Yield & stem morphology among alfalfa lines ranging in stem digestibility

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Outline

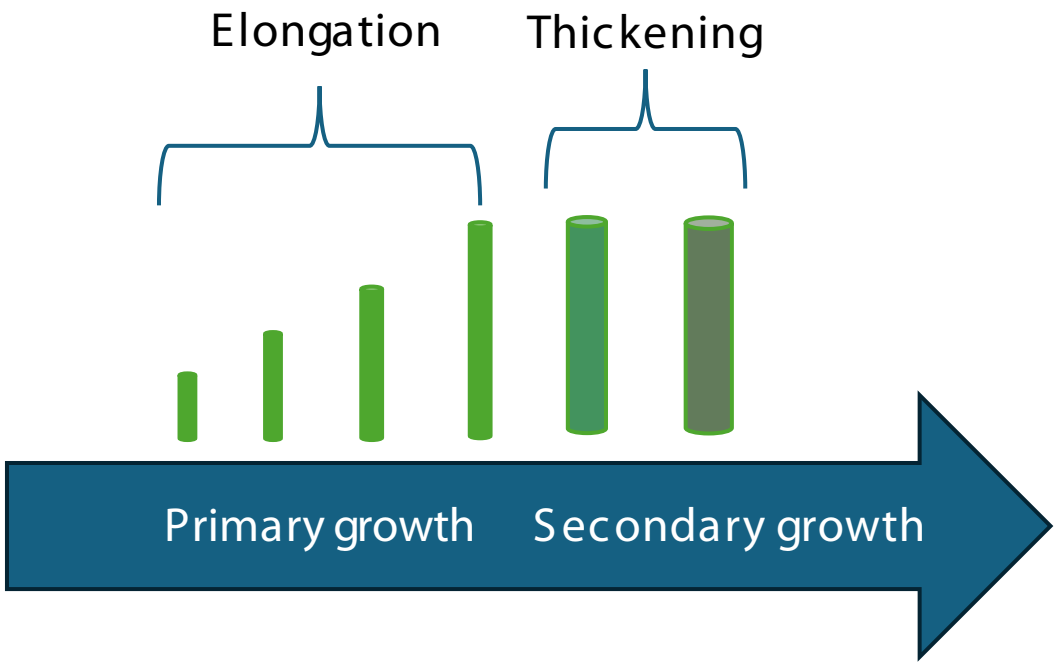
- Rationale, Research objective & hypothesis
- Methods
- Results
  - Yield
  - Stem morphological traits
- Conclusions

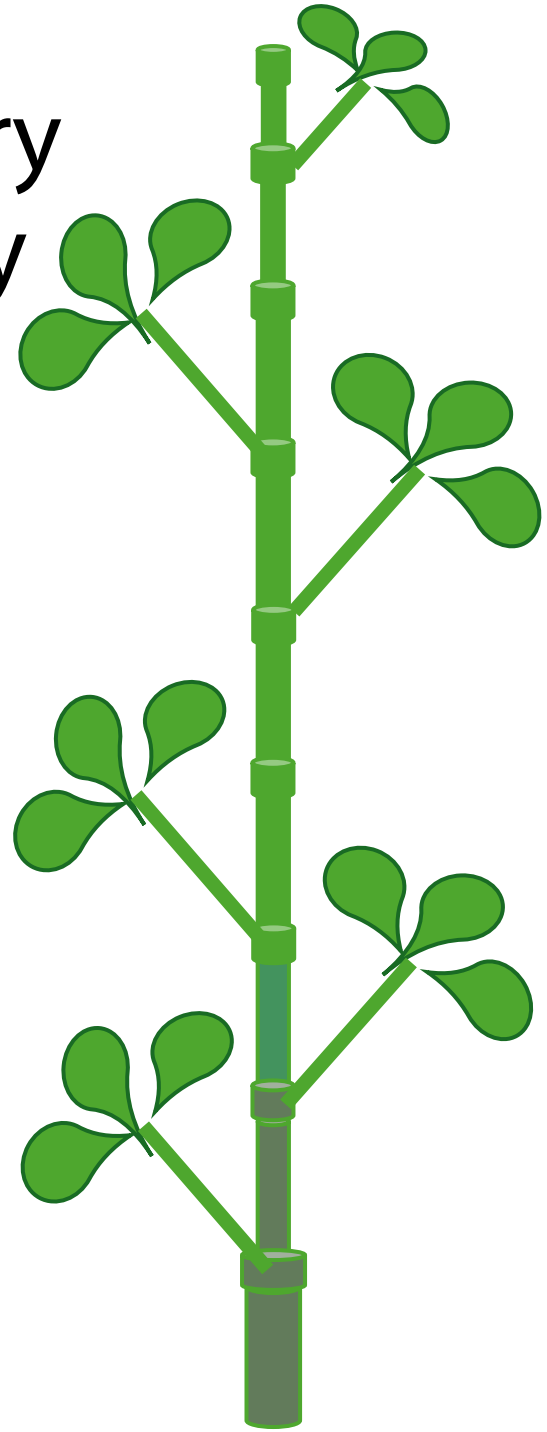

Photo credit: Undersander et al (2011)

Alfalfa stems impact forage yield & quality

- Stem proportion increases as plants mature while leaf concentration declines (Lamb et al., 2003)
- Stems have less crude protein, more NDF, ADF so they are less digestible than leaves (Sheaffer et al., 2000; Grev et al., 2020)

Lignin accumulation in stem secondary cell wall diminishes forage digestibility





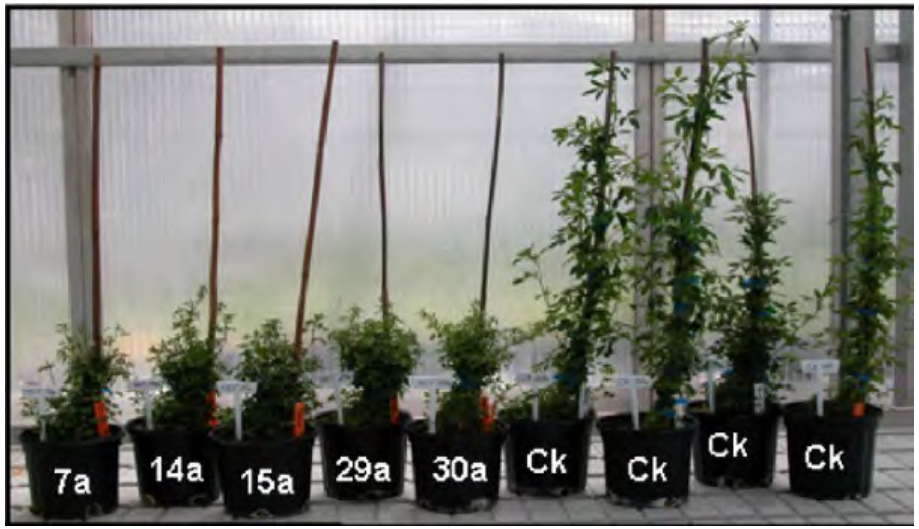
Strategies to improve digestibility have consequences for yield & morphology

Downregulation of lignin in alfalfa:

- stunted plant height (Shadle et al., 2007; Nakashima et al., 2008; Gallego-Giraldo et al., 2011; Bhattarai et al., 2018)
- produced more nodes, shorter internodes (Gallego-Giraldo et al., 2011; Gronwald & Bucciarelli, 2013)
- lower herbage yields (Arnold et al., 2019)

Enhanced IVNDFD lines

- Low 16hr-IVNDFD lines had longer stem and average internode length (Lamb et al., 2006)



Shadle et al. (2007)

First-cut alfalfa yields more than subsequent harvests

- In Minnesota, 3-4 harvests per growing season (Undersander et al., 2011)
- 40% to 60% of total annual herbage from first-cut alfalfa harvested depending on maturity (Sheaffer et al., 2000)

Objectives & Hypothesis

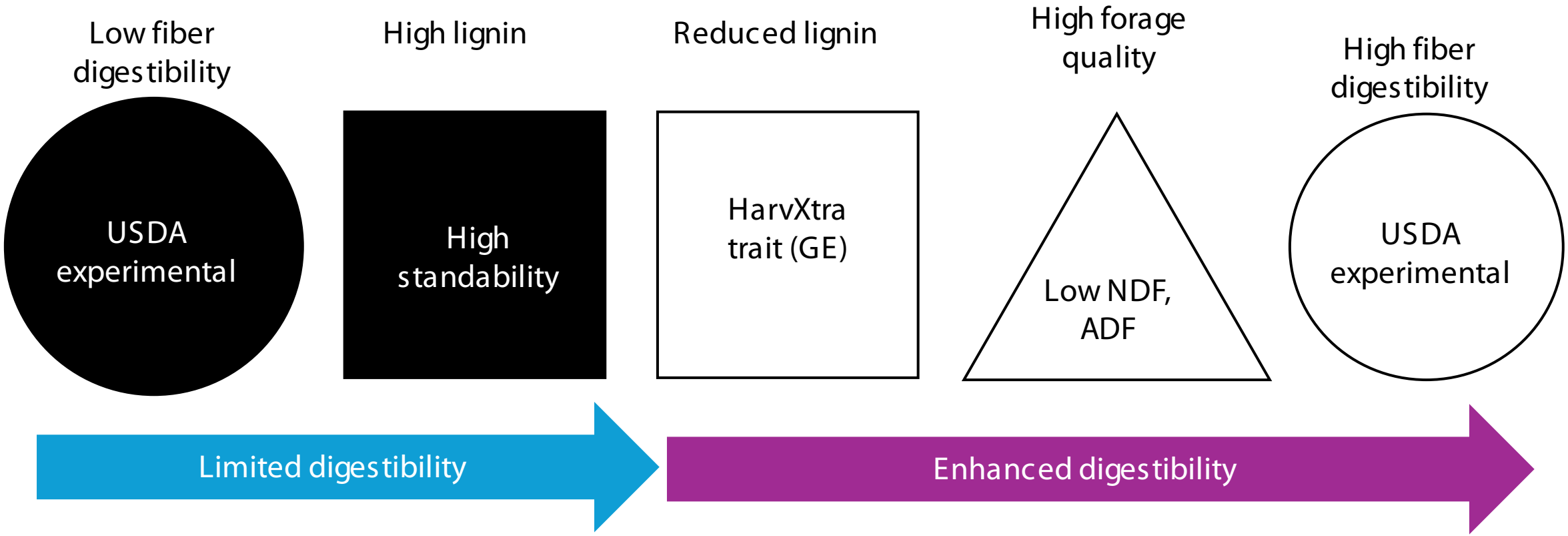
- To evaluate the yield and stem morphological traits of five modern alfalfa lines ranging in stem fiber digestibility at first-cut harvest
- High lignin line with upright growth pattern will yield more & have longer, thicker stems than alfalfa lines with enhanced digestibility

Methods

Experimental design

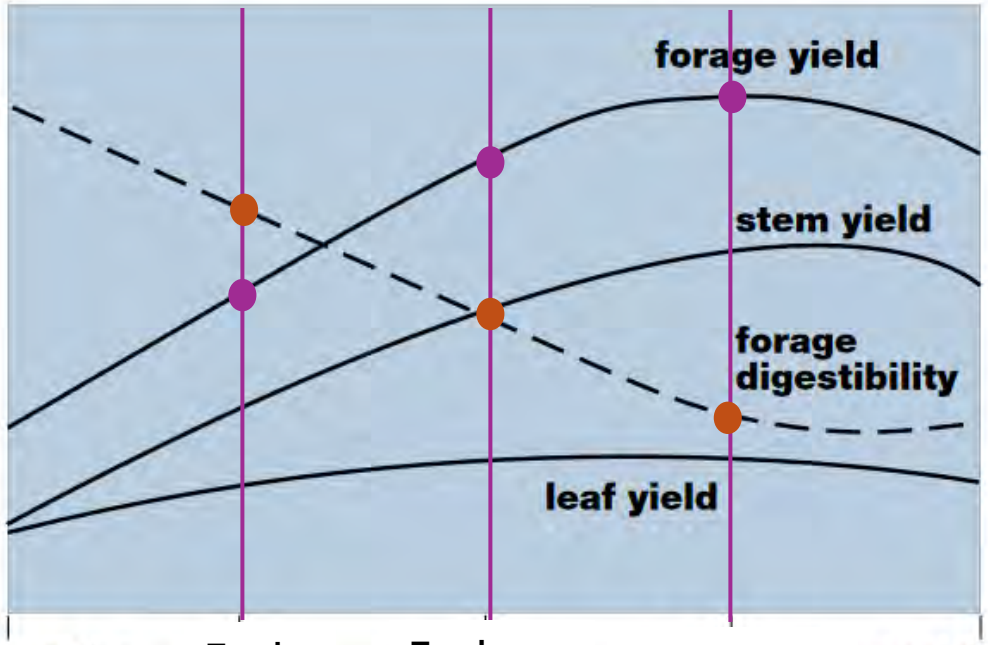
- Established in May 2021 at Rosemount, Minnesota, USA
- 3 reps in a RCBD with a split plot arrangement
  - Whole plot: Alfalfa line
  - Split plot: Maturity

Whole plot treatment: 5 clonal alfalfa lines



Subplot treatment: 3 maturity stages

Figure 22. Forage yield relative to quality at different growth stages.

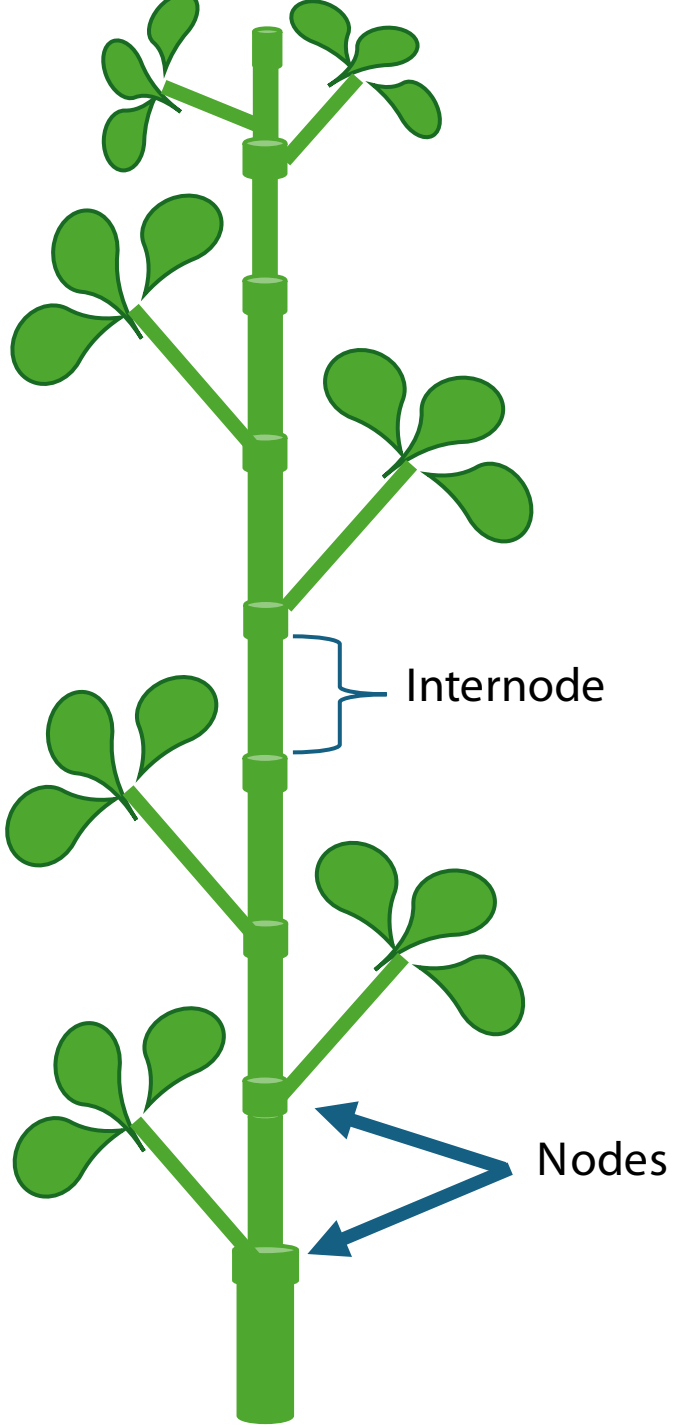


2023:	5/23	6/2	6/9
2024:	5/20	5/31	6/6

Adapted from Undersander et al., 2011

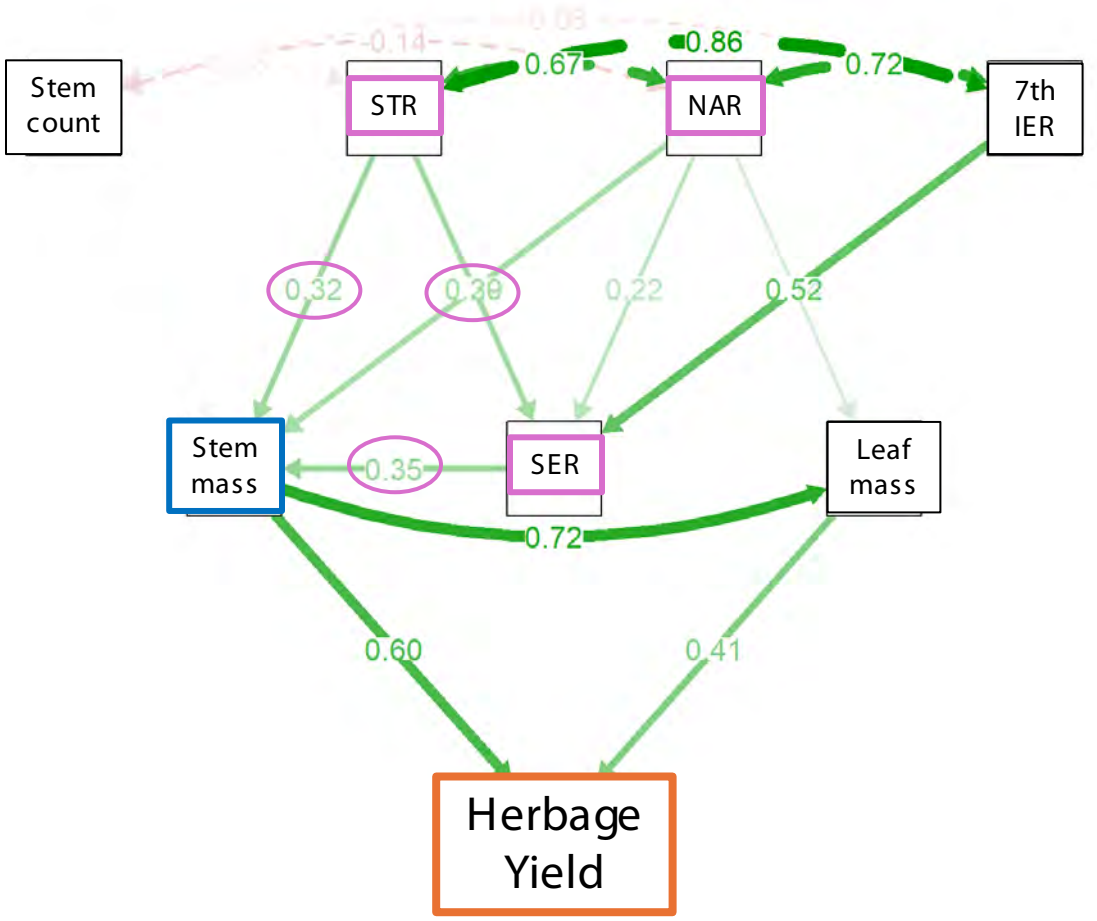
Data collection

- 2023 & 2024 field seasons
  - 2nd & 3rd year alfalfa stands
- Yield (experimental plot)
  - Herbage accumulation
- Stem morphology (10 stems)
  - Stem length, bottom internode stem diameter, node count



Stem traits impacting stem mass, herbage yield

- Stem elongation rate (SER)
- Stem thickening rate (STR)
- Node appearance rate (NAR)

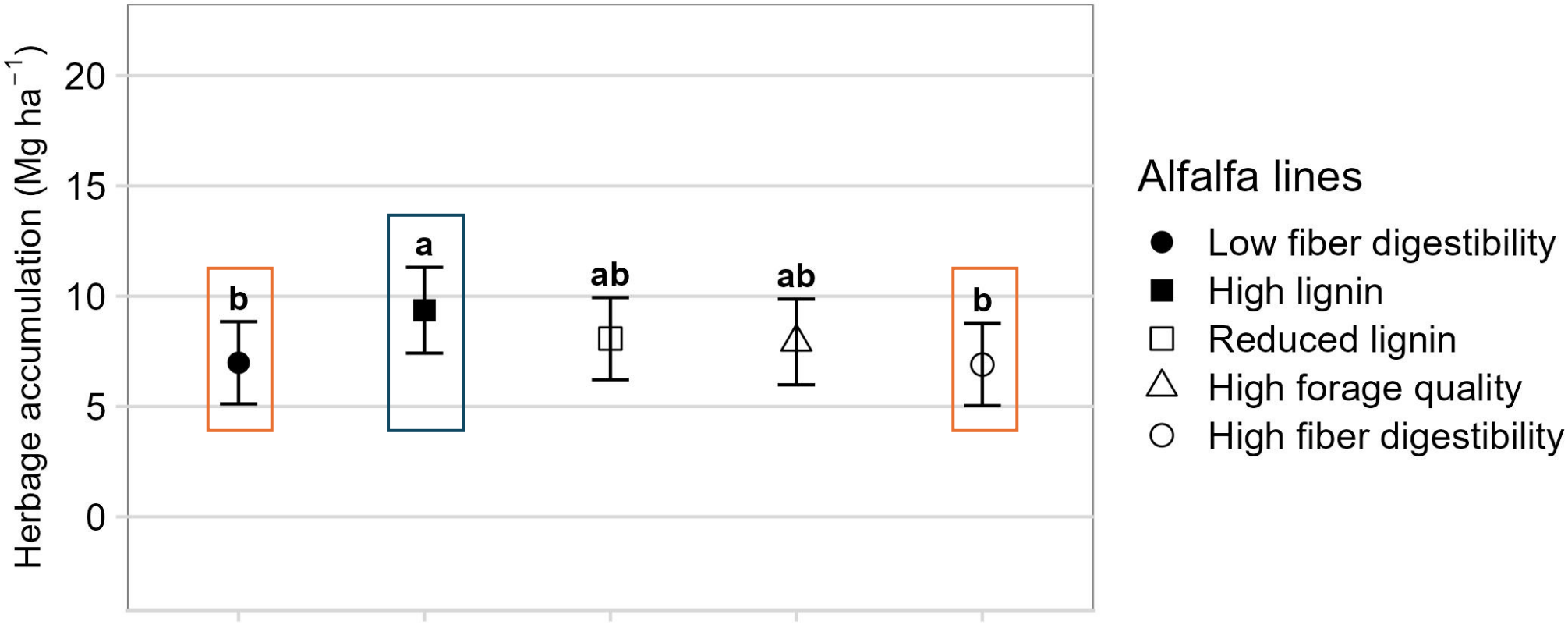


Statistical analysis

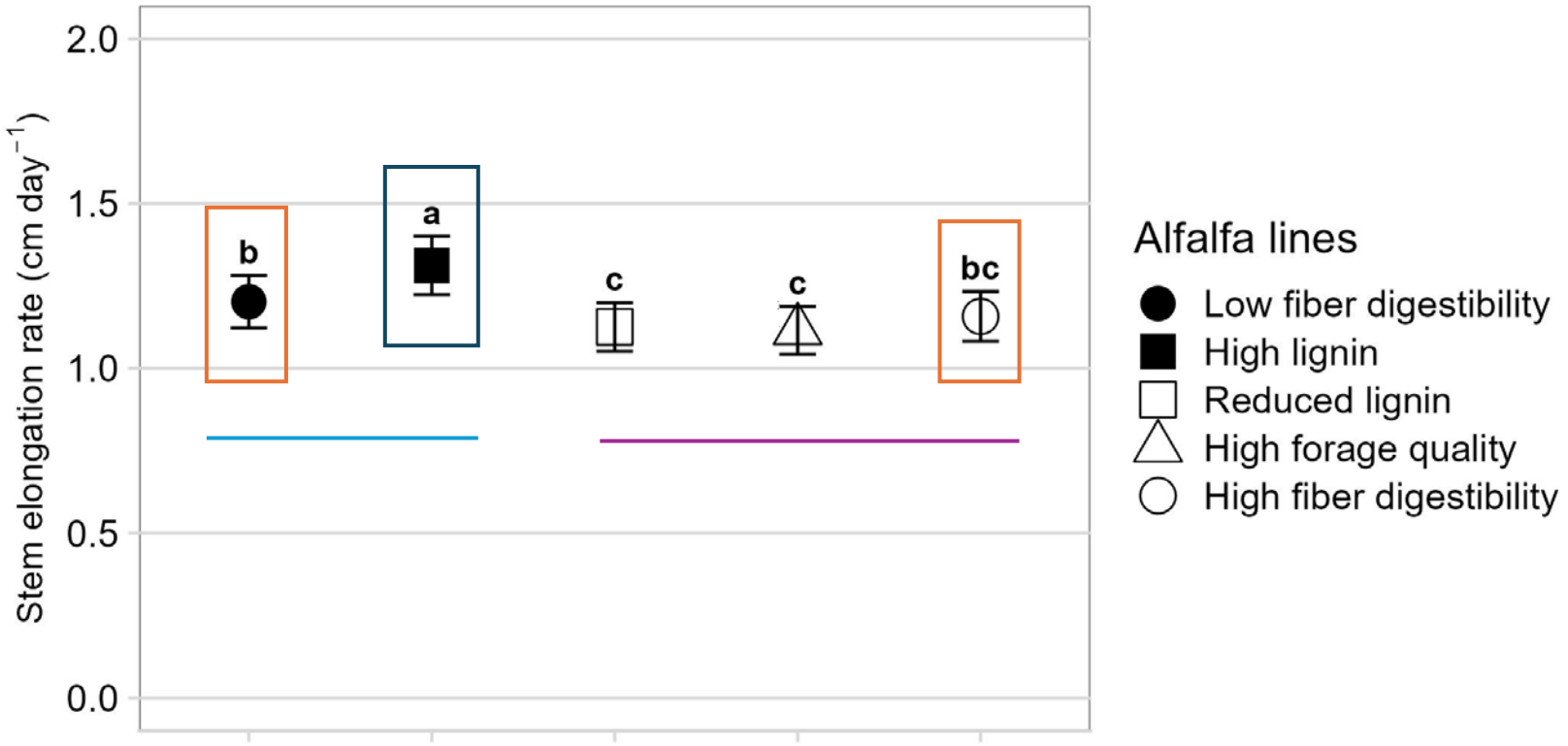
- Linear mixed effects model run with ‘lme’ from nlme R package
  - Fixed effects: Alfalfa line × Year × Maturity
  - Random effects: Year nested within Rep, Alfalfa line

Results

Yield: High lignin line produced more than both experimental lines



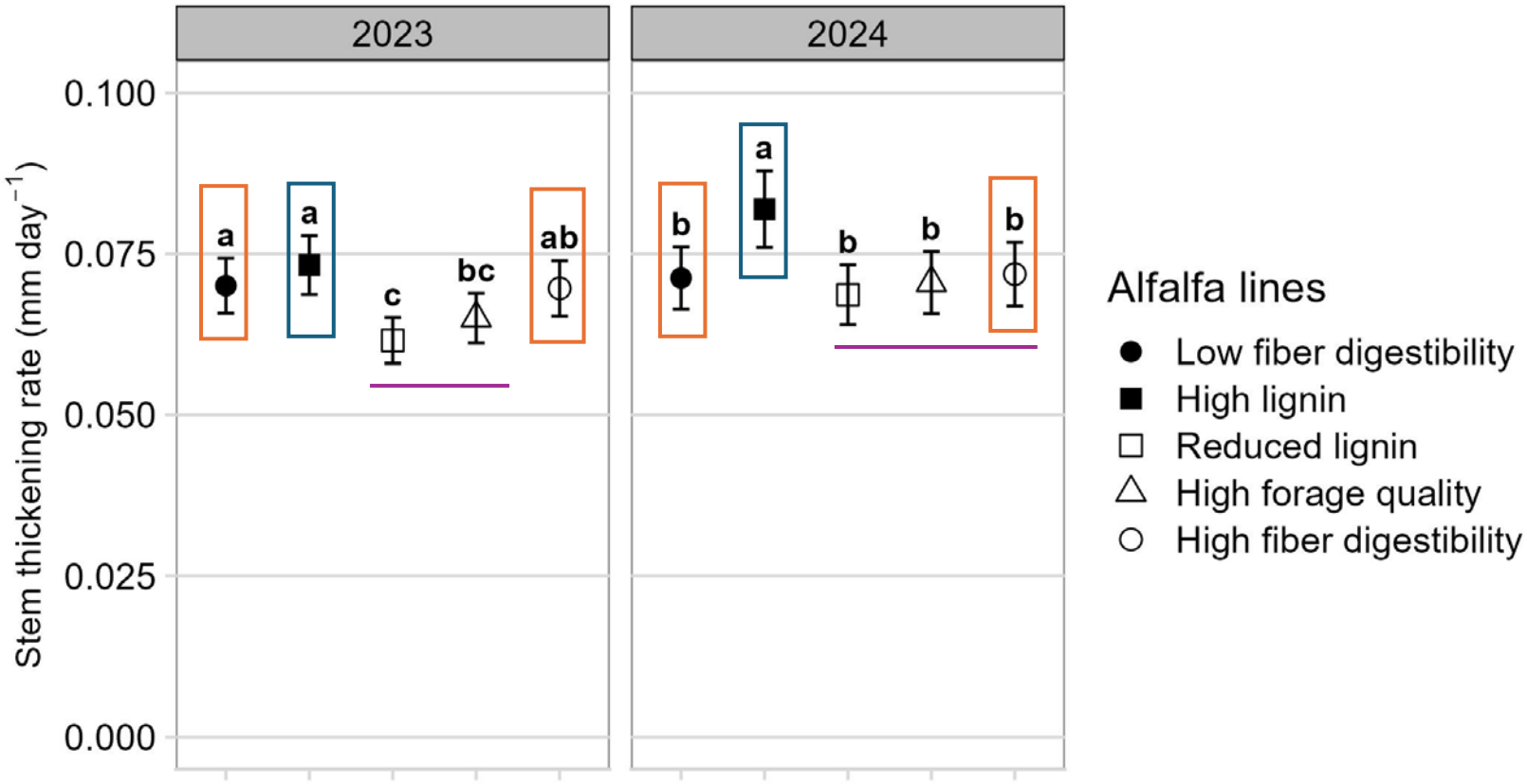
Stem elongation rate: High lignin line had taller stems than all other lines



Experimental lines had similar stem elongation rates

Enhanced digestibility lines had lower rates of stem elongation

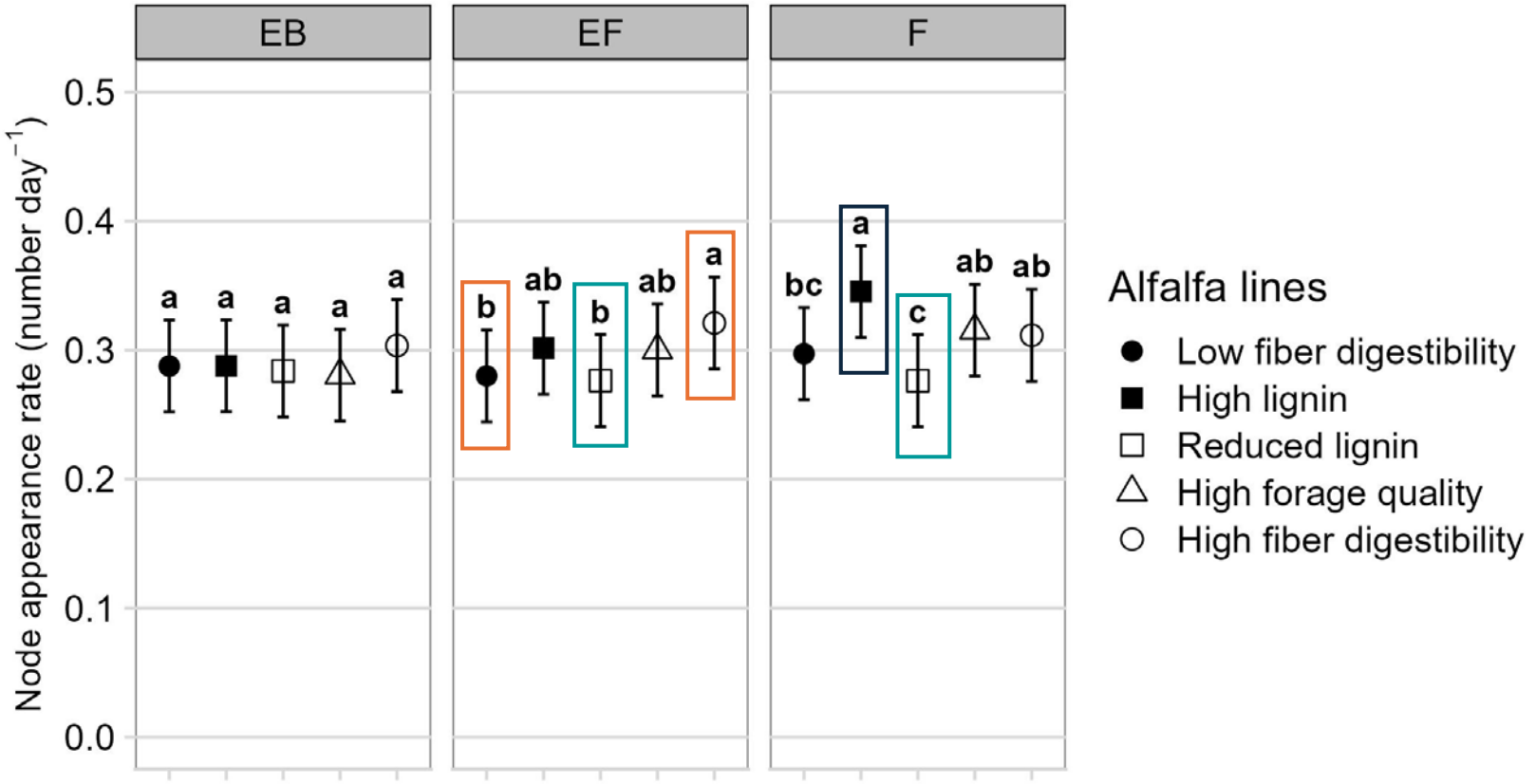
Stem thickening rate: High lignin line had consistently thicker stems



Experimental lines differed from High lignin line in 2024

Reduced lignin & High forage quality had consistently thinner stems

Node appearance rate: Variability among lines increased with maturity



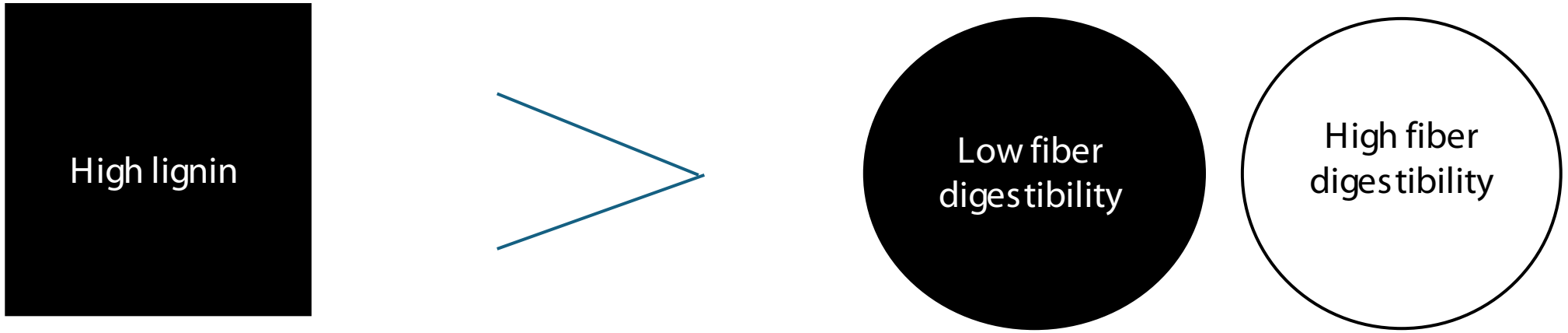
Reduced lignin line had fewer nodes as maturity advanced

Experimental lines diverged at early flower

High lignin, High forage quality & High fiber digestibility similar throughout

Patterns emerging from the data

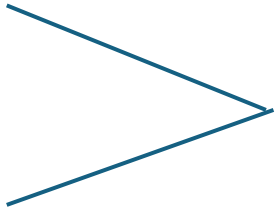
Greater yield



Patterns emerging from the data

Greater yield

High lignin



Low fiber digestibility

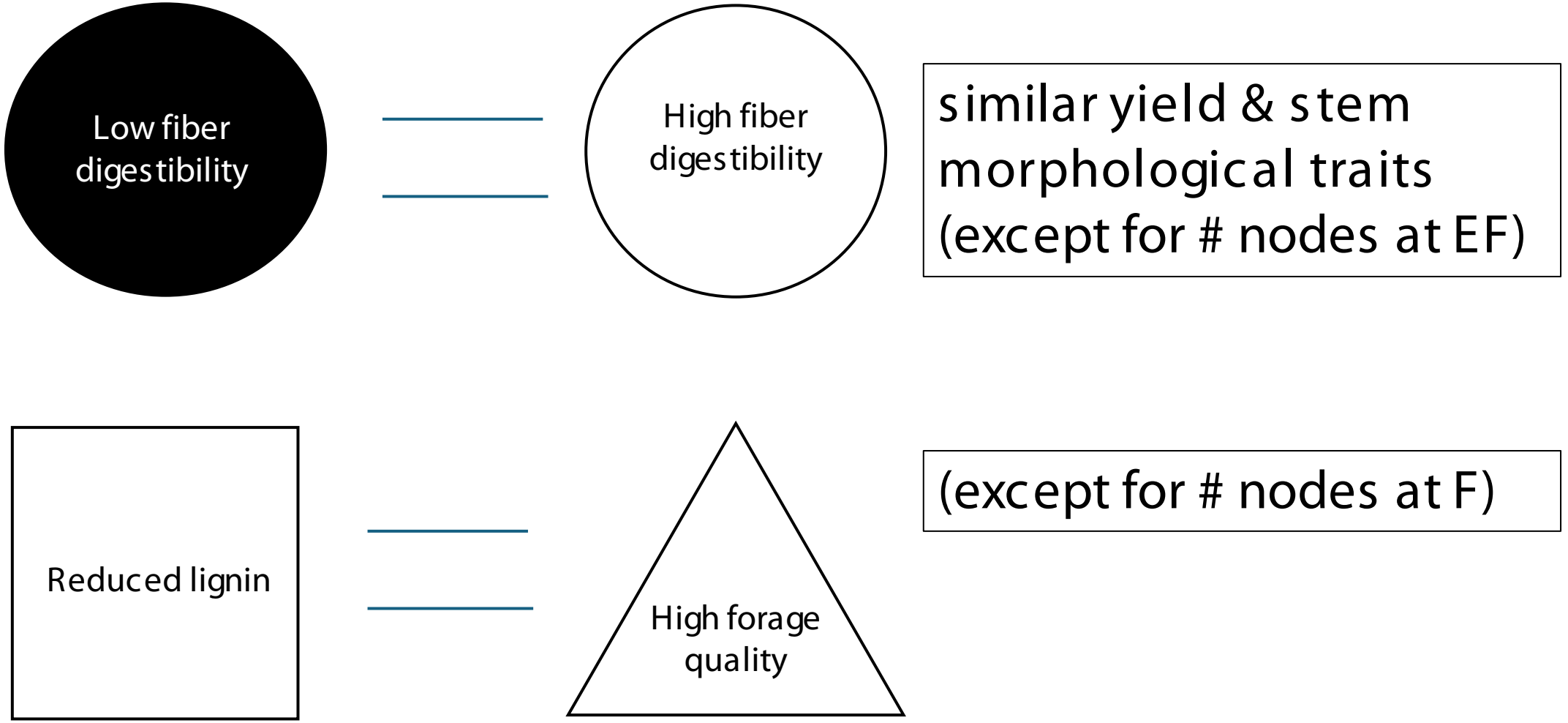
High fiber digestibility

Shorter, thinner stems with fewer nodes

Reduced lignin

High forage quality

Patterns emerging from the data



Conclusions

- Evidence to support the hypothesis that High lignin line would yield more, have longer, thicker stems than alfalfa lines with enhanced digestibility
  - Some enhanced digestibility lines similar for stem thickness & node count
- Year × Maturity interaction influenced herbage yield ($p<0.001$), stem elongation rate ($p<0.0001$) & node appearance rate ($p<0.0001$)
- Chemical analysis forthcoming to evaluate forage nutritive value among lines

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