Intensive wheat production: How to manage source and sink

- Agvise Seminars
- March 11 & 13, 2025
- Brent Jaenisch, Ph.D.

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Outline

- Yield gap
- Yield components
  - Kernels/foot
  - Kernel weight
- On Farm Survey
  - Overview of Their Importance
  - Materials and Methods
  - Results
  - Conclusions
- Field Experiments of IWM
  - Introduction
  - Materials and Methods
  - Results
  - Conclusions

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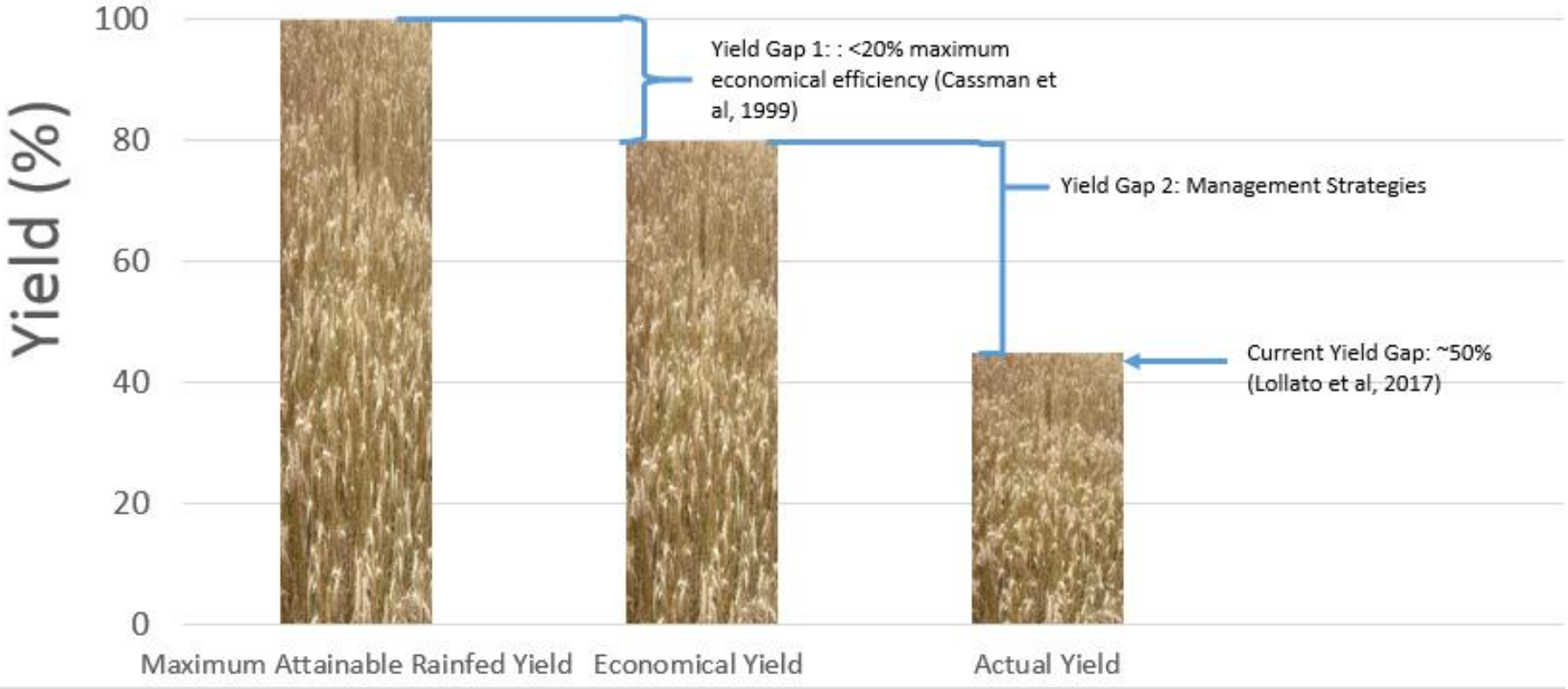
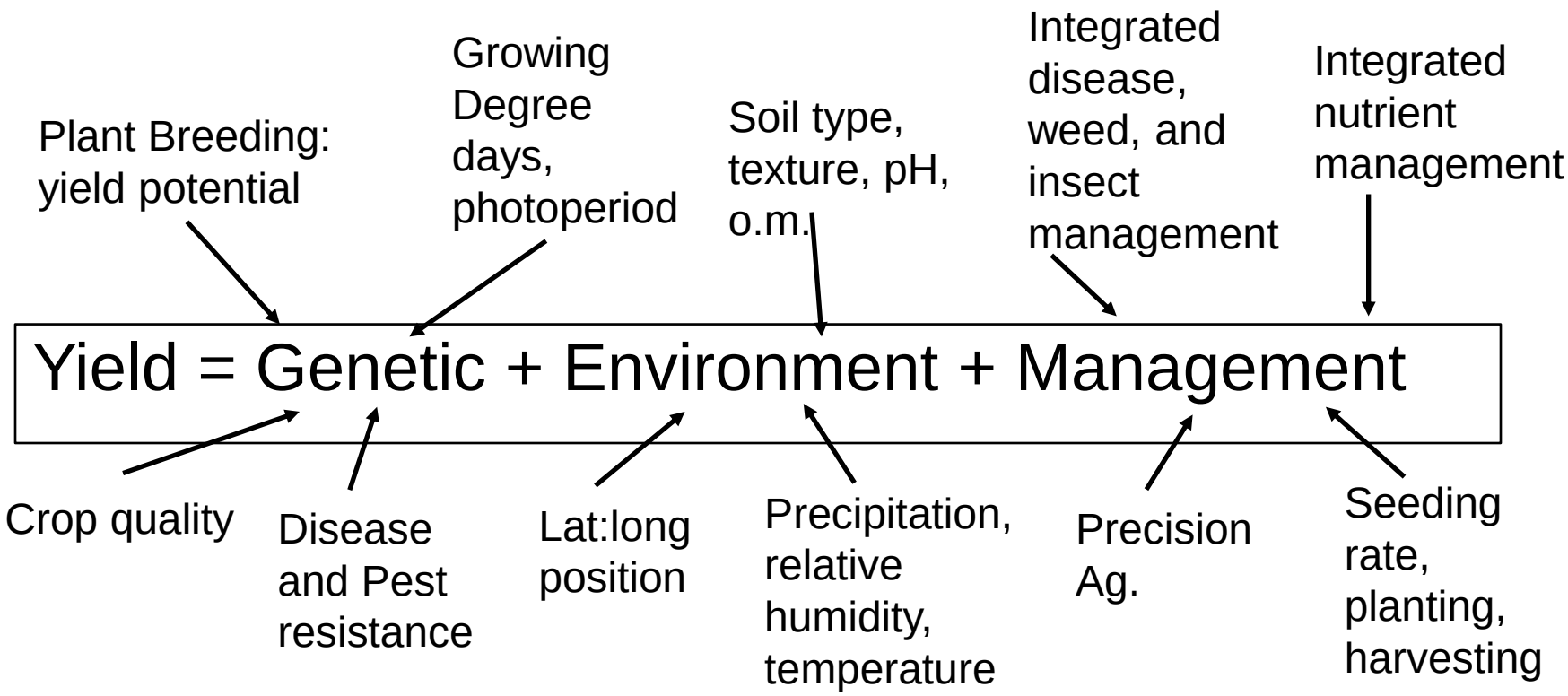
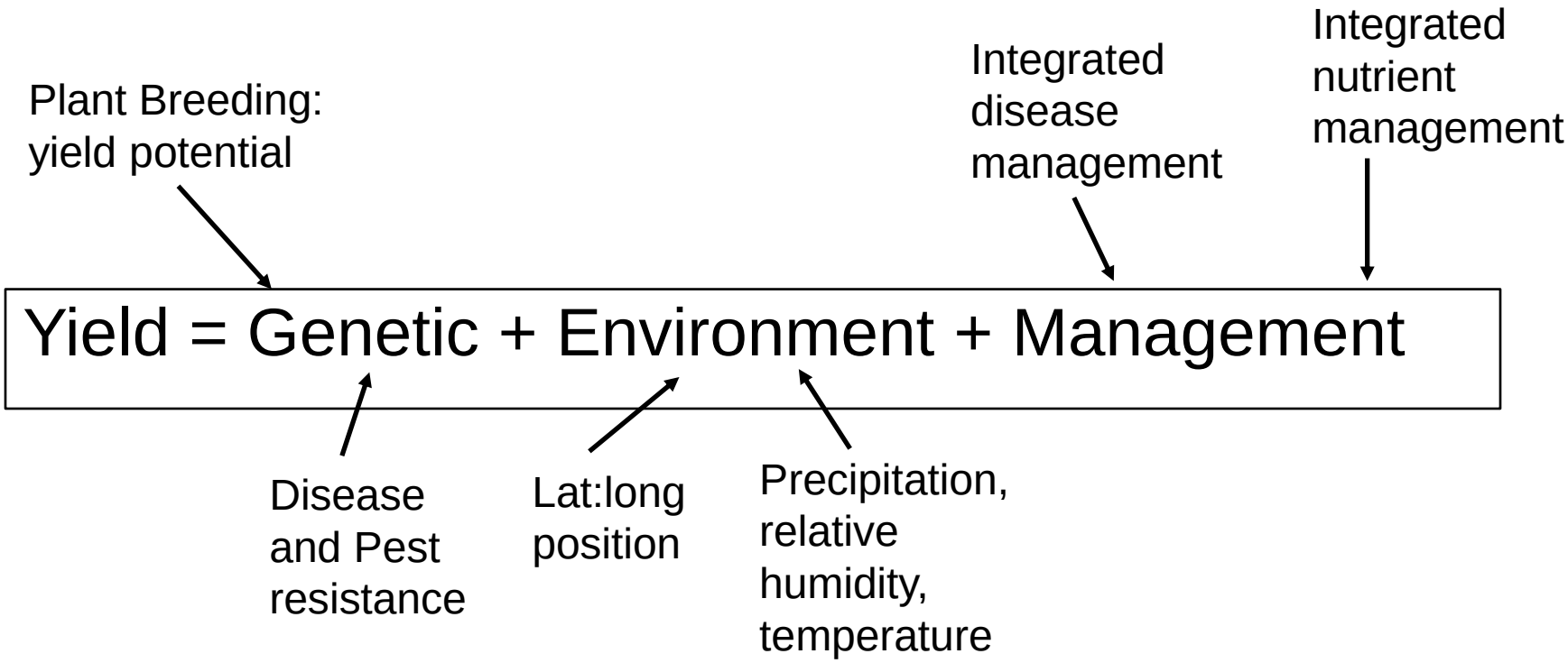
Yield Gap Concept

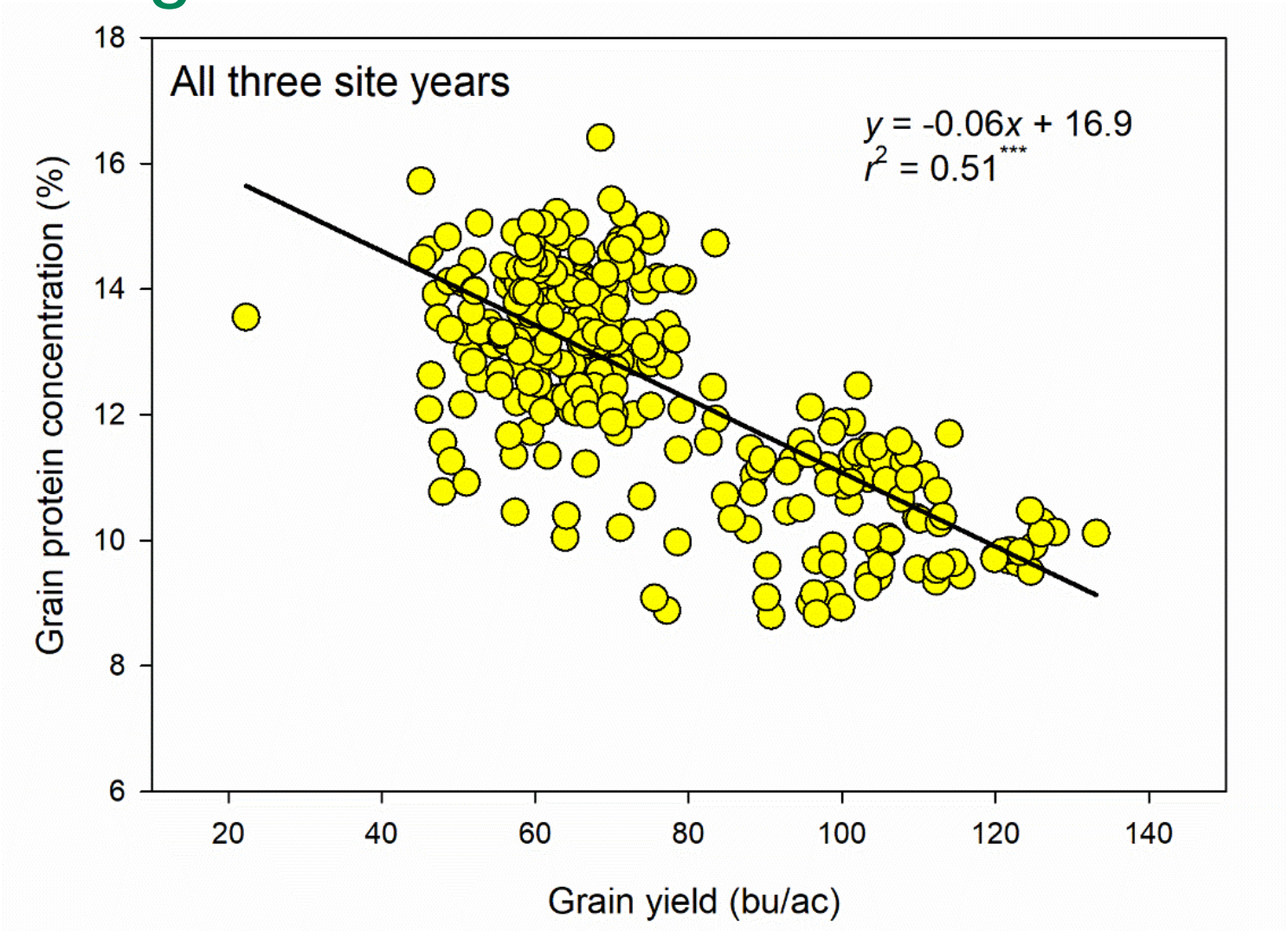


Yield = Genetic + Environment + Management


Plant Breeding: yield potential
Growing Degree days, photoperiod
Soil type, texture, pH, o.m.
Integrated disease, weed, and insect management
Integrated nutrient management
Yield = Genetic + Environment + Management
Crop quality
Disease and Pest resistance
Lat:long position
Precipitation, relative humidity, temperature
Precision Ag.
Seeding rate, planting, harvesting

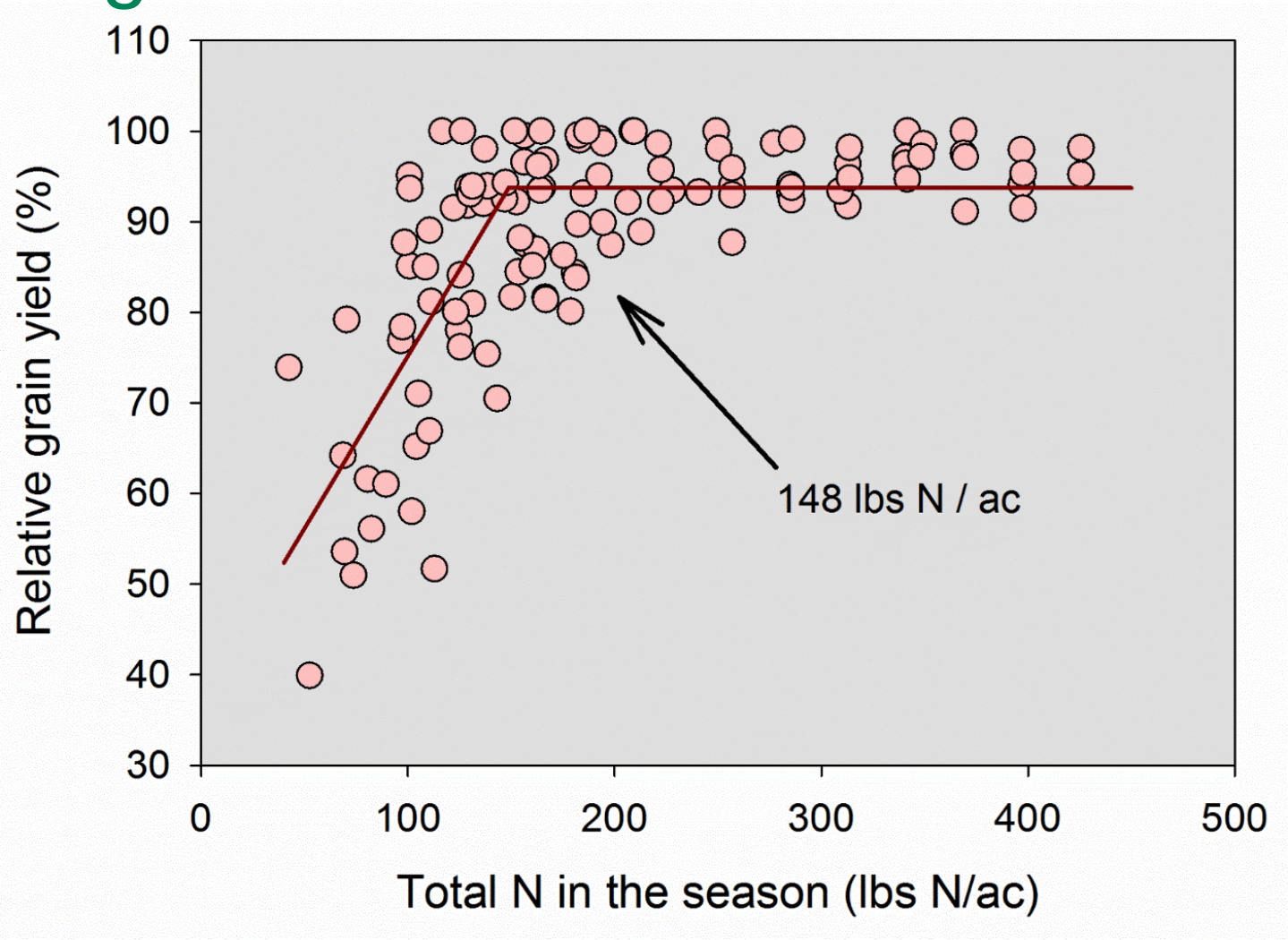

Plant Breeding:
yield potential
Integrated
disease
management
Integrated
nutrient
management
Yield = Genetic + Environment + Management
Disease
and Pest
resistance
Lat:long
position
Precipitation,
relative
humidity,
temperature

Nitrogen



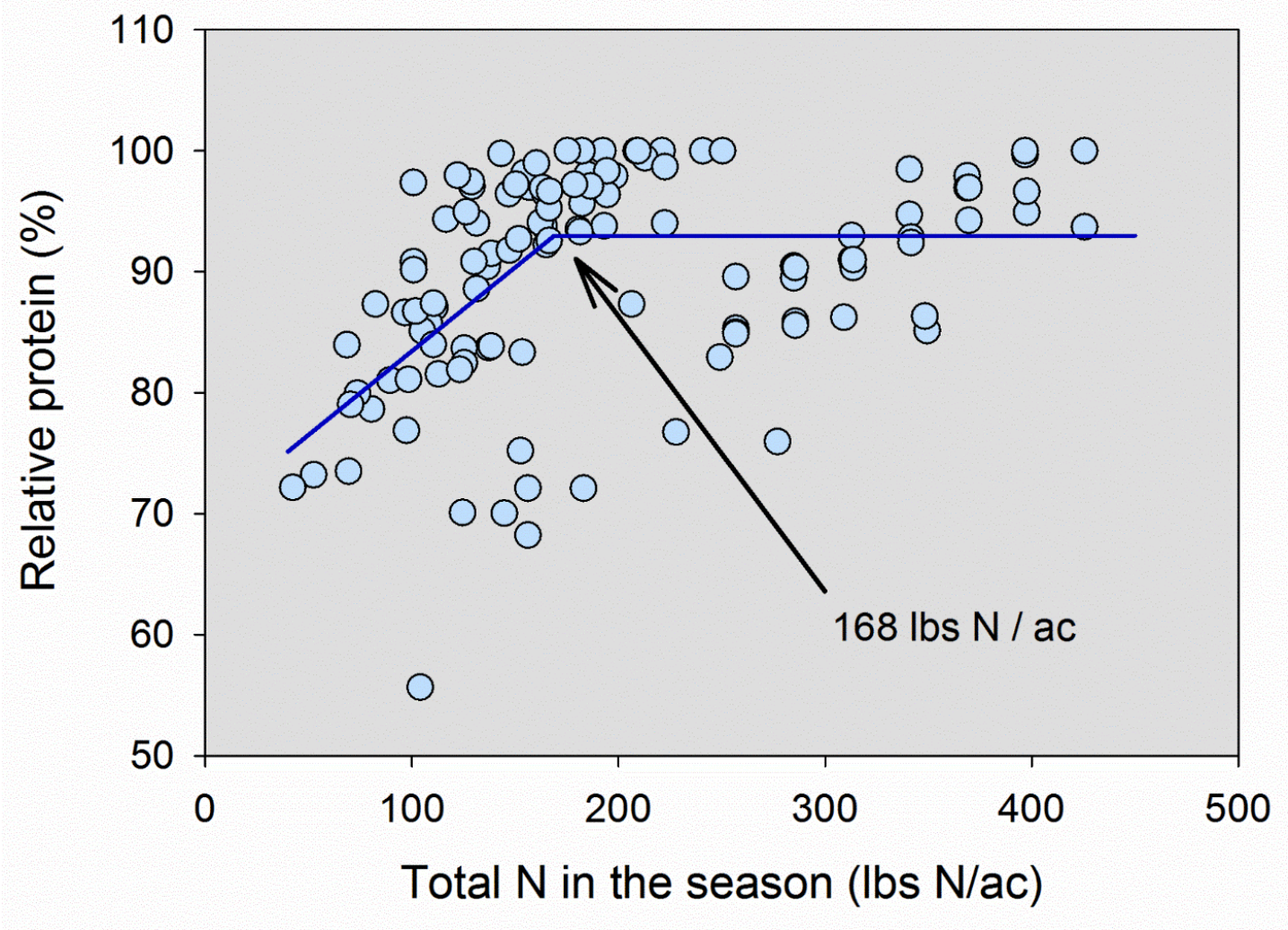
Lollato et al. (2021)

Nitrogen

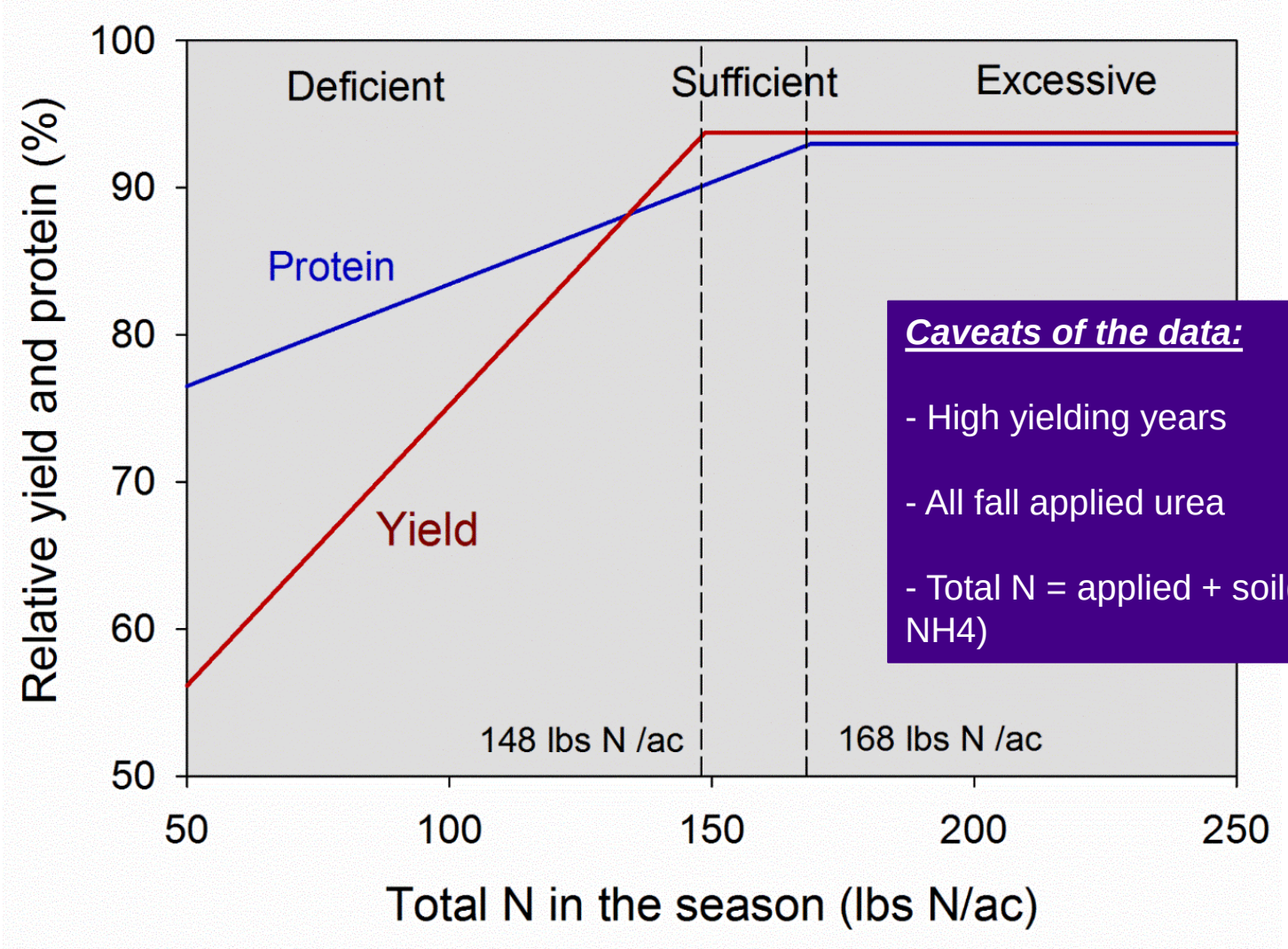


Lollato et al. (2021)

Nitrogen



Lollato et al. (2021)



Caveats of the data:

- High yielding years
- All fall applied urea
- Total N = applied + soil(NO3 + NH4)

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Lollato et al. (2021)

Stripe Rust

De Oliveira Silva et al. *In preparation.*

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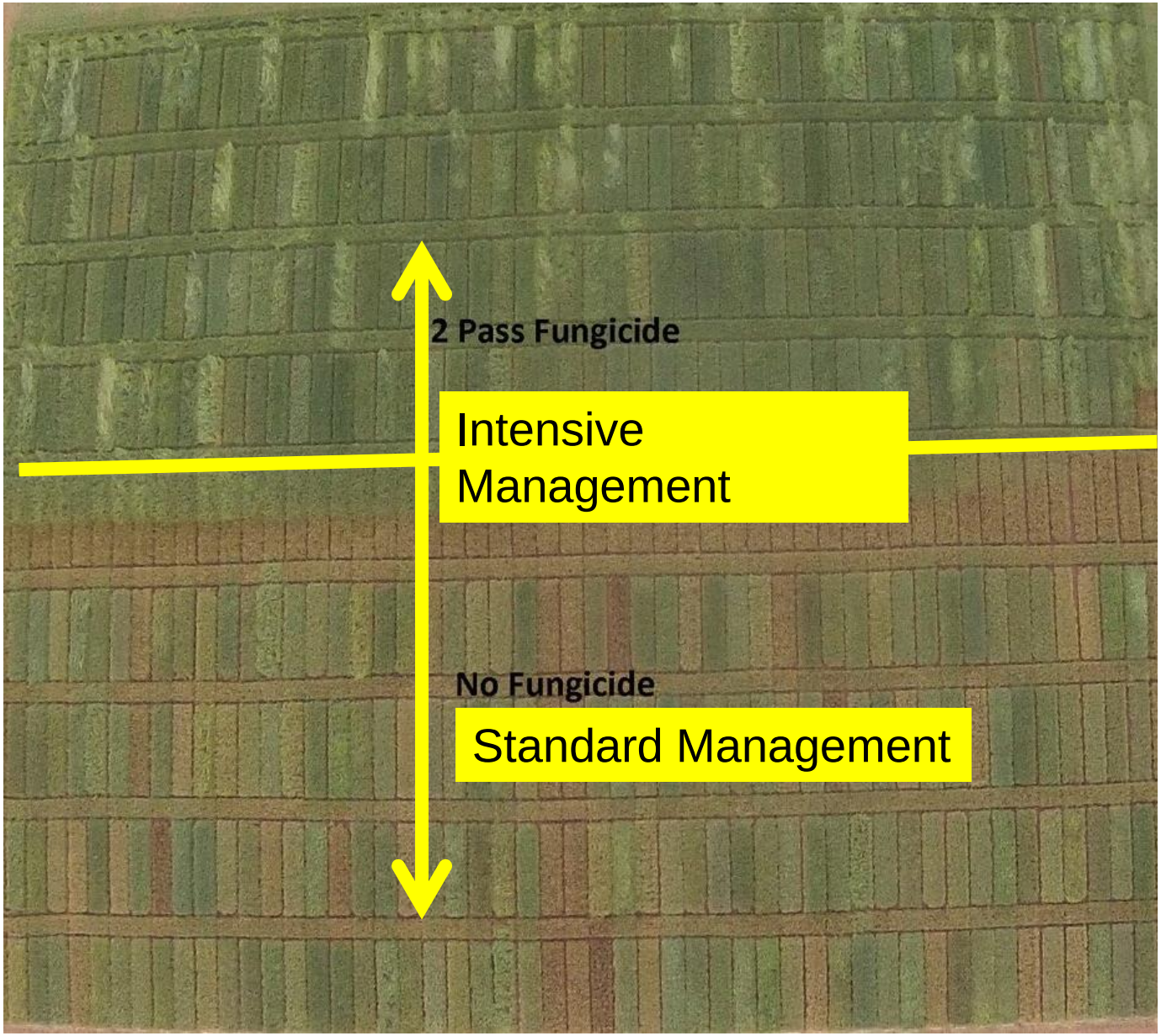
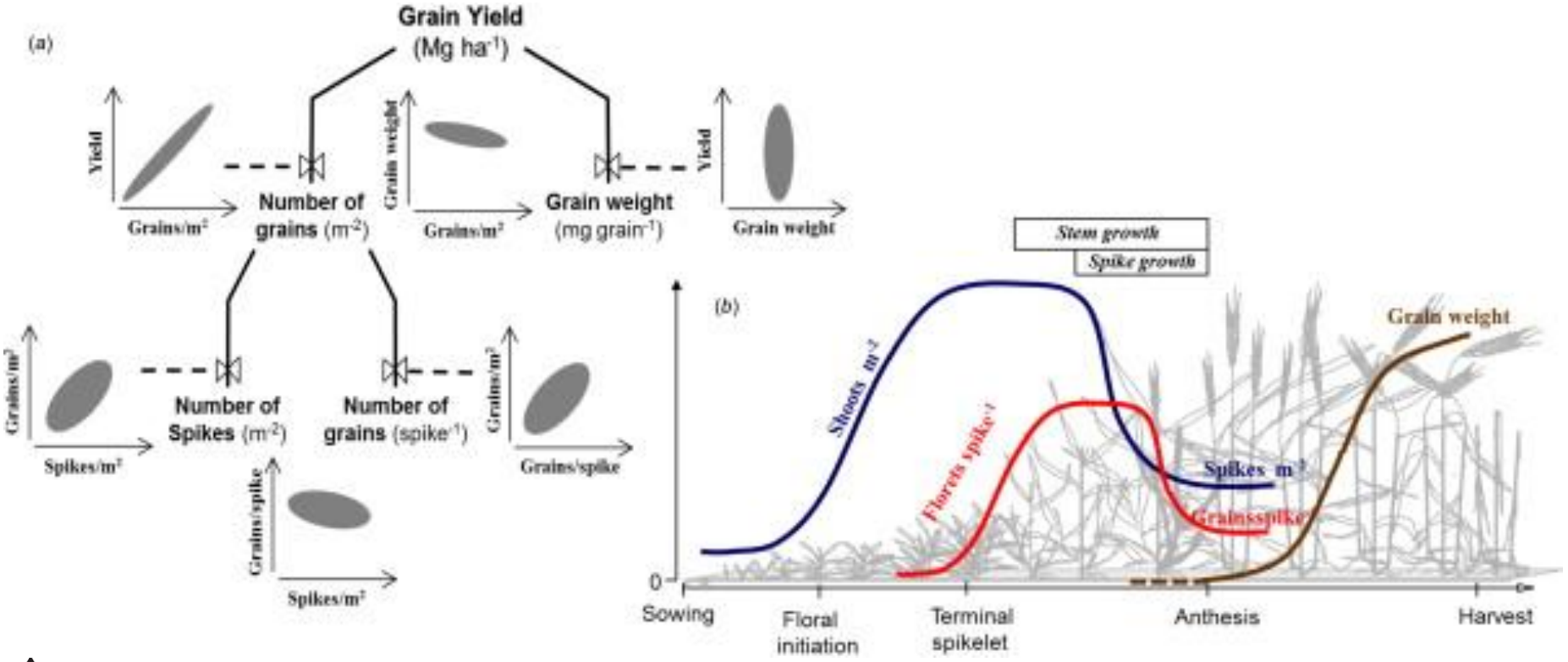


Photo courtesy of Brian Arnall, OSU Soil Fertility Extension Specialist

What is source and sink?

- Source: Photosynthates
- Sink: Grains



K-STATE Research and Extension

Modulation of wheat yield components in response to management intensification to reduce yield gaps

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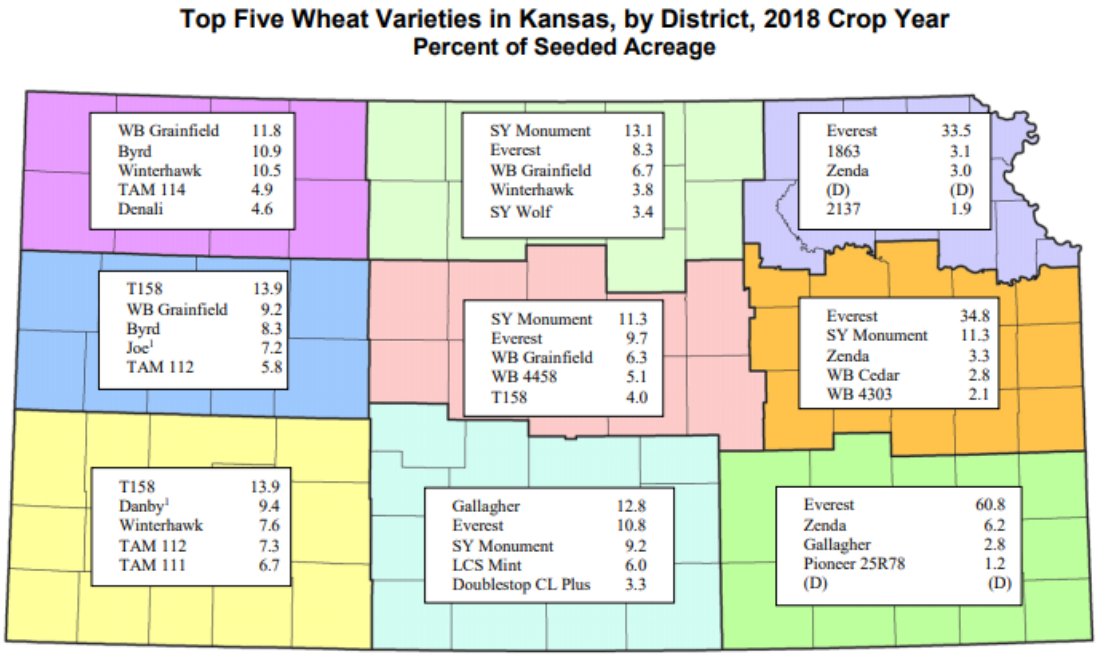
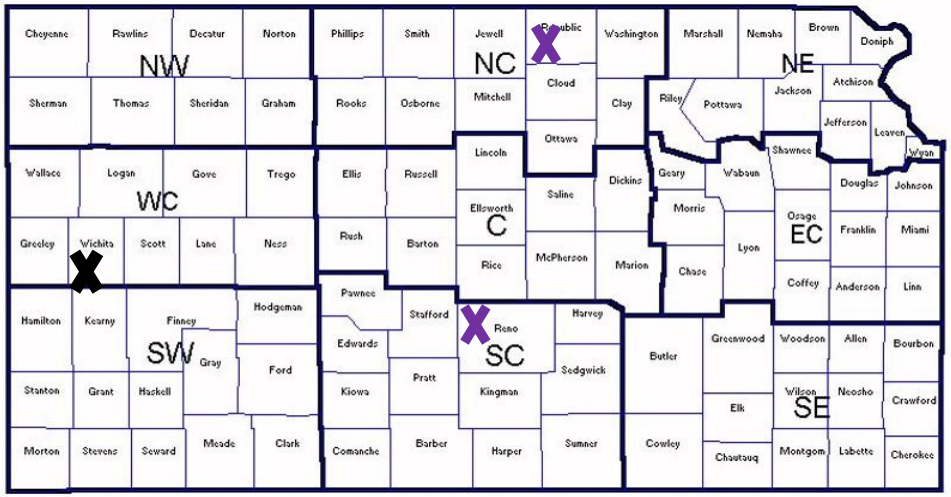
Variety Selection

- Variety selection is an important decision for a wheat producer.



Experiment Design and Treatment Structure

- Three locations in Kansas in 2018 and 2019
  - Belleville, Hutchinson, and Leoti
- Complete factorial in a split-plot design
- Whole Plot (RCBD)
  - Management Strategy
- Sub plot
  - Wheat Varieties



Experiment Design and Layout

- Six Management Strategies
  - Farmer Practice (FP)
  - Enhanced Fertility (EF)
  - Economical Intensification (EI)
  - Increased Foliar Protection (IFP)
  - Water limited Yield (Yw)
  - Increased Plant Productivity (IFP)
- Four wheat varieties widely adapted for the region
  - Hutchinson and Belleville
    - WB Grainfield
    - WB 4458
    - WB 4303
    - Zenda

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)
FP	No	No	No	No	Standard

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)
FP	No	No	No	No	Standard
EF	Yes	No	No	No	Standard

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FP	No	No	No	No	Standard
EF	Yes	No	No	No	Standard
EI	Yes	Yes	No	No	Standard

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)
FP	No	No	No	No	Standard
EF	Yes	No	No	No	Standard
EI	Yes	Yes	No	No	Standard
IFP	Yes	Yes	Yes	No	Standard

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)
FP	No	No	No	No	Standard
EF	Yes	No	No	No	Standard
EI	Yes	Yes	No	No	Standard
IFP	Yes	Yes	Yes	No	Standard
Yw	Yes	Yes	Yes	Yes	Standard

Treatment Structure

Mgmt	+N rate for 100 bu/ac +100 lbs MESZ/ ac	+Fungi. (Flag Leaf)	+Fungi. (Jointing and Flag Leaf)	+Micro	+Plant Pop. (Million seeds/ ac)
FP	No	No	No	No	Standard
EF	Yes	No	No	No	Standard
EI	Yes	Yes	No	No	Standard
IFP	Yes	Yes	Yes	No	Standard
Yw	Yes	Yes	Yes	Yes	Standard
IPP	Yes	Yes	Yes	Yes	Ultra-Low

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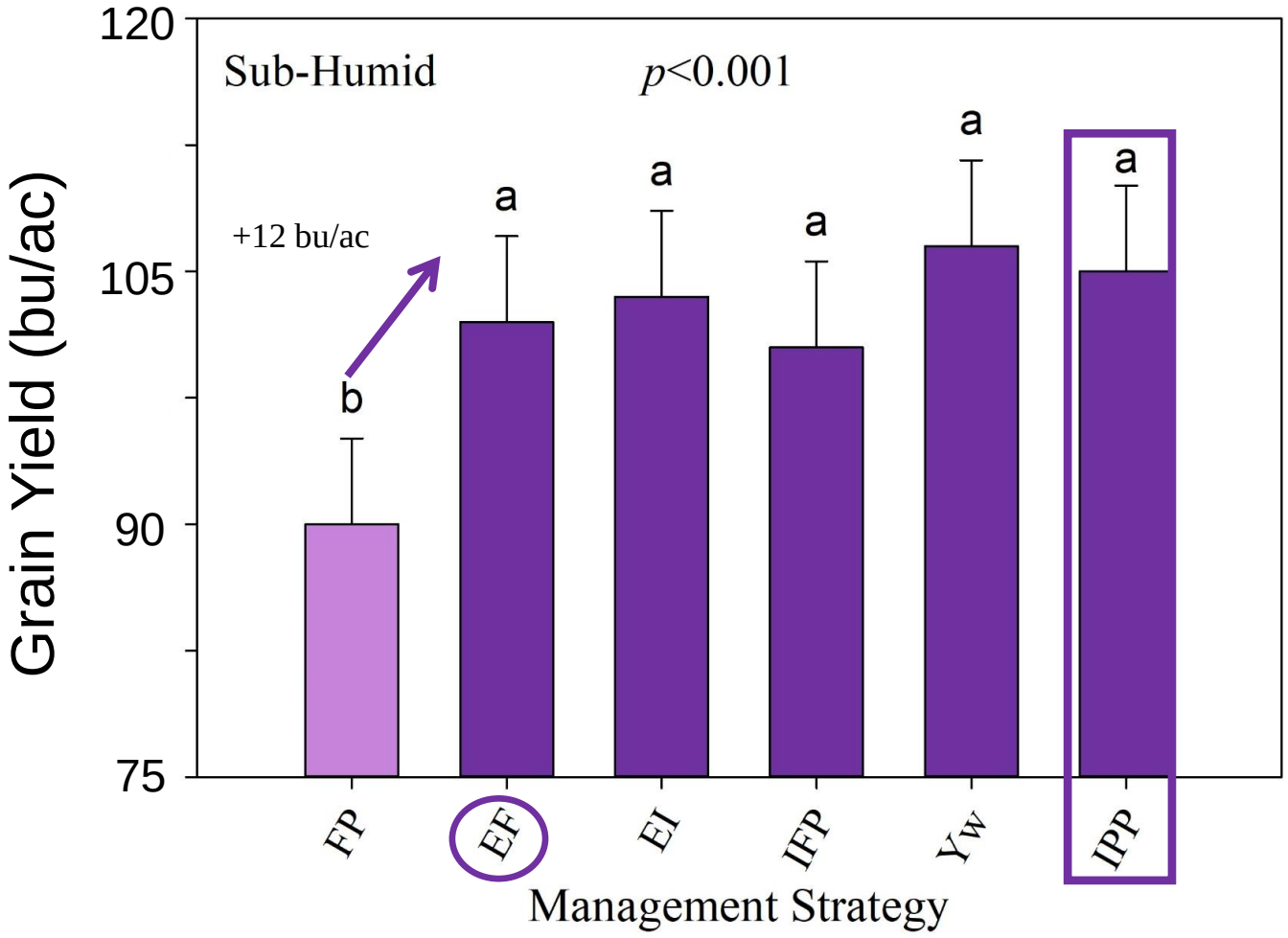
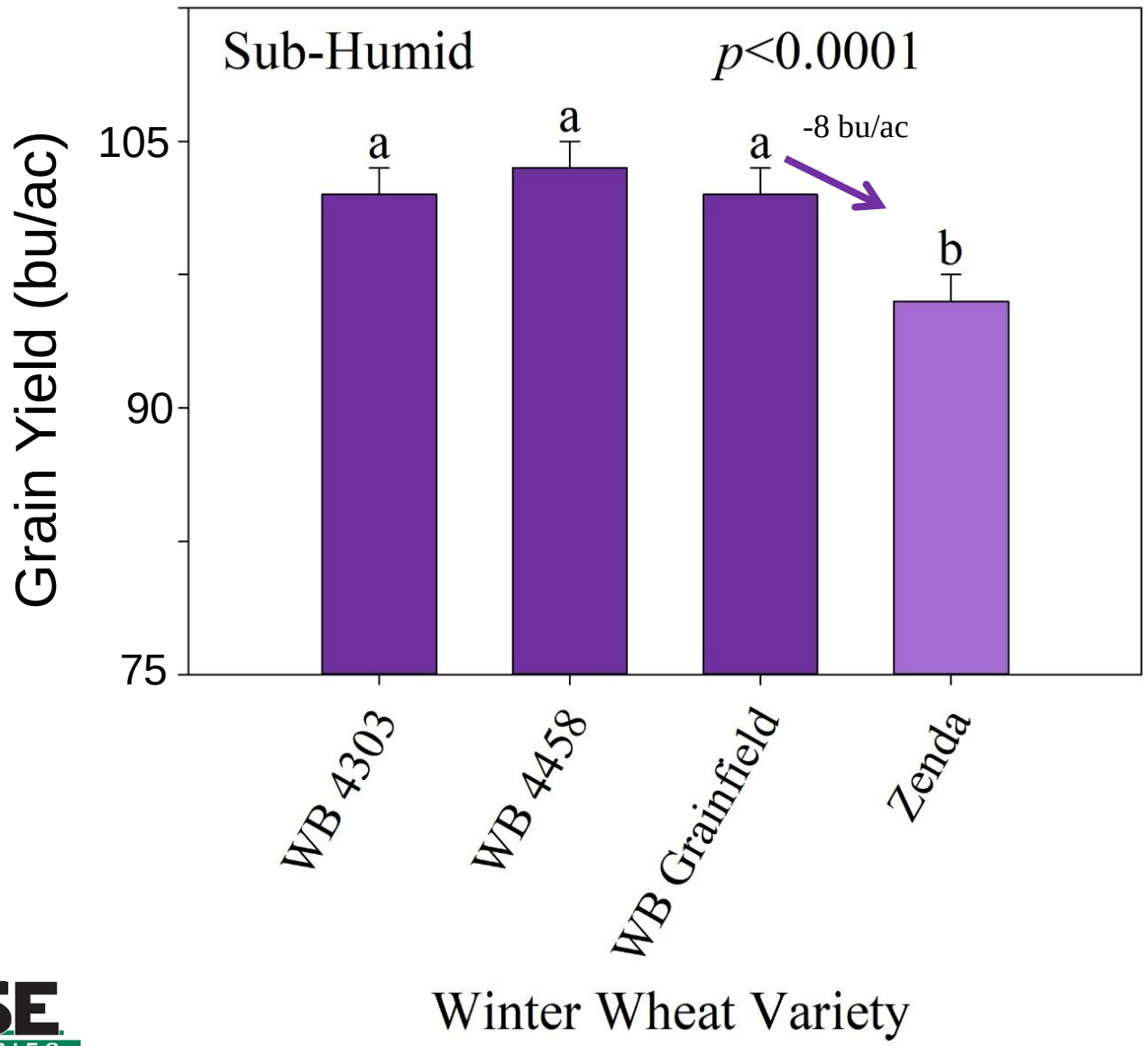
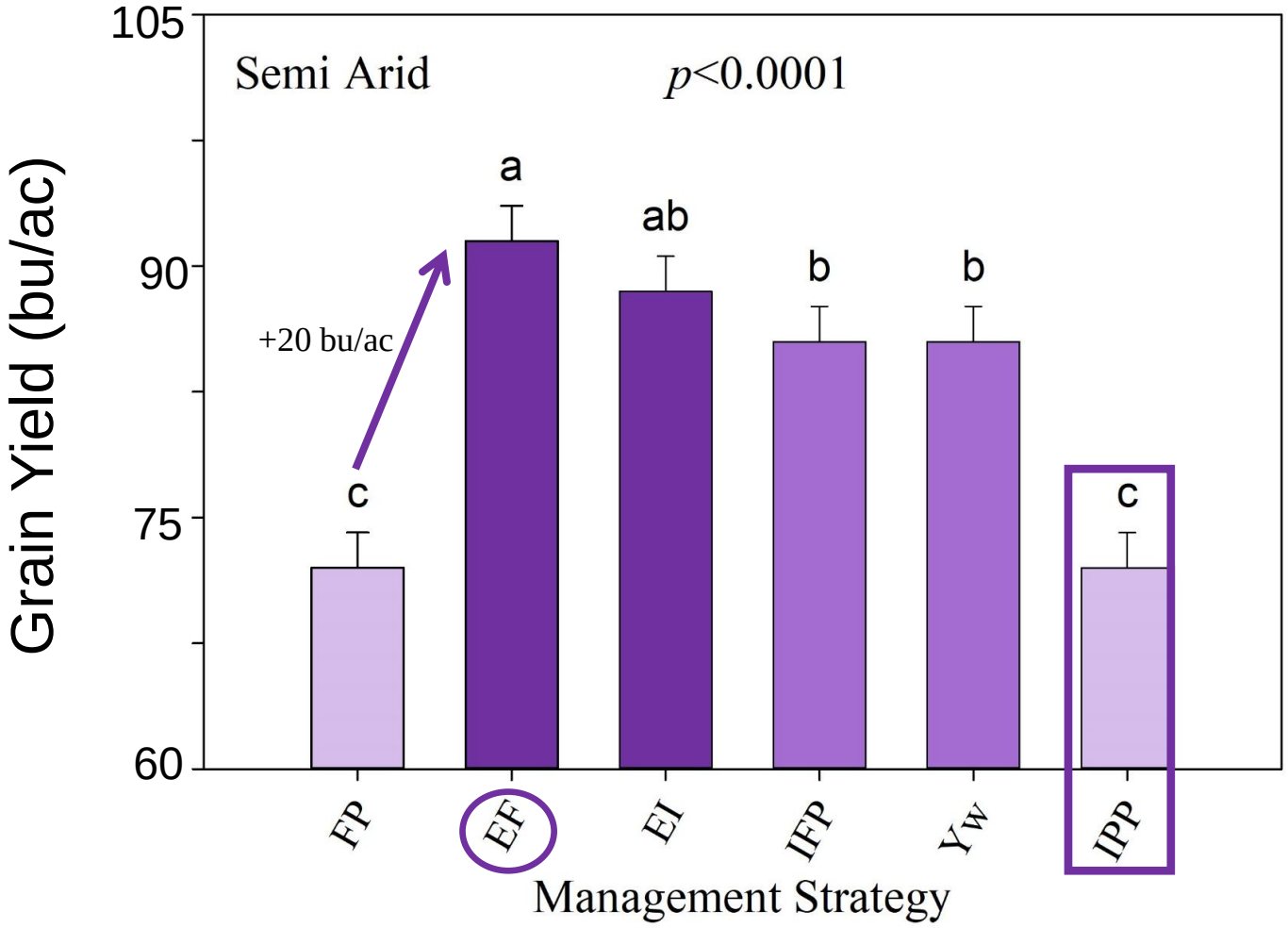
Results

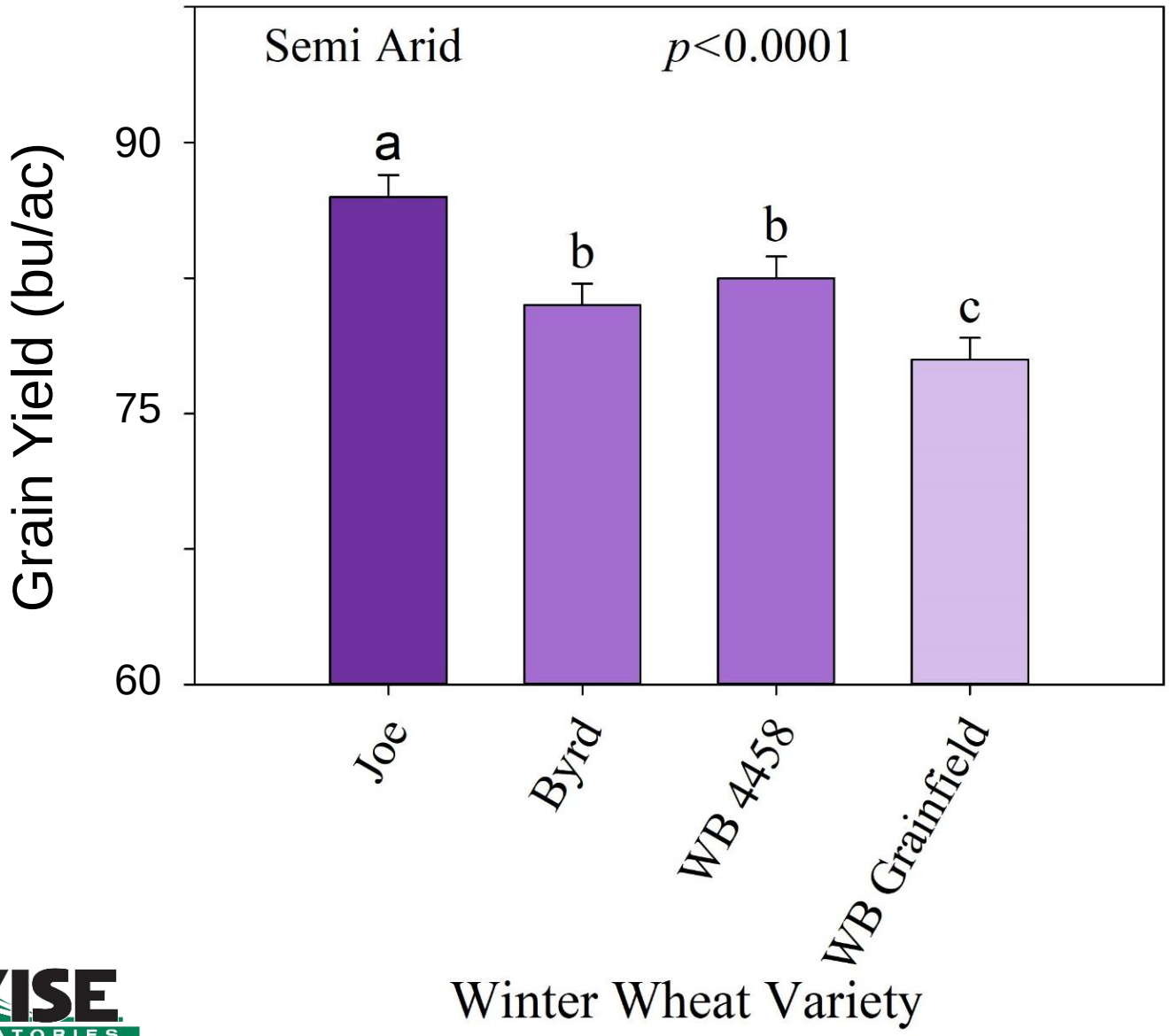
Results: Across all location and varieties

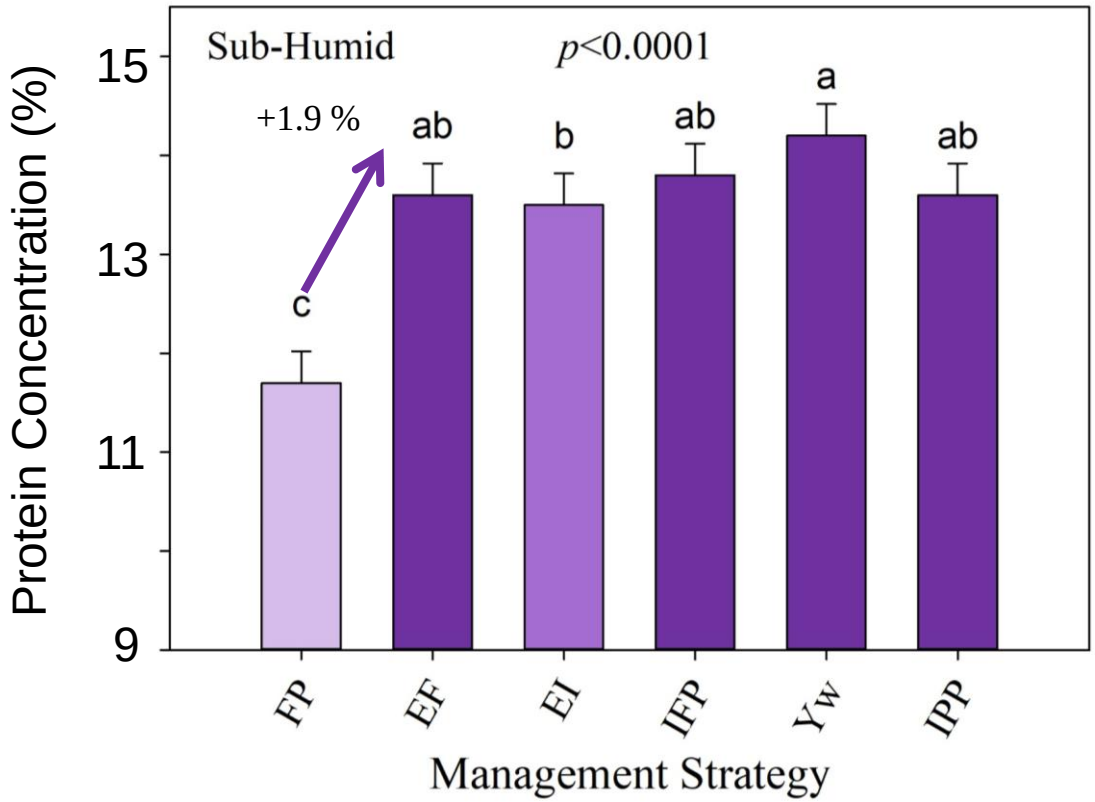
Management Practice	Grain Yield (bu/ac)	Protein (%)
FP	60 C	11.1 b
EF	67 B	12.6 a
EI	81 A	12.7 a
IFP	78 A	13.0 a
Yw	80 A	13.1 a
IPP	72 B	13.1 a

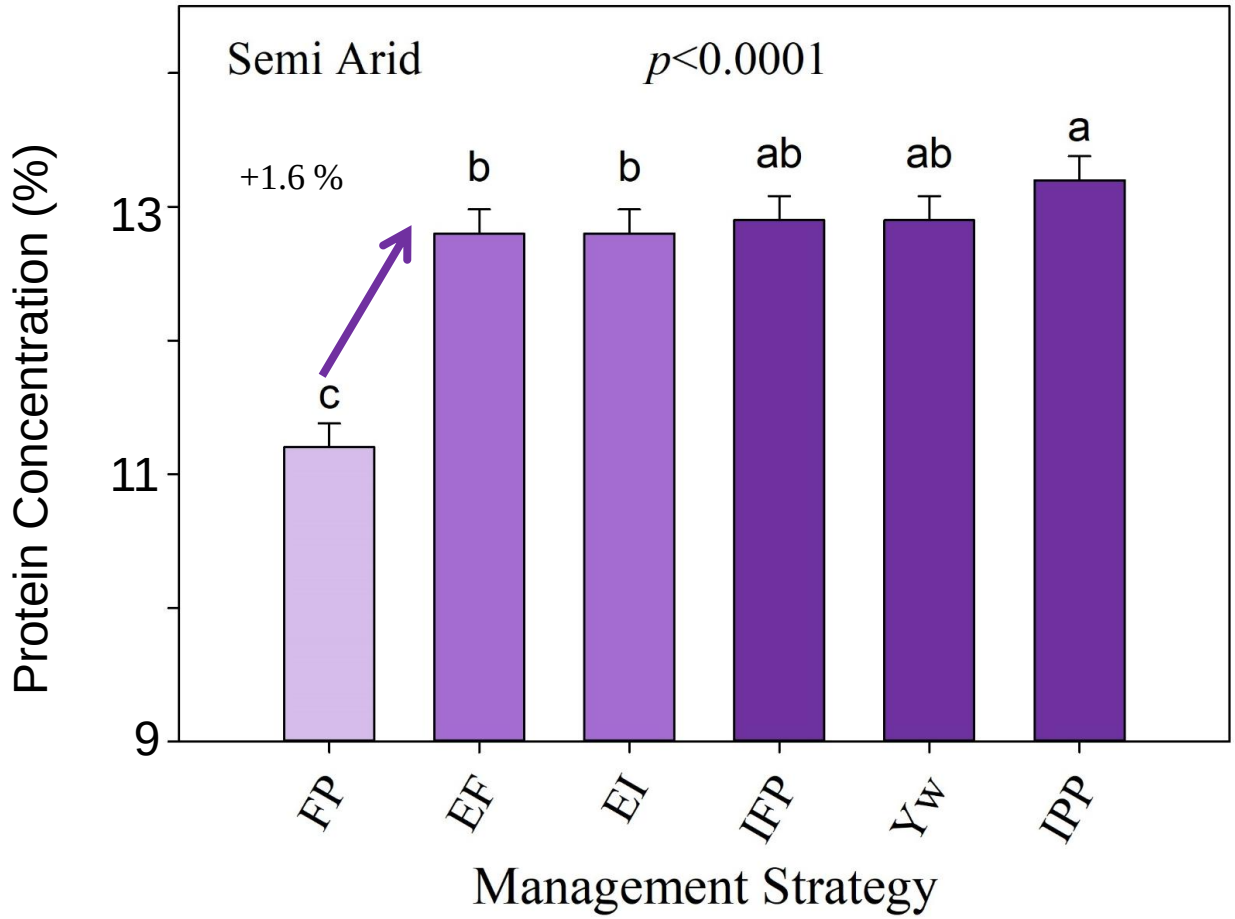

Sub-Humid
p<0.001
+12 bu/ac
Grain Yield (bu/ac)
120
105
90
75
a
a
a
a
b
FP
EF
EI
IFP
Yw
IPP
Management Strategy


Sub-Humid
p<0.0001
-8 bu/ac
a
a
a
b
105
90
75
Grain Yield (bu/ac)
WB 4303
WB 4458
WB Grainfield
Zenda
Winter Wheat Variety


Semi Arid
p<0.0001
Grain Yield (bu/ac)
105
90
75
60
+20 bu/ac
a
ab
b
b
c
c
FP
EF
EI
IFP
Yw
IPP
Management Strategy

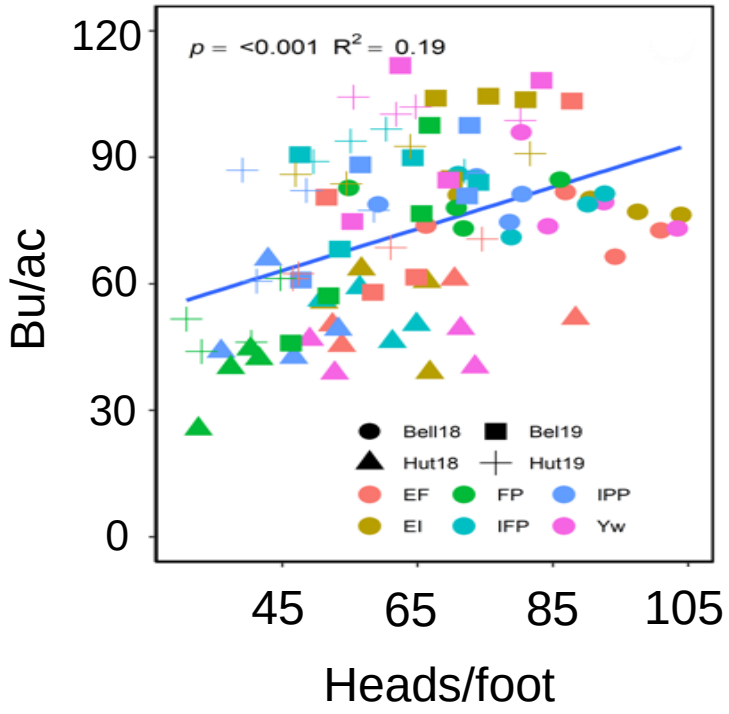

Semi Arid
p<0.0001
Grain Yield (bu/ac)
90
75
60
a
b
b
c
Joe
Byrd
WB 4458
WB Grainfield
Winter Wheat Variety

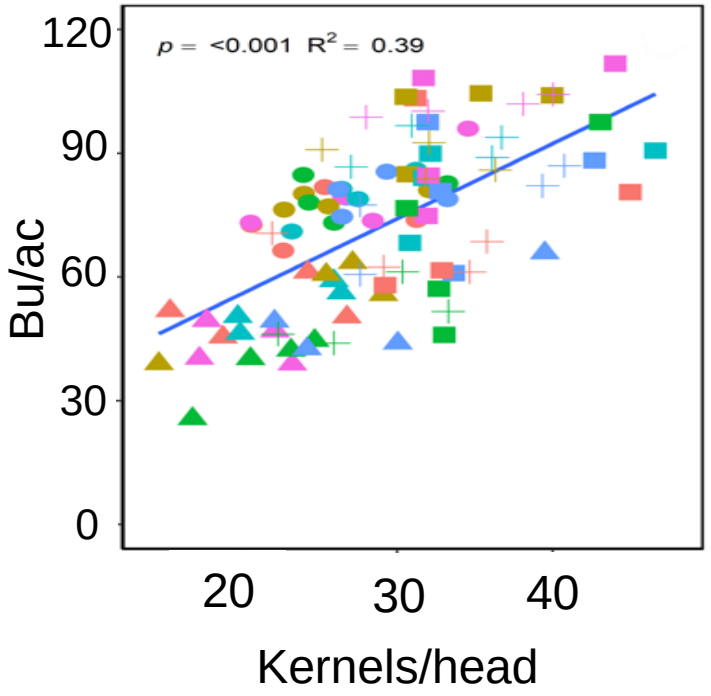

Sub-Humid
p<0.0001
+1.9 %
Protein Concentration (%)
15
13
11
9
c
ab
b
ab
a
ab
FP
EF
EI
IFP
YW
IPP
Management Strategy


Semi Arid
p<0.0001
+1.6 %
Protein Concentration (%)
13
11
9
c
b
b
ab
ab
a
FP
EF
EI
IFP
Yw
IPP
Management Strategy

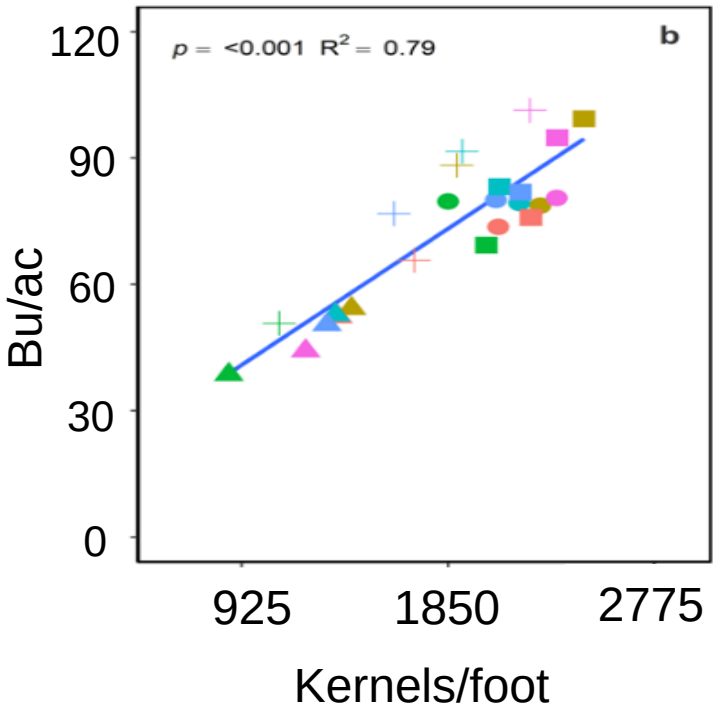
Yield Components

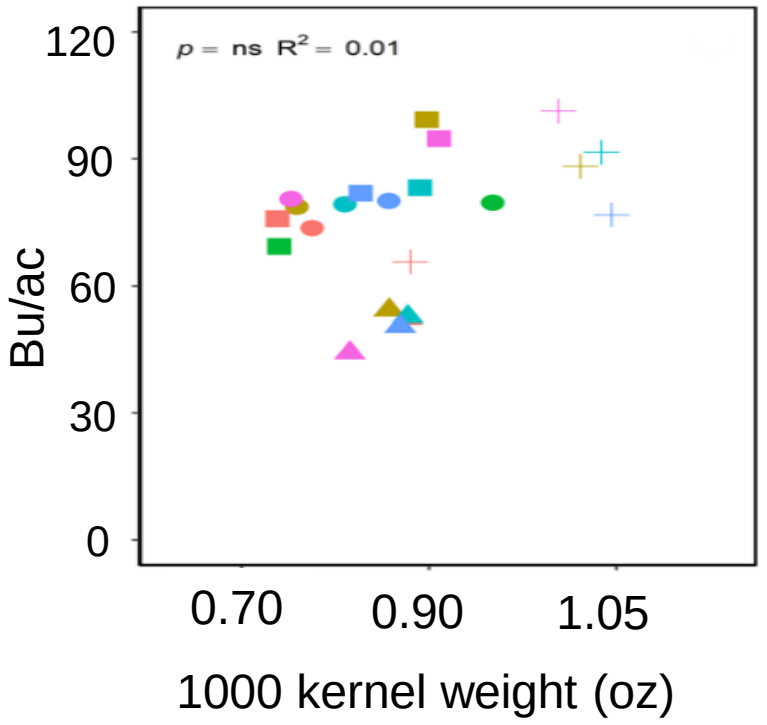
Across Management and Varieties



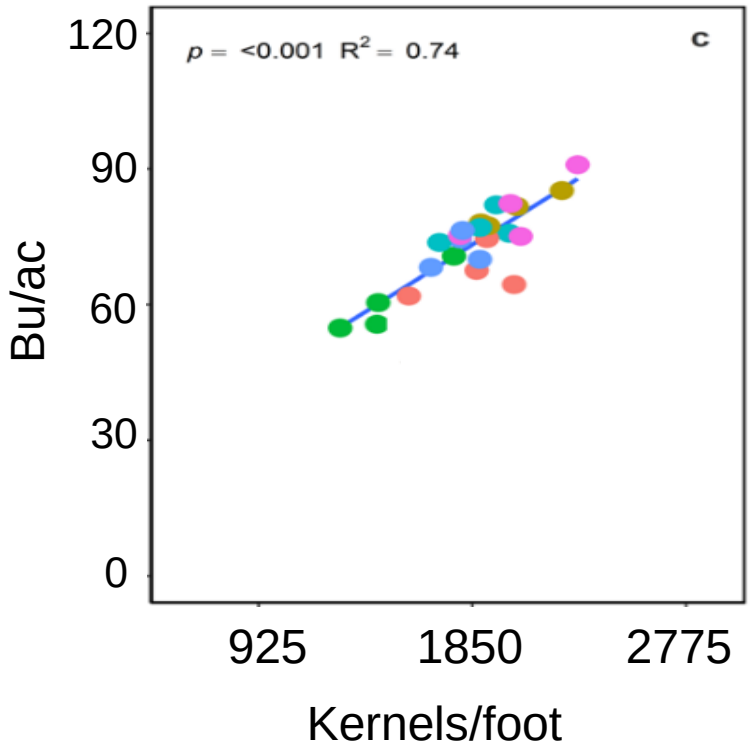


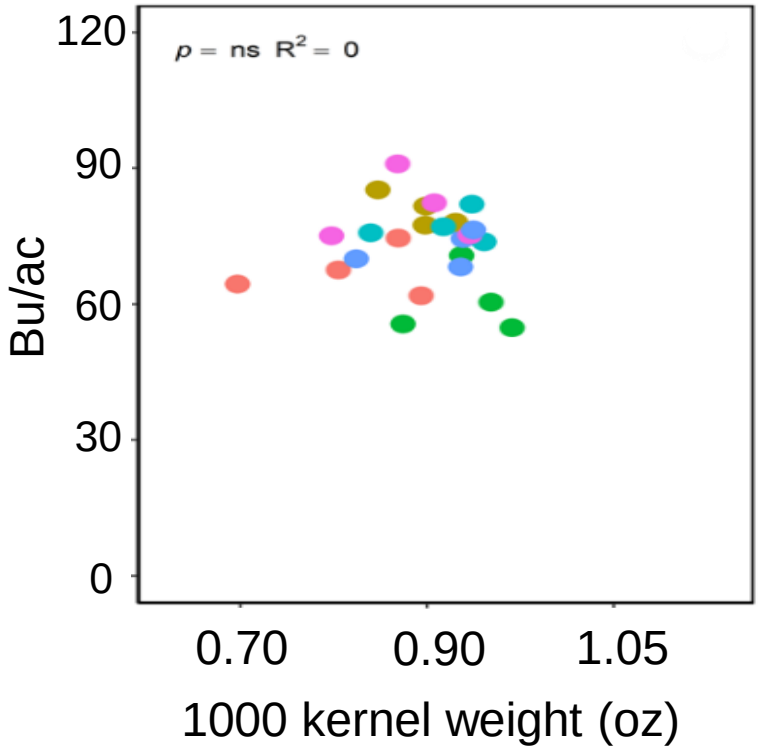
Across Management





Across Varieties





Conclusions

- Grain yield
  - Kernels per foot > kernel weight
  - N rate + Flag leaf fungicide
  - Never limited by source

K-STATE Research and Extension

On-farm data-rich analysis explains yield and quantifies yield gaps of winter wheat in the U.S. central Great Plains

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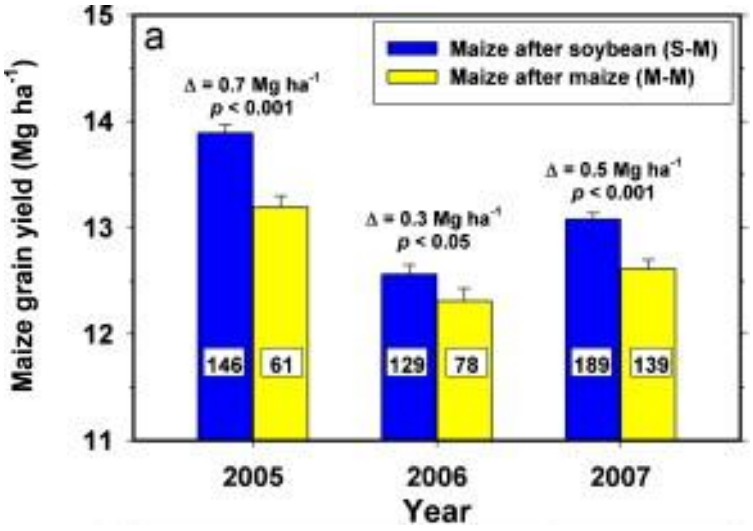
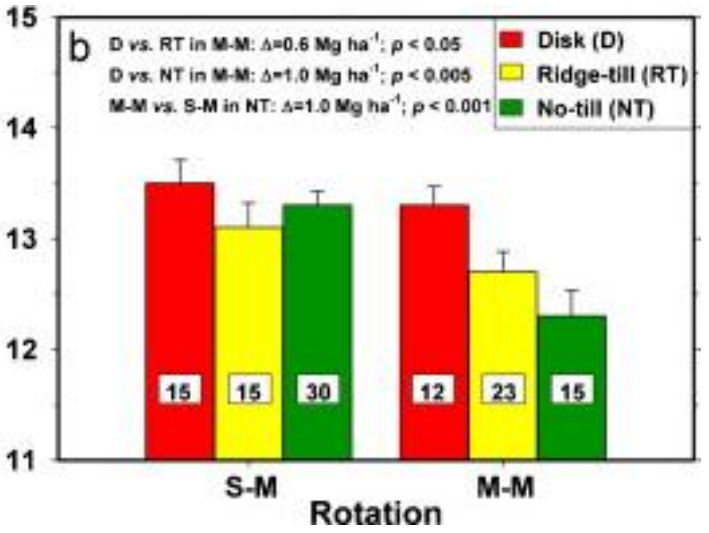
On-Farm Surveys

- Provide different opportunities to evaluate management practices
- Differ from small plot research

On-Farm Surveys

- Corn

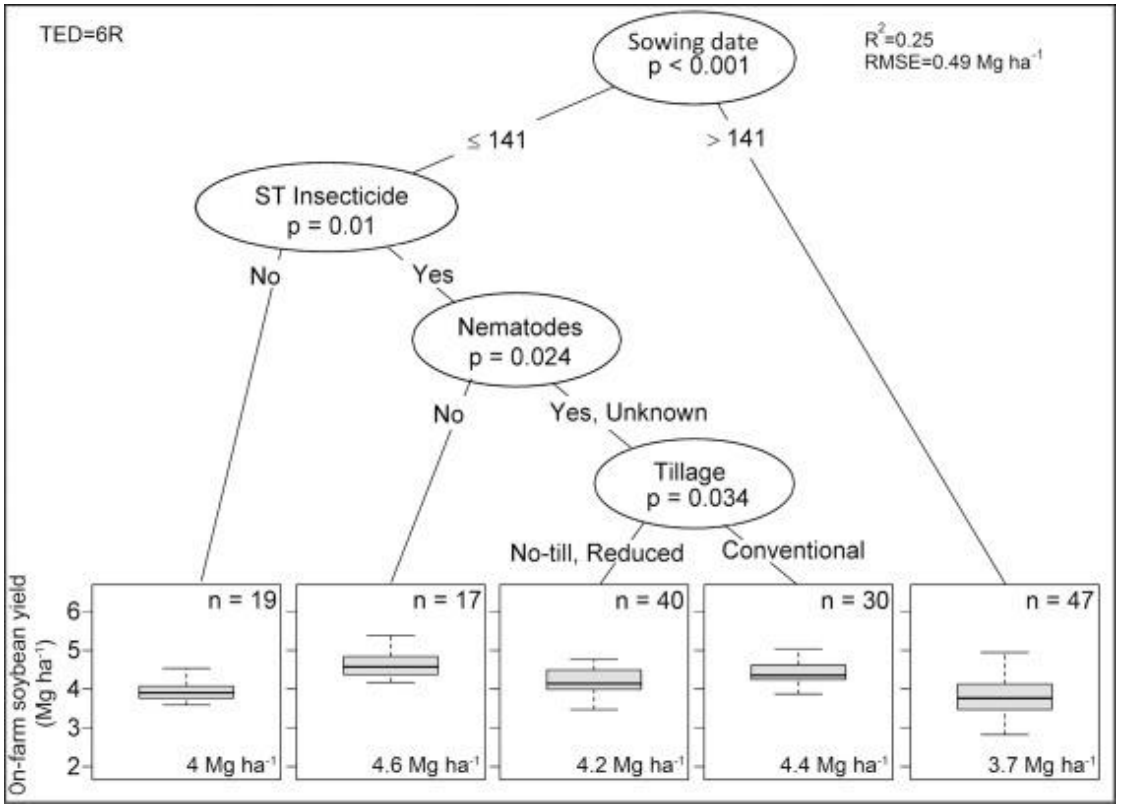




Grassini et al. 2011

On-Farm Surveys

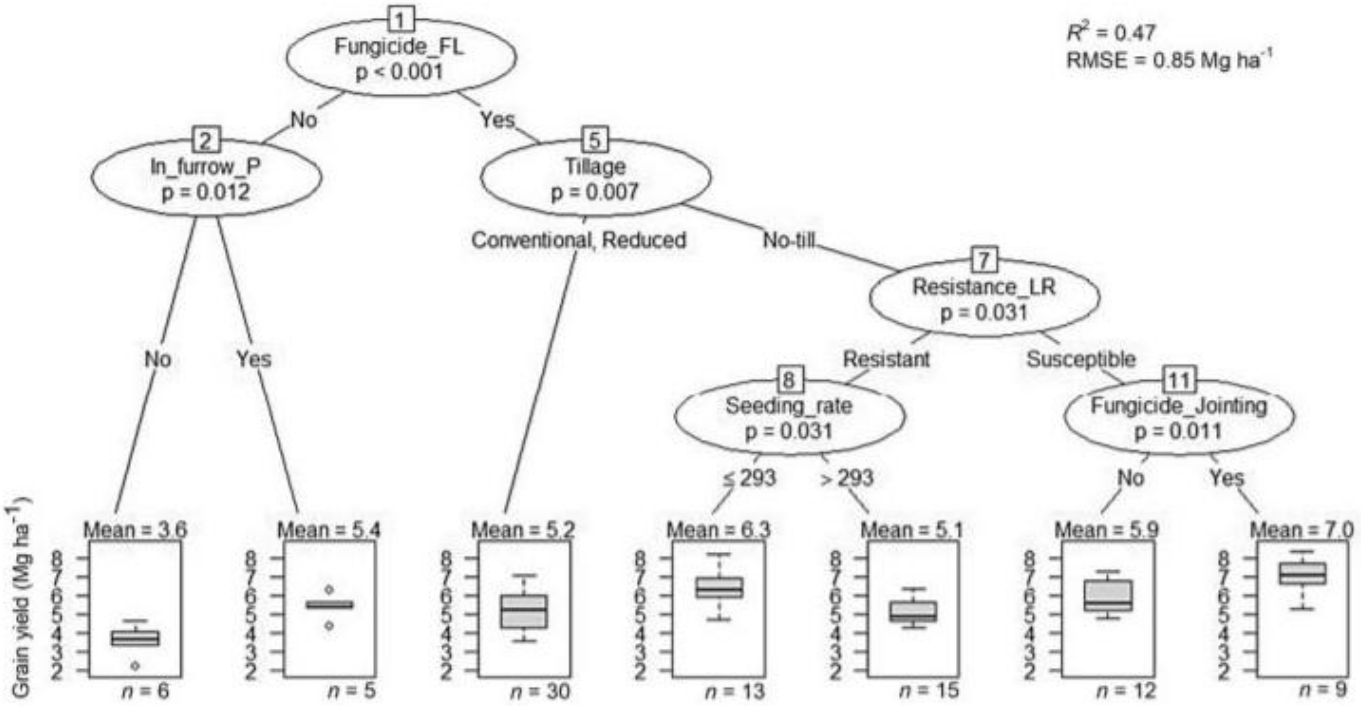
Soybeans



Mourtzinis et al. 2018

On-Farm Surveys

Wheat



Lollato et al. 2019

Objectives

- To evaluate wheat grain yield relationships with management practices in commercial wheat fields in Kansas.
- To determine wheat grain yield relationships with weather variables during the growing season.

Survey Questions

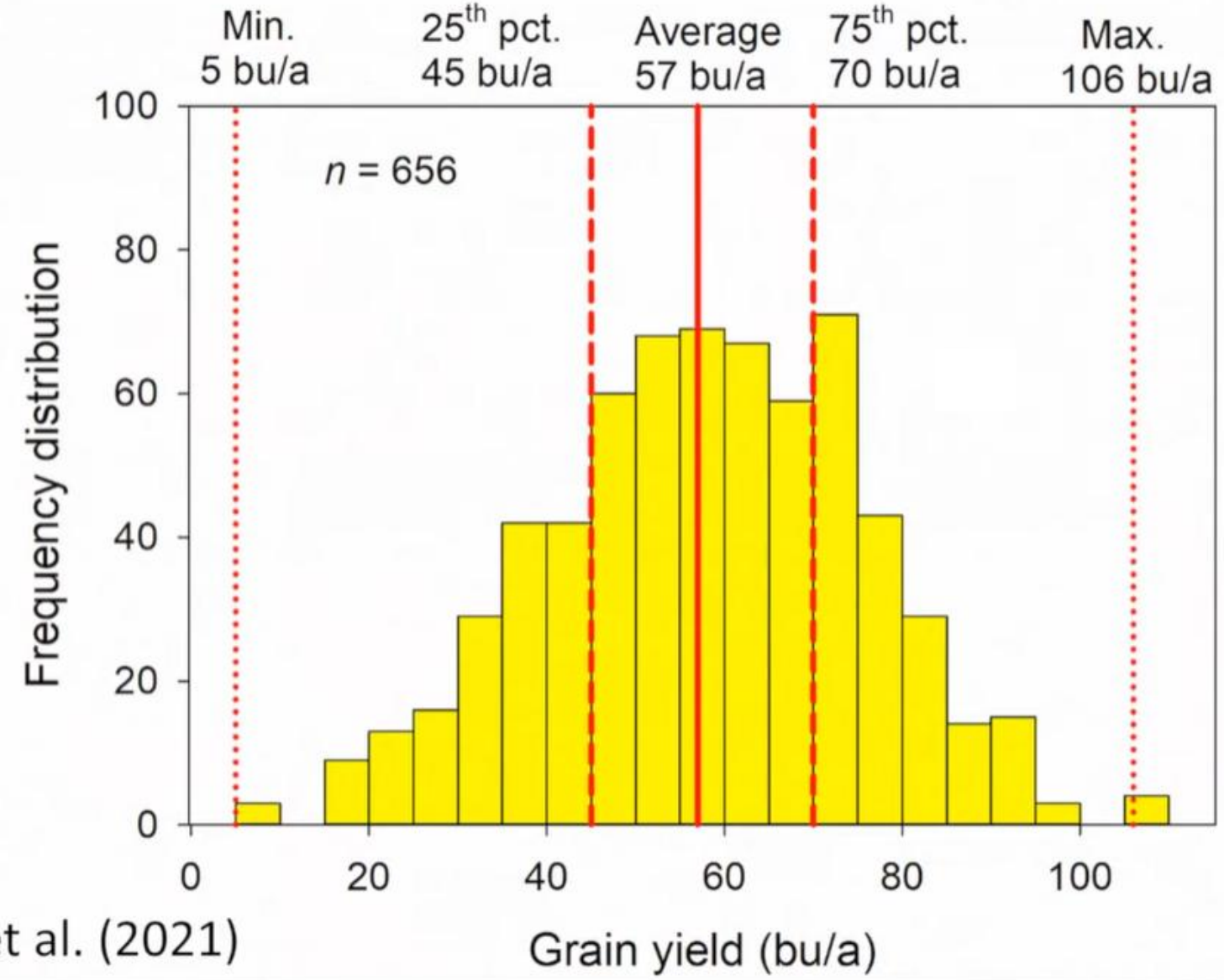
Independent Variable	Unit (or classes)
Prior Crop	Wheat, soybean, corn, milo, fallow
Planting Date	Day of Year
Variety Name	unitless
Seeding Rate	Lbs/ac
Seed Fungicide	Yes/No
Seed Insecticide	Yes/No
Tillage	Coventional or no-till
Infurrow-Phosphours	Yes/No
Manure	Yes/No
Lime	Yes/No
Broadcast or Band P	Yes/No
Phosphours Rate	Lbs/ac
Nitrogen Source	Urea, UAN, or A.A
Nitrogen Rate	Lbs/ac
Nitrogen Application Method	Streamer nozzle, broadcast, knife
Nitrogen Timing	Preplant, tillering, jointing, heading
Total Nitrogen Rate	Lbs/ac
Sulfur	Yes/No
Chloride	Yes/No
Zinc	Yes/No
Flag Leaf Fungicide	Yes/No
Jointing Fungicide	Yes/No

On-Farm Research Survey

Your name and phone number will not be reported on any reports or publications. If you have any questions, please call me. Brent Jaenisch at 785-370-1275.

Questions	Example:	2015-16 wheat	2015-16 wheat	2016-17 wheat	2016-17 wheat
Name		Brent Jaenisch			
Phone		—			
Specify field location by Section: Township: Range.		—			
OR GPS coordinates of field:	41.678, -100.257				
OR County & field location relative to Rd intersection:	Riley Co, SW of Rd 11 & N				
Dryland? OR Pivot? Indicate field size (acres)	Dryland (90 ac)	Dryland (100 ac)	Dryland (80 ac)	Dryland (60 ac)	Dryland (150 ac)
Crop rotation?	Prior Crop to wheat: Corn; Two crops before wheat: Fallow	Prior Crop to wheat: wheat; Two crops before wheat: soybean	Prior Crop to wheat: wheat; Two crops before wheat: wheat	Prior Crop to wheat: corn; Two crops before wheat: wheat	Prior Crop to wheat: wheat; Two crops before wheat: soybean
Planting Date in this FIELD (Month/Day/Year):	10/5/2015	10-1-15	10-2-15	10-3-16	10-1-16
Variety Name (Brand & Number):	Everest	Everest	WB 4458	Everest	LCS Mint
Seeding Rate (lbs/ac):	70	70	80	70	70
Row spacing (inches):	7.5	7.5	7.5	7.5	7.5
Seed Treated (Yes/No)? What Brand Name Product(s)?	Yes (Cruiser-Max)	Yes	Yes	No	No
Prior Crop in this FIELD? Residue harvested or grazed?	Corn / no	No	No	No	No
Tillage before prior crop? No-Till (NT); Ridge (RT); Strip (ST); Disk (D); - Indicate timing (month-year)	ST (September-2015)	CT	CT	CT	CT
PRE- or POST-emergence herbicide program or BOTH?	Product: Paraquat; Timing: Sept. 2015; GS: PRE Product: Widematch; Timing: Feb 2015; GS: tillering	Product: —; Timing: Yes; Growth Stage: —	Product: —; Timing: Yes; Growth Stage: —	Product: —; Timing: Yes; Growth Stage: —	Product: —; Timing: Yes; Growth Stage: —
Any STARTER fertilizer (Yes/No)? If Yes, specify product and rate	Yes (P- 50 lbs DAP)	Yes 5gal 10-34-0 →	→	→	→
Any Lime (L) or Manure (M)? If yes, specify timing (mm-yy) and rate	Lime (April-2015)	No	No	No	No

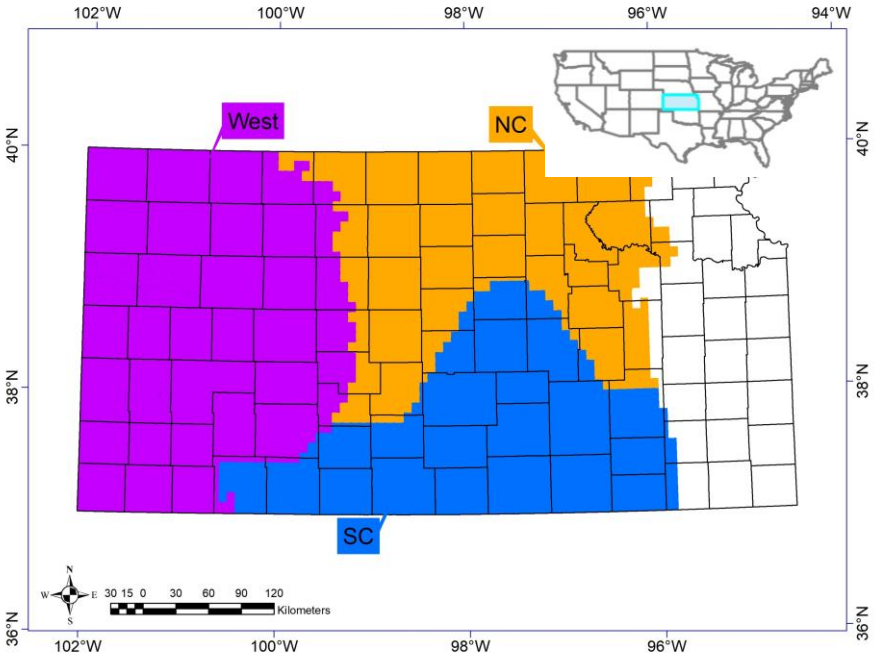
	EXAMPLE:			Continued 2015-16 wheat			Continued 2015-16 wheat			Continued 2016-17 wheat			Continued 2016-17 wheat		
Any (non-starter) fertilizer before wheat crop? If yes, speficy product and rate	Product: 75 lbs/ac MESZ			Product: No			Product: No			Product: No			Product: No		
Specify rate (pounds product/ac) and timing (month-year)	Other: S (11 lbs S/ac)			Other:			Other:			Other:			Other:		
	Time: Sept-2015			Time:			Time:			Time:			Time:		
Nitrogen Program	First Timing	Second Timing	Third Timing	First Timing	Second Timing	Third Timing	First Timing	Second Timing	Third Timing	First Timing	Second Timing	Third Timing	First Timing	Second Timing	Third Timing
Rate (lbs N/acre)	N: 40 lbs	60 lbs	50	N: 100			N: 100			N: 50		50	N: 50	50	
Source- urea , UAN, Anydrous ammonium (AA)	Urea	urea	urea	Source: UAN			Source: UAN			Source: urea		UAN	Source: urea	UAN	
Method- variable rate (VR), blanket application (BA)	BA	BA	BA	Method: BA			Method: BA			Method: BA		BA	Method: BA	BA	
Timing (MM/YYYY)	Sep-15	Feb 2015	Late March	Timing: Jan-16			Timing: Jan 16			Timing: [illegible]	Sept-16	Feb-17	Timing: Sept 16	Feb 17	
Growth Stage (GS)- preplant (PP), tillering (T), jointing (J), heading (H)	GS: PP	T	J	GS: tillering			GS: tillering			GS: pre	1	tillering	GS: pre	tillering	
Was the field grazed? When was grazing terminated?	Yes, jointing			No			No			No			No		
	Product	Timing	GS	Product	Timing	Growth Stage	Product	Timing	Growth Stage	Product	Timing	Growth Stage	Product	Timing	Growth Stage
Any in-season foliar fungicide (F) / insecticide (I)?	F- Priaxor	March 2016	Jointing	F- Generic	April	Flag Leaf	F- Generic	April	Flag Leaf	F- Generic	May	Flag Leaf	F Generic	May	Flag leaf
	F - Tebustar	April 2016	Flag Leaf												
	I- Warrior	May 2016	Heading												
Control Volunteer Wheat	August 2015			Yes tillage			→			→			→		
Any significant yield loss due to Insects, Diseases, Weeds, Frost, Hail, Flood, Lodging?	Stripe Rust (May-2017) if NATURAL DISASTER occurred, please use another field			No			No			No			No		
Harvest Date (MM/DD/YYYY).	6/25/2016			6-25-16			6-26-16			6-18-17			6-20-17		
Yield goal going into the season (bu/ac)?	50														
Average field yield (bu/ac)?	62			75			75			68			68		
Average protein content (%)?	11.5			NA			NA			NA			NA		



Jaenisch et al. (2021)

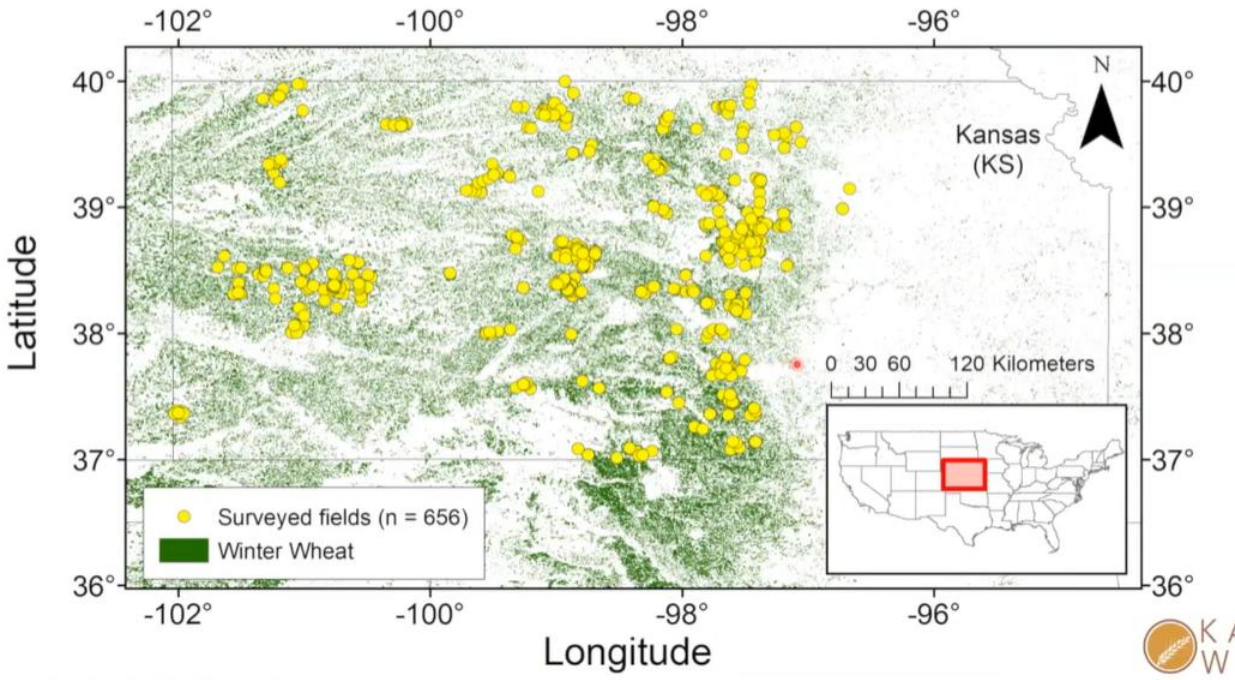
Clustering of Fields

- West:
  - <25 inches
  - 3792-4829 GDD
- North Central:
  - 25-35 inches
  - 3792-4829 GDD
- South Central:
  - 25-35 inches
  - 4830-5949 GDD



Distribution of Fields

- Growing Seasons
  - 2016, 2017, 2018
- Fields
  - Total (*n*= 656)
  - West (*n*= 150)
  - NC (*n*= 221)
  - SC (*n*= 285)



Conditional Inference Trees

- Are useful in determining the interactions that occur in unbalanced data sets
- Sensitivity analysis to determine minimum number of observations within a specific node
  - Intermediate node contained 5–40% of total observations
  - Terminal node contained 5–20% of total observations
  - Trees was selected based on the r^2 and rmse

Weather Variables

- Rainfall
- Max. Temperature
- Min. Temperature
- Solar Radiation
- Evapotranspiration
- Photothermal Quotient=

$$\frac{\text{Daily Average Solar Radiation}}{\text{Daily Average Temperature}}$$

**Adapted from (Fischer, 1985)

- Weather Effects on Yield
  - Raw yield data
  - Divided into three growth stages
    - Pre-Critical Period
    - Critical Period
    - Grain Fill

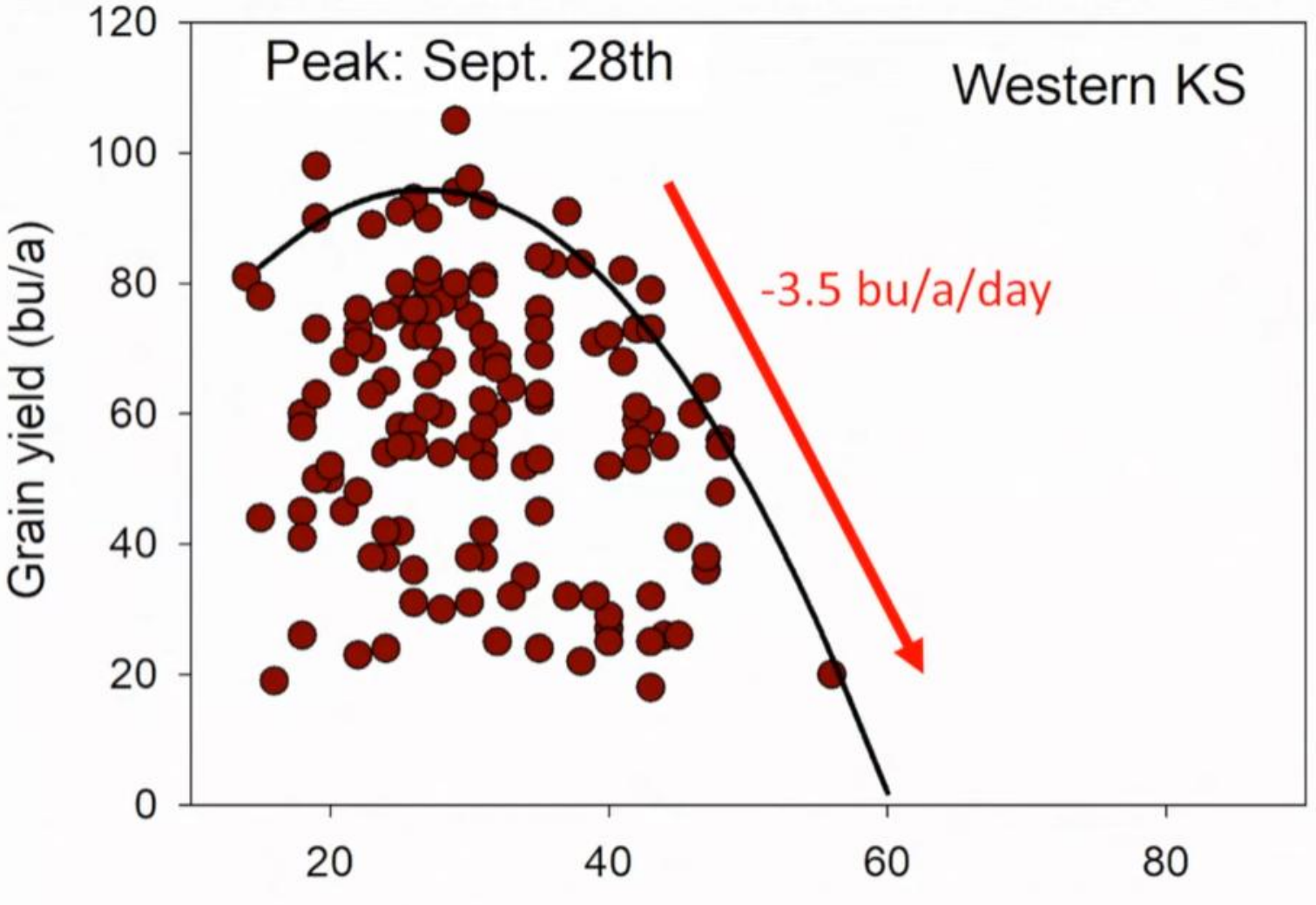
Results

Average Grain Yield and Yield Gaps

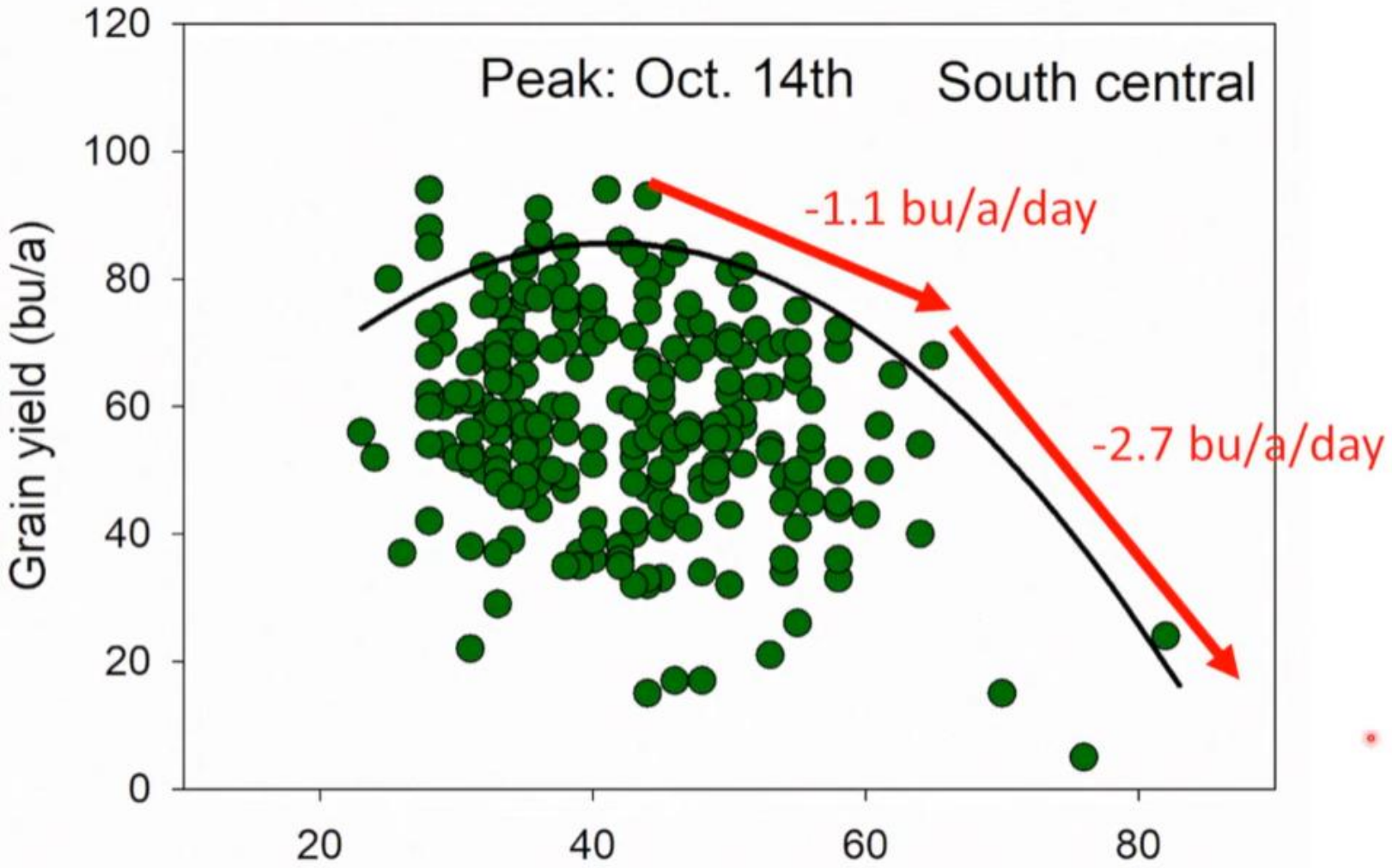
	Ya (bu/ac)	Yw (bu/ac)	Yg (%)
NC	59	98	32
SC	57	108	40
West	59	104	40

Average Rate and Adoption of Management Practices

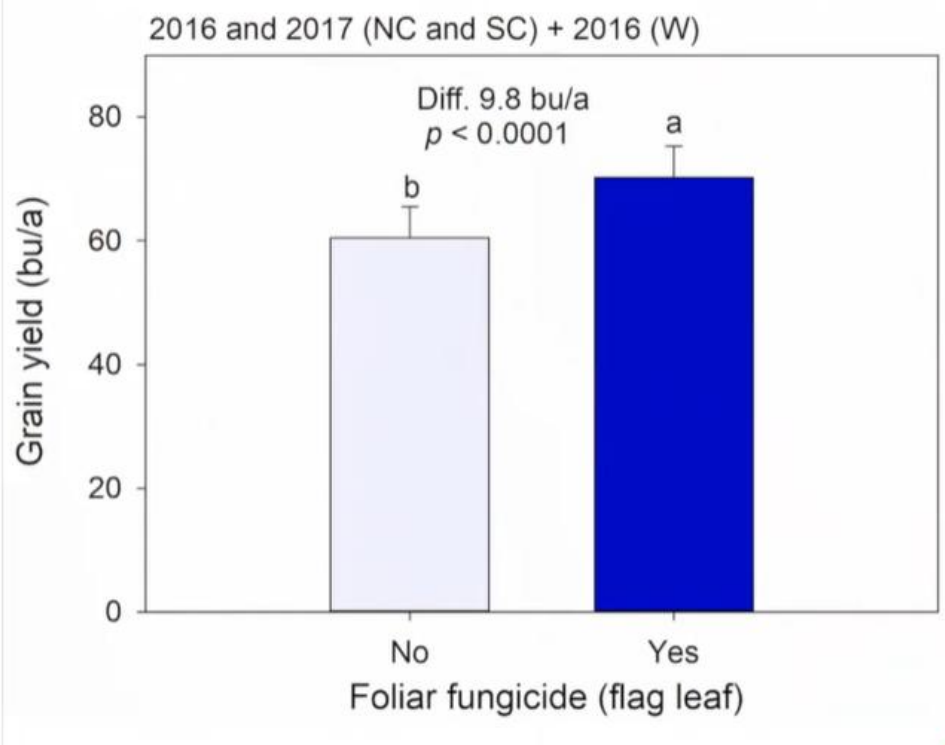
Independent Variable	Units	NC Mean	SC Mean	West Mean
Sow Date	Day of year	282	287	275
Seed Rate	Lbs/ac	83	80	60
Seed Fungicide	%	81	71	29
Seed Insecticide	%	55	62	28
No-Till	%	75	52	48
In-Furrow Phosphorus	%	70	65	62
Phosphorus Rate	Lbs/ac	24	32	52
First N Rate	Lbs/ac	64	64	58
Second N Rate	Lbs/ac	10	20	0
Total N Rate	Lbs/ac	88	99	60
Sulfur	%	52	45	28
Zinc	%	43	14	38
Flag Leaf Fungicide	%	55	56	42
Jointing Fungicide	%	10	4	7
Prior Crop				
Corn	%	2	11	14
Fallow	%	10	4	75
other	%	1	4	5
Soybean	%	44	30	1
Wheat	%	42	51	4

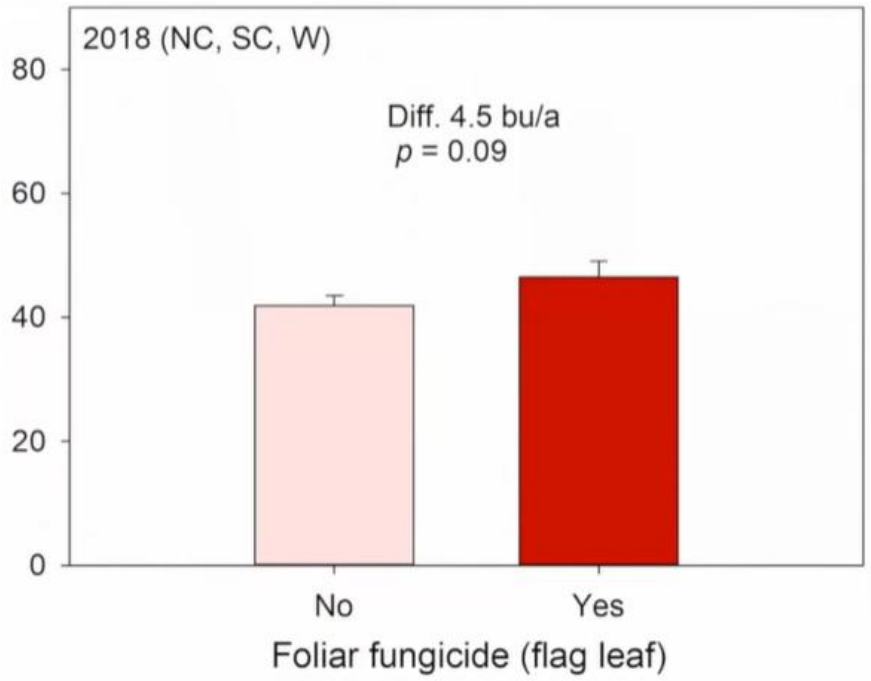


Jaenisch et al. (2021)



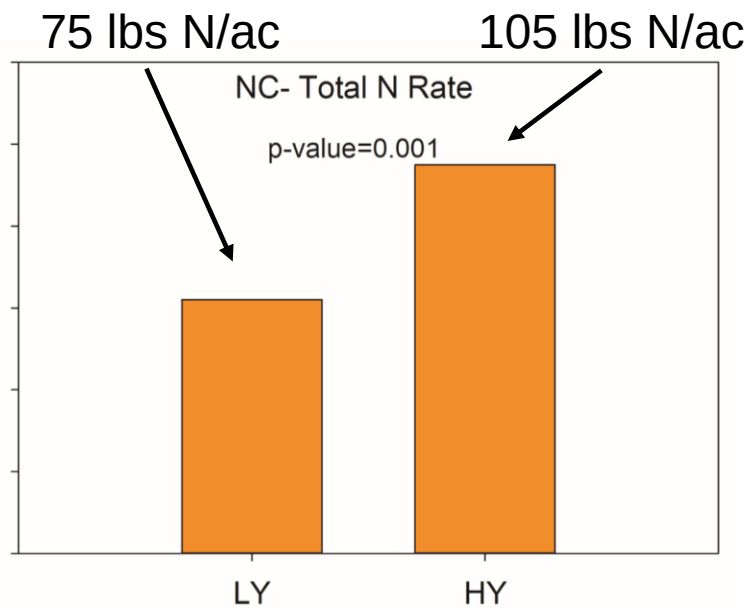
Jaenisch et al. (2021)

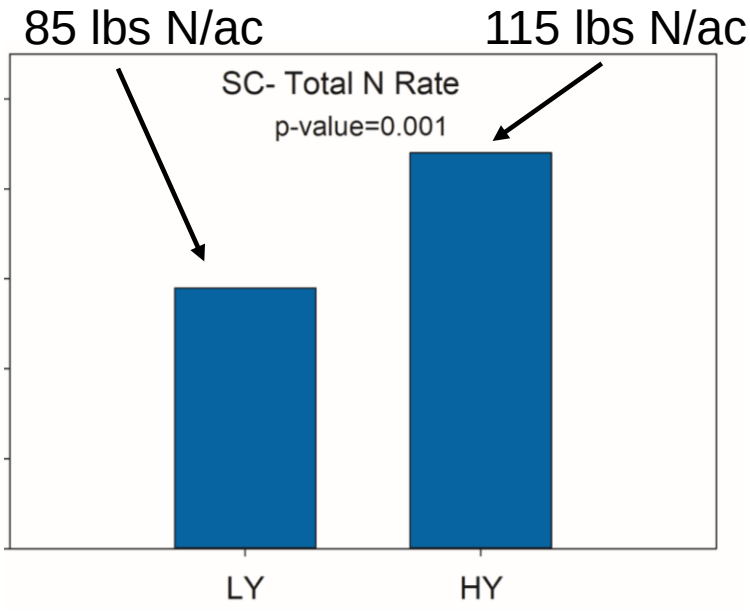




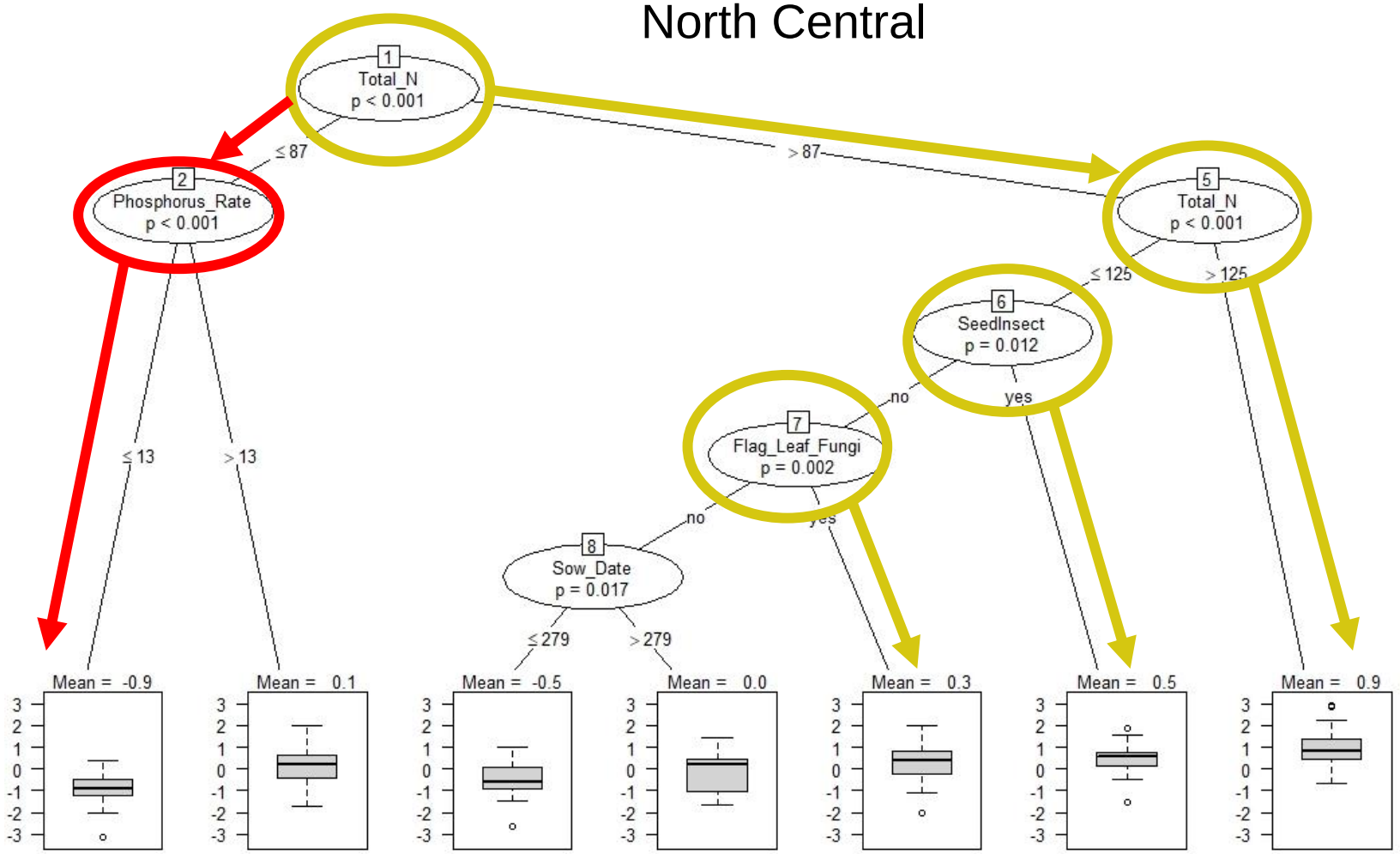
Jaenisch et al. (2021)

Total N rate = lbs N/ ac



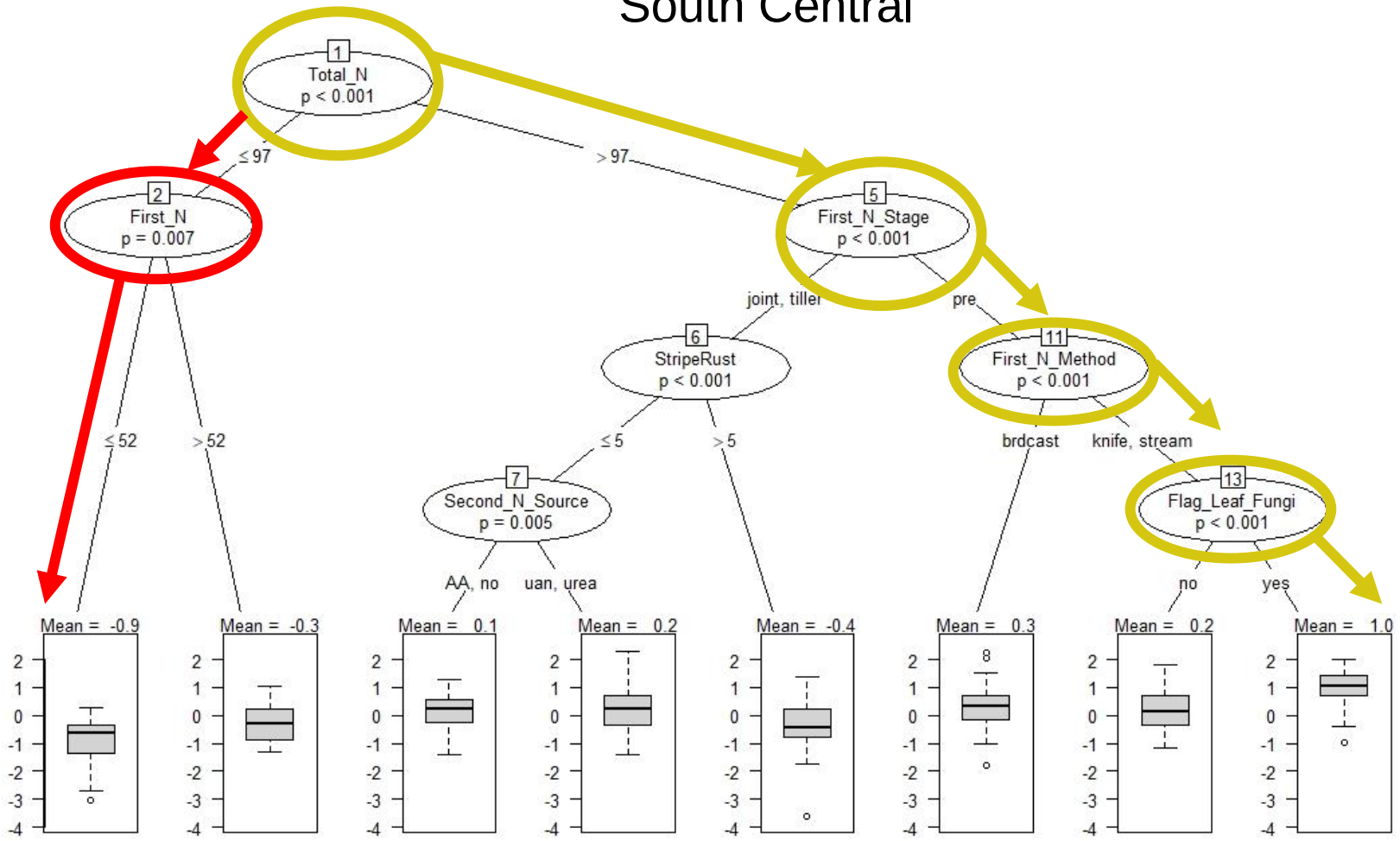


North Central

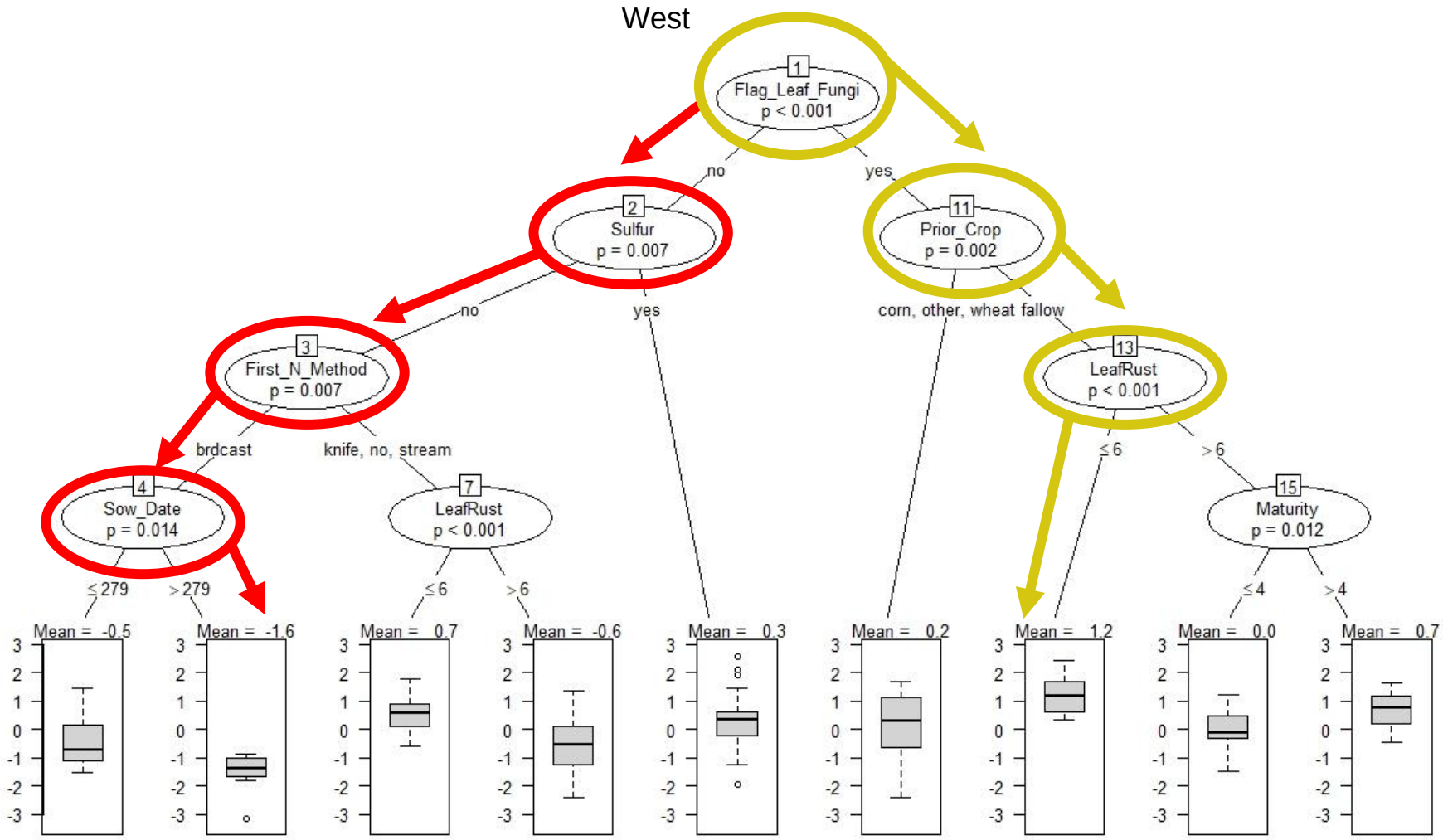


1 Mg/ha = 15 bu/ac

South Central



1 Mg/ha = 15 bu/ac



1 Mg/ha = 15 bu/ac

Summary

- Management
  - Increased N rate, method, and timing
  - Flag leaf fungicide

- Yield components
  - Course regulator
  - Kernels/foot
  - Heads/foot
  - Fine regulator
  - Kernel weight

Questions

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