

A wide-angle photograph of a lush green wheat field. The wheat is in the foreground, filling the lower half of the frame. In the background, there are rolling green hills under a bright, clear sky. The overall scene is a typical agricultural landscape.

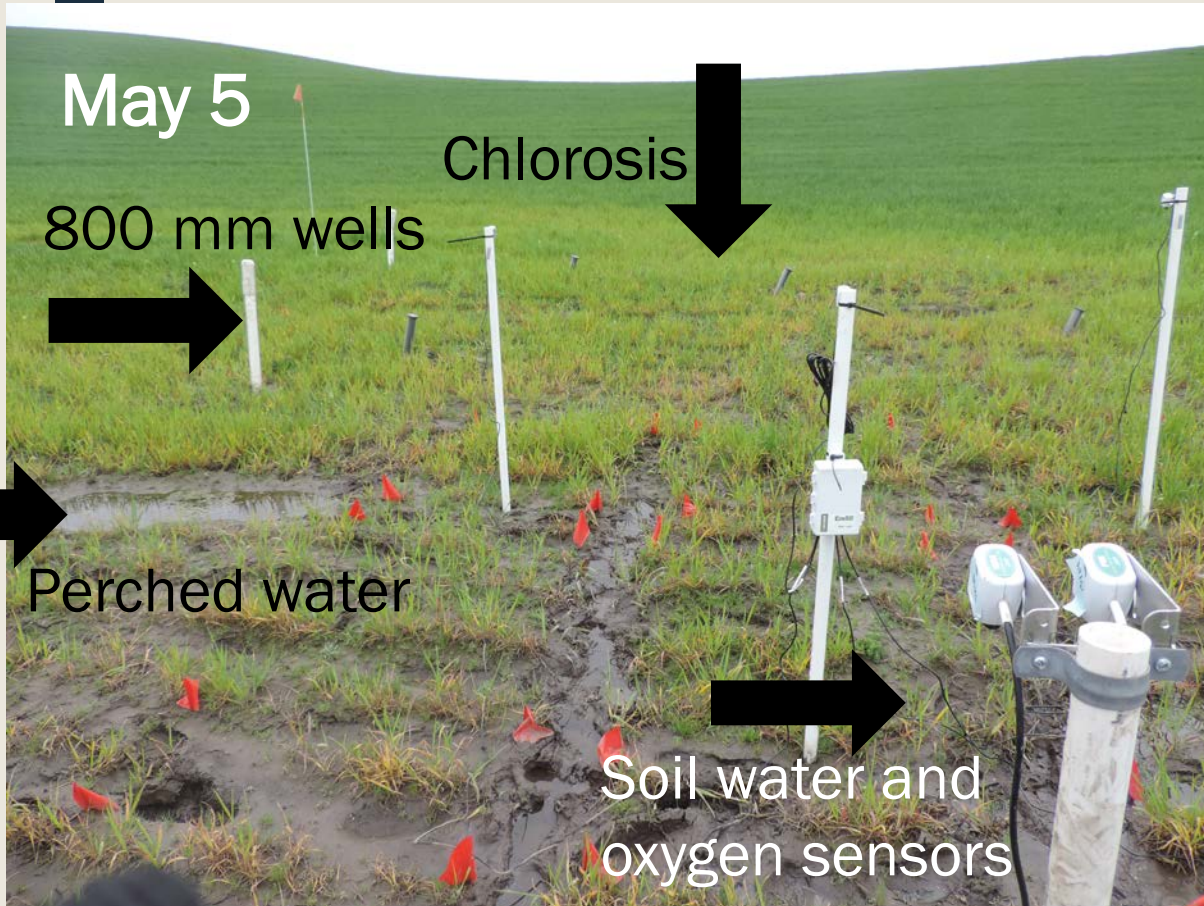
# NITROGEN DEFICIENCY IN WATERLOGGED WHEAT

Kristina Estrada

# Introduction

- Wetter springs lead to seasonal flooding in poorly drained soil
- Roots exposed to periods of water cause differences in growth of winter wheat (Herzog et al., 2016; Ghobadi et al., 2016)
- Waterlogging lead to chlorosis, but plants green up when soils drain
- Is the soil deficient in nitrogen (N) or can waterlogged plants not take up the N? What role do roots play?

# Waterlogging

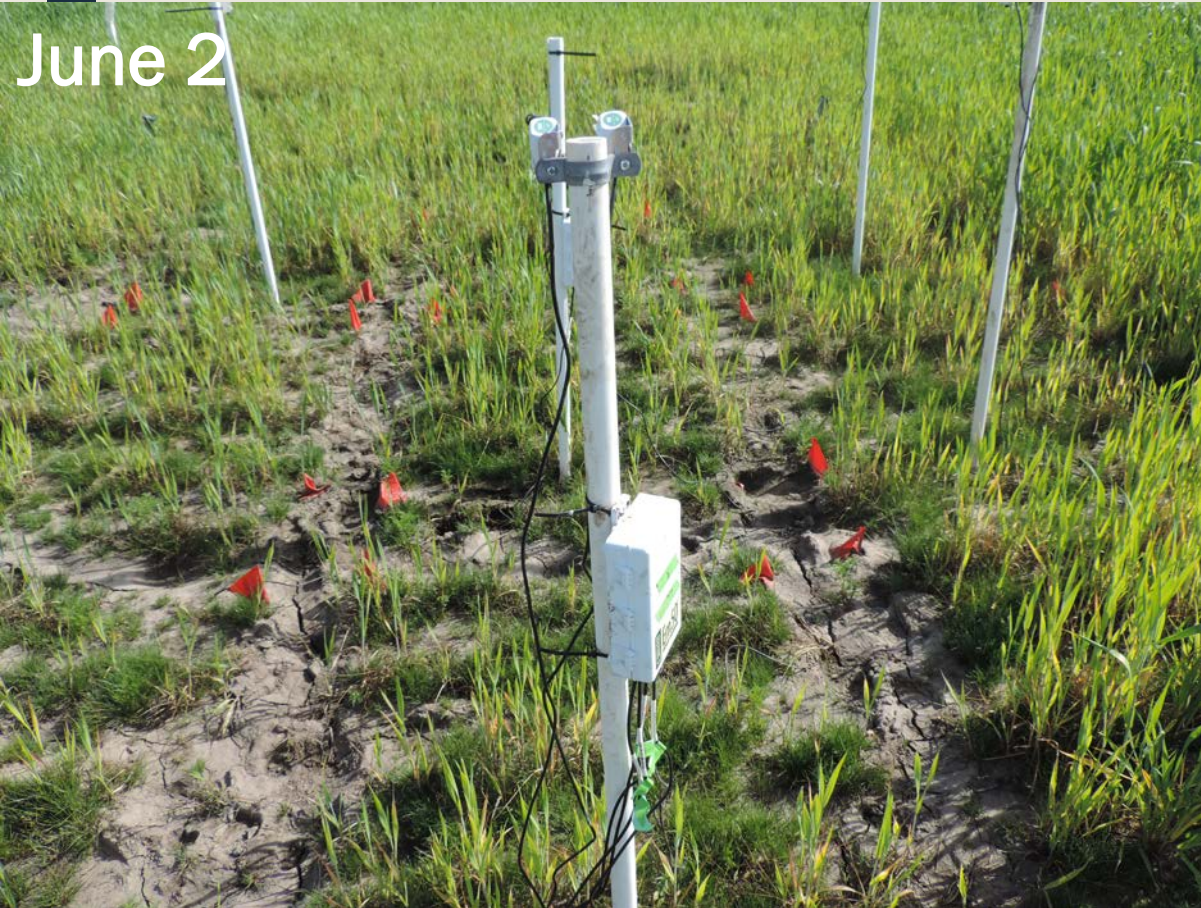


**Waterlogged**



**Aerated**

# Drying Up

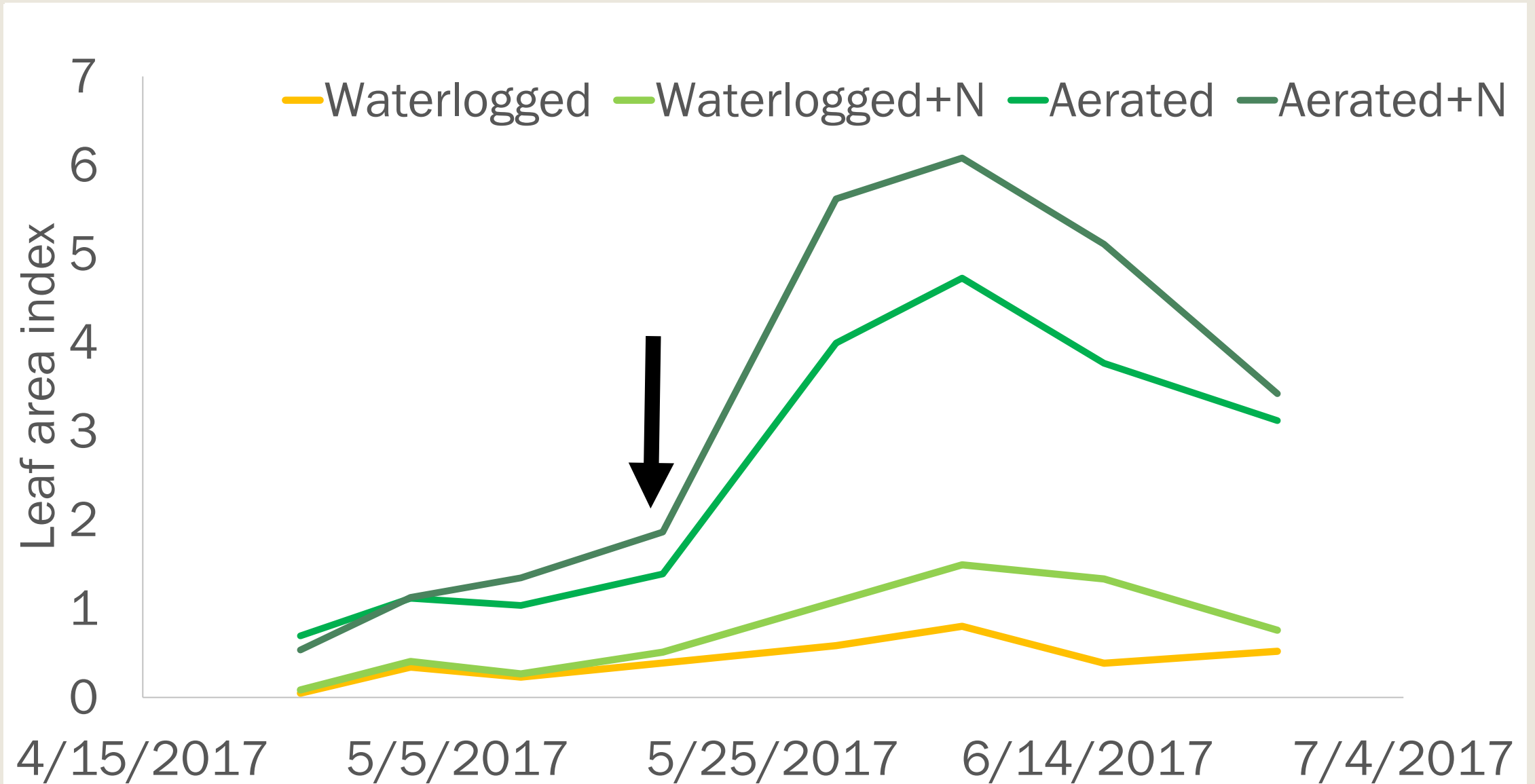


**After waterlogging**



**Always aerated**

# Background: When did soils begin to dry out?

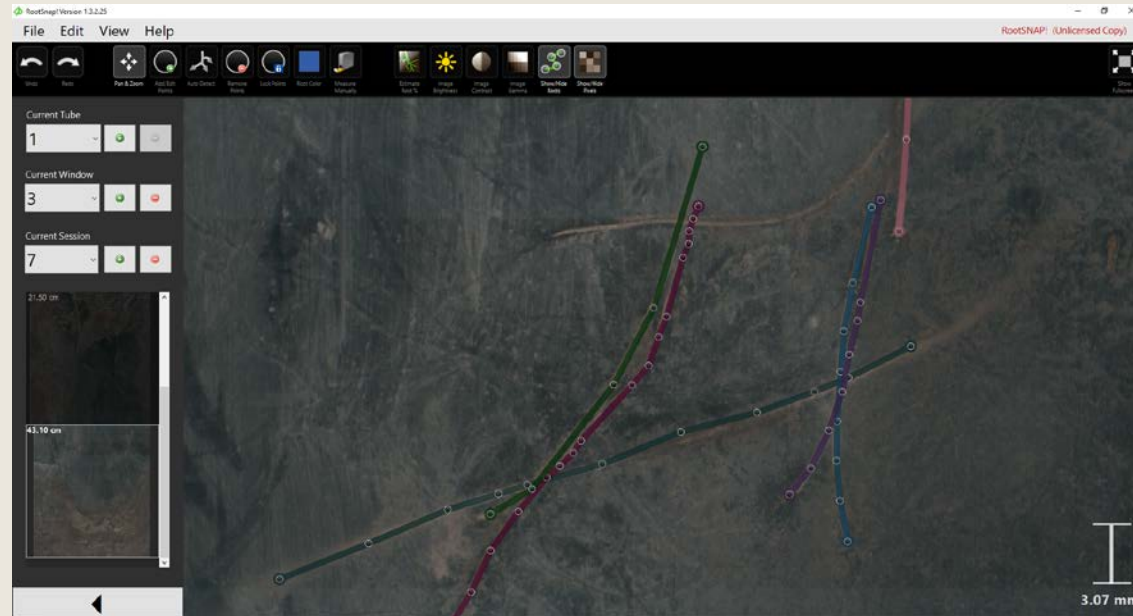


# Hypotheses

- Waterlogging restricts rooting depth (Shao et al., 2013), but aerenchyma helps the wheat survive (Huang et al., 1994).
- Aerated wheat has more new appearances of roots early on, but as the water table recedes, waterlogged wheat catches up.
- Spring nitrogen fertilization will stimulate plant growth (Horchani et al., 2010) and more appearances of roots in flooded soil.

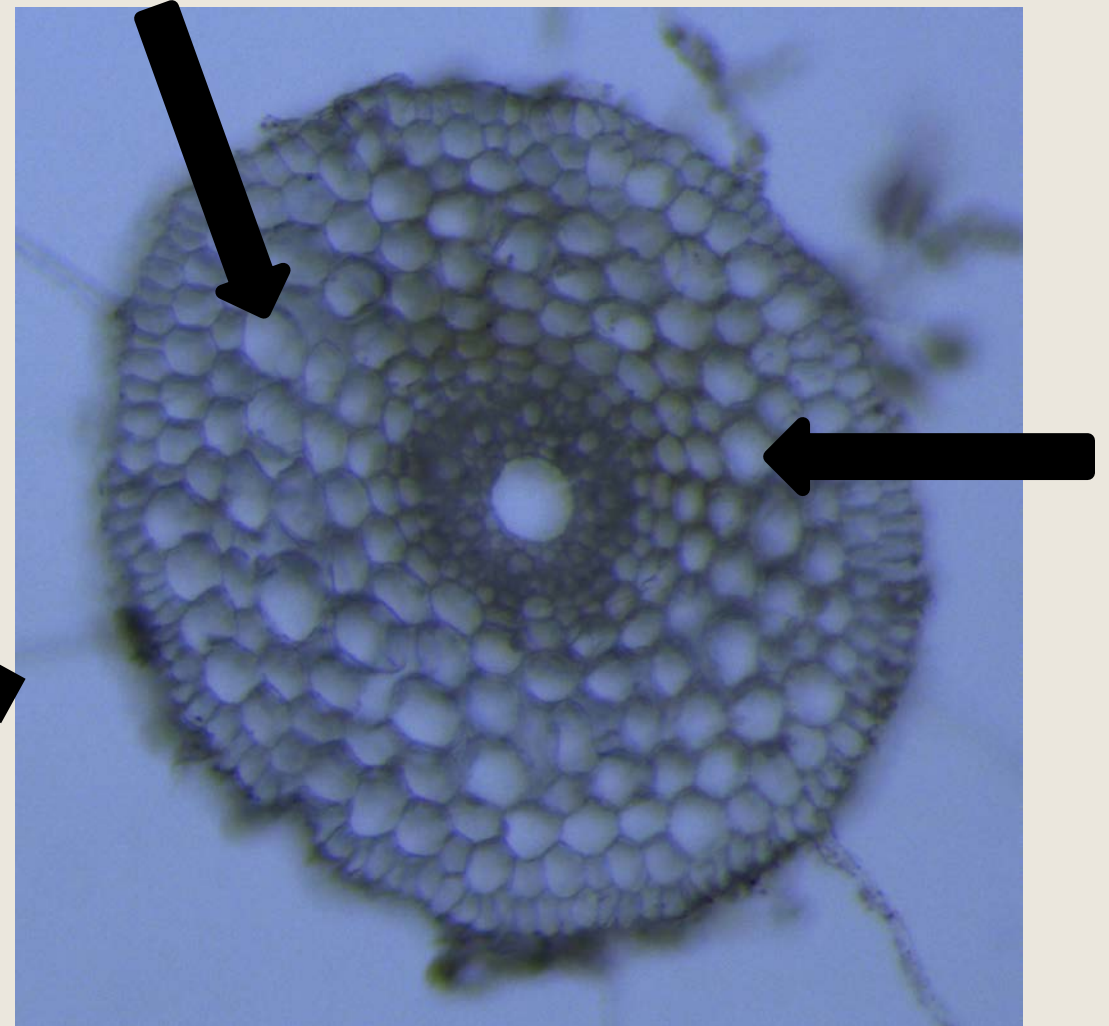
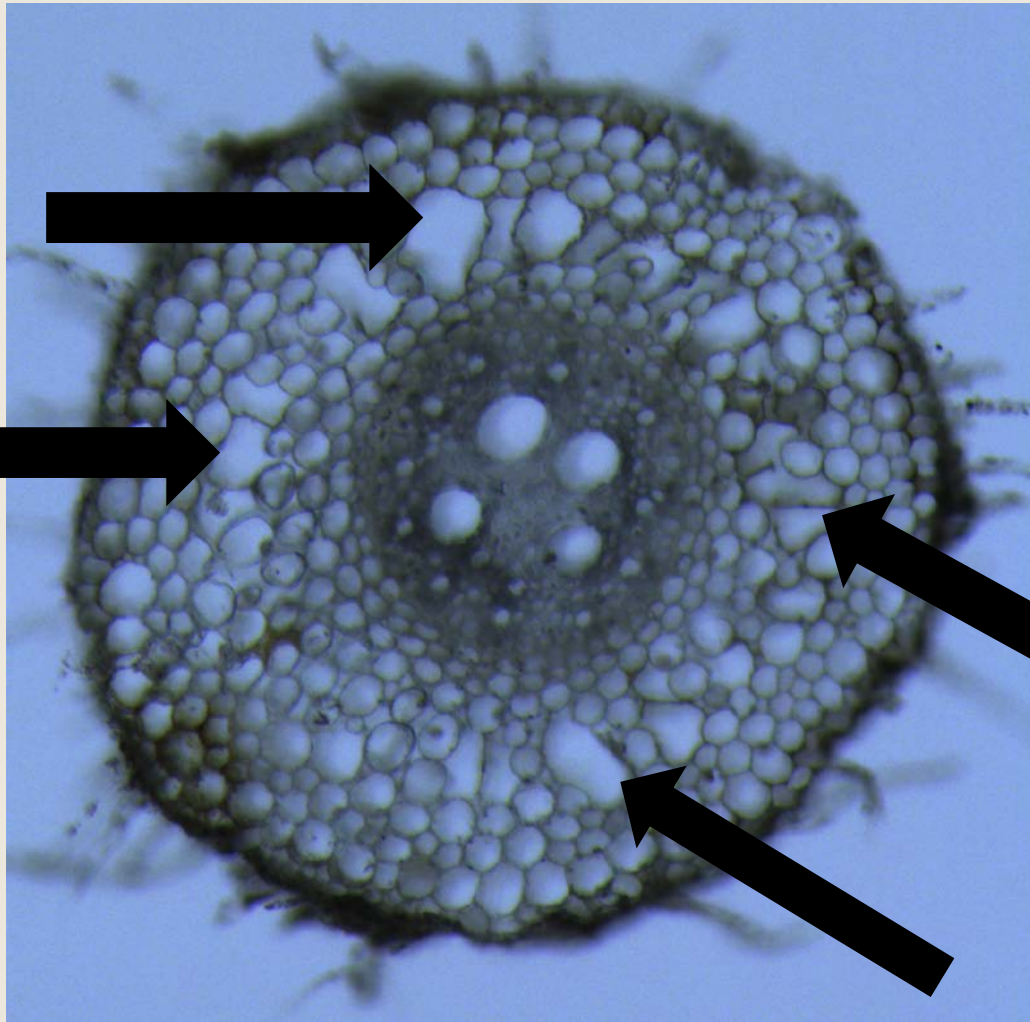
# Methods

- Mini rhizotron
- RootSnap Software
- Slicer
- Microscope



# Results: Qualitative Data

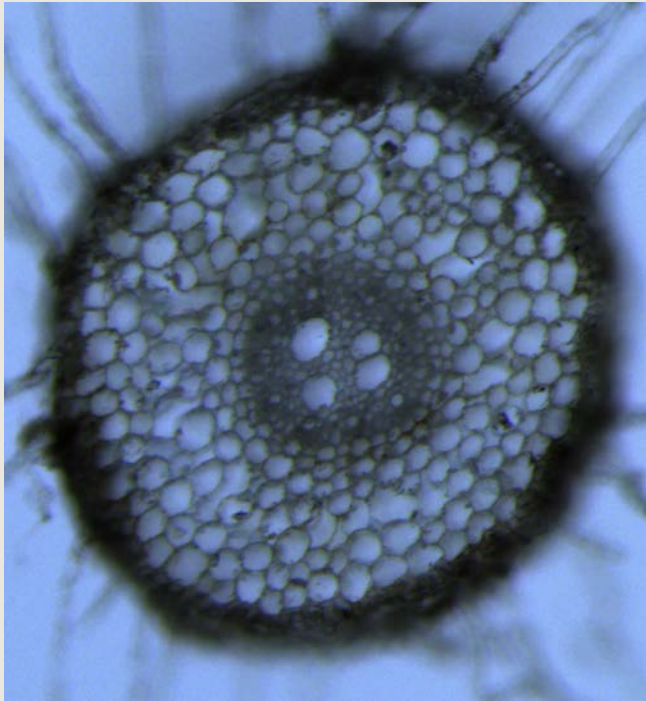
- Aerenchyma in waterlogged roots vs good structure in aerated roots



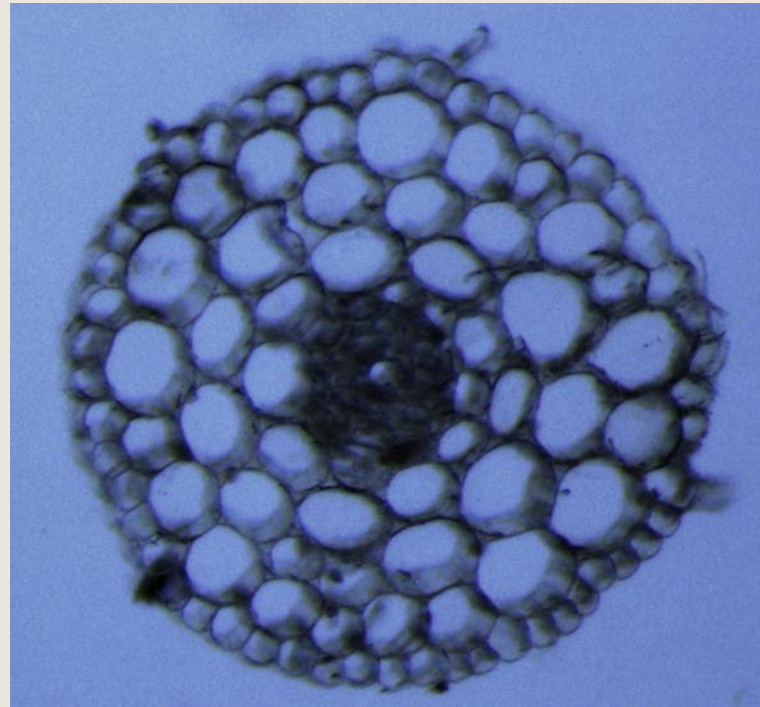


# Microscope: Qualitative Data

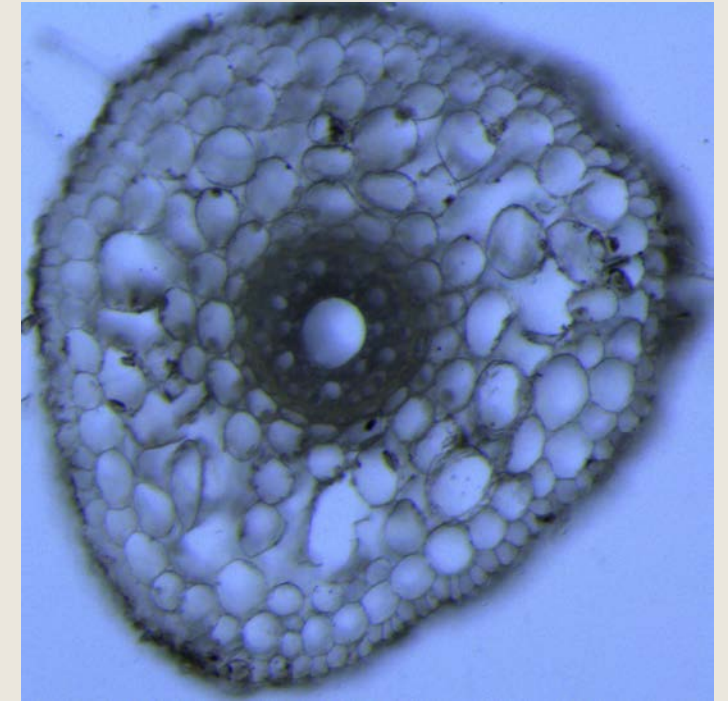
- Outliers leave some uncertainty



Waterlogging  
aerenchyma uncertain  
in two of the samples

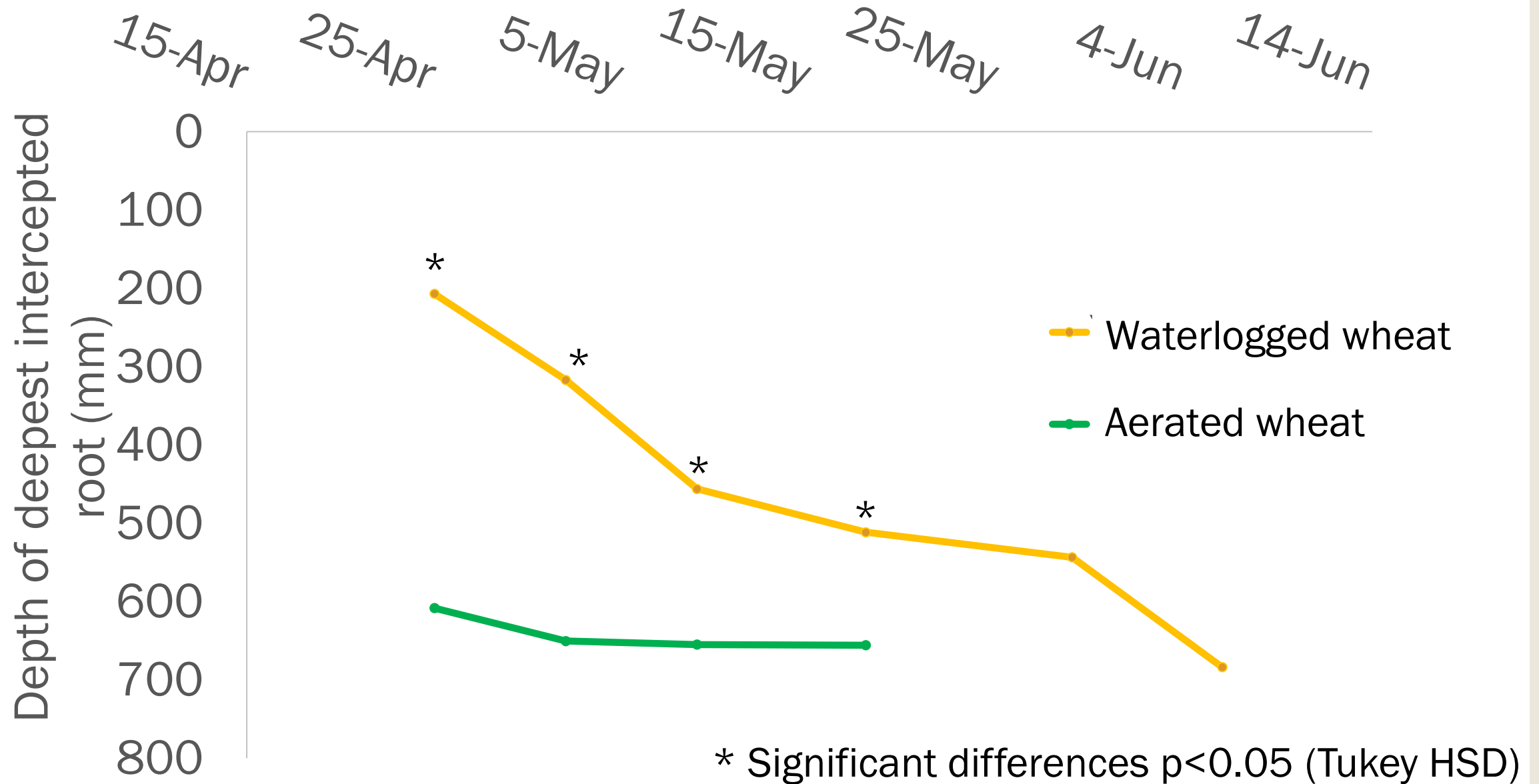


Large cell space in  
aerated root, but all  
relatively even in size

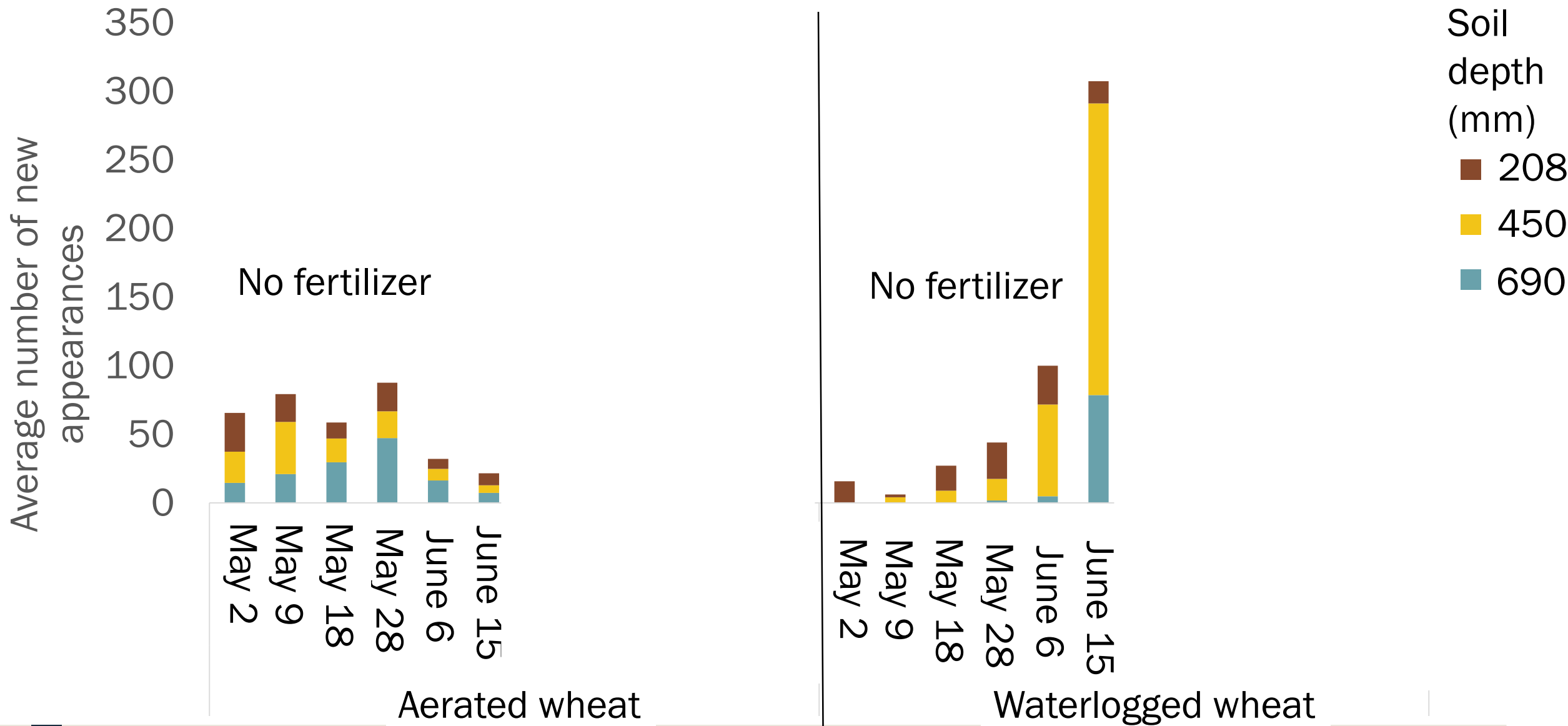


Misshapen root cells in  
aerated roots may be  
aerenchyma, or a result  
of breakdown

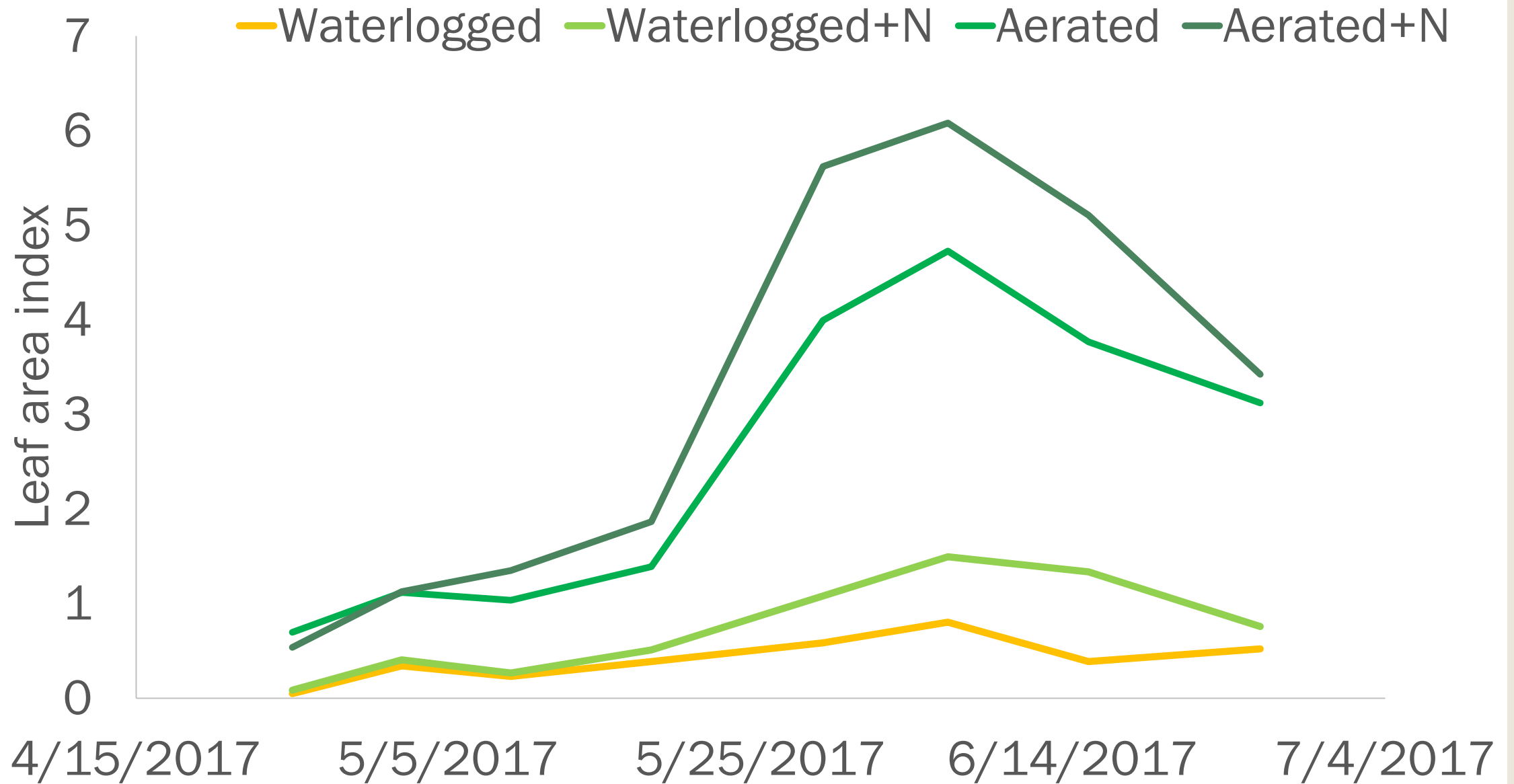
# Results: Rooting depth



# Appearances of new roots



# Relationship to “greening up” of wheat



# Conclusions

- Aerenchyma *may* have helped plants survive waterlogging
- Waterlogging restricted rooting depth
- After soils drained, roots began to appear and plants greened up
- However, plants were injured and leaf area did not recover
- Spring application of N reduced injury and *may* have stimulated new roots, especially shallower roots in waterlogged soils

# Extension Project

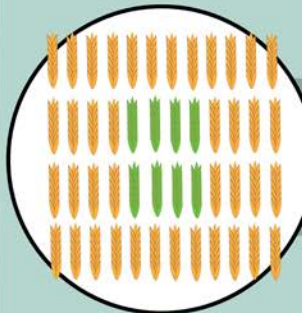
## 4Rs of Nutrient Management

An estimated 30-50% of applied nitrogen fertilizer is taken up by plants.  
How can we improve nitrogen use efficiency using 4Rs?



### Right Time

Application of fertilizer at tillering can maximize the uptake of N by wheat. Splitting the application of N fertilizer between spring and fall can increase fertilizer recovery by more than 10% compared to applying all of the fertilizer in the fall to winter wheat.



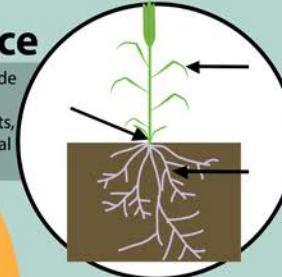
### Right Rate

At economic optimal fertilizer rates, growers maximize profits and balance agronomic and environmental goals. Optimal fertilizer rates vary depending on crop, landscape, soil N, and climate conditions.

2018																		
January						February						March						
M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
1	2	3	4	5	6	7						1	2	3	4			
8	9	10	11	12	13	14	5	6	7	8	9	10	11	5	6	7	8	
15	16	17	18	19	20	21	12	13	14	15	16	17	18	12	13	14	15	
22	23	24	25	26	27	28	19	20	21	22	23	24	25	19	20	21	22	
29	30	31				26	27	28				26	27	28	29	30	31	
April						May						June						
M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
						1	1	2	3	4	5			1	2	3		
2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	
9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	
%	24	25	26	27	28	29	28	29	30	31		25	26	27	28	29	30	
July						August						September						
M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
						1	1	2	3	4	5			1	2	3		
2	3	4	5	6	7	8	6	7	8	9	10	11	12	3	4	5	6	
9	10	11	12	13	14	15	13	14	15	16	17	18	19	10	11	12	13	
16	17	18	19	20	21	22	20	21	22	23	24	25	26	17	18	19	20	
%	25	26	27	28	29	27	27	28	29	30	31	24	25	26	27	28	29	
October						November						December						
M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
1	2	3	4	5	6	7	1	2	3	4				1	2	3		
8	9	10	11	12	13	14	5	6	7	8	9	10	11	3	4	5	6	
15	16	17	18	19	20	21	12	13	14	15	16	17	18	10	11	12	13	
22	23	24	25	26	27	28	19	20	21	22	23	24	25	17	18	19	20	
29	30	31				26	27	28	29	30		%	25	26	27	28	29	30

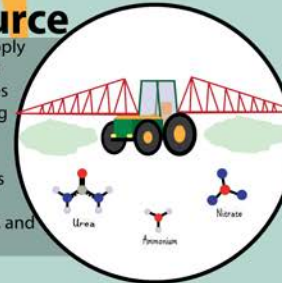
### Right Place

Banding N below or to the side avoids toxicity to the plant. Toxicity to crops with taproots, such as canola, can prove fatal to the entire plant.



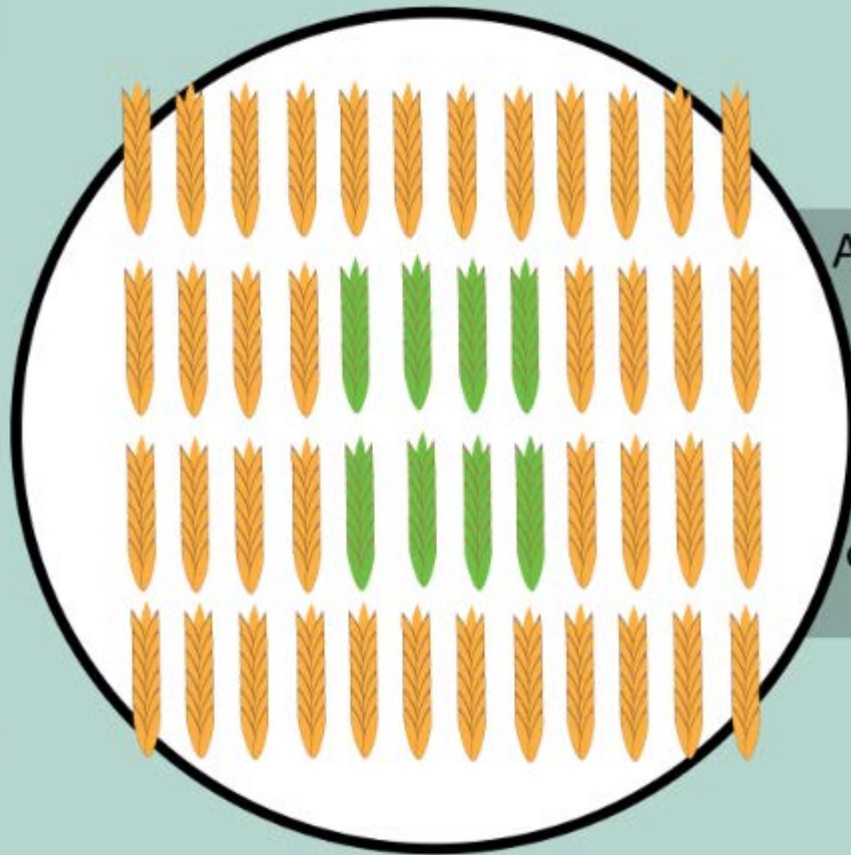
### Right Source

When the soil does not supply enough N, ammonium and nitrate fertilizers are sources of plant available N. N fixing pulses can also be rotated. Urease and nitrification inhibitors can reduce losses of these fertilizers to the atmosphere, ground water, and streams.



Other factors can improve fertilizer recovery, such as organic matter management, crop rotation, and management history.

An estimated 30-50% of applied nitrogen fertilizer is taken up by plants.  
**How can we improve nitrogen use efficiency using 4Rs?**



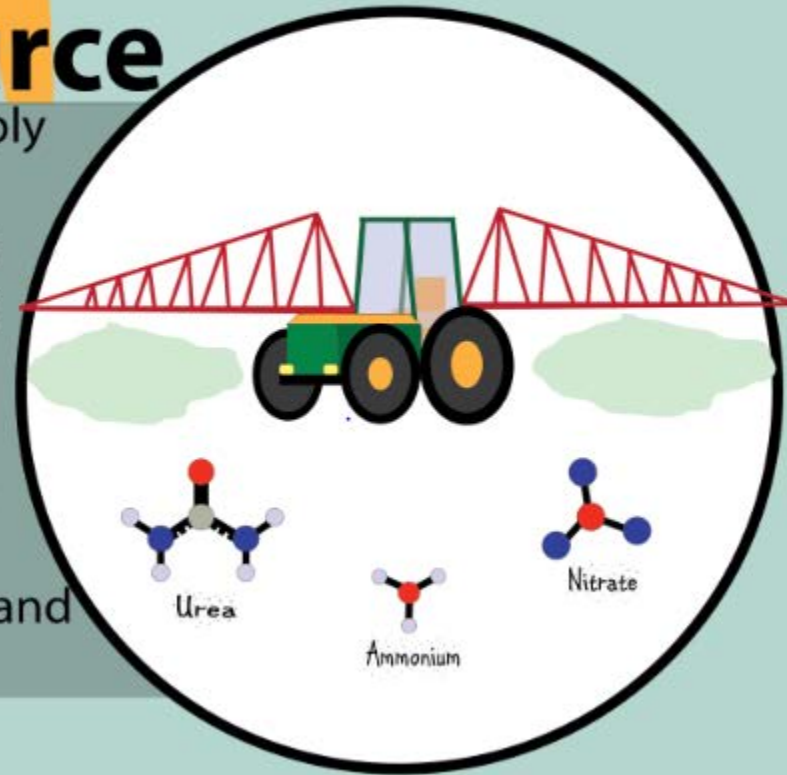
## **R**ight Rate

At economic optimal fertilizer rates, growers maximize profits and balance agronomic and environmental goals. Optimal fertilizer rates vary depending on crop, landscape, soil N, and climate conditions.

# Extension Project: The 4 R's


## Right Source

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# Extension Project: The 4 R's



**R**ight Time

Application of fertilizer at tillering can maximize the uptake of N by wheat. Splitting the application of N fertilizer between spring and fall can increase fertilizer recovery by more than 10% compared to applying all of the fertilizer in the fall to winter wheat.

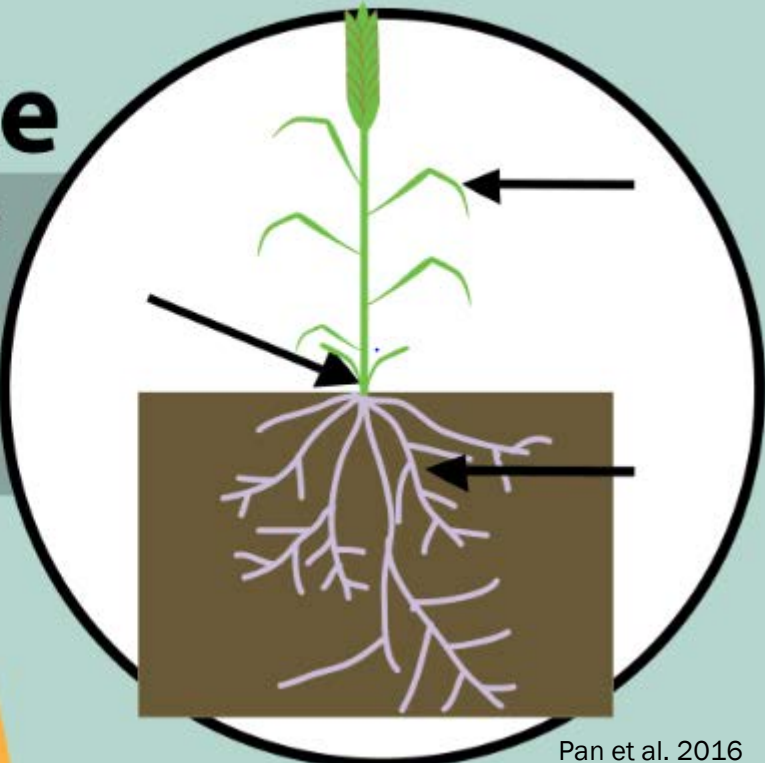
Melaj et al., 2003  
Sowers et al., 1994  
Gardner and Drinkwater, 2009

The diagram shows a series of wheat plants at different growth stages from left to right: seedling, young plant, tillering (marked with a star), jointing, heading, and maturity. The plants are shown with their root systems in a brown soil layer. The background is light blue with a stylized orange sun in the top right corner.

# Extension Project: The 4 R's


**R**ight Place

Banding N below or to the side avoids toxicity to the plant. Toxicity to crops with taproots, such as canola, can prove fatal to the entire plant.



The diagram shows a cross-section of a plant with a prominent taproot system growing in a soil profile. A circular inset highlights the plant's root system. Three black arrows point to different locations: one points to the stem, one points to the soil surface near the base of the stem, and one points to the taproot in the soil. This illustrates the concept of banding nitrogen below or to the side of the plant to avoid toxicity.

Pan et al. 2016

A vast field of golden wheat under a clear blue sky. The wheat is in full bloom, with many heads visible. The field extends to the horizon under a bright, clear blue sky.

Questions?



THANK YOU!

# Acknowledgements

Washington State University, University of Idaho

Pan Lab: Dr. Bill Pan, Dr. Tai Maaz

Sanguinet Lab: Dr. Karen Sanguinet, Thiel Lehman

Ian Clark

Gillian Gavino

*This work was supported by the National Institute of Food and Agriculture (NIFA), USDA  
Award Number:2016-67032-25012*

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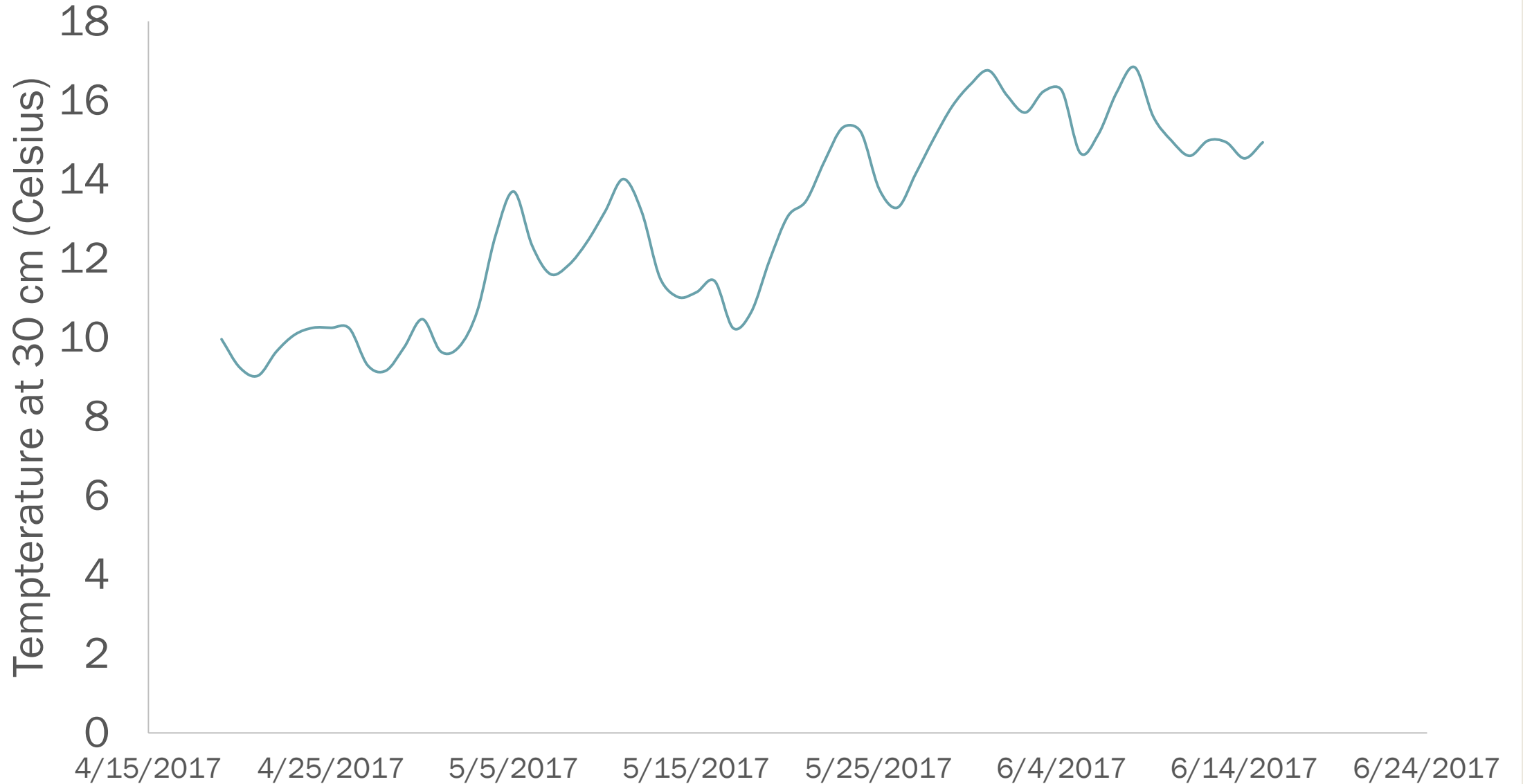
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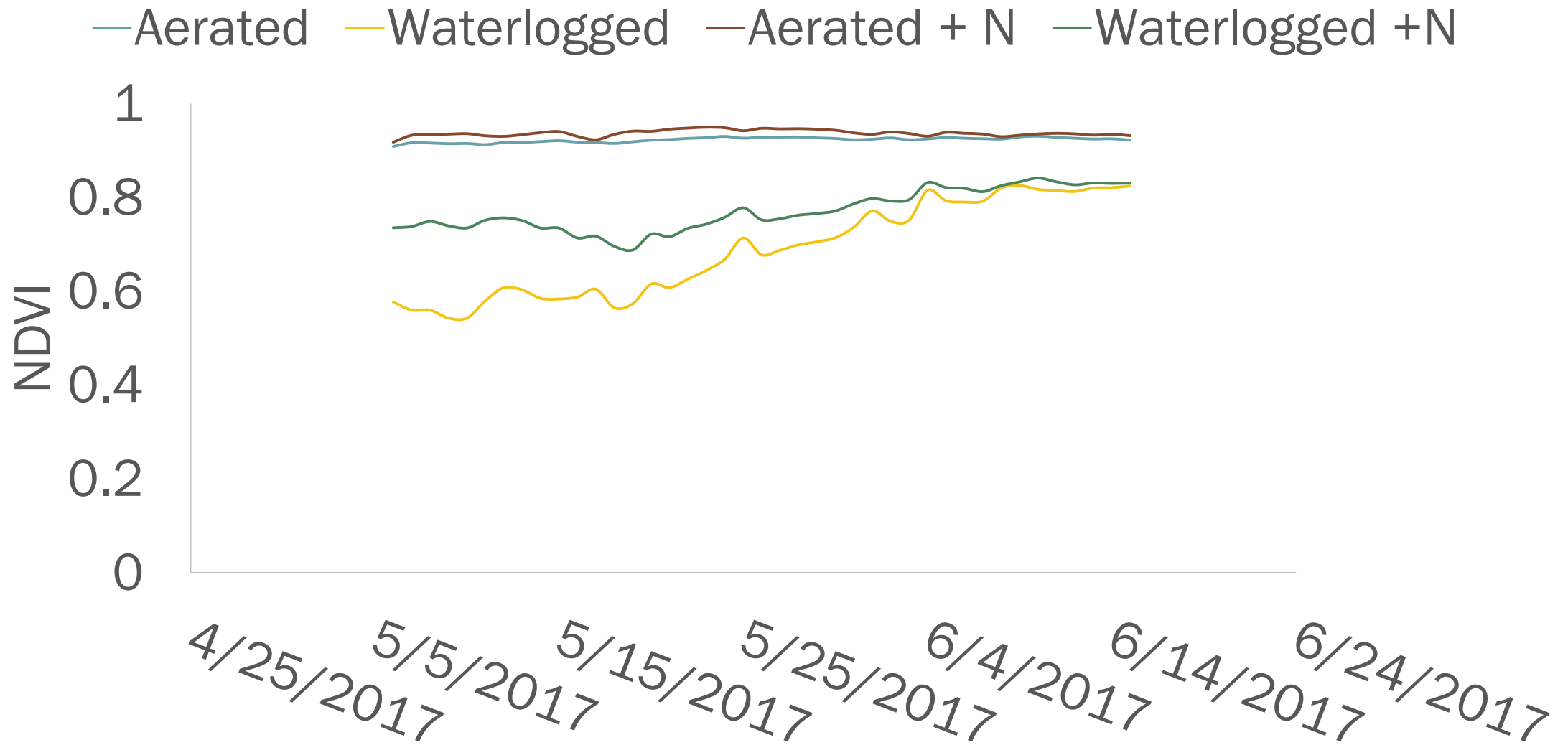
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# Temperature

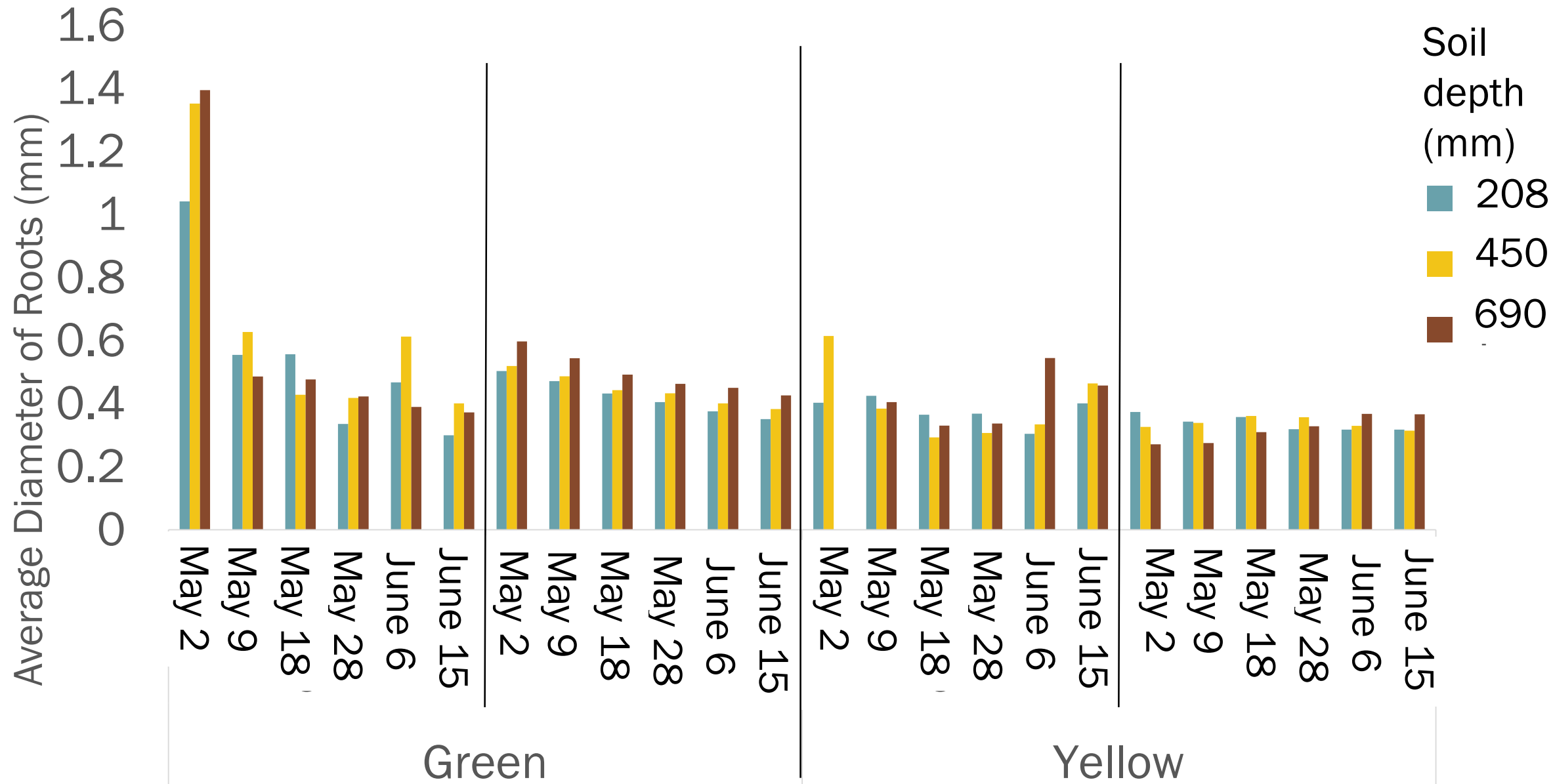


# NDVI





# Average Diameter



# Volumetric Water Content

