REDUCED LIGNIN ALFALFA TECHNOLOGY UPDATE

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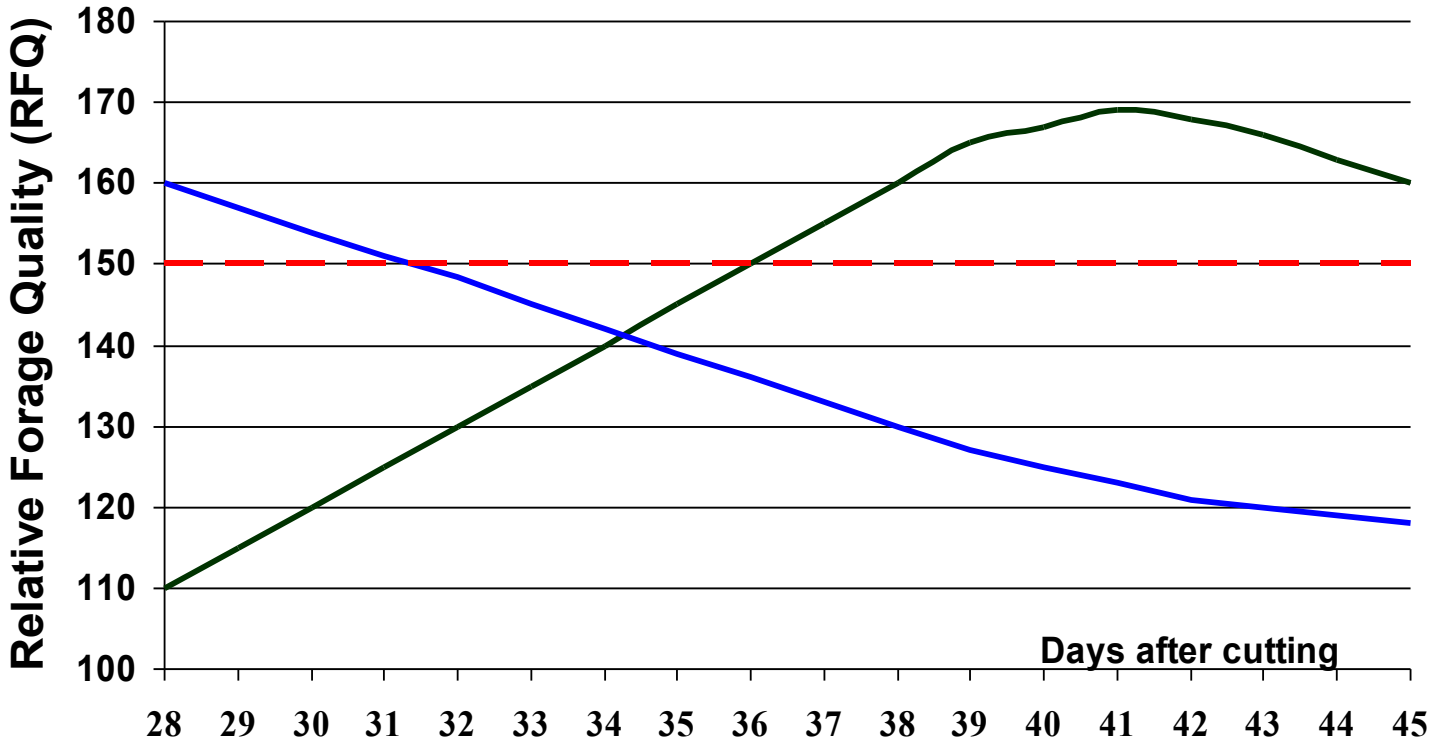
ALFALFA YIELD/QUALITY TRADEOFF

- Relatively small annual strides for increased yield, quality, and persistence with alfalfa



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Consortium *for* Alfalfa Improvement

USDFRC

THE SAMUEL ROBERTS NOBLE FOUNDATION

PIONEER®
A DUPONT COMPANY

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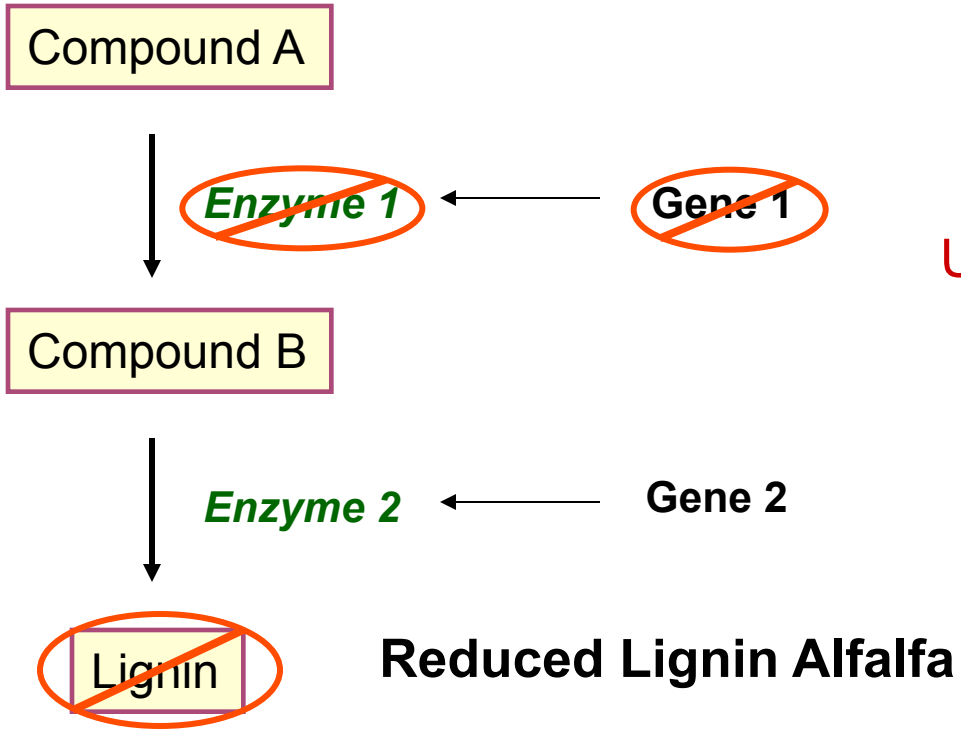
RE-DESIGNING ALFALFA FOR IMPROVED FORAGE QUALITY

- The CAI concept:
  - Interdisciplinary, inter-institutional collaboration
  - Ruminant nutrition
  - Biochemistry
  - Plant molecular biology
  - Plant breeding/agronomy
- CAI target traits – “re-designing alfalfa”
  - Increased cell wall digestibility
  - Improved efficiency of protein utilization

LIGNIN IN ALFALFA

- Lignin increases with advanced maturity in alfalfa
- Lignin is indigestible, and binds with cellulose/ hemicellulose – reducing fiber digestibility
- Reducing lignin content should increase fiber digestibility and change in quality w/ maturity
- Genetic engineering used to reduce lignin content in alfalfa
  - “silencing” genes for key enzymes in the lignin biosynthetic pathway

GENE KNOCKOUT TO MODIFY LIGNIN PATHWAY



Use genetic engineering to silence “lignin gene(s)” in alfalfa

RL ALFALFA PRODUCT CONCEPT

- Over the life of an alfalfa stand, a grower using Reduced Lignin Alfalfa can, at each cutting, interchangeably:
  - Maintain harvest schedule routines and obtain forage that is more likely to meet or exceed the intended quality standard targeted by the grower; OR
  - Delay a harvest several days and obtain higher tonnage without sacrificing forage quality.

PROOF OF CONCEPT GOALS

- 8-10% increase in whole plant NDFD
  - Enables multiple day delayed harvest
- Breeding stack w/ RRA
  - High trait purity – both traits
- Competitive agronomic performance
  - At or near competitive checks
  - No increase in lodging incidence
  - Best in class MPR, WH and persistence

PROOF OF CONCEPT - NAMPA, ID. 2007

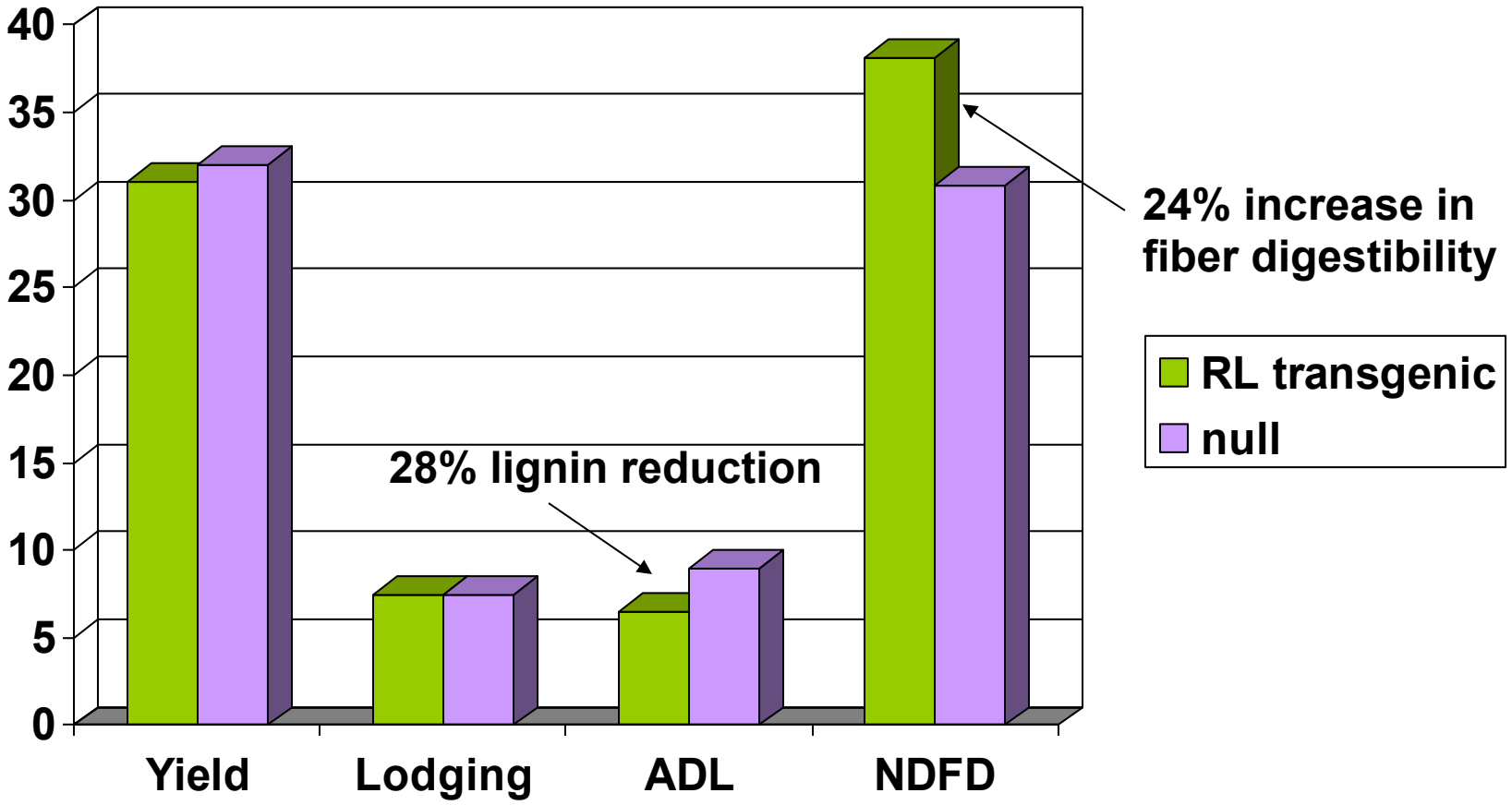
RL1

RL1 NULL

RL2

RL2 NULL

2008 SUMMARY – RL1 ALFALFA



Note: lower stem samples, CAI equation, average of 25 elite events

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Land O' Lakes Purina Feed
Large Animal Metabolism Unit (LAMU

USDFRC Sheep Feeding Studies

FIBER DIGESTIBILITY (% NDFD)
IN VITRO VS *IN VIVO*

Treatment	Hay samples *in vitro*	Cows Ad lib TMR	Lambs Ad lib Hay only	Lamb Restr Hay only
RL1	53.2	48.6	48.8	46.8
RL1 null	48.6	44.5	45.0	41.8

Note: RFQ advantage for RL alfalfa – 15-20 points

2009 CUTTING MANAGEMENT TRIALS (WI, MN)

- Compare 3-cut (35-day) and 4-cut (28-day)

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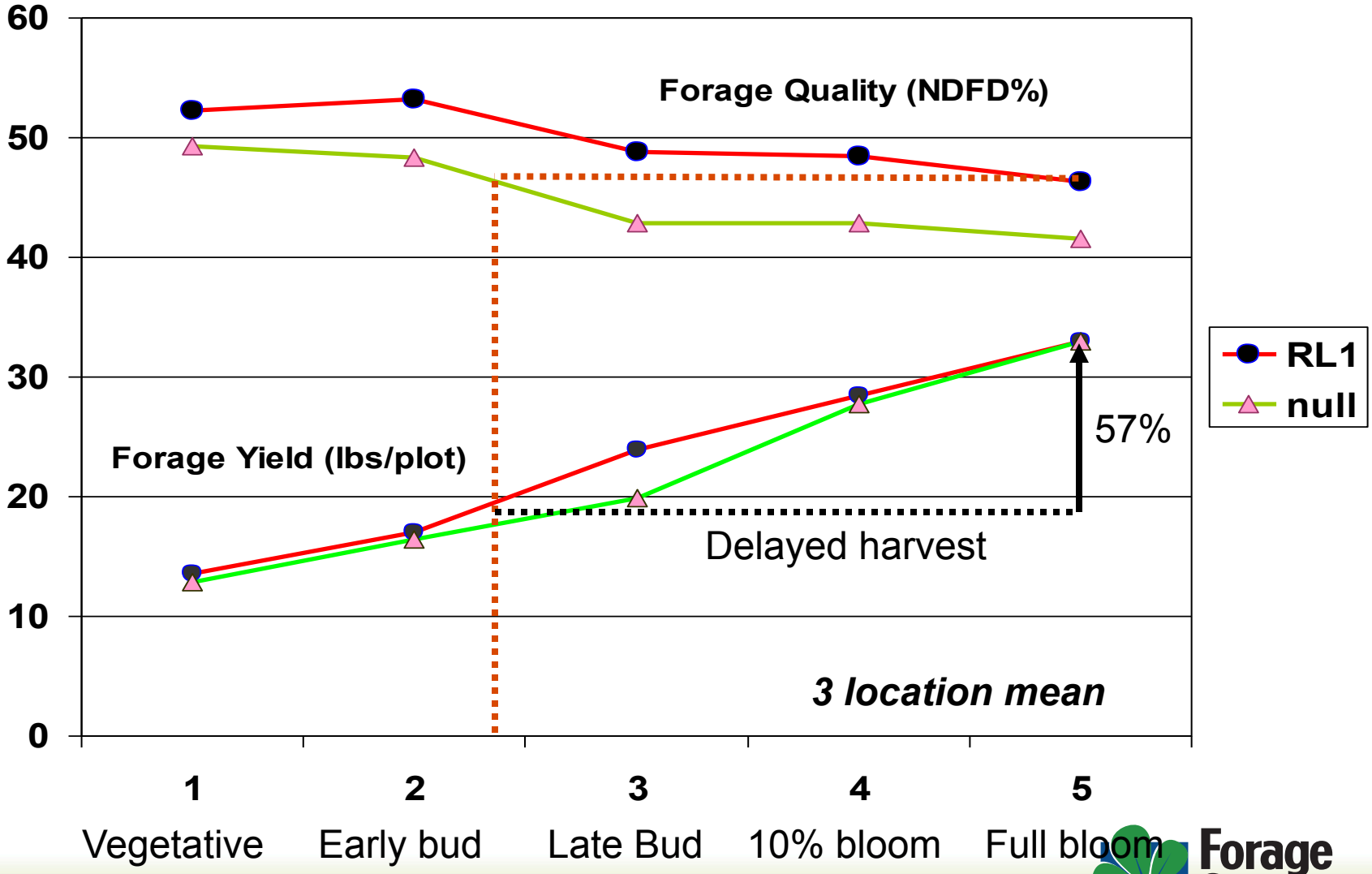
2008 Cutting Management Trials (WI, MN)



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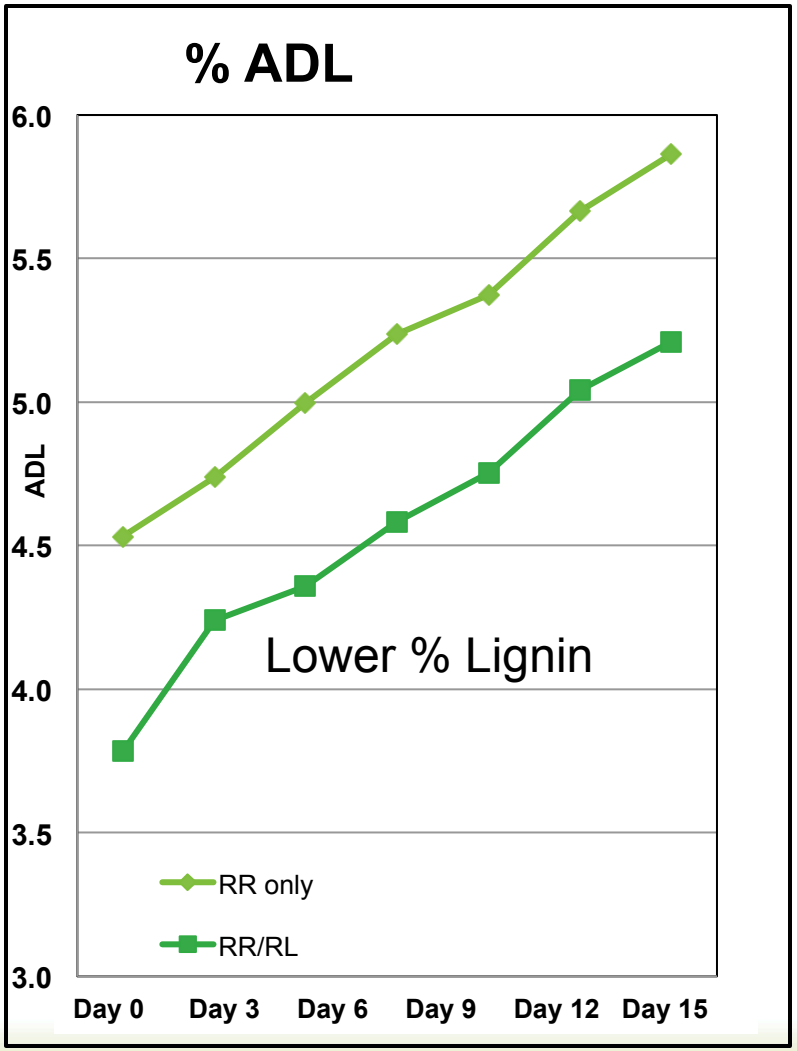
QUALITY CHANGE OVER TIME STUDY

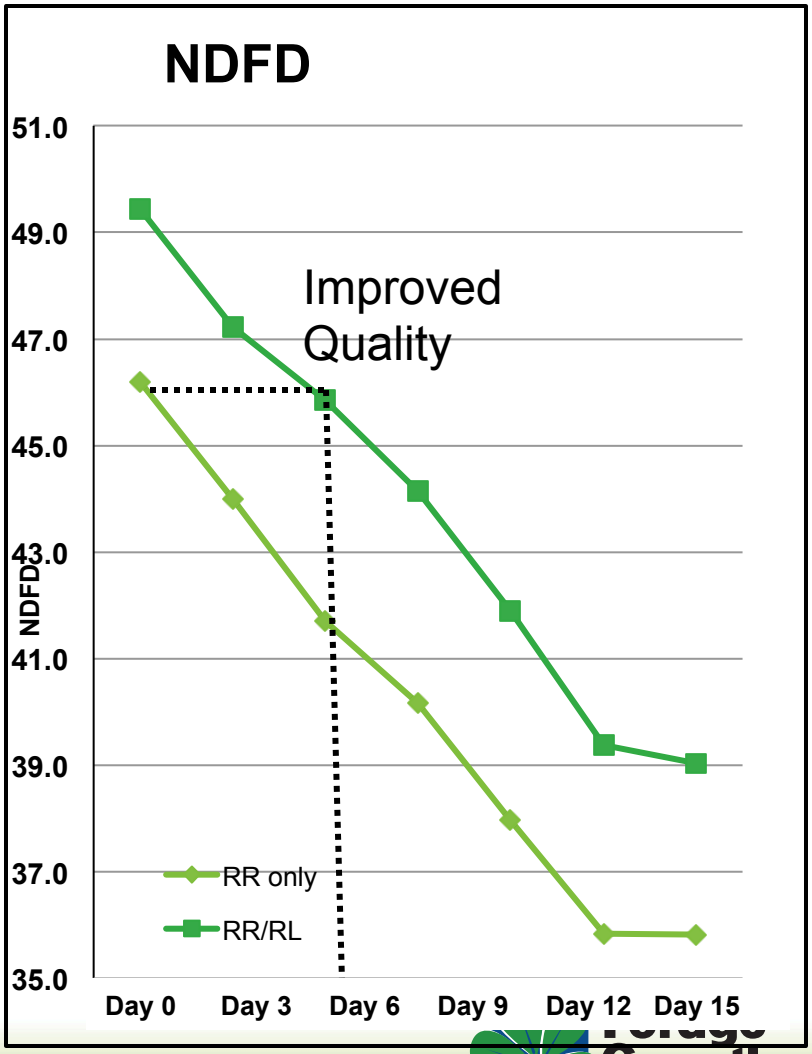
QUALITY CHANGE OVER TIME STUDY

- Track changes in forage quality as the alfalfa matures
- Locations: Wisconsin (2), Iowa and Washington
- Forage quality samples taken at 3-day intervals
  - Harvest timing pre-bud to 50% bloom
  - ADL and NDFD measured via NIRS
- RL/RRA stack compared to RRA only (isolines)

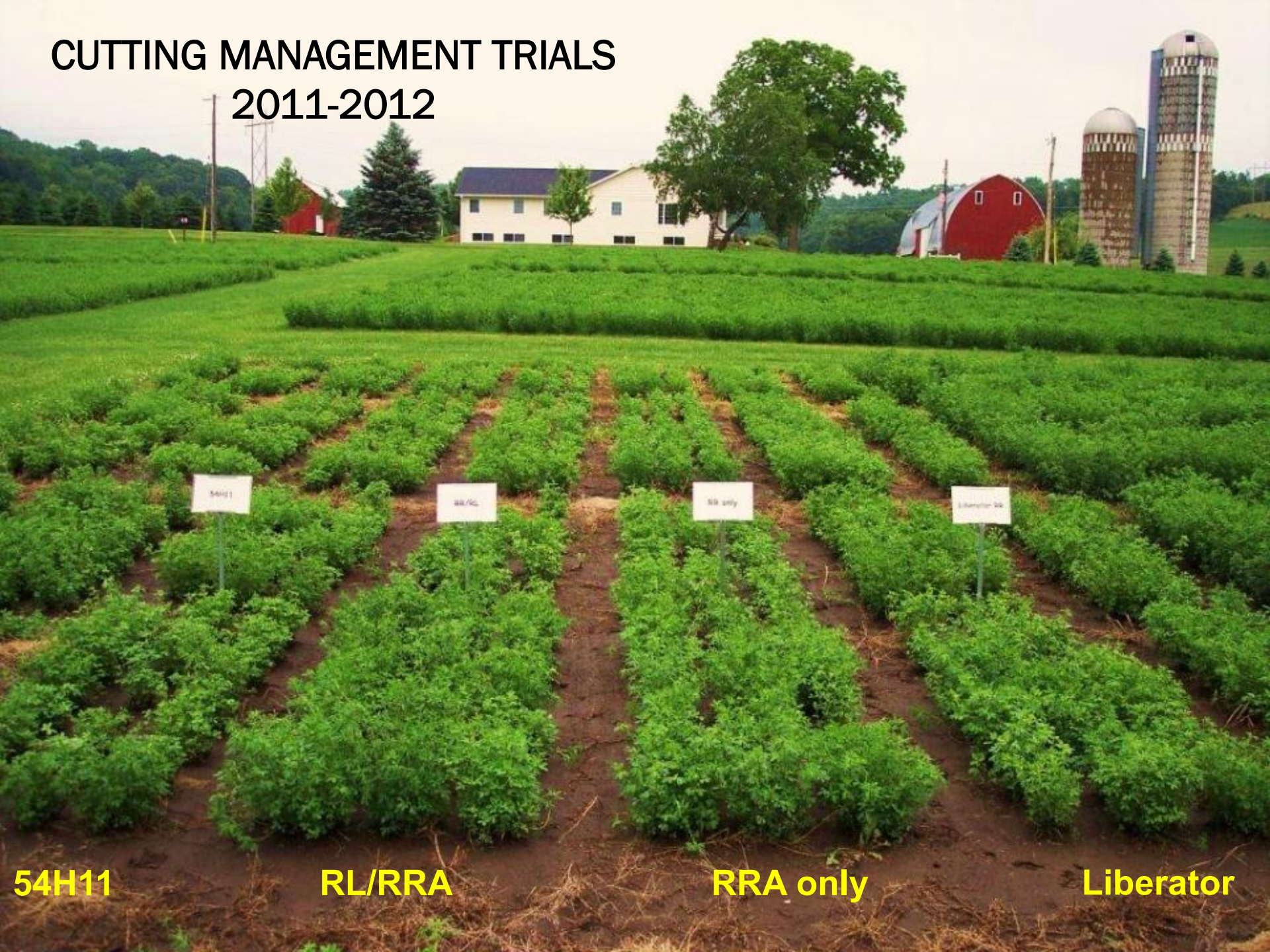
QUALITY CHANGE STUDY – 2011-2012

Locations: Wisconsin (2), Iowa, Washington

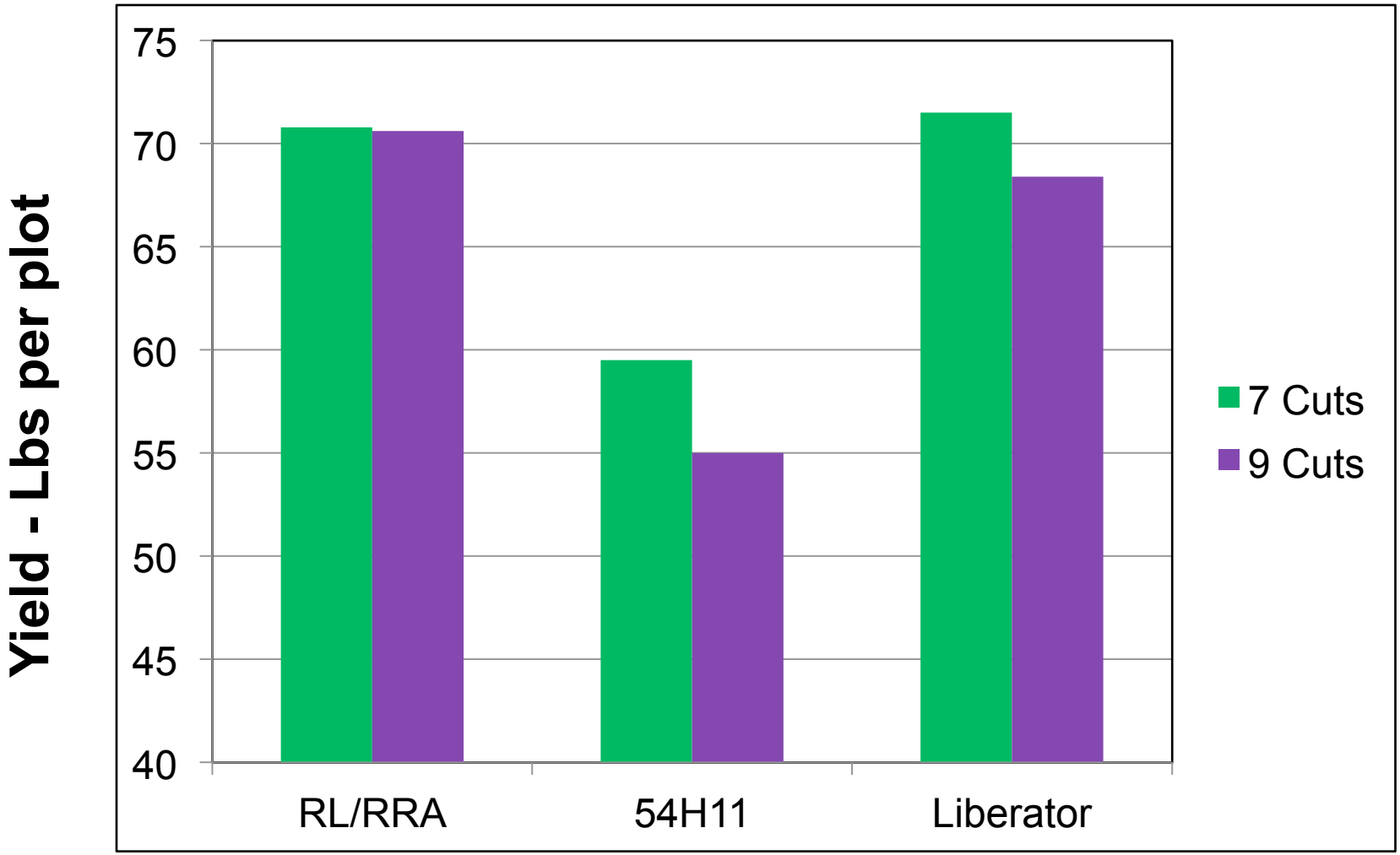




CUTTING MANAGEMENT TRIALS
2011-2012



CUTTING MANAGEMENT TRIALS - 2011



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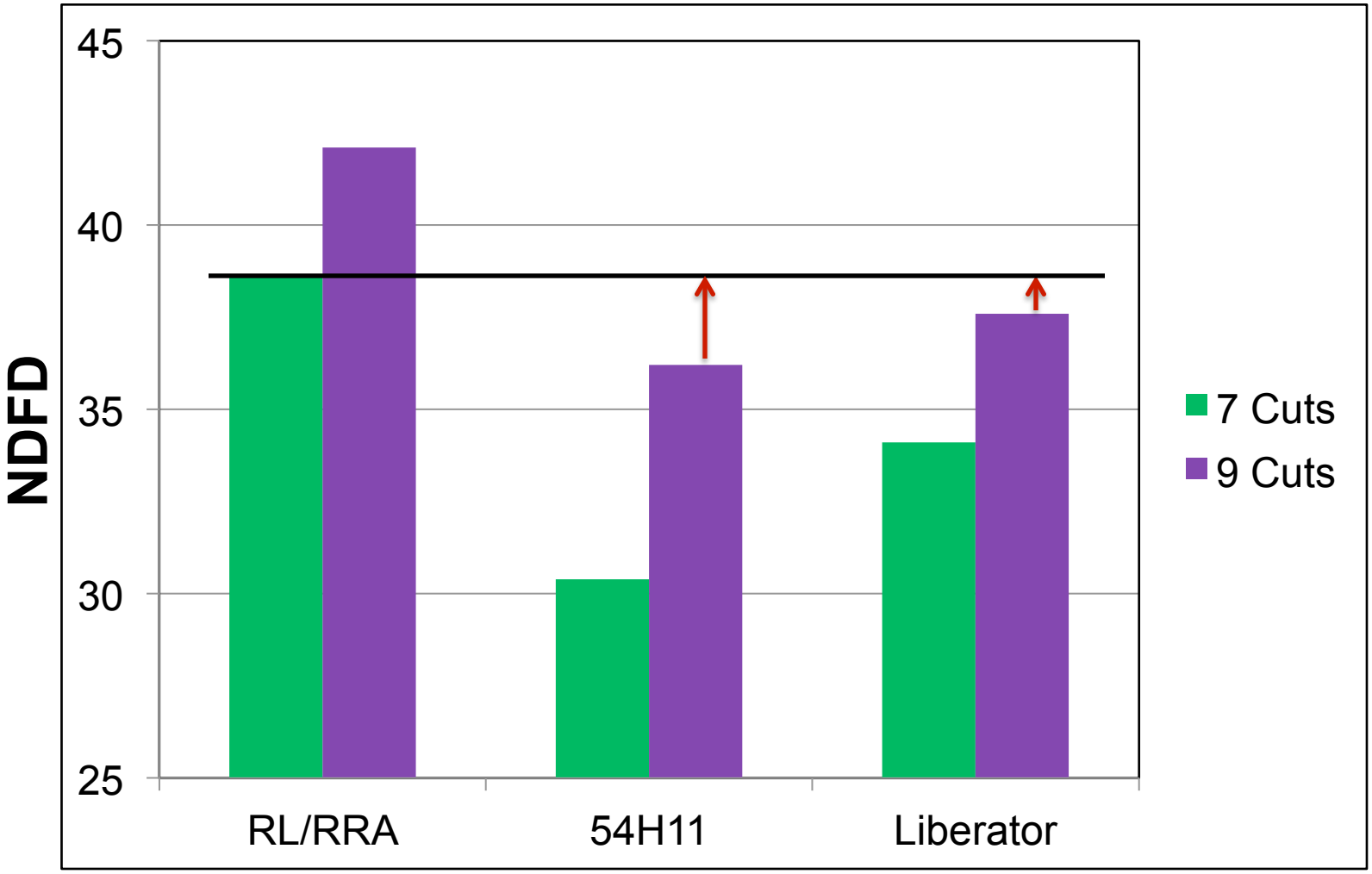

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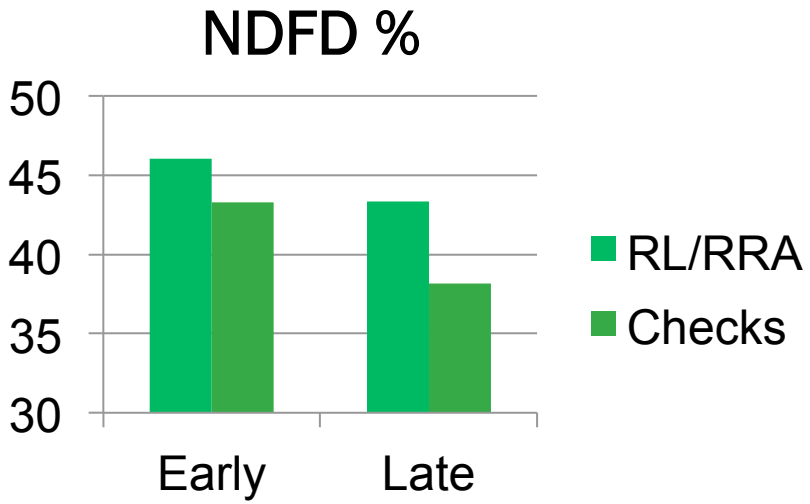

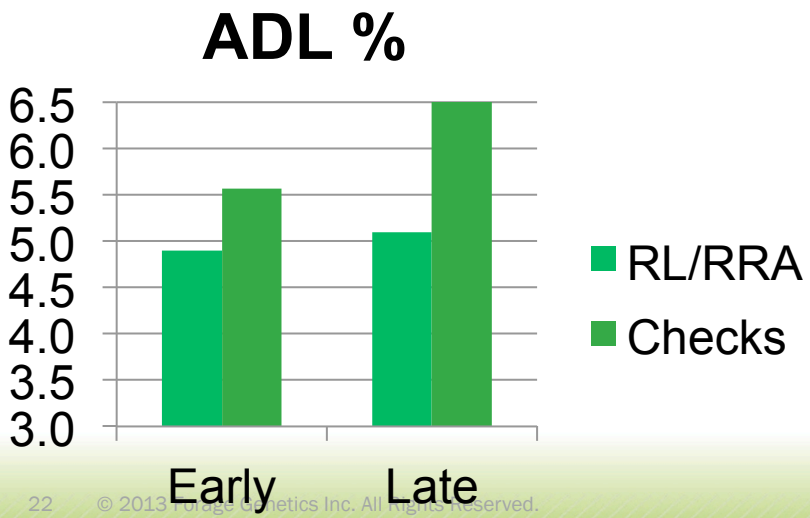

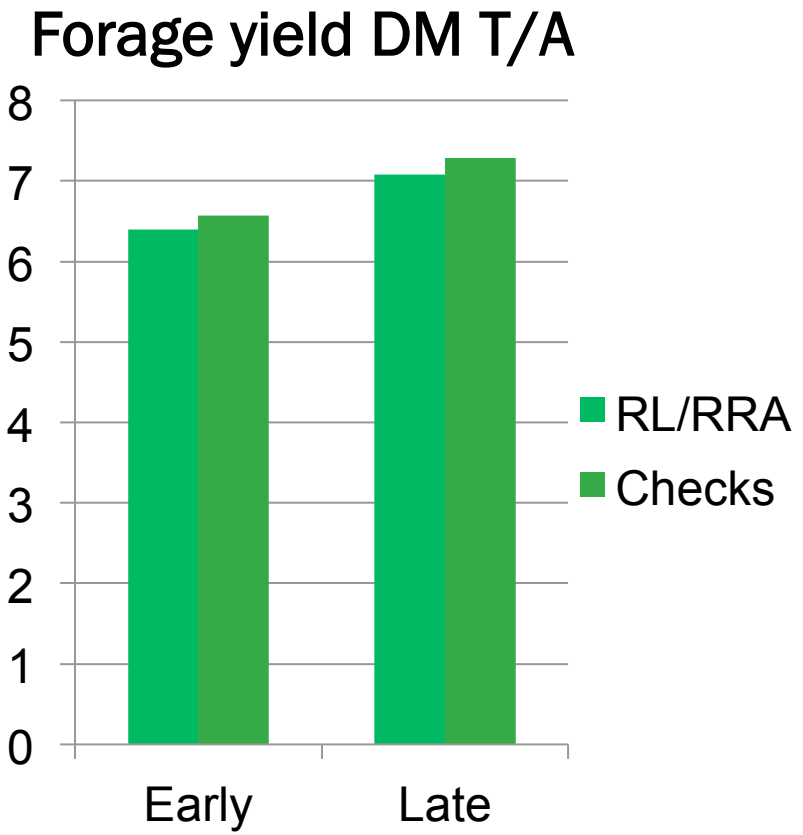

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FUTURE OF REDUCED LIGNIN ALFALFA

- Commercial Product Concept Goals Met
  - Decreased lignin, NDFD, and delayed harvest
  - Agronomic equivalence of null checks
  - RL/RRA trait purity
- Wide scale product testing 2013-2016
- Estimated Commercial Timeline
  - 2015 Deregulation/Domestic Launch

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RL PRODUCT TIMELINE

- 2015 – Very select on-farm trials
- 2016 – Small commercial launch
- 2017 – Broad sales
- All pending appropriate regulatory approvals

GROWER INTERVIEW REACTIONS

- **Perceived Benefits of Fewer Cuttings:**
  - "…fewer cuttings…same tonnage…that would save time and costs…that would be $7,000 in just fuel costs…"
  - "…fewer cuttings…that's a lot of money…I could save $20,000 on that last harvest…"
- **Perceived Benefits of Flexibility:**
  - "…this would give us a better chance of getting quality and tonnage…"
  - "…this would be a several day window…that would be a tremendous help…we deal with weather all the time…"

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