



Insights on Forage Variety Testing from a Multi-Decade, Multi-Species Dataset

Neal Tilhou, Heathcliffe Riday, and countless others



My presentation today

- Why perennial forage variety trials are important
- Lessons from a re-analysis of historical variety trial datasets
- Future research ideas and goals

Historical breeding progress

From 1945 to 2023:

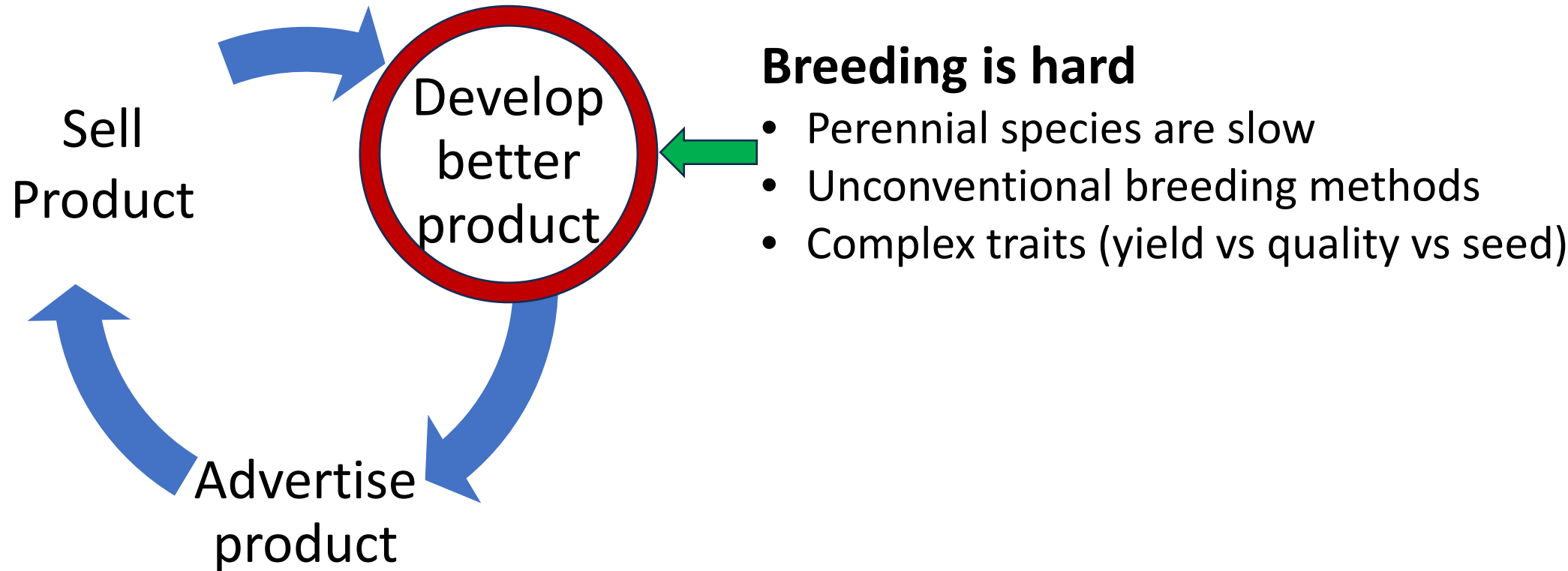
Grass hay yield improved 13%

Corn yield increased 382%

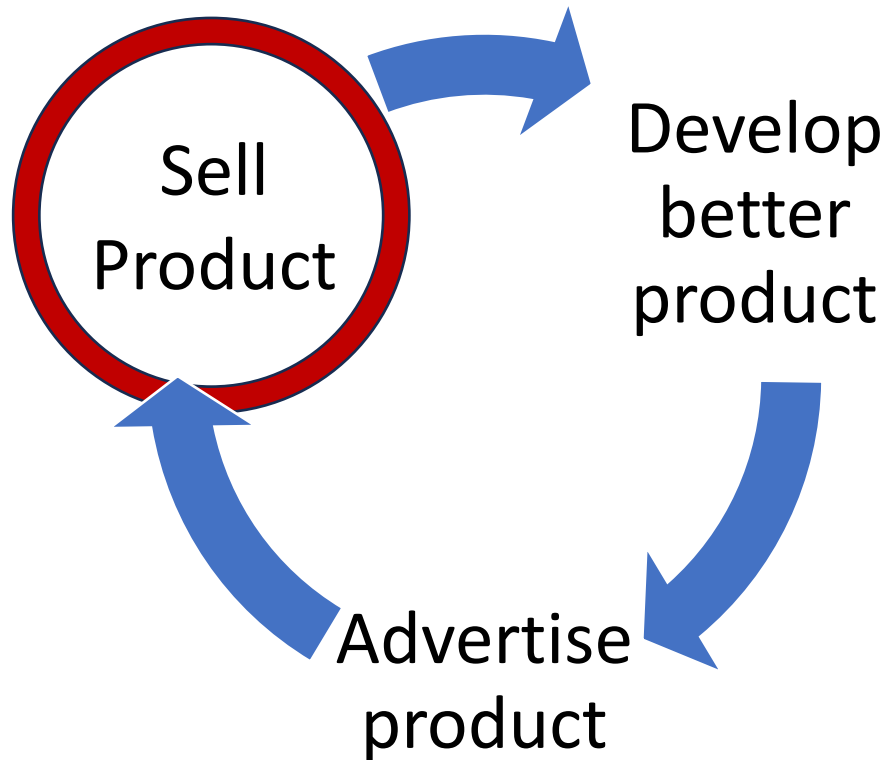
Wisconsin ag. Census data



A stalled R&D cycle in forage breeding



A stalled R&D cycle in forage breeding



Are improved forages worth it for farmers?

For every 1% improvement in yield, 6% increase in profit!

Seed cost as % of revenue by enterprise:

Corn +10%

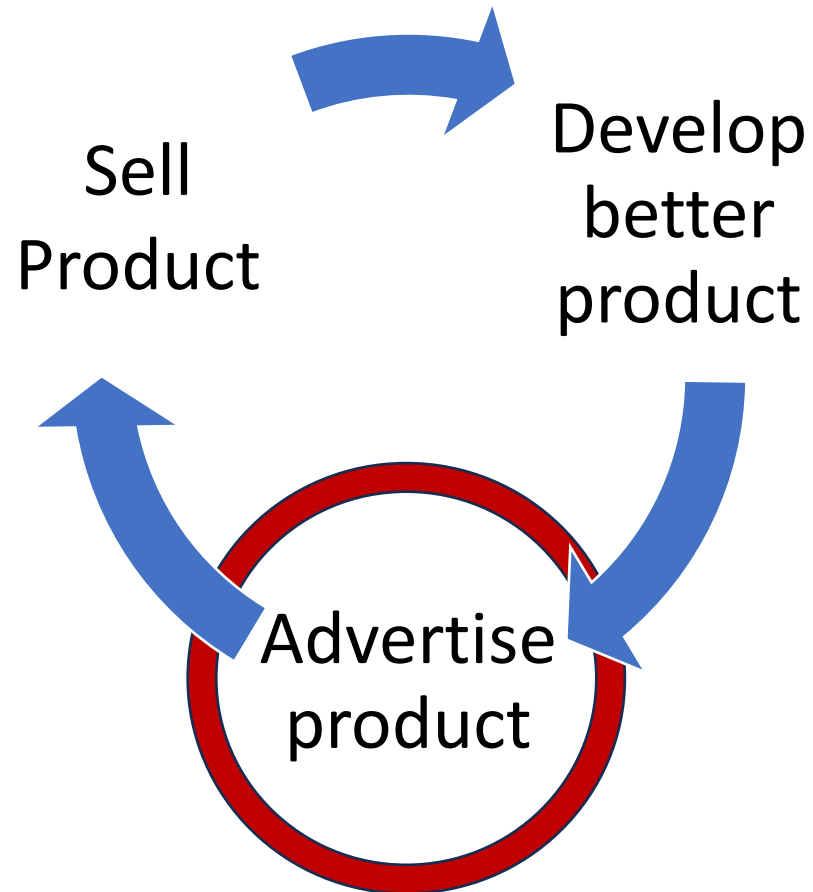
Soy 7%

Wheat 7%

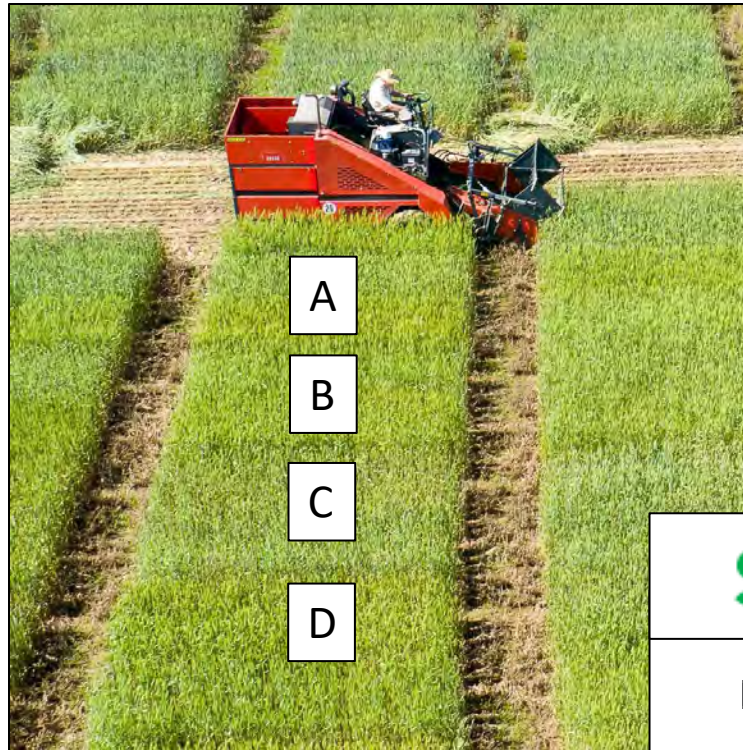
Alfalfa 2%

Grass hay: 1% (!)

A stalled R&D cycle in forage breeding



Public forage variety testing



Seed company ads

Soft Leaf Tall Fescue

Key features

- Soft-leaf tall fescue
- Late Maturing
- Yields equal to or greater than alfalfa
- High amounts of digestible fiber

Research questions

- How reliable are variety trial results?
- Can we make trial results more persuasive?
- Do trials show breeding progress?

New Hampshire

Variety	1951
Narragansett	5563
Atlantic	3845
Ontario Variegated	3734
Ranger	3875
Buffalo	3206
Grimm	1576
Average	3633
L.S.D. (.05) †	479

New York Alfalfa 2013

Varieties	3-Yr Total
CRAVE	20.78
STOCKPILE	20.62
4030	20.35
PILLAR	20.33
PERSIST III	20.21
...	...
ONEIDA VR (check)	17.47
VERNAL (check)	17.43
WL353 LH	17.37
Mean	18.90
5% LSD	0.87

Merged Variety Trials From “Greater Northeast” U.S.

Alfalfa

- 494 trials evaluating >1,000 cultivars
- 12,870 data points from 1988 to 2017
- Iowa, Illinois, Indiana, Kansas, Kentucky, Michigan, Minnesota, North Dakota, Nebraska, New York, Ohio, Pennsylvania, South Dakota, and Wisconsin

Red Clover

- 4,138 data points from 1965 to 2022
- Iowa, Indiana, Kentucky, Michigan, Minnesota, New York, Ohio, Pennsylvania, Tennessee, Virginia
- 61% Wisconsin. 7% Kentucky. 5% New York.

Orchardgrass

- 903 data points from 1981 to 2021
- 46% Kentucky (1997-2021). 26% Wisconsin (1981-1994).

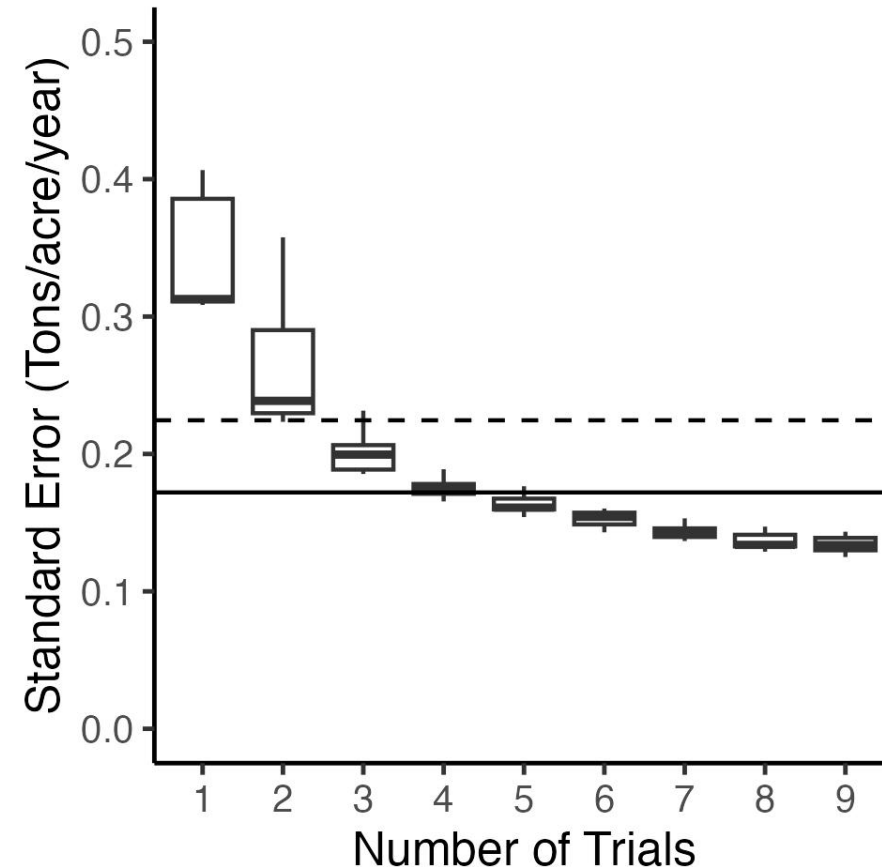
Tall Fescue

- 859 data points from 1999 to 2021
- 81% Kentucky. 11% New York. 8% Tennessee.

Summary of alfalfa trial genetic variance

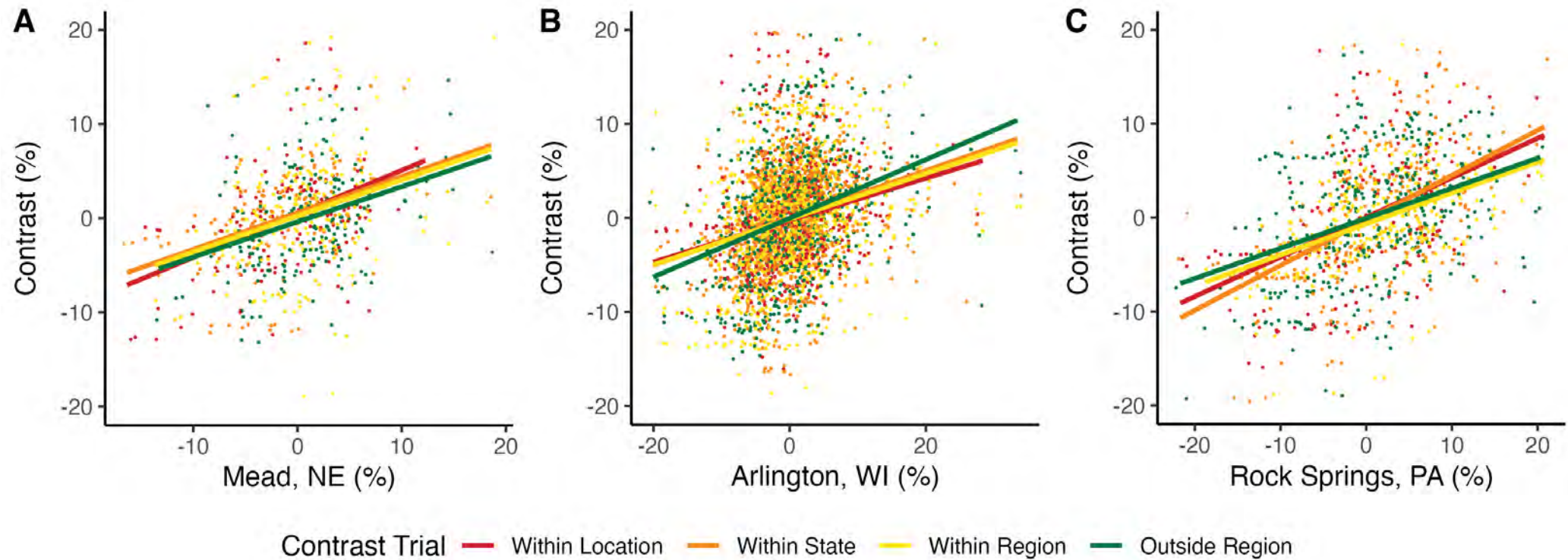
Source	n	Variance	%	
Variety	827	0.323	36.2	Extremely important
Variety × location	8256	0.072	8.1	
Variety × state	3889	0.018	2.0	Can be harnessed in complex models
Variety × year	2703	0.074	8.3	
Variety × state × year	7225	0.070	7.8	
Error (includes variety × trial)	12,532	0.335	37.6	Error: useless (but job security) Variety x Trial: useless AND unsettling

We can report generalized yield superiority



The dashed horizontal line is the threshold of precision required to confirm (95% confidence) that the average modern cultivar is superior to Vernal. The solid line is the threshold of precision required to confirm that a superior cultivar is in the top 25% of entries for a set of trials.

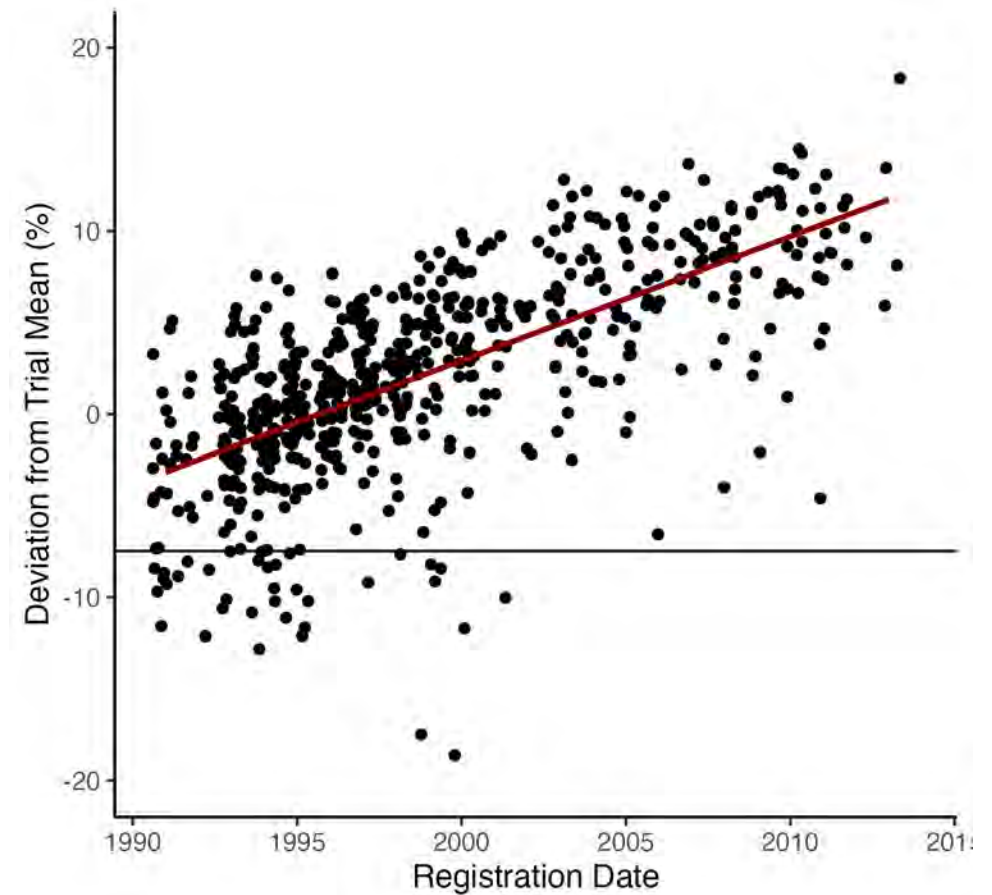
Results can be shared between testing programs



Regression between commercial variety performance at a target location (a: Mead, NE; b: Arlington, WI; or c: Rock Springs, PA) and other trial locations based on geographic categories. Each point is single alfalfa cultivar average at the target location. Percentages are the deviation from the trial average for each pair of observations.

Yield progress in alfalfa

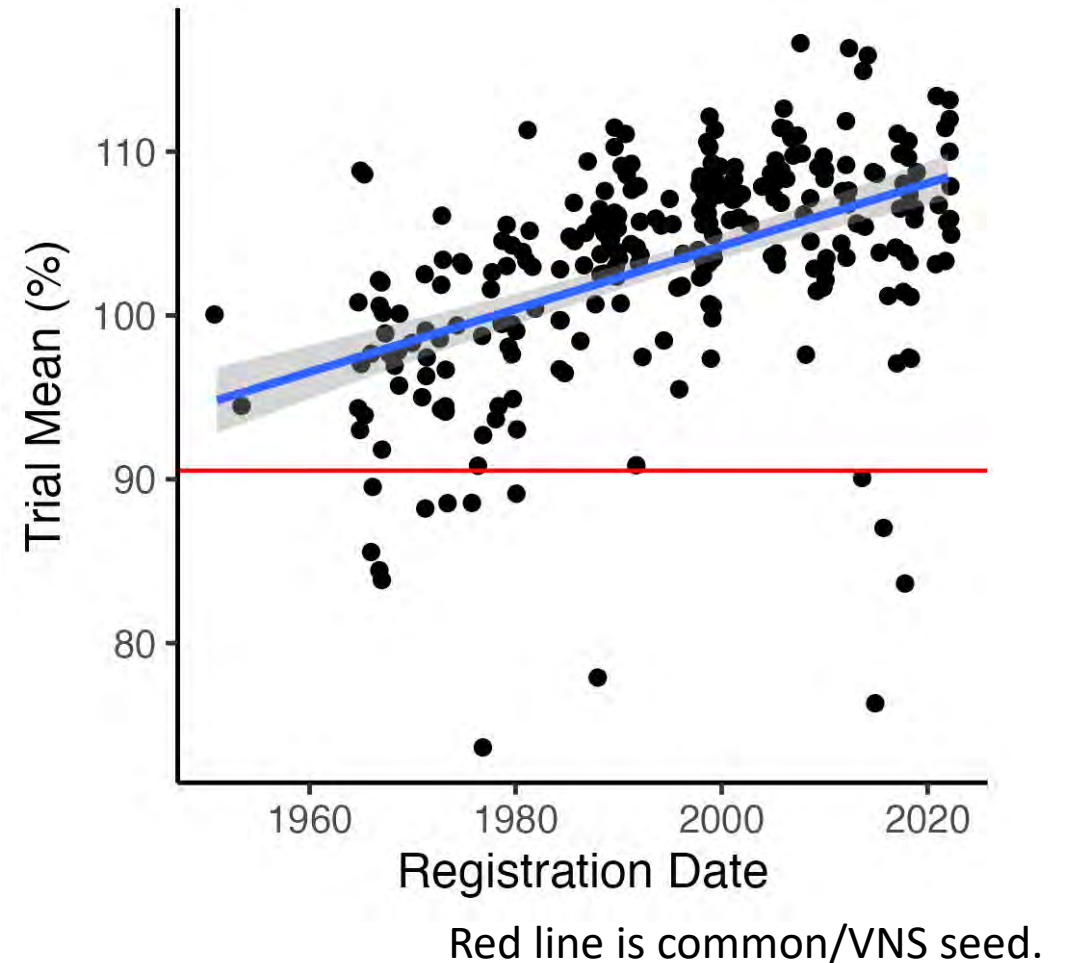
- Industry-wide improvement of 0.63% per year (SE 0.03%, p-value LOD=78).
- Within a cohort, range between cultivars is >10%
- 0.38 tons per season per decade
- 2.5% gain per 100 tested entries



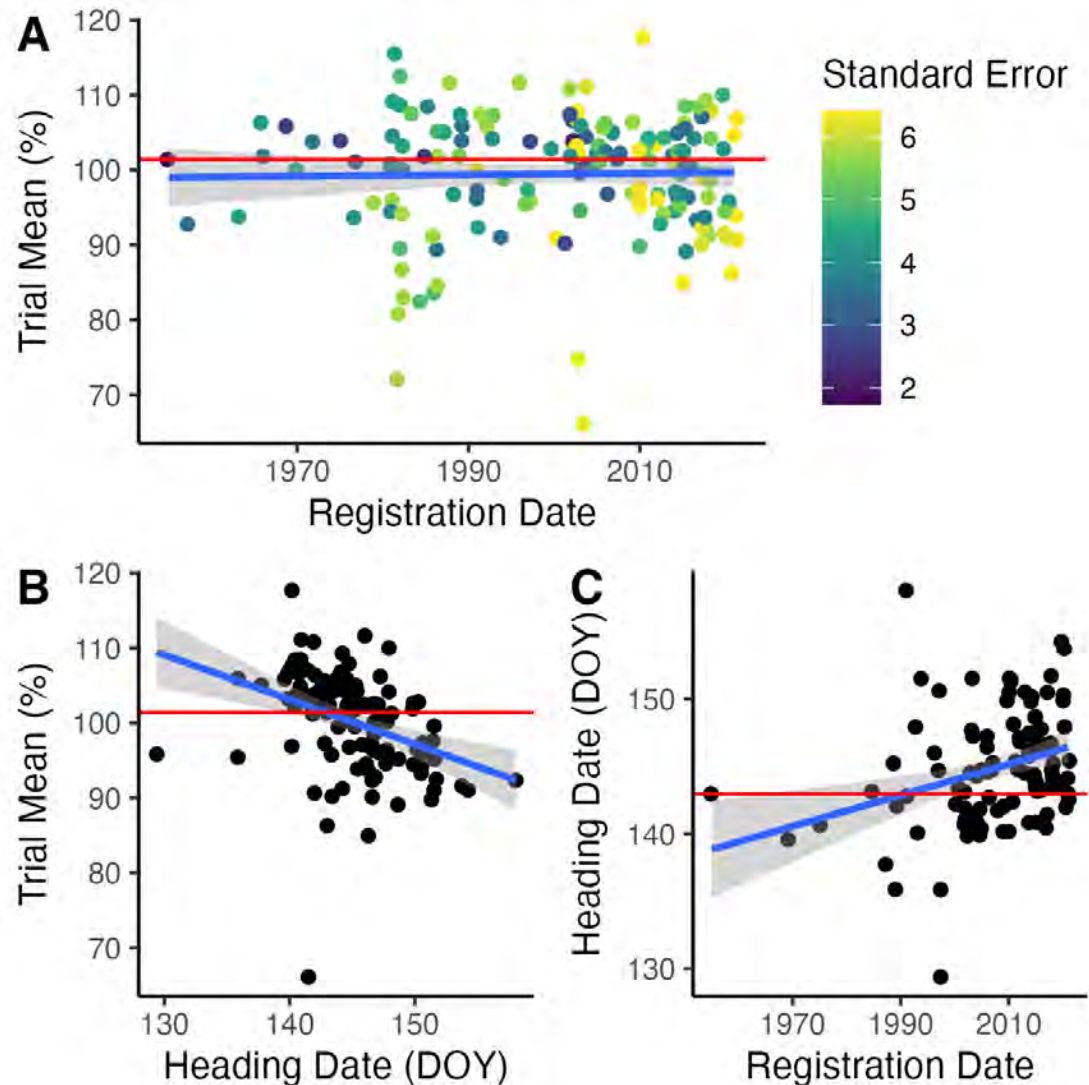
Each point is a cultivar evaluated in >3 trials
Horizontal line is Vernal

Yield progress in red clover

- Similar variance distribution to alfalfa
- Average 2020 cultivar performance 15% above Common/VNS seed
- Industry-wide improvement of 0.19% per year (SE 0.02%, p-value LOD=16).
- 2.5% gain per 100 tested entries



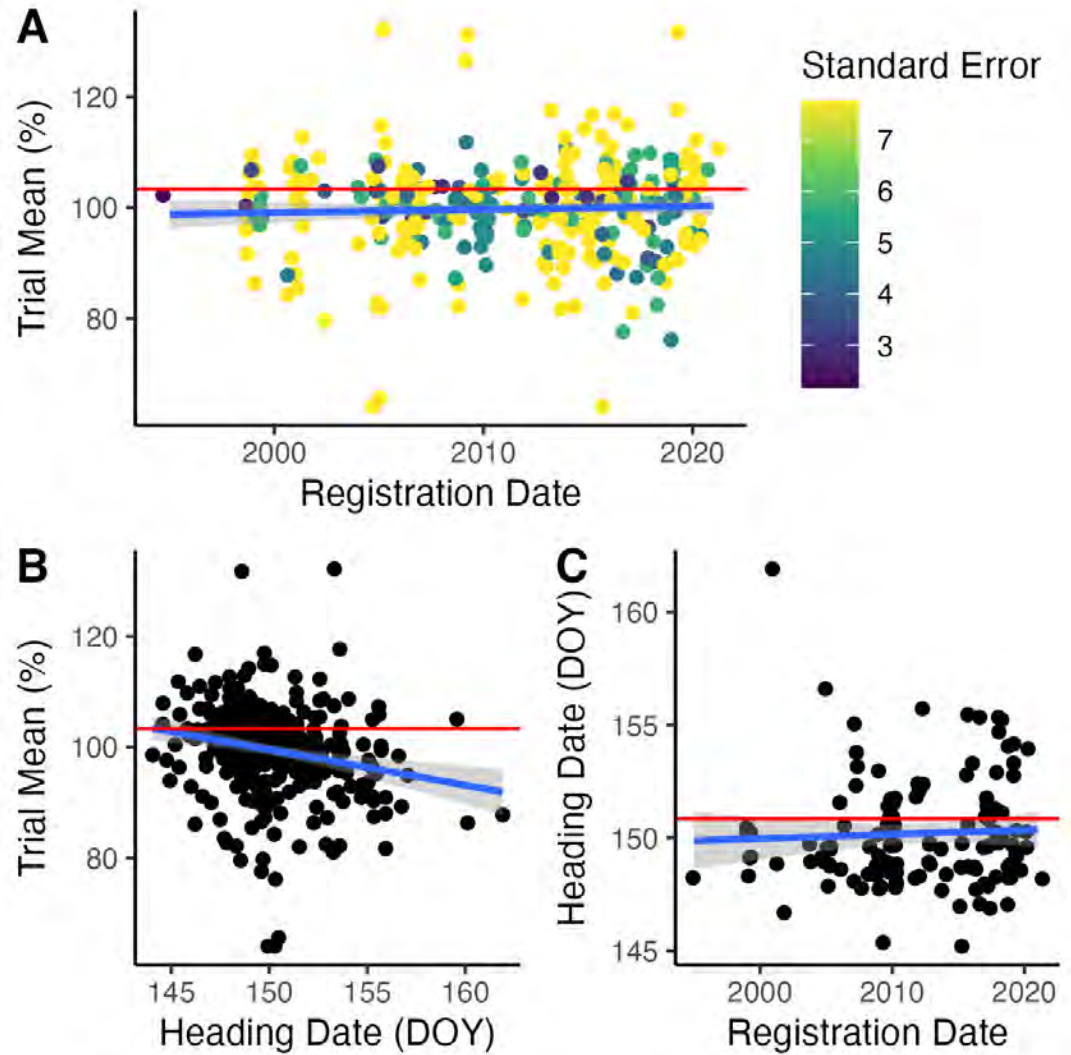
Progress in orchardgrass



Horizontal red line is Potomac

- Complicated
- Similar variance distribution to alfalfa
- No evidence of yield improvement (A)
- New cultivars have later maturity (C)
- Early maturity artificially increases trial yield estimates (B)

Progress in tall fescue



Horizontal red line is KY-31

- No improvement in trials
- Minor maturity effect
- Endophyte effects are quite large.
- Analysis of endophyte effects will occur....eventually.....

Conclusions

- Trust the averages of multiple trials
- Trials from nearby regions are informative
- Forage breeding works



Future research goals

Improve trial precision

- Multi-site models
 - Relationship between representativeness and measures of quality (CV or LSD or yield)
 - Can we reduce error with weather variables?
- Model yield factors
 - Persistence
 - Early biomass
 - Harvest distribution
- Trial design
 - Deal with maturity effects
 - Major GxT sources

Improve public trial program sustainability

- Reduce costs
- Increase company enrollment and trust
- Build shared resources



Acknowledgments

- Countless publicly supported scientists who contributed to decades of trials.
- Researchers assembling the Forage Data Hub who assembled these datasets.
- Heathcliffe Riday for the red clover dataset.
- My USDA-ARS Dairy Forage Research Center co-workers.

