Achieving efficient N fertilizer management in Sacramento Valley wheat

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Outline

- Overview of spring wheat production in California with emphasis on Sacramento Valley conditions
- How can we construct a N budget for wheat?
- How does management influence crop N requirements?
- How can site-specific, real-time measurements assist in determining crop N needs?

Background: Spring wheat production in California

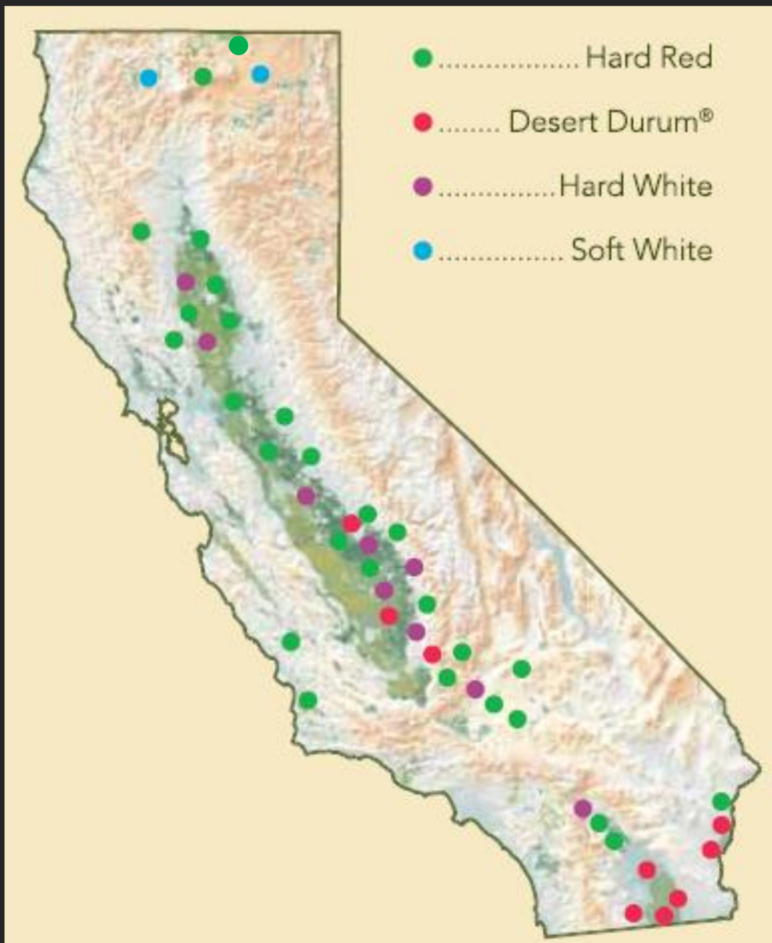


Image courtesy: California Wheat Commission

- Acreage :
  ≈ 400,000 - 700,000 ac yr^{-1}
  mostly hard red/white;
- 40-60% grown for grain
- Yields ≈ 5000-6000 lb ac^{-1}
- Grain growers receive payment for quantity ± quality
- Protein (quality) varies by region ≈ 11-14%

Nitrogen-related management in CA spring wheat

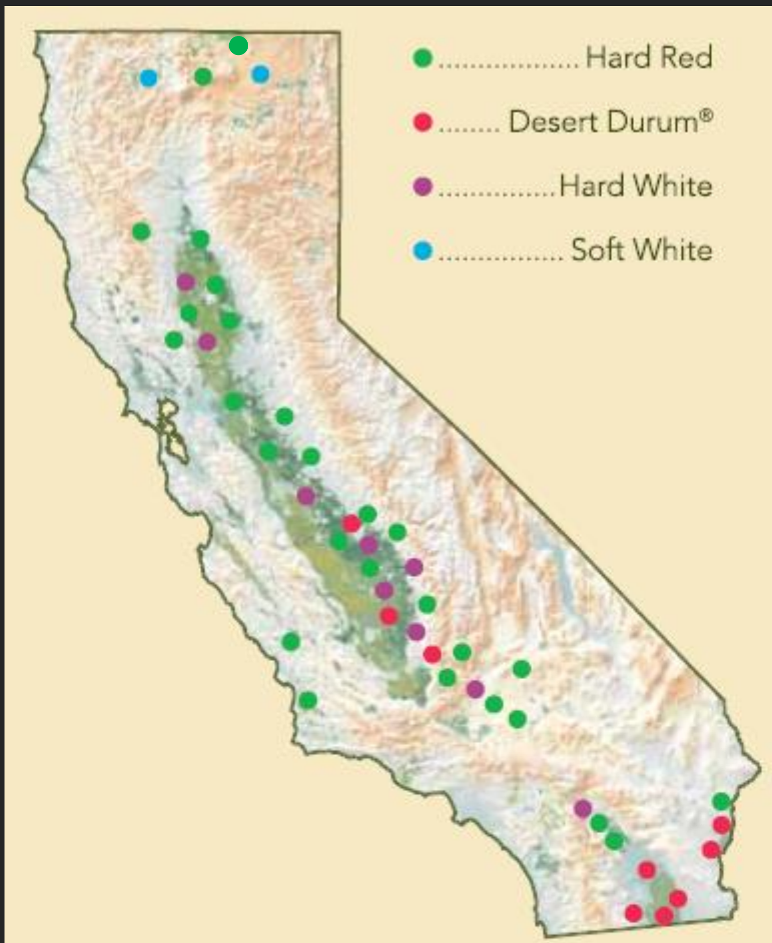
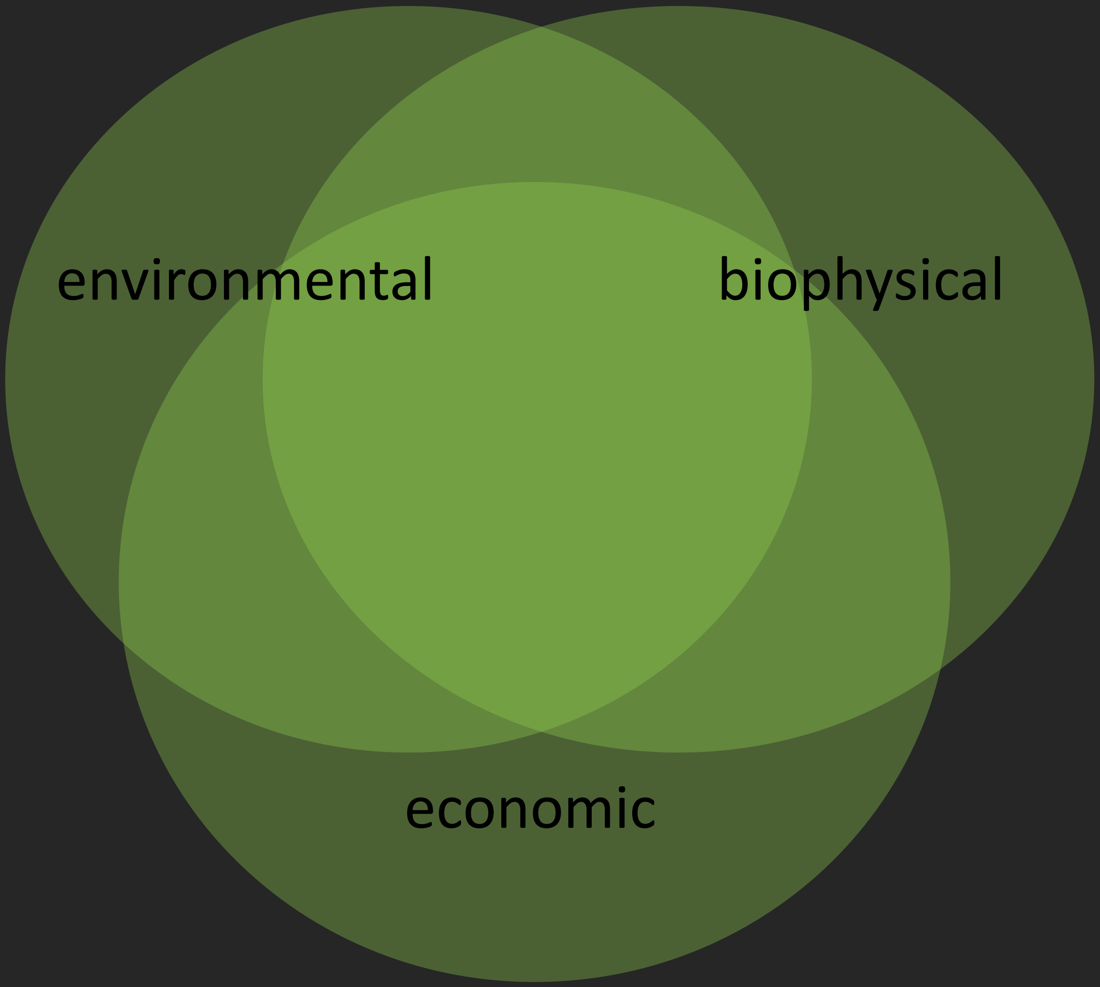


Image courtesy: California Wheat Commission

- Irrigation varies by region:
  - More opportunistic in the Sacramento Valley
  - More standard in the southern part of the state and Intermountain area
- Many growers in the Sacramento Valley split N applications between sowing and tillering-stem elongation
  - Total rates: 100 – 225 lb acre^{-1}

Why should we care about site-specific N management in wheat?



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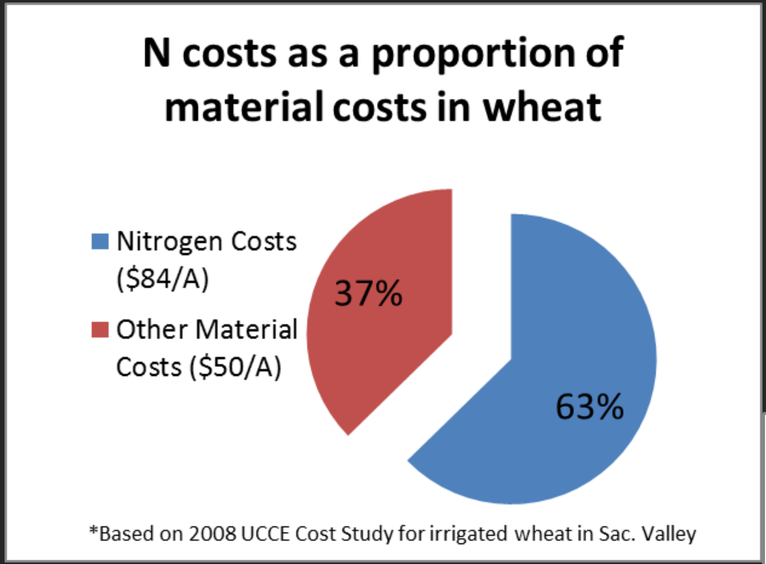
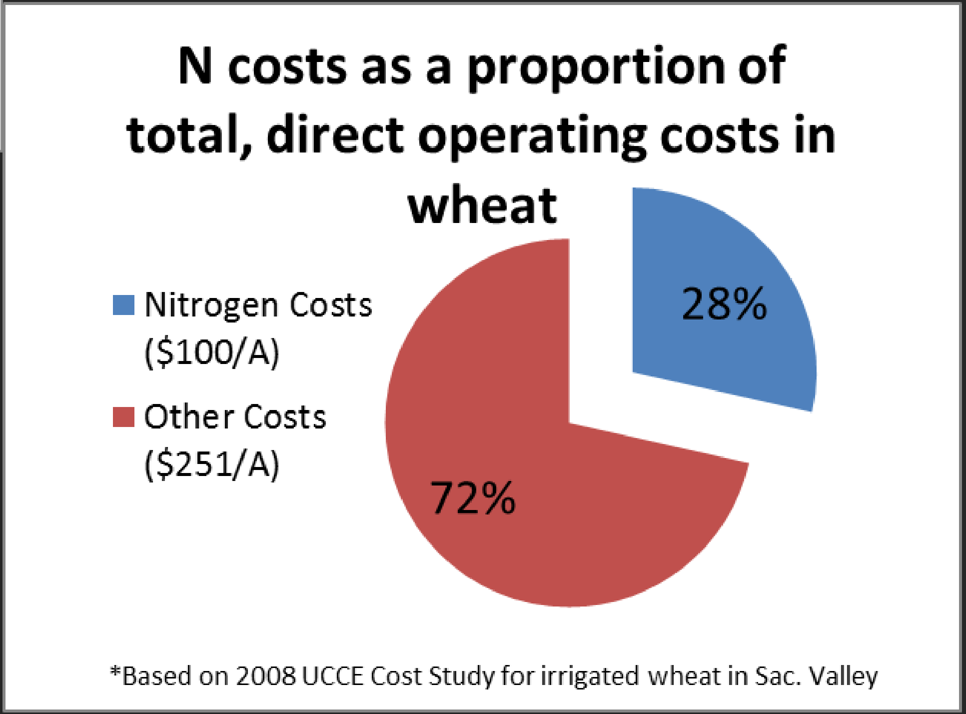




N applied at the Right Rate & Right Time:

- Improves fertilizer use efficiency
- Increases the value of the crop

Why should we care about site-specific N management in wheat?

- N management plan implementation

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____________

1. Crop Year (Harvested): ________	4. APN(s):	5. Field(s) ID	Acres
2. Member ID# ________			
3. Name:			

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop		**17. Nitrogen Fertilizers**		
7. Production Unit		18. Dry/Liquid N (lbs/ac)		
8. Projected Yield (Units/Acre)		19. Foliar N (lbs/ac)		
9. N Recommended (lbs/ac)		**20. Organic Material N**		
10. Acres		21. Available N in Manure/Compost (lbs/ac estimate)		
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)		
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)		
14. Notes:		25. N in Irrigation water (annualized, lbs/ac)		
		26. Total N Credits (lbs per acre)		
		27. Total N Applied & Available		

Wheat response to N fertilizer addition at various growth stages is generally well-understood

Fertilizer N effects on yield and protein at various growth stages

YIELD: ↑ number of tillers and kernels per head | ↑ kernel weight

PROTEIN: ↑ biomass N for remobilization during grain fill | ↑ remobilization rate, direct

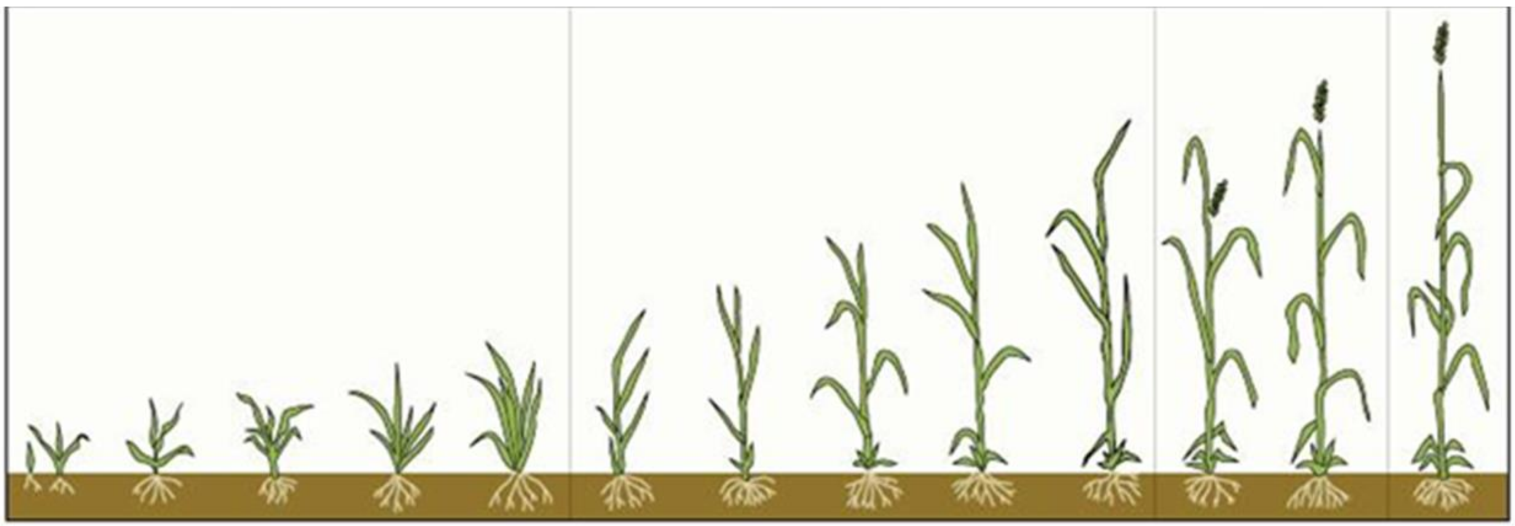
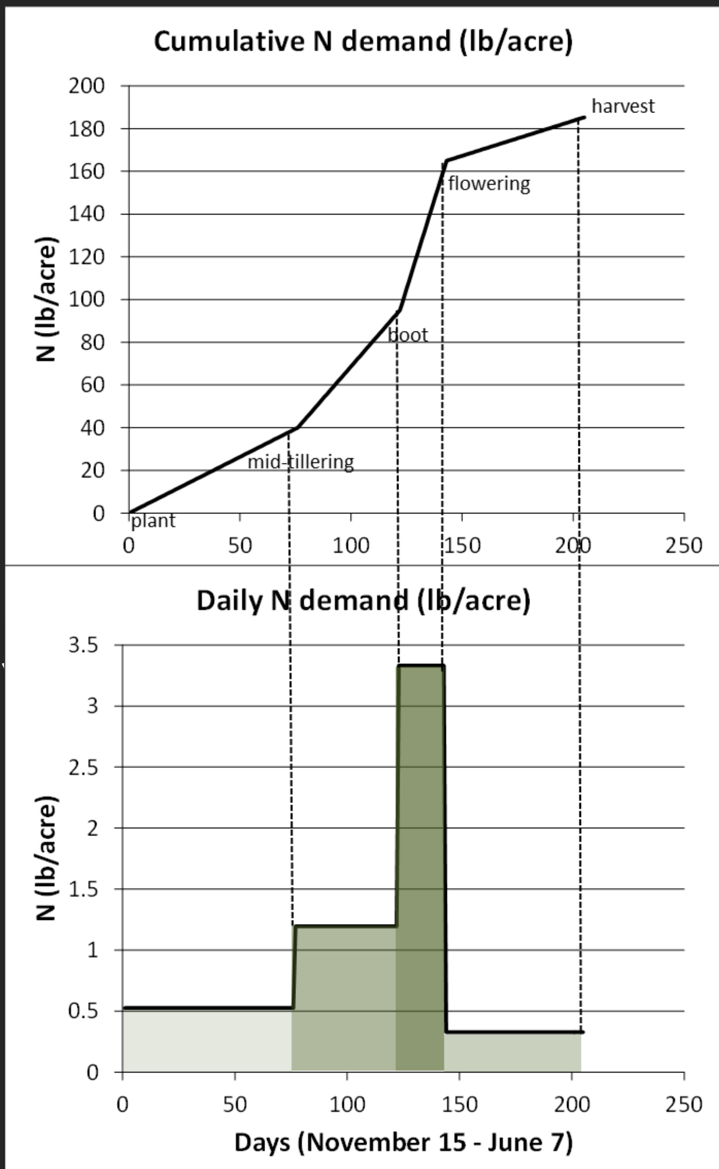


Image courtesy: U. Kentucky

Growth Stage

Early Leaf | Tillering | Stem Elongation (jointing to boot) | Heading to Maturation

Constructing a N budget for wheat



- Crop N demand varies according to the protein yield potential of the crop

  [WHAT IS A REASONABLE YIELD EXPECTATION?]. ↓

  Water is more limiting than N [IRRIGATION?].

- Crop N demand varies across the growing season [TIMING MATTERS].

- [SOIL] supplies a large portion of N to the crop.

Constructing a N budget for wheat: methods

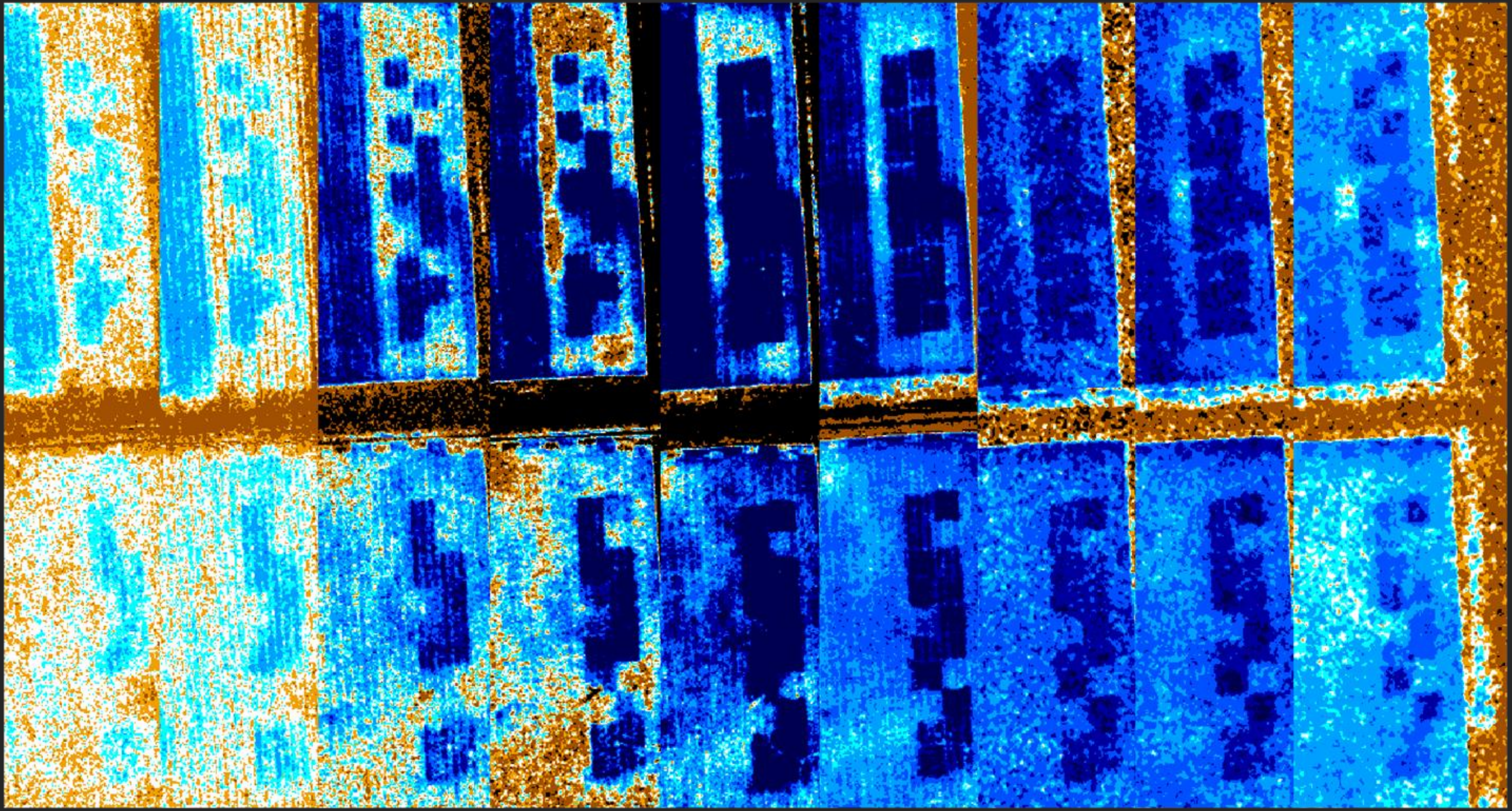


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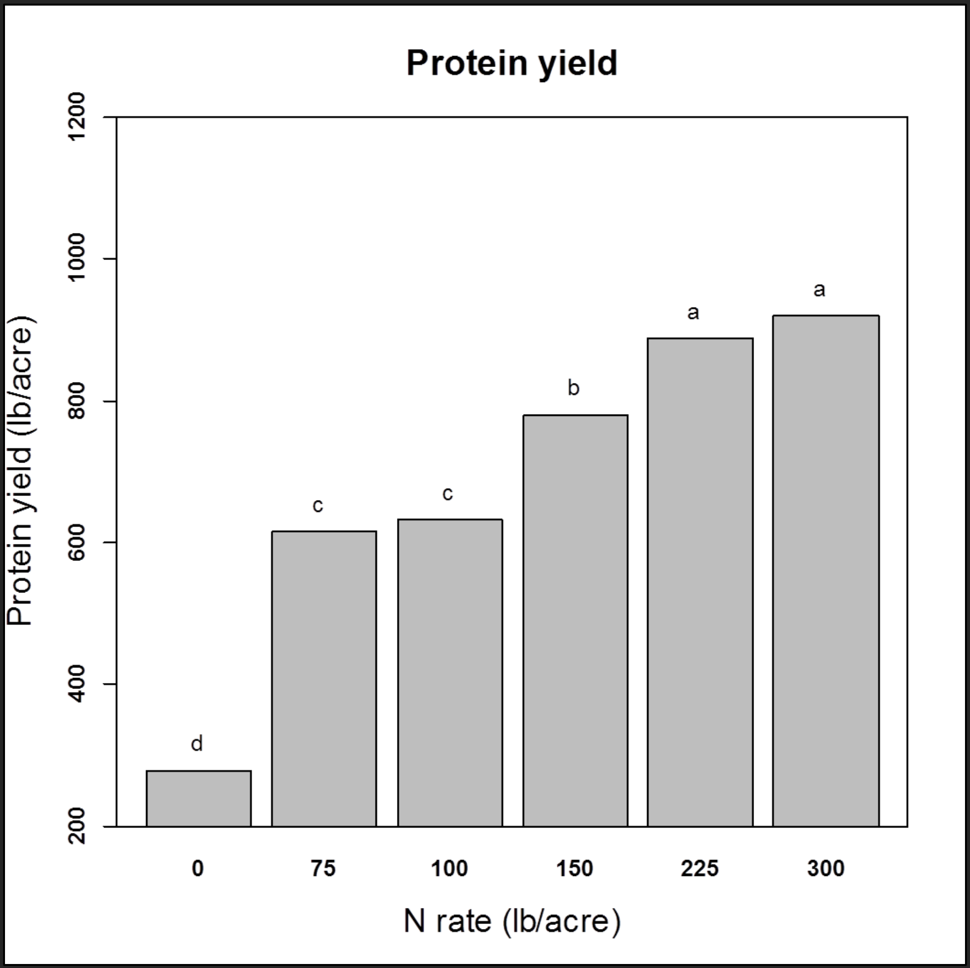
Image courtesy: TerrAvion

Right Rate? Irrigated wheat Sacramento Valley



7500 lb acre^{-1}; 12% protein

- Apparent N demand:
  900 lb ac^{-1} – 300 lb ac^{-1} = 600 lb ac^{-1}
  600 lb ac^{-1} / 5.7 = 105 lb ac^{-1}
  105 lb ac^{-1} / 0.5 (apparent N recover in grain ≈ 63% overall NUE) = 210 lb ac^{-1}

  2.6 lb N / 100 lb grain

- Apparent N demand:
  900 lb ac^{-1} – 300 lb ac^{-1} = 600 lb ac^{-1}
  600 lb ac^{-1} / 5.7 = 105 lb ac^{-1}
  105 lb ac^{-1} / 0.4 (apparent N recovery in grain ≈ 50% overall NUE) = 263 lb ac^{-1}

  3.7 lb N / 100 lb grain

Right Rate? Supplementally irrigated wheat Sacramento Valley

5500 lb acre^{-1}; 11% protein

- protein yield = 605 lb ac^{-1}

2500 lb acre^{-1}; 8% protein

- protein yield = 200 lb ac^{-1}

- Apparent N demand:
  605 lb ac^{-1} – 200 lb ac^{-1} = 405 lb ac^{-1}
  405 lb ac^{-1} / 5.7 = 71 lb ac^{-1}
  71 lb ac^{-1} / 0.5 = 142 lb ac^{-1}

  2.6 lb N / 100 lb grain

- Apparent N demand:
  605 lb ac^{-1} – 200 lb ac^{-1} = 405 lb ac^{-1}
  405 lb ac^{-1} / 5.7 = 71 lb ac^{-1}
  71 lb ac^{-1} / 0.4 = 178 lb ac^{-1}

  3.2 lb N / 100 lb grain

Right Rate? Rainfed wheat
Sacramento Valley

4000 lb $acre^{-1}$; 12.5% protein

- protein yield = 500 lb ac^{-1}

2500 lb $acre^{-1}$; 8% protein

- protein yield = 200 lb ac^{-1}

Range of N demand:

106 – 263 lb ac^{-1}

- Depends on:

  Water availability

  Fertilizer Use Efficiency

- Apparent N demand:

  500 lb ac^{-1} – 200 lb ac^{-1} = 300 lb ac^{-1}

  300 lb ac^{-1} / 5.7 = 53 lb ac^{-1}

  53 lb ac^{-1} / 0.5 = 106 lb ac^{-1}

  2.6 lb N / 100 lb grain

- Apparent N demand:

  500 lb ac^{-1} – 200 lb ac^{-1} = 300 lb ac^{-1}

  300 lb ac^{-1} / 5.7 = 53 lb ac^{-1}

  53 lb ac^{-1} / 0.4 = 133 lb ac^{-1}

  3.4 lb N / 100 lb grain

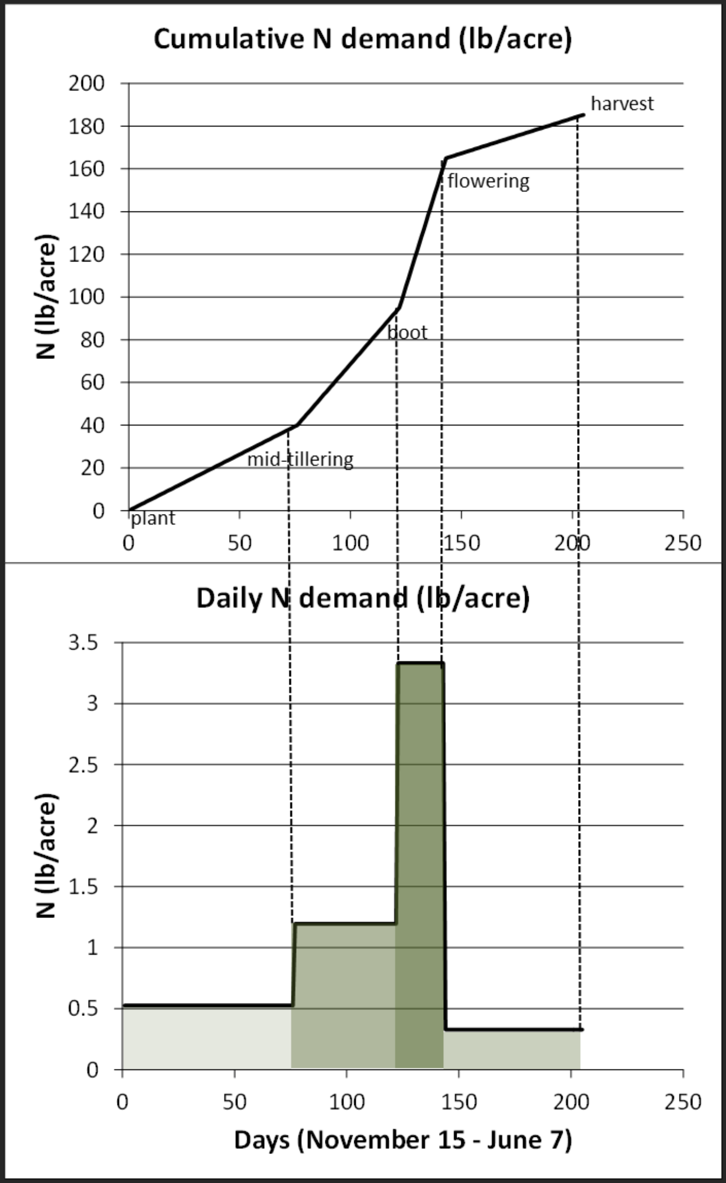
Right Time?

A. Preplant N only

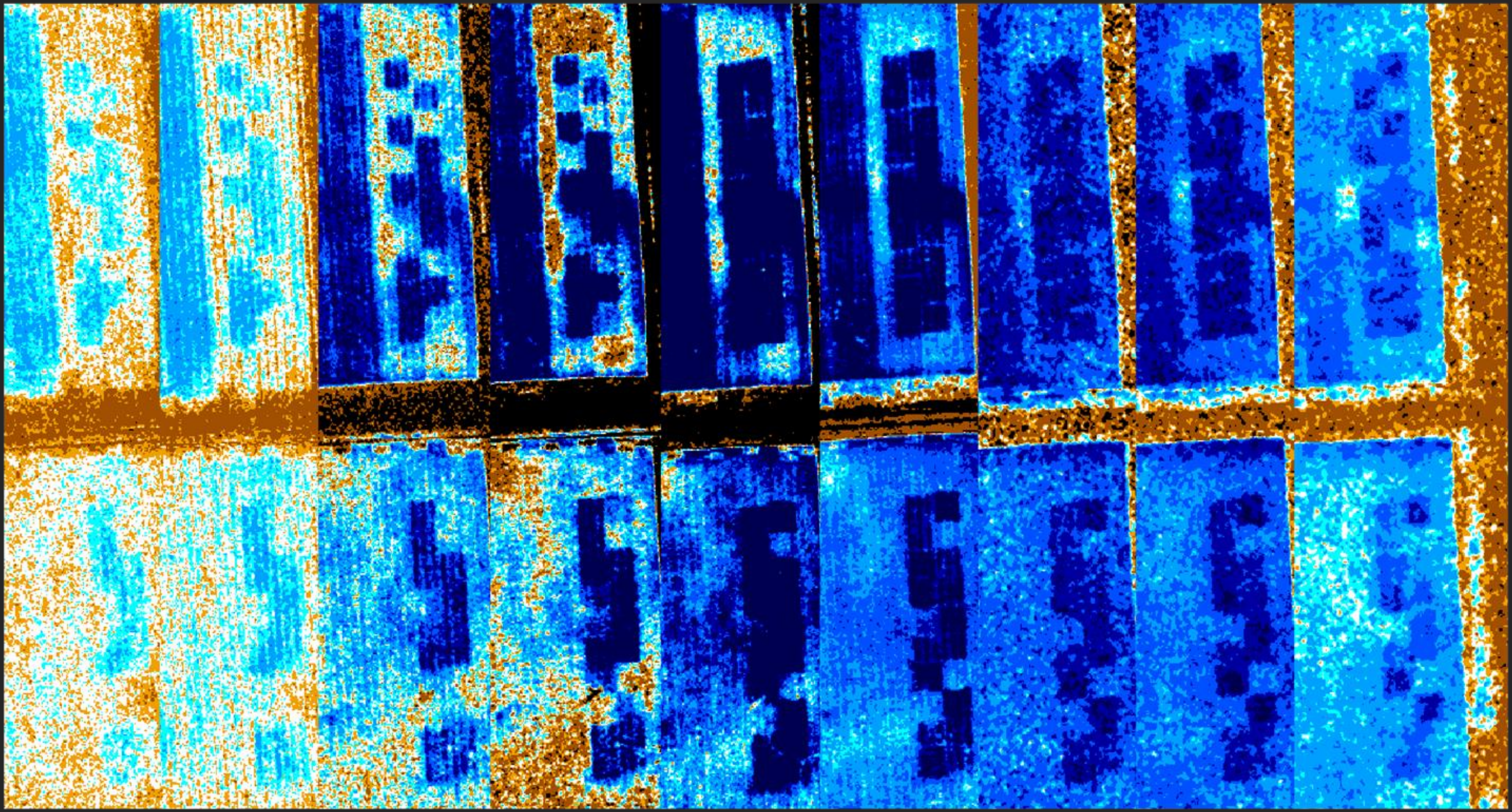
B. Tillering-Flowering N

- 16% higher yield
- > 1% higher protein

Right Time?


Cumulative N demand (lb/acre)
N (lb/acre)
200
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
harvest
flowering
boot
mid-tillering
plant
Daily N demand (lb/acre)
N (lb/acre)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
Days (November 15 - June 7)

Right Time?



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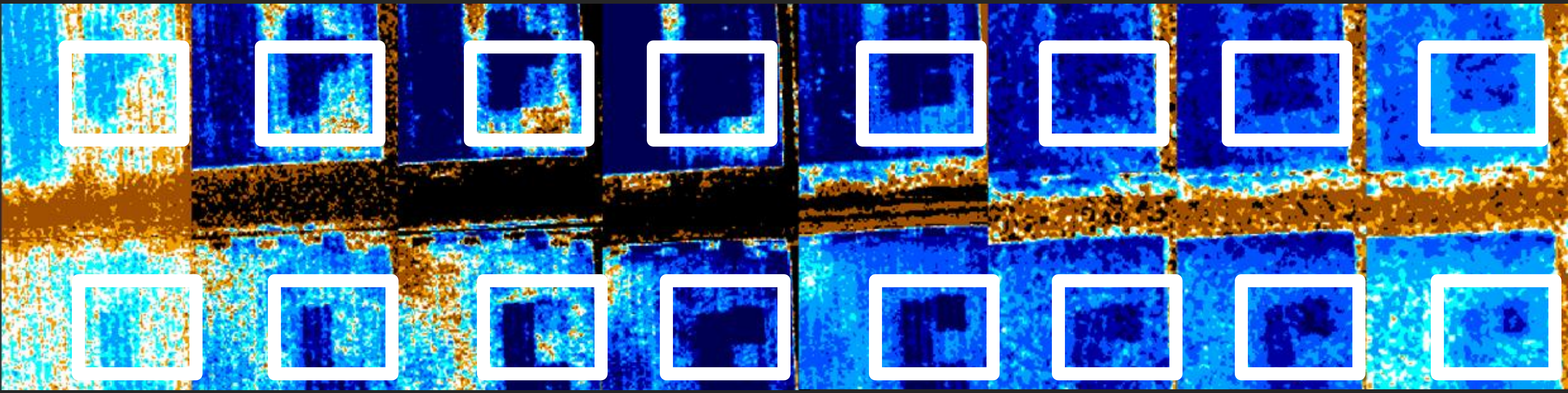
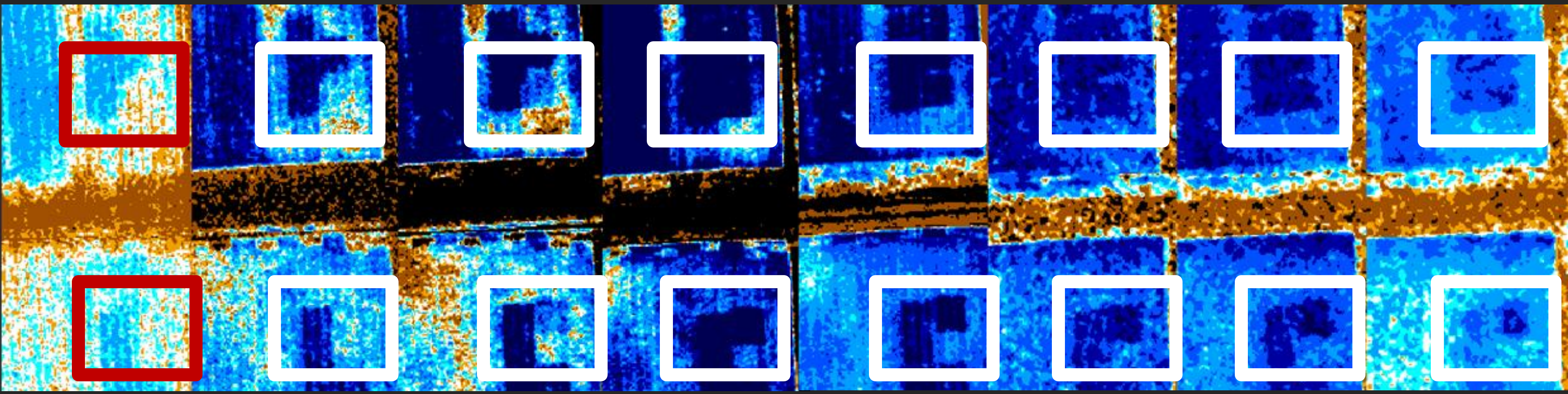
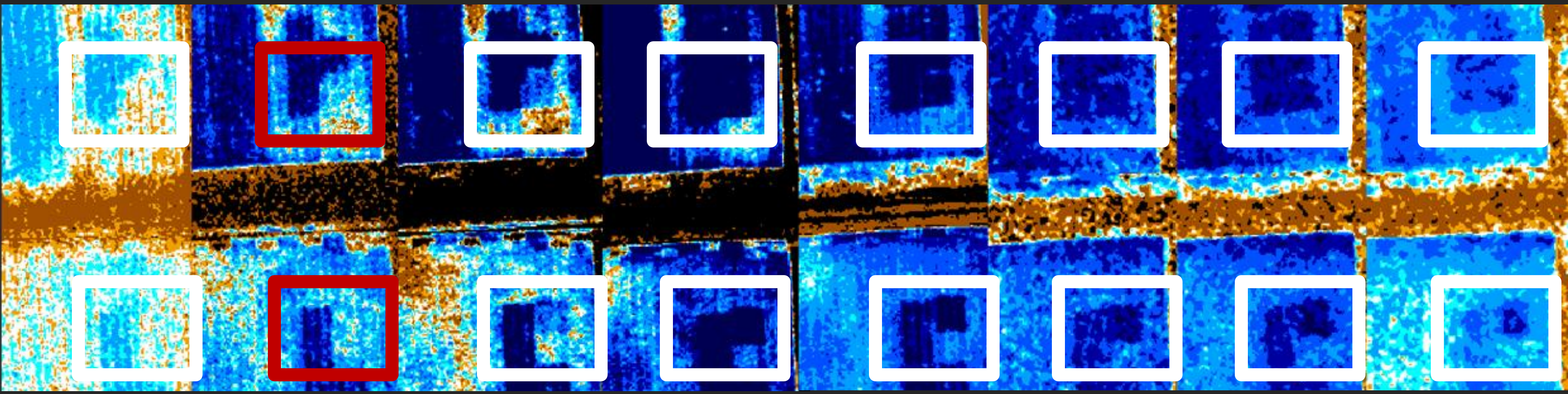
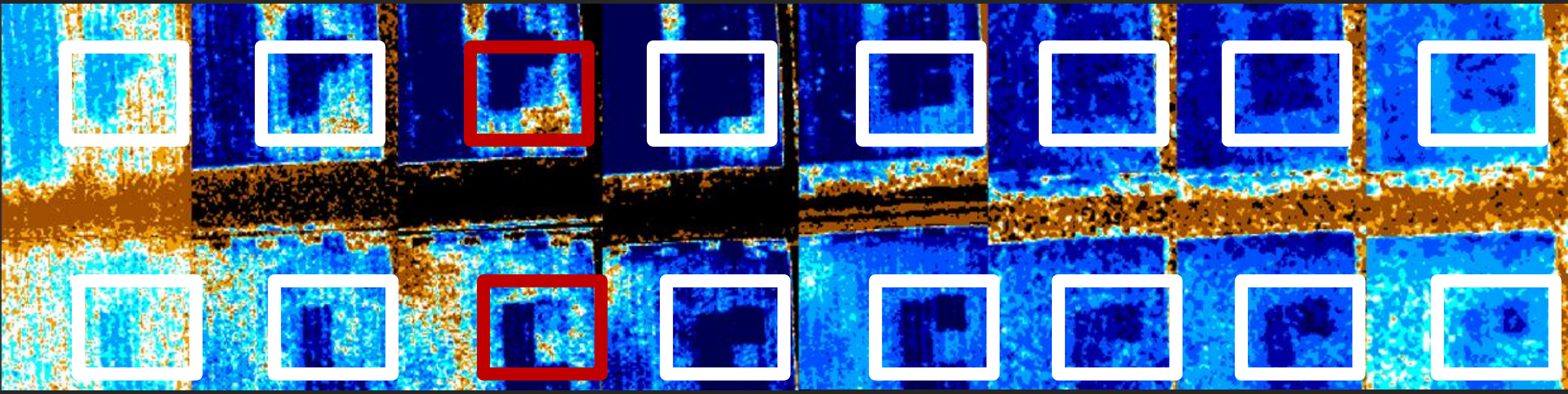
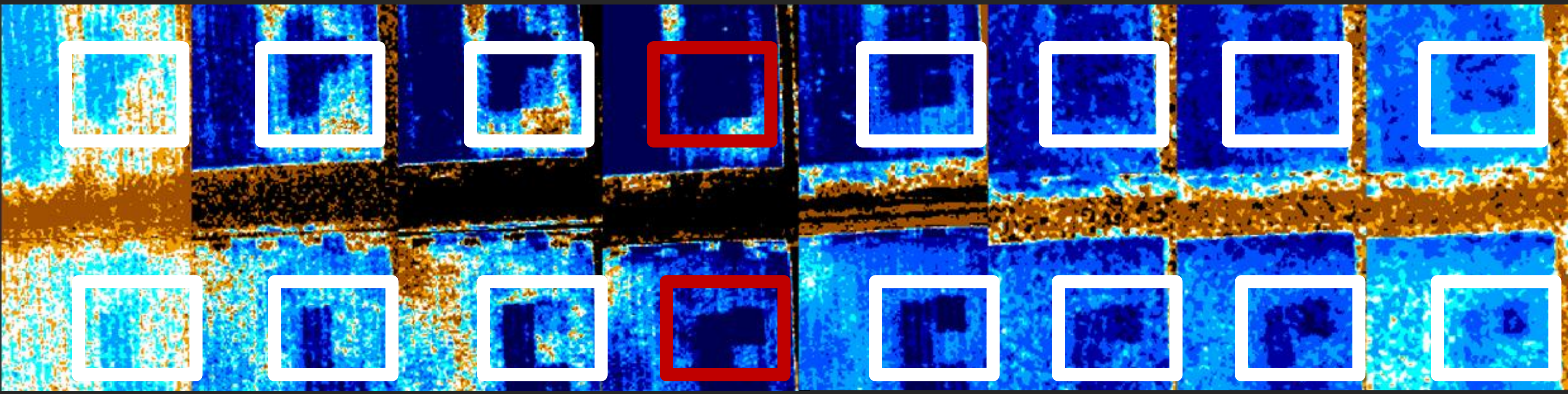
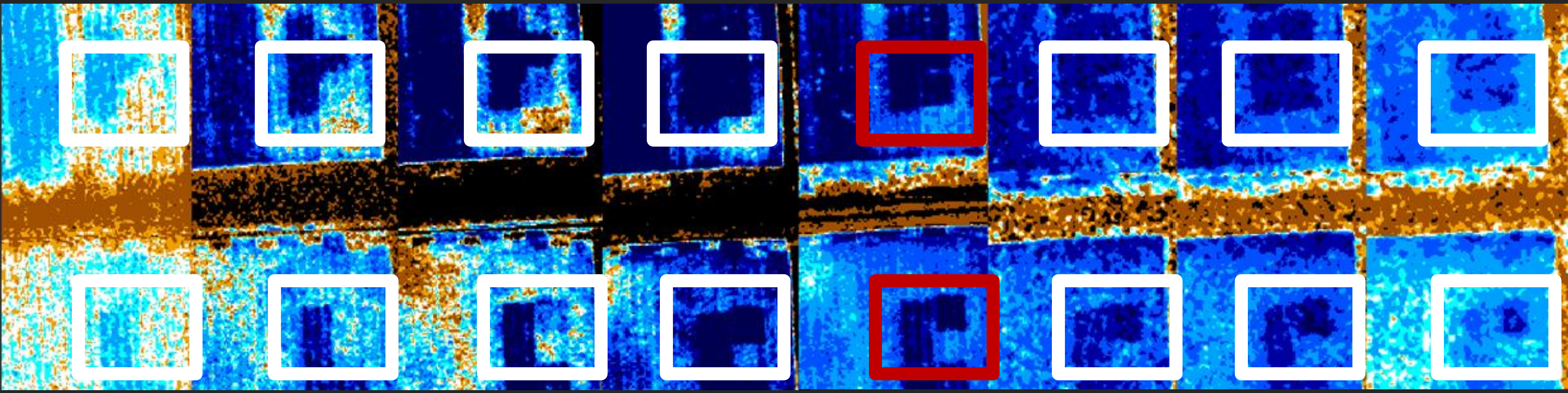


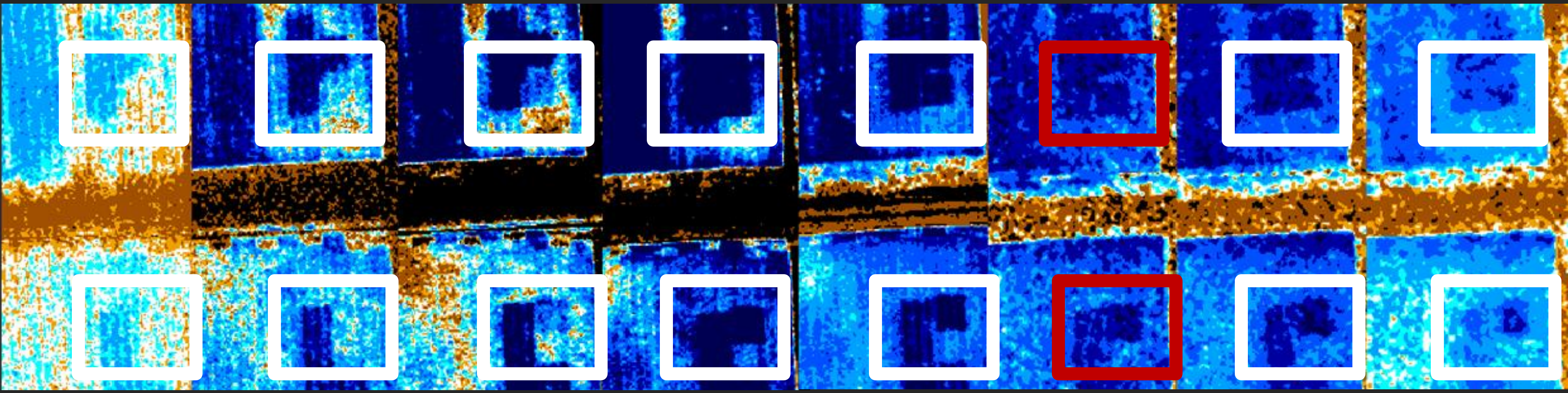


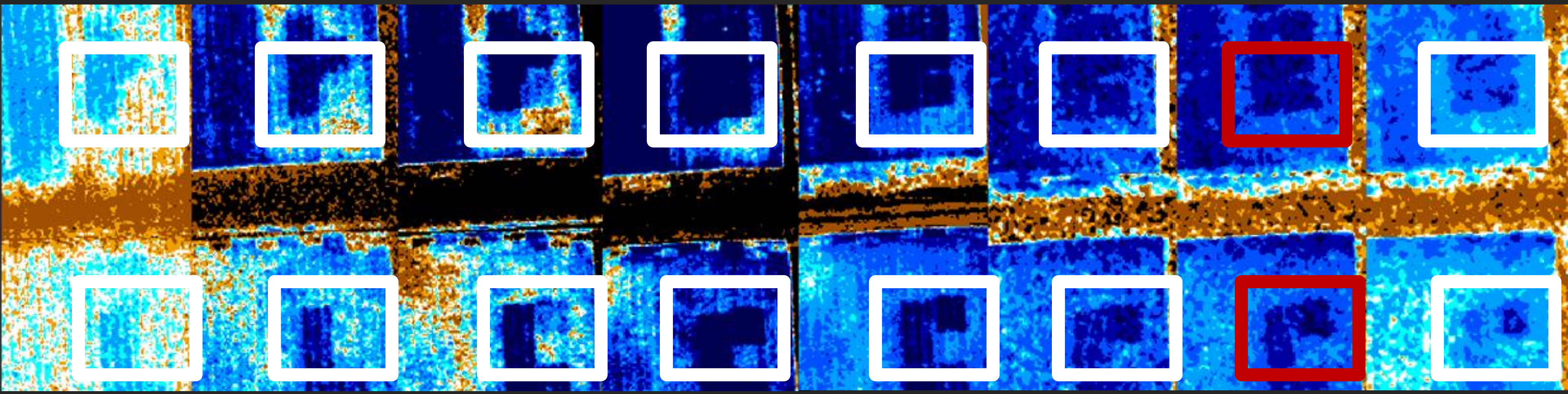


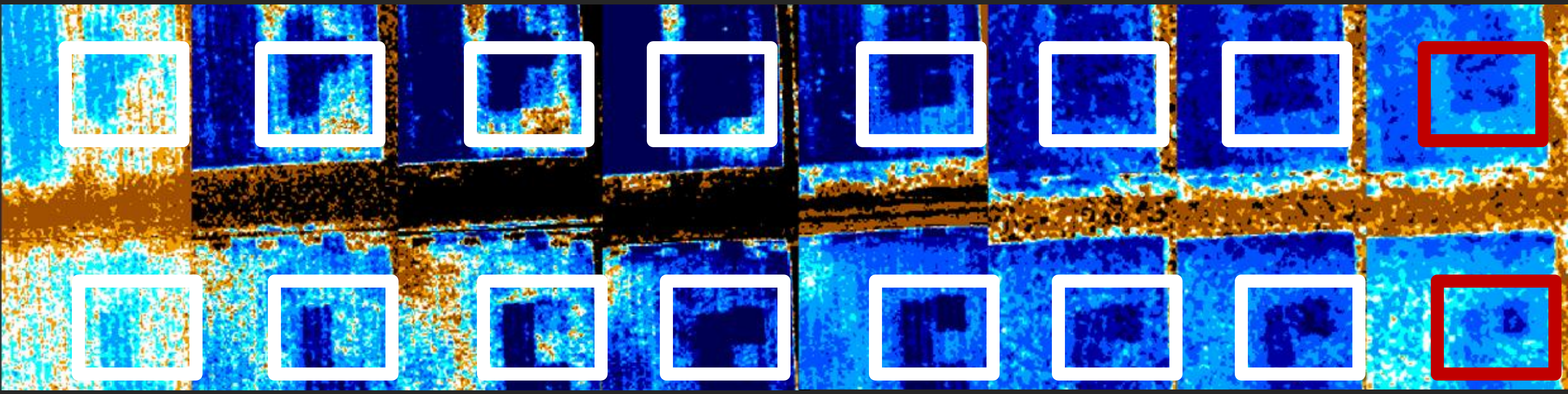




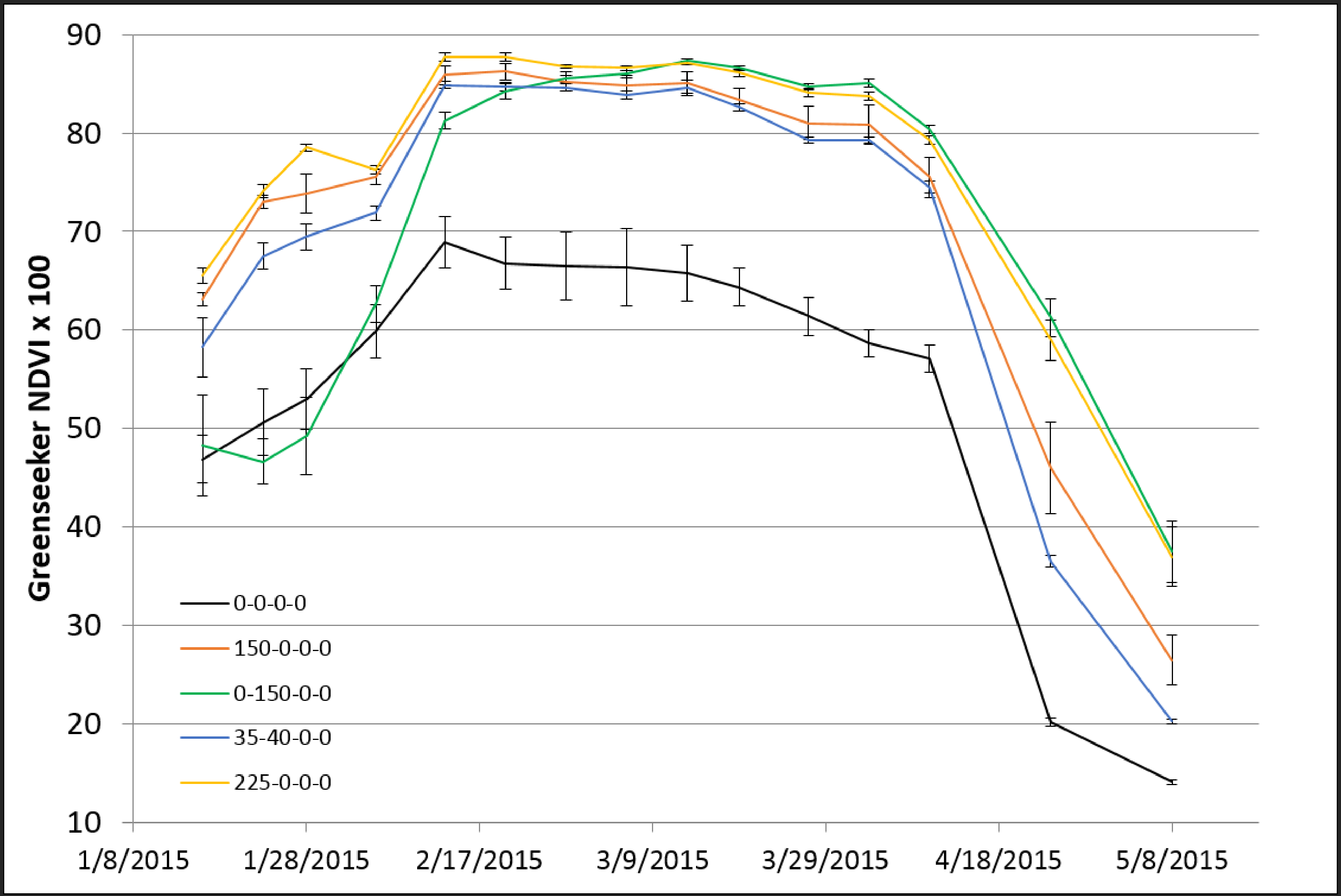






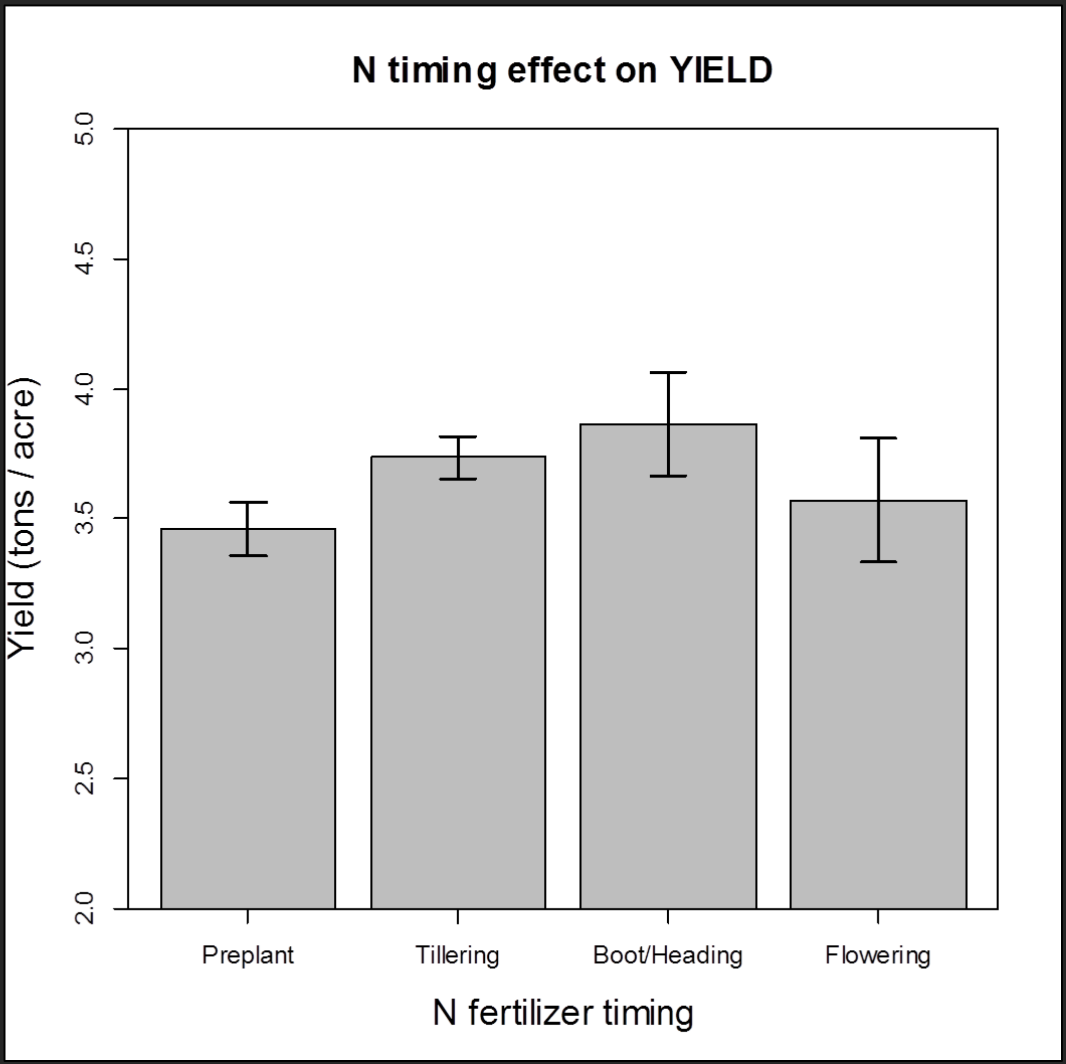


Right Time?



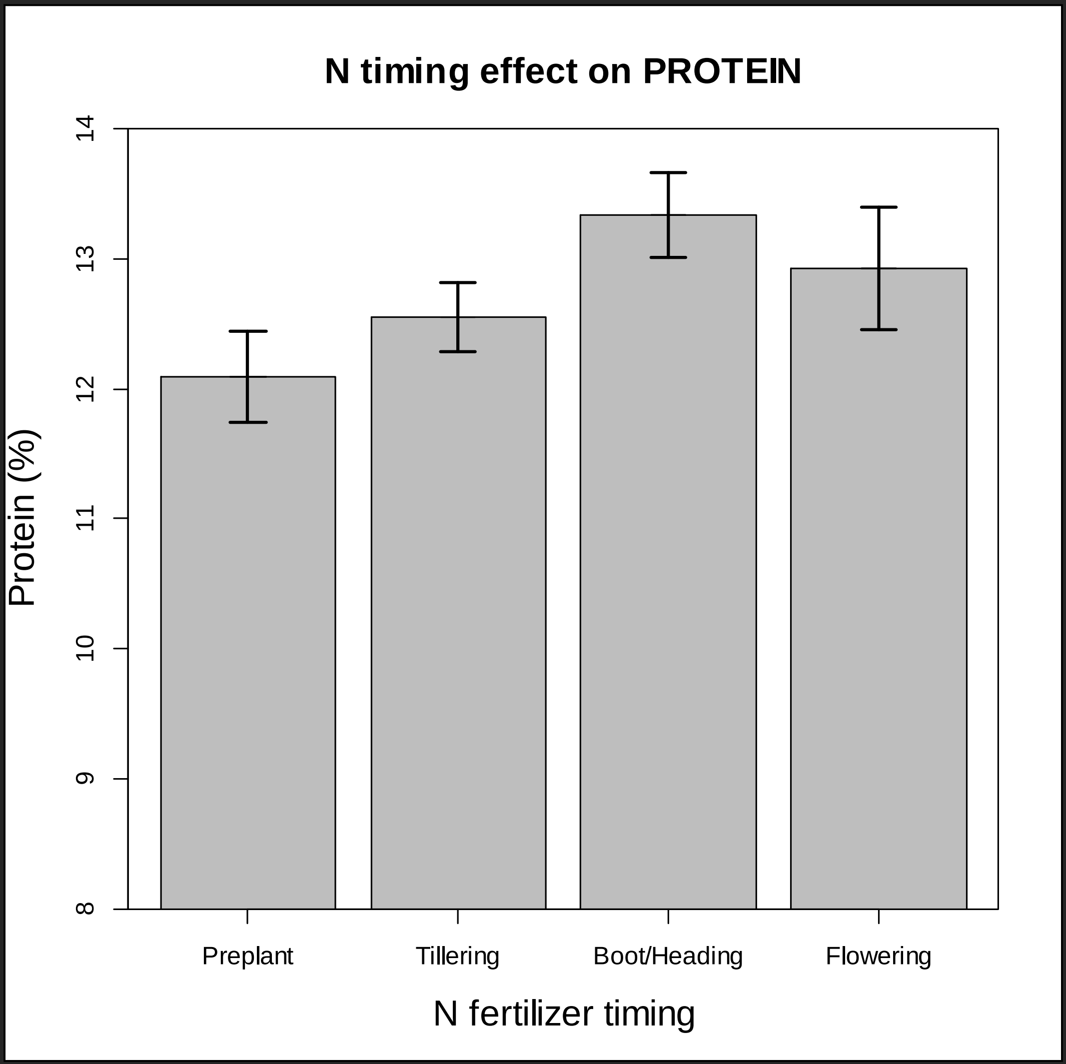
Greenseeker NDVI x 100
90
80
70
60
50
40
30
20
10
1/8/2015
1/28/2015
2/17/2015
3/9/2015
3/29/2015
4/18/2015
5/8/2015
0-0-0-0
150-0-0-0
0-150-0-0
35-40-0-0
225-0-0-0

Timing of N application affects YIELD



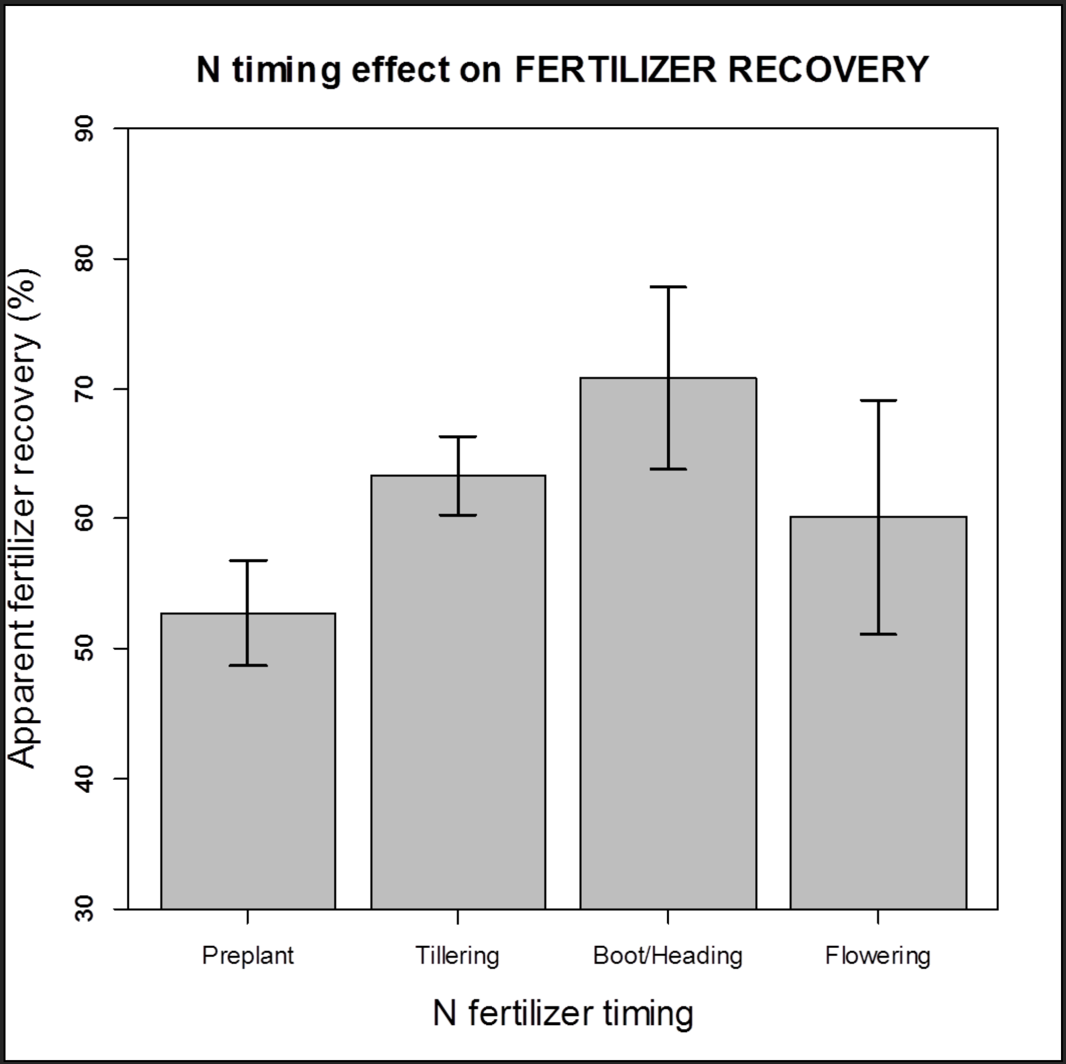
- Applications of N at Tillering and Boot boost yields compared to Preplant applications
  - Assuming sufficient water follows N application

Timing of N application affects PROTEIN



- Applications of N at Boot and Flowering boost grain protein content relative to other application timings
  - Assuming sufficient water follows N application
  - Assuming crop has sufficient yield potential

Timing of N application affects FERTILIZER USE EFFICIENCY



- In-season applications of N boost grain fertilizer recovery compared to pre-plant applications
  - Interacts strongly with water availability & timing
  - Large range of possibilities (0.3 – 0.70)

How much N will the SOIL supply?

Multiple ways to estimate, many things to estimate…

- One method (top 1 foot)
  - ppm NO3-N x 4
    - Example: 12ppm NO3-N x 4 ≈ 48 lb ac^{-1}

- Prior Crop:
  - Tomato residue estimated at 50 lb ac^{-1} returned, but probably reflected in soil nitrate test
  - Alfalfa contribution ≈ 100 lb ac^{-1} +

- In-season soil organic matter N mineralization:
  - 0.8% OM % x 30 lb N / % OM ≈ 24 lb ac^{-1}

A brief note on other small grains:

- Barley and Oats require substantially less N
  - Optimal yields can be achieved between 50 and 120 lb N / acre

- Durum wheat may require 130% N to achieve quality targets
  - good timing can help

What tools are available to assist in real-time N management in wheat?

AtLEAF Chlorophyll Meter ≈ $250

Greenseeker handheld NDVI ≈ $500

Soil Nitrate Quicktest < $50

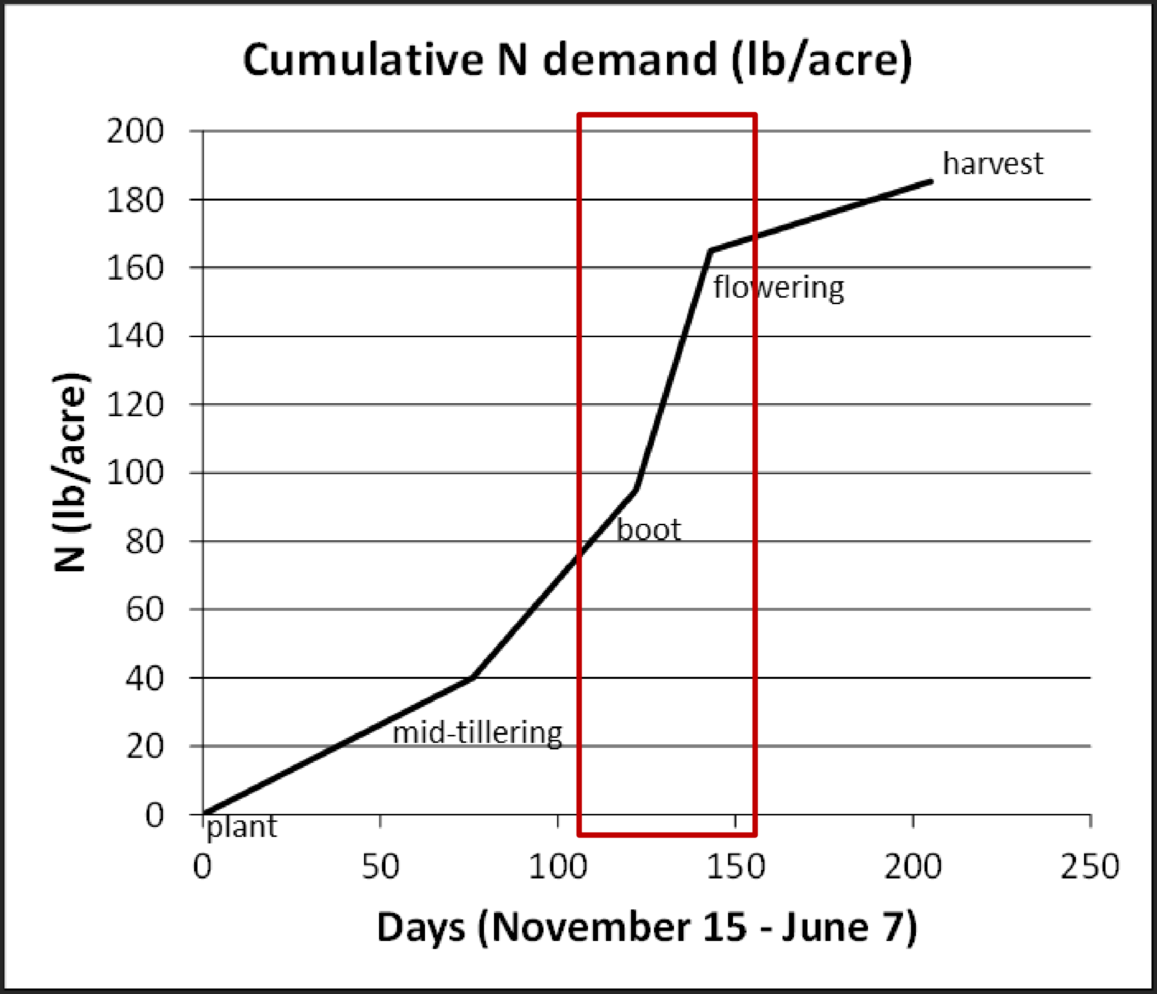
LAQUA NO_3 ISE ≈ $500

Image courtesy: http://www.agriculturesolutions.com

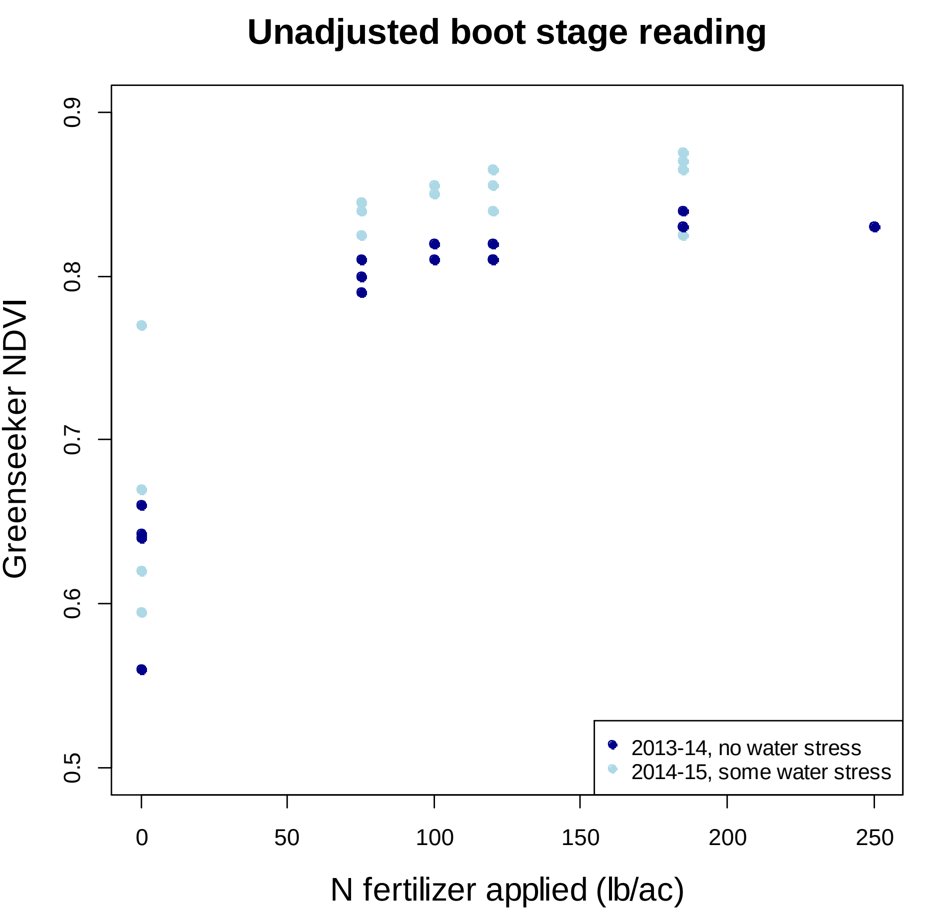
Site-specific calibration?

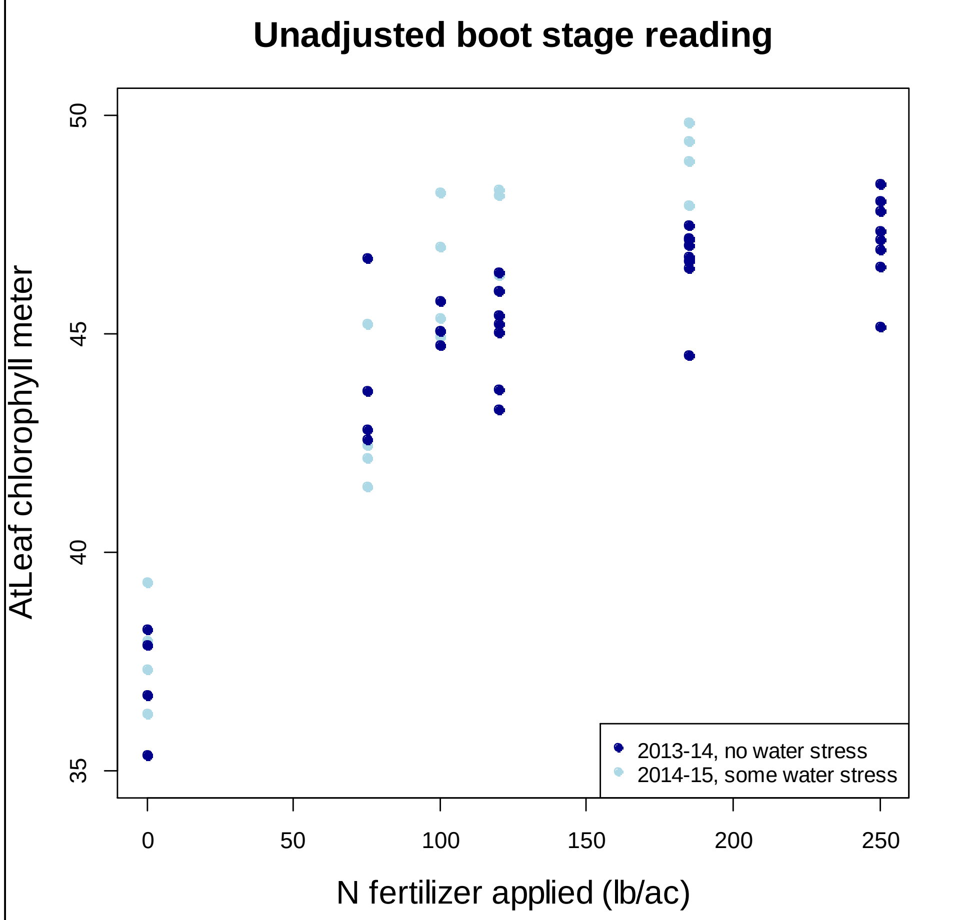
Image courtesy: Oklahoma State University

Objective: Decision support thresholds that inform whether and how much N to apply at any given point in the crop cycle.



Results: Calibration





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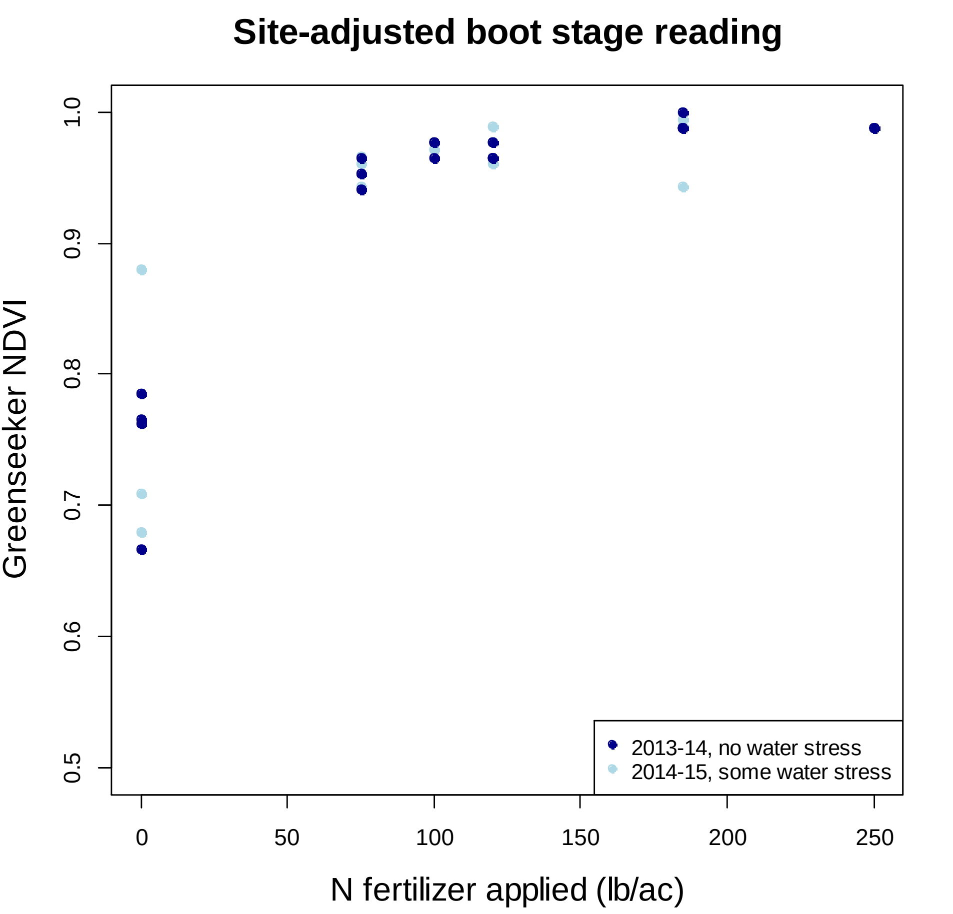

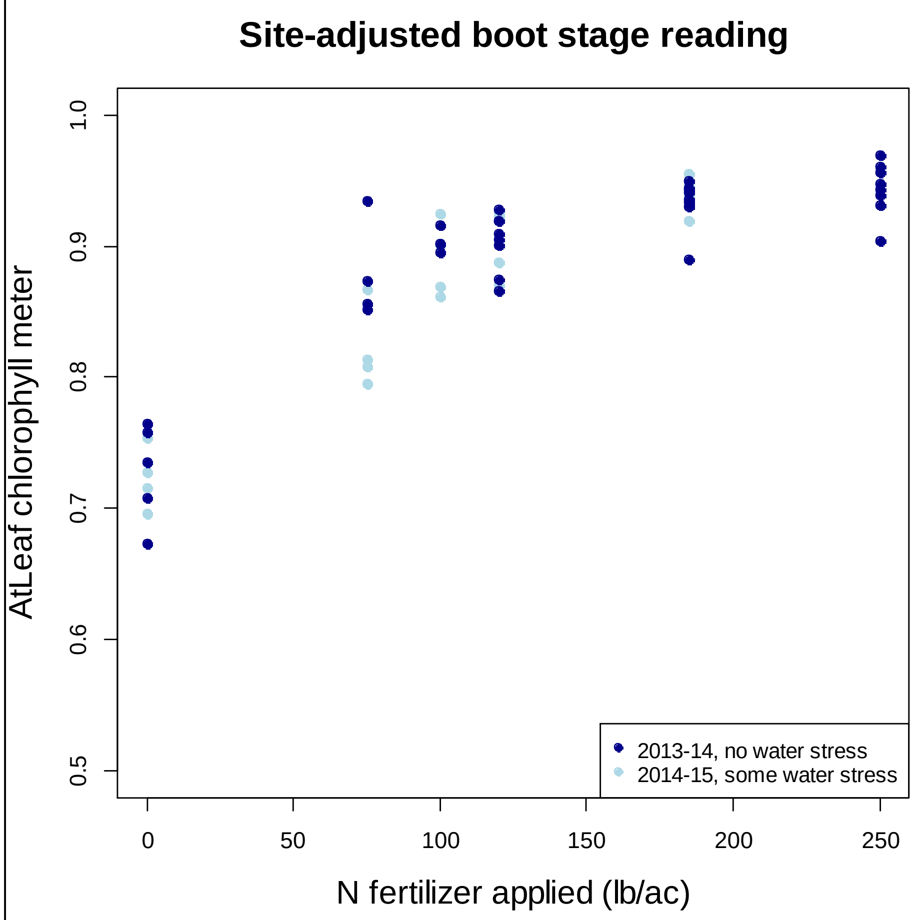

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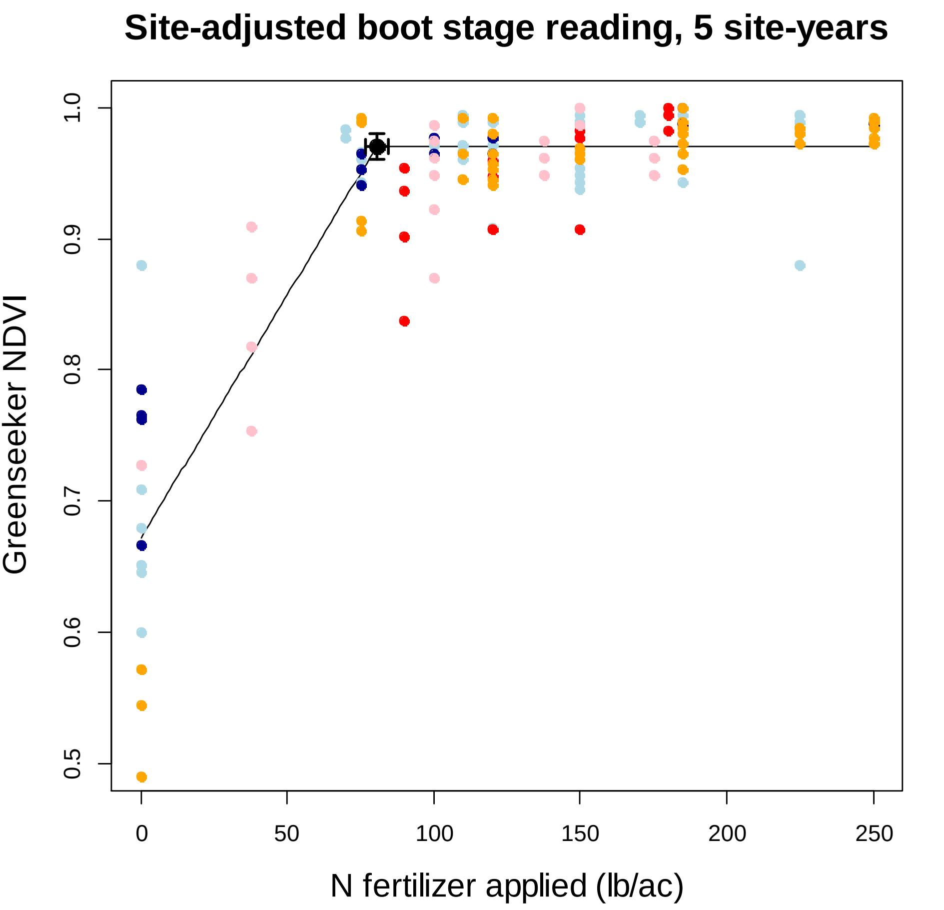
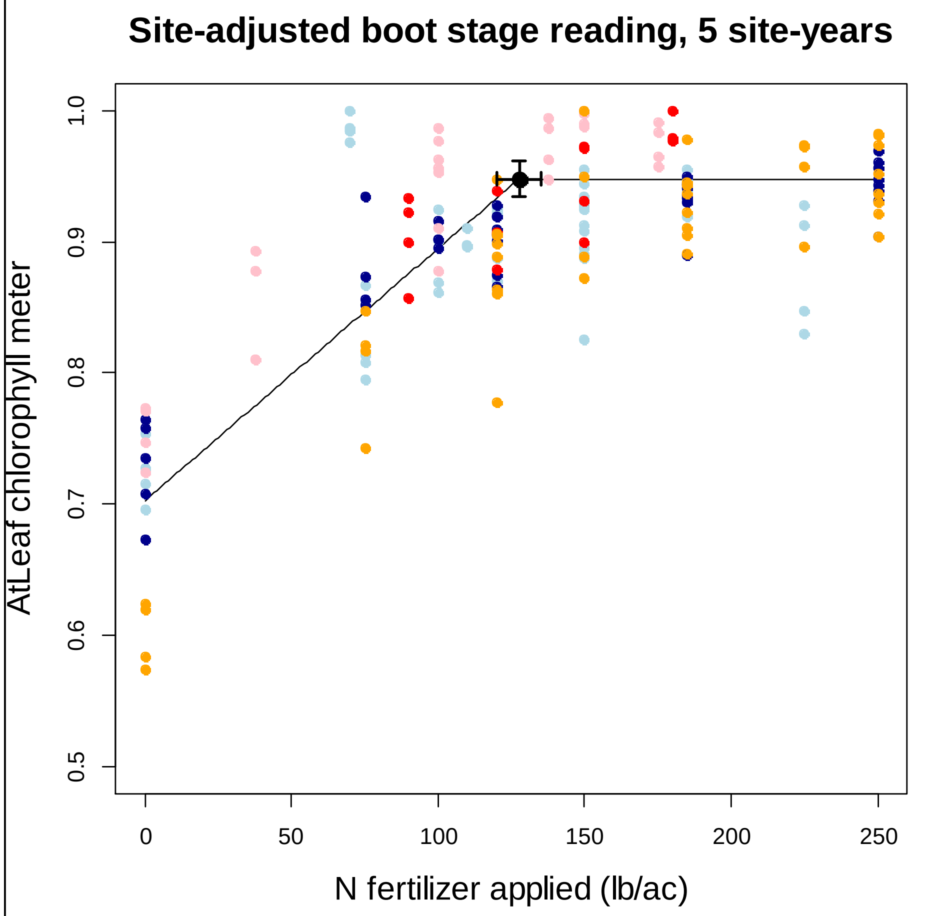
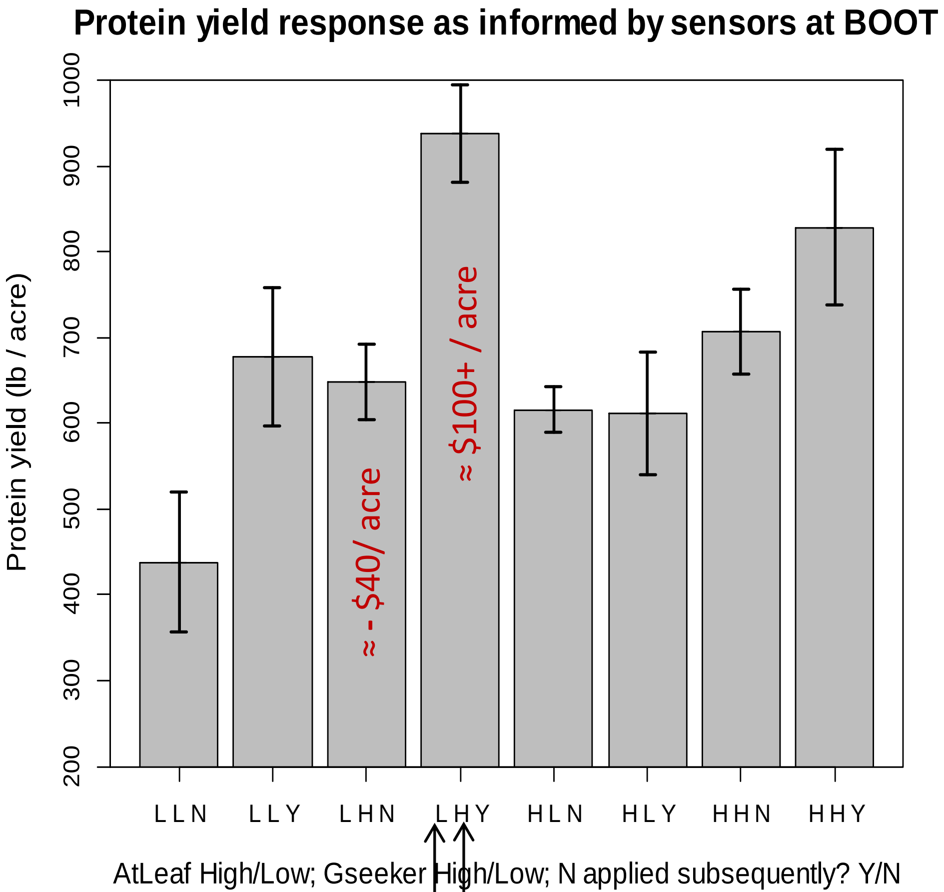
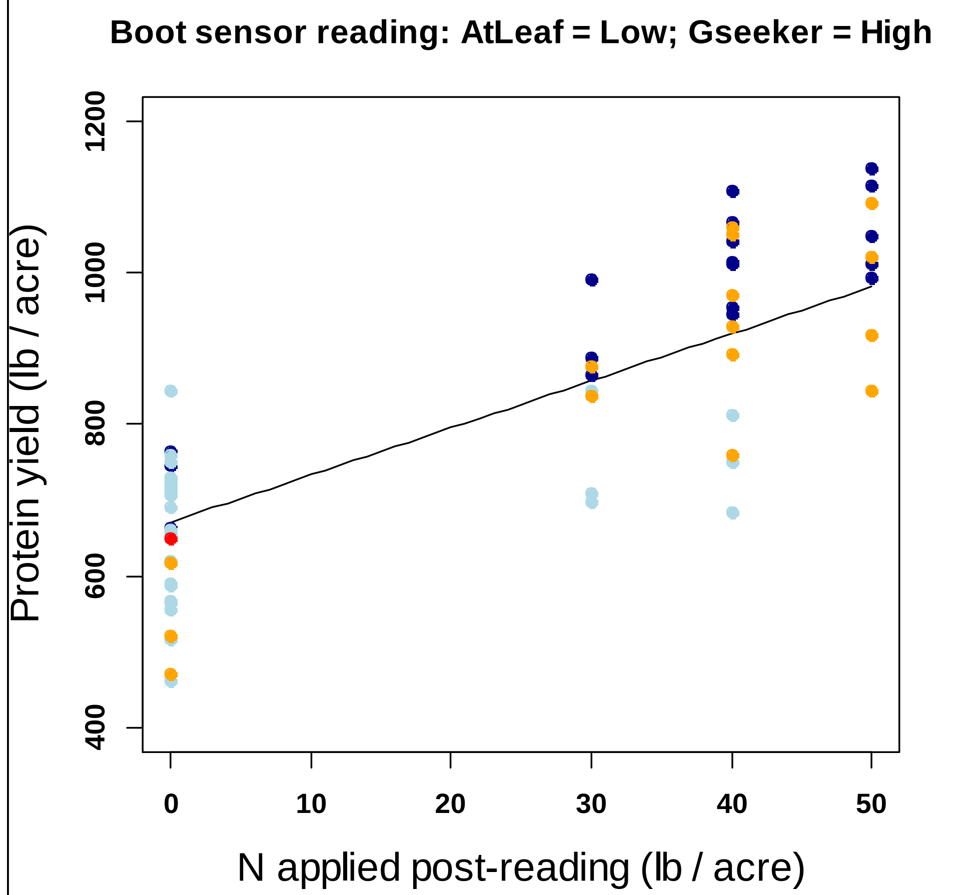




Results: Decision support





Summary

1. N demand varies across the season & from field-to-field, depends on water availability, timing.

2. The timing of N application can influence yield, protein and fertilizer use efficiency.

3. The use of site-specific, real-time measurements can provided actionable information about whether and how much N fertilizer to apply.

4. Combining information from more than one test may improve the ability to predict outcomes in-season.

Acknowledgments

Jason Tsichlis, Ryan Byrnes, Phil Mayo, Gerry Hernandez, Lalo Banuelos, Israel Herrera, Emma Torbert, Rika Fields, Katy Mulligan, Eric Lin, Dan Putnam, Chris de Ben, Israel Herrera, Fred Stewart, Jim Jackson, IREC, WSREC, and UCD Plant Sciences Field Crews.