

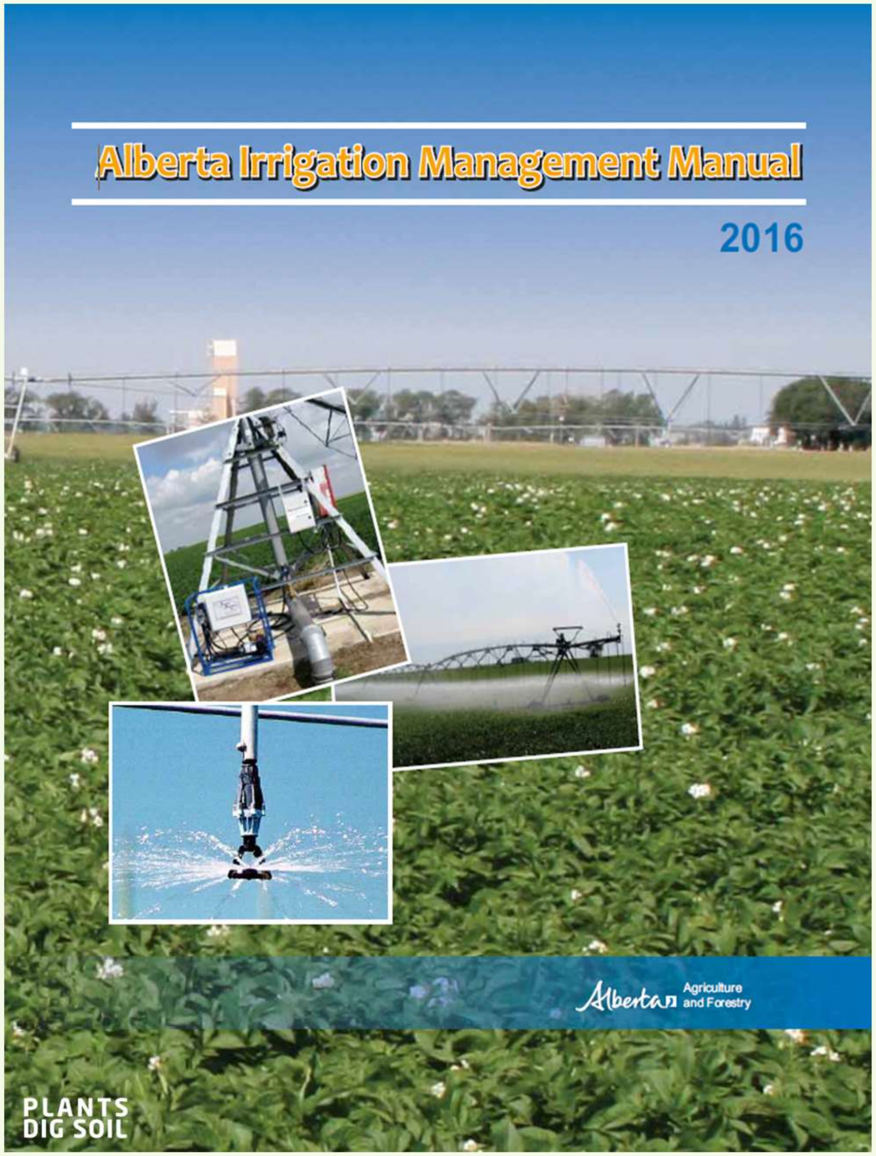
# NAVIGATING DROUGHT

Scott Gillespie M.Sc. P.Ag CCA

PLANTS DIG SOIL

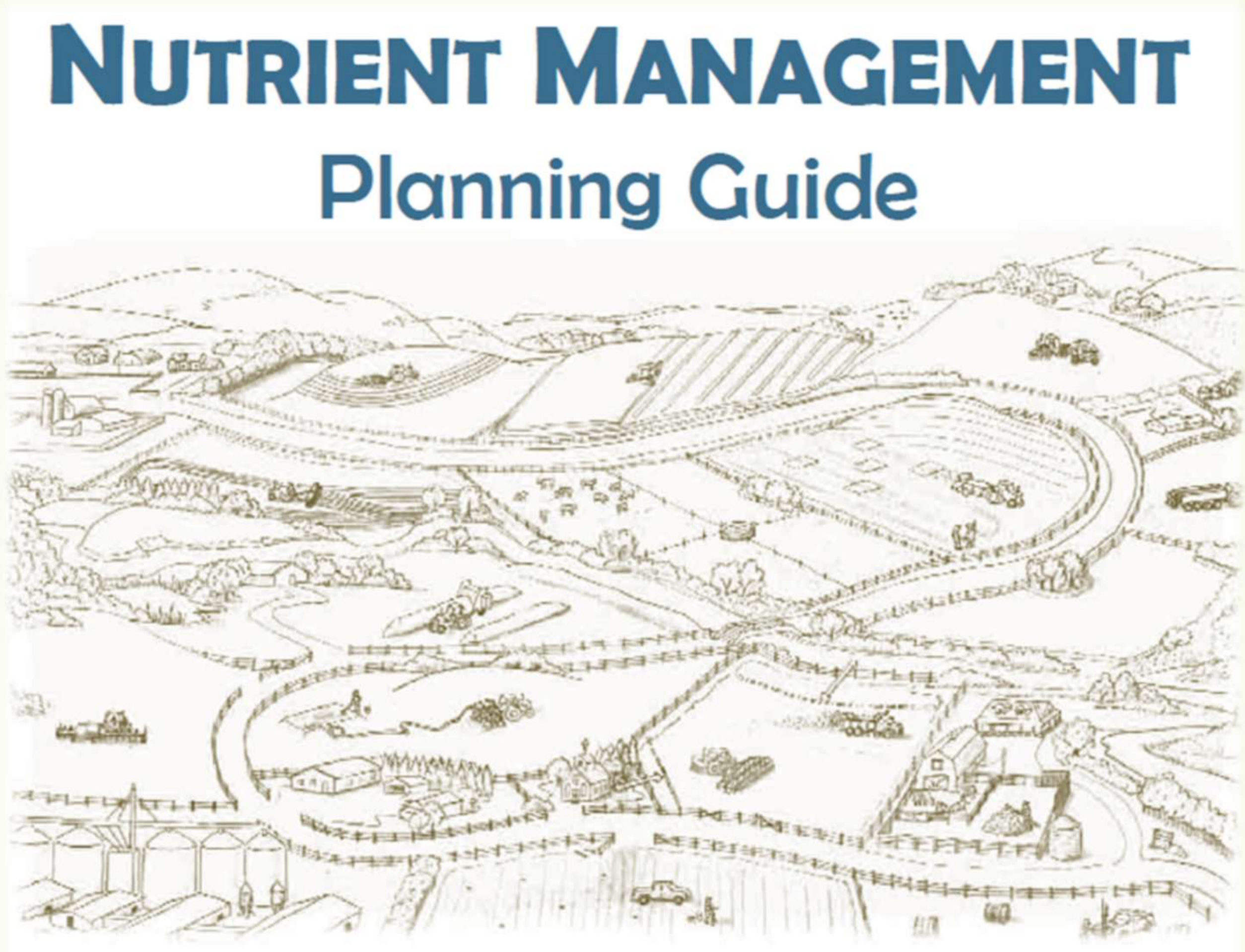
# OUTLINE OF TALK

1. Plant available water (easy & difficult)
2. Soil texture & water holding capacity
3. Rooting depth zones in season
4. How to determine texture & moisture
5. How much organic matter can you accumulate (and where in the profile)
6. Influence of tillage on organic matter and water holding capacity
7. A revised flow chart for how we can prioritize what to focus on
8. Discussion of best use of tools (tillage, cover crops, grazing, etc.)




ALBERTA IRRIGATION MANAGEMENT MANUAL

HTTPS://OPEN.ALBERTA.CA/PUBLICATIONS/ALBERTA-IRRIGATION-MANAGEMENT-MANUAL




# NUTRIENT MANAGEMENT PLANNING GUIDE

HTTPS://WWW.ALBERTA.CA/NUTRIENT-MANAGEMENT-PLANNING

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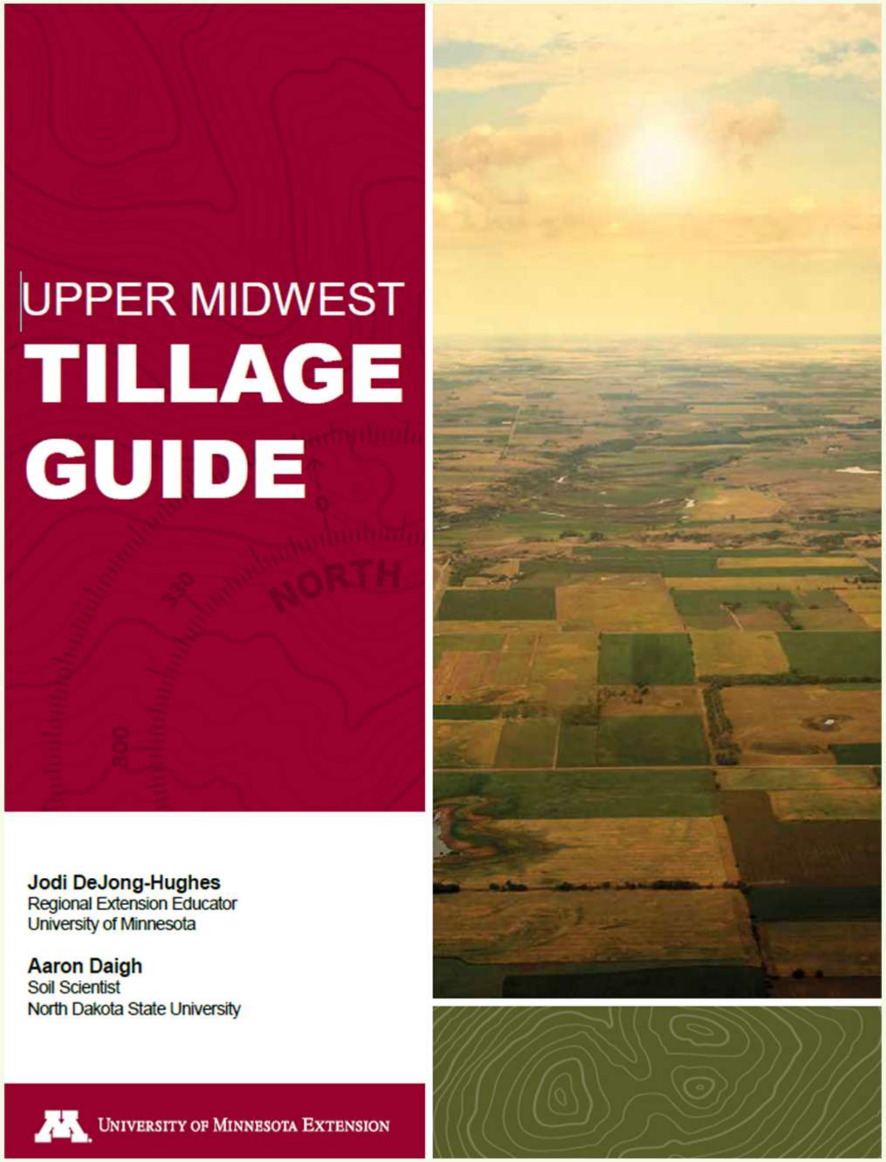
# UPPER MIDWEST TILLAGE GUIDE

https://www.researchgate.net/publication/360141128_Upper_Midwest_Tillage_Guide_-_2nd_Edition

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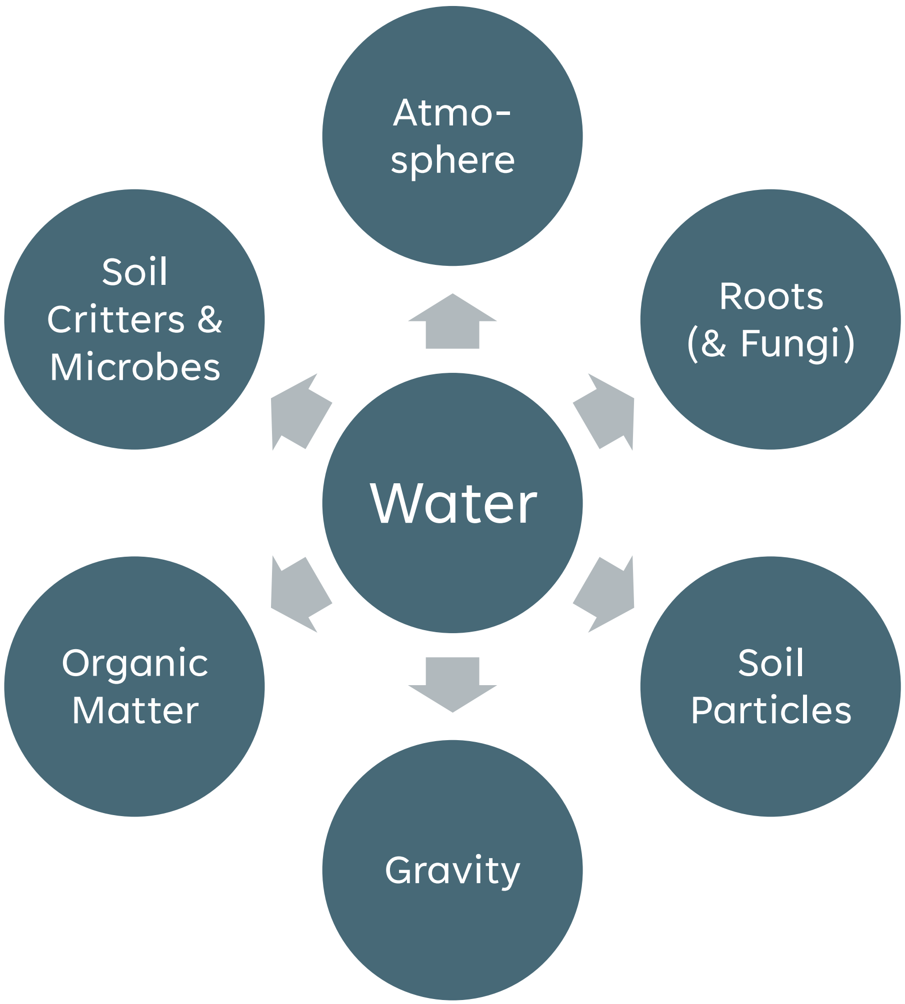
# THE FORCES ACTING ON WATER IN THE SOIL

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## DEFINITIONS

- Saturation point
  - Every available space is taken up with water. Think of when it’s raining – the top few inches are fully saturated, but they don’t stay that way
- Field capacity
  - After ~24-48 hours the water goes deeper down and what is left are the air spaces plus the water that soil particles & organic matter hold
  - Plants can easily access this water
- Permanent wilting point
  - The water in the soil that the plant can’t access. Even what we feel as a dry soil still has water
  - Near this point plants work hard to get water

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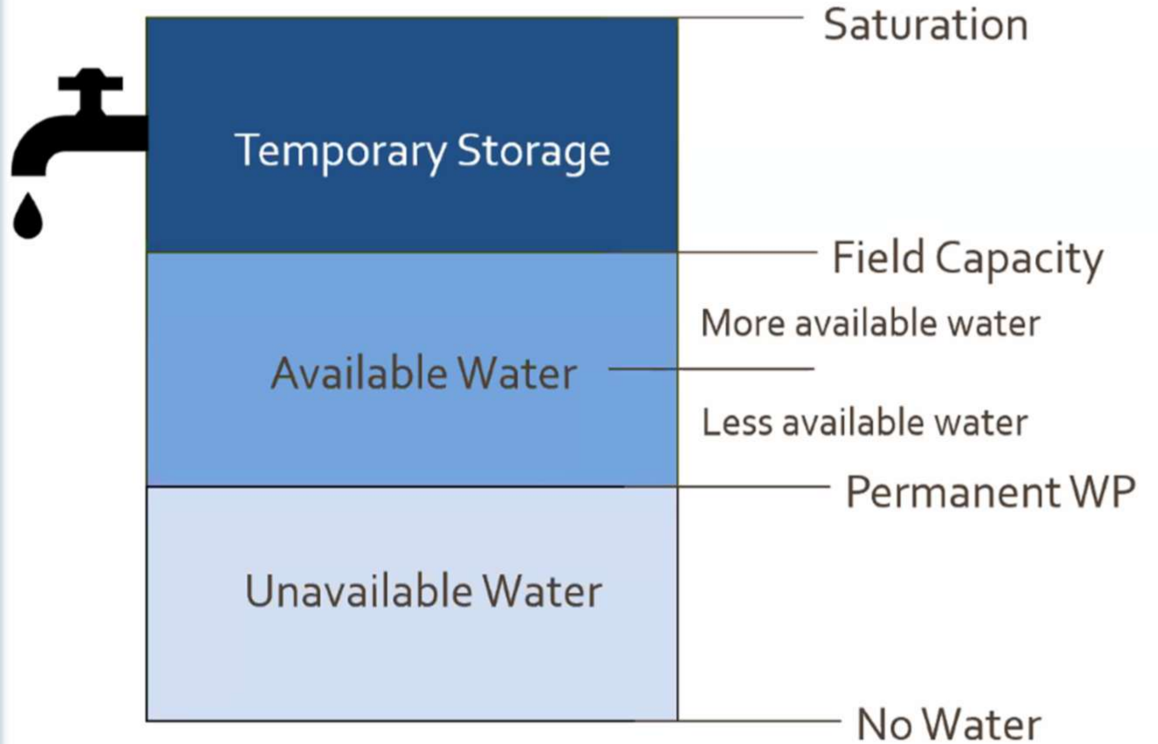
# DEFINITIONS

Alberta Nutrient Management Webinar

Len Hingley

Jan 27, 2024

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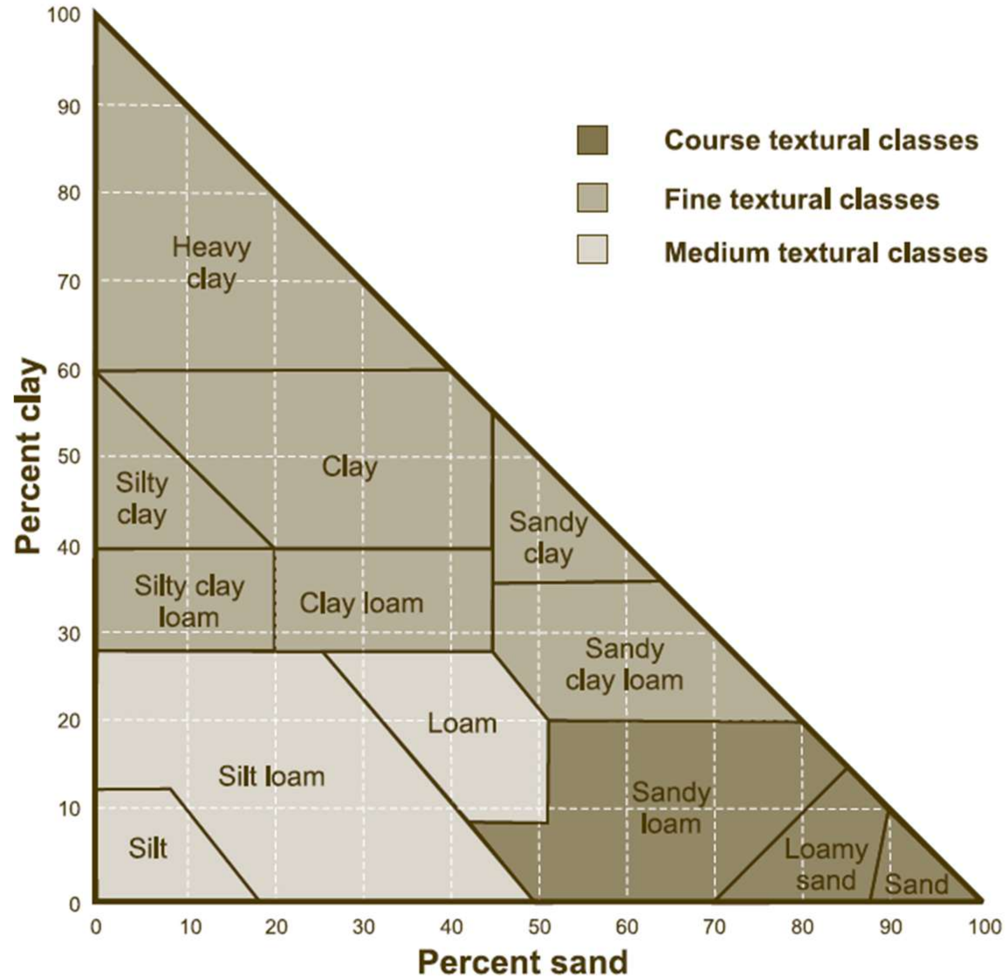
# SOIL TEXTURE TRIANGLE




https://www.alberta.ca/nutrient-management-planning

## HOW MUCH WATER CAN YOUR SOIL HOLD?

## HOW MUCH IS AVAILABLE TO PLANTS?

**Table 2. Estimated hydraulic properties of southern Alberta soils (AAFRD, 2004).**

| Textural class | Bulk density ($Mg\ m^{-3}$) | Porosity (%) | Field capacity (% by weight) | Permanent wilting point (% by weight) | Available water-holding capacity† (% by weight) | (% by volume) | ($mm\ m^{-1}$) | inch/ft |
|---|---|---|---|---|---|---|---|---|
| Loamy Sand | 1.60 | 40 | 10 | 4 | 6 | 10 | 100 | 1.2 |
| Sandy Loam | 1.55 | 42 | 14 | 5 | 9 | 14 | 140 | 1.7 |
| Loam | 1.50 | 43 | 20 | 8 | 12 | 18 | 180 | 2.2 |
| Sandy Clay Loam | 1.45 | 45 | 20 | 9 | 11 | 16 | 160 | 2.0 |
| Silt Loam | 1.45 | 45 | 21 | 7 | 14 | 20 | 200 | 2.4 |
| Clay Loam | 1.40 | 47 | 26 | 12 | 14 | 20 | 200 | 2.4 |
| Silty Clay Loam | 1.40 | 47 | 29 | 13 | 16 | 22 | 220 | 2.7 |
| Sandy Clay | 1.45 | 45 | 26 | 14 | 12 | 17 | 170 | 2.1 |
| Silty Clay | 1.40 | 47 | 33 | 18 | 15 | 21 | 210 | 2.6 |
| Clay | 1.35 | 49 | 31 | 17 | 14 | 19 | 190 | 2.3 |

† Available water-holding capacity by volume for each textural class was derived by multiplying bulk density by percent available water-holding capacity by weight.

PLANTS DIG SOIL

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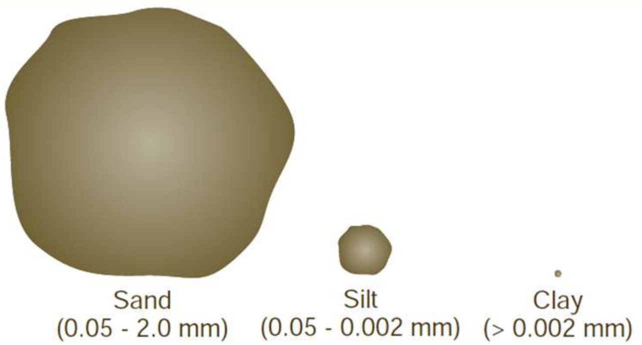
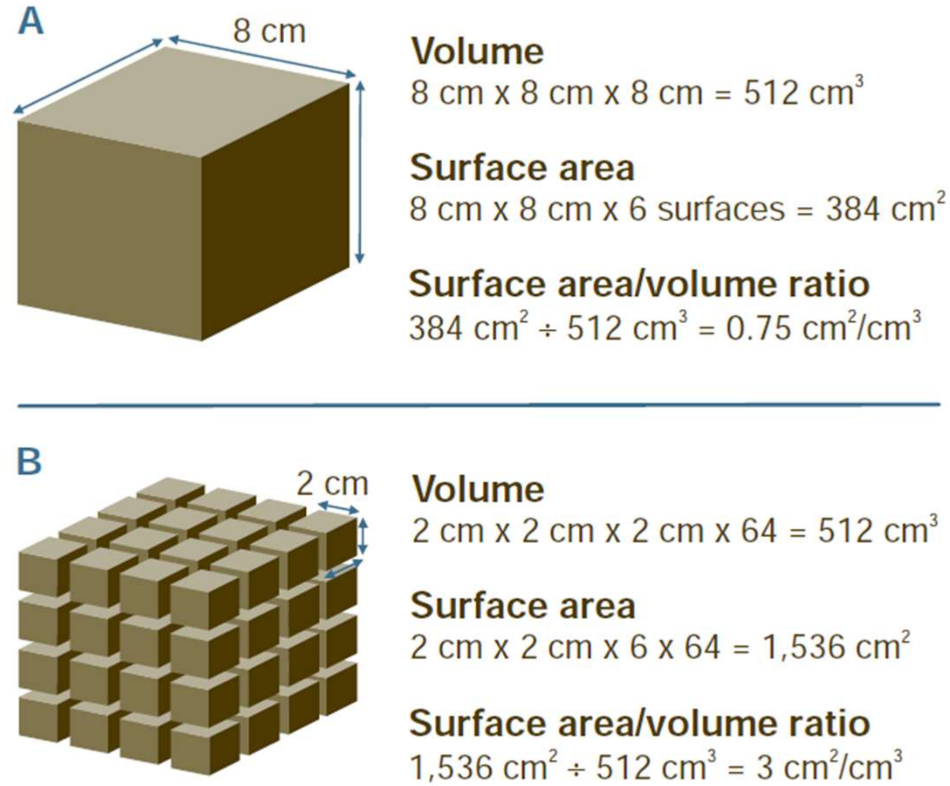
PLANTS DIG SOIL




| Soil Particles | Diameter (mm) |
|---|---|
| Very coarse sand | 2.0 - 1.0 |
| Coarse sand | 1.0 - 0.5 |
| Medium sand | 0.50 - 0.25 |
| Fine sand | 0.25 - 0.10 |
| Very fine sand | 0.10 - 0.05 |
| Silt | 0.05 - 0.002 |
| Clay | < 0.002 |
| Fine clay | < .00002 |

Based on Canadian Soil Classification Group, 1998

**Figure 3.1.2 Relative Size of Different Types of Particles**




Adapted from Brady and Weil, 2000

**Figure 3.1.3 Relationship Between Surface Area and Volume**

https://www.alberta.ca/nutrient-management-planning

# LET'S BRING IT ALL TOGETHER

| Textural class | Bulk density ($Mg\ m^{-3}$) | Porosity (%) | Field capacity (% by weight) | Permanent wilting point (% by weight) | Available water-holding capacity† | | | |
|---|---|---|---|---|---|---|---|---|
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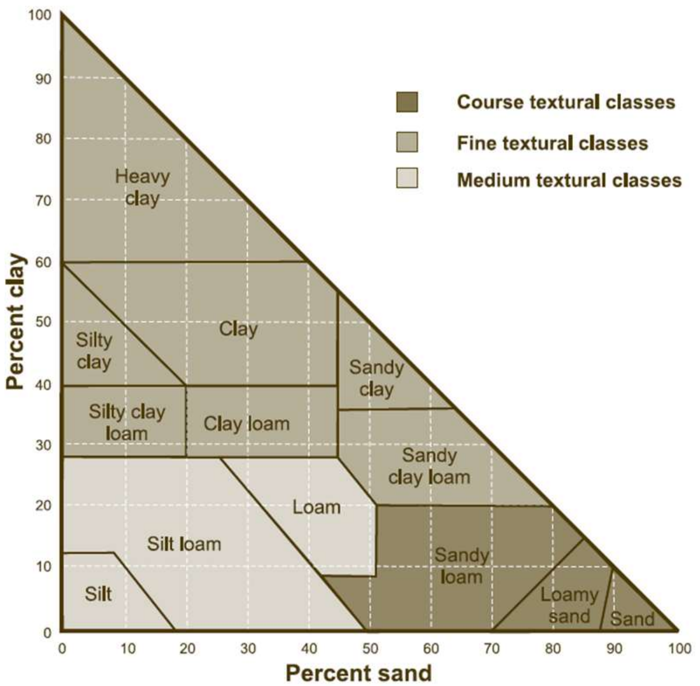
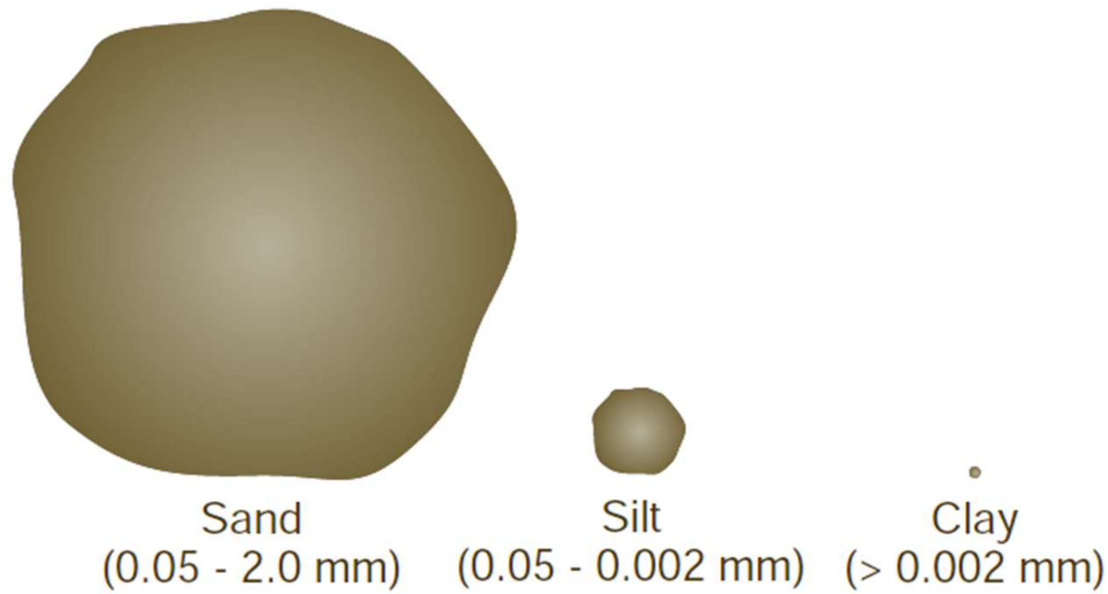
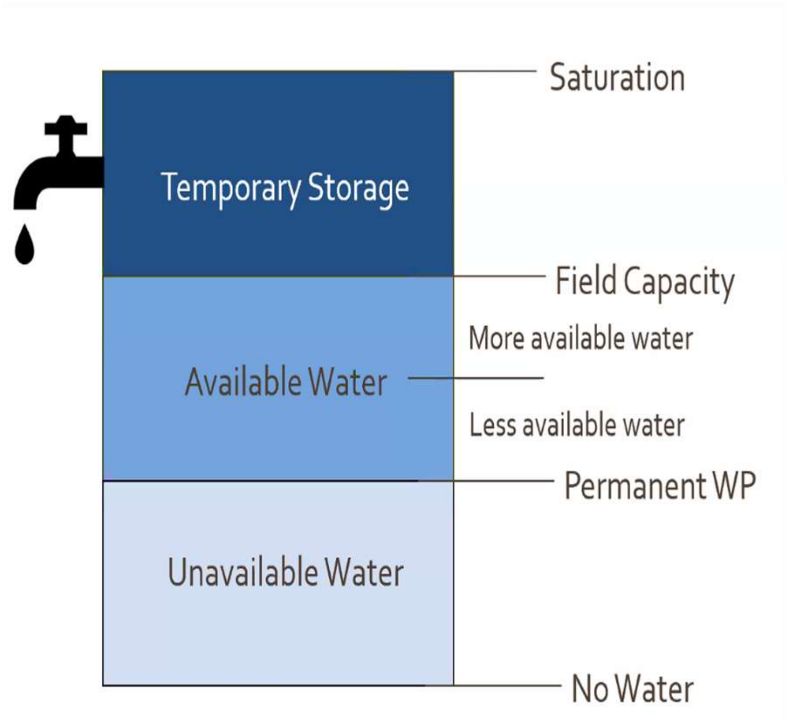


# PLANT AVAILABLE WATER

| mm \| inch | Sandy Loam | Loam | Clay Loam |
|---|---|---|---|
| Total per 30cm | 42 \| 1.7 | 54 \| 2.2 | 60 \| 2.4 |
| Ideal Range 65%-85% | 8.5 \| 0.3 | 11 \| 0.4 | 12 \| 0.5 |
| Typical Range 55%-95% | 17 \| 0.7 | 22 \| 0.9 | 24 \| 1.0 |
| Wide Range 35%-100% | 27 \| 1.1 | 35 \| 1.4 | 39 \| 1.6 |

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## WHERE DOES THE PLANT TAKE WATER FROM?

## (IT DEPENDS ON THE TIME OF THE SEASON)

https://open.alberta.ca/publications/alberta-irrigation-management-manual

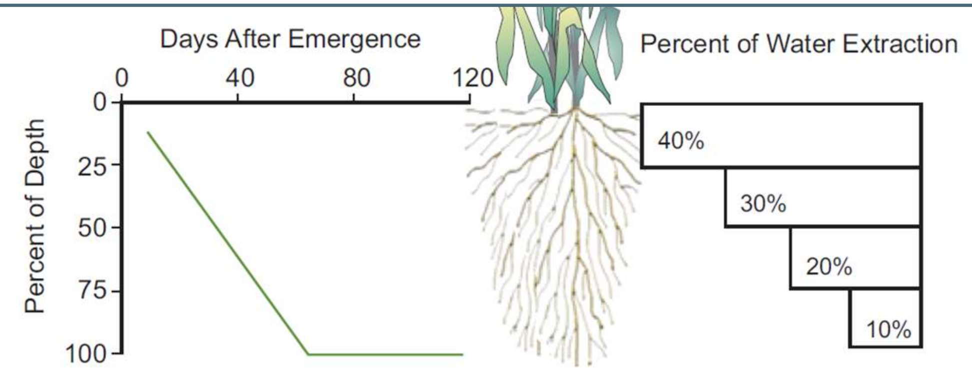


**Figure 2. Effective root zone soil water extraction and plant root development patterns (adapted from Kranz et al., 2008).**

| Crop | Early Rooting Depth | Late Rooting Depth |
| --- | --- | --- |
| Alfalfa | 60cm / 2.0ft | 1.2m / 4.0ft (or more) |
| Grain/Oilseed | 50cm / 20” | 1.0m / 40” |
| Peas/Beans | 35cm / 14” | 70cm / 28” |
| Potato | 30cm / 12” | 75cm / 30” |

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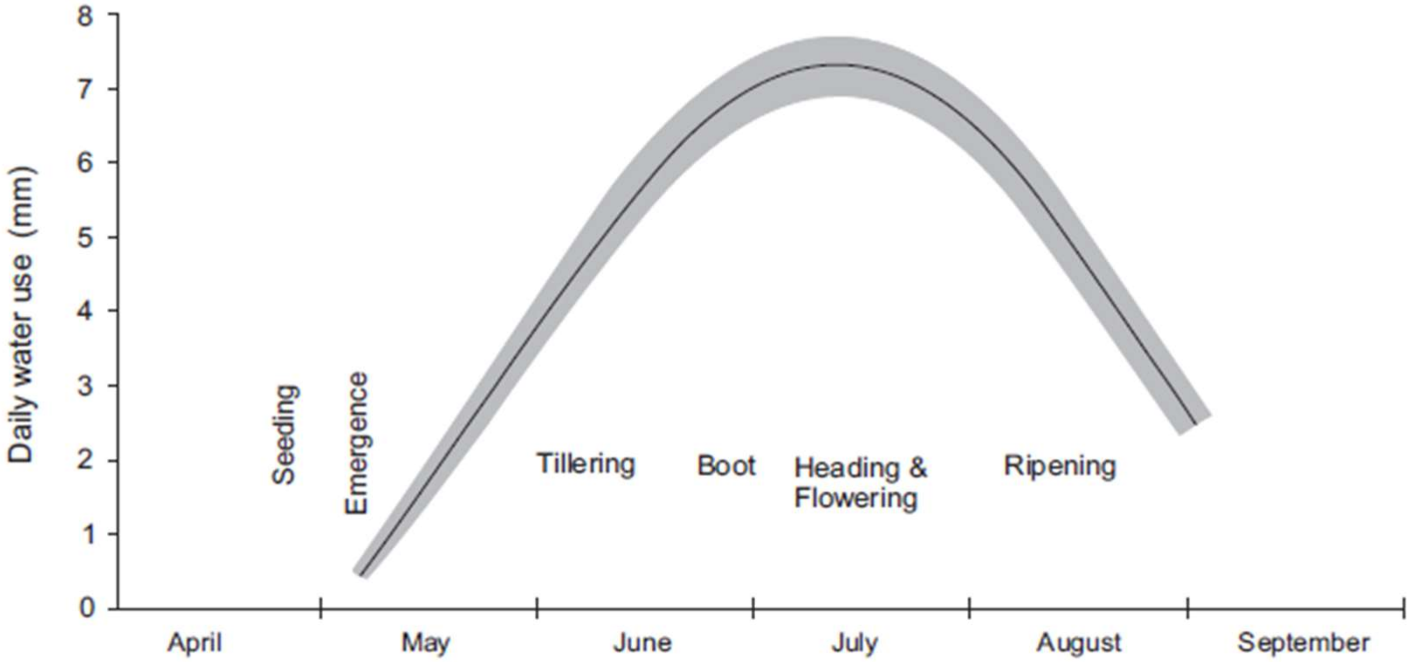
# IRRIGATED WHEAT CROP USE DEMAND

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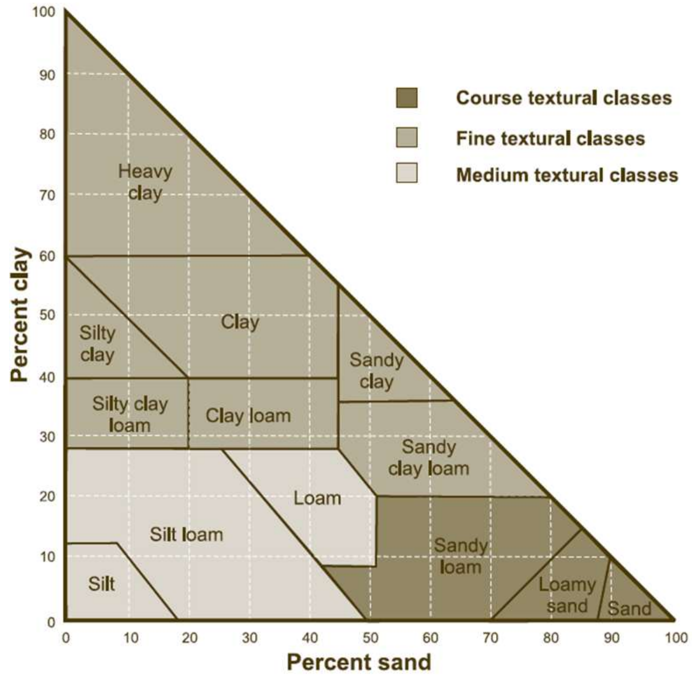
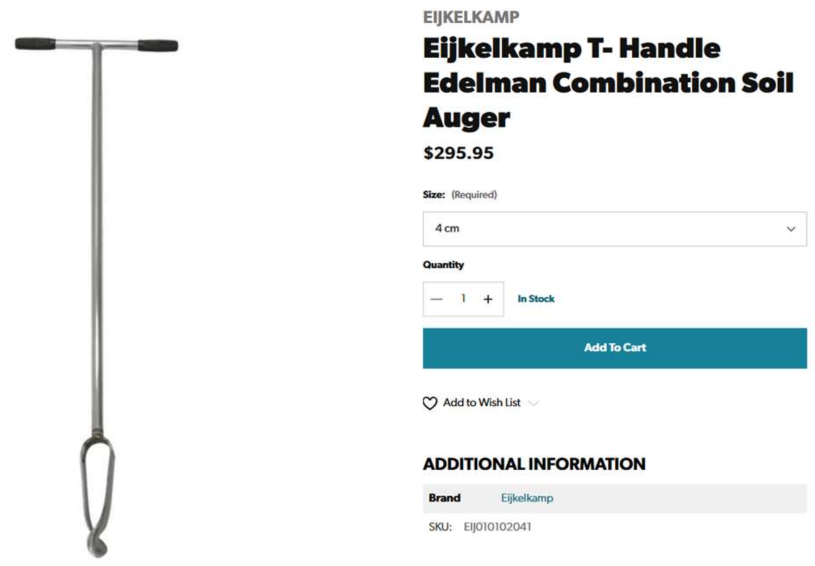
# SOIL TEXTURE DETERMINES YOUR SOIL WATER HOLDING CAPACITY. YOU CANNOT CHANGE IT. EXCEPT BY EROSION!

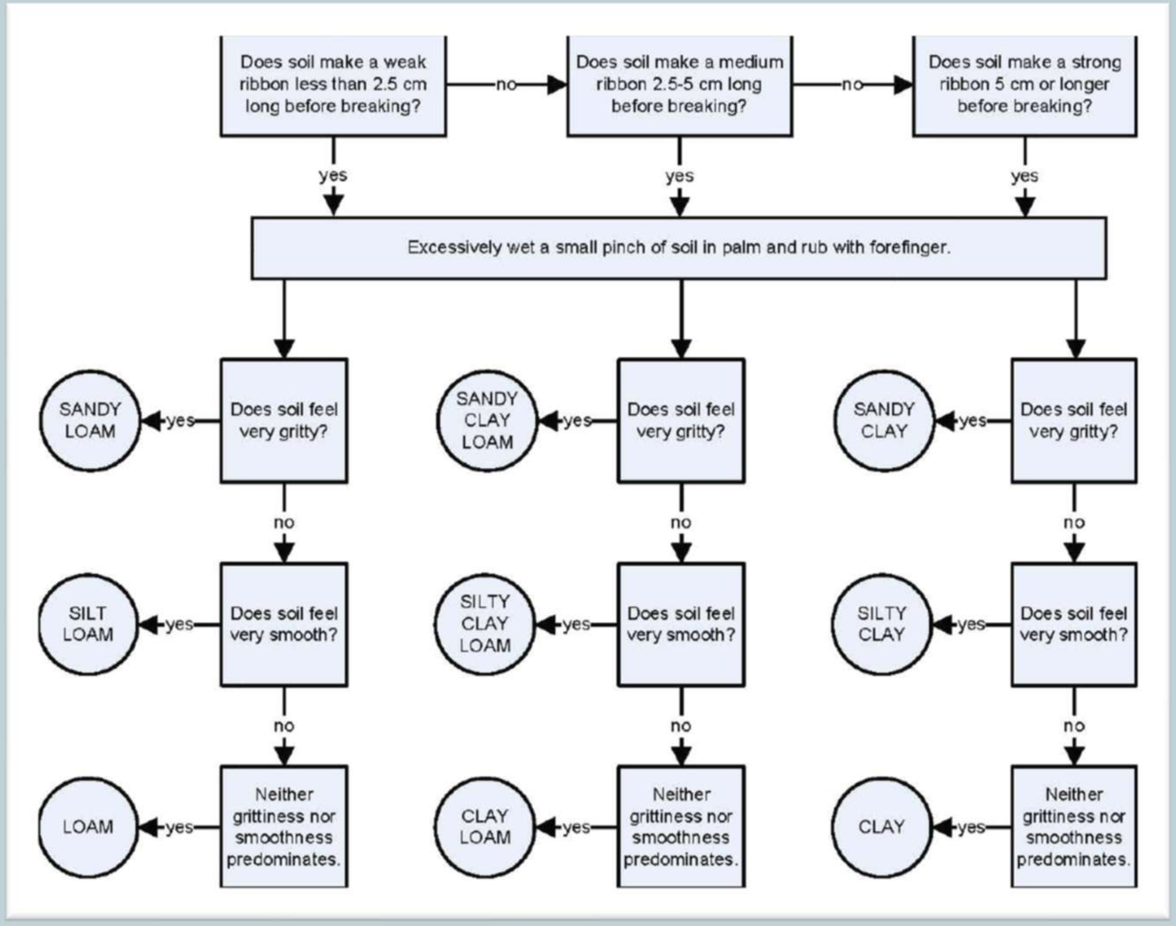



https://thearboriststore.com/eijkelkamp-t-handle-edelman-combination-soil-auger/

# ESTIMATE SOIL TEXTURE BY HAND

https://www.nrcs.usda.gov/sites/default/files/2022-11/texture-by-feel.pdf

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# ESTIMATE SOIL TEXTURE BY HAND

https://www.wcc.nrcs.usda.gov/ftpref/wntsc/waterMgt/irrigation/EstimatingSoilMoisture.pdf

## Appearance of sandy clay loam, loam, and silt loam soils at various soil moisture conditions.

*Available WaterCapacity*
*1.5-2.1 inches/foot*

**Percent Available:** Currently available soil moisture as a percent of available water capacity.

**In/ft. Depleted:** Inches of water currently needed to refill a foot of soil to field capacity.

**0-25 percent available**
**2.1-1.1 in./ft. depleted**

Dry, soil aggregations break away easily, no staining on fingers, clods crumble with applied pressure. (Not pictured)

**25-50 percent available**
**1.6-0.8 in./ft. depleted**

Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.

**50-75 percent available**
**1.1-0.4 in./ft. depleted**

Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon between the thumb and forefinger.

**75-100 percent available**
**0.5-0.0 in/ft. depleted**

Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.

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# WATER HOLDING CAPACITY & CARBON

- Going from sand → clay: plant available water ↑
  - Total water holding increases as well
  - However – the amount of water that is *not* plant available also increases
- The carbon connection:
  - There are hundreds to thousands more nooks and crannies in a clay soil
  - These areas allow many, many more microbes to flourish. When they die it can take decades, centuries, or millennia for their carbon to break down. Thus – clays inherently can store more carbon. (Organic matter is ~60% carbon.)

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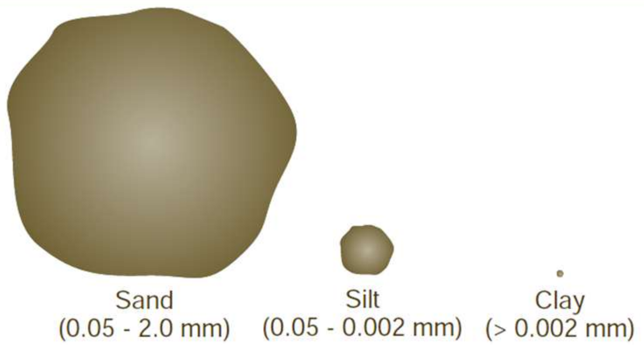


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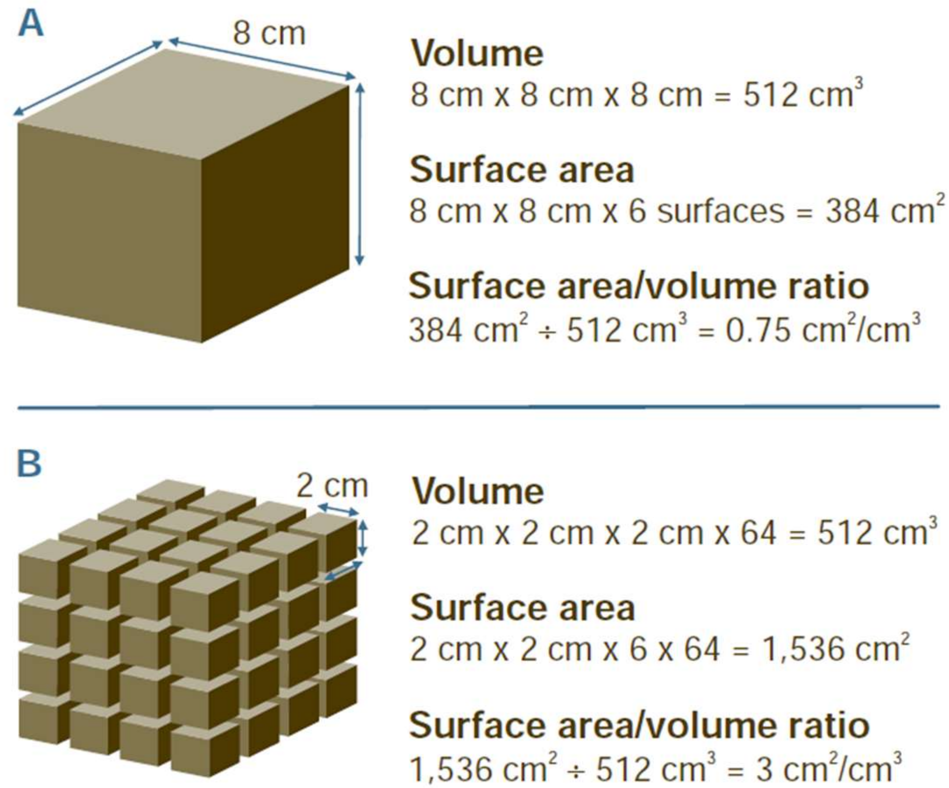


Adapted from Brady and Weil, 2000

**Figure 3.1.3 Relationship Between Surface Area and Volume**

https://www.alberta.ca/nutrient-management-planning

# ORGANIC MATTER
# &
# WATER HOLDING CAPACITY

Water holding capacity has organic matter already factored in.

At 326,000 gal/acre-foot this equals ~0.9”


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# ORGANIC MATTER SATURATION POINT

https://pubs.extension.wsu.edu/understanding-and-measuring-organic-matter-in-soil

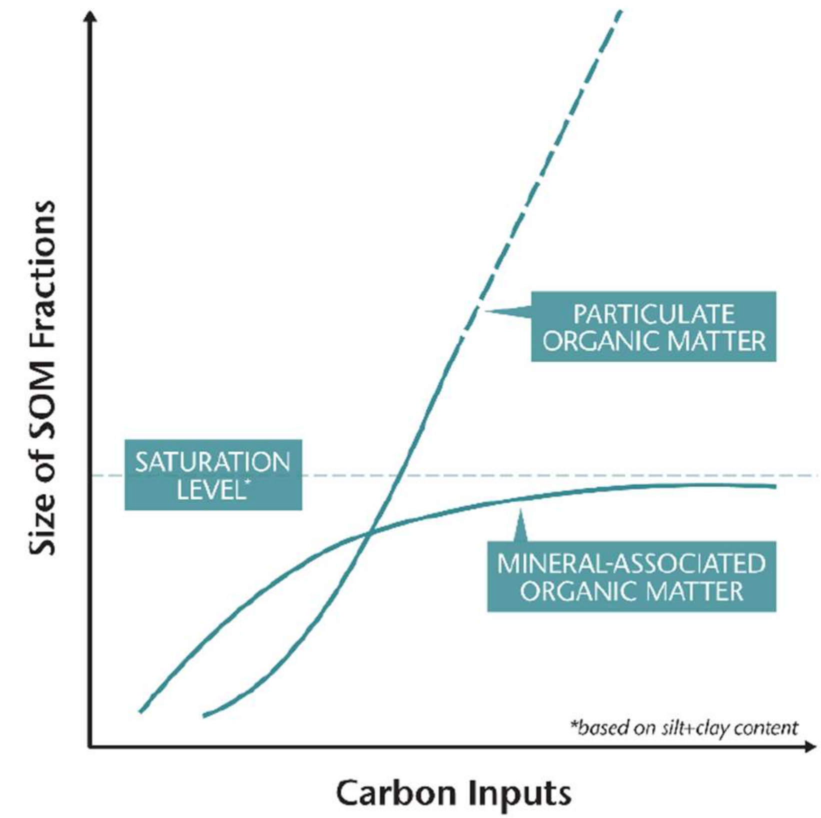


Figure 2. Amount of soil organic matter associated with minerals or as free particulate organic matter with increasing carbon inputs (Adapted from Castellano et al. 2015).

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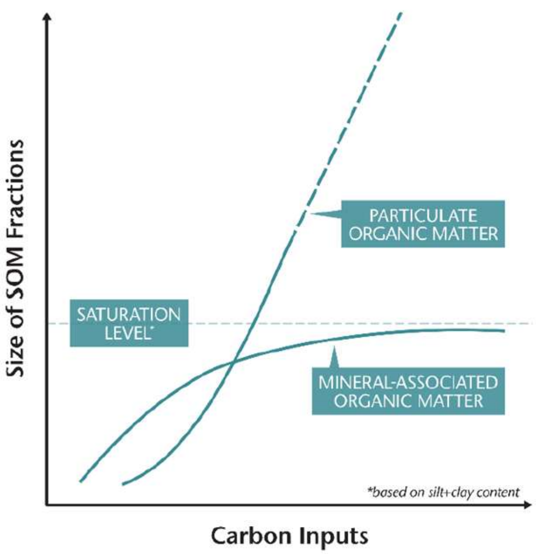
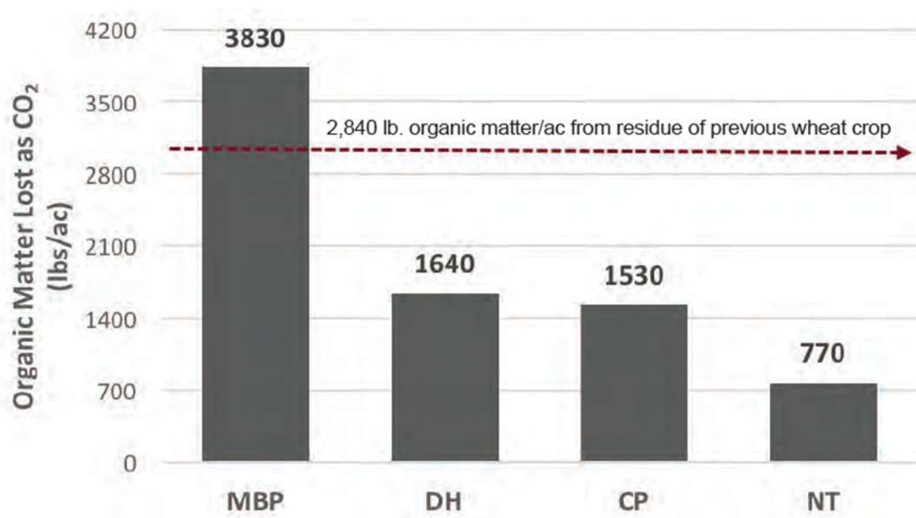
# TILLAGE MOSTLY LOWERS THE PARTICULATE ORGANIC MATTER (THE STUFF THAT DOESN'T STICK AROUND LONG ANYWAYS)




https://blog-nwcrops.extension.umn.edu/2018/05/upper-midwest-tillage-guide.html

# SOIL ORGANIC MATTER EXPECTATIONS

- "pounds per acre per year" is the above ground straw
- Assume harvest index = 0.4
- 34lb/bu oats = 85lb/ac straw
- 60bu/ac ~ 5000lb/ac
- Chart is U.S. based
  - Higher with more rainfall
  - Higher with lower temperatures

**Table 3.4**
**Estimated Levels of Soil Organic Matter after Many Years with Various Rates of Decomposition (Mineralization) and Residue Additions***

| | | Fine texture, poorly aerated ⟷ Coarse texture, well aerated | | | | |
|---|---|---|---|---|---|---|
| | | Annual rate of organic matter decomposition | | | | |
| Annual organic material additions** | Added to soil if 20% remains after one year | 1% | 2% | 3% | 4% | 5% |
| -----pounds per acre per year----- | | -----equilibrium % organic matter in soil----- | | | | |
| 2,500 | 500 | 2.5 | 1.3 | 0.8 | 0.6 | 0.5 |
| 5,000 | 1,000 | 5 | 2.5 | 1.7 | 1.3 | 1 |
| 7,500 | 1,500 | 7.5 | 3.8 | 2.5 | 1.9 | 1.5 |
| 10,000 | 2,000 | 10 | 5 | 3.3 | 2.5 | 2 |

*Assumes the upper 6 inches (15 centimeters) of soil weighs 2 million pounds.
**10,000 pounds per acre addition is equivalent to 11,200 kilograms per hectare.

Building Soils for Better Crops. Chapter 3. Page 44.
https://www.sare.org/resources/building-soils-for-better-crops/

Global Change Biology

PRIMARY RESEARCH ARTICLE

**Deep soil inventories reveal that impacts of cover crops and compost on soil carbon sequestration differ in surface and subsurface soils**

Nicole E. Tautges, Jessica L. Chiartas, Amélie C. M. Gaudin, Anthony T. O'Geen, Israel Herrera, Kate M. Scow

The addition of WCC to a conventionally managed system increased SOC stocks by 3.5% (1.44 Mg C/ha) in the 0–30 cm layer, but decreased by 10.8% (14.86 Mg C/ha) in the 30–200 cm layer, resulting in overall losses of 13.4 Mg C/ha. If we only measured soil C in the top 30 cm, we would have assumed an increase in total soil C increased with WCC alone, whereas in reality significant losses in SOC occurred when considering the 2 m soil profile. Ignoring the subsoil carbon dynamics in deeper layers of soil fails to recognize potential opportunities for soil C sequestration, and may lead to false conclusions about the impact of management practices on C sequestration.

**Tilled soils can be as healthy as no-till ground**

By Robert Arnason

Reading Time: 5 minutes

Published: April 2, 2020
Crops

"We have vilified tillage, in the Prairies, for years. (But) if you have to choose between tillage and growing plants, you would choose a good crop rotation before no-till, anytime; and the data supports that," said Entz, University of Manitoba plant science professor and organic cropping systems specialist, who spoke at the 2020 Prairie Organics conference held in early March in Brandon.

Entz added some farmers may believe that tillage destroys soil, but the perception is incorrect.

"It doesn't," he said. "Minimizing tillage is good for soils. But eliminating tillage is not necessary for a healthy soil. We can talk about that in the hallways."

# ORGANIC MATTER MYTHS

## Cover Crops

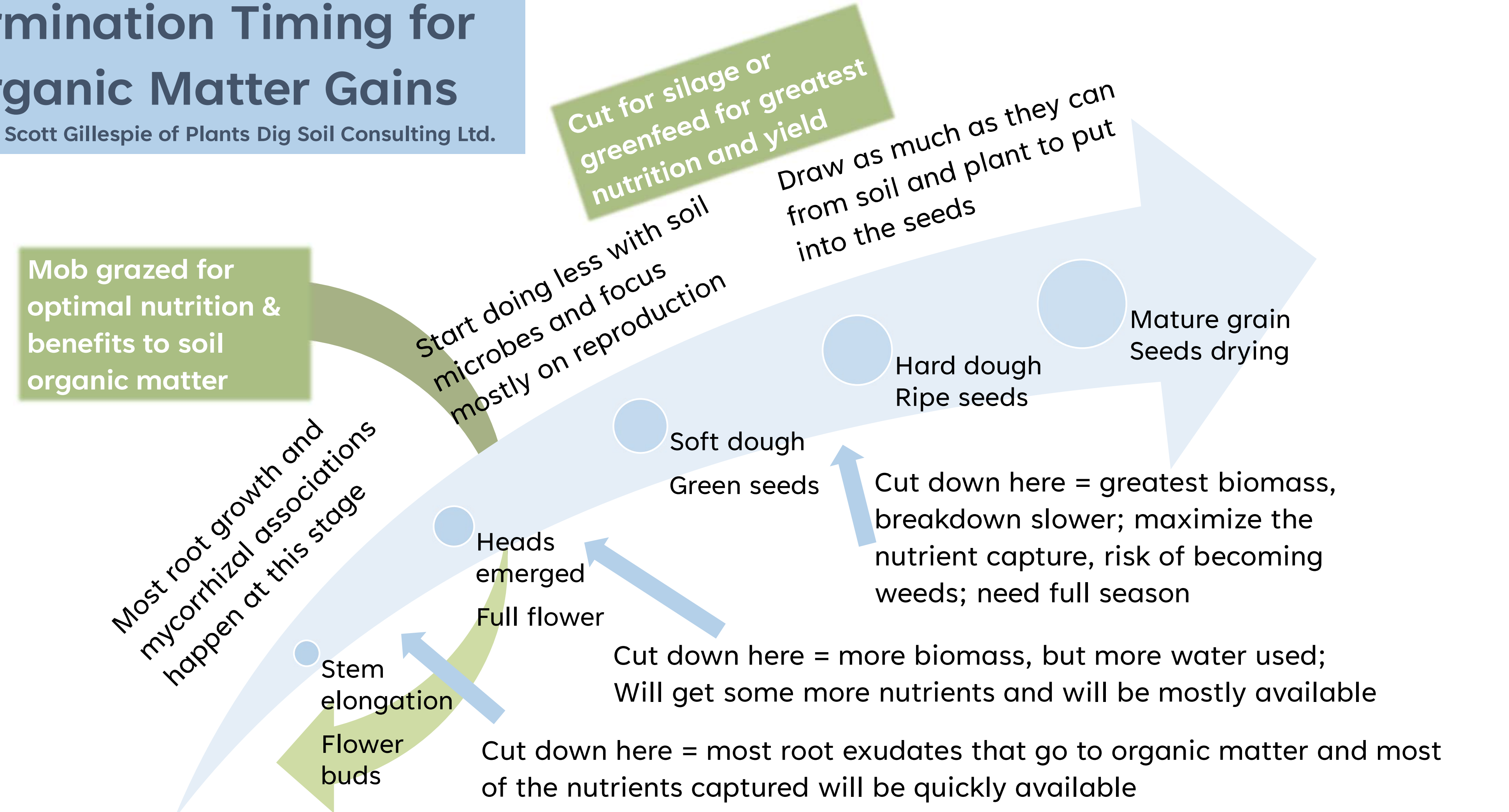
- Long term studies with measurements to 2m (>6') show cover crops lower organic matter deeper down but increase organic matter near the surface
- https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14762

## No-till

- Long term studies at shows no-till tends to concentrate organic matter near the surface and rob from depth.
- https://www.producer.com/crops/tilled-soils-can-be-as-healthy-as-no-till-ground/

# Termination Timing for Organic Matter Gains

Chart by Scott Gillespie of Plants Dig Soil Consulting Ltd.



SOIL WATER LOSS IS THE BIGGER ISSUE WITH TILLAGE

+

IT INCREASES THE RISK OF EROSION

(BUT DON'T BE AFRAID TO USE IT IF IT WILL RESULT IN BETTER PLANT GROWTH)

https://blog-nwcrops.extension.umn.edu/2018/05/upper-midwest-tillage-guide.html

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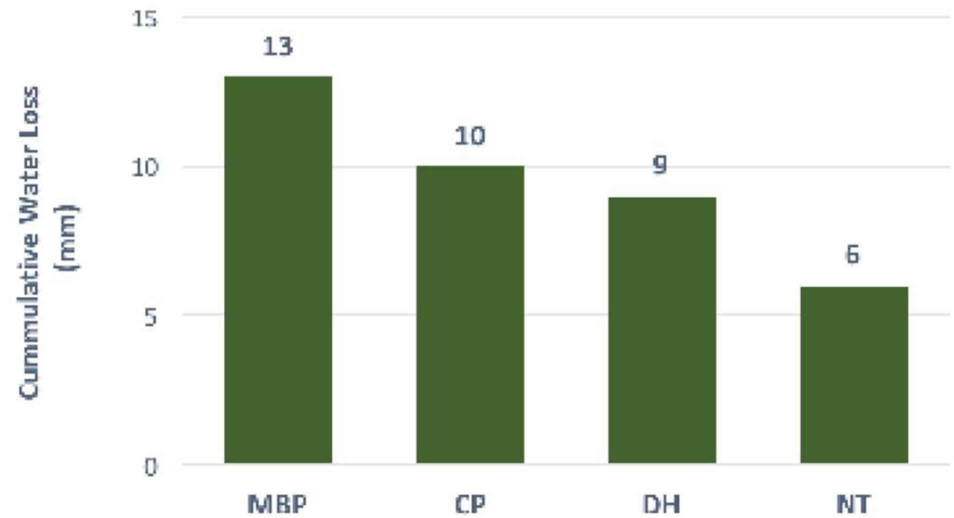


Figure 4
Soil water loss 80 hours after four tillage systems (Reicoski, et al. USDA-ARS in Morris, MN).

# SOIL WATER & TEMPERATURE TRADE-OFFS

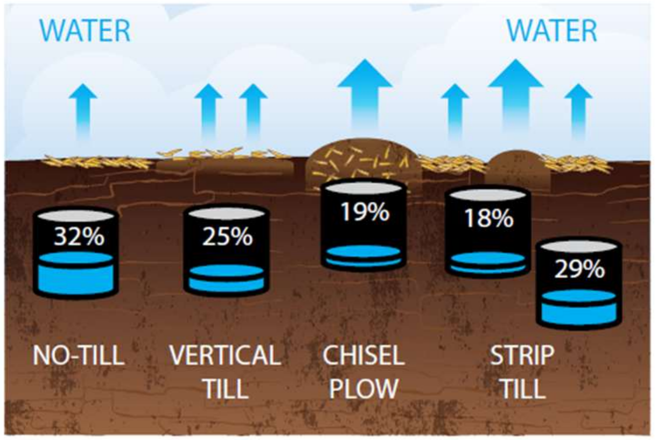


Figure 5
Average soil moisture levels (actual percentage points of the soil) taken from thaw to canopy closure to a depth of 2 inches below four tillage systems near Wahpeton, North Dakota and Fergus Falls, Minnesota.

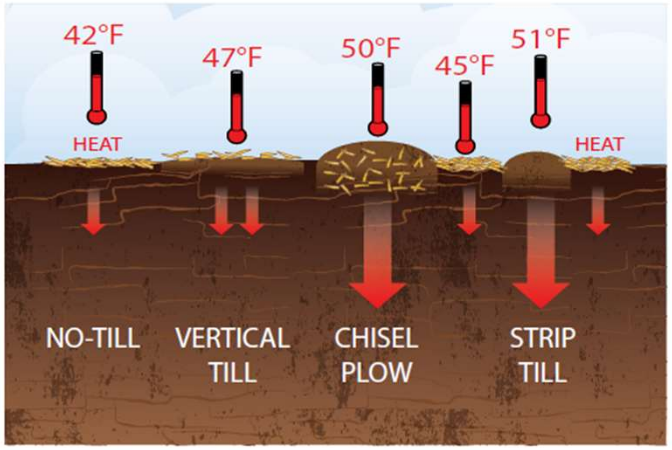


Figure 3
Average soil temperatures taken from thaw to crop canopy closure in 2015 to a depth of 2 inches below four tillage systems near Wahpeton, North Dakota and Fergus Falls, Minnesota.

https://blog-nwcrops.extension.umn.edu/2018/05/upper-midwest-tillage-guide.html

# SOIL HEALTH FOR THE PRAIRIES

Adapted by
Scott Gillespie
from Andrew McGuire*

https://csanr.wsu.edu/whats-the-problem-with-my-soil/

*who adapted it from Caley Gasch

| More Healthy | Less Healthy |
|---|---|
| Stays in place | Wind/water erosion concerns |
| Saline/sodic values below thresholds | Salinity and/or sodacity building or high |
| Good infiltration & minimal crusting | Low infiltration rates and/or crusting |
| Rooting zone fills with water; deep drains if needed | Can't capture large rains and/or doesn't drain deeply |
| Nutrient release well timed | Nutrient release is erratic |
| Pests mostly under control (weeds/insects/disease) | Pests are building or gaining a foothold |

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