# Combining abilities and heterosis for biomass yield and quality related traits in single-cut forage sorghum adapted to temperate climates

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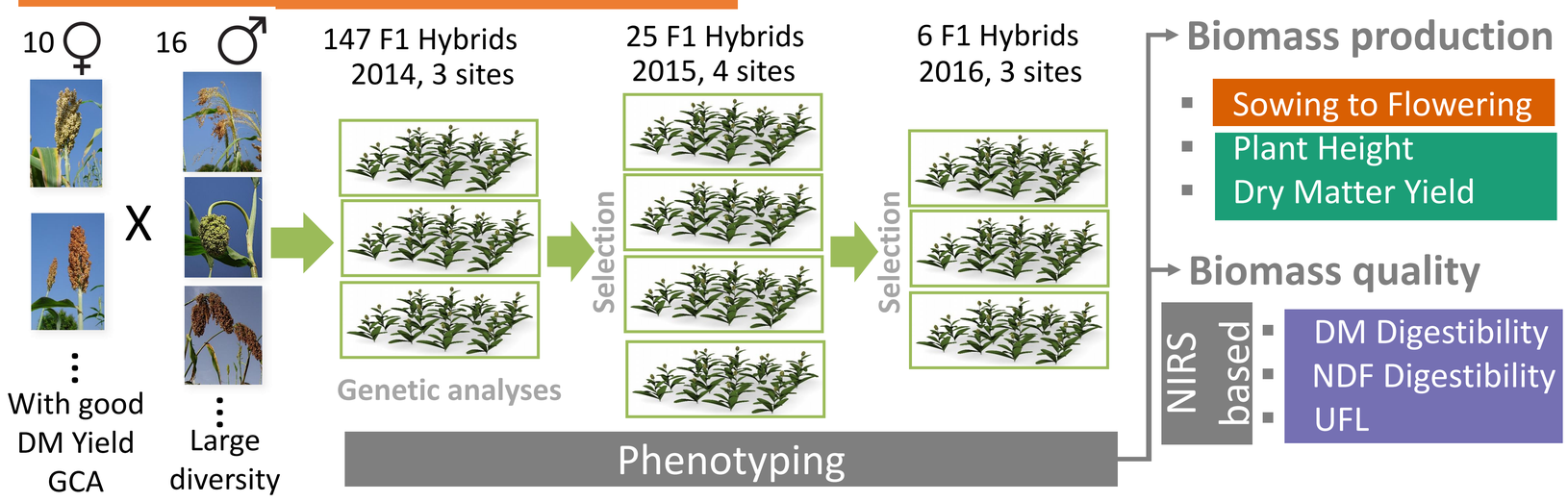
## Challenges and Objectives

The development of varieties fitting the expectations of the biomass value chains including animal feed, energy and fiber-based products requires a better understanding of the genetic determinism of the traits contributing to the targeted ideotypes. In this context, the objectives of this study were to estimate the general and specific combining abilities of biomass production and quality related traits, explore their correlations, assess the heterosis levels achieved and allow the identification of the most relevant hybrids for the animal feed market segment.

## Materials and Methods




## F1 Hybrids and parental values

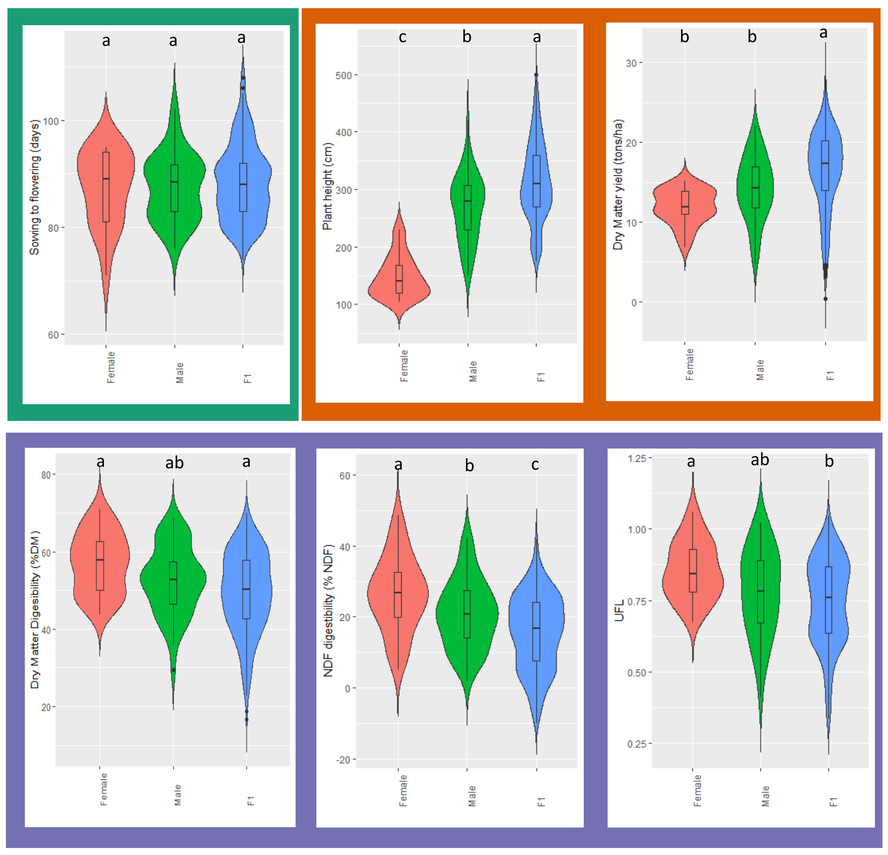



Figure 1: Variability of the 26 parental lines and 147 F1 hybrids based on the three trials established in 2014

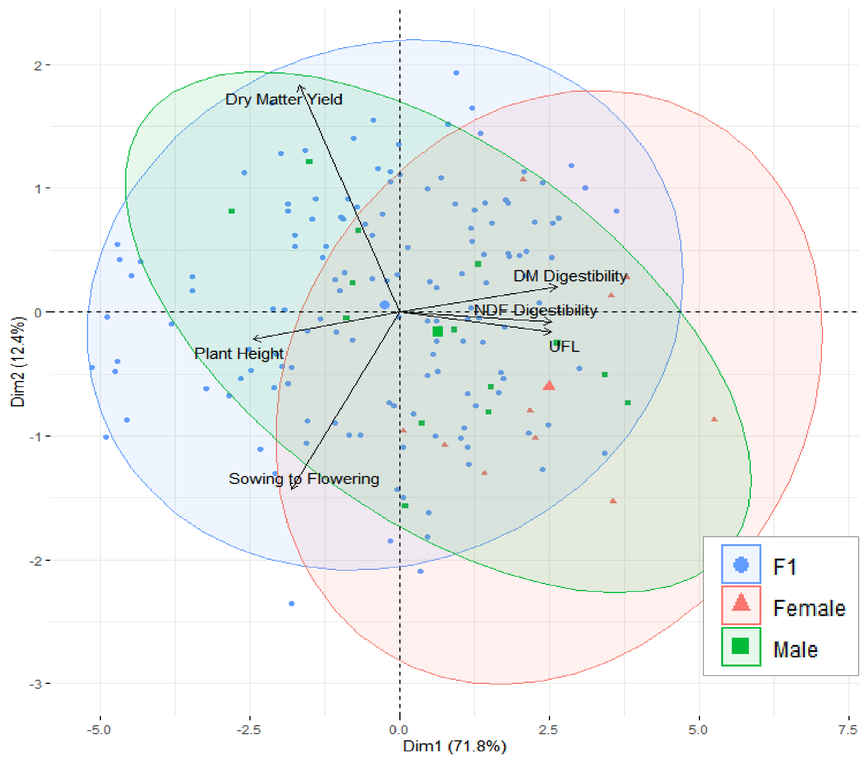



Figure 2: Principal Component Analysis of the genetic values (blup) of the 26 parental lines and 147 F1 hybrids based on the three trials established in 2014

- Hybrid's plant height and Dry Matter yield (DM yield) are significantly higher than the male parents (Fig.1).
- Energetic values (UFL) of the hybrids and their DM/NDF digestibility are significantly lower than the female parents (Fig.1)
- At the multitrait level, the male and female parental lines present contrasting diversity structure (Fig.2).
- For the Dry Matter yield related traits, the male lines exhibit twice the variability of the female lines.
- For the forage quality related traits, with the exception of the NDF Digestibility, the male lines exhibit a larger variability than the one available in the female lines (Fig.1 and Fig.2).
- Forage quality traits are positively correlated together (0.76<r<0.92, results not presented) whereas they exhibit negative correlations (-0.41<r<-0.53, results not presented) with the Dry Matter Yield related traits (Fig.2).

## Combining abilities and Best Parent Heterosis

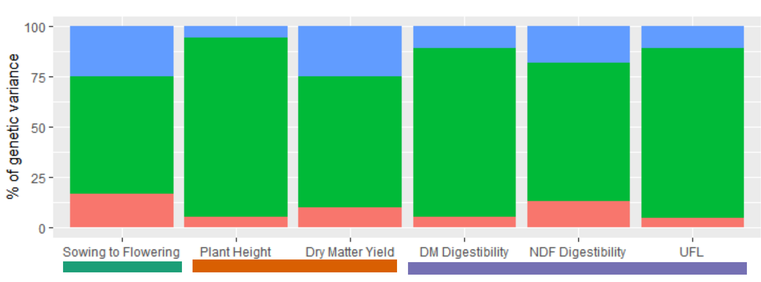



Figure 3: Contributions of GCA (Female and Male) and SCA to the F1 hybrid values

- Male GCA is, in this factorial design, the key component impacting the F1 Hybrid values for all the analyzed traits (*i.e.* Yield and Quality related ones) (Fig.3).
- This result is convergent with the ones obtained by Oliveira et al., 2019 and Zhou et al., 2021.

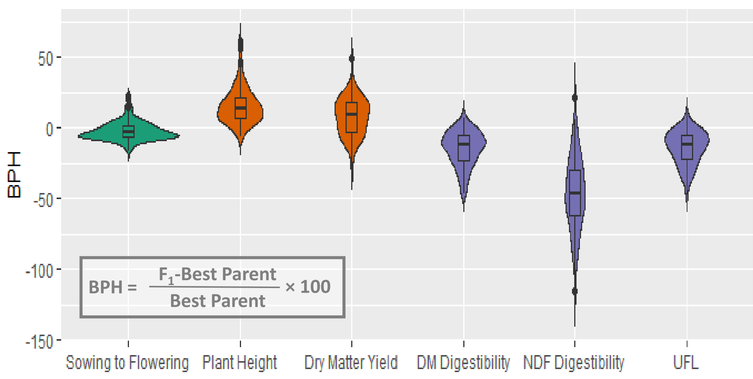



Figure 4: Best Parent Heterosis (BPH)

- Best Parent Heterosis (BPH) values are mainly positive for Plant Height and Dry Matter Yield.
- Mainly negative BPH values are observed for forage quality related traits.
- NDF Digestibility, which is a key component of DM Digestibility and UFL, exhibits the highest negative BPH values(Fig.4).

## Best hybrids performances over 3 years

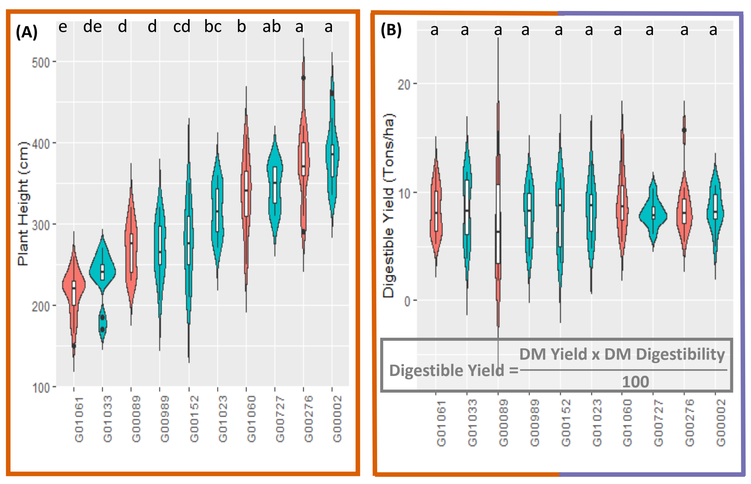



Figure 5: Variability of the 6 best F1 hybrids (turquoise) and of 4 commercial hybrids (red) across 10 sites for Plant Height (A) and Digestible Yield (B)

- The best hybrids compete with the commercial offer (Fig.5B) for Digestible Yield, which provides an integrative measurement of the « useful » dry matter.
- The same performances (Fig.5B) are obtained with the different ideotypes (tall vs medium plant heights) (Fig.5A).

## Conclusion and perspectives

- When a large diversity of male parents is considered, male GCA is the key component impacting F1 Hybrid values for all the analyzed traits. As a consequence, in broad based forage breeding programs, the first target should be the improvement of male forage quality traits.
- Whereas positive heterosis for DM yield is largely exploited to develop new forage varieties, the observation of mainly negative heterosis values for forage quality traits merits further attention, in particular for NDF Digestibility.
- The negative correlations observed between Yield and quality traits and their opposite heterosis values advocate for a better understanding of the genetic determinism of quality related traits (especially in the male pool), in order to maximize the realized digestible yield.

**Bibliography**:

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Zhou F, He S, Wang ML, *et al.* 2021. Correlation and combining ability of main chemical components in sorghum stems and leaves using cytoplasmic male sterile lines for improving biomass feedstocks. *Industrial Crops and Products* 167: 113552.

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