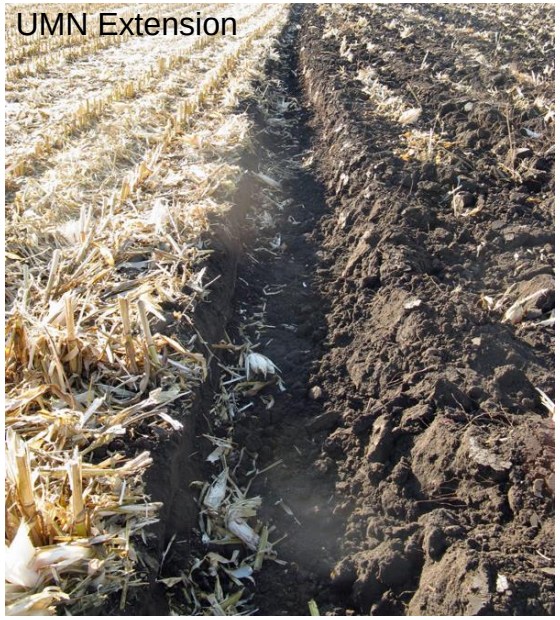


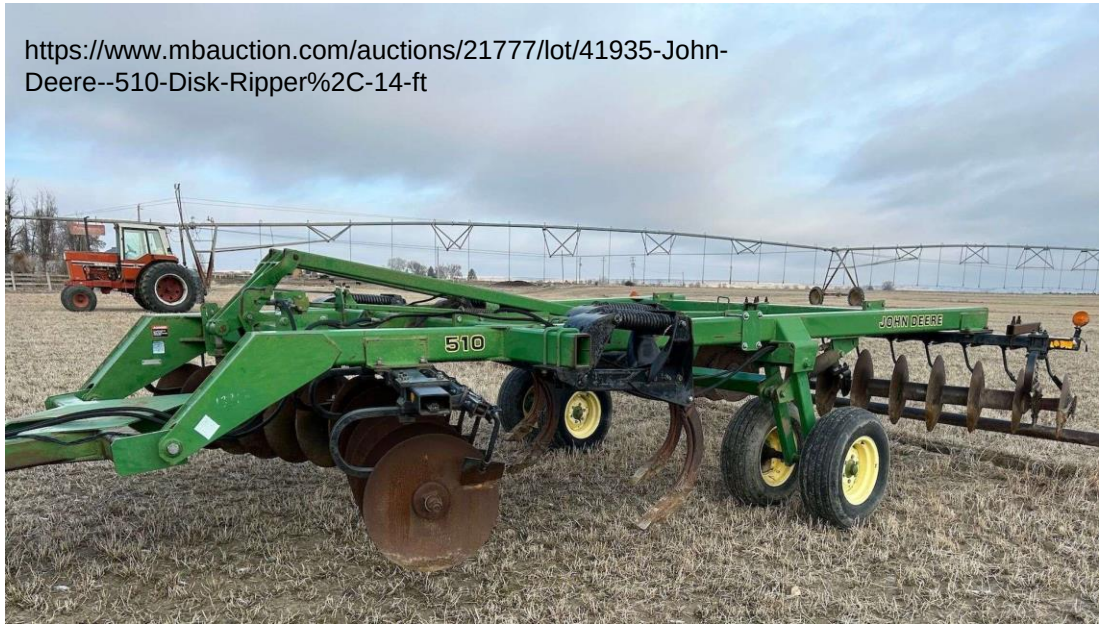
Is All Tillage Created Equal?

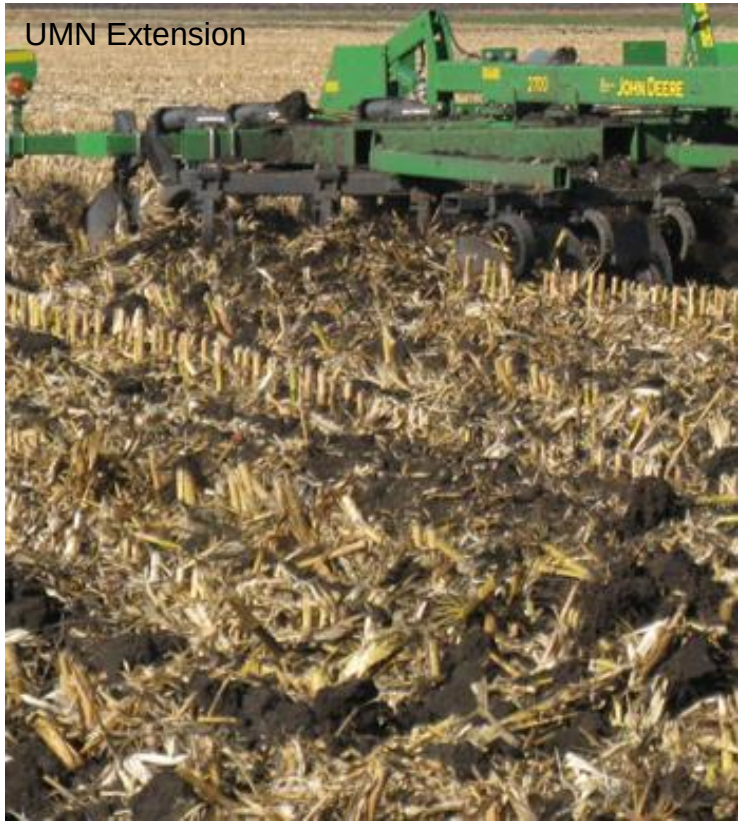


Moldboard plow

- 8-10”
- Deep tillage
- Complete soil inversion

Is All Tillage Created Equal?

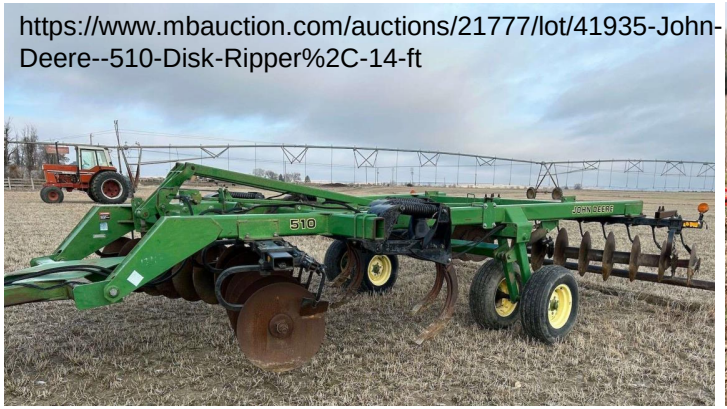




Disc plow/ disc ripper

- 12-16”
- Deep tillage
- Cut and Mix

Is All Tillage Created Equal?



Disc plow/ disk ripper

- 12-16”
- Deep tillage
- Cut and Mix

Disc harrow (offset)

- 5-8”
- Medium tillage
- Cut and Mix

Shallow Tandem Disc

- 2-4”
- Shallow tillage
- Cut and Mix

Vertical Tillage

- 2-4”
- Shallow tillage
- Cut and minimal mix
- Disc at 0 (or very small) angle

Rotary Hoe

- 6”
- In season weeding

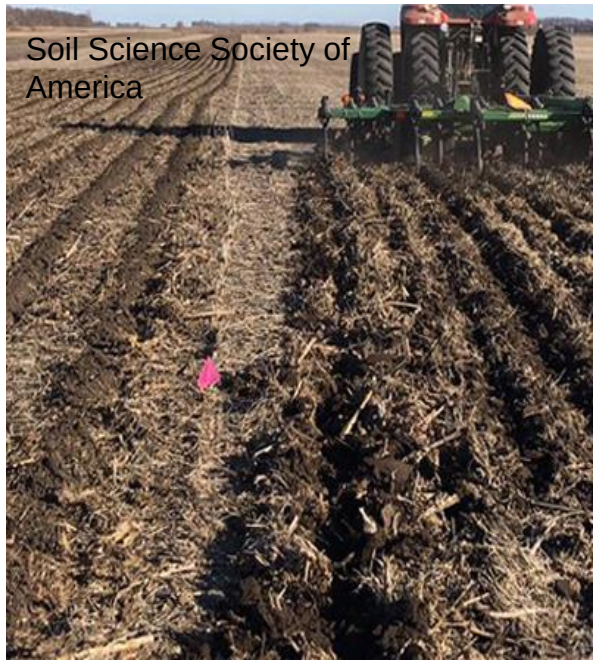
Is All Tillage Created Equal?

Subsoiler

- 15-20”
- Break up deep compaction
- Rip, no mix, no cut

Chisel Plow

- 6-8”
- Break up deep compaction
- Rip, no mix, no cut



Cultivator

- 2-4”
- Finisher for seed bed prep

Is All Tillage Created Equal?


https://agromaster.com/en/products/cultivation/rotary-tillers


https://www.midwayusa.com/product/1020521545


https://www.einboeck.at/en/products/crop-care/weeding-technology/aerostar-exact

Rotary Tiller

- 4-6", Medium depth
- Cut and mix

Chain Harrow/Drag Harrow

- 0-2"
- Shallow
- Finishing

Tine Harrow/Rake

- 0"-1"
- Very shallow or just surface scratch
- Weeding in season

Is All Tillage Created Equal?

Conservation/Reduced Tillage

Strip/Zone Tillage

- Only till where the next crop will be seeded, space between rows not tilled

Permanent Beds

- A form of zone tillage

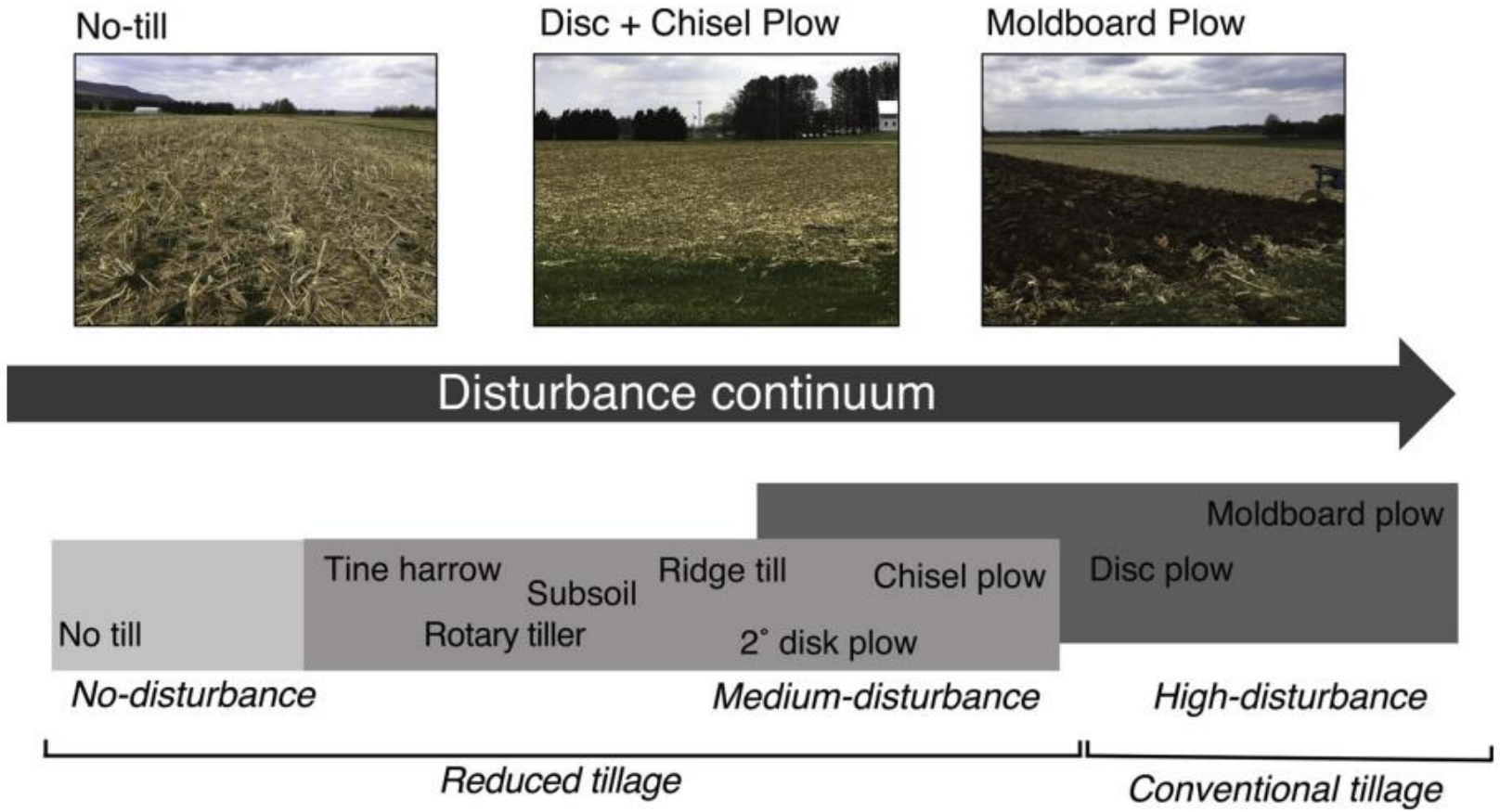
Ridge Tillage (*Conservation, not reduced)*

- Crops planted on top of ridge
- Water drains into low points between rows, ideally covered with residue
- Improves water infiltration
- ***Potatoes***

It would be fair to say that shallow tillage is a form of reduced tillage.

Is All Tillage Created Equal?

E.K. Rowen, et al.



No, it's not. Reduced tillage is a good thing. Don't let perfect be the enemy of good or "better than it was."

No-Till

- Just what it sounds like!
- Crops are planted without disturbing the soil.
- An easy fit in perennial systems. Ex:
  - Pasture
  - Hayfield
  - Orchards
  - Small Fruit
  - Perennial cut flowers

No-Till

- All crop residue left on the surface.
- Increasing in popularity among annual field crops
  - Silage corn
  - Grain corn
  - Sweet corn
  - Soybeans
  - Grains (wheat, barley, rye)
  - Pumpkins
  - Winter squash

No-Till

https://www.cleanlakesalliance.org/ldmi/

No-Till & Herbicide

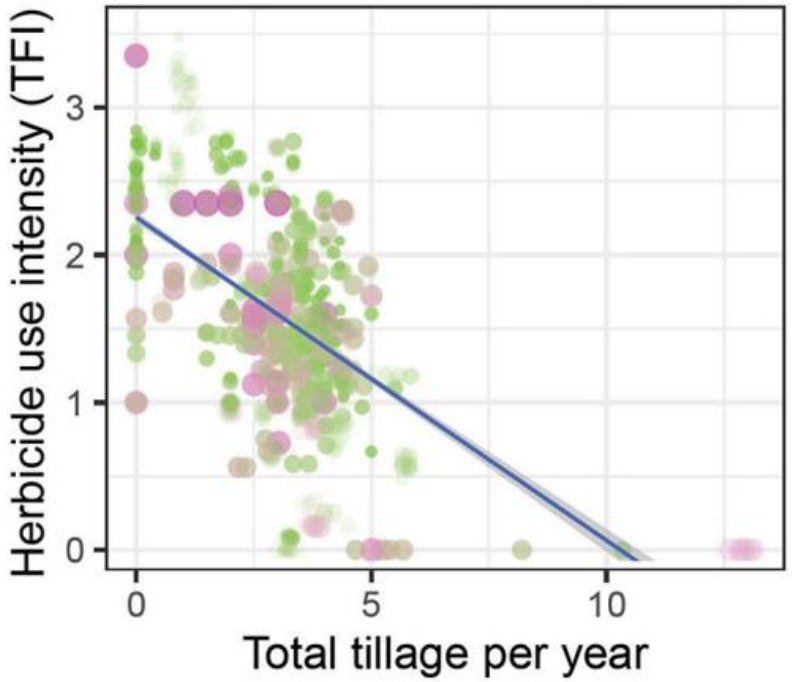


FIGURE 1 | Herbicide use intensity vs. tillage intensity in the 395 recorded cropping systems (the blue line shows the fitted regression y = 2.24–0.217 x, with the confidence interval in gray). The color and size of the data points illustrate the simulated grain yield loss averaged over 30 simulated years, ranging from zero loss (green, smallest symbol) to total loss (magenta, largest symbol). Symbols are partially transparent to take account of overlaying. HTFI, herbicide treatment frequency index (unitless), i.e., average number of doses at the recommended dose per ha per year (Colbach, 2022 CC BY NC ND).

- **Study finding**: Tillage/herbicide tradeoff for weed control.
  - Herbicide use increases and tillage use decreases.
- **Study finding**: You can't go no-till without introducing another practice to manage weeds.

Colbach, N., & Cordeau, S. (2022). Are no-till herbicide-free systems possible? A simulation study. *Frontiers in Agronomy*, *4*, 17.

No-Till & Roller Crimper

Best organic method but sometimes also used with herbicide

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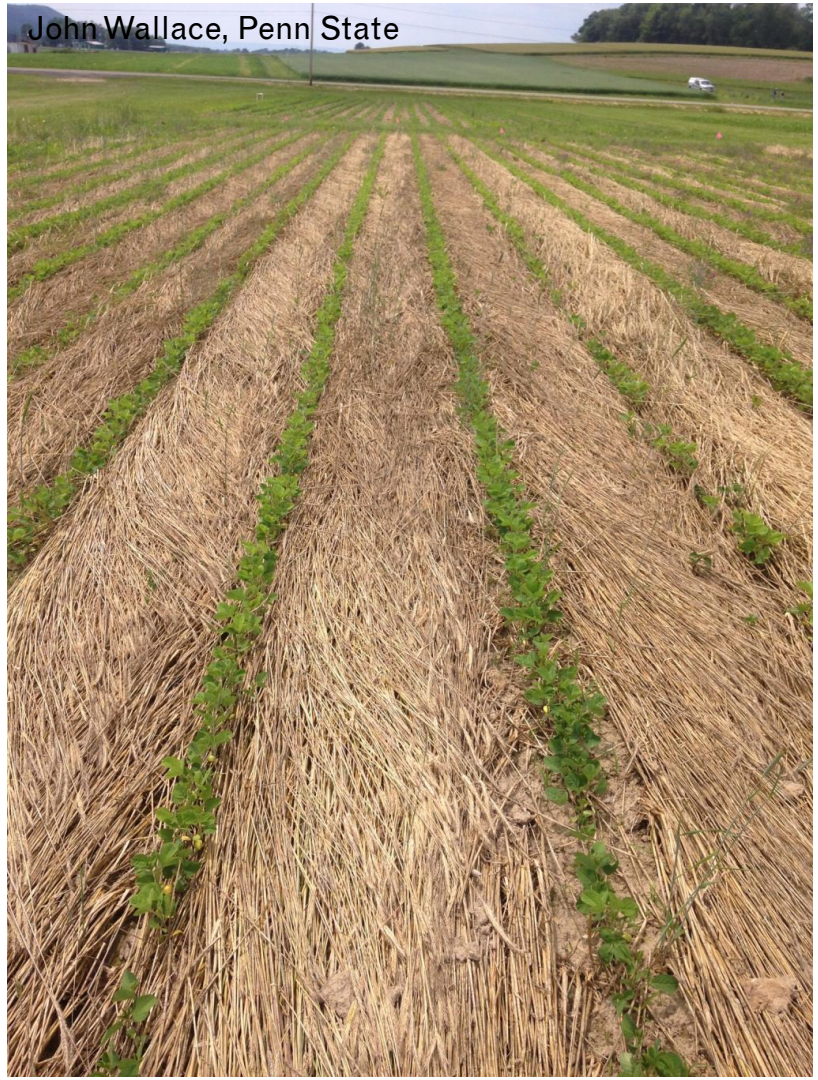
No-Till & Roller Crimper



No-Till, Roller Crimper, Tarp, Organic

No-Till & Tarp/Plastic Mulch & Organic

Challenges with No Till: Insects

Insect pests that overwinter in weeds at field edges and may overwinter in mulched/cover cropped no-till systems:

- Cutworms
- Earwigs
- Stink bugs
- Thrips
- Aphids
- Leafhoppers
- Caterpillars
- Slugs

Beneficial insect predators that have been shown to overwinter with cover crop and no-till management (organic):

- Spiders!
- Ground beetles
- Daddy-long-legs
- Ants

Pest pressure is likely to decrease overtime, but it may be an early challenge in the transition. Increased predators help tip the scales.

https://extension.psu.edu/predators-control-pests-and-crop-damage-in-transition-to-organic

Challenges with No Till: Disease

From the Compendia of Lettuce Diseases and the management of *Xanthomonas campestris* (causes bacterial leaf spot).

Infested plant residues should be plowed into the soil to allow them to decompose before planting subsequent lettuce crops.

From the Compendia of Pepper Diseases and the management of *Phytophthora capsici* (causes blight).

Splash dispersal of inoculum can be reduced by planting in beds mulched with straw or in the stubble of a ***no-till cover crop****, such as rye, vetch, or wheat.*

Disease specific. Good crop rotation and sterilization of equipment remain paramount in any system.

https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=10883 https://content.ces.ncsu.edu/phytophthora-blight-of-peppers

https://www.covercropstrategies.com/articles/2300-k-state-pumpkin-study-shows-cover-crop-benefits-for-horticulture

Challenges with No Till: Nitrogen

Yield drag associated with no-till.

- ~3 year conversion
- Increased N-needs may be a significant cause.
- Decomposing crop residue and undisturbed soil increases the microbial community. They need extra nitrogen until the system stabilizes.

https://www.agfax.com › 2017/06/20 › cover-crops-g...

Cover Crops: Get a Plan To Avoid Nitrogen Tie-Up – DTN

Jun 20, 2017 — However, covers crops, particularly those high in carbon, can also temporarily **tie up nitrogen** as their residue decomposes.

DTN/Progressive Farmer
https://www.dtnpf.com › crops › article › 2017/06/16

Do Cover Crops Tie Up Nitrogen?

Jun 16, 2017 — However, covers crops, particularly those high in carbon, can also temporarily **tie up nitrogen** as their residue decomposes.

Farm Progress
https://www.farmprogress.com › Corn

Nitrogen tie-up a common cause of yellow wheat

Until the crop residues have been sufficiently decomposed, **nitrogen** will remain **tied up** in the microbes. During this period, wheat plants may show **nitrogen** ...

LinkedIn
https://www.linkedin.com › pulse › how-avoid-nitrogen-...

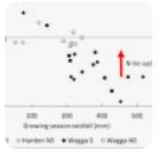
How to avoid nitrogen tie up in my crop?

May 4, 2022 — Banding N at planting could potentially decrease immobilization by physically separating the N from the C residues in order to slow turnover ...

Grains Research and Development Corporation
https://grdc.com.au › grdc-update-papers › 2018/02

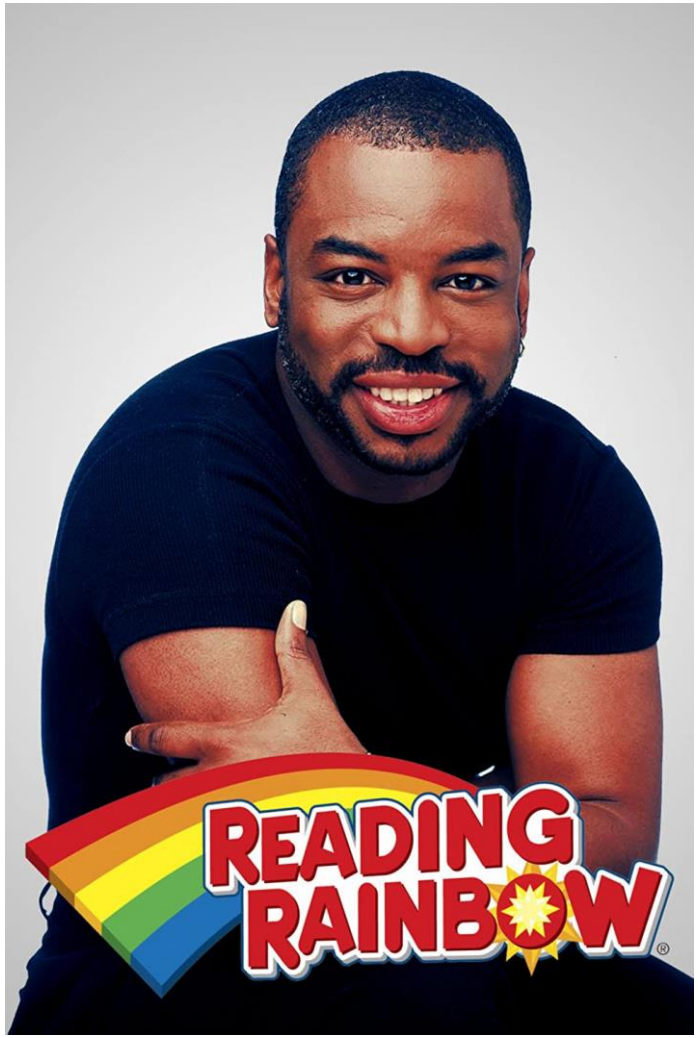
The effects of stubble on nitrogen tie-up and supply

Feb 13, 2018 — The process of 'N-**tie up**' (immobilisation) — put simply ... There are two main differences between these two 'crops' — firstly the microbes can't ...



“But you don’t have to take my word for it”

1. <u>You can start small.</u>
   - Try no till, reduced till, conservation tillage where it makes sense for you.
2. <u>Equipment sharing programs</u>
   - UMass no-till veg transplanter can be borrowed (purchased by AFT)
   - Conservation districts
3. <u>Take advantage of NRCS and EQUIP funding</u>
4. <u>Set realistic expectations.</u>
   - Year one might be tough.
5. <u>Know your farm budget</u>
   - Compare numbers under till and no-till management as you go
6. <u>Farmer-to-farmer field days, workshops, advice</u>
7. <u>Involvement in research programs</u>
   - Write your own Northeast SARE farmer grant! Up to $30,000 to conduct research. Opens fall 2023 for 2024 funds.



Gardeners...it's **easy** for you to go no-till (you should do it!). Be kind to your farmers and know it's not so easy for them.

Why All the Fuss About No-Till?

University of Massachusetts Amherst

Sam Corcoran
Image from November 2018

Practice ranked **when soil health is the goal.**

1. Don't till and use a cover crop
2. Till and use cover crop

3/4. Don't till and don't use a cover crop

3/4. Till and use no cover crop but use organic inputs (mulch, manure, compost)

5. Till and use no cover crop and no organic inputs

When **yield is the goal,** results are variable.

- Crop and Cover Crop
- Location
- Seasonal/annual
- Soil Type

Cover crops maximize living roots AND soil cover AND biodiversity. Prevent erosion, add carbon.

Tyler, H. L. (2021). Single-versus double-species cover crop effects on soil health and yield in Mississippi soybean fields. *Agronomy*, *11*(11), 2334

Why All the Fuss About No-Till?

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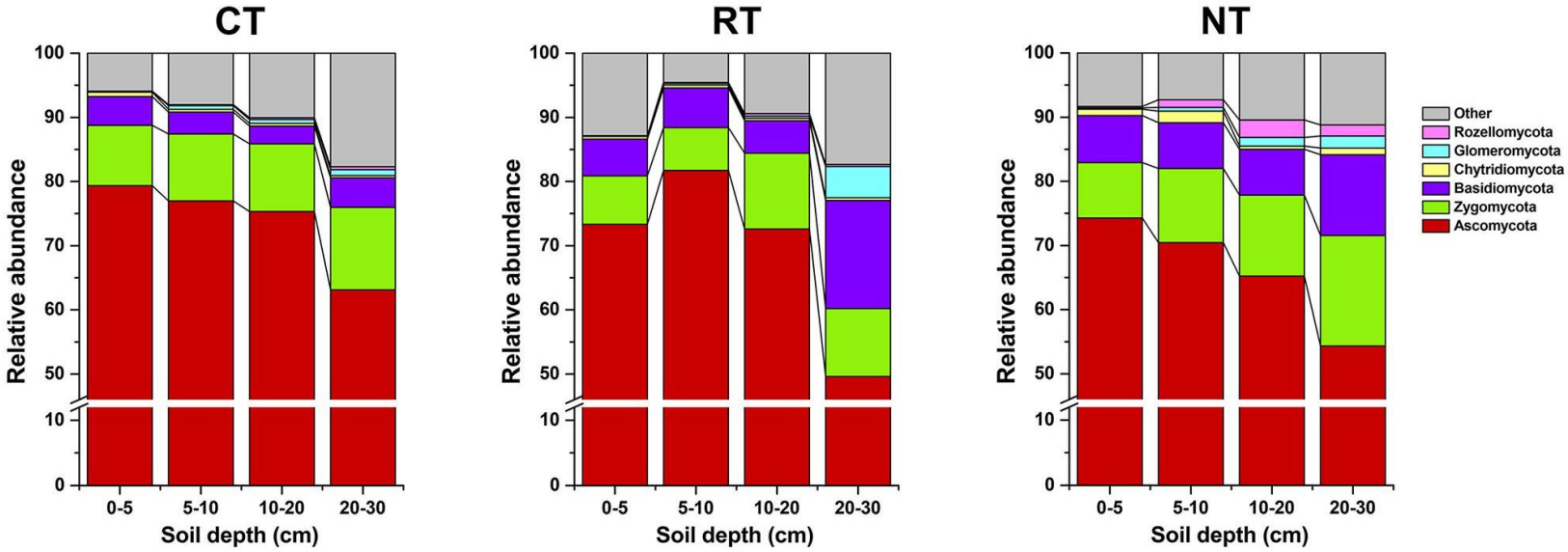
David Lead in *The Atlantic*

Sun, R., Li, W., Dong, W., Tian, Y., Hu, C., & Liu, B. (2018). Tillage changes vertical distribution of soil bacterial and fungal communities. *Frontiers in microbiology*, *9*, 699.



Cover crops help feed soil microbes, tillage can harm soil microbes, change species, change distribution. Includes beneficial AND pathogenic microbes.