Achieving efficient N fertilizer management in California spring wheat

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Outline

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

Background: Spring wheat production in California

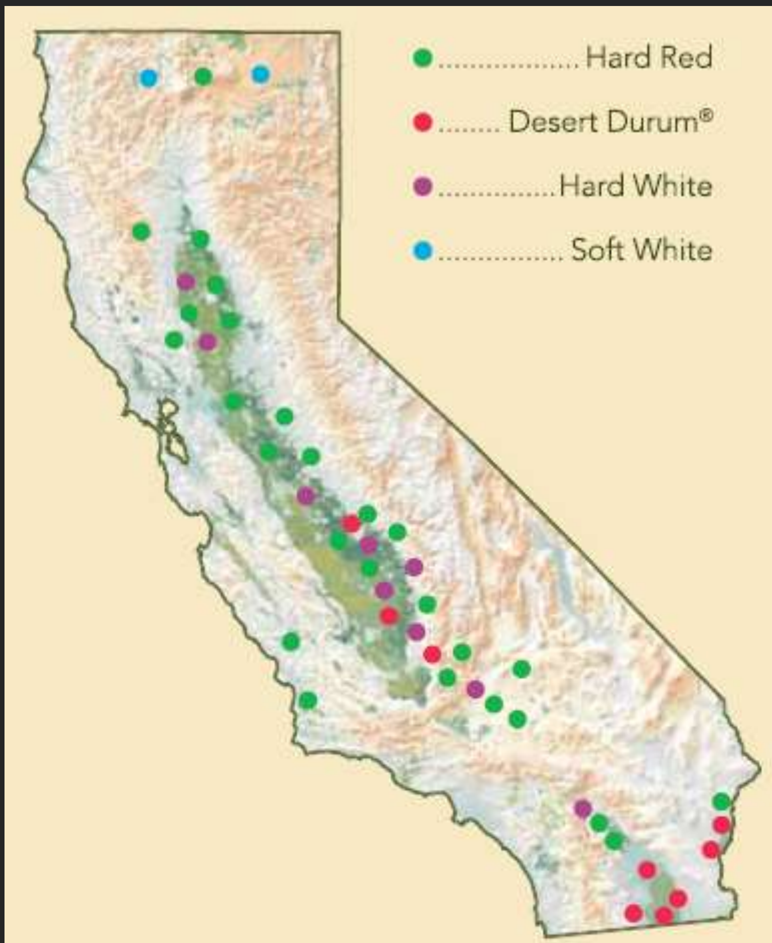


Image courtesy: California Wheat Commission

- Acreage :
  ≈ 500,000 ac yr^{-1} hard red/white;
  ≈ 60,000 ac yr^{-1} durum
- 50% grown for grain
- Yields ≈ 5500-6000 lb ac^{-1}
- Grain growers receive payment for quantity ± quantity
- Protein (quality) varies by region ≈ 11-14%

Nitrogen-related management in CA spring wheat

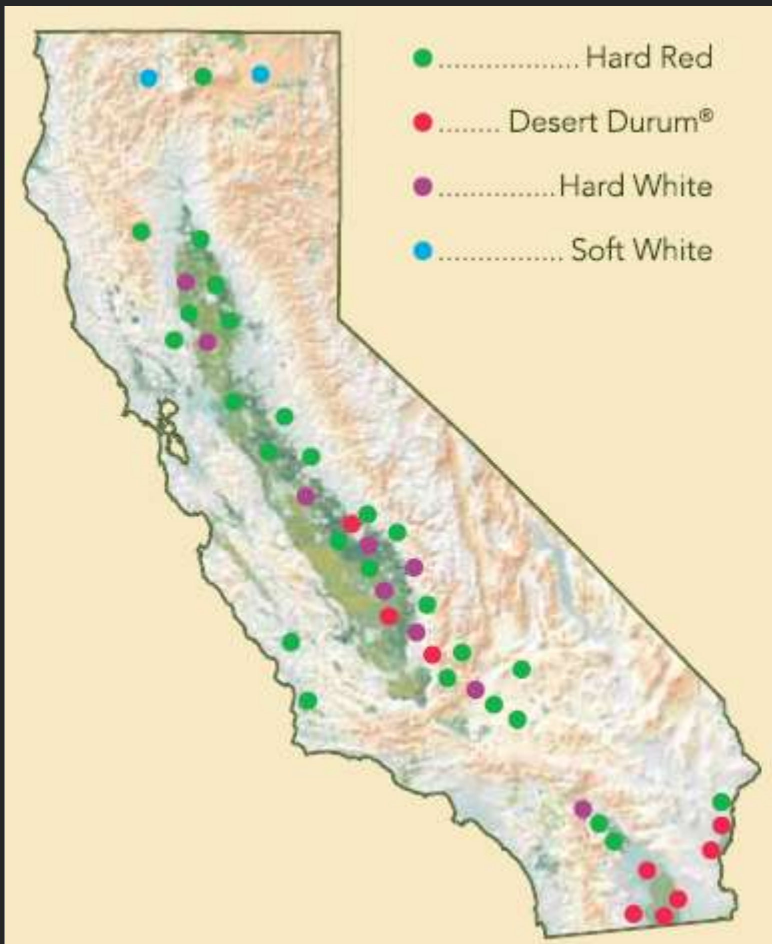
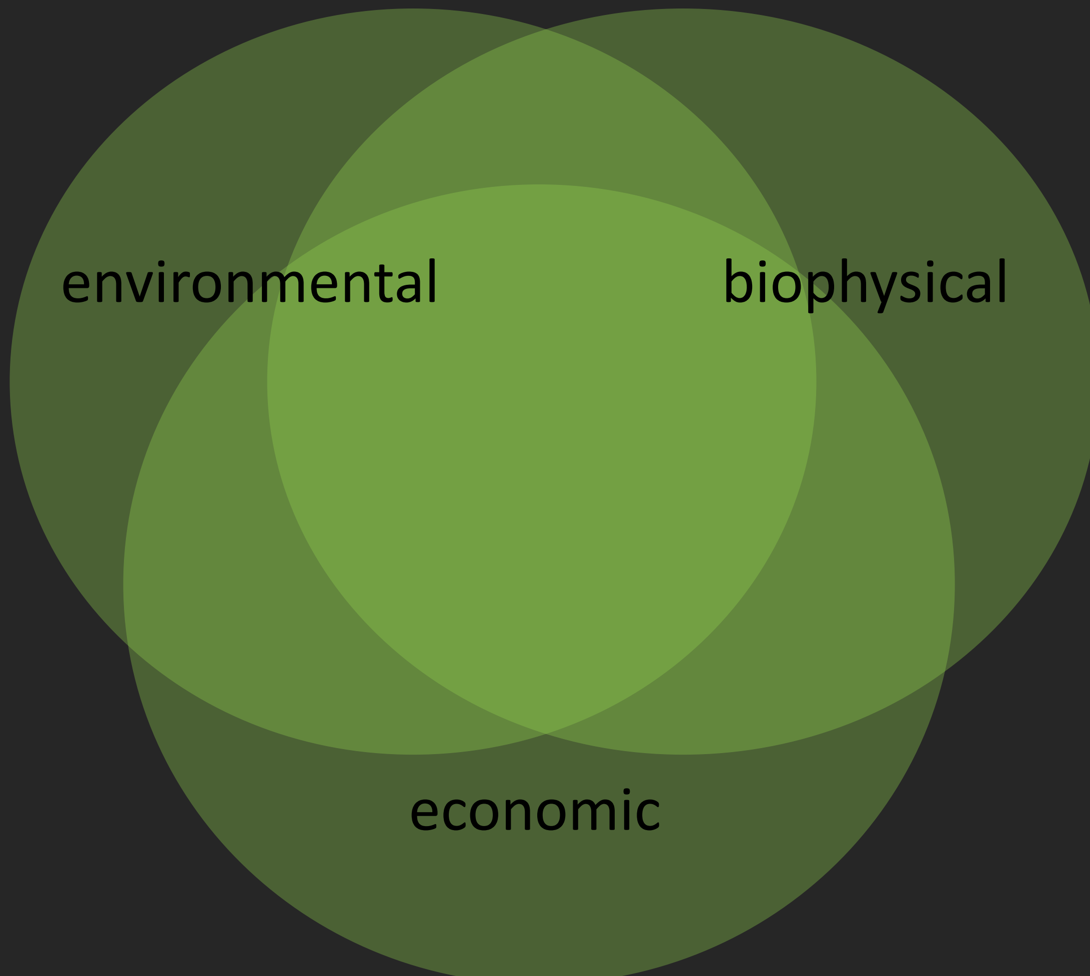


Image courtesy: California Wheat Commission

- Irrigation varies by region:
  - More opportunistic in the Sacramento Valley
  - More standard in the southern part of the state and Intermountain area
- Many growers 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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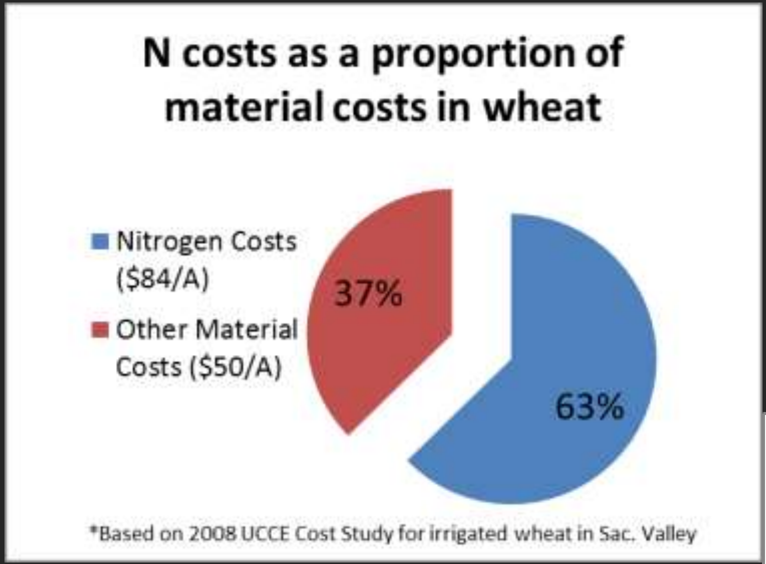
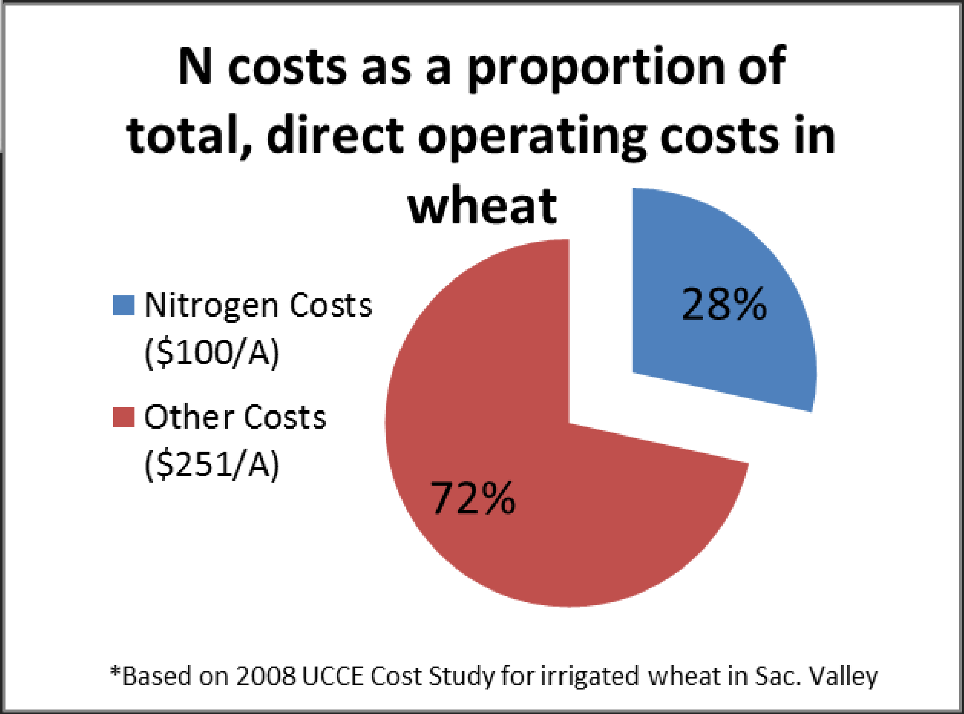


Optimizing the rate, timing of N application:

- 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): ____________

2. Member ID# ____________

3. Name:

4. APN(s):	5. Field(s) ID	Acres

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

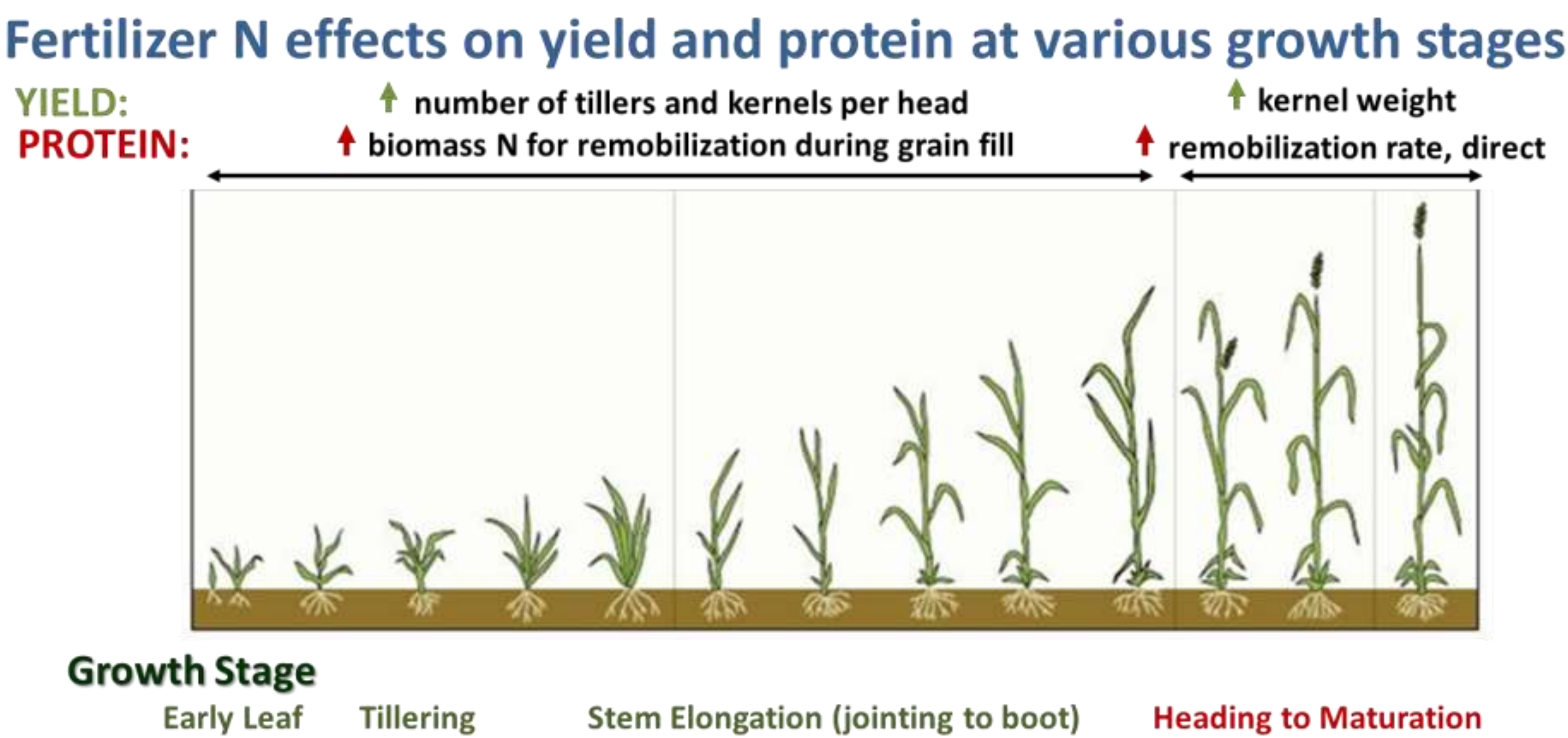
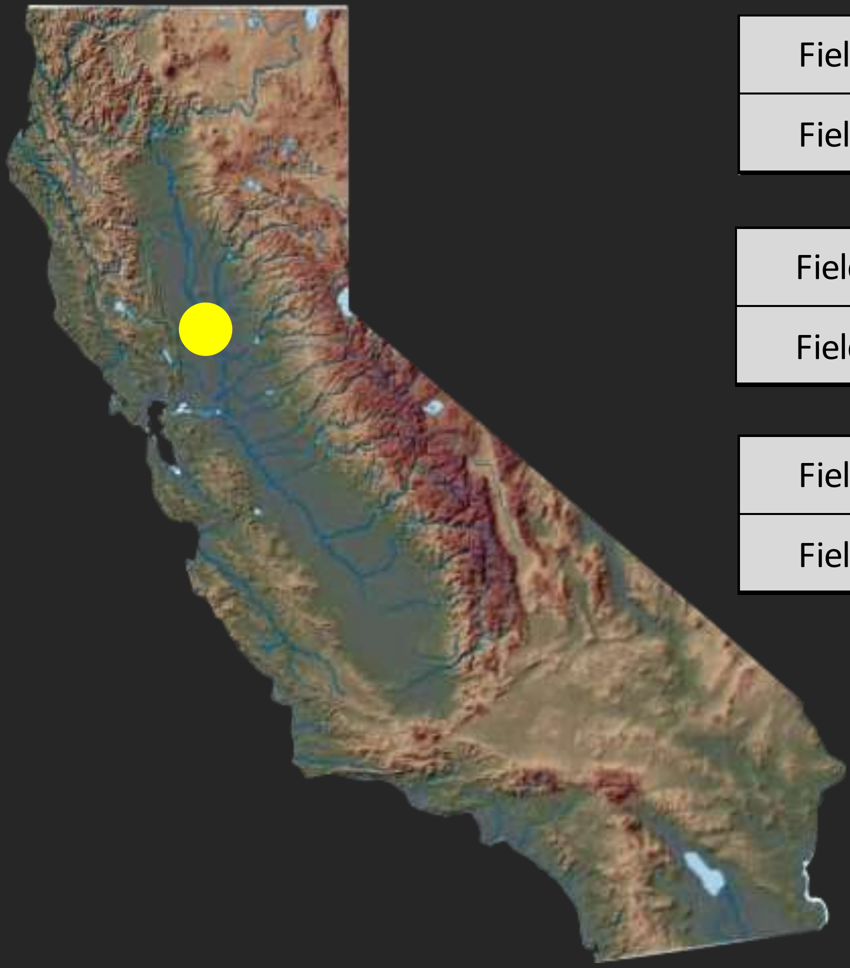


Image courtesy: S. Orloff

METHODS



Fertilizer treatments	PREPLANT	TILLERING	BOOT	FLOWERING	TOTAL
	% of N fertilizer applied				kg / ha
	0 - 100%	0 - 100%	0 - 50%	0 - 20%	0 - 335 kg/ha

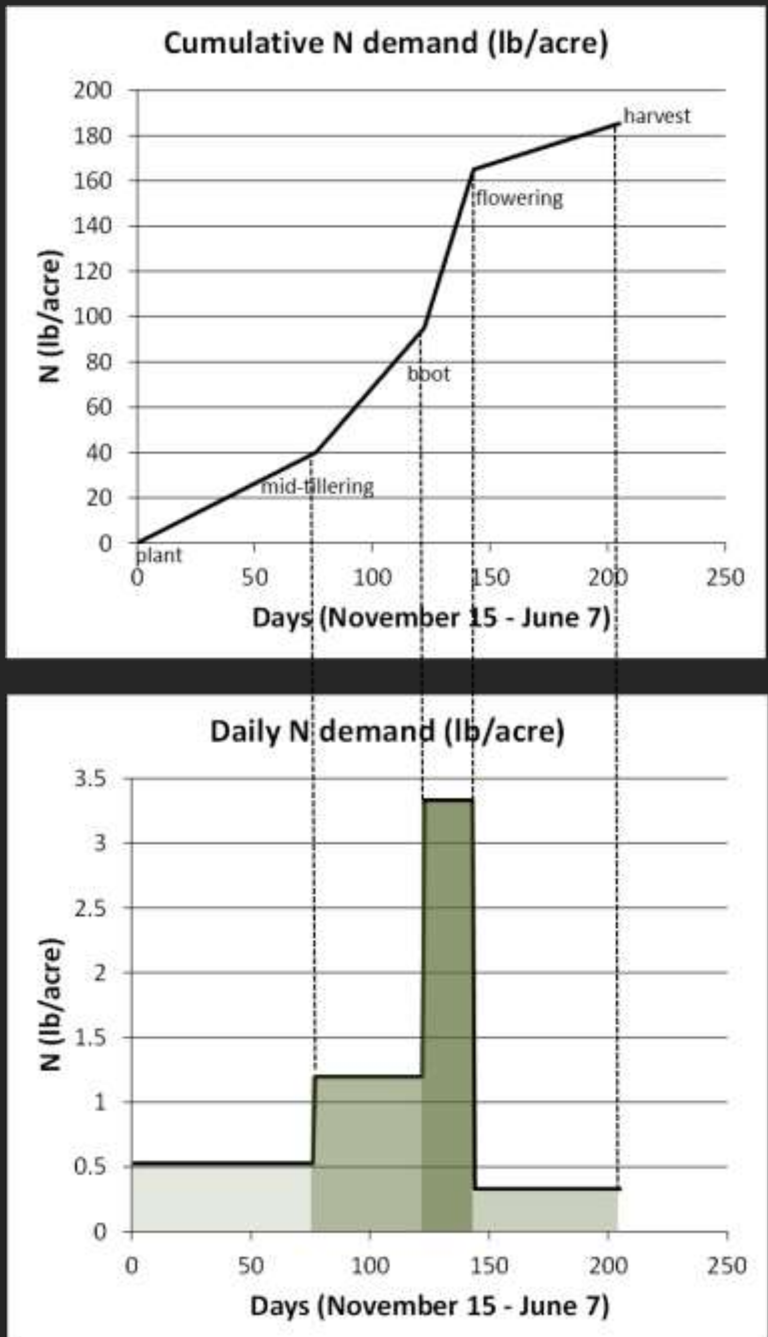
Field 1	fully irrigated
Field 2	not irrigated
	supplemental irrigation

Field 1	Variety: hard white
Field 2	Variety: hard red

Field 1	Soil: Entisol, preplant NO3-N = 1 ppm, 0 - 60 cm
Field 2	Soil: Alfisol, preplant NO3-N = 10 ppm, 0 - 60 cm

Gradients (HIGH to LOW):

- Nitrogen availability
- Water availability



Yield = 7500 lb $acre^{-1}$; Protein = 11.5%

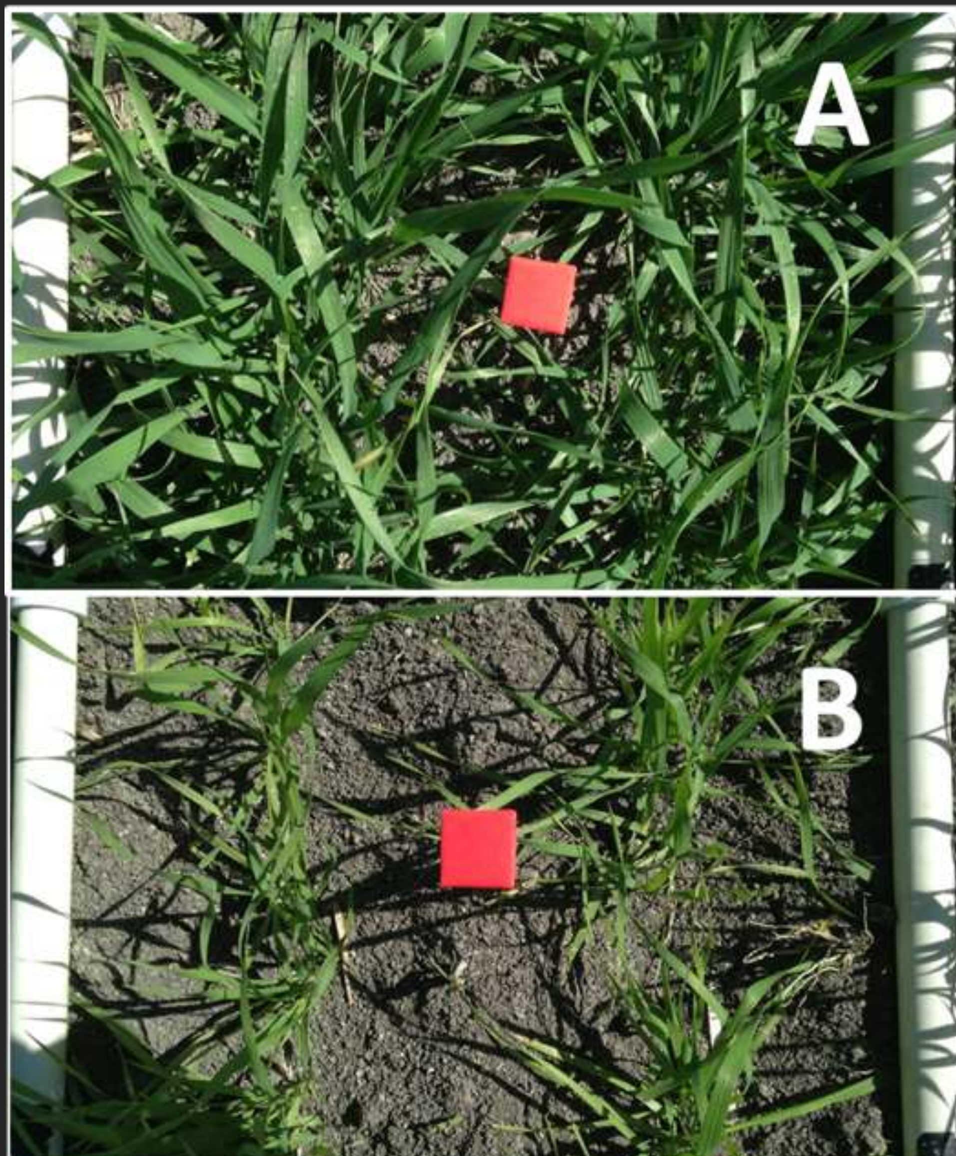
- Rate of fertilizer N demand varies across the growing season [TIMING MATTERS].
- Total fertilizer N demand varies according to the protein yield potential of the crop

  [WHAT IS A REASONABLE YIELD EXPECTATION?].

  ↓

  Water is more limiting than N [IRRIGATION?].
- [SOIL] supplies a large portion of N to the crop.

TIMING MATTERS

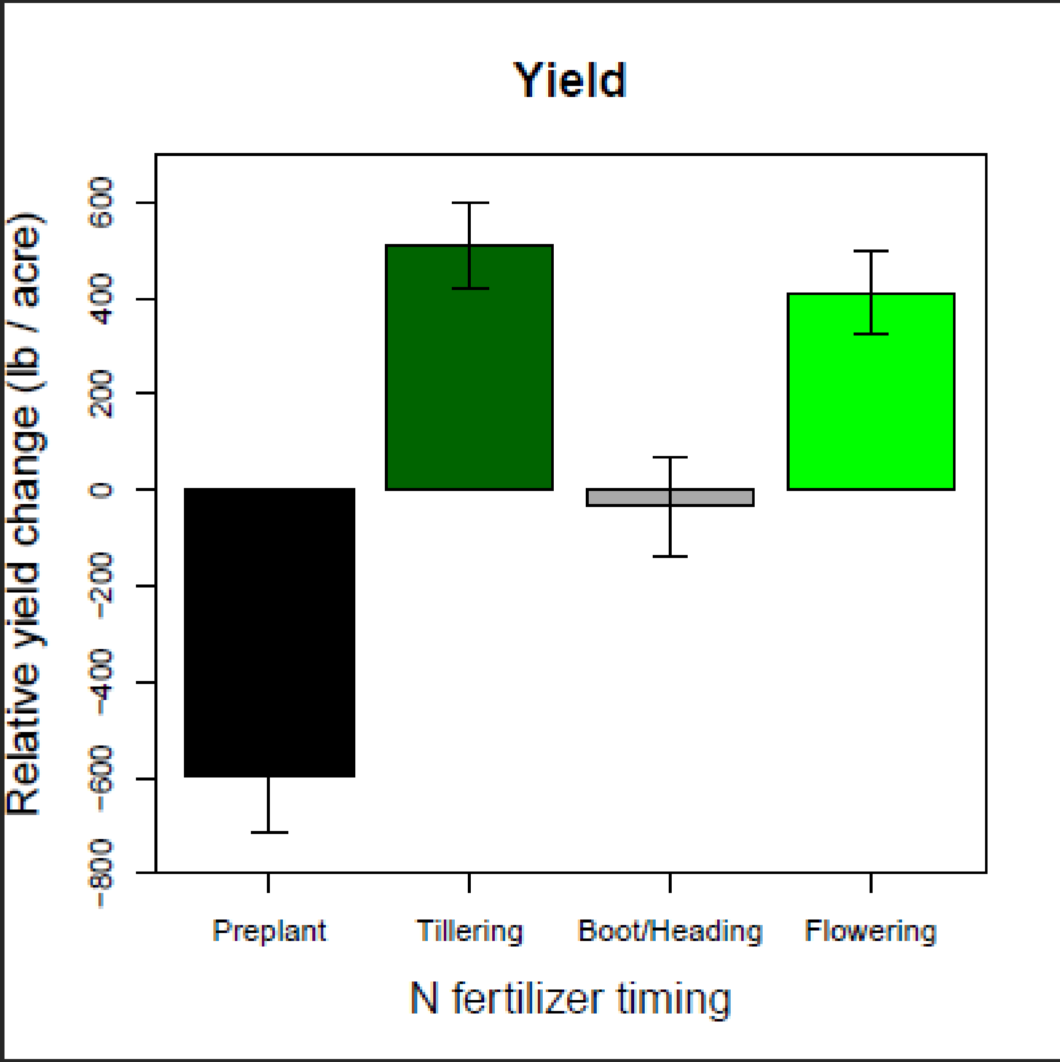


A. Preplant N only

B. Tillering-Flowering N

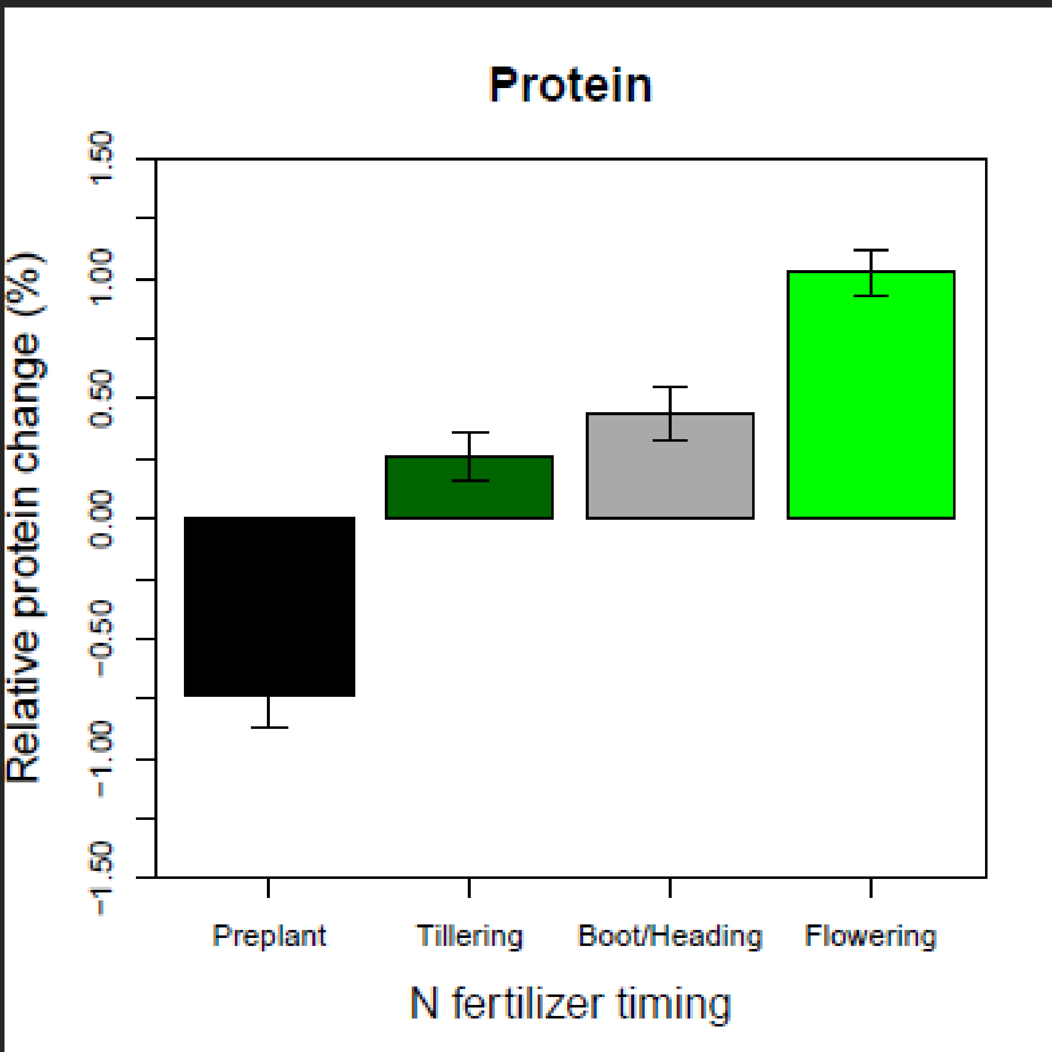
- 16% higher yield
- > 1% higher protein

Timing of N application affects YIELD



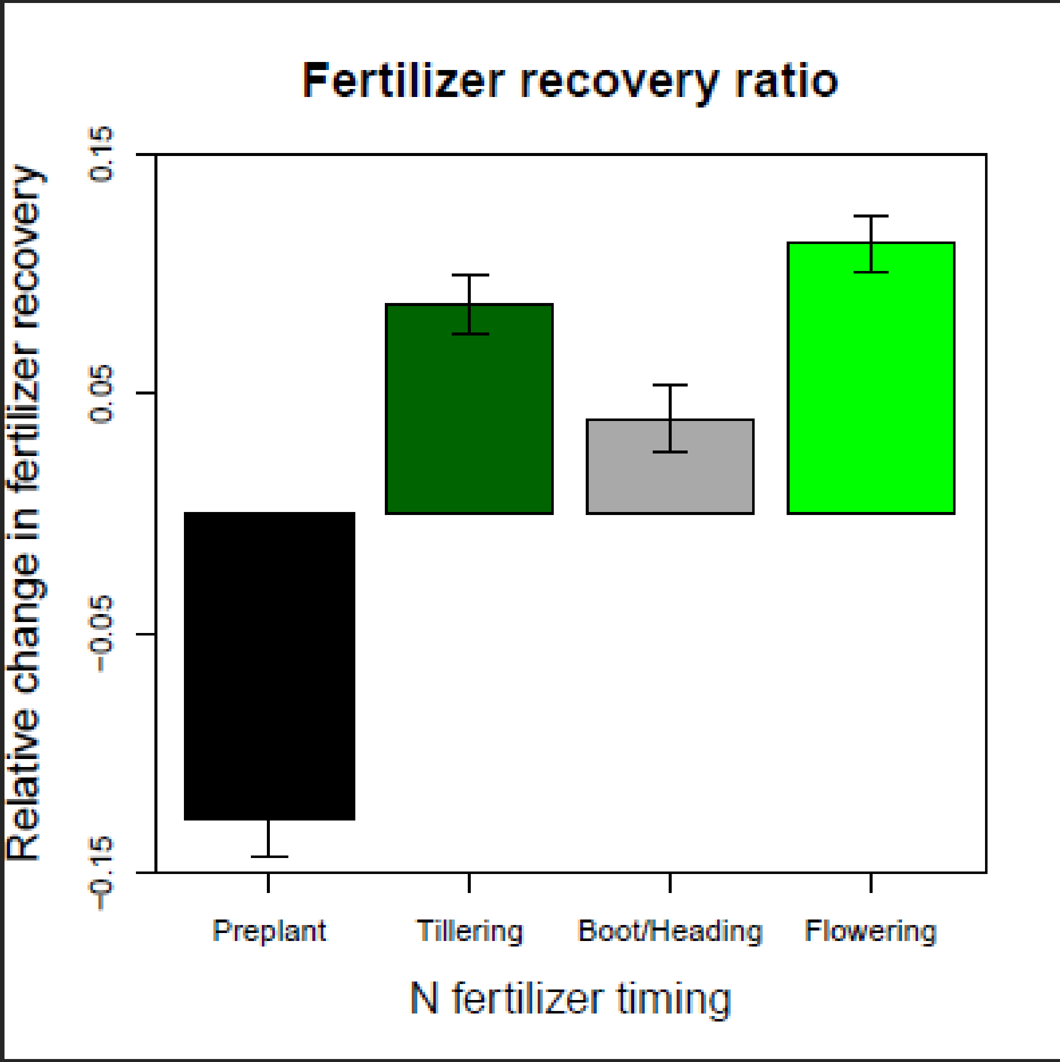
- Applications of N at Tillering and Flowering significantly boost yields compared to Preplant and late-Boot/early-Heading applications
  - Assuming sufficient water follows N application

Timing of N application affects PROTEIN



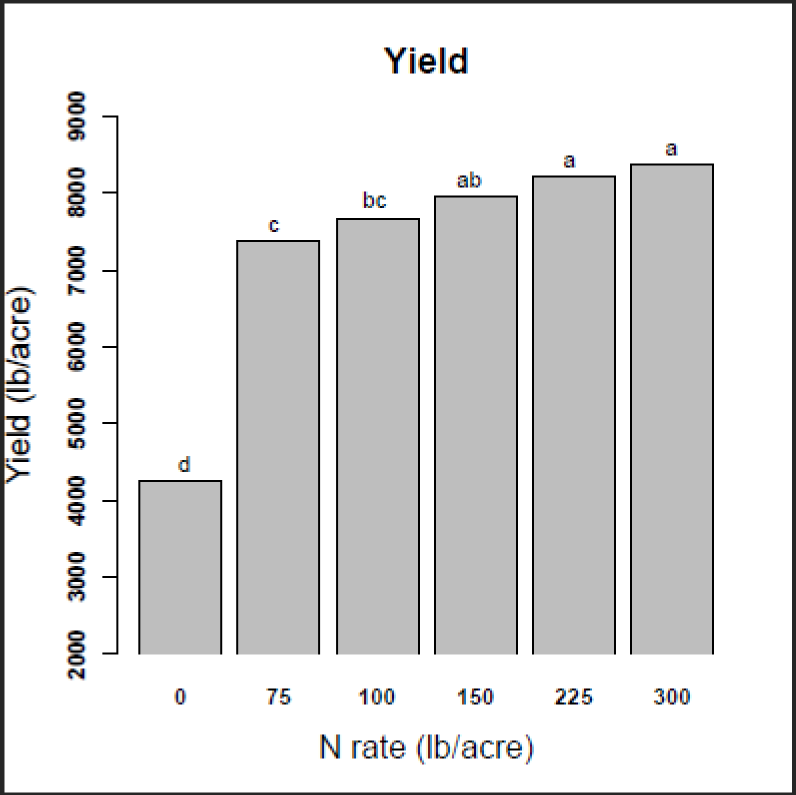
- Applications of N at Flowering boost grain protein content relative to other application timings
  - Assuming sufficient water follows N application
  - Assuming crop has sufficient yield potential

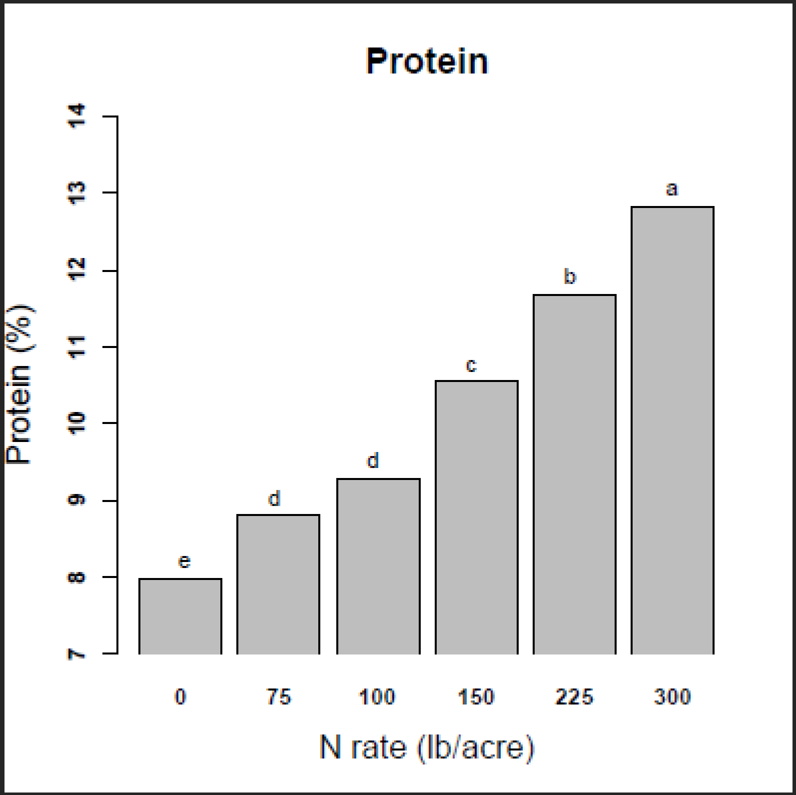
Timing of N application affects FERTILIZER USE EFFICIENCY



- Applications of N at Tillering and Flowering boost grain fertilizer use efficiency relative to other application timings
  - Interacts strongly with water availability & timing
  - Large range of possibilities (0.3 – 0.65)

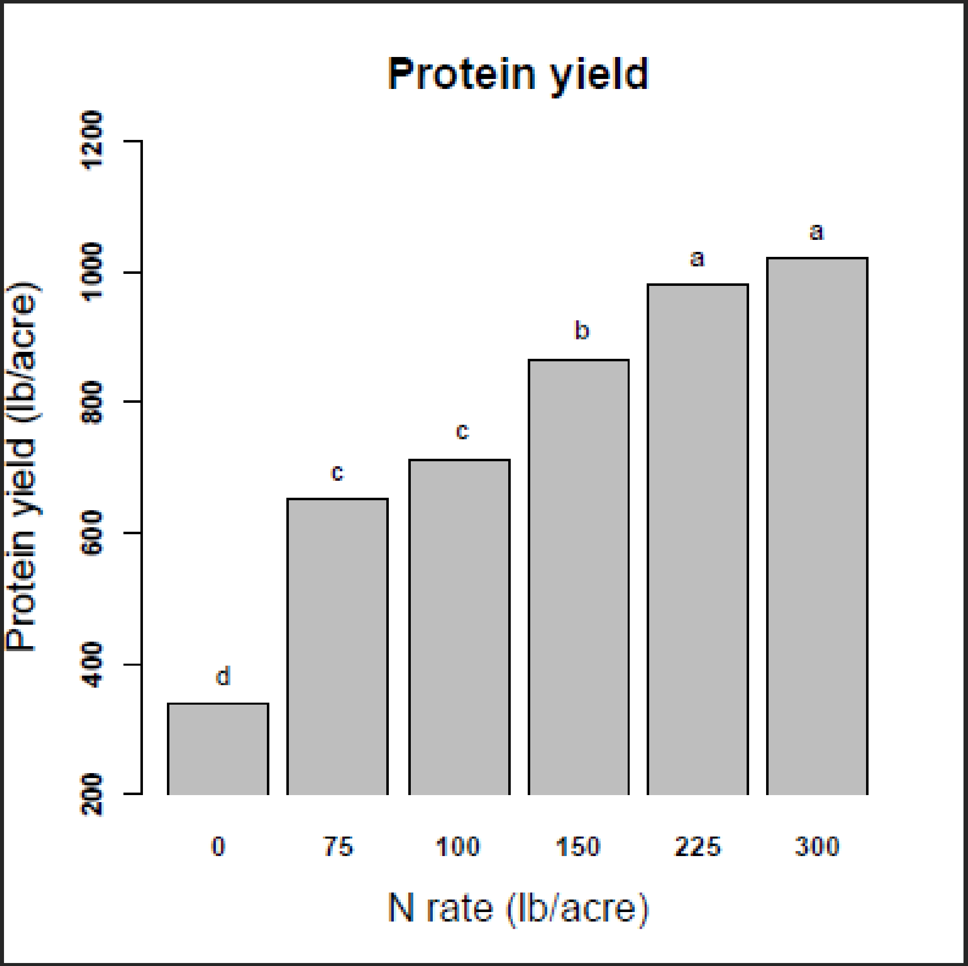
Overall demand for fertilizer N by irrigated wheat in the Sacramento Valley





Timing: preplant - tillering

Overall demand for fertilizer N by irrigated wheat in the Sacramento Valley



8000 lb $acre^{-1}$; 12% protein

- Fertilizer N demand:
  960 lb ac^{-1} – 360 lb ac^{-1} = 600 lb ac^{-1}
  600 lb ac^{-1} / 5.7 = 105 lb ac^{-1}
  105 lb ac^{-1} / 0.5 = 210 lb ac^{-1}

  2.6 lb N / 100 lb grain

- Fertilizer N demand:
  960 lb ac^{-1} – 360 lb ac^{-1} = 600 lb ac^{-1}
  600 lb ac^{-1} / 5.7 = 105 lb ac^{-1}
  105 lb ac^{-1} / 0.4 = 263 lb ac^{-1}

  3.7 lb N / 100 lb grain

Overall demand for fertilizer N by supplemental irrigated wheat in the 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}

- Fertilizer 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

- Fertilizer 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

Overall demand for fertilizer N by rainfed wheat in the Sacramento Valley

4200 lb acre^{-1}; 12.5% protein

- protein yield = 525 lb ac^{-1}

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

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

Range of N rates:

<u>114 – 263 lb ac^{-1}</u>

- depending on:

  water

  fertilizer use efficiency

- Fertilizer N demand:

  525 lb ac^{-1} – 200 lb ac^{-1} = 325 lb ac^{-1}

  325 lb ac^{-1} / 5.7 = 57 lb ac^{-1}

  57 lb ac^{-1} / 0.5 = 114 lb ac^{-1}

  2.6 lb N / 100 lb grain

- Fertilizer N demand:

  525 lb ac^{-1} – 200 lb ac^{-1} = 325 lb ac^{-1}

  325 lb ac^{-1} / 5.7 = 57 lb ac^{-1}

  57 lb ac^{-1} / 0.4 = 143 lb ac^{-1}

  3.4 lb N / 100 lb grain

How much N will the SOIL supply?

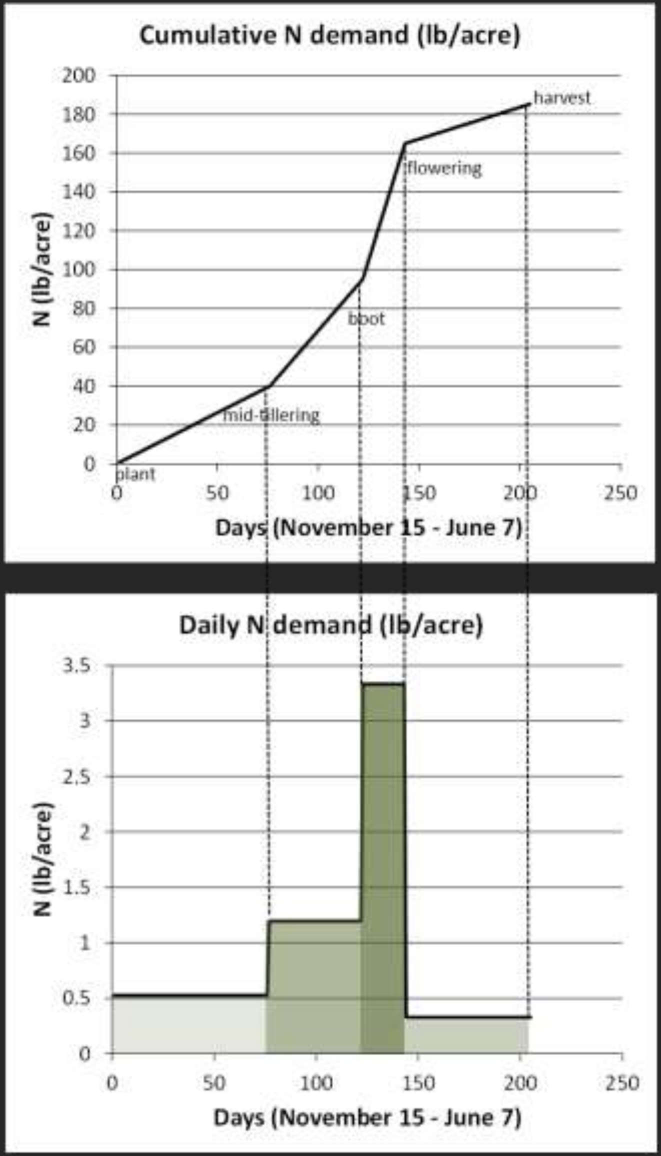
Multiple ways to estimate, many things to estimate…

- One method (top 1 foot)
  - ppm NO3-N x 4 or 5
    - Example: 12ppm NO3-N x 4 or 5 ≈ 48 – 60 lb ac^{-1}
- Second method (top 2 feet):
  - ppm NO3-N * 3.8 ≈ lb N ac^{-1} ft^{-1} of soil
    - Example: 12 ppm (1^{st} ft)*3.8 ≈ 46 lbs; 7 ppm (2^{nd} ft)*3.8 ≈ 27 lbs
      - Total ≈ 73 lb ac^{-1}
      - Or: 73 lb ac^{-1} x 0.75 ≈ 54 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} +

How much N will the SOIL supply?

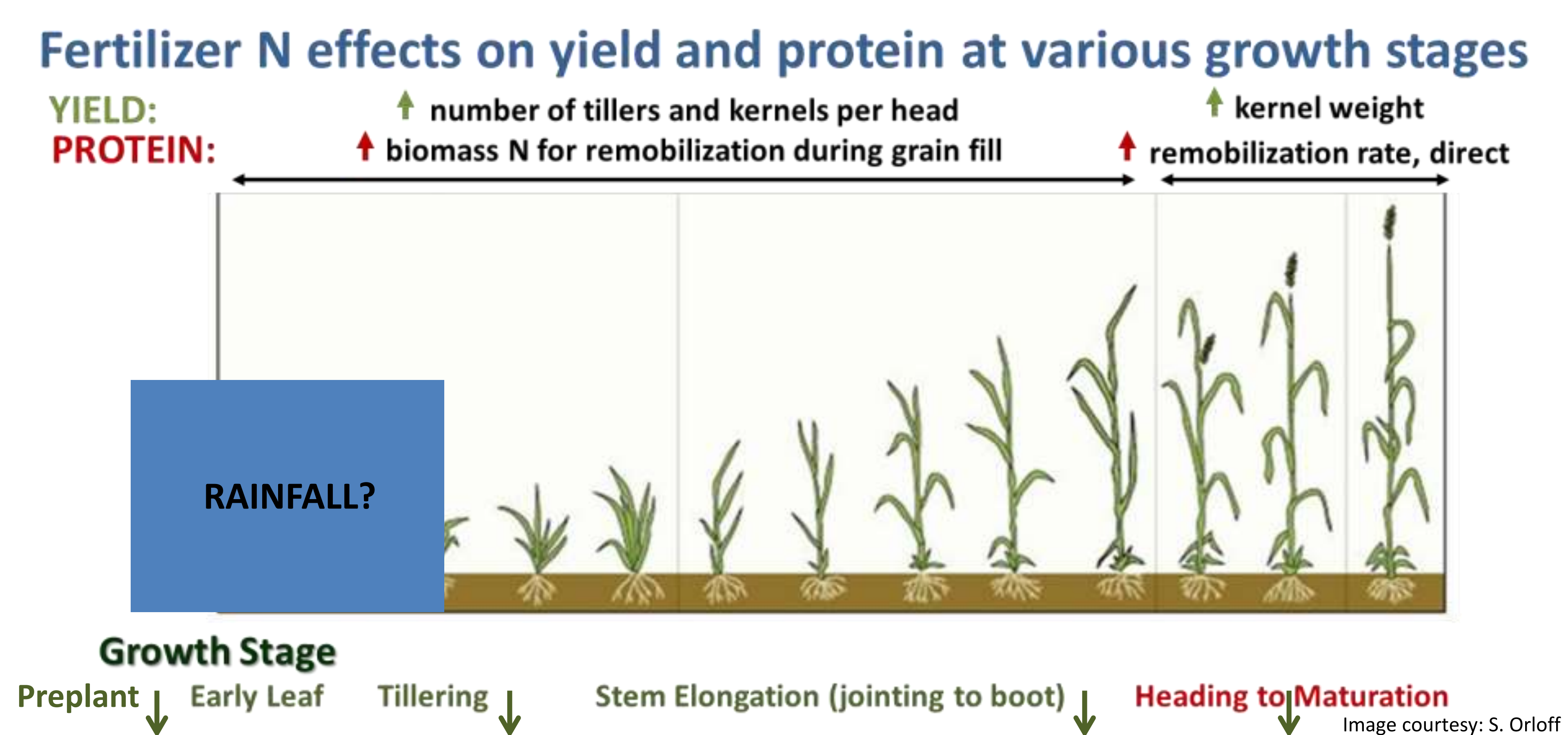
Multiple ways to estimate, many things to estimate…

- In-season soil organic matter N mineralization:
  - 0.8% OM % * 30 lb N / % OM ≈ 24 lb ac^{-1}
- Other sources:
  - irrigation
  - manure



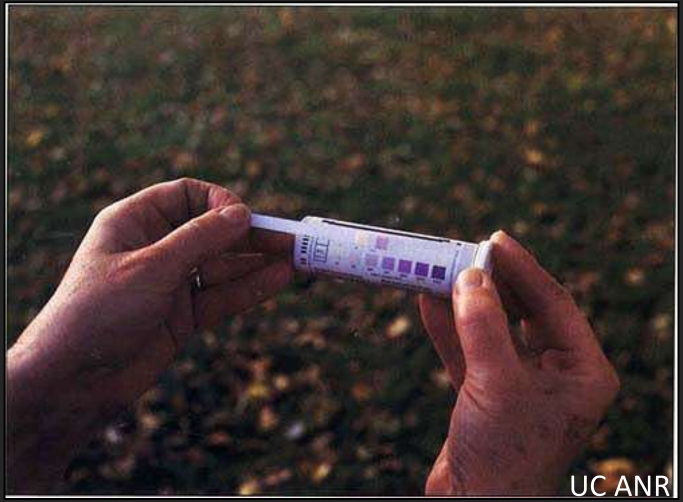
Yield = 7500 lb $acre^{-1}$; Protein = 11.5%

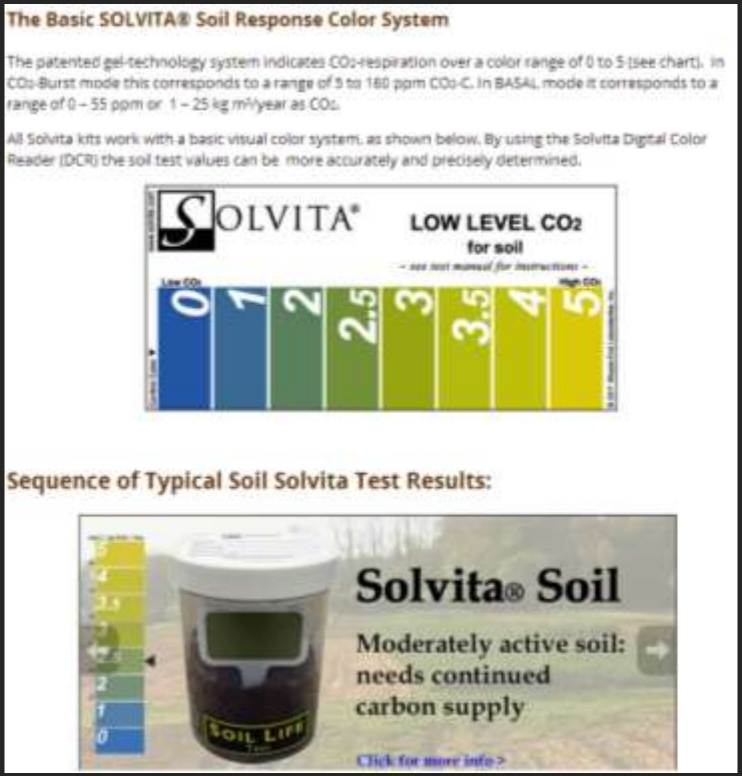
Key management variables to consider when determining N fertility at various growth stages



Preplant	Tillering	Stem Elongation	Heading to Maturation
yield potential	yield potential	yield potential	yield potential
irrigation	water status	water status	water status
site fertility	soil N status	plant N status	plant N status
variety	plant N status	logistics	logistics
end use	logistics	soil N status	
premium / discount			

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





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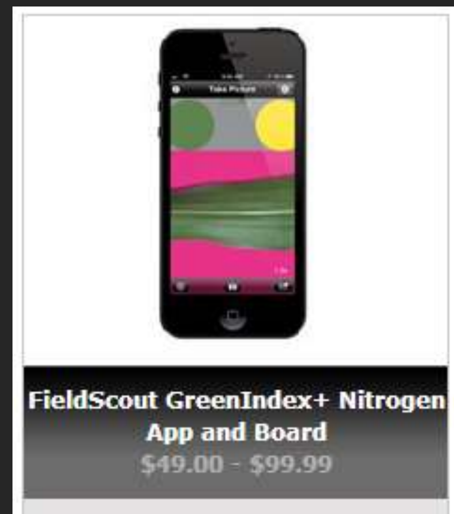
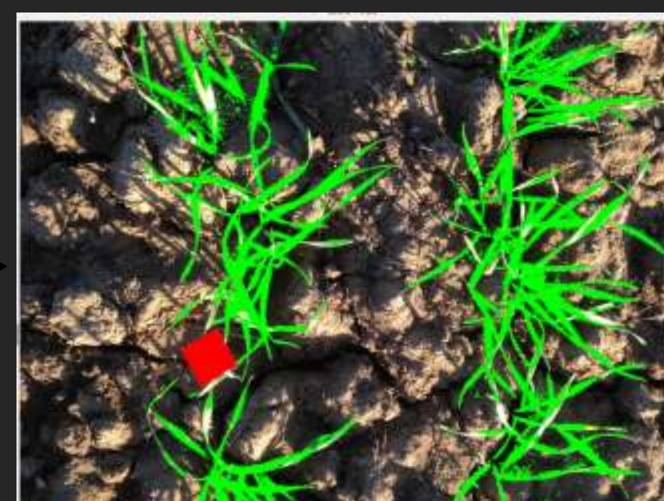
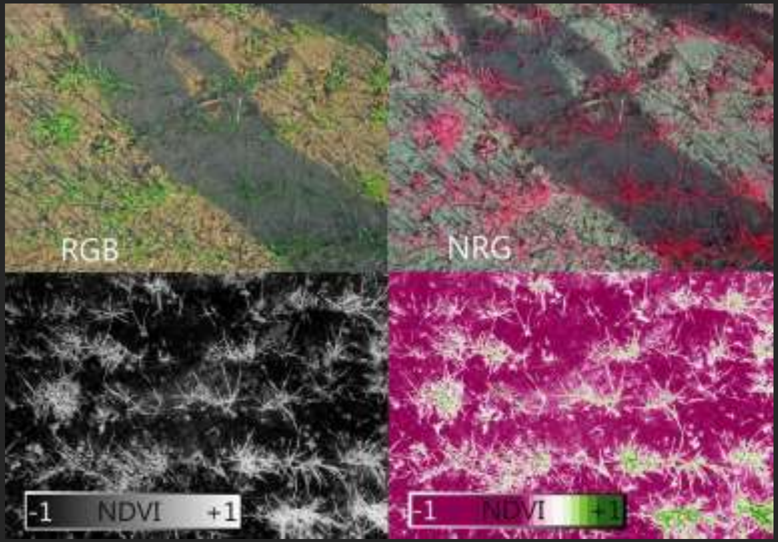
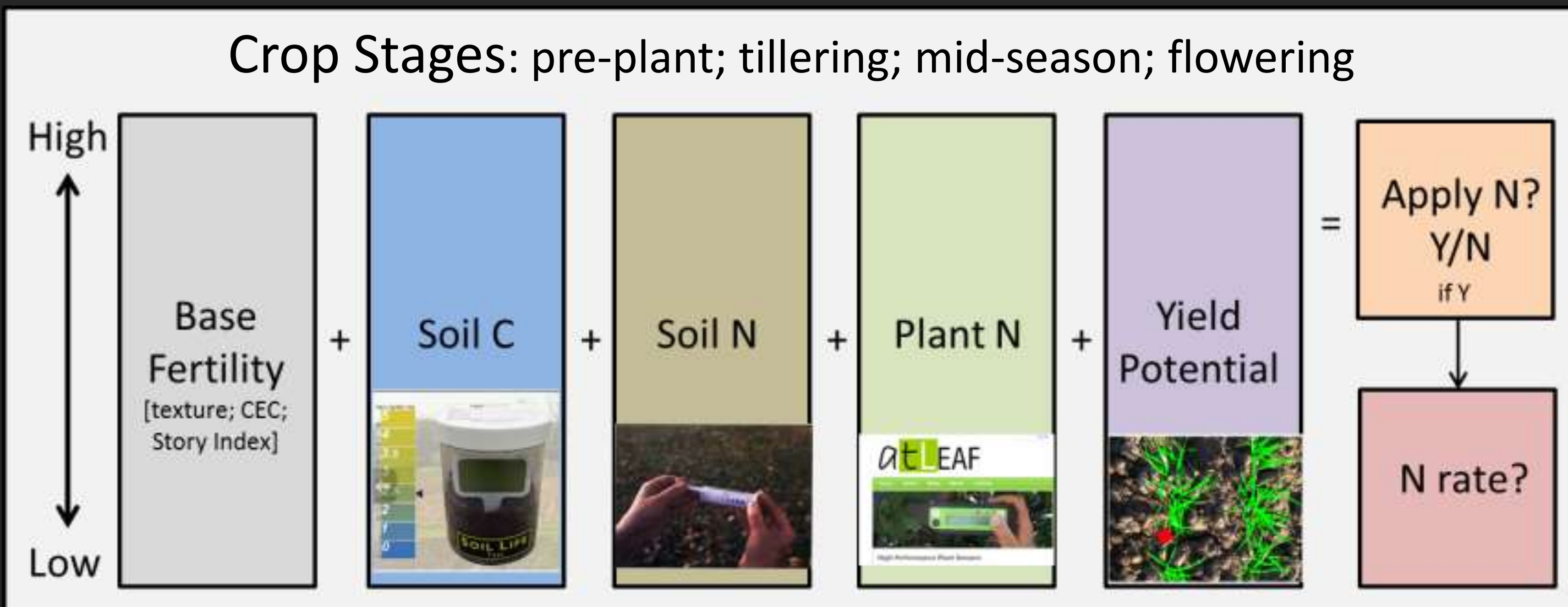




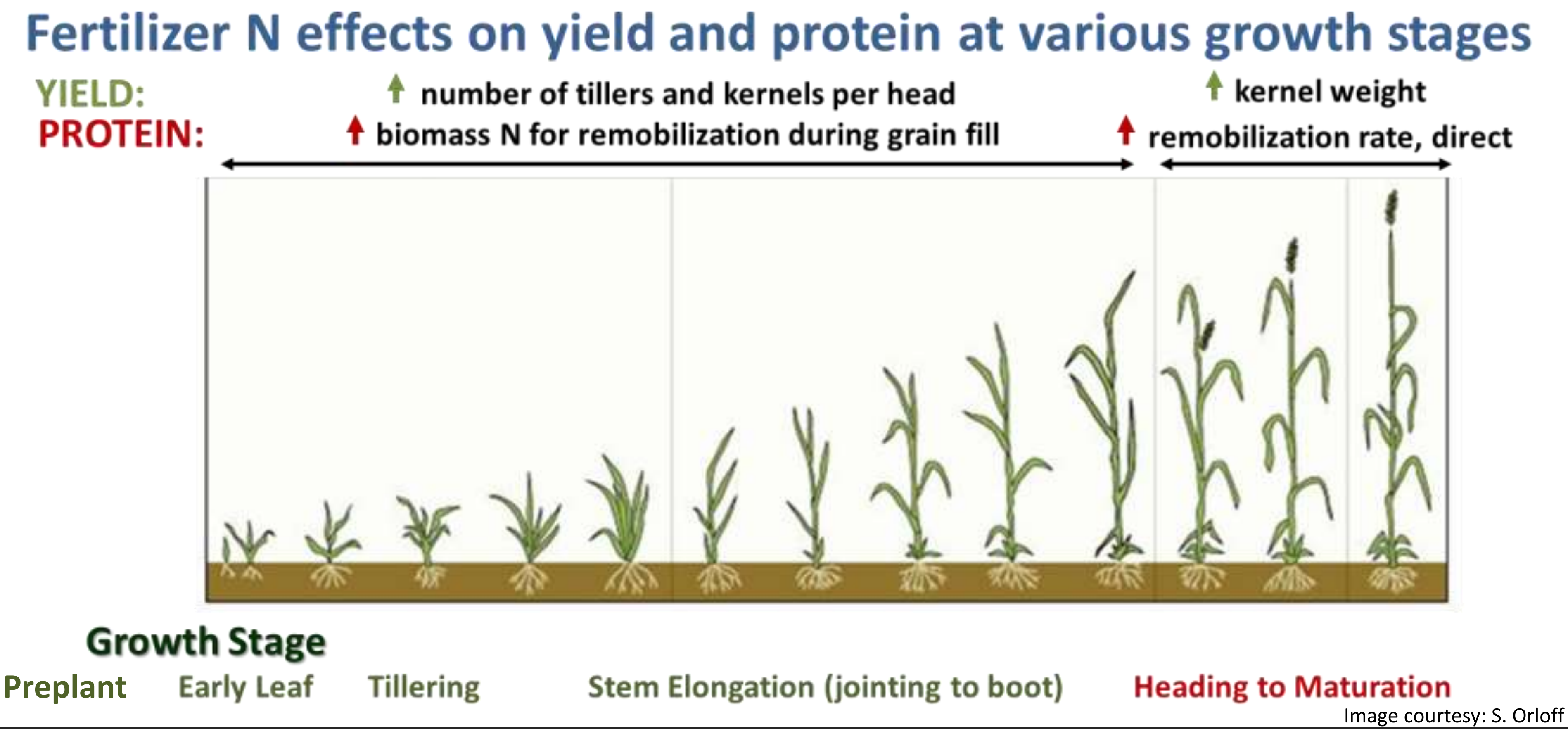
What tools are available to assist in real-time N management in wheat?



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



Management variables that can be approximated by low-cost, in-field technologies



yield potential	yield potential	yield potential	yield potential
irrigation	water status	water status	water status
site fertility	soil N status	plant N status	plant N status
variety	plant N status	logistics	logistics
end use	logistics	soil N status	
premium / discount			

Management variables that can be approximated by low-cost, in-field technologies

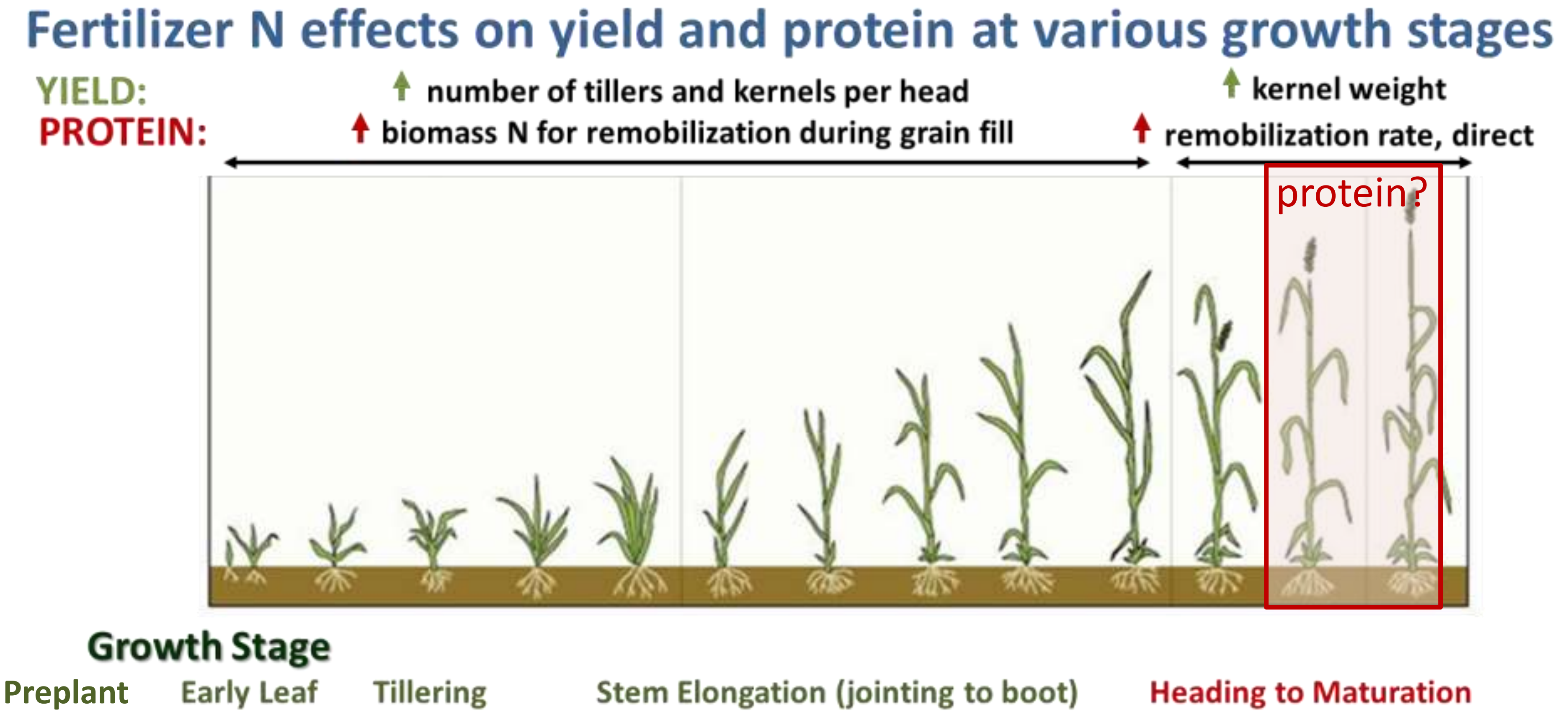


Image courtesy: S. Orloff

yield potential
plant N status

In-field measurement devices

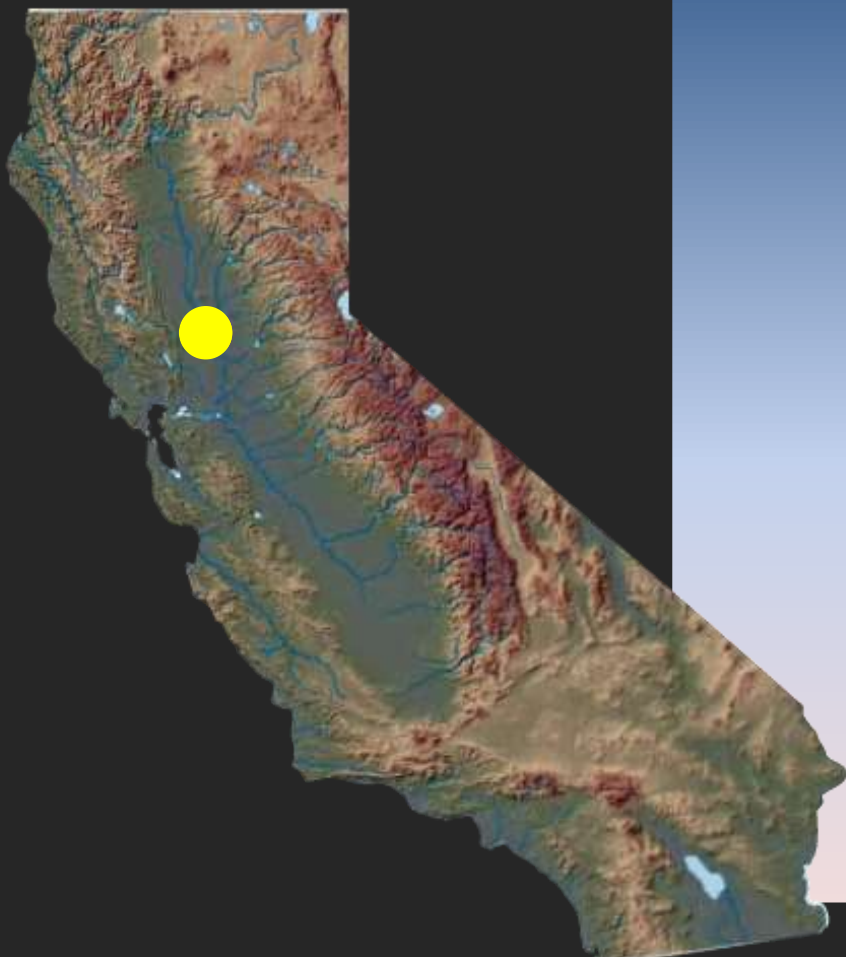
atLEAF chlorophyll meter

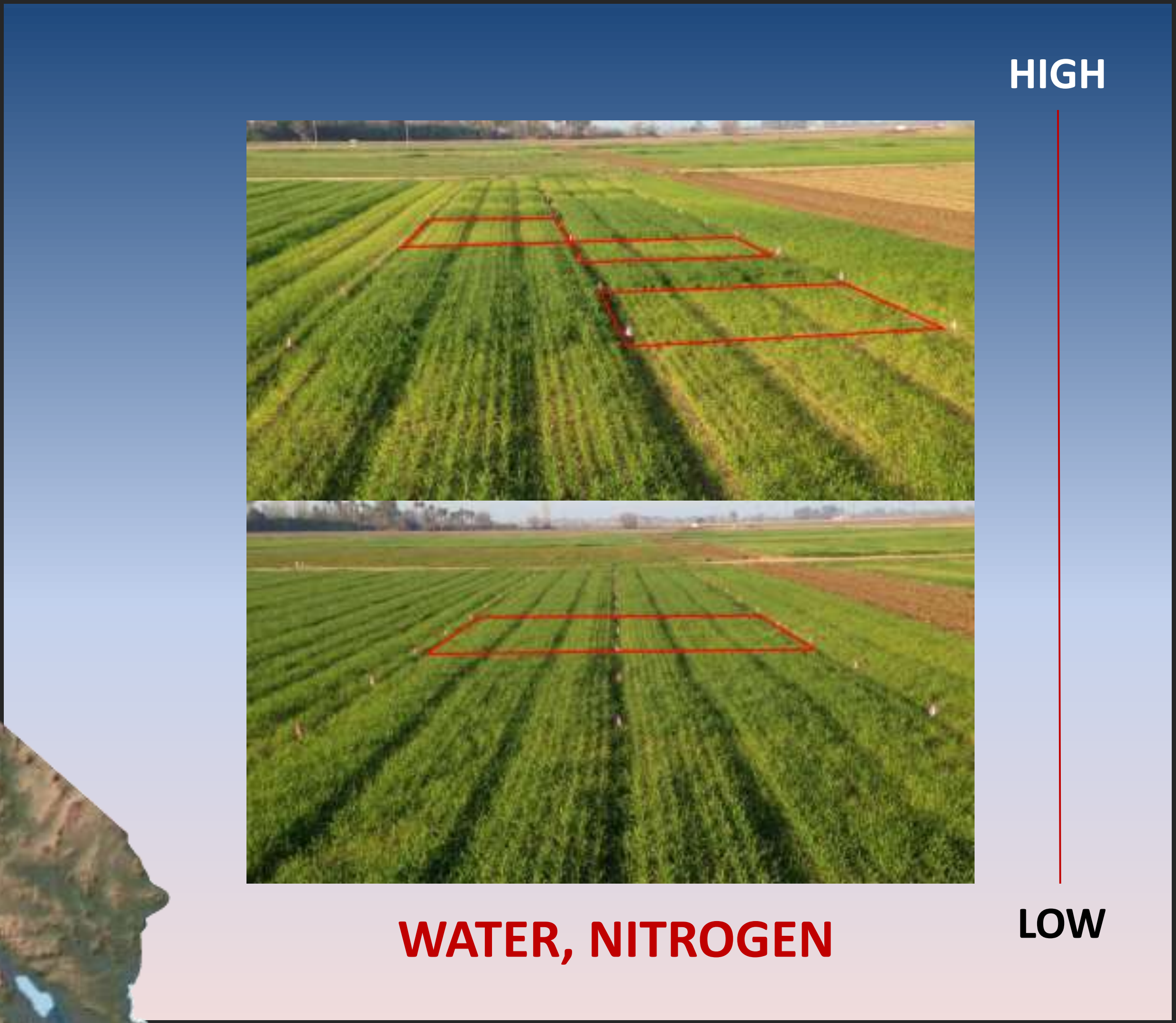
- SPAD proxy (660 and 940 nm)
- proxy for yield leaf N concentration
- Retail: ≈ $250

Trimble Greenseeker handheld

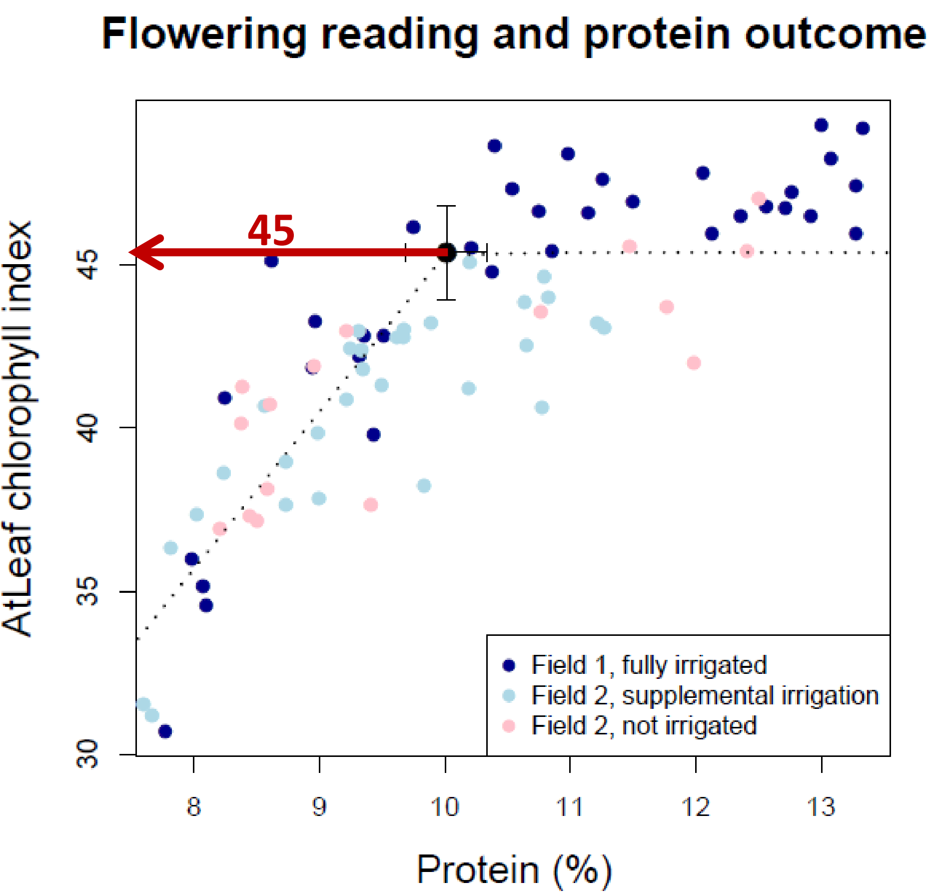
- NDVI (660 and 770 nm)
- Suitable proxy for yield potential?
- Retail: ≈ $500

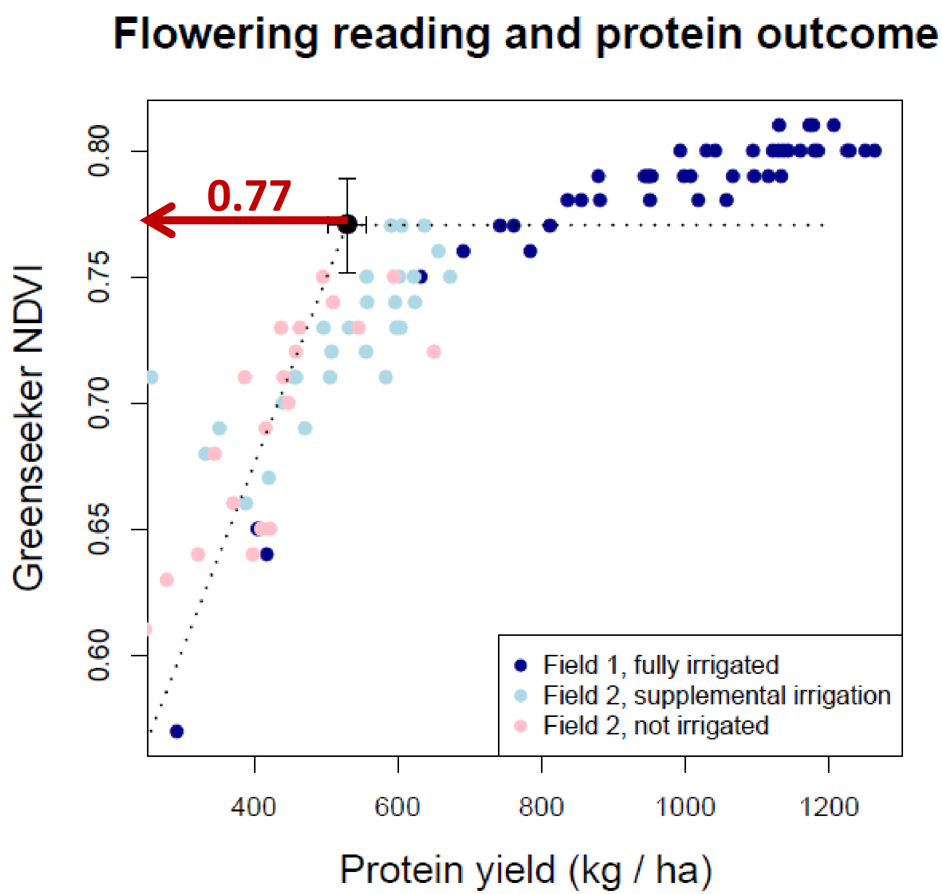
Methods: Calibrate across N and water gradients at key points during crop growth



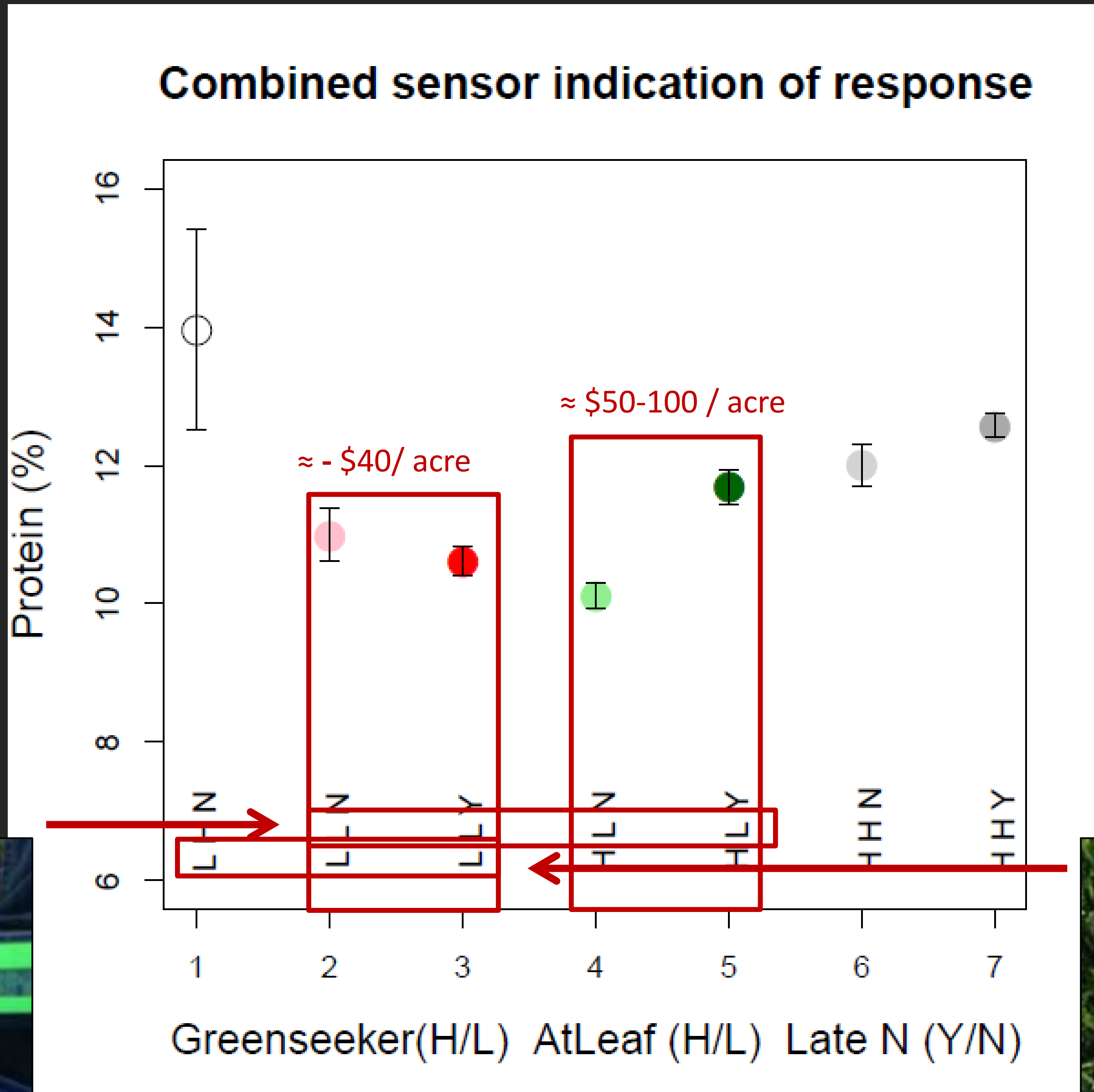


Results: Calibration





Results: Decision support



*For $7.50/bu wheat with $0.01/ lb premium or discount / % above or below target (11%).

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 in-field sensors provided actionable, real-time information as to the protein and protein-yield outcomes of the crop.

4. Combining information from more than one sensor resulted in additive information that improved the in-season ability to predict outcome.

DIY calibration?

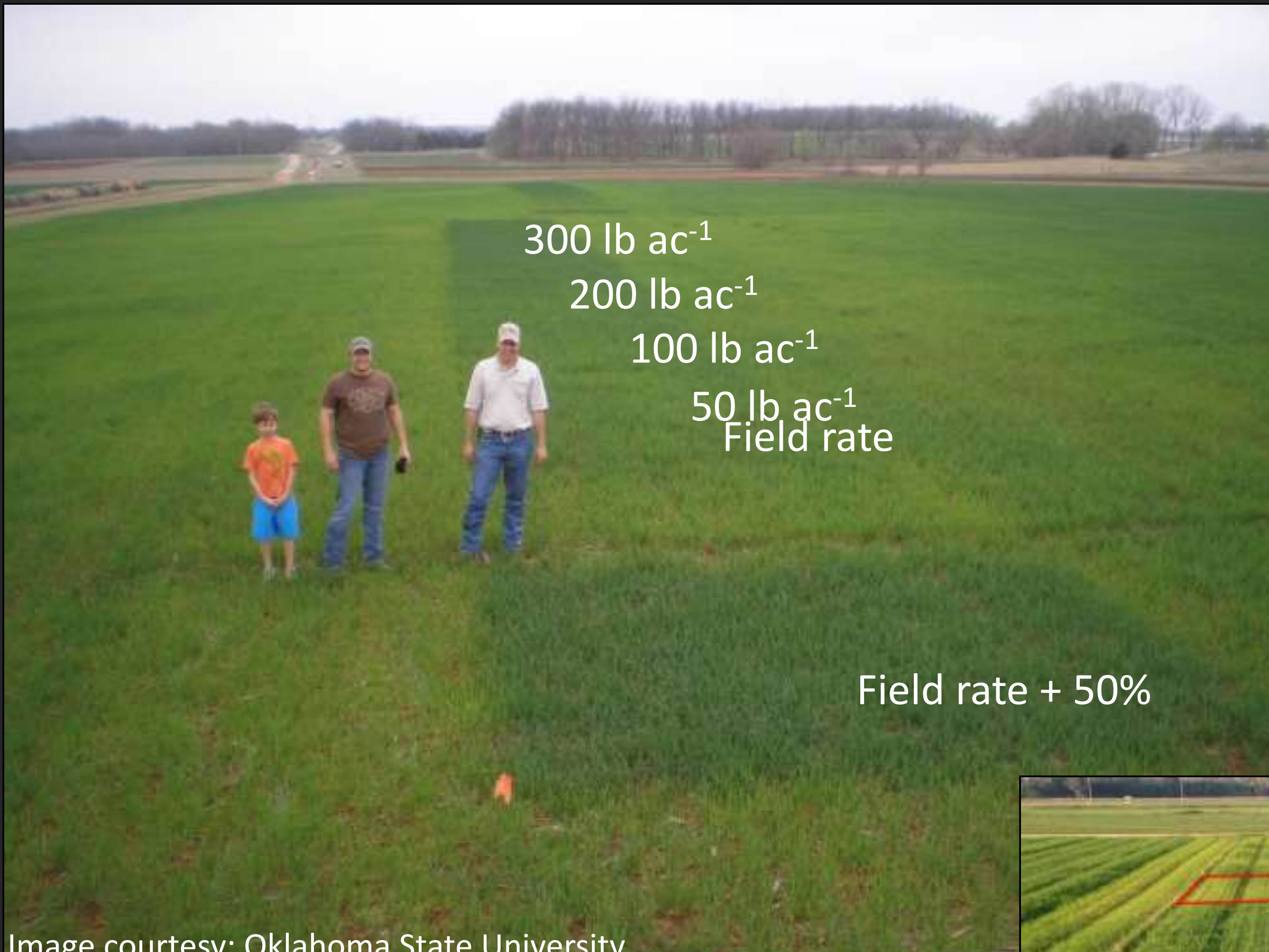
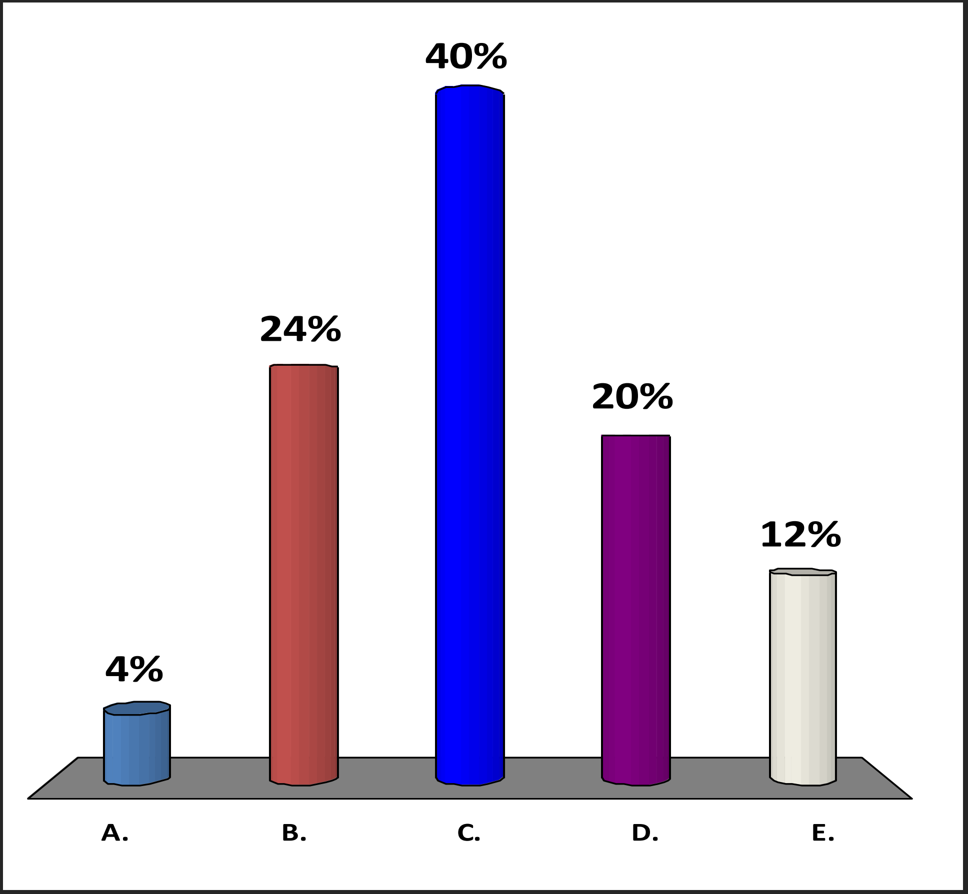


Image courtesy: Oklahoma State University

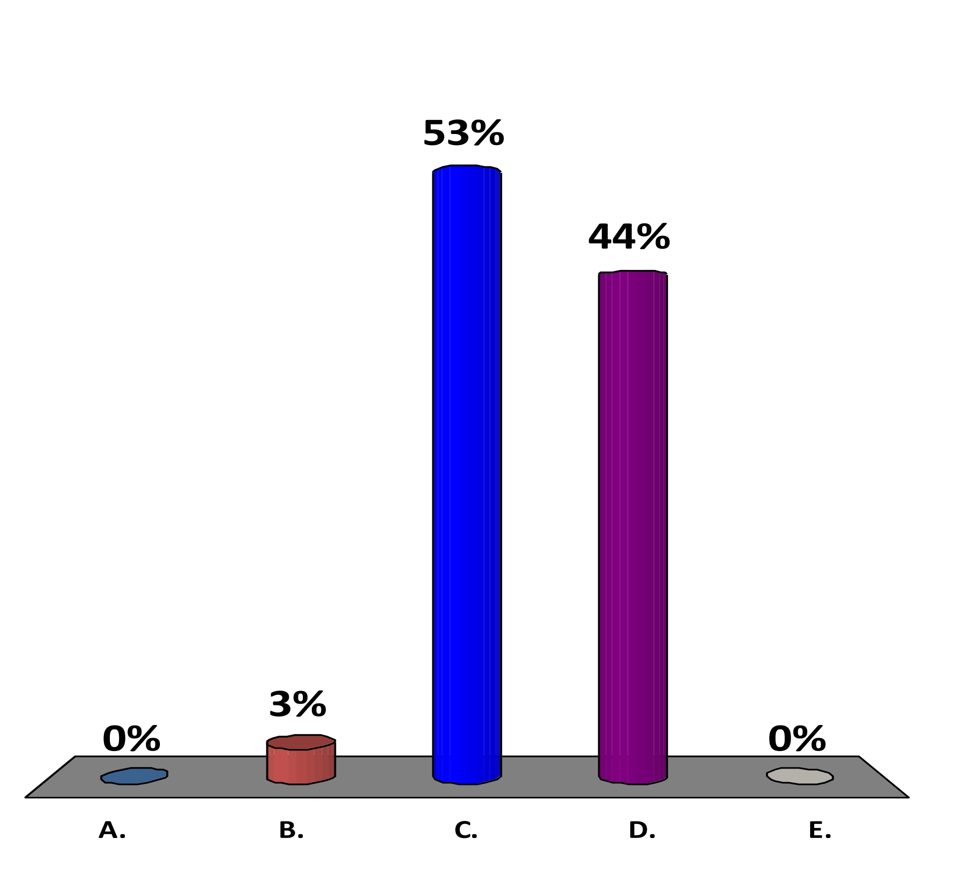
If a suite of 3-4 in-field tests/measures at flowering could predict your ability to add 1% protein to your wheat crop with 60-70% accuracy, how much extra time would you be willing to invest to accomplish this on a 100 acre wheat field?

A. None
B. 30 minutes
C. 1 hour
D. 2 hours
E. 4 hours



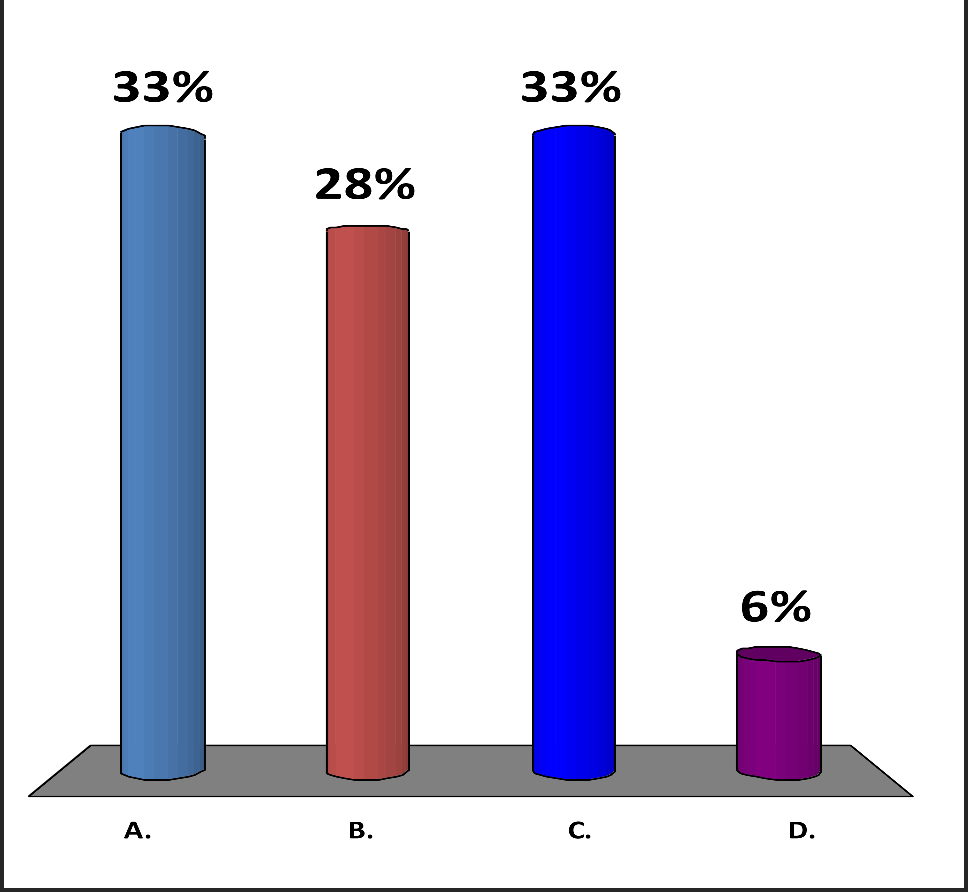
On an annual basis, how much would you be willing to invest in tools/tests that would enable this type of decision?

A. Nothing
B. $10
C. $100
D. $1000
E. $10000



Is calibrating in-field diagnostic tools for improved fertility management something you are interested in…

A. Participating in actively
B. Participating in casually
C. Learning more about
D. Not interested



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