Proceedings from the 6th Annual Nutrient Management Conference

Irrigation and nitrogen management for profitable corn production and groundwater quality protection

Vasudha Sharma
Assistant Extension Professor
Irrigation and Water Quality
University of Minnesota Twin Cities
vasudha@umn.edu

SIXTH ANNUAL NITROGEN: MINNESOTA'S GRAND CHALLENGE & COMPELLING OPPORTUNITY CONFERENCE

UNIVERSITY OF MINNESOTA
Driven to Discover®

Outline

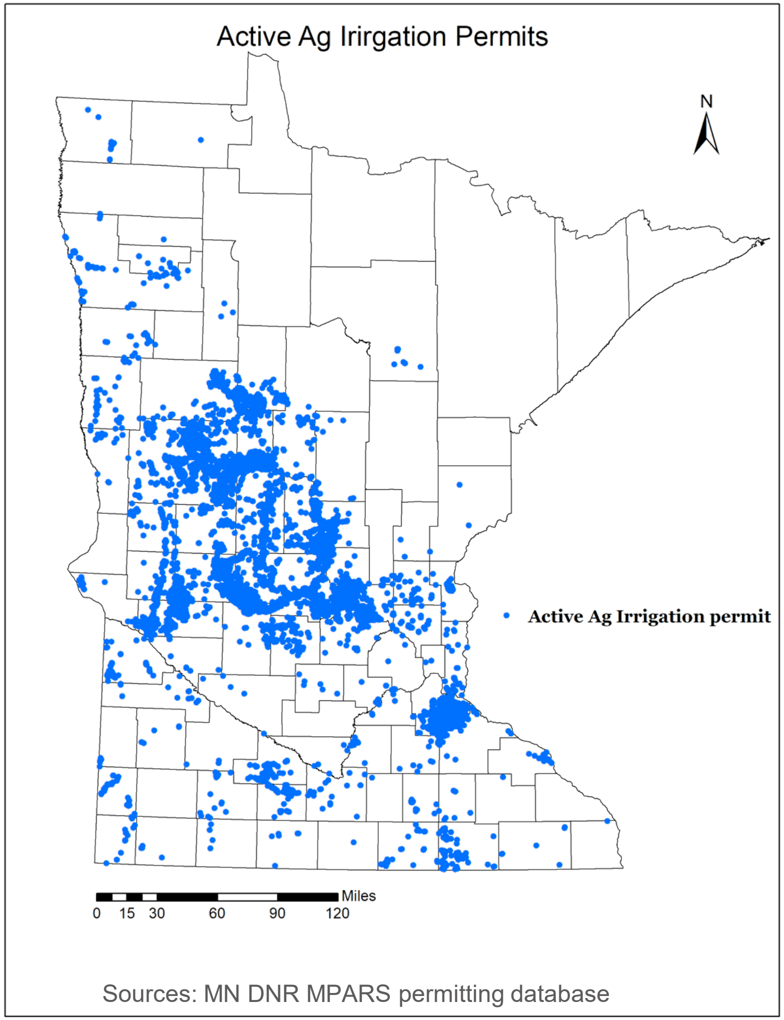
- Importance of irrigation in Minnesota
- Importance of irrigation management
- Irrigation management research projects in Minnesota

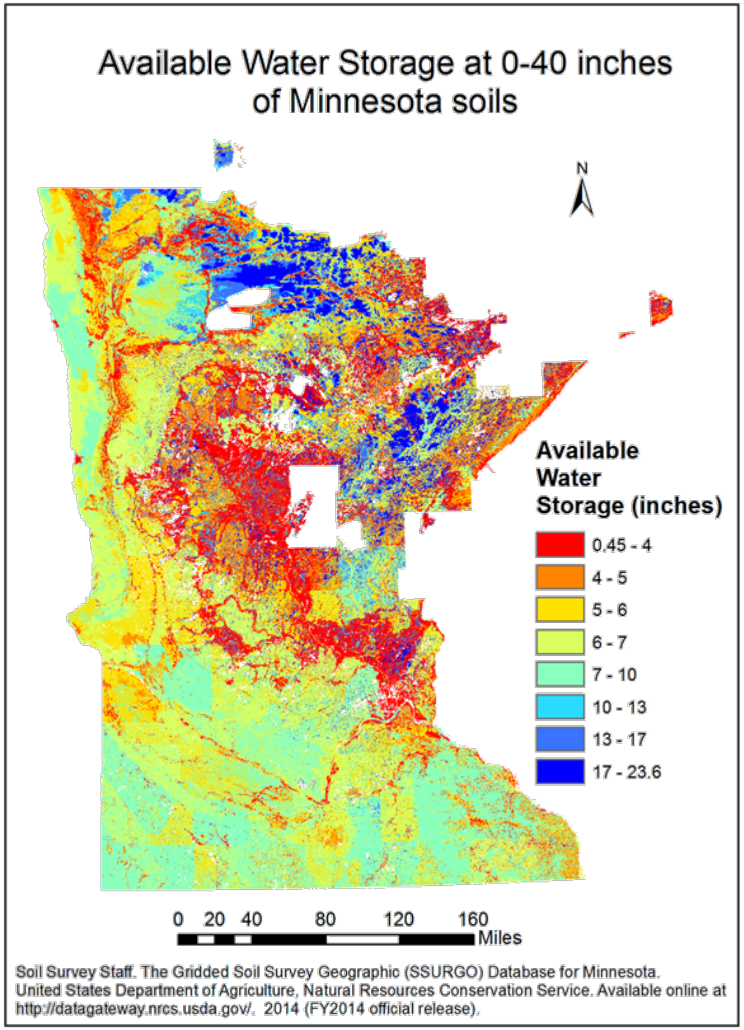
Irrigation- Why is it important?

- Irrigation plays an important role in Minnesota's Ag economy
- Data from 2009-2018 from 9 irrigated counties in Central Sands regions shows that
  - **Irrigated corn was 56% more profitable than non-irrigated corn**
  - **Irrigated soybeans were 75% more profitable than non-irrigated soybeans**
- There are more than 650,000 acres or irrigated land in MN
- 17% increase in Irrigated acreage from 2012-2017 (USDA 2017)

Sources: https://finbin.umn.edu/
https://www.mda.state.mn.us/sites/default/files/2018-016/irrigationforumrpt.pdf

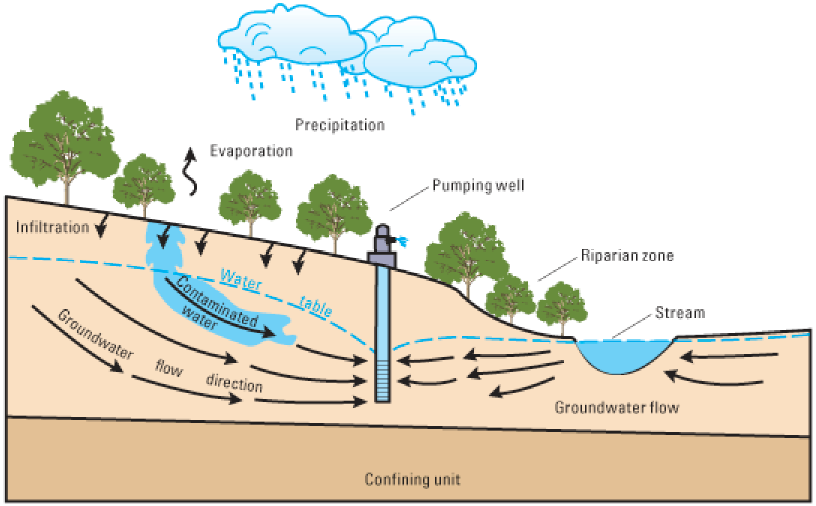
Irrigation- Why is it important?





Irrigation- Why is it important?

- Many streams does not meet water quality standards for aquatic life
- Shallow wells (less than 30 feet deep) have higher nitrate concentrations



https://www.pca.state.mn.us/sites/default/files/wq-am1-10.pdf

What is Irrigation Management?

- Irrigation Water Management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner.
  - *Benefits:*
    - *Manage soil moisture to promote desired crop response Decrease non-point source pollution of surface and groundwater resources*
    - *Optimize the use of available water supplies*
    - *Manage air, soil or plant micro-climate*
    - *Minimize irrigation induced erosion*

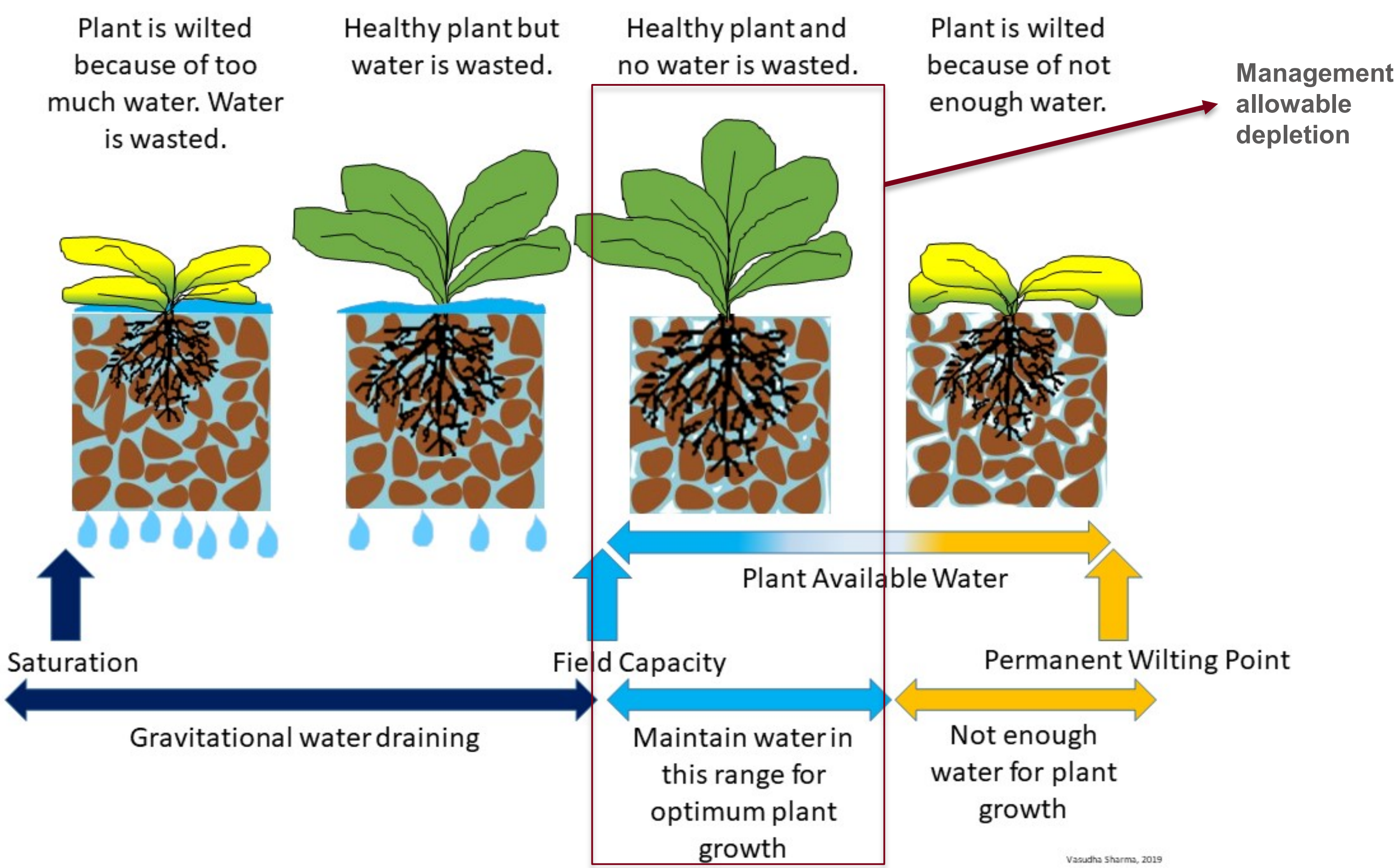
Irrigation management strategies

- Several irrigation management strategies have a potential in reducing nitrate-N losses due to leaching and runoff:
  - Irrigation scheduling
  - Deficit/limited irrigation management
  - Variable rate irrigation

Research questions

- Which irrigation scheduling methods is best in reducing nitrate leaching to groundwater, while maintaining optimum corn yields.
- Will reduction in irrigation rates (using deficit/limited irrigation management) reduce the N fertilizer requirement and nitrate leaching?

Soil water and plant growth



How can we manage irrigation efficiently?

- Irrigation scheduling

When to irrigate?
(Timing)

↓

Turn the system ON

How much water?
(Amount)

↓

Turn the system OFF

Irrigation Scheduling Methods

Simple

- **Visual Observation-** Hand feel or neighbor

- **Measure real-time moisture status-** Soil moisture sensors

- **Estimate soil water deficit in the root zone-** weather data

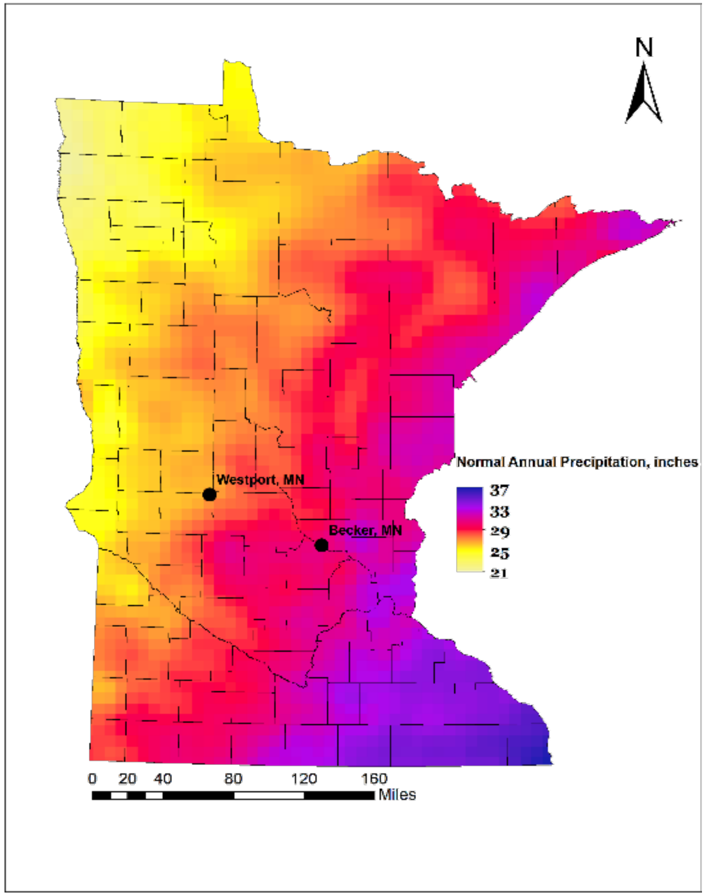
- **Modelling techniques**

Complex

University of Minnesota Extension

Irrigation scheduling methods: Research

- Site: Sand Plain Research Farm, Becker and Rosholt Farm, Westport
- Variable rate irrigation system at both locations allowed irrigating small plots without overlap
- Four irrigation scheduling techniques were evaluated, replicated 3 times in a randomized complete block design

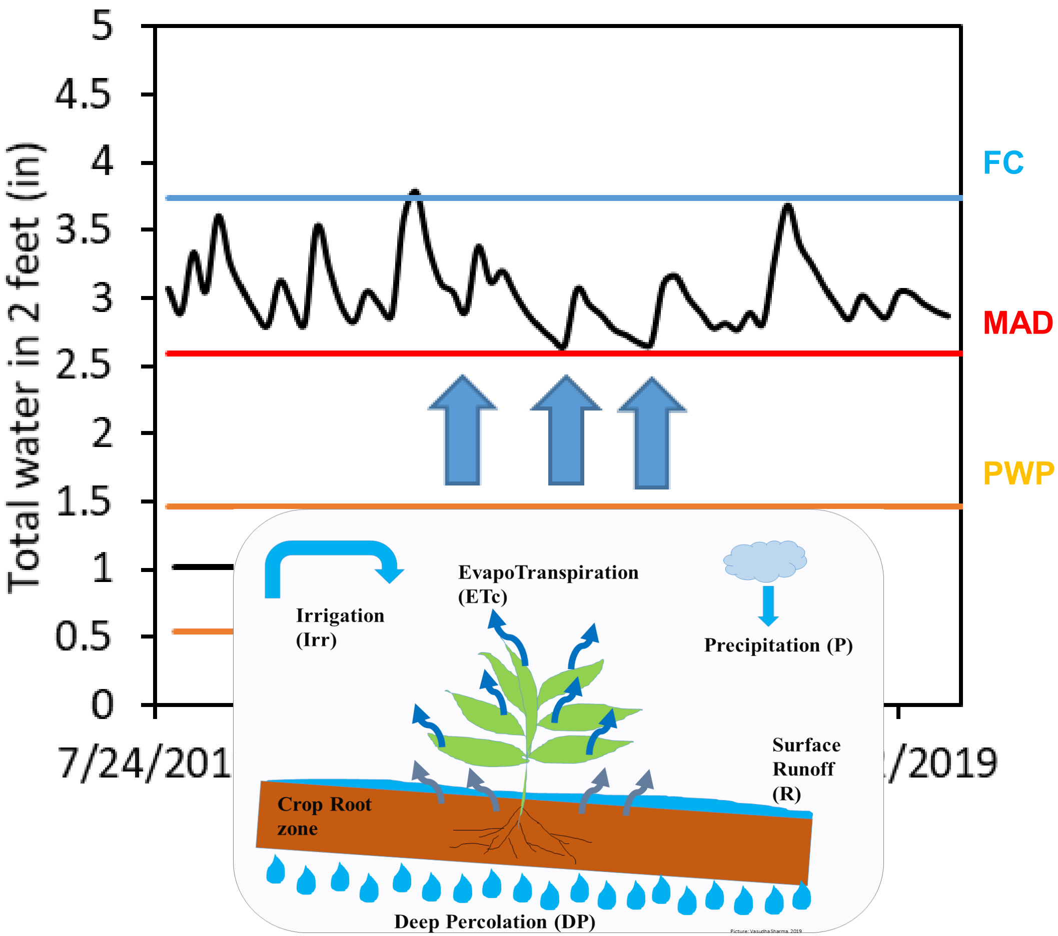


Irrigation scheduling treatments

- Four treatments were:
  - Soil moisture monitoring using soil moisture sensors- Soil based
  - Checkbook Method- weather and soil based
  - Irrigation Management Assistant (IAM): 100% Crop Evapotranspiration (ETa) replacement- weather and soil based
  - Crop Growth Model (EPIC)

Details about each irrigation method is present at https://extension.umn.edu/soil-and-water/irrigation

Irrigation scheduling treatments



1. **Soil moisture monitored** using soil moisture sensors: using neutron gauge moisture meter

2. **Soil moisture estimated** using Checkbook method: using soil water balance Dc= Dp + ETa – P – Irr

3. **Soil moisture estimated** using Irrigation management assistant tool: using soil water balance Dc= Dp + ETa – P – Irr

4. **Soil moisture estimated** using EPIC crop growth model: predict real-time irrigation timing using a threshold irrigation trigger (likely -150 kPa soil moisture potential) based on updated daily weather records.

FC- Field Capacity
MAD- Management Allowable Depletion
PWP- Permanent Wilting Point

Measurements

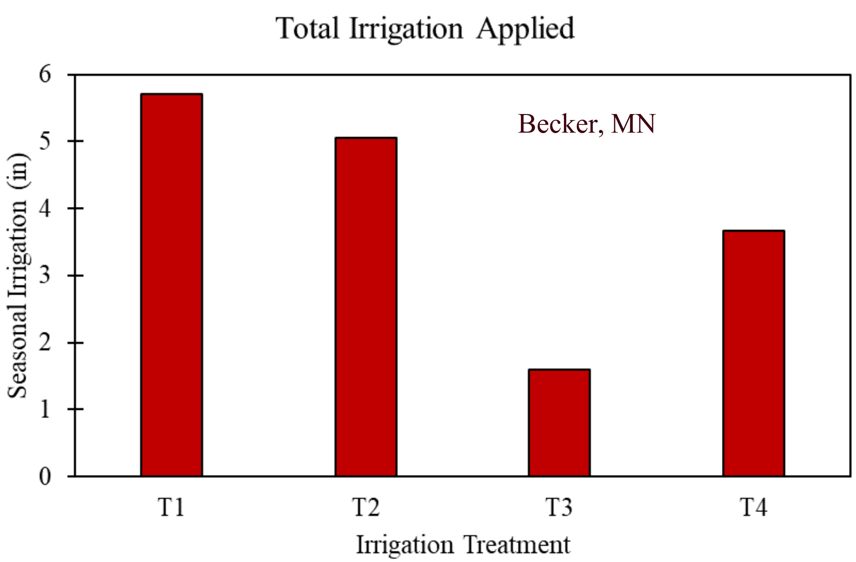
- Soil moisture sensor for moisture monitoring – Neutron probe
- Suction cup lysimeters to measure nitrate in the water that percolates below the root zone
- Weather station for precipitation
- Plant sampling (V8, R1 and R6) and soil sampling after harvest for nitrate for total N

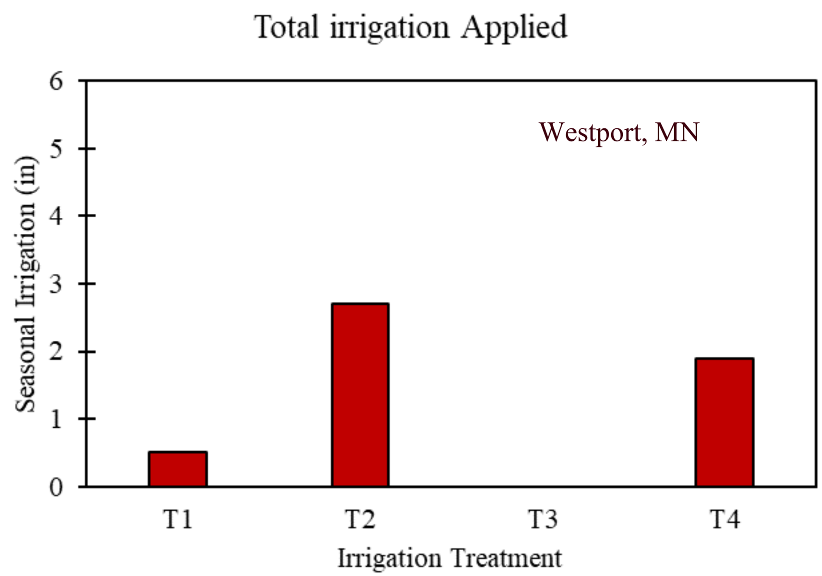
Neutron Probe

Lysimeter

Weather station

Irrigation amounts in 2019

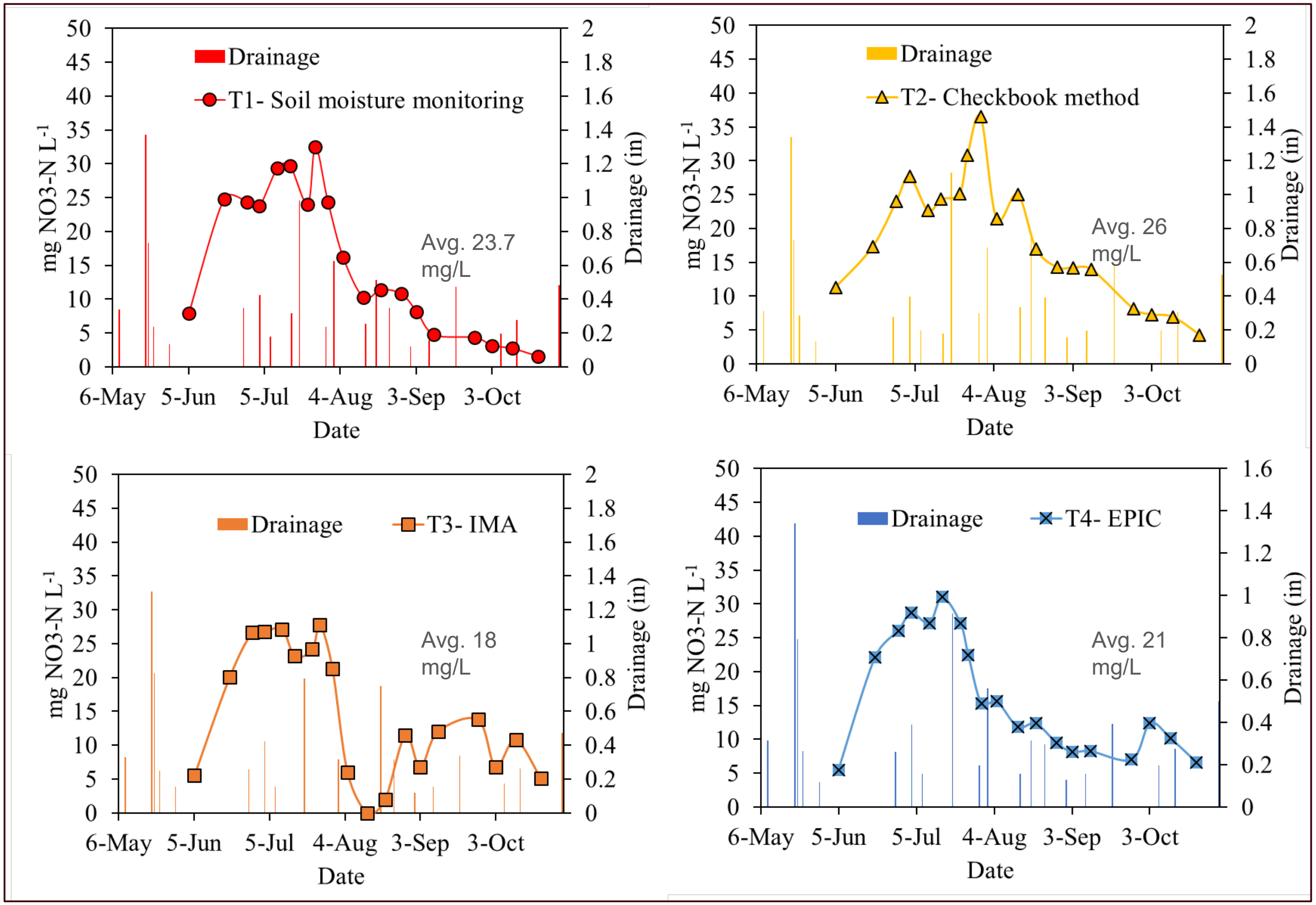




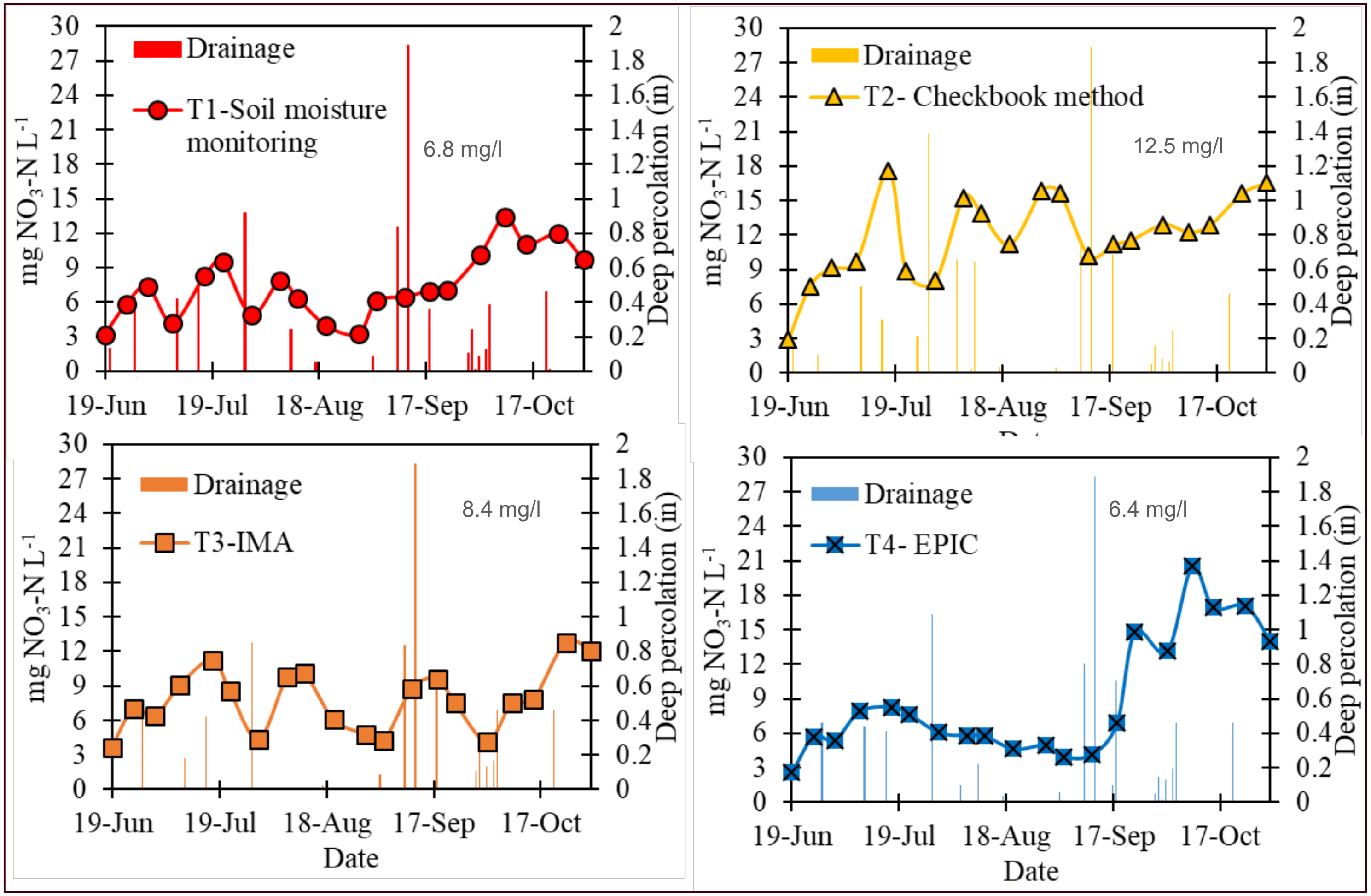
- Total growing season rain = 25 in
- Total growing season rain = 21.2 in

T1- soil moisture monitoring using soil moisture sensors
T2- University of Minnesota checkbook method
T3- Irrigation management assistant tool (IMA)
T4- crop growth model (EPIC)

NO_3-N concentration in water below rooting depth at Becker in 2019

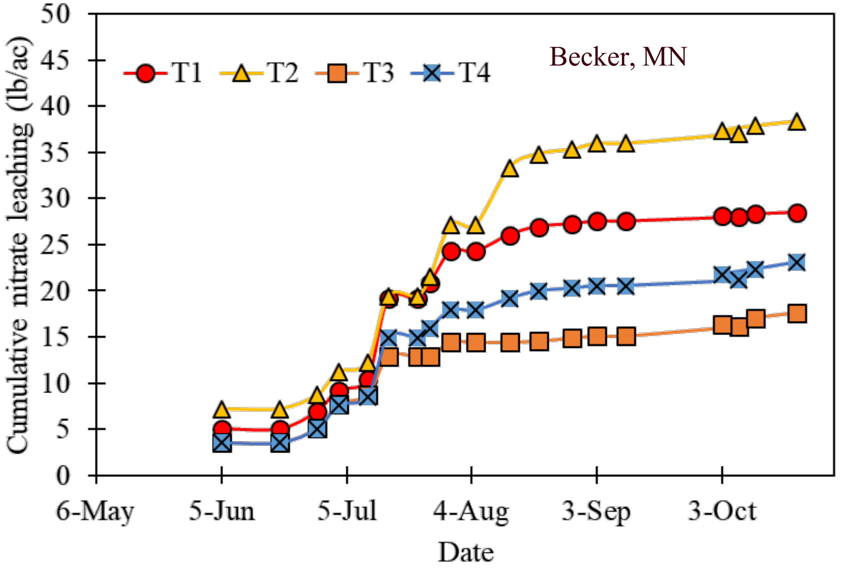


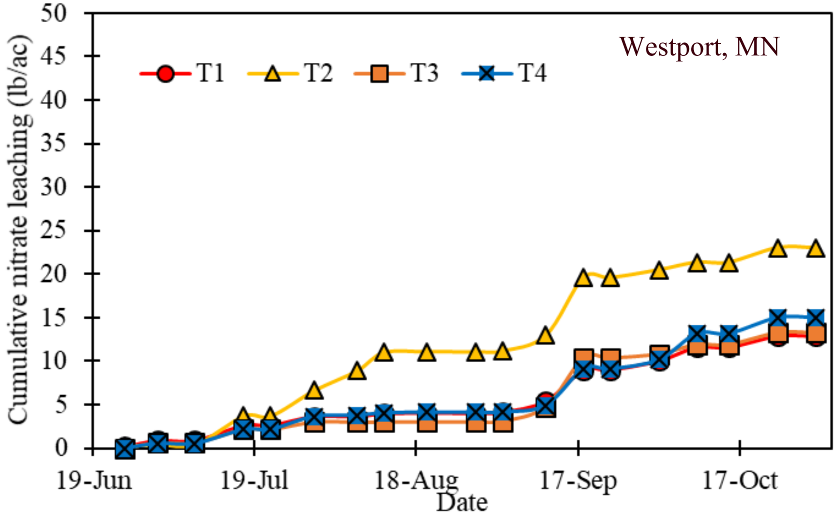
NO_3-N concentration in water below rooting depth at Westport in 2019



Sharma et al. 2019 unpublished data

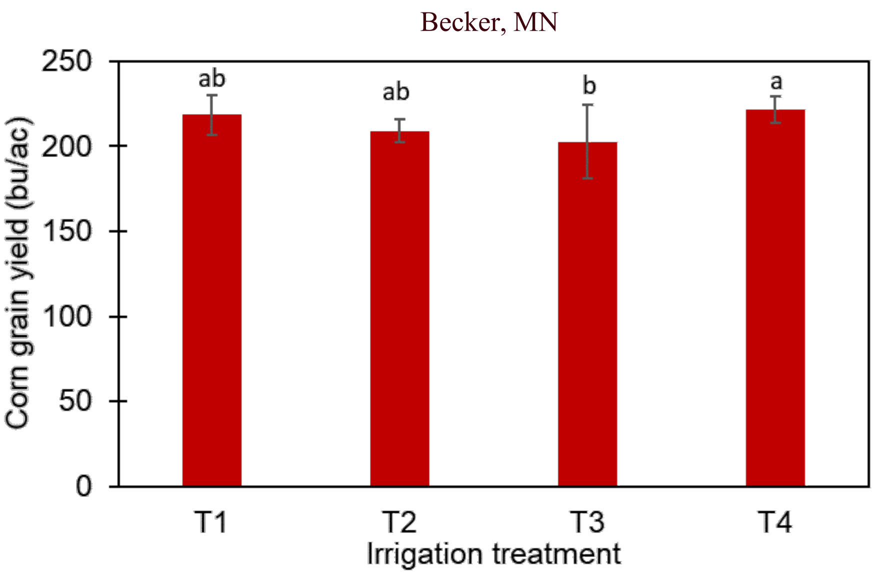
Cumulative NO_3-N leaching (lb/ac) below the root zone in four irrigation treatments

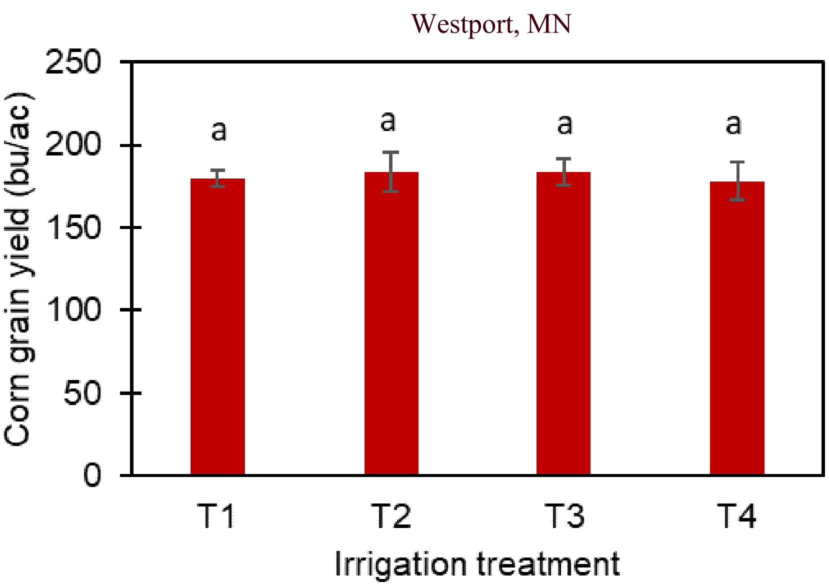




T1- Soil moisture monitoring using soil moisture sensors
T2- University of Minnesota checkbook method
T3- Irrigation management assistant tool (IMA)
T4- Crop growth model (EPIC)

Corn grain yield in different irrigation treatments





T1- Soil moisture monitoring using soil moisture sensors
T2- University of Minnesota checkbook method
T3- Irrigation management assistant tool (IMA)
T4- Crop growth model (EPIC)

Irrigation scheduling methods: Summary

- Irrigation amounts and timing are different under different irrigation scheduling methods.
- NO_3-N concentration was highest in Checkbook method which can be attributed to higher irrigation amounts per irrigation after July 25 in that treatment.
- We observed that plots under IMA irrigation method produced comparable yield, with minimal nitrate leaching losses at both locations
- Also, IMA tool recommended least amount of irrigation in both locations.

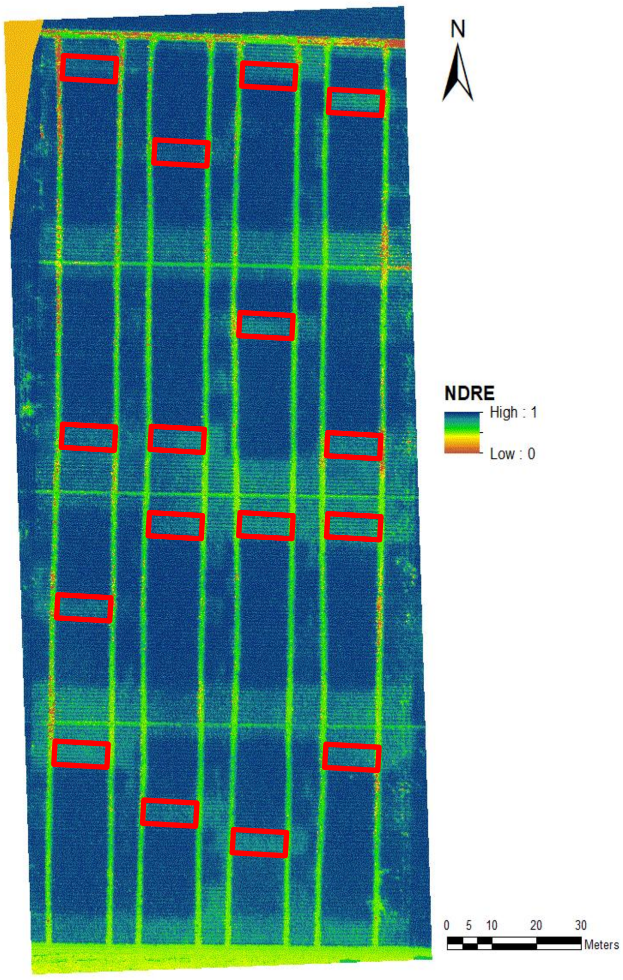
Sharma et al. 2019 unpublished data

How can we manage irrigation efficiently?

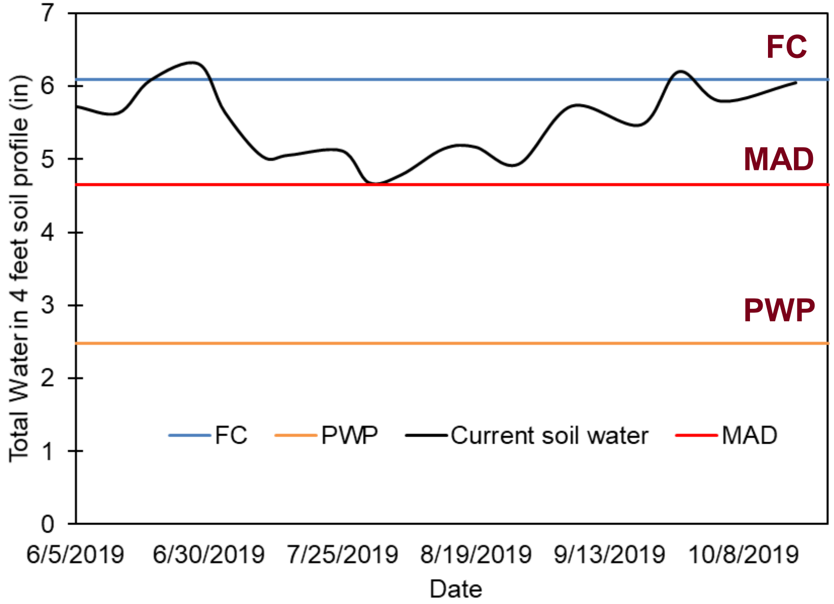
- Using **deficit/limited irrigation management**
- Will reduction in irrigation rates (using deficit/limited irrigation management) reduce the nitrate leaching?

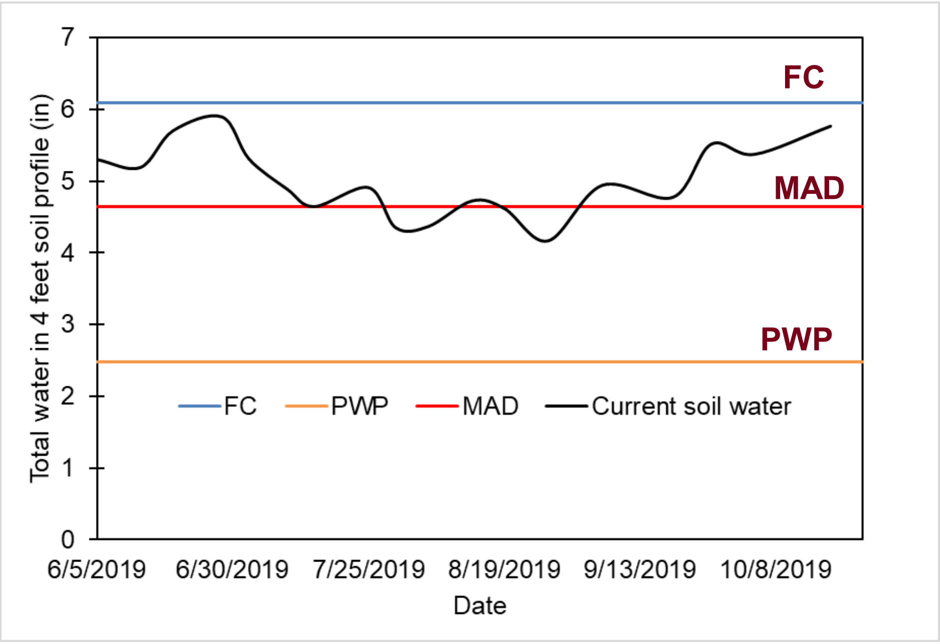
Experimental design

- Irrigation and Nitrogen Research at Becker Sand Plain Research Farm
- Main plots (4) are irrigation levels: 100%, 75%, 50% irrigation and rainfed
- Subplots (6) are nitrogen rates: 0, 70 140, 210, 280 and 350 lb/ac N
- Four replications : 96 plots



What is 100% Irrigation in our research?

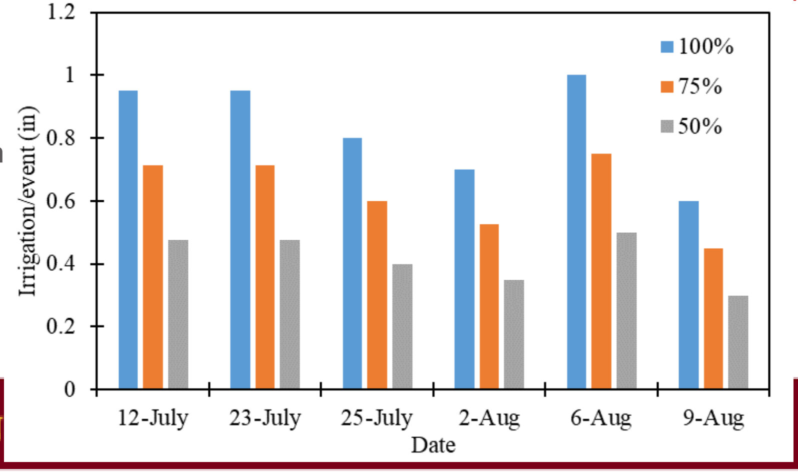




100% Irrigation

75% Irrigation

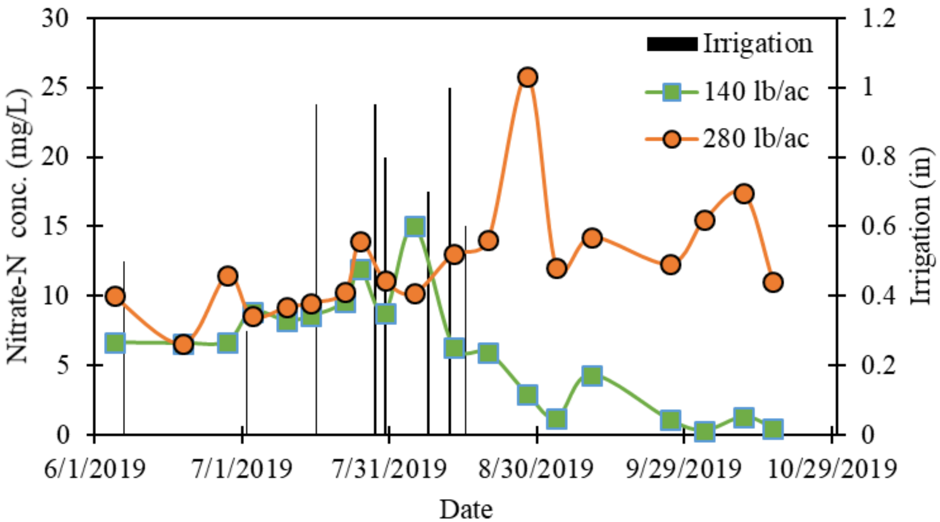
FC- Field Capacity
MAD- Management Allowable Depletion
PWP- Permanent Wilting Point



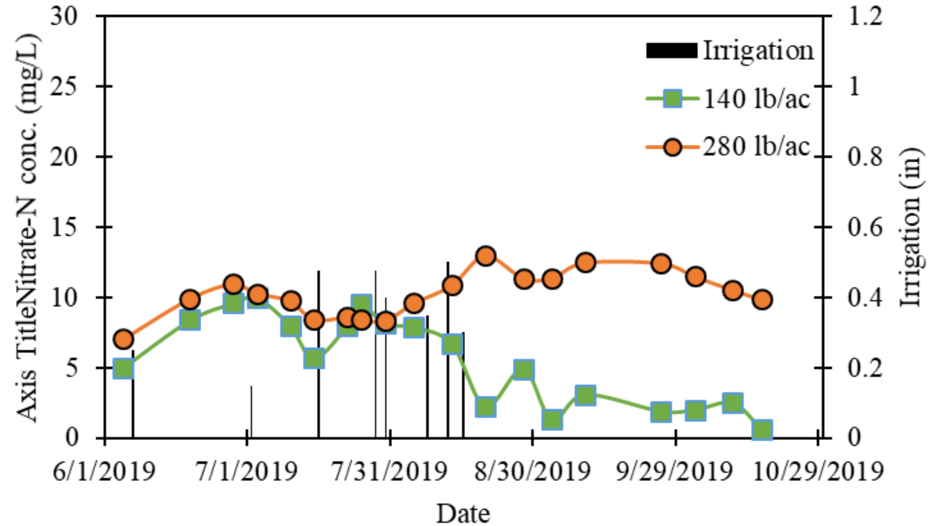
Sharma et al. 2019 unpublished data

Nitrate-N concentration under 100% and 50% Irrigation

100% irrigation



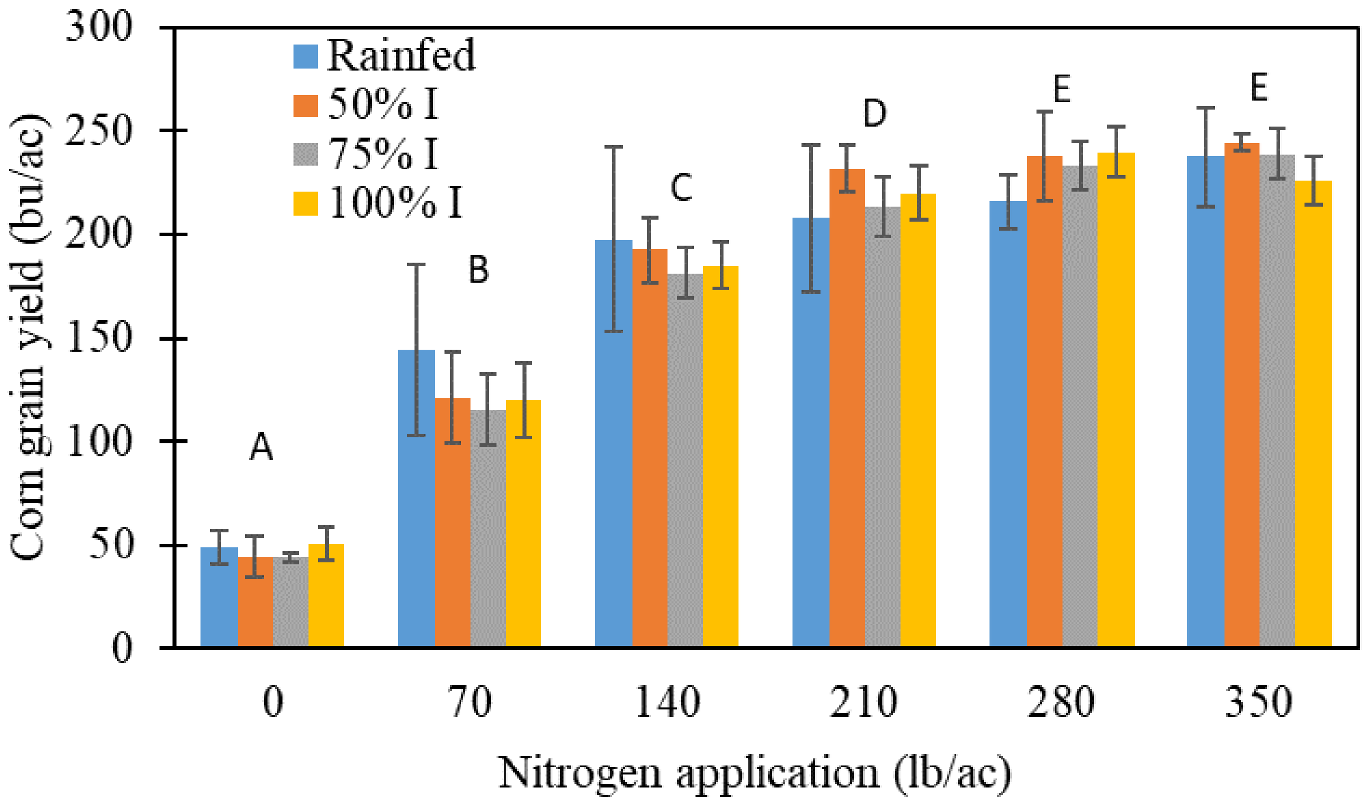
50% irrigation



	Irrigation	
N rate	50%	100%
	Nitrate-N conc. (mg/L)	
140 lb/ac	7.7	9.8
280 lb/ac	9.1	11.04

Sharma et al. 2019 unpublished data

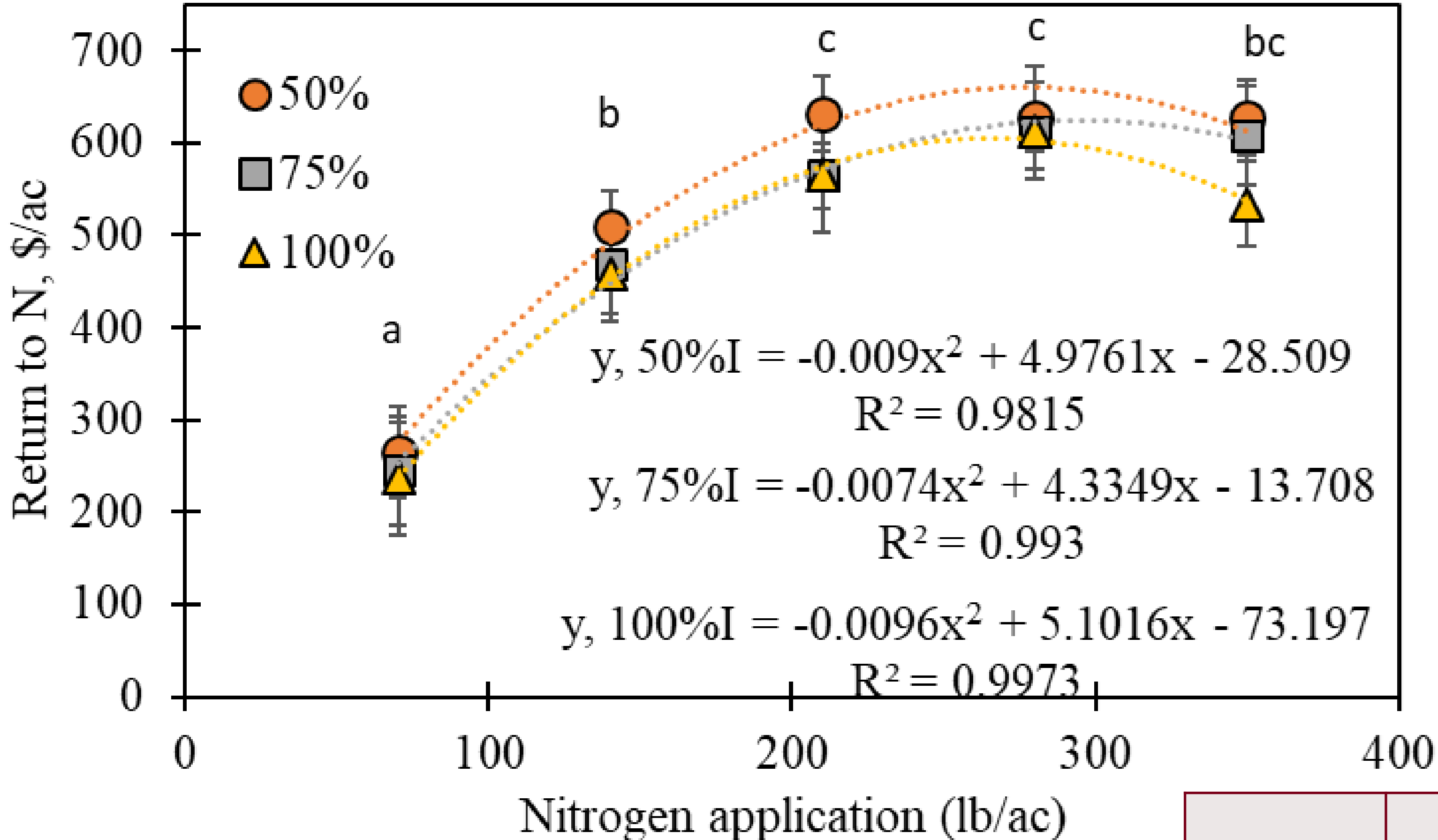
Effects of irrigation and nitrogen rates on corn yield in 2019



- Reducing irrigation did not reduce corn grain yield.

Sharma et al. 2019 unpublished data

Effects of irrigation and nitrogen rates on Return to N in 2019



N($/lb)	Corn ($/bu)
0.38	3.8

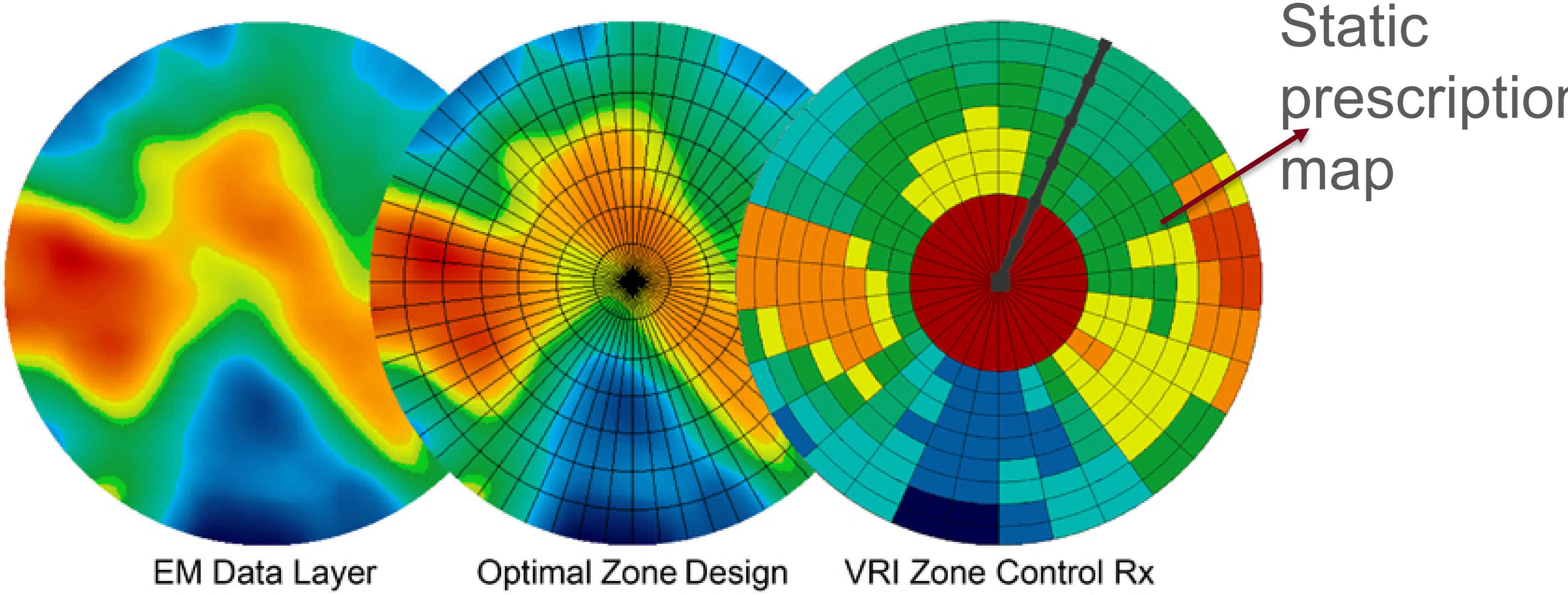
Deficit/Limited Irrigation Research : Summary

- Crop yield between Irrigation treatments was not significantly different.
- Maximum Return to Nitrogen ($/ac) was obtained under 50% irrigation treatment between 210 lb/ac to 250 lb/ac.
- 2019 data shows that 50% irrigation could be superior to full irrigation (100%) in wet years like 2019.

Sharma et al. 2019 unpublished data

Variable Rate Irrigation

- Variable rate irrigation (VRI) is an emerging technology that may have some merit in Minnesota.
- Variable rate technologies = proper amount of water and fertilizer to specific locations in the field



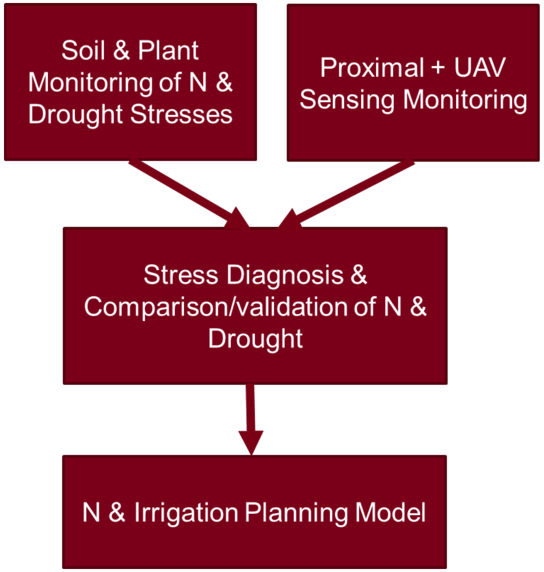
Source: http://www.thecropsite.com/articles/796/irrigation-meets-innovation/

Dynamic prescription maps

- The irrigation requirements based on spatiotemporal variability of the field
- Researches have used an array of soil moisture sensors or canopy temperature sensors to capture the field variability
- The irrigation decision accuracy depends on the number of sensors in the large-scale planting area
- Large-scale deployment of these sensors is not economical

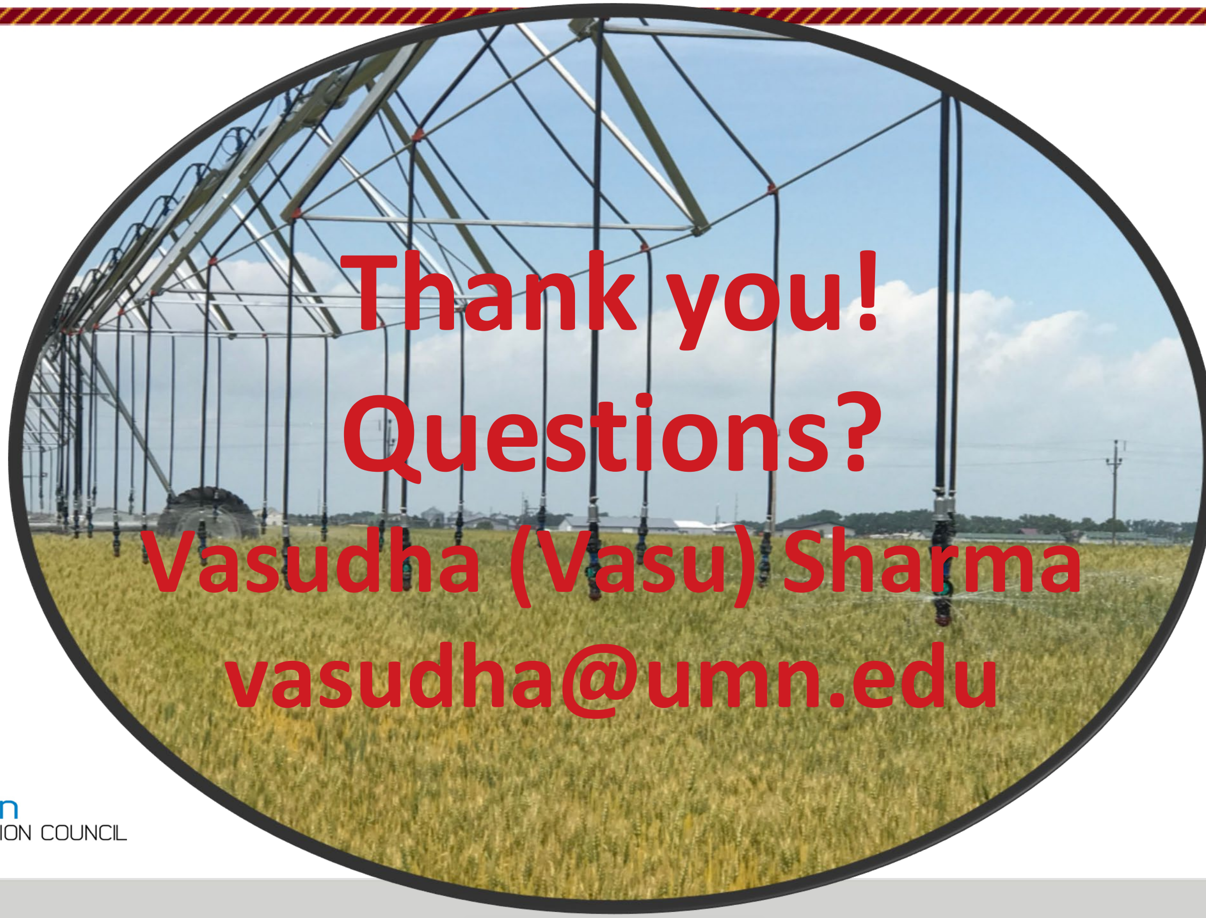
Variable rate irrigation and nitrogen research

- Our research aimed at using Unmanned aerial vehicle (UAV) to monitor variables like NDVI, NDRE, LAI, canopy chlorophyll content estimation, incident and canopy reflected PAR, canopy and air temperature, relative humidity and atmospheric pressure.
- In-season variable rate N and irrigation (drought stress) Diagnosis & Management Algorithm Development



Take home message

- Irrigation management is very critical in MN especially in central sands region
- Efficient irrigation scheduling is maintaining soil water between field capacity and management allowable depletion
- IMA and EPIC irrigation scheduling methods worked best in terms of reducing nitrate leaching and producing optimum corn grain yield
- Deficit irrigation management (50% irrigation) helped in reducing N-leaching while maintaining optimum corn grain yields and maximum return to nitrogen



Thank you!
Questions?

Vasudha (Vasu) Sharma
vasudha@umn.edu

MinnesotaCorn
RESEARCH & PROMOTION COUNCIL

mn DEPARTMENT OF AGRICULTURE