WASHINGTON STATE UNIVERSITY EXTENSION

How Far Can the Genetics of Alfalfa Improve Quality

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USDA United States Department of Agriculture

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Objectives

1) Determine quality at first harvest of 200 alfalfa plant introductions and varieties at three locations in the PNW
2) Quantify the genetic diversity of alfalfa that is related to forage quality
3) Identify genetic areas associated with forage quality
4) Extend the knowledge gained

Materials and Methods

- Grow 200 varieties from diverse germplasm at three locations in PNW in an augmented design using Vernal and Alforex Hi-Gest 360 as checks in 11 blocks per location
- DNA analysis of germplasm
- Fiber analysis including NDF, NDFD24, NDFD30, NDFD48, kd, iNDF, TTNDFD etc.
- Determine genetic areas and molecular markers related to fiber quality

Plant introductions and varieties

- Diverse Germplasm including:
  - 148 PI and std. cultivars from USDA National Plant Germplasm database
  - 52 varieties ranging in quality from:
    - S&W Seed Co.
    - Alforex (Corteva) Seeds
    - Legacy Seeds
    - Blue River Hybrids

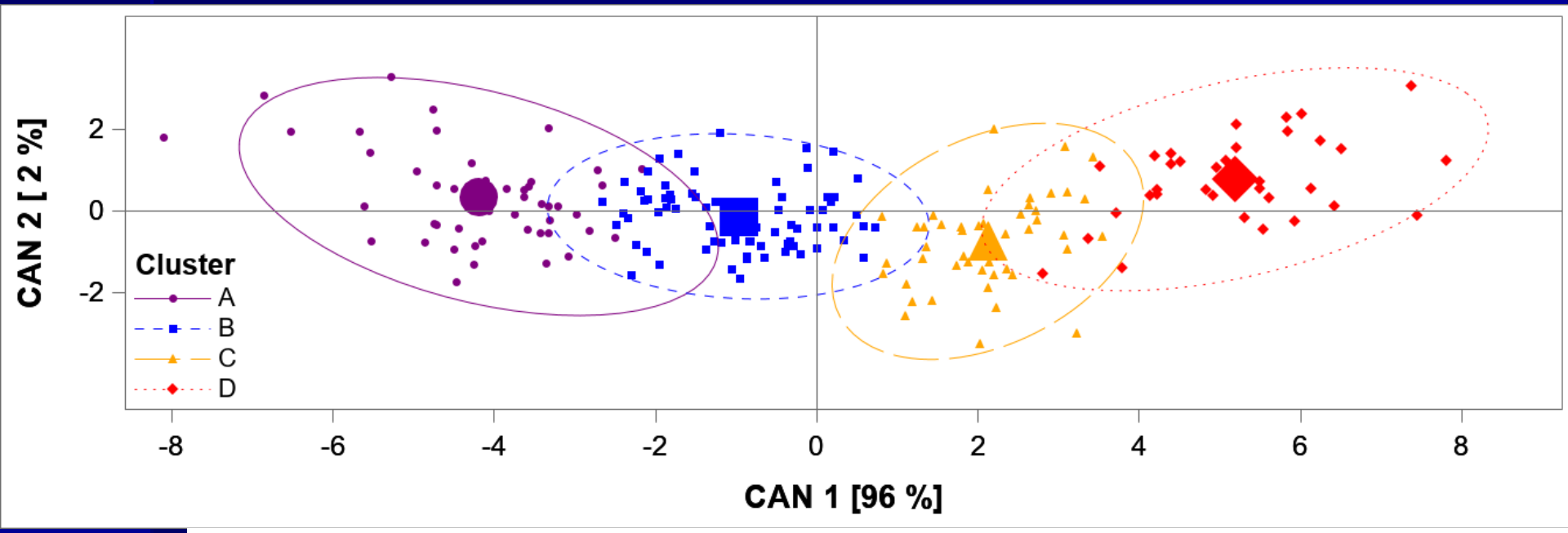
Breakdown of the 200 entries in this study

Region	Country	N
North America	Canada (21), United States (121)	138
Turkey	Turkey	21
Central Asia	Afghanistan, Armenia, Georgia, Kazakhstan, Turkmenistan	14
Eastern Europe	Belarus (1), Russian Federation (8)	9
China	China	8
Central_Europe	Czech Republic, Denmark, France, Germany	4
Mediterranean	Greece, Morocco, Romania, Spain	4
Other	Australia, Japan	2


Salish Sea
Strait of Juan de Fuca
Washington
Cascade Range
Prosser
Elevation 203 m (665 ft)
Bitterroot Range
Rocky Mountains
Union
Elevation 851 m (2,791 ft)
Salmon River Mountains
Oregon
Idaho
Kimberly
Kimberly
Elevation of 1,196 m; (3,924 ft.)
Klamath Mountains

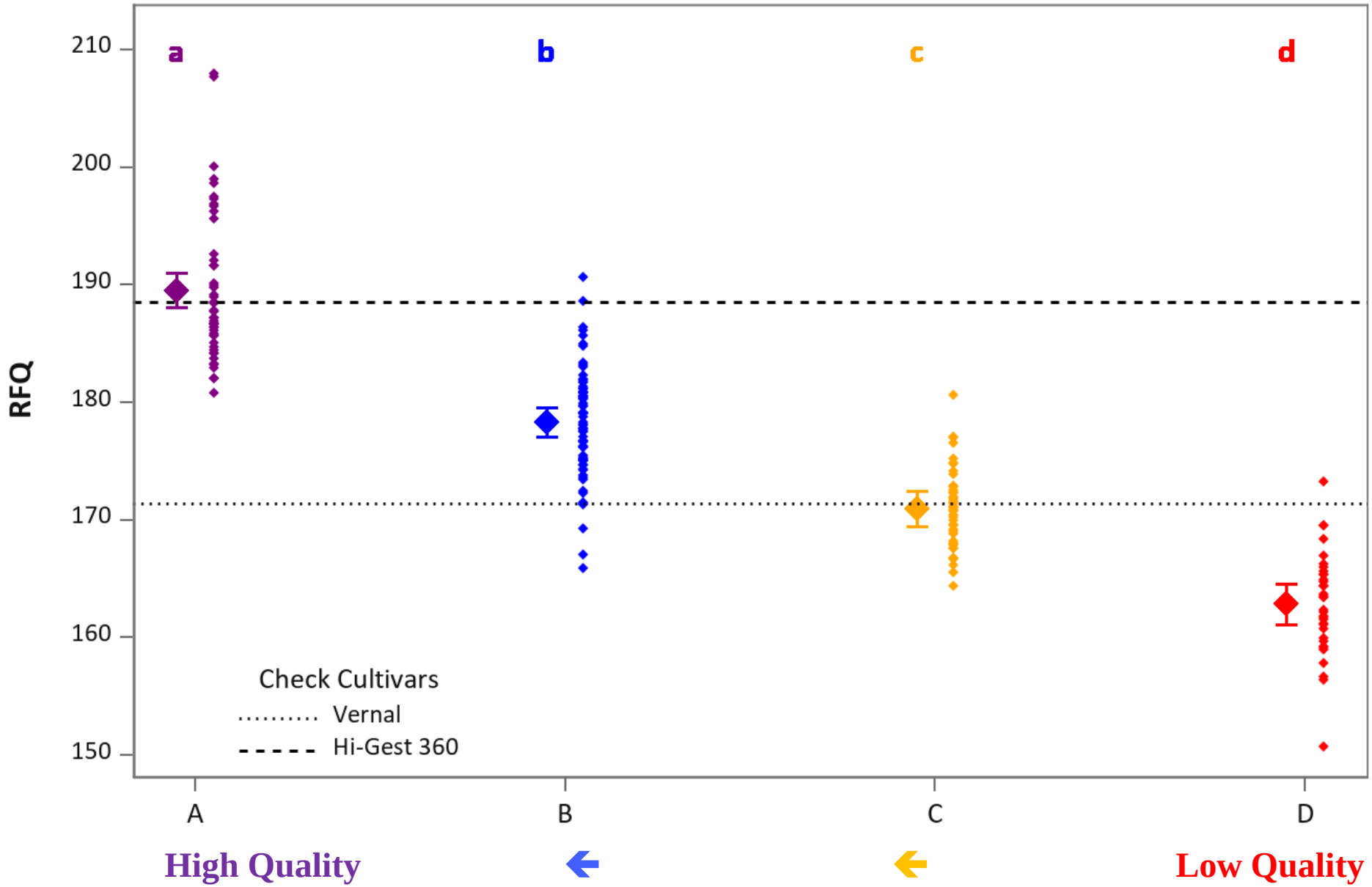

Prosser, WA
Before second cutting
on 8/23/2018

Canonical Analysis Analysis for Forage Quality based on RFQ

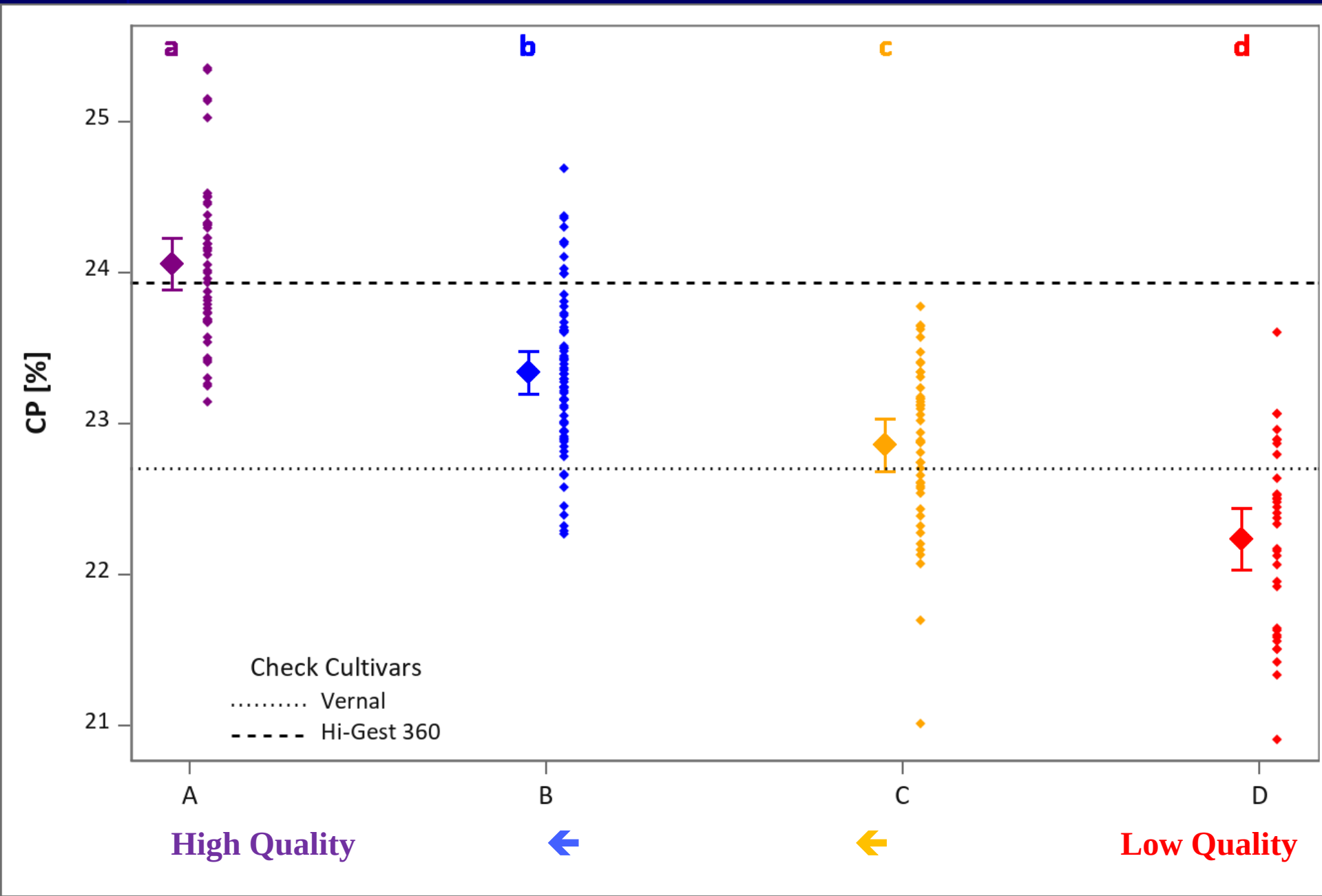


High Quality ← ← Low Quality

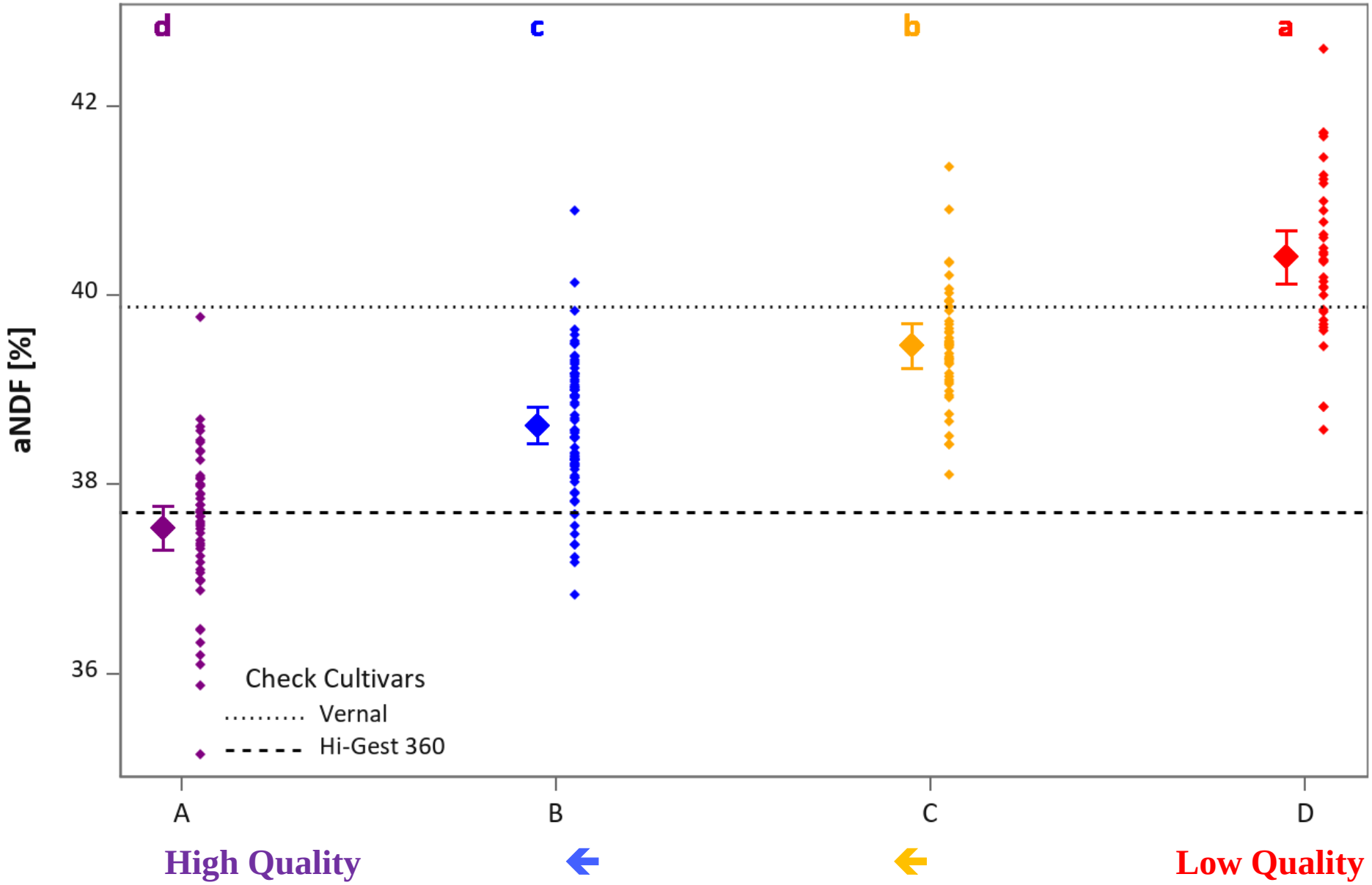
RFQ


RFQ
210
200
190
180
170
160
150
a
b
c
d
A
B
C
D
Check Cultivars
Vernal
Hi-Gest 360
High Quality
Low Quality

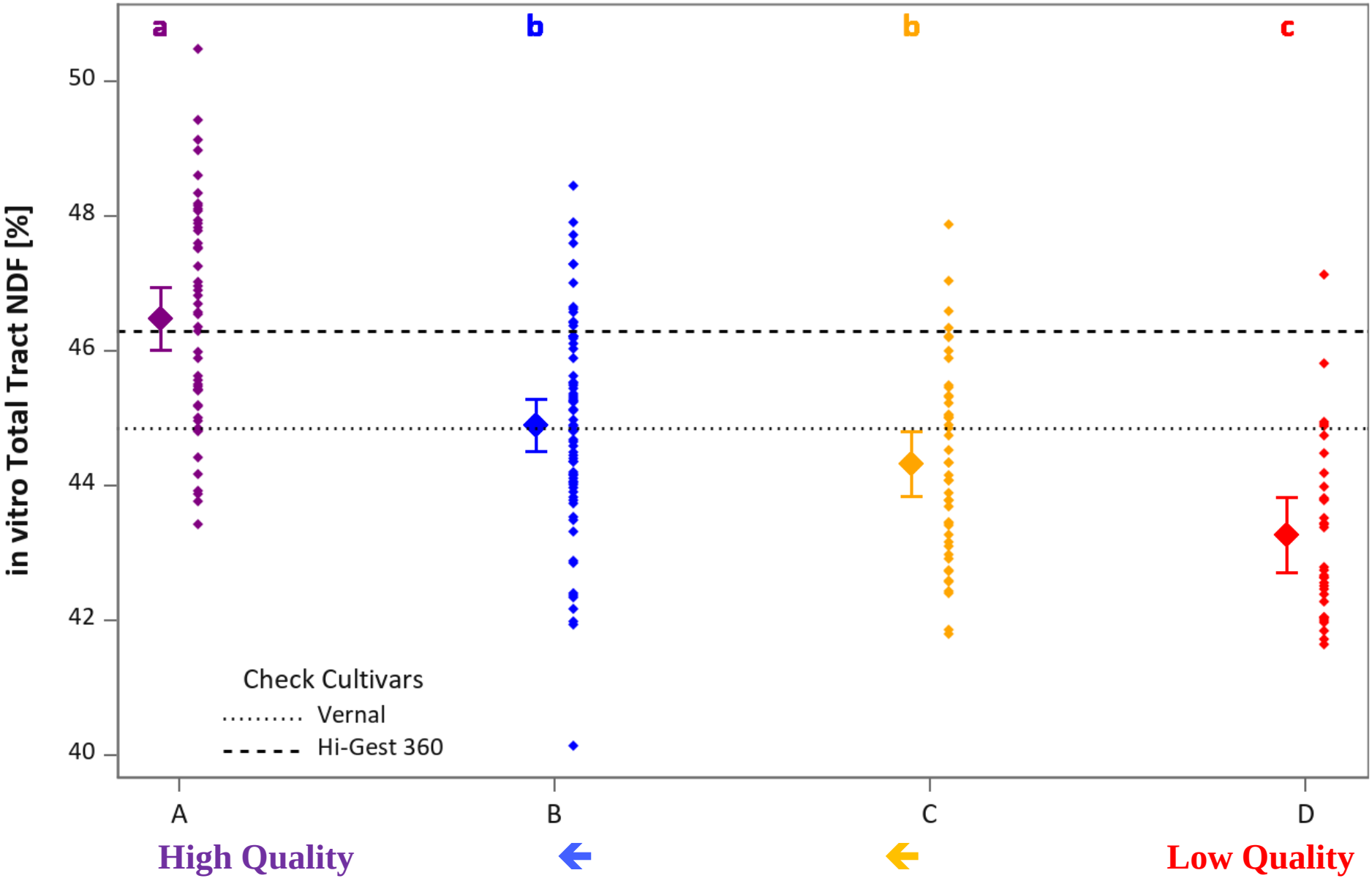
Crude Protein



aNDF


d
c
b
a
42
40
38
36
aNDF [%]
Check Cultivars
Vernal
Hi-Gest 360
A
B
C
D
High Quality
Low Quality

TTNDFD


a
b
b
c
50
48
46
44
42
40
in vitro Total Tract NDF [%]
Check Cultivars
Vernal
Hi-Gest 360
A
B
C
D
High Quality
Low Quality

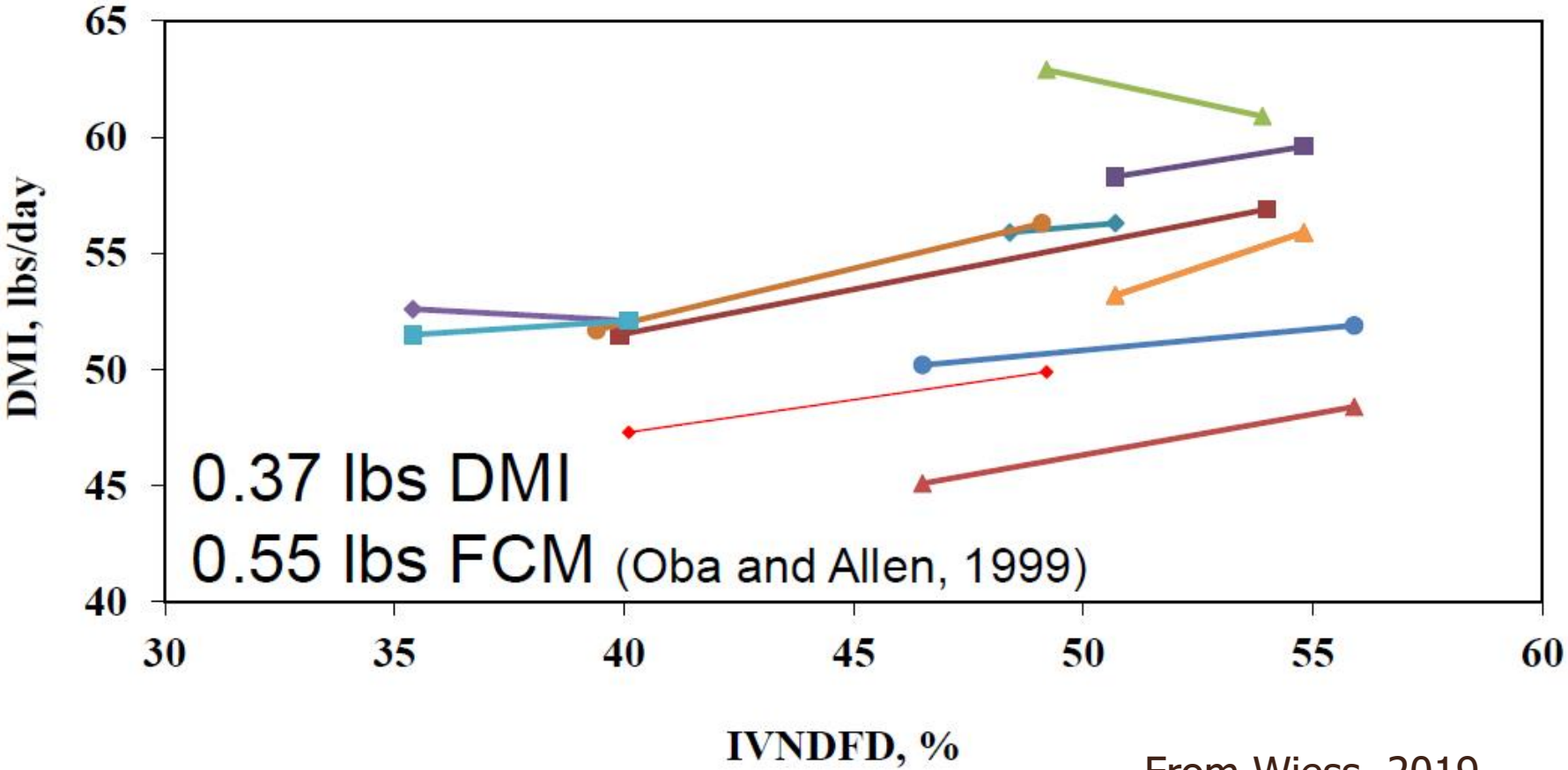
Putting a Dollar Value to Alfalfa Hay

- Highest value of hay is to Dairy Cows
- Based on all dairy feed stuffs in an area and used to calculate competitive values
- Main nutrients used by dairy are:
  - Energy - use NEL (NRC 2001)
  - Protein - Metabolizable Protein
  - Fiber - some is needed but too much limits animals' ability to eat more which limits milk production

Effect of **Change** in IVNDFD on DMI

12 new comparisons (Oba and Allen, 2005)

Avg: **0.26 lbs**/IVNDFD unit = **0.5 lbs FCM**



From Wiess, 2019

Value of quality depends on milk and feed prices

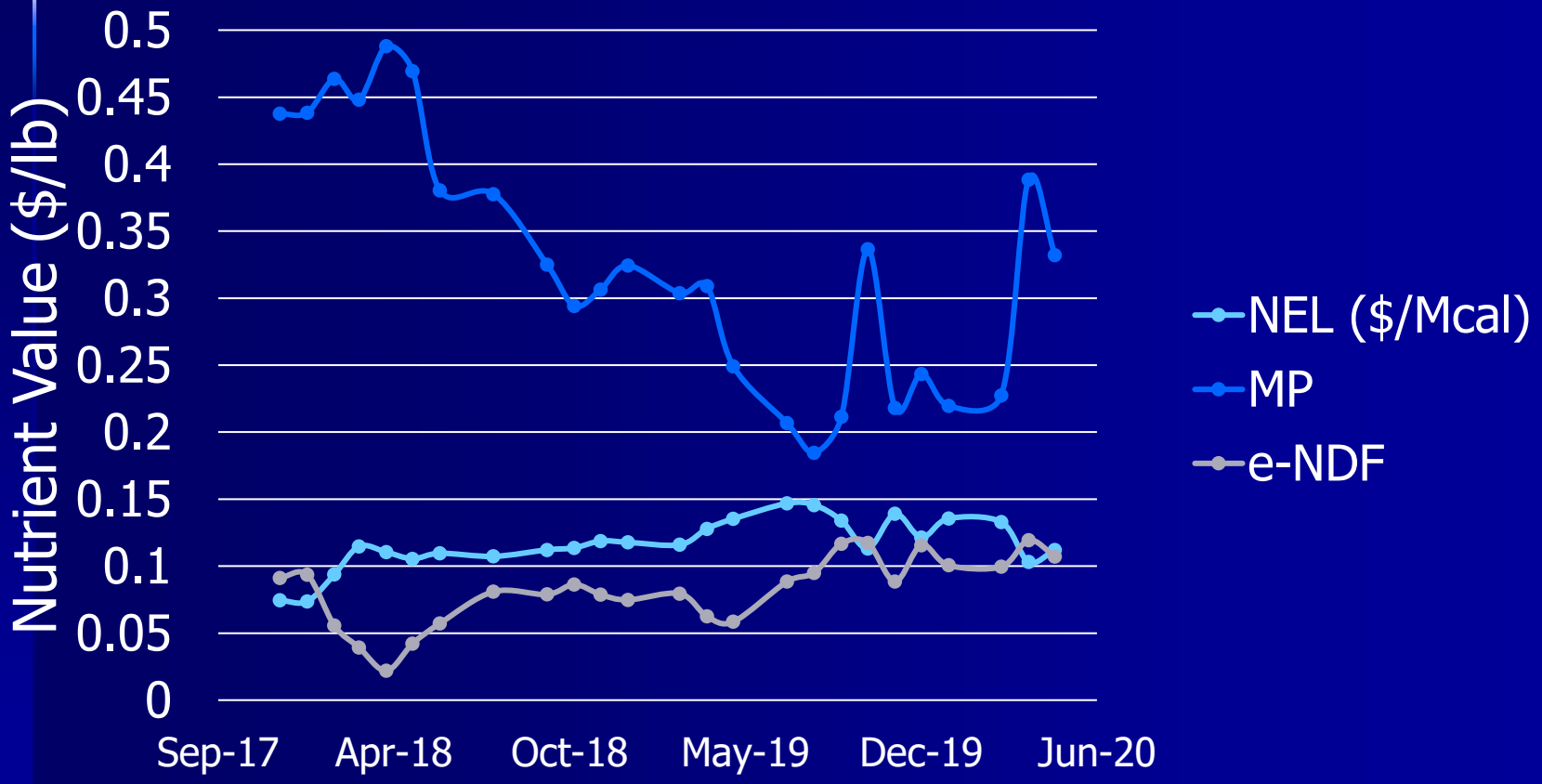
Quality adjustment/ton of DM

	$16/cwt	$20/cwt	$24/cwt
$0.06/lb DM	5.4	7.1	8.6
$0.08/lb	5.0	6.7	8.4
$0.10/lb	4.5	6.2	7.9
$0.12/lb	4.0	5.7	7.4

Add or subtract value/% unit change in IVNDFD

From Wiess, 2019

Value of Nutrients in PNW over Time



Tebbe and Wiess, 2020

Avg. over Locations, Value of Hay for Protein, Energy, Fiber, Fiber Fill and Total $ ton^{-1} of for First Cutting 2018 and 2019.

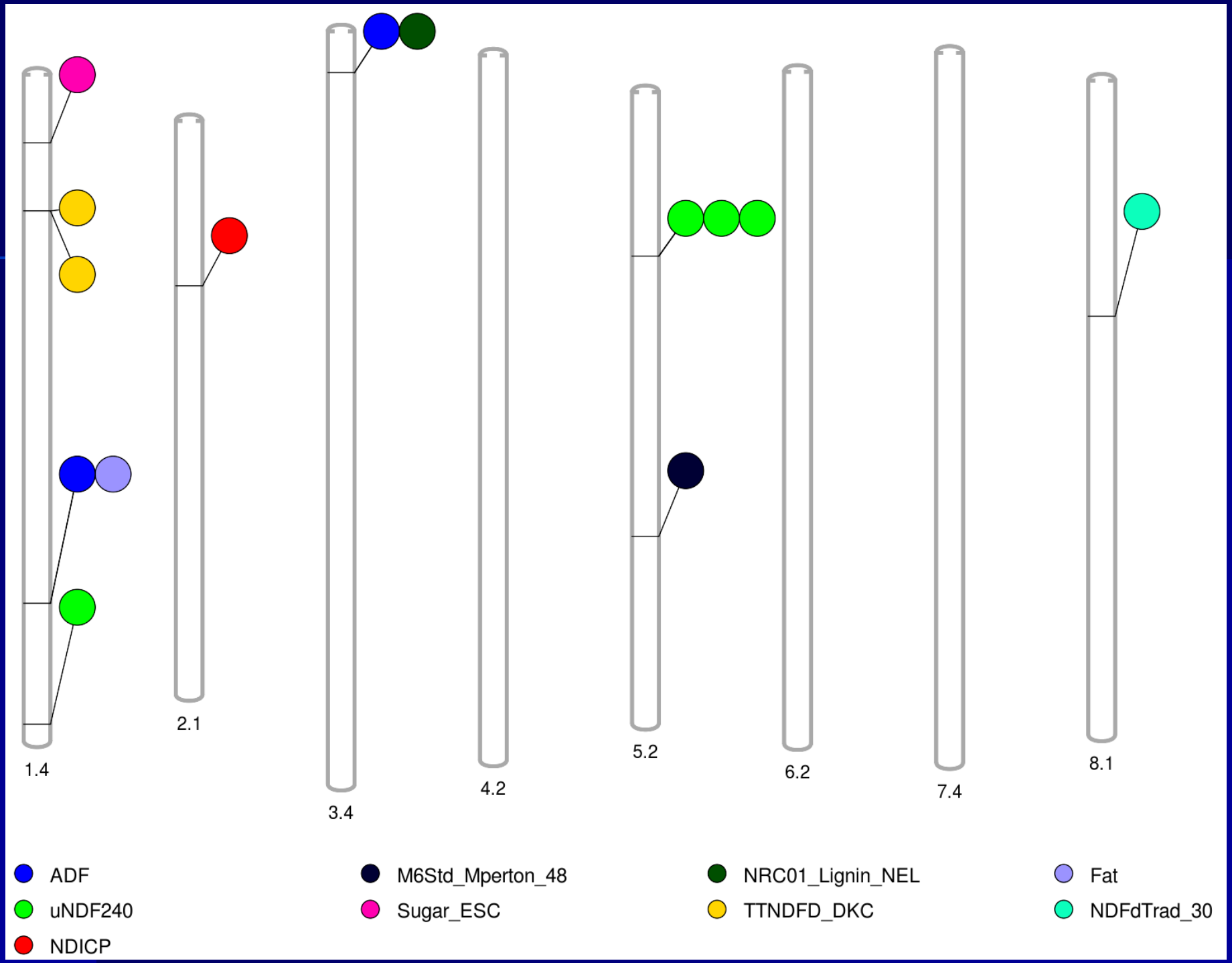
Statistic	Protein Value	Energy Value	Net Fiber Value	Quality Adjustment	Dollar Value ton
Maximum	$83.25	$135.60	$61.48	$103.33	$372.91
Minimum	$68.89	$113.75	$50.72	$3.60	$247.73
Hi-Gest - 360	$75.83	$127.38	$54.42	$82.51	$340.14
Vernal	$74.53	$122.52	$57.55	$71.05	$325.66

Value of Optimizing Constituents

Constituent	Hi-Gest 360 Response (% of plant)	Optimum Response Received (% of plant)	Added Value ($ Ton^{-1})
NDFD 48 hr	63.5	67.7	20.82
Crude Protein	23.9	25.4	5.79
Ash	10.0	9.2	2.24
Lignin	6.2	5.8	1.48
Fats	2.0	2.2	0.56
NDICP	1.0	1.3	0.24
ADICP	0.56	0.5	0.26
All constituents optimized			29.85

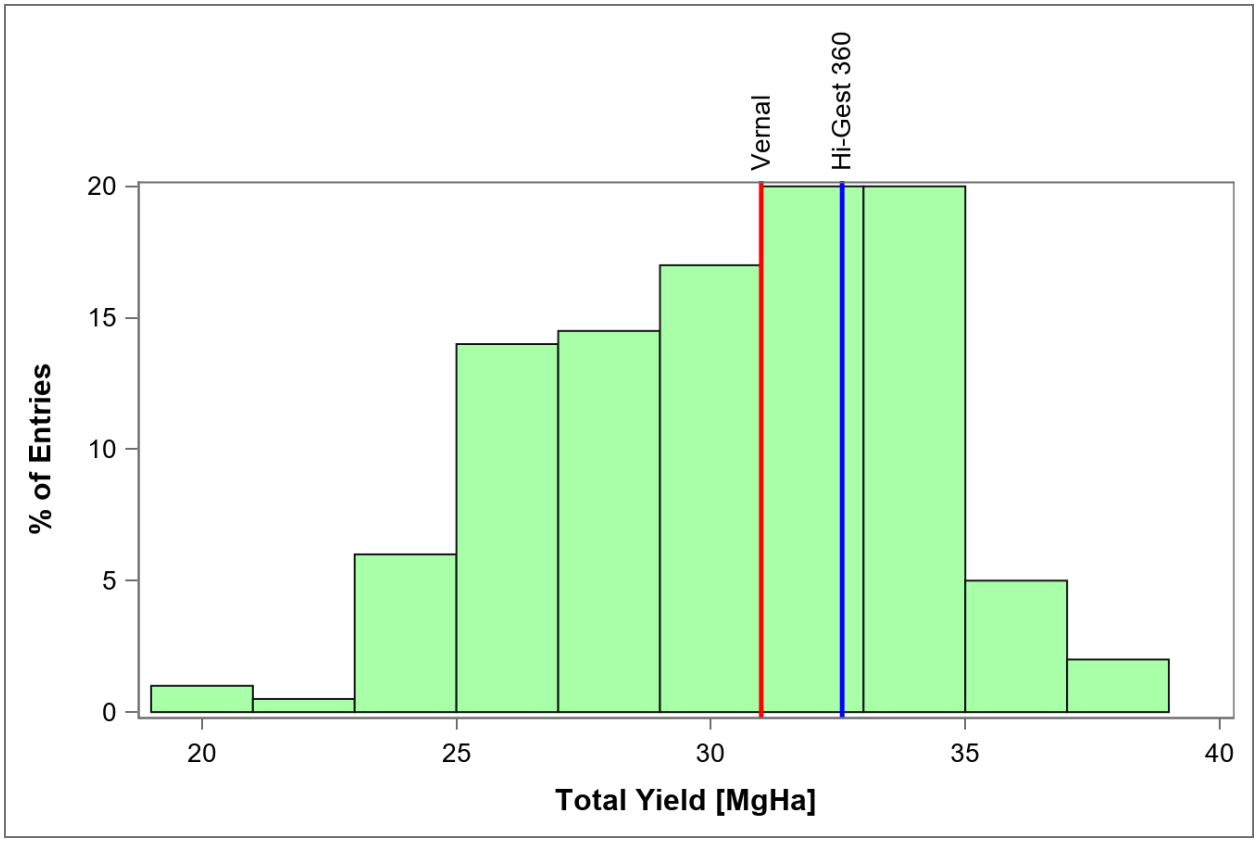
Correlation of Constituents NDFD 48 hr. & C. Protein

Constituent	Correlation with NDFD48 hr.	Correlation with Crude Protein
NDFD 48 hr.	1.000	0.66
aNDF	-0.57	-0.87
Crude Protein	0.66	1.00
Ash	0.26	0.48
Lignin	-0.79	-0.76
Fats	0.61	0.68
NDICP	0.06	0.23
ADICP	-0.31	0.04

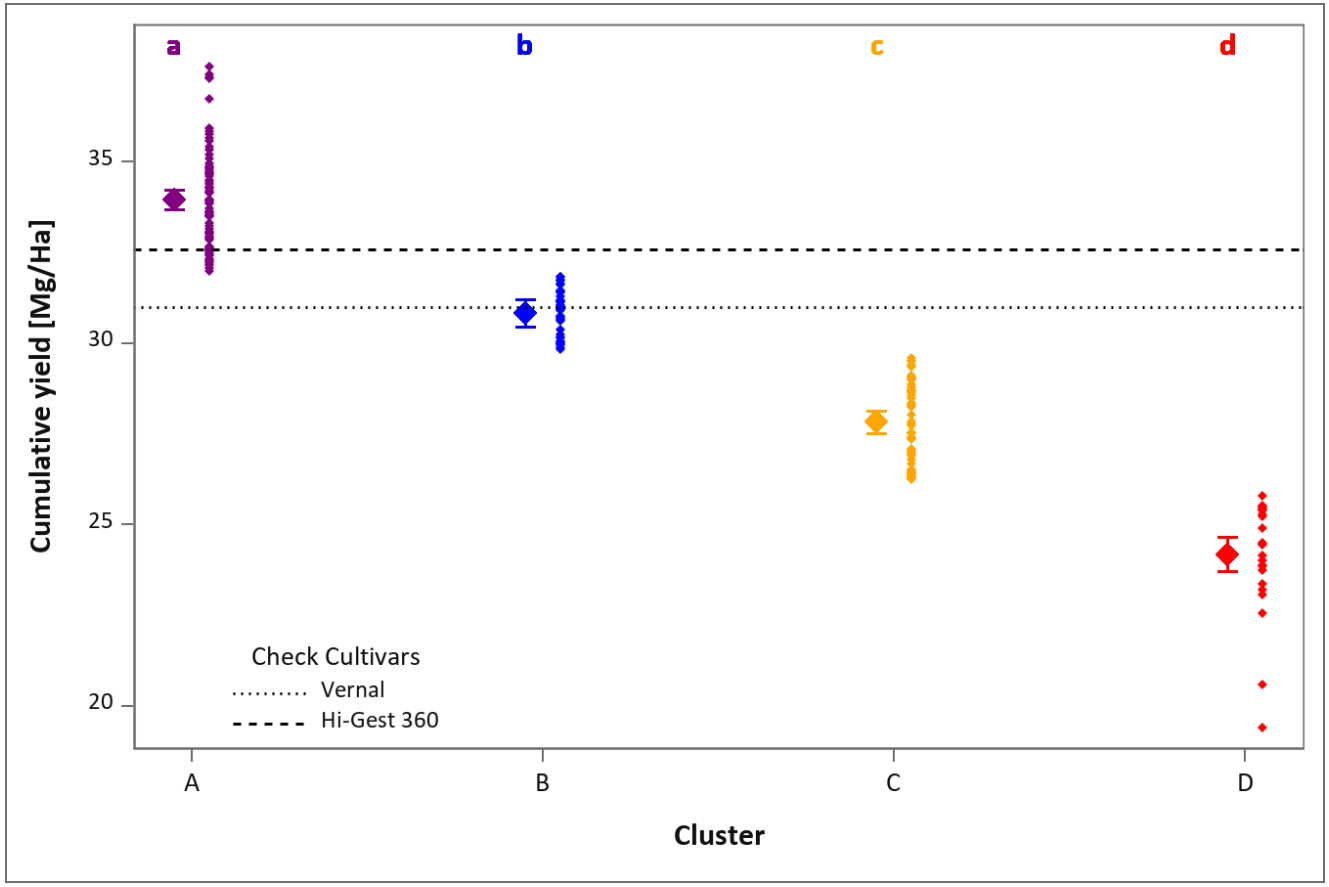

1.4
2.1
3.4
4.2
5.2
6.2
7.4
8.1
ADF
uNDF240
NDICP
M6Std_Mperton_48
Sugar_ESC
NRC01_Lignin_NEL
TTNDFD_DKC
Fat
NDFdTrad_30

Yield

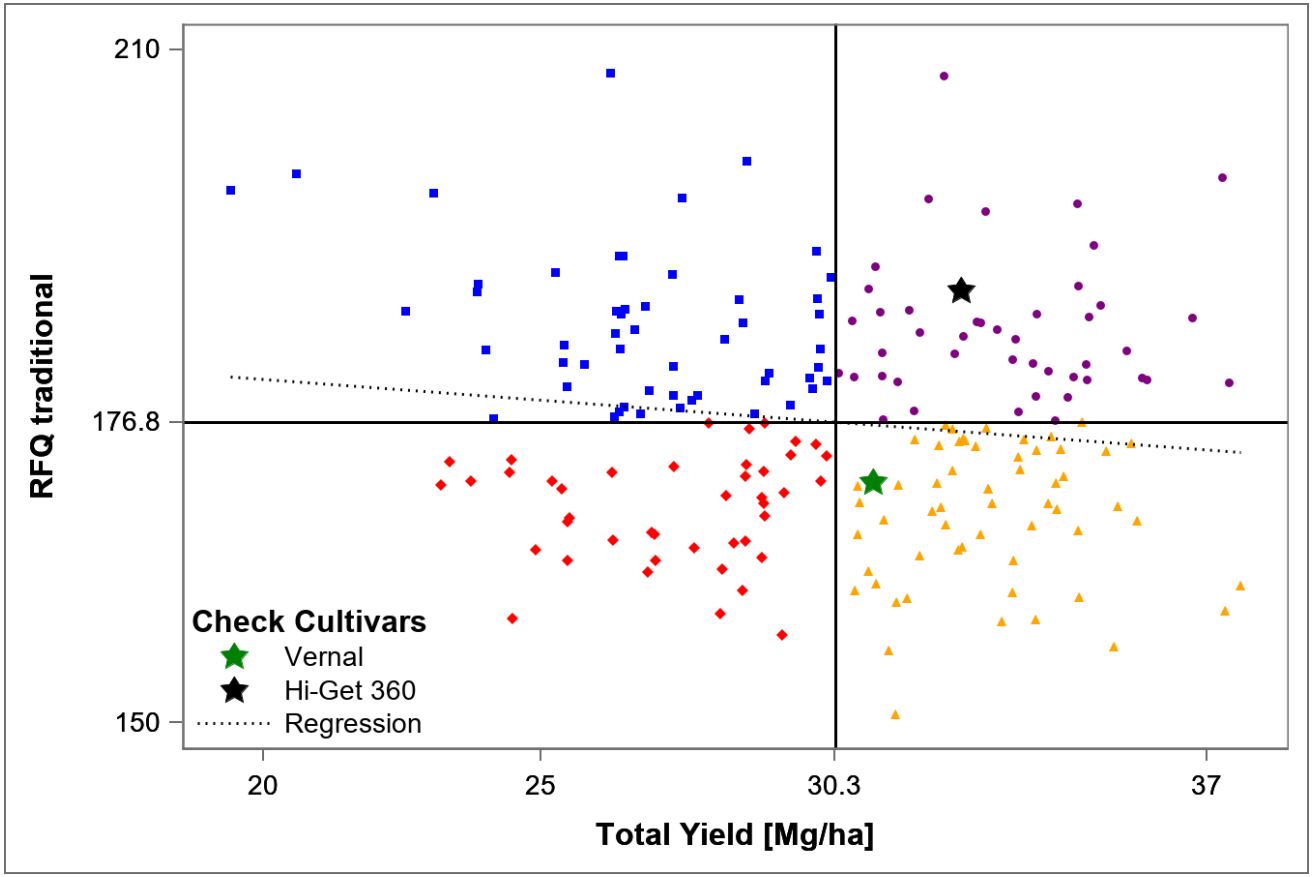
Yield Distribution in General



Yield Distribution in Clusters



Relationship between Yield and Quality



P value = 0.066
R square = 0.02
Slope = -0.36

Conclusions

- There is room for genetic improvement especially with digestibility and protein.
- Energy and Protein carry the majority of the value of hay
- Digestibility genes have been located on the chromosomes
- Yield and quality appear not to be as closely linked and improvement is possible.

Conclusions

- 10 markers were found on 9 quality traits
- Yield and quality seem to be more independent of each other than previously thought
- Acceleration of breeding programs for quality can occur with the use of molecular markers
- Recent meeting with 4 major private breeders they would like to cooperate with us.


Questions?