Integrating Handheld NIRS and Multi Trait Indices to Accelerate Breeding for Nitrogen Efficient Grasses

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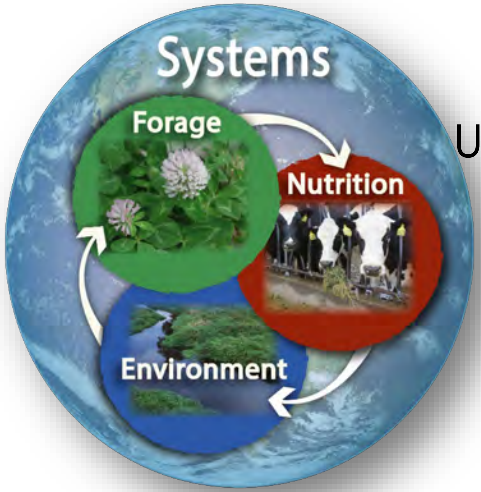
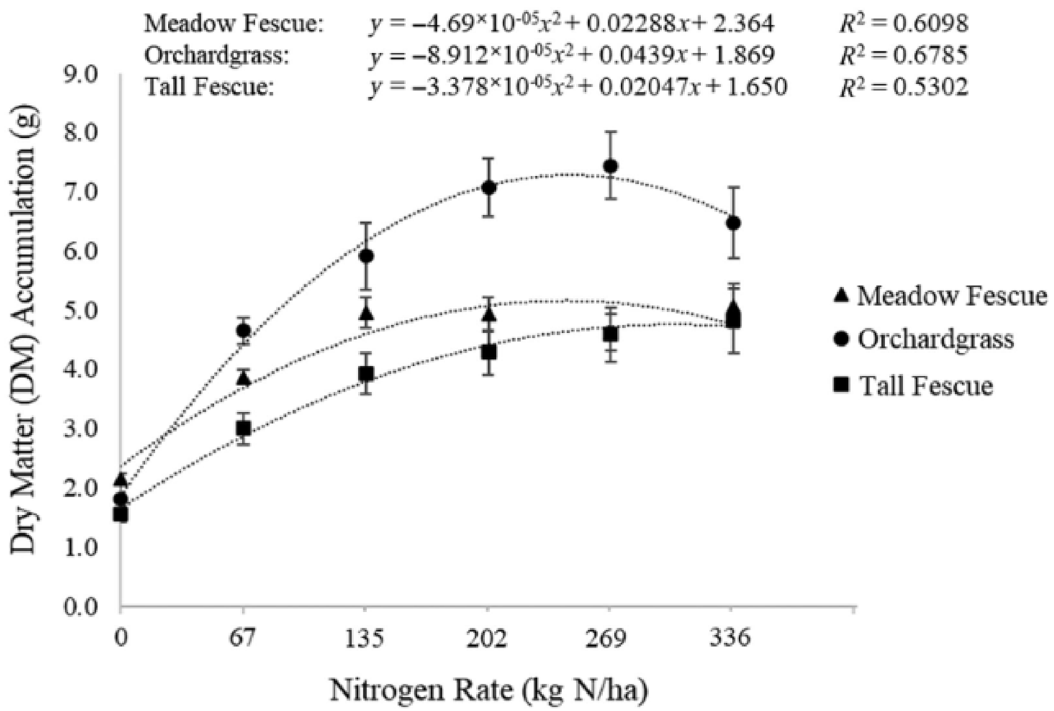
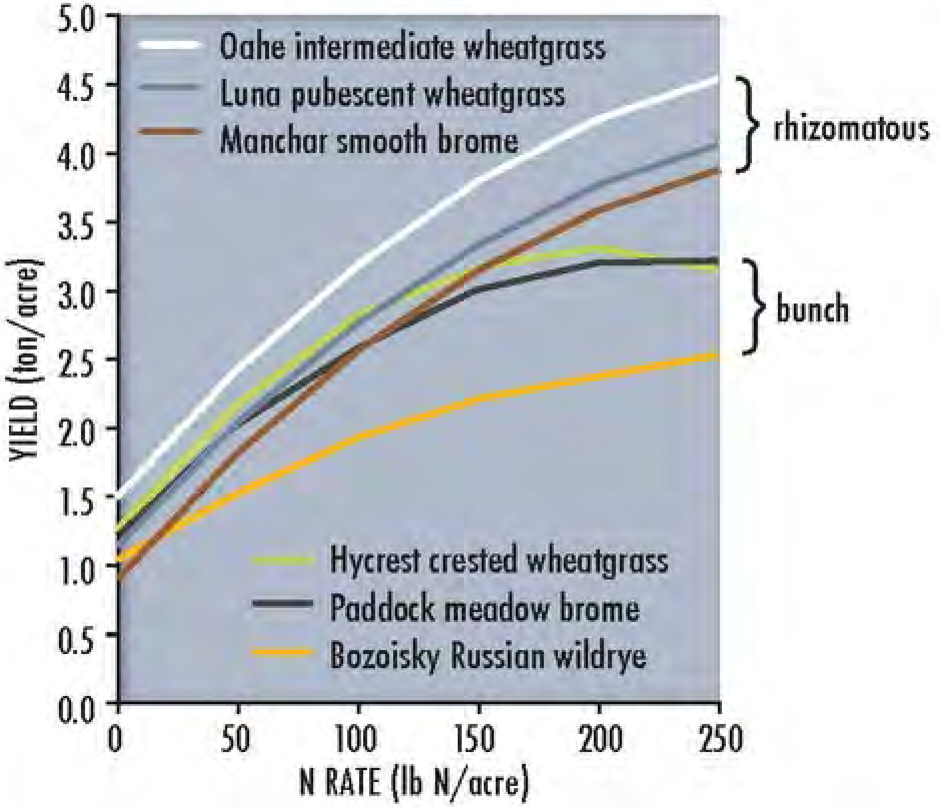



Credit: AgriEXPO

Do we need NUE grasses?

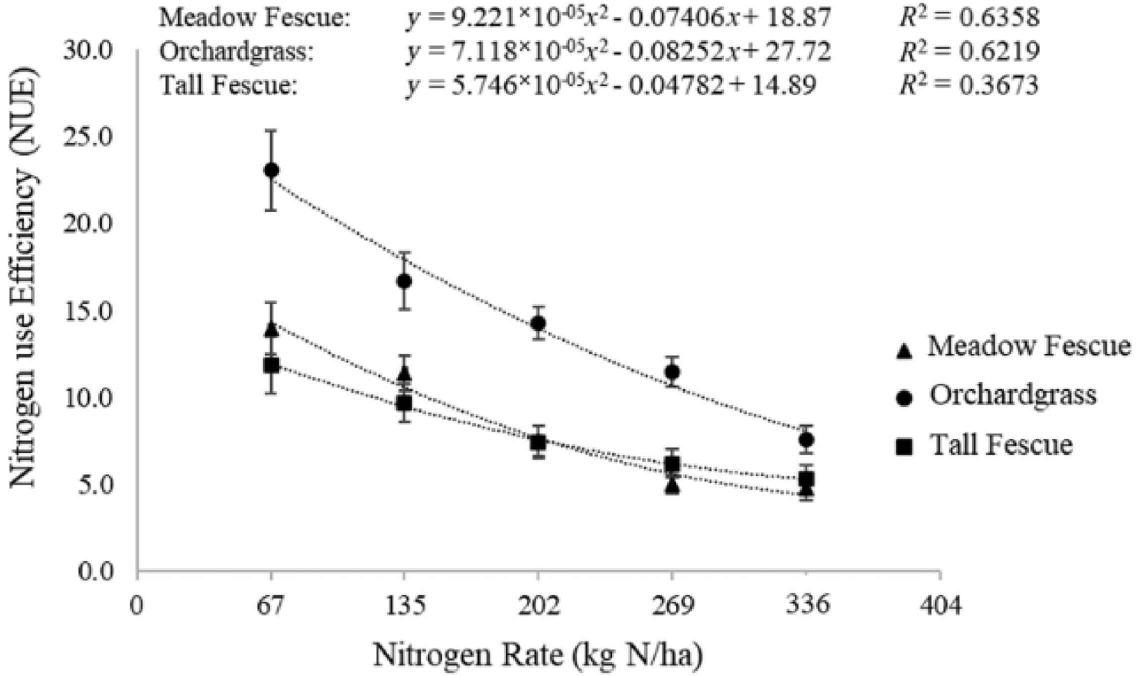


Duff et al., doi.org/10.1002/agg2.70308



https://animalrangeextension.montana.edu/forage/nitrate-soil-nutrient.html

N rates and NUE



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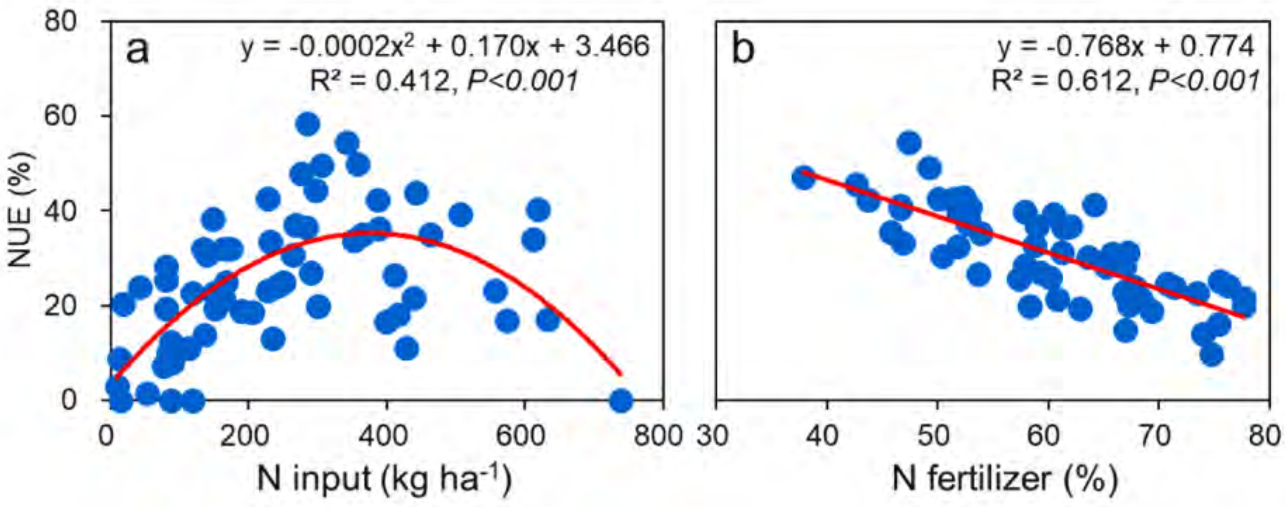
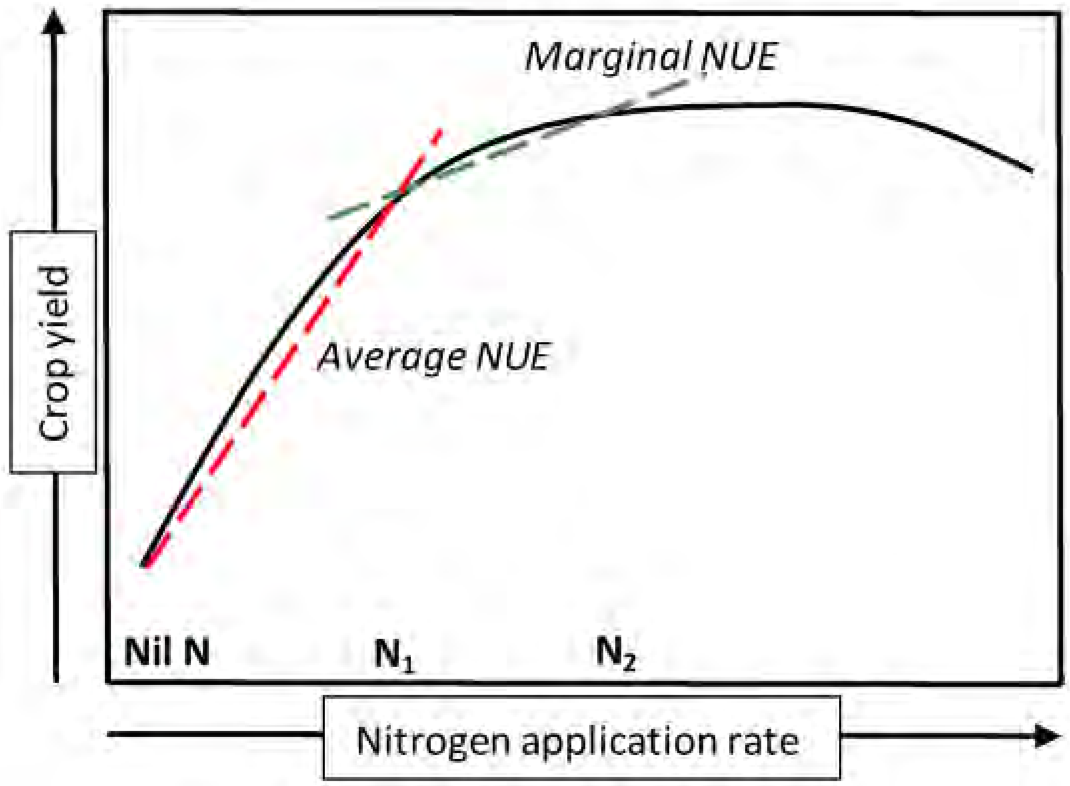


Chen et al., doi.org/10.1016/j.envpol.2022.120610

Why do we need NUE grasses?

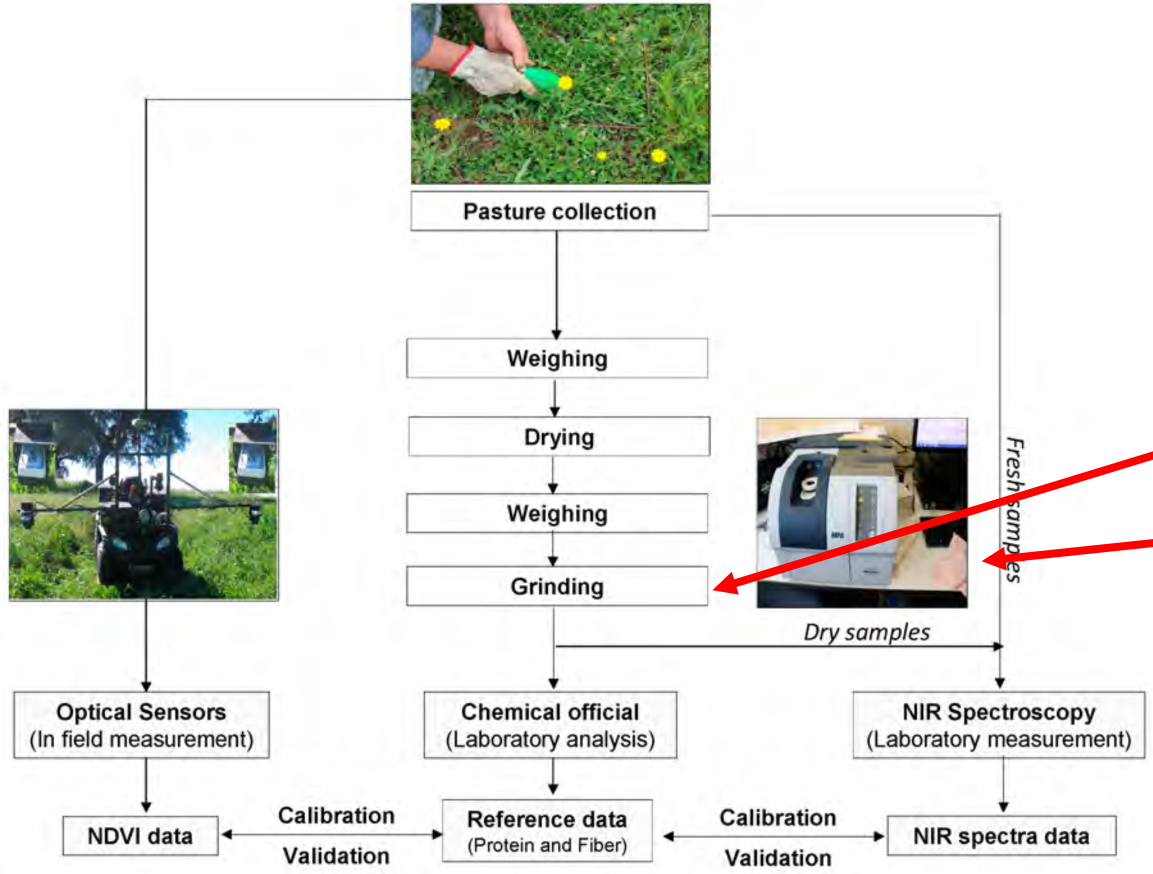
Key benefits

- Productive pasture and plant stands with less N
- Maintain high soil fertility, health
- Reduced runoff and leaching
  - More N available for the plants
  - Less problems downstream
- Reduce cost in farm operations



Chen et al., doi.org/10.1016/j.indic.2020.100099

Forage sample evaluation, a typical workflow



Big rate-limiting step

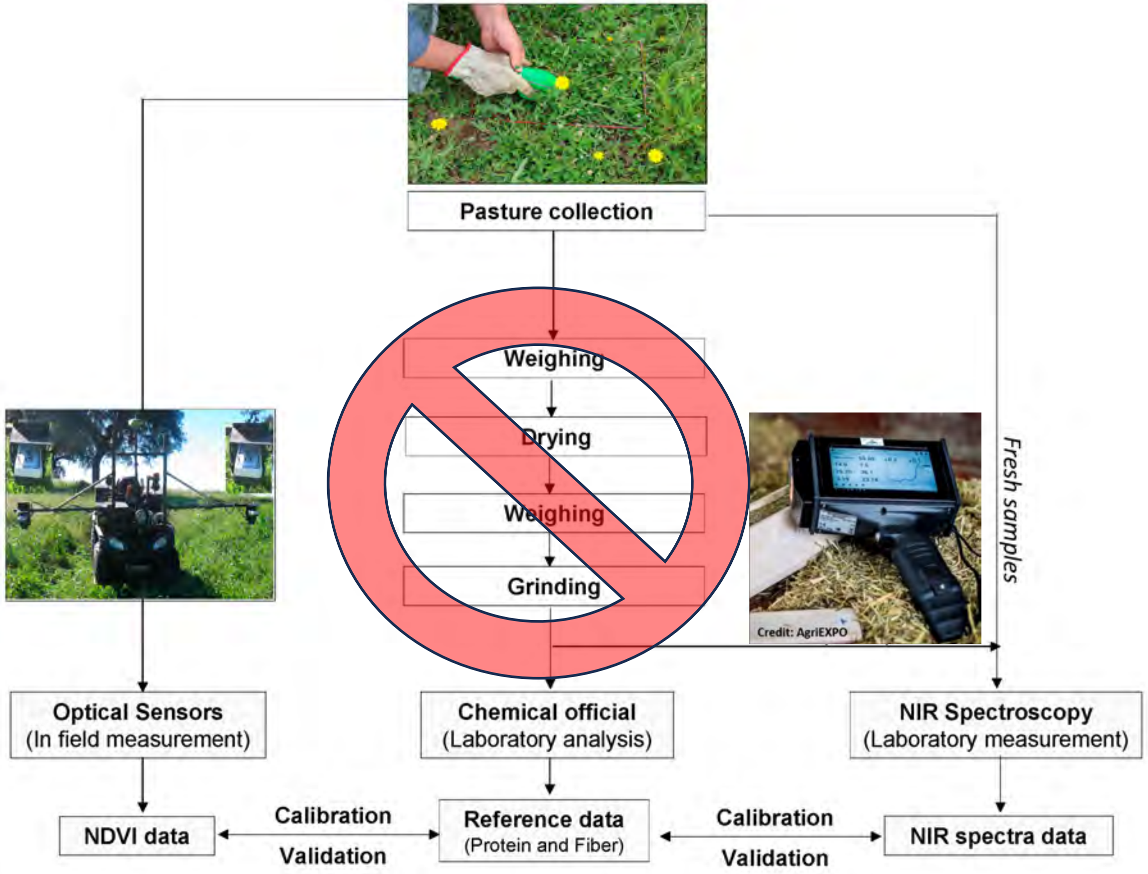
Another rate-limiting step

[Serrano et al., doi.org/10.3390/agriengineering3010005](https://doi.org/10.3390/agriengineering3010005)

Can we:

1. Assess NUE differently?
2. Make the process go faster?
3. Select for NUE & biomass yield?

Forage sample evaluation, a slightly different workflow



[Serrano et al., doi.org/10.3390/agriengineering3010005](https://doi.org/10.3390/agriengineering3010005)

Switchgrass case study

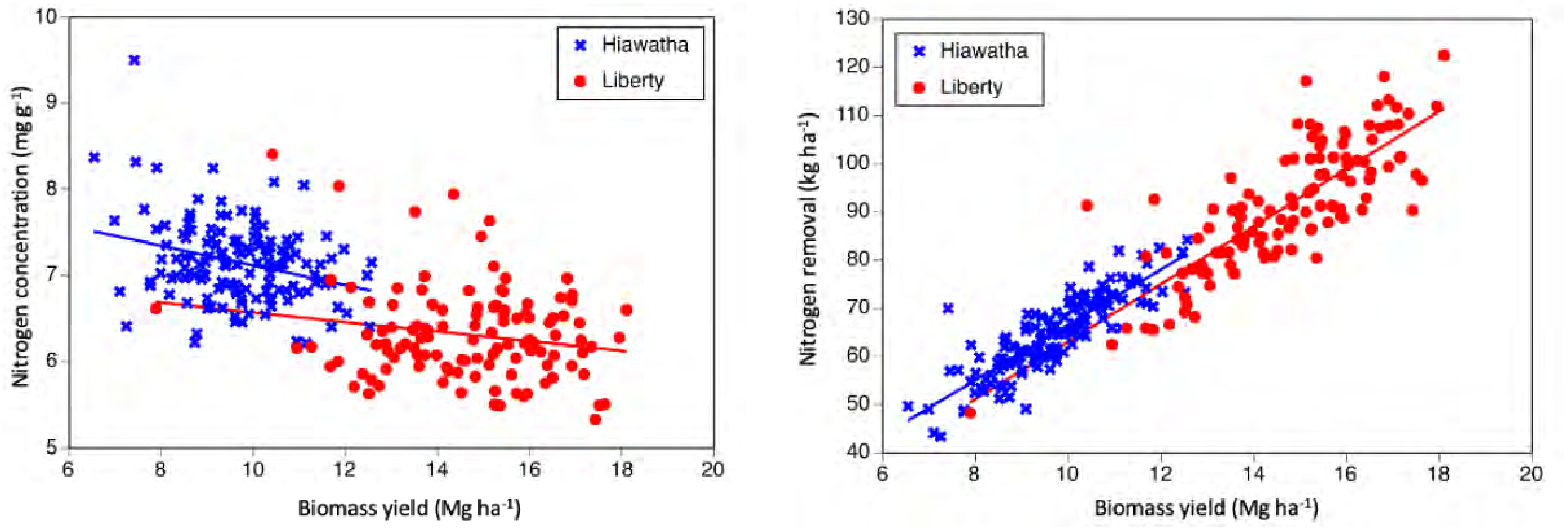
- Two populations
  - 144 half-sibs, upland
  - 110 half-sibs, upland x lowland
  - RCBD, four replicates per entry
- Biomass (fresh and dry)
- N content
  - Wet-lab assay
  - Handheld NIRS (Aurora) on fresh material
    - ~40 cm long stems
    - 10 scans along the length
    - Data calibrated with wet-lab and benchtop values
  - Bench-top (FOSS) on dry material
    - Ground through 1 mm mill
- Five trait indices with varying weights on biomass and N concentration

Credit: AgriEXPO

[Casler & Bajgain, doi.org/10.1002/glr2.70055](https://doi.org/10.1002/glr2.70055)

A slight negative correlation between biomass yield and N concentration

- Selecting plants with high yield **AND** low N concentration is possible
- Might need a larger population to discover desirable, and more, segregants



Casler & Bajgain, doi.org/10.1002/glr2.70055

1. That said, N removal (from soil) is strongly and positively correlated with both biomass yield and N concentration.

2. The weak negative correlation between biomass yield and N concentration might not be enough to reduce N demand.

3. Reducing plant N demand will require revised selection criteria rather than relying on single traits or simple trait correlations.

	h^2		*r* (Y)		*r* (N)	
Trait / Index	**H**	**L**	**H**	**L**	**H**	**L**
Biomass Yield (Y)	0.45	0.25	—	—	—	—
Nitrogen (N)	0.28	0.43	0.32	-0.05	—	—
N Removal	0.67	0.41	0.94	0.81	0.64	0.64
Ratio Y/N	0.37	0.08	0.9	0.43	-0.46	-0.99
Index 1	0.55	0.19	0.99	0.8	0.46	-0.64
Index 2	0.43	0.33	1	0.53	0.29	-0.87
Index 3	0.29	0.37	0.95	0.38	0.02	-0.94
Index 4	0.2	0.4	0.76	0.29	-0.38	-0.97
Index 5	0.18	0.41	0.4	0.24	-0.74	-0.98

H: Hiawatha
L: Liberty

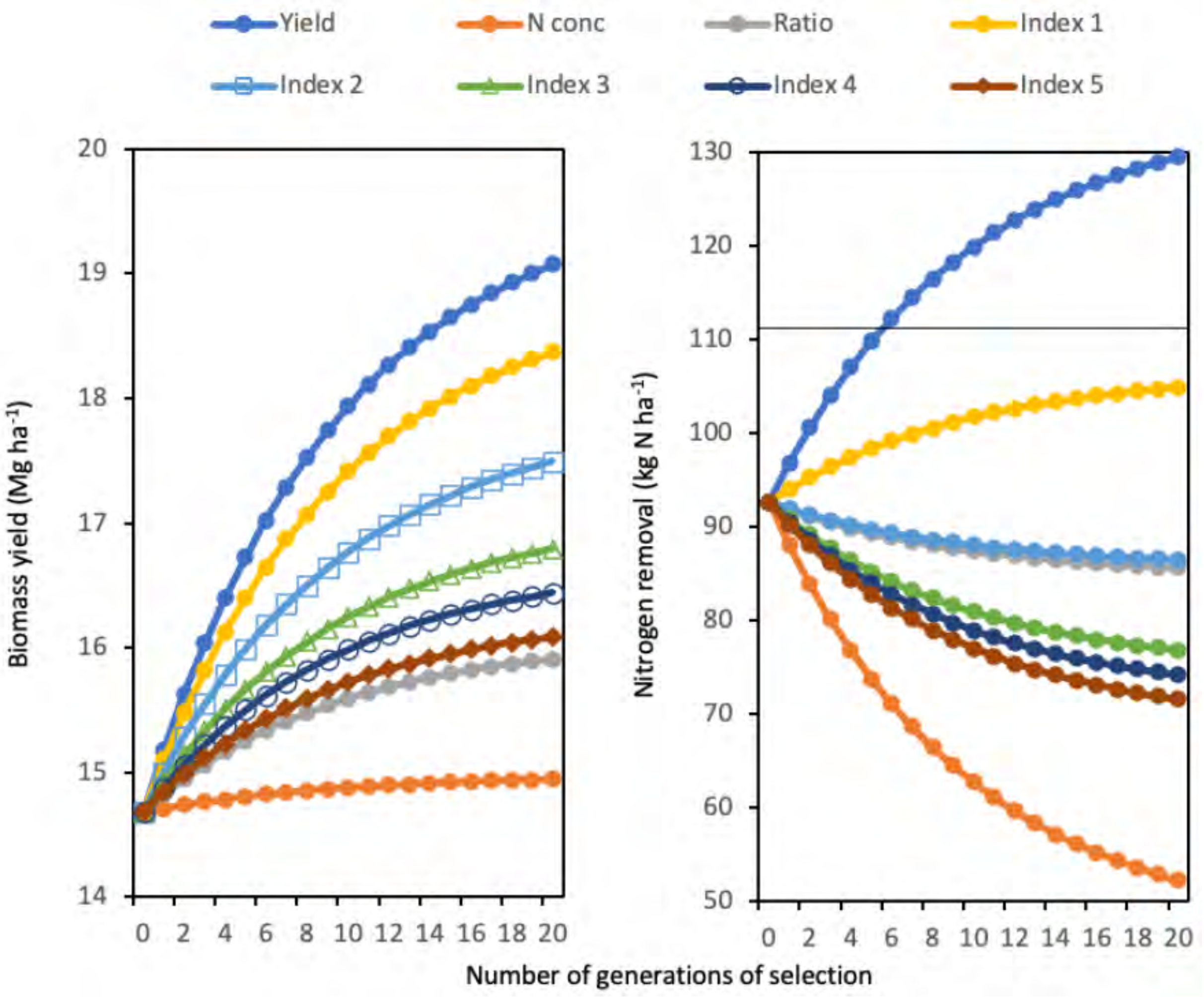
Casler & Bajgain, doi.org/10.1002/glr2.70055

1. Continued selection **only** for improved biomass in Liberty would push N demand above fertilization rates within six cycles.

2. Index 1 (equal weights on yield and N concentration) reduces yield gain by 16% but also lowers the rise in N demand by 75%.

3. N demand appears to plateau over several generations, which is unlikely in real world scenario.

4. A germplasm ‘refresh’ with better and efficient populations could be done after few generations to continue to lower N demand while improving biomass.



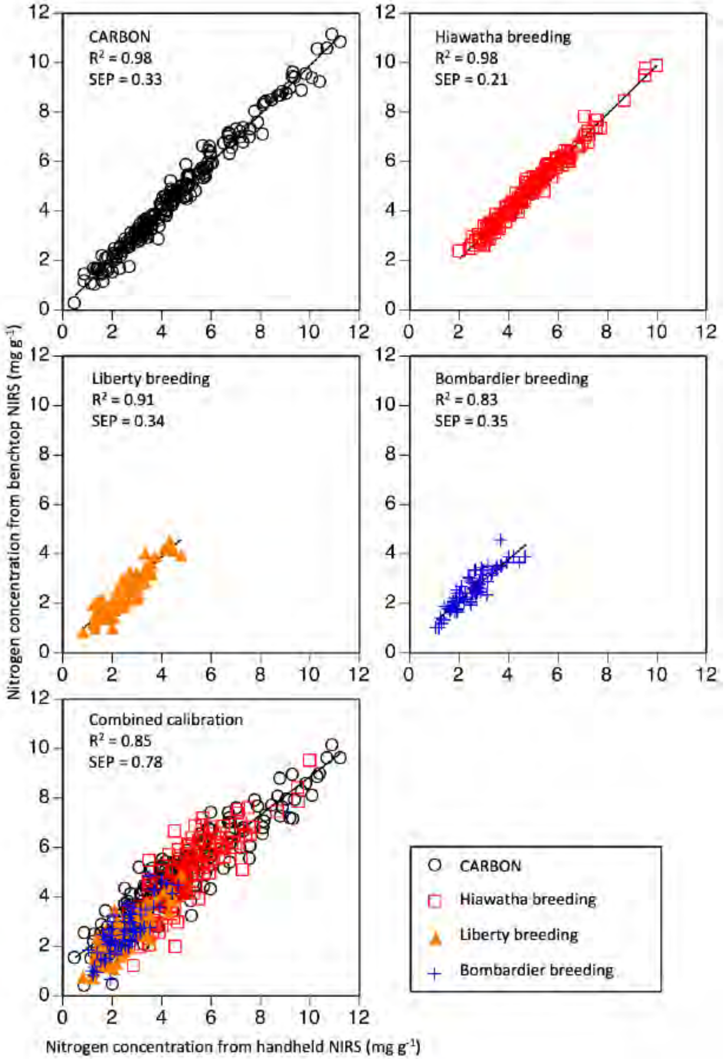
Casler & Bajgain, doi.org/10.1002/glr2.70055

1. The handheld NIRS device showed very high predictive accuracy ($R^2 \geq 0.91$; low prediction errors of 2.1%–3.5%) across nurseries.

2. Larger breeding populations increase selection intensity and genetic gain, but require evaluating thousands of plots for yield and N concentration.

3. Traditional off-season N analysis creates major workflow bottlenecks due to equipment limits, personnel issues, and unexpected disruptions.

4. Using two handheld NIRS units during autumn harvest removes most delays and is essential for maintaining a fast 2-year breeding cycle.



Casler & Bajgain, doi.org/10.1002/glr2.70055

Crop, Forage & Turfgrass Management

ORIGINAL ARTICLE

Forage and Grazinglands

Performance evaluation of two handheld NIR spectrometers to determine forage nutritive value using custom calibrations

Miguel S. Castillo[1] | Leandro Valqui[2] | Hector Vasquez[2] | Eduardo Alava[3] | Eduardo Chavez[3] | Juan J. Acosta[4]

FIGURE 1 Samples being scanned with two portable handheld spectrometers. Trinamix spectrometer (A) in direct contact with the sample (ground to pass a 0.04-inch screen); NeoSpectra spectrometer (B) with the sample (ground with a cyclone mill) in a sampling container provided by the manufacturer.

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Original papers

Handheld NIRS for forage evaluation

J.H. Cherney[a,*], M.F. Digman[b], D.J. Cherney[c]

Fig. 1. Relative size of instruments used in this study.

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Original papers

Prediction performance of portable near infrared reflectance instruments using preprocessed dried, ground forage samples

P. Berzaghi[a,*], J.H. Cherney[b], M.D. Casler[c]

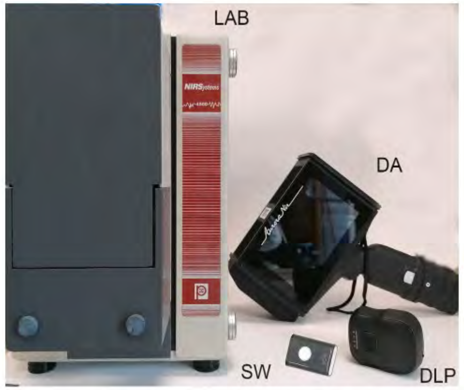

Fig. 1. Average alfalfa spectrum using four different instruments. LAB = Foss NIRSystem 6500; DA = Grainit s.r.l. AuroraNir; DLP = Innospectra NIR-S-G1; and SW = Consumer Physics SCiO.

In summary:

- Possible to select for higher NUE, i.e. increased biomass yield and less N demand
- Selection over several generations using trait index could sustain genetic gain
- Hand-held NIRS just as good as a benchtop machine, but faster and more efficient
- Observations might differ in other species (e.g. C3s) - independent research necessary

Thank you!