Alfalfa Genetic Gain for Forage Yield Using Single-Cross Hybrid Progeny Testing

S. Wagner[1] (steven.wagner@dlf.com), S. Damon[1] (steve.damon@dlf.com)
[1] DLF USA, Inc, West Salem, WI, USA

INTRODUCTION

- On-farm Alfalfa forage yields reported by the USDA indicate that significant yield gains were being made prior to the 1980's, however, since then, they have been flat (USDA, 2023).
- Lack of on-farm alfalfa yield progress can, in part, be attributed to alfalfa being pushed to more marginal and less productive land on average, and also, in part, to alfalfa being managed more intensively for better forage quality at the expense of forage yield.
- Estimates for alfalfa genetic gain for forage yield over the last century in the literature have had some disappointing reports of 0.1% to 0.3% per year to strong reports of 0.56% to 1.19% per year.
- Genetic gain in alfalfa lags behind other crops for a number of reasons:
  - The challenge of improving the entire biomass of alfalfa versus allocation of assimilates to the grain of other crops.
  - The perennial nature of alfalfa requires breeding for more traits and significantly increases the testing resources required for breeding
  - The industry has focused on breeding for defensive traits like disease and pest resistance distracting from forage yield
  - The autotetraploidy of alfalfa makes it more difficult to capitalize on heterosis in alfalfa
  - There are fewer companies and research programs with a significant investment in alfalfa genetic improvement relative to other crops.

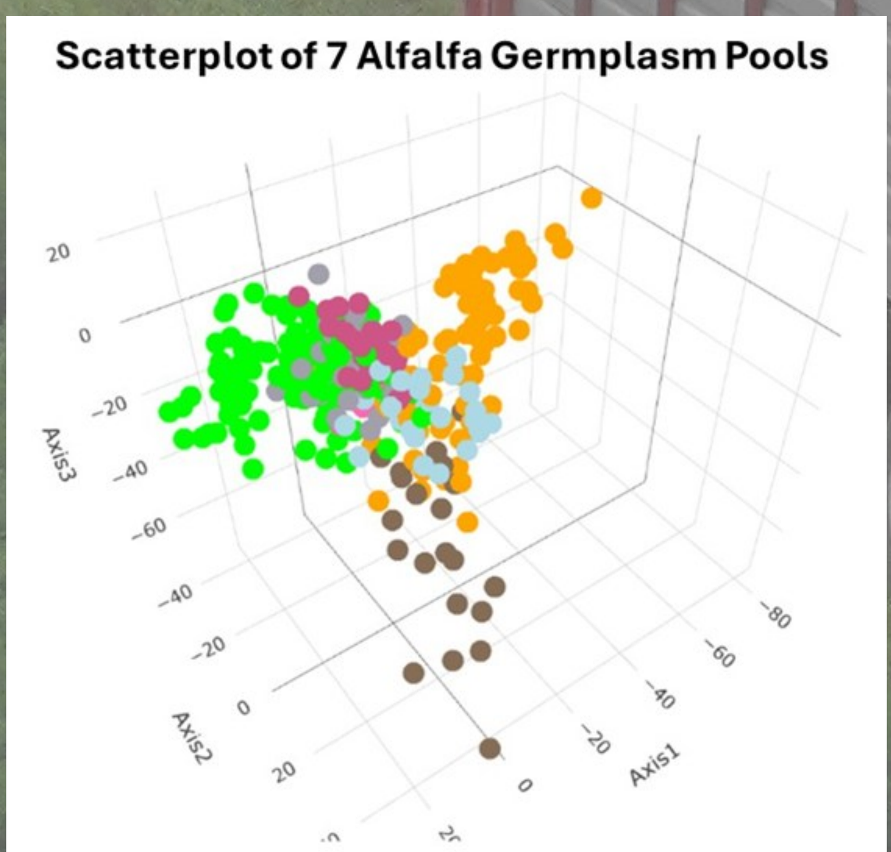

Figure 1

MATERIALS and METHODS

SINGLE-CROSS HYBRIDS

- A reciprocal recurrent selection breeding scheme has been conducted for the last 13 years between a male sterile population and six other unique breeding pools.
- Each year between 30 and 60 new male sterile female clones and between 90 and 100 new male fertile male clones were testcrossed to two testers to create single-cross hybrids.
- The single-cross hybrids were forage yield tested in swards at 3 locations in Wisconsin, USA.

GENETIC GAIN CALCULATION

- The forage yield advantage of each new clone was compared head-to-head against a check clone when in the same trial, at the same location, and when crossed against the same tester.
- This forage yield advantage of the best clones from each year of selection were regressed against the year the clone was selected from the spaced plant nursery. The slope of the regression indicates the genetic gain.

GENETIC GAIN ON A VARIETAL BASIS

- Clones that were selected based on progeny testing forage yield performance have then been used in various ways from 2012 to 2018 to develop populations in breeder seed cages as potential commercial varieties.
- These populations were forage yield tested at 4 locations in the Midwest.
- The yield advantage of the top 10% of the populations each year was compared against common sets of checks and regressed across years those years.

RESULTS and DISCUSSION

CLONAL GENETIC GAIN

- The most robust (with largest dataset) estimate for genetic forage yield gain in the female pool was 0.54% per year.
- The most robust (with largest dataset) estimate for genetic forage yield gain in the male pool was 0.66% per year.

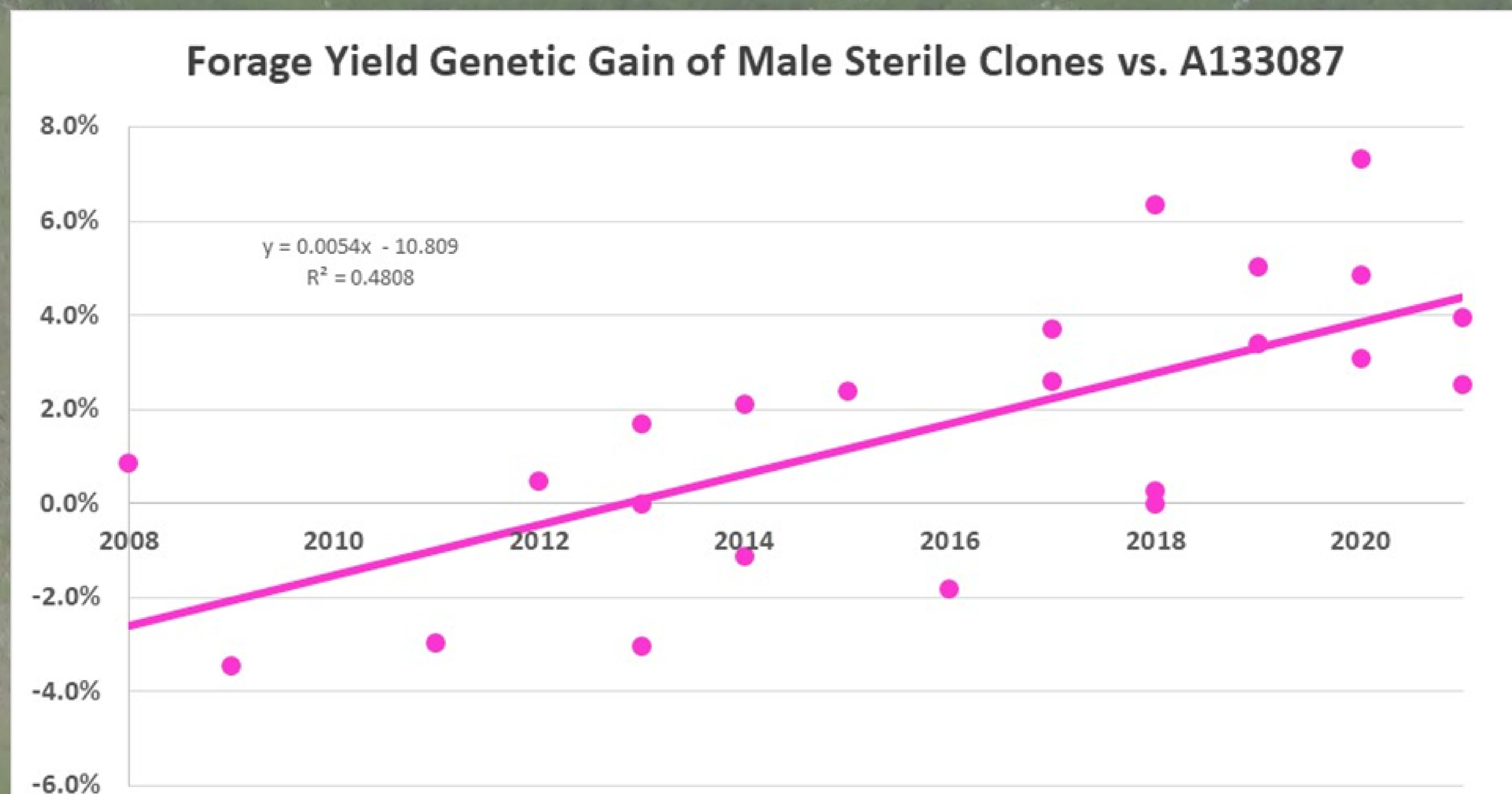

Figure 2

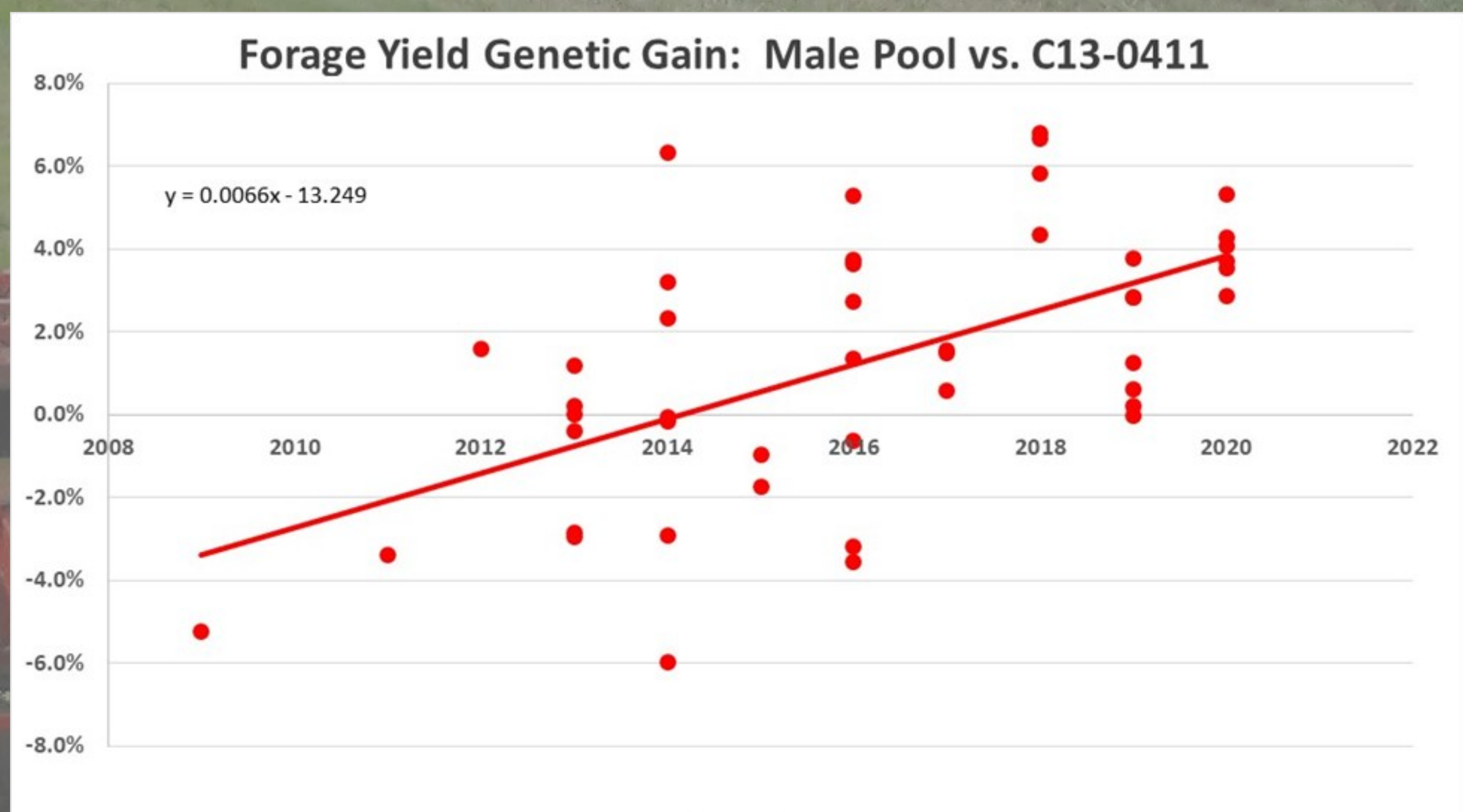

Figure 3

VARIETAL GENETIC GAIN

- On a varietal basis, over a period of 11 years, seven different regressions were calculated against different check sets.
- Varietal genetic gain averaged 0.86%/year, and ranged from 0.49%/year to 1.42%/year.
- Summarized over 100,000 data points.

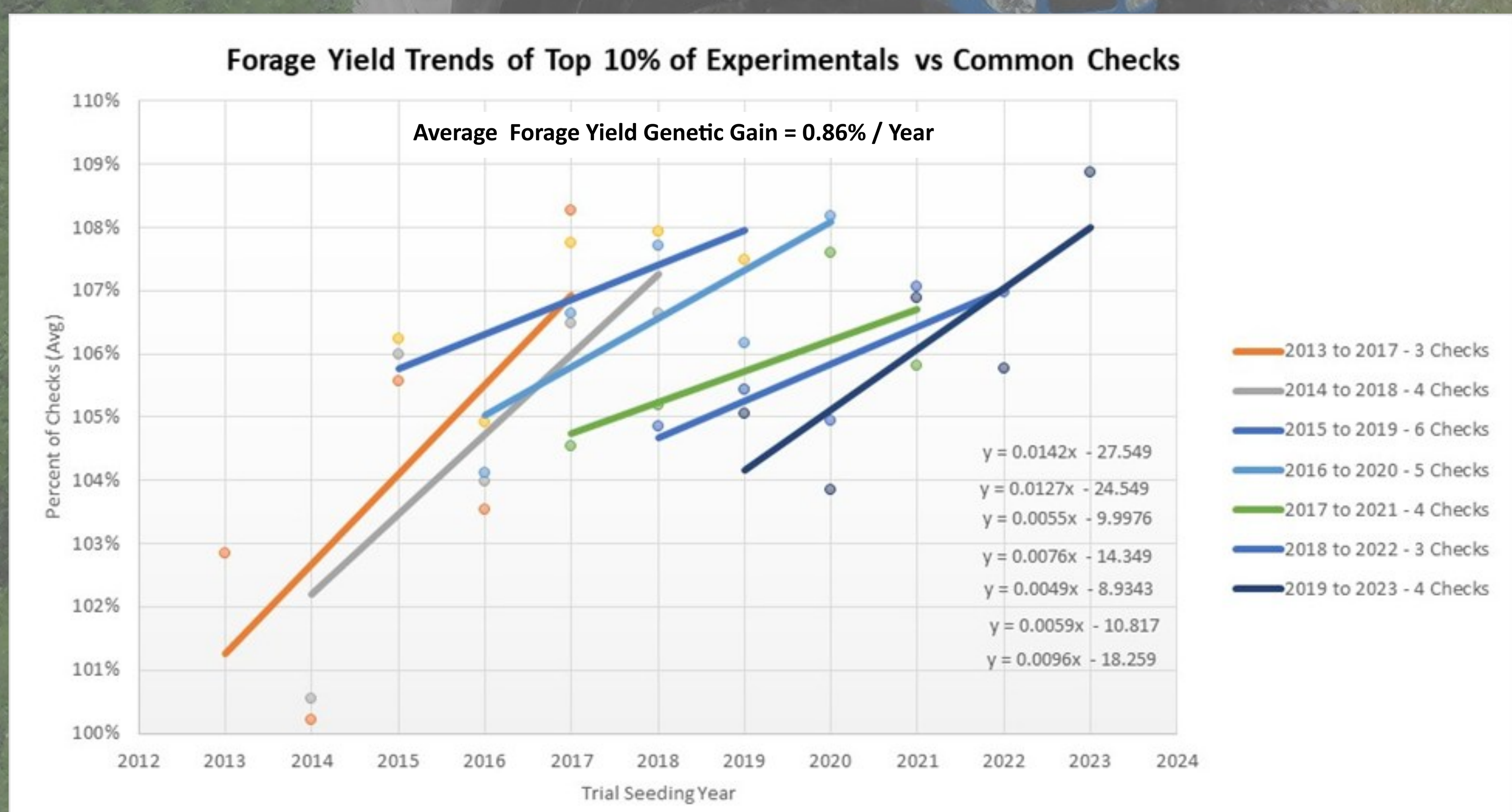

Figure 5

CONCLUSION

- Significant genetic gain for forage yield in alfalfa was demonstrated on a clonal basis independently in seven unique and diverse germplasm pools by utilizing a reciprocal recurrent selection breeding scheme and a progeny testing program for parent evaluation.
- Significant genetic gain for forage yield in alfalfa was also demonstrated on a varietal basis by utilizing clones as parents that were identified in the reciprocal recurrent selection breeding scheme and progeny testing program.
- A robust progeny testing program which identifies clonal general combining ability and exploits heterosis among pools of elite and diverse alfalfa germplasm is driving genetic gain for forage yield in alfalfa.