WORLD DAIRY EXPO
October 1-5, 2019

World Forage Analysis Superbowl

Incorporation of Cereal-Grain Forages into Rations for Lactating Cows

World Dairy Expo

(October 4, 2019; Madison, WI)

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Cereal Grain Forages

Disclaimer

- Mention of commercial services or products does not imply either recommendation or endorsement

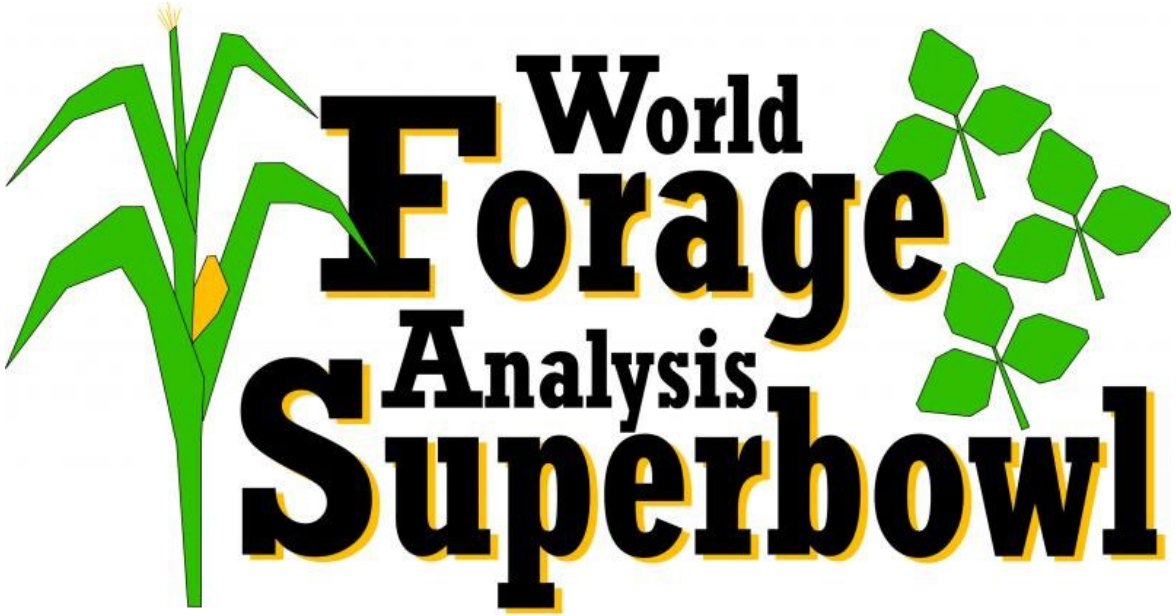
Forage Quality & Management

Big Picture – Importance of Forages

How do we define the best forage?

Cereal Grain Forages

Let's Talk About Forage Quality

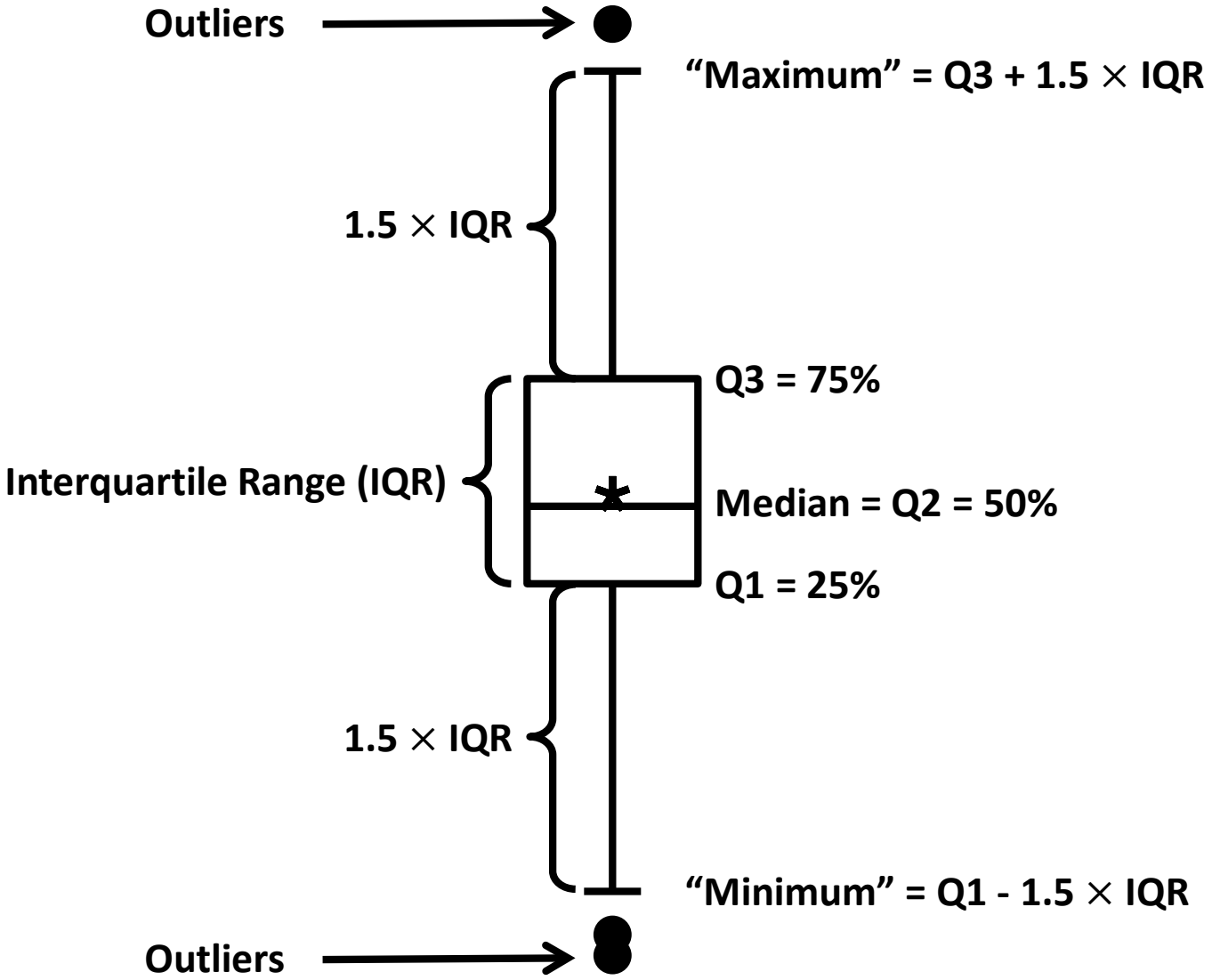


Cereal Grain Forages
Database

- Provided by a commercial forage test laboratory
  - 36,218 forage analyses
  - From 07/2017 to 06/2019
  - Focus on silages
  - Some cleaning
    - >80% DM ⇒ hay ∴ out
    - <18% DM ⇒ pasture ∴ out

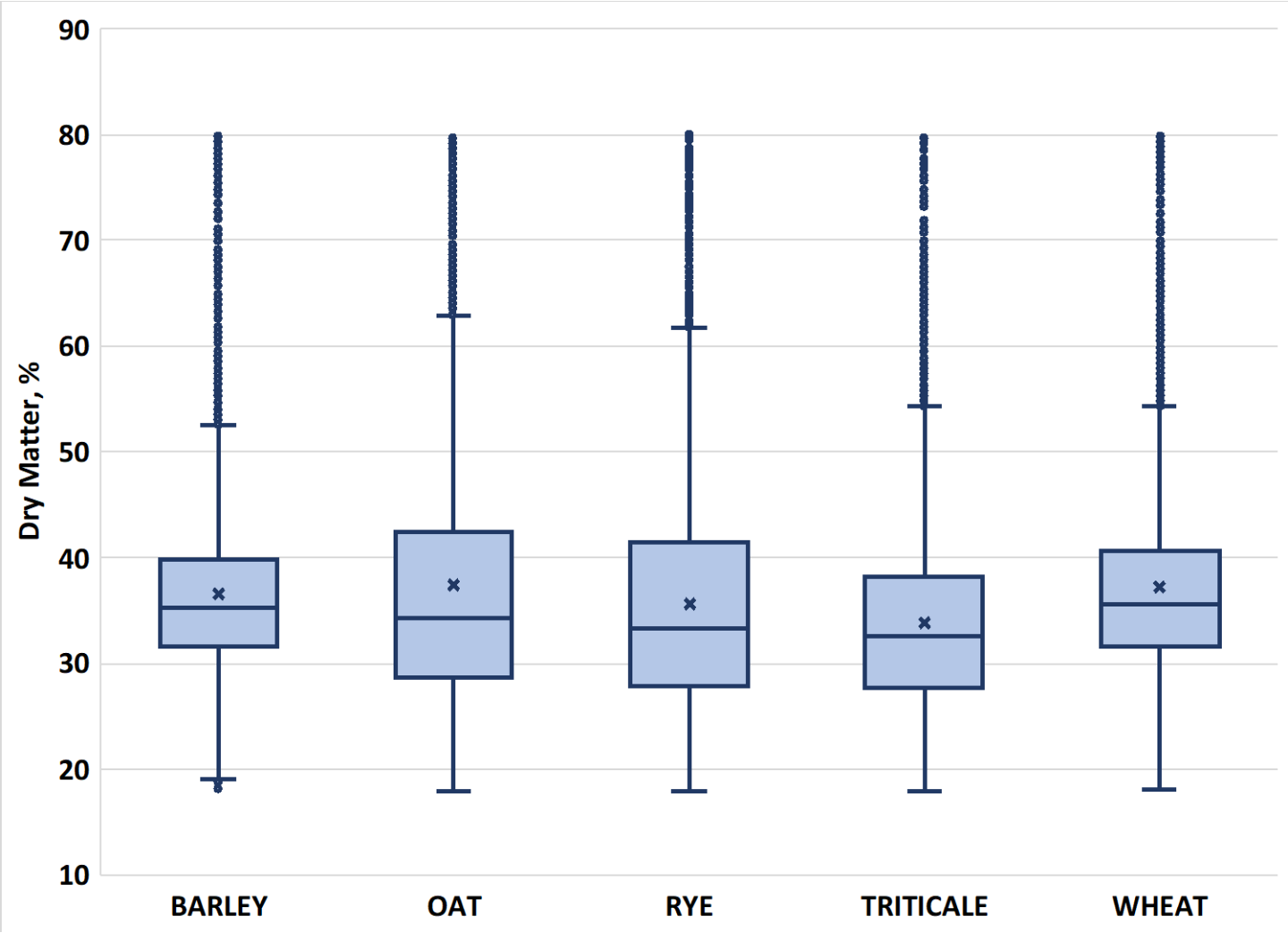
Cereal Grain Forages

Boxplots



Cereal Grain Forages

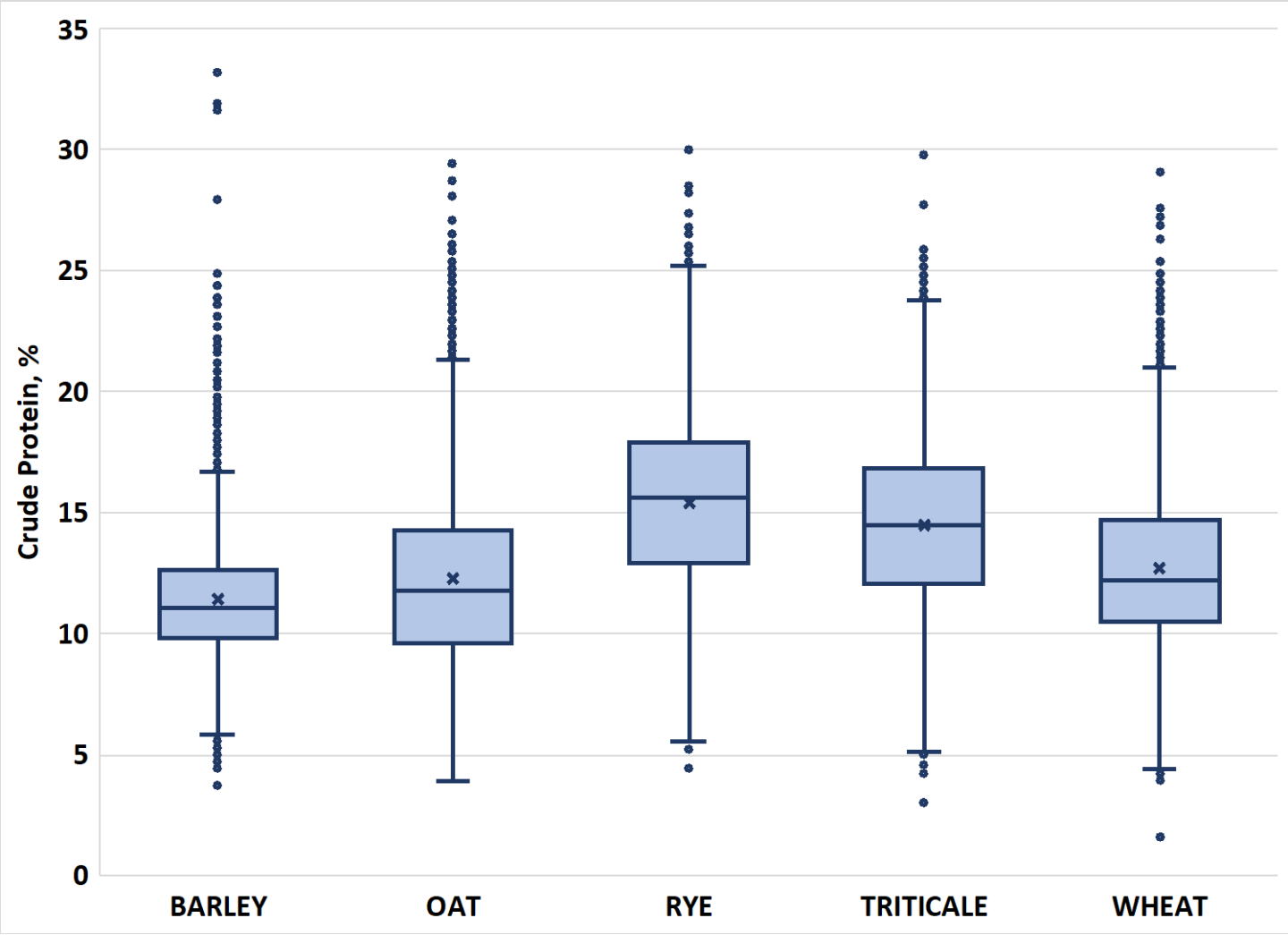
Dry Matter – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

Cereal Grain Forages

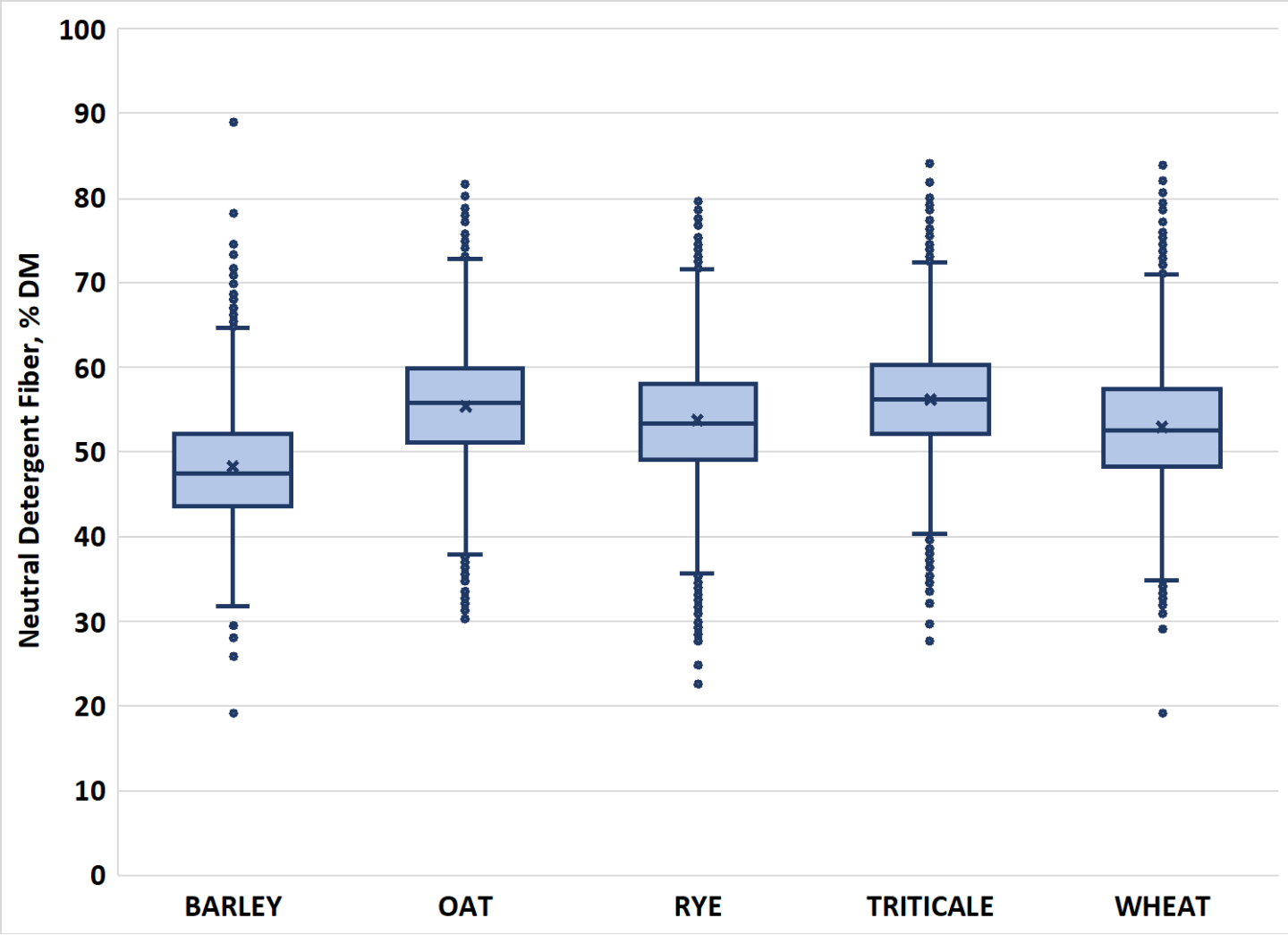
Crude Protein – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

Cereal Grain Forages

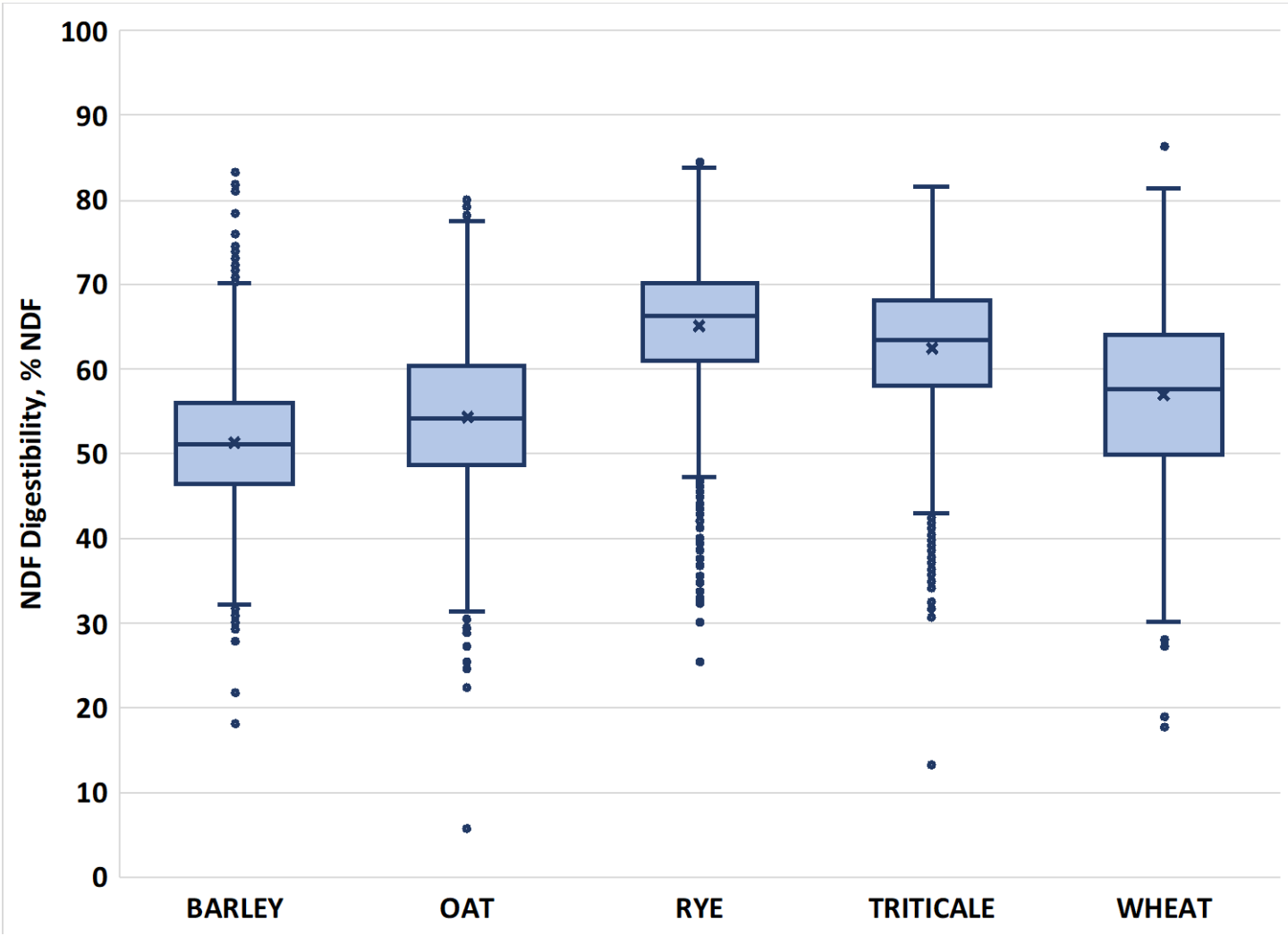
Fiber (NDF) – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

Cereal Grain Forages

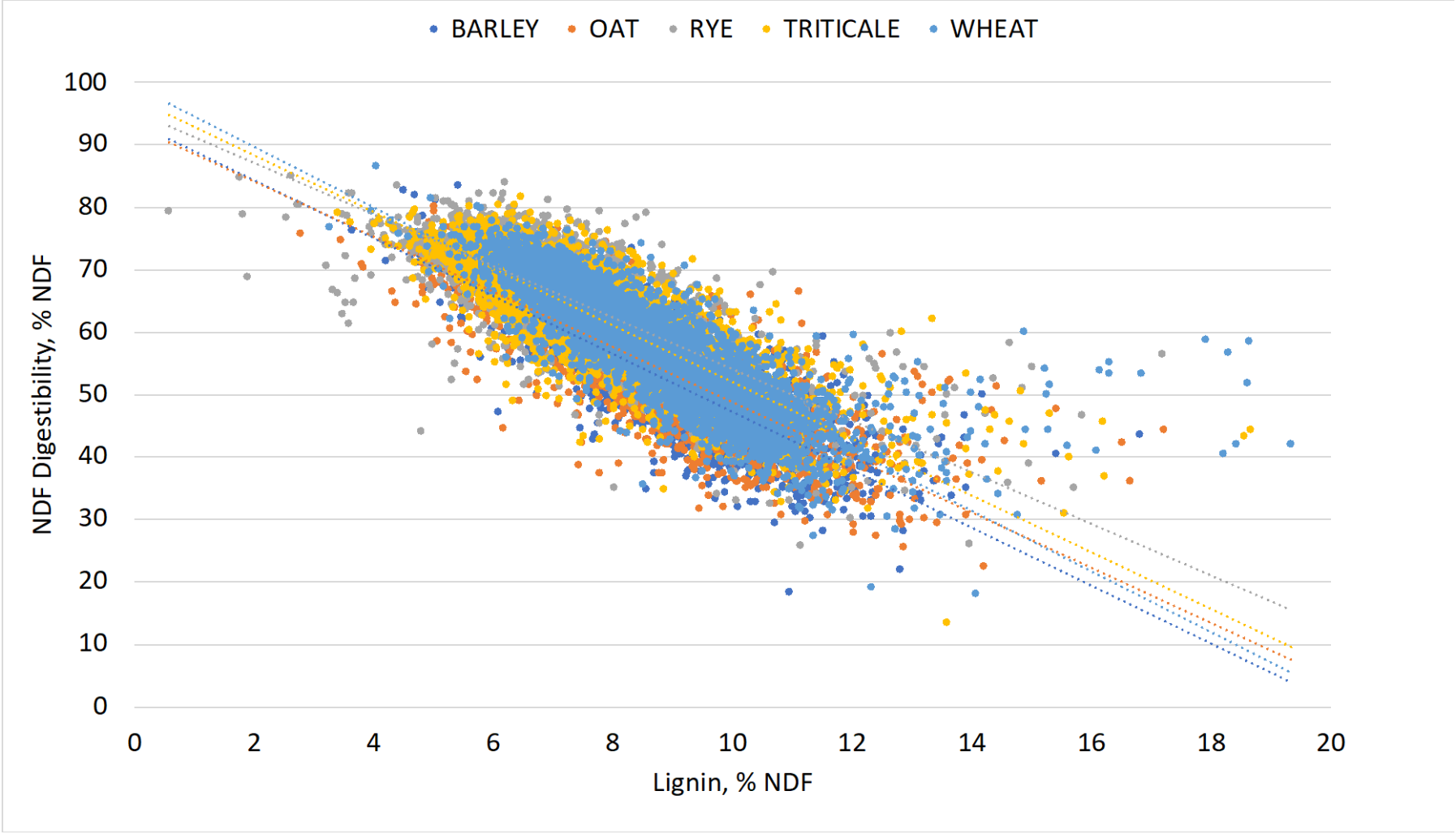
NDF Digestibility – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

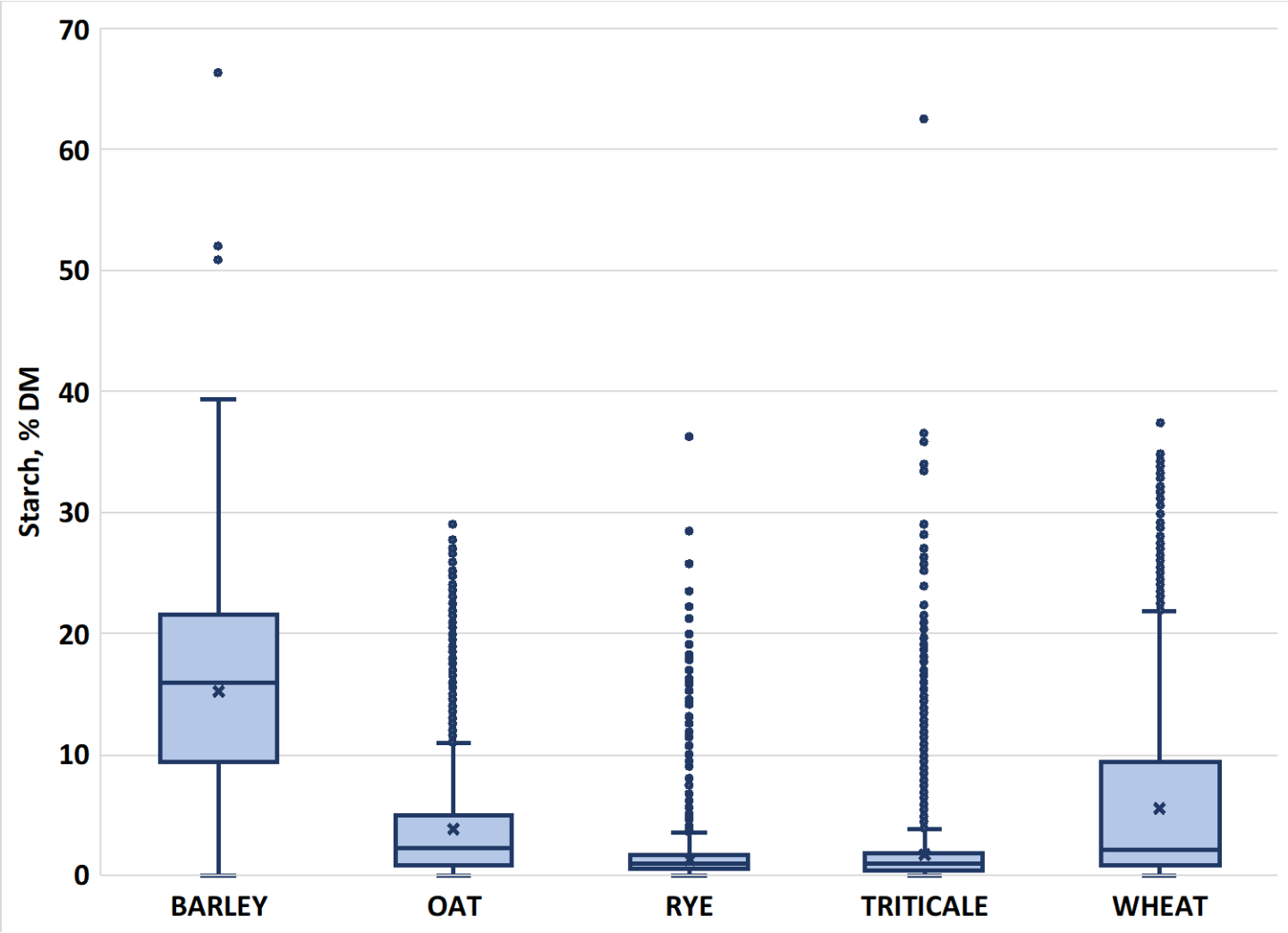
Cereal Grain Forages

NDF Digestibility & Lignin



Cereal Grain Forages

Starch – Descriptive Statistics



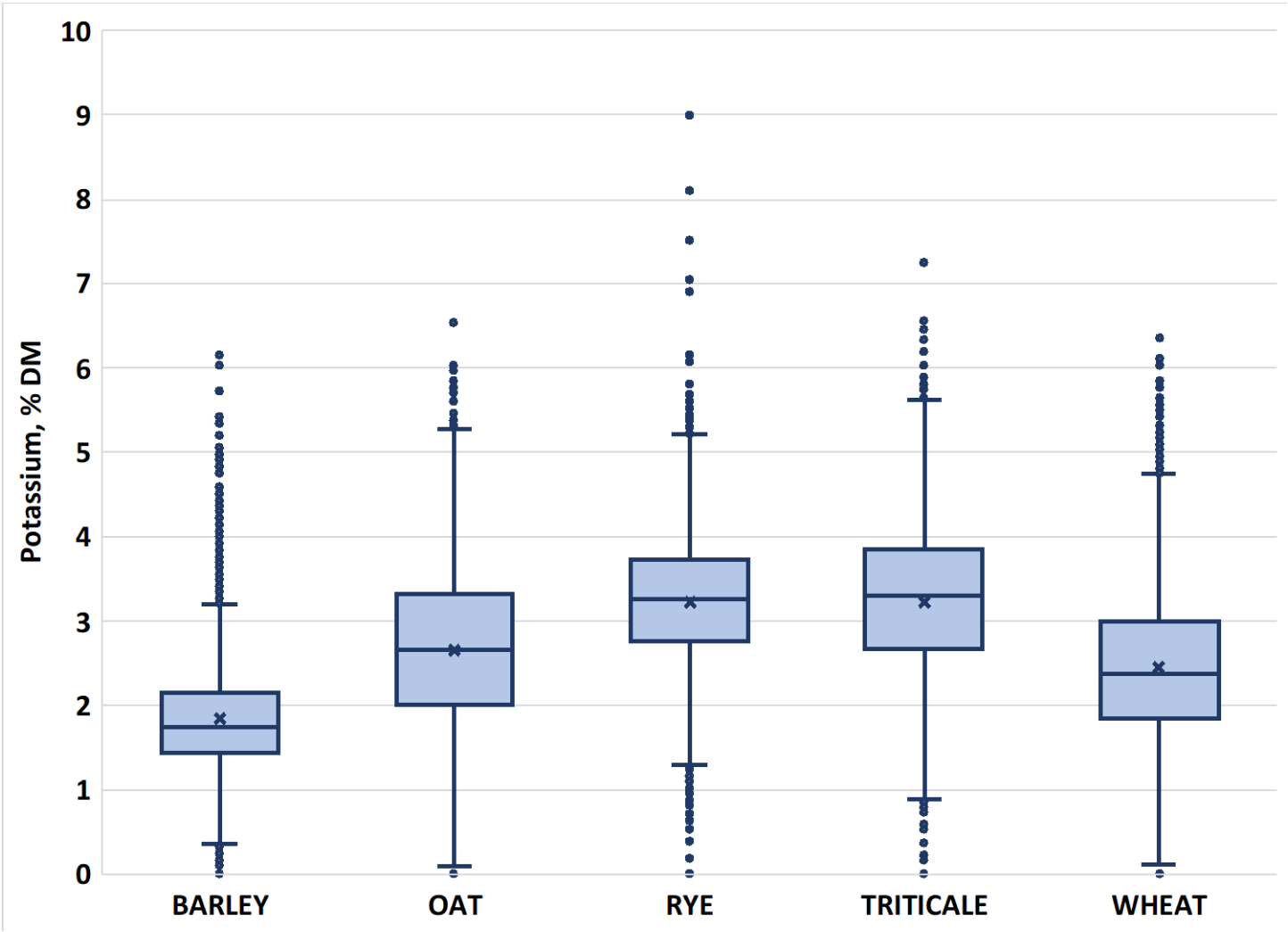
Database provided by Cumberland Valley Analytical Services

Cereal Grain Forages

Potassium & Prepartum

Cereal Grain Forages

Potassium – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

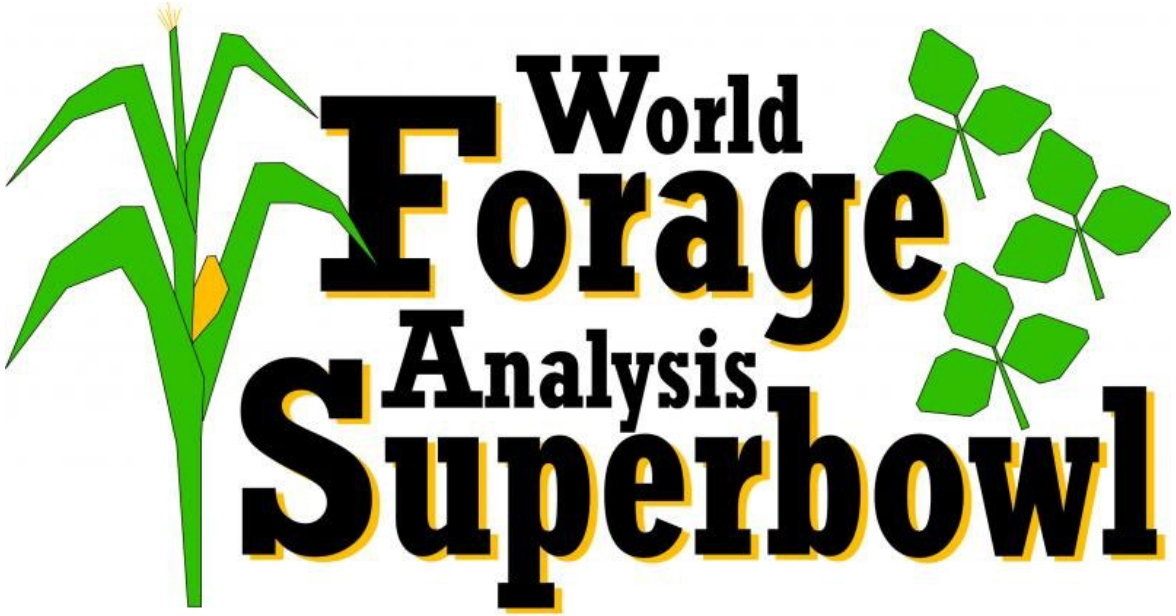
Cereal Grain Forages
Partial Conclusions #1

- Rye and Triticale
  - Greatest CP (% DM) **(+)**
  - Greatest NDFD (% NDF) **(+)**
  - Lowest uNDF (% DM) **(+)**
  - Lowest starch (% DM) **(-)**
  - Greatest K (% DM) **(-)**
- Lignification affects all species similarly


Harvesting Time

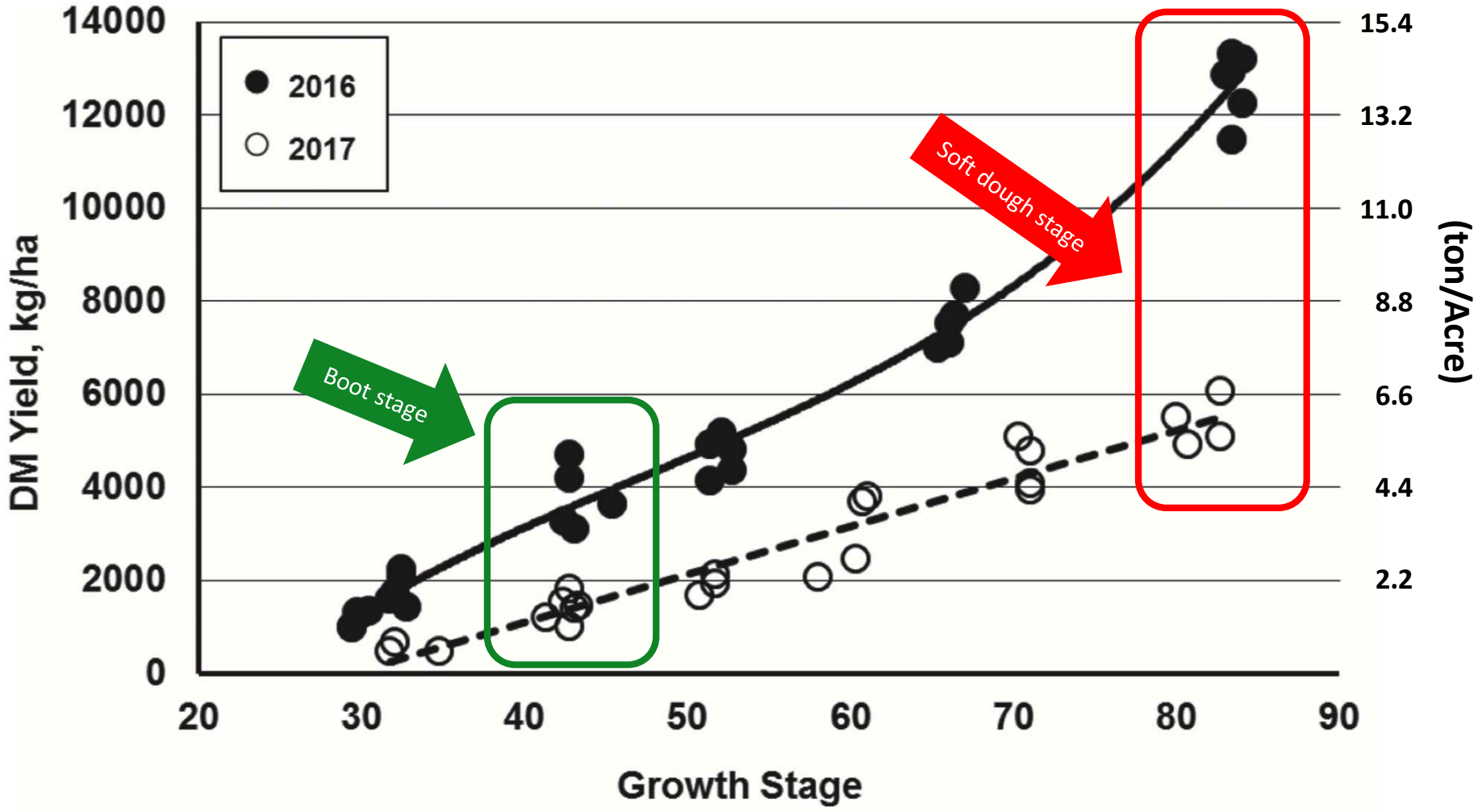
Cereal Grain Forages

Let's Talk About Forage Quality



Cereal Grain Forages

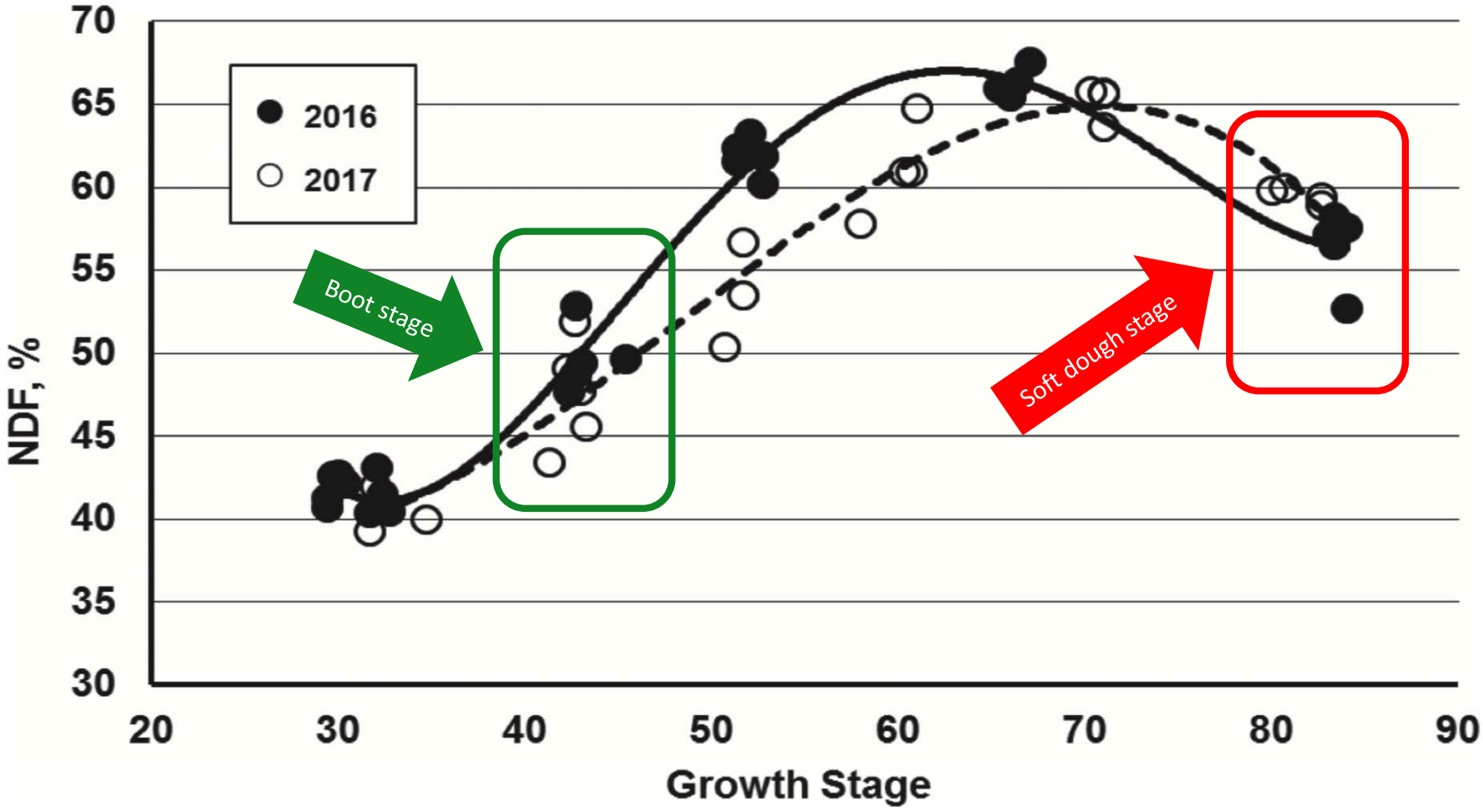
DM Yield - Triticale



Coblentz et al. (2018a)

Cereal Grain Forages

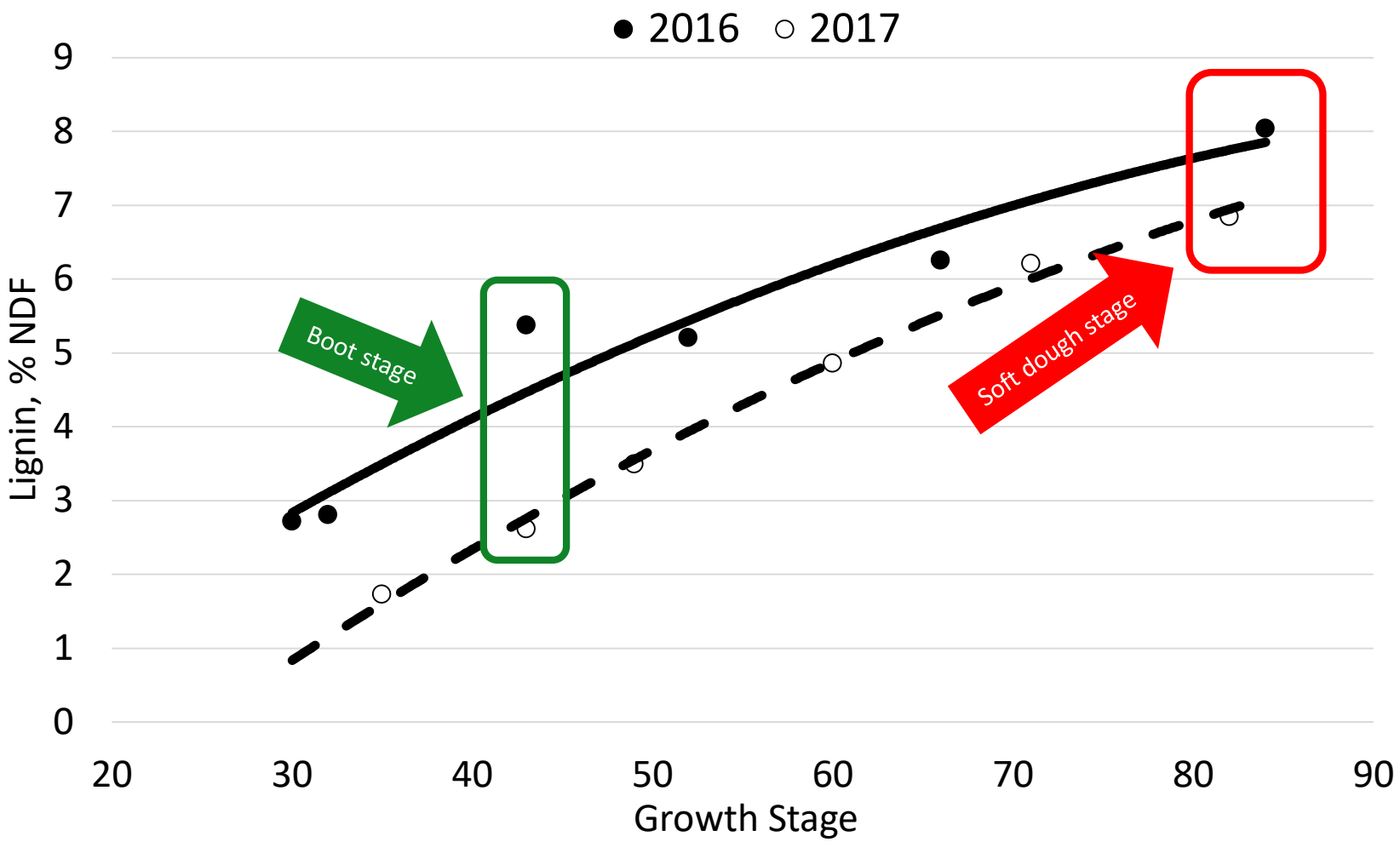
NDF Concentration (% DM) - Triticale



Coblentz et al. (2018a)

Cereal Grain Forages

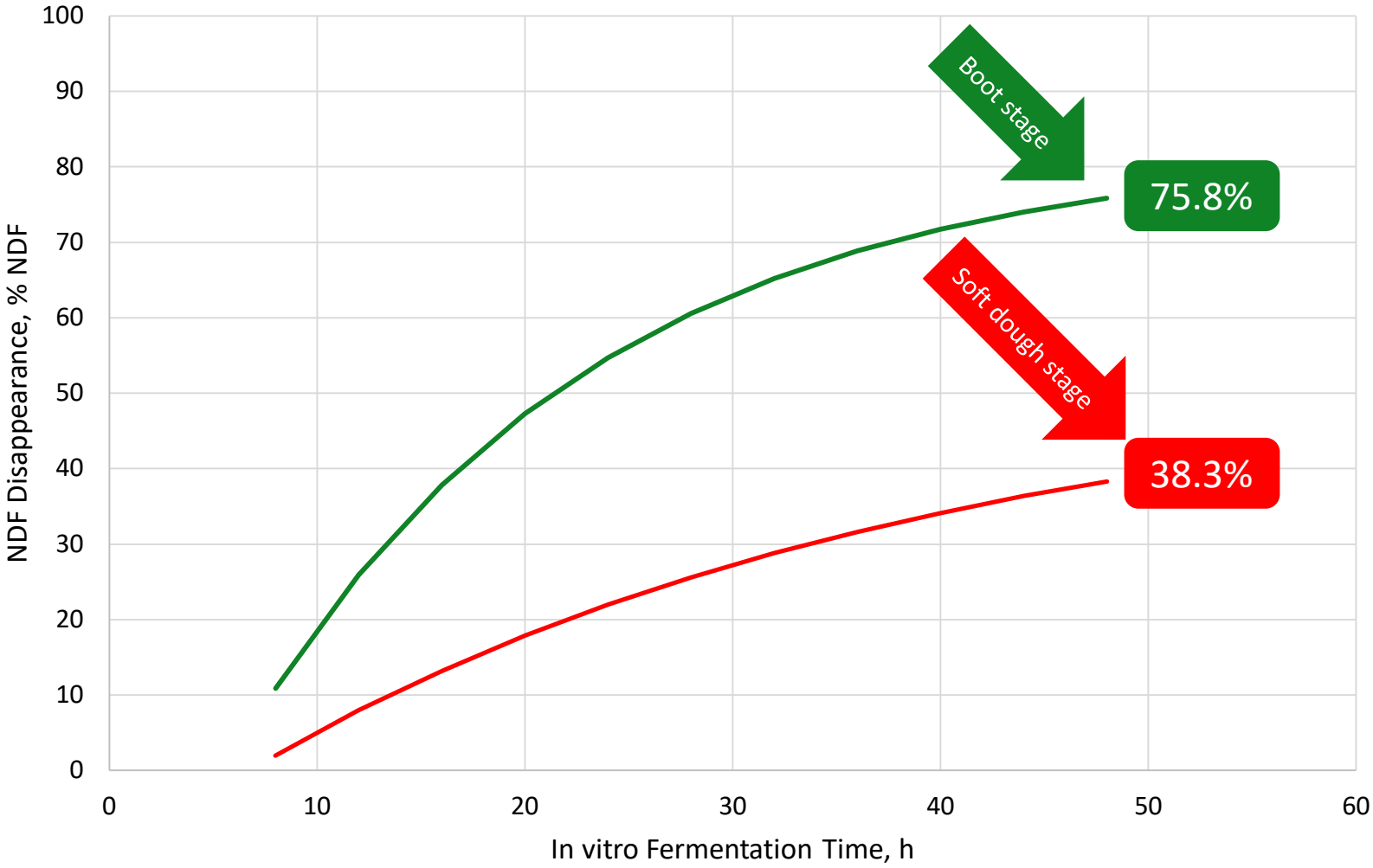
Lignin Concentration (% NDF) - Triticale



Data from Coblentz et al. (2018a)

Cereal Grain Forages

NDF Digestibility (% NDF) - Triticale



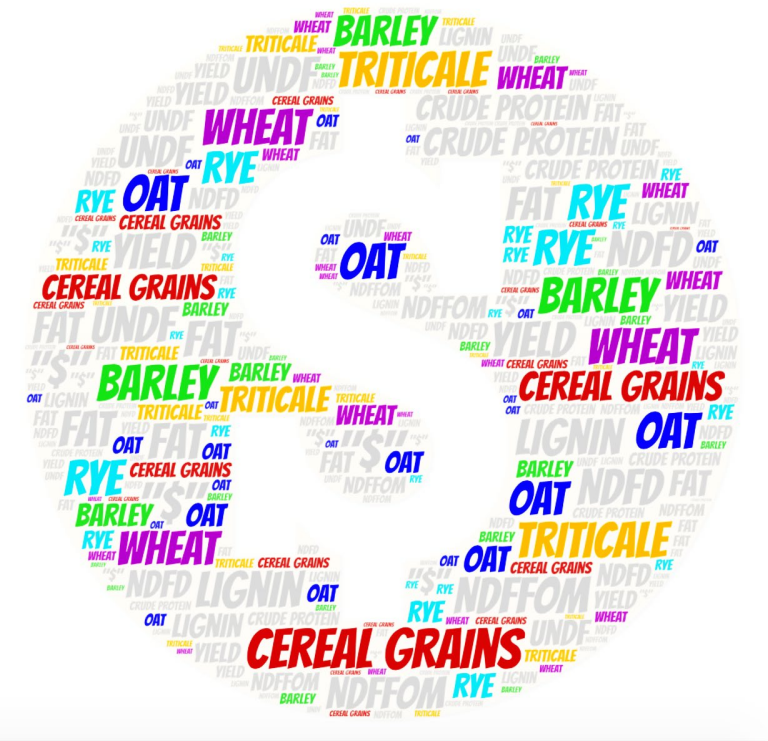
Data from Coblentz et al. (2018b)

Cereal Grain Forages
Partial Conclusions #2

- Boot stage
  - Less yield **(-)**
  - Greatest CP (% DM) **(+)**
  - Greater NDF (% DM) **(-)** / **(+)**
  - Least lignification of CW **(+)**
  - Greatest NDFD (% NDF) **(+)**

Cereal Grain Forages

Harvesting Time



Forage Quality & Management

Big Picture – Importance of Forages

- Definition of "best forage" (i.e., silage, hay, pasture)
  - The one that allows me to formulate the cheapest diet while covering the requirements of the animal (financial and nutritional perspective)
  - The one I can grow/obtain according to my environment (i.e., soil, weather) and location (agronomic and logistic perspective)

Cereal Grain Forages

Silage Cost

	2 ton DM/Ac		4 ton DM/Ac		6 ton DM/Ac	
	$/Ac	%	$/Ac	%	$/Ac	%
Spreading manure	90	33	90	26	90	24
Weed control	19	7	19	6	19	5
No-till planting TRITICALE (2 bu/Ac)	55	20	55	16	55	14
Land rental (6 months)	35	13	35	10	35	9
Interest (6% rate)	7	3	7	2	7	2
Chopping, hauling & ensiling	57	21	114	33	141	37
Inoculant (@ 2/ton)	11	4	23	7	34	9
Total cost	**274**	**100**	**343**	**100**	**381**	**100**
Silage yield (after 10% shrinkage), ton/Ac	5.1	-	10.3	-	15.4	-
Silage cost, $/ton	**53.7**	**-**	**33.3**	**-**	**24.7**	**-**

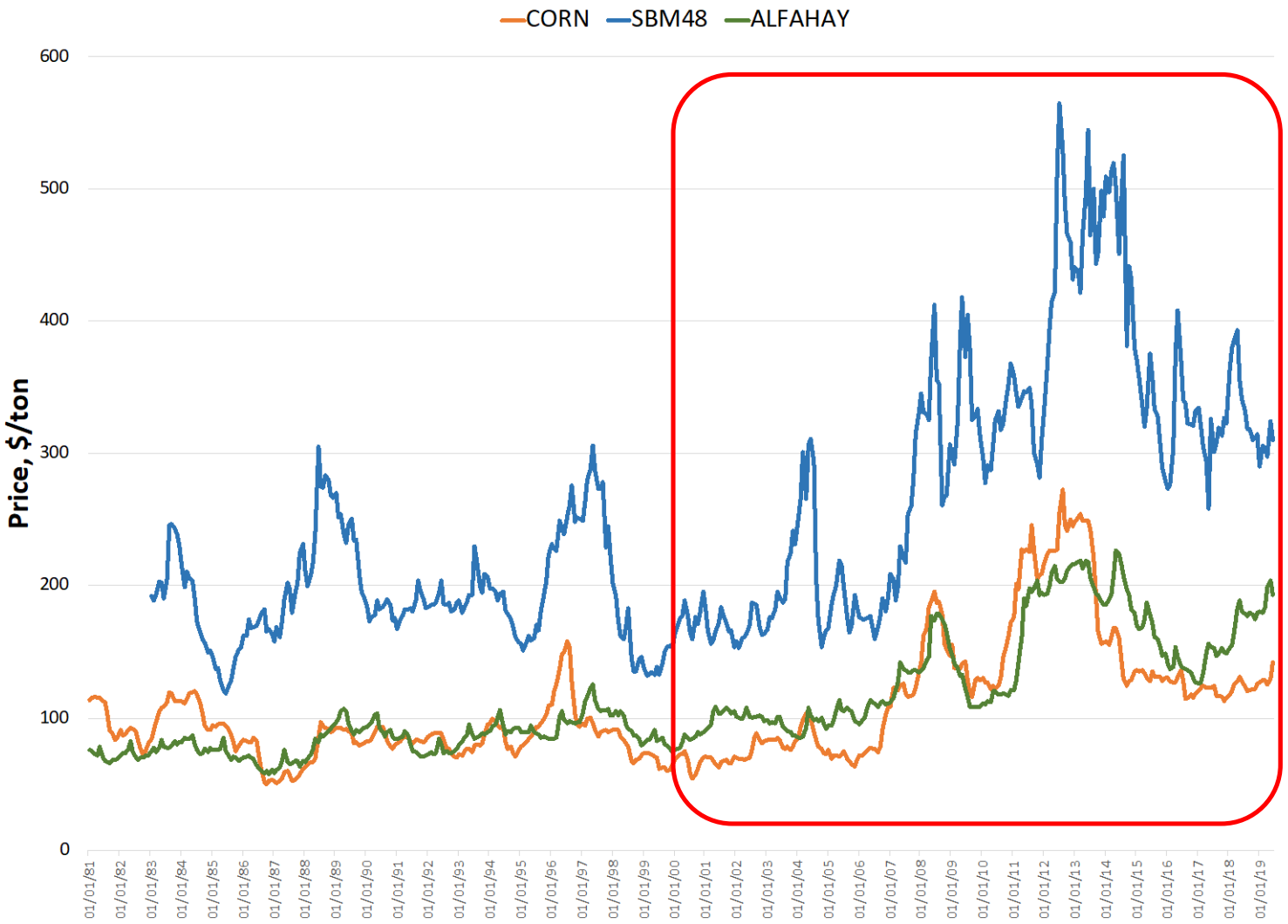
Cereal Grain Forages
Ration Formulation

- 8 scenarios
  - Boot stage vs. Soft-dough stage
  - High grain prices vs. low grain prices
  - High-forage diets vs. low-forage diets

Low $				High $			
High Forage		Low Forage		High Forage		Low Forage	
Boot	Soft Dough	Boot	Soft Dough	Boot	Soft Dough	Boot	Soft Dough
1	2	3	4	5	6	7	8

Cereal Grain Forages

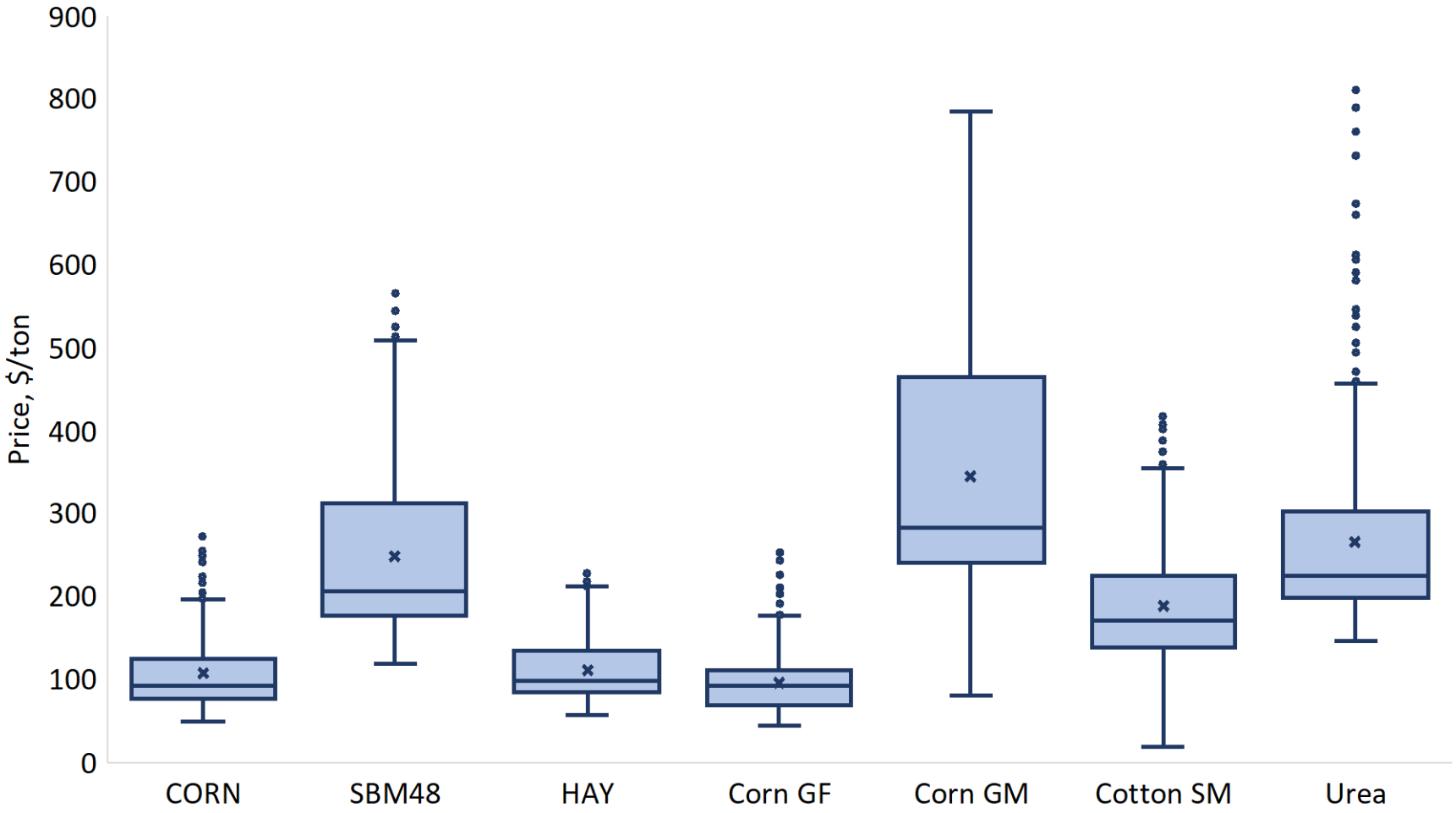
Commodities' Prices



Data obtained from USDA-ERS

Cereal Grain Forages

Commodities' Prices



Data obtained from USDA-ERS

Cereal Grain Forages

Hauling

- $16/ton for all commodities
  - 24-ton load
  - 150 miles
  - $2.56/mile

Cereal Grain Forages
Ration Formulation

- Commodities' prices from USDA
  - Alfalfa hay: $195 vs. $119/ton
  - Corn grain: $161 vs. $95/ton ($135/ton)
  - Soybean meal 48CP: $368 vs. $203/ton ($305/ton)
  - Corn gluten feed: $139 vs. $78/ton
  - Corn gluten meal: $565 vs. $289/ton
  - Cottonseed meal: $200 vs. $167/ton
  - Urea: $434 vs. $179/ton

CME Prices on 08/29/19

Cereal Grain Forages
Ration Formulation

- Optimization for least-cost ration
- Constraints
  - Forage (40 vs. 60% based on scenario)
  - 100-110% NEL
  - 100-110% MP
  - < 17.0% CP
  - 28-32% NDF
  - < 42% NFC
  - < 6.0% Fat

Cereal Grain Forages

Ration Formulation

Scenario	Prices	Forage in Diet	Harvest	Feed Cost
1	Low	High	Boot	$3.13
2	Low	High	Soft Dough	NS / $3.00
3	Low	Low	Boot	$3.05
4	Low	Low	Soft Dough	NS / $2.82
5	High	High	Boot	$4.22
6	High	High	Soft Dough	**$4.05 (kicked out!)**
7	High	Low	Boot	$3.80
8	High	Low	Soft Dough	$4.04

Cereal Grain Forages

Low Prices / High Forage / Boot

Ingredient	kg DM/day	$/d
Triticale Boot	6.7	1.03
Triticale Soft Dough		
Corn silage	7.7	0.66
Alfalfa hay (20% CP)		
Ground corn grain	4.4	0.47
Soybean meal 48%	3.7	0.84
Corn gluten meal		
Cottonseed meal		
Corn gluten feed	1.5	0.13
Urea		
Ration	24.0	3.13

Entity	Result
Forage, % DM	60.0
ME, % Req.	107
MP, % Req.	110
CP, % DM	17.0
$aNDF_{OM}$, % DM	32.0
Forage NDF, % NDF	83.3
NFC, % DM	42.0
Starch, % DM	26.3
Fat	3.4

Cereal Grain Forages

Low Prices / High Forage / Soft Dough

Ingredient	kg DM/day	$/d
Triticale Boot		
Triticale Soft Dough	5.7	0.54
Corn silage	4.7	0.41
Alfalfa hay (20% CP)	3.9	0.52
Ground corn grain	5.2	0.56
Soybean meal 48%	4.3	0.97
Corn gluten meal		
Cottonseed meal		
Corn gluten feed		
Urea		
Ration	23.8	3.00

Entity	Result
Forage, % DM	60.4
ME, % Req.	105
MP, % Req.	108
CP, % DM	17.1
$aNDF_{OM}$, % DM	32.2
Forage NDF, % NDF	88.4
NFC, % DM	42.3
Starch, % DM	24.0
Fat	3.3

Cereal Grain Forages

Low Prices / Low Forage / Boot

Ingredient	kg DM/day	$/d
Triticale Boot	9.6	1.47
Triticale Soft Dough		
Corn silage		
Alfalfa hay (20% CP)		
Ground corn grain	7.6	0.82
Soybean meal 48%	1.2	0.27
Corn gluten meal		
Cottonseed meal		
Corn gluten feed	5.6	0.49
Urea		
Ration	24.0	3.05

Entity	Result
Forage, % DM	40.0
ME, % Req.	104
MP, % Req.	107
CP, % DM	16.9
$aNDF_{OM}$, % DM	31.3
Forage NDF, % NDF	63.3
NFC, % DM	42.0
Starch, % DM	27.4
Fat	3.8

Cereal Grain Forages

Low Prices / Low Forage / Soft Dough

Ingredient	kg DM/day	$/d
Triticale Boot		
Triticale Soft Dough	8.8	0.84
Corn silage		
Alfalfa hay (20% CP)	0.8	0.11
Ground corn grain	7.0	0.76
Soybean meal 48%	3.6	0.80
Corn gluten meal	3.7	0.32
Cottonseed meal		
Corn gluten feed		
Urea	0.006	
Ration	23.8	2.82

Entity	Result
Forage, % DM	40.3
ME, % Req.	104
MP, % Req.	110
CP, % DM	17.1
$aNDF_{OM}$, % DM	32.2
Forage NDF, % NDF	70.6
NFC, % DM	42.3
Starch, % DM	24.9
Fat	3.6

Cereal Grain Forages
Partial Conclusions #3

- With low-price scenarios - soft-dough stage
  - Soft-dough stage results in cheaper diets
  - Boot stage kicks corn silage out of the formula (do we want that?)
  - Dependency off alfalfa hay (bad?)

Cereal Grain Forages

High Prices / High Forage / Boot

Ingredient	kg DM/day	$/d
Triticale Boot	7.4	1.13
Triticale Soft Dough		
Corn silage	7.0	0.60
Alfalfa hay (20% CP)		
Ground corn grain	5.1	0.93
Soybean meal 48%	3.0	1.23
Corn gluten meal		
Cottonseed meal	1.5	0.33
Corn gluten feed		
Urea		
Ration	24.0	4.22

Entity	Result
Forage, % DM	60.0
ME, % Req.	107
MP, % Req.	110
CP, % DM	17.0
$aNDF_{OM}$, % DM	32.0
Forage NDF, % NDF	84.1
NFC, % DM	42.0
Starch, % DM	26.7
Fat	3.4

Cereal Grain Forages

High Prices / High Forage / Soft Dough

Ingredient	kg DM/day	$/d
Triticale Boot		
Triticale Soft Dough		
Corn silage	9.1	0.78
Alfalfa hay (20% CP)	5.3	1.15
Ground corn grain	3.7	0.67
Soybean meal 48%	1.5	0.62
Corn gluten meal	0.2	0.11
Cottonseed meal	1.0	0.22
Corn gluten feed	3.2	0.50
Urea		
Ration	24.0	4.05

Entity	Result
Forage, % DM	60.0
ME, % Req.	101
MP, % Req.	108
CP, % DM	17.0
$aNDF_{OM}$, % DM	32.0
Forage NDF, % NDF	75.0
NFC, % DM	42.0
Starch, % DM	27.2
Fat	3.3

Cereal Grain Forages

High Prices / Low Forage / Boot

Ingredient	kg DM/day	$/d
Triticale Boot	6.6	1.02
Triticale Soft Dough		
Corn silage	3.0	0.26
Alfalfa hay (20% CP)		
Ground corn grain	6.7	1.22
Soybean meal 48%		
Corn gluten meal		
Cottonseed meal	1.7	0.38
Corn gluten feed	6.0	0.93
Urea		
Ration	24.0	3.80

Entity	Result
Forage, % DM	40.0
ME, % Req.	102
MP, % Req.	107
CP, % DM	16.4
$aNDF_{OM}$, % DM	32.0
Forage NDF, % NDF	58.2
NFC, % DM	42.0
Starch, % DM	29.0
Fat	3.8

Cereal Grain Forages

High Prices / Low Forage / Soft Dough

Ingredient	kg DM/day	$/d
Triticale Boot		
Triticale Soft Dough	4.6	0.44
Corn silage	2.3	0.20
Alfalfa hay (20% CP)	2.7	0.58
Ground corn grain	6.2	1.14
Soybean meal 48%	1.5	0.60
Corn gluten meal		
Cottonseed meal	0.7	0.15
Corn gluten feed	6.0	0.93
Urea		
Ration	24.0	4.04

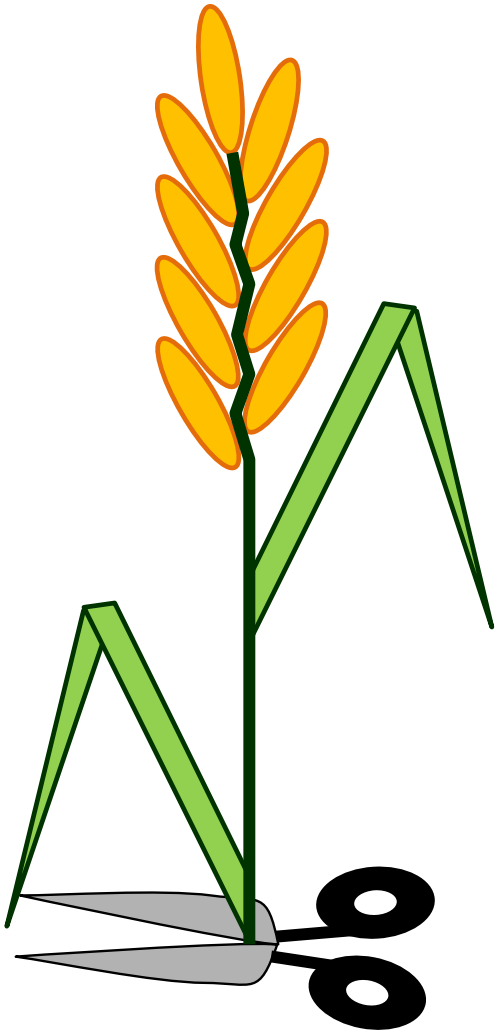
Entity	Result
Forage, % DM	40.0
ME, % Req.	101
MP, % Req.	108
CP, % DM	17.0
$aNDF_{OM}$, % DM	32.0
Forage NDF, % NDF	61.0
NFC, % DM	42.0
Starch, % DM	26.8
Fat	3.6

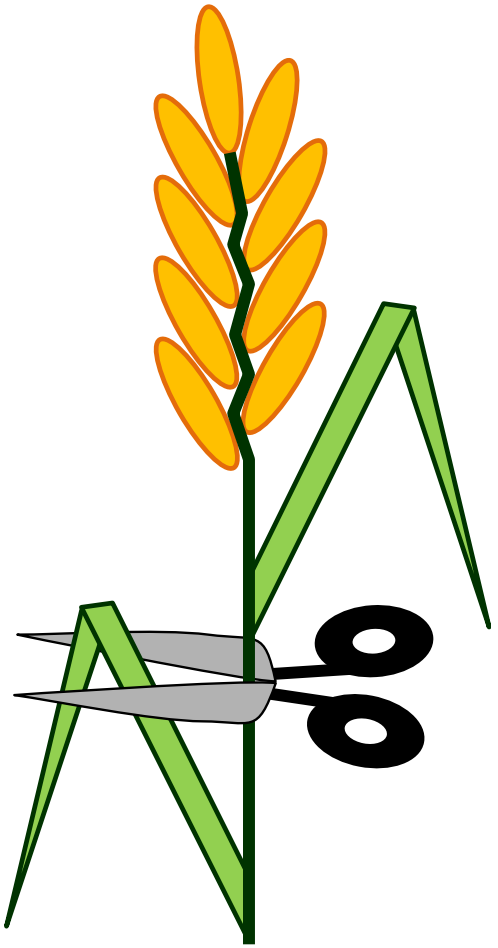
Cereal Grain Forages
Partial Conclusions #4

- With high-price scenarios - boot stage
  - The relatively high [CP] ensures simple diets
  - The low [CP] of soft-dough forces alfalfa hay into the formula

Cereal Grain Forages

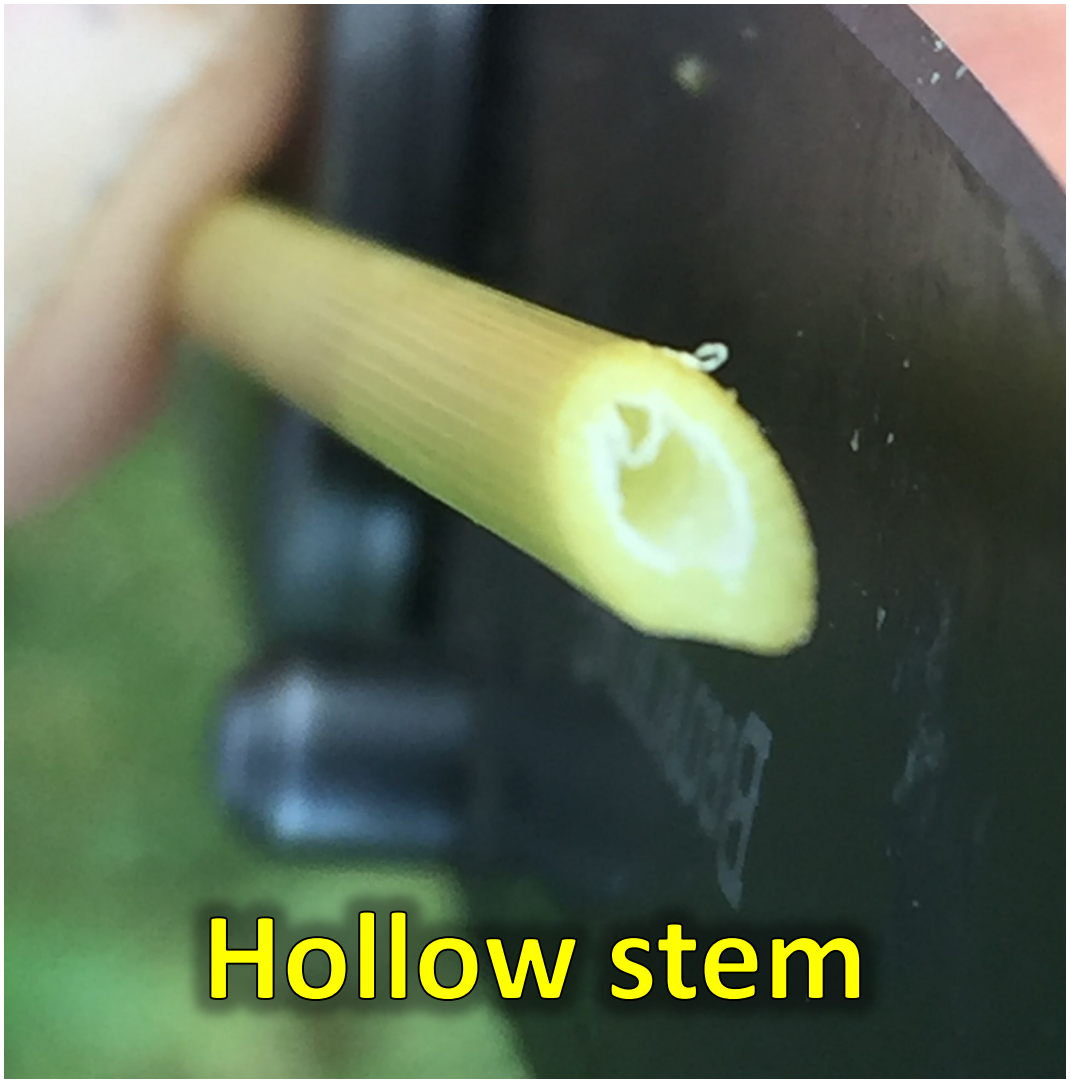
Cutting Height





Cereal Grain Forages

Cereal Grains – Pooideae subfamily



Cereal Grain Forages

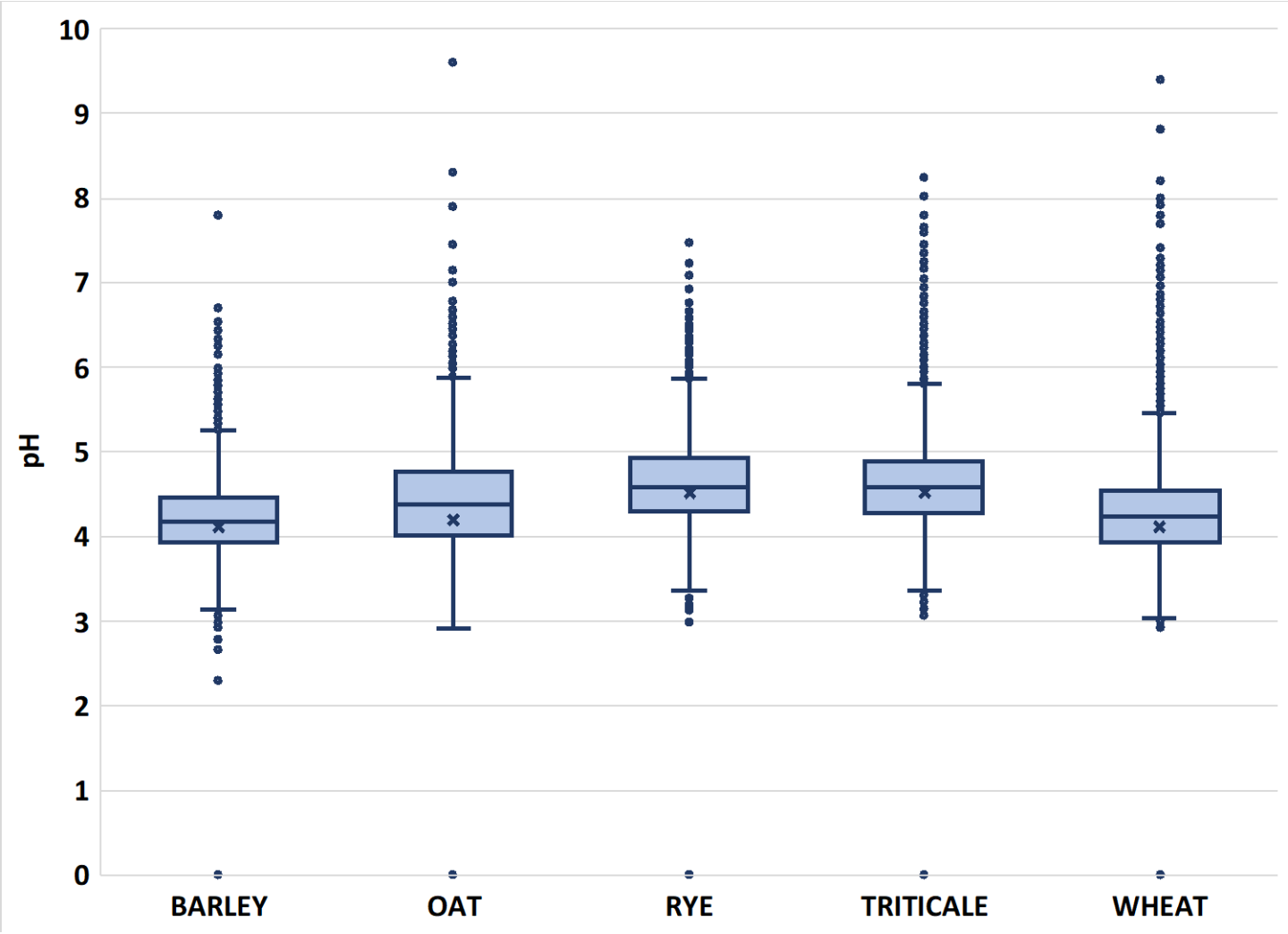
Ensiling – Ensure Adequate Packing Density!!!

Cereal Grain Forages

Ensiling – Eat It Quickly!

Cereal Grain Forages

pH – Descriptive Statistics



Database provided by Cumberland Valley Analytical Services

Cereal Grain Forages

Ensiling

	Sugars, % DM	Starch, % DM	Silage pH
Corn	11.8	34.6	3.74
Barley	12.1	2.8	4.25
Rye	14.1	3.5	4.17
Ryegrass	11.2	2.8	4.10
Triticale	15.0	3.4	4.15
Wheat	18.8	3.7	4.00

Brown et al. (2018)

Cereal Grain Forages

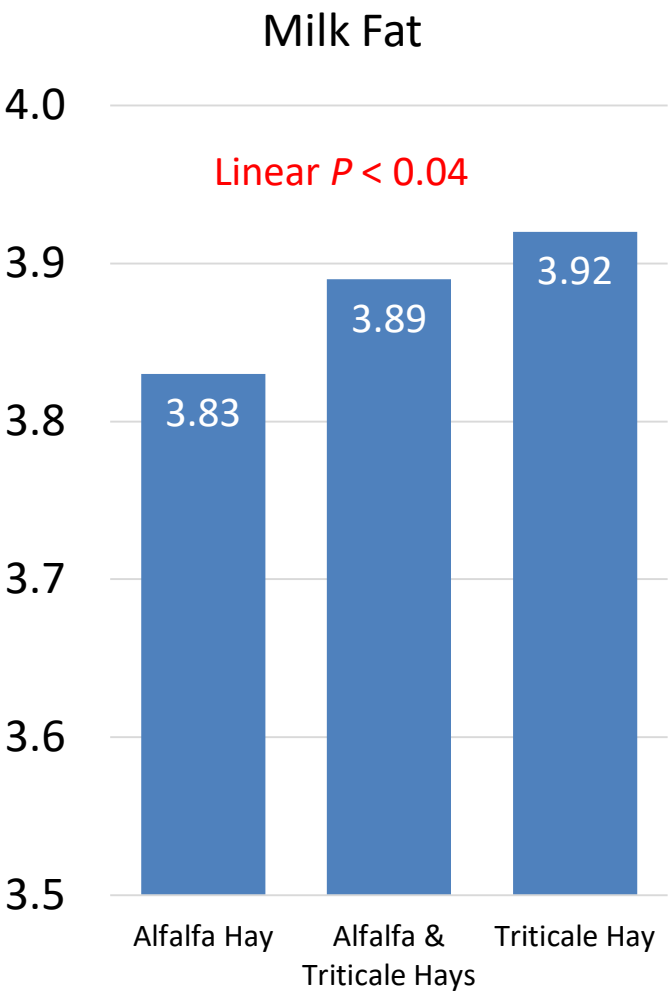
Ensiling

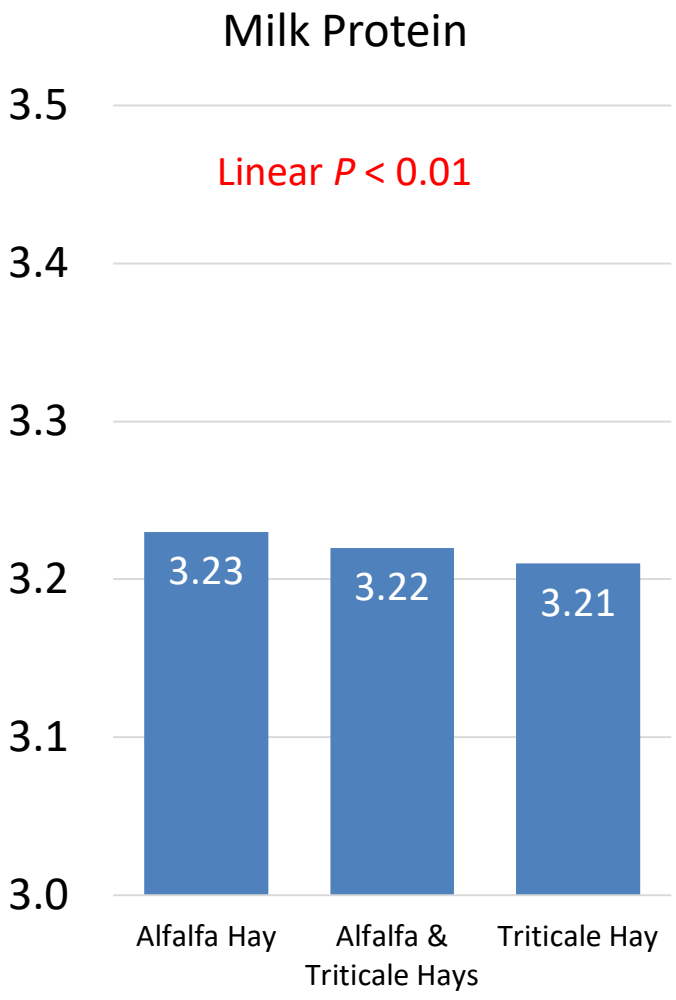
	Sugars, % DM	Starch, % DM	Silage pH
Corn	11.8	34.6	3.74
Barley	12.1	2.8	4.25
Rye	14.1	3.5	4.17
Ryegrass	11.2	2.8	4.10
Triticale	15.0	3.4	4.15
Wheat	18.8	3.7	4.00
Barley + Hairy vetch	9.5	3.0	4.56
Rye + Hairy vetch	10.9	3.4	4.48
Ryegrass + Hairy vetch	8.8	2.6	4.27
Triticale + Hairy vetch	11.1	3.3	4.47
Wheat + Hairy vetch	12.5	3.6	4.32

Brown et al. (2018)

Cereal Grain Forages

Feeding Cereal Grain Silages





Santana et al. (2019)

Cereal Grain Forages
Overall Conclusions

- Rye and triticale tend to provide better forage quality than barley, oats, and wheat
- Harvesting at boot stage will ensure better forage quality
- Harvesting at soft dough stage will allow cheaper diets when commodities' prices are low
- Harvesting at boot stage will allow cheaper and simpler diets when commodities' prices are high
- Effects of harvesting time on production performance need to be determined

Cereal Grain Forages

Acknowledgements

- Forage Seminar Committee at World Dairy Expo
- Mr. Clint Steger (Virginia Tech)
- Cumberland Valley Analytical Services (CVAS)
- Agricultural Modeling and Training Systems (AMTS)


THANK YOU!!!