Exploring the biochemical and histological diversity in the GCP BCNAM parental lines : Towards a high resolution mapping of genomic regions affecting biomass quality

Korotimi Théra[1], Niaba Témé[1], Michel Vaksmann[2], Diarah Guindo[1], Mamoutou Kouressy[1], Mohamed Doumbia[1], Mohamed Lamine Tékété[1], Baptiste Guitton[3], Jean-François Rami[1], Sidi B. Coulibaly[1], Laurent Bonnal[2], Florian Larue[2] , Jean-Luc Verdeil[2] , David Pot[2]

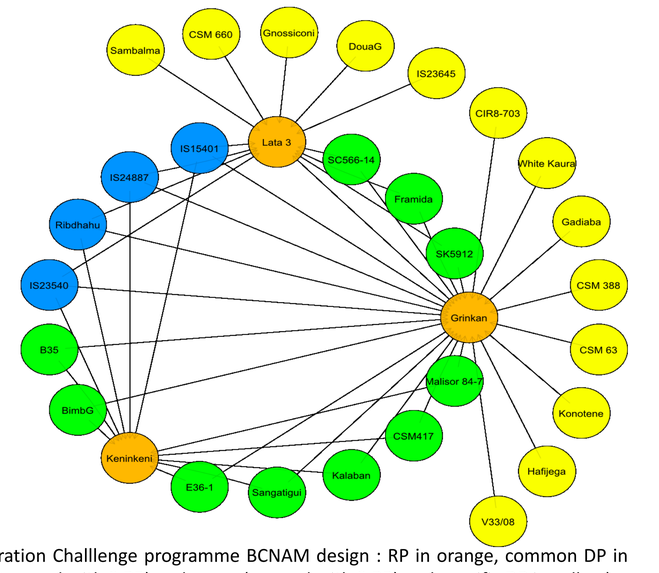
[1] *Institut d'Economie Rurale du Mali (IER), BP:258, Rue Mohamed V, Bamako, Mali*

[2] *Cirad , UMR AGAP, Av. Agropolis 34398 Montpellier cedex5 France*

[3] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP: 320, Bamako, Mali

The development of multi-purpose sorghum varieties suitable not only for food, but also for feed and other applications became a priority for most of the breeding programs. However, a better understanding of the genetic determinism of stover quality is required. A BCNAM design involving 3 recurrent parents (RP) and 29 donor parents (DP) has been developed in order to provide the sorghum community with a high resolution mapping design and a relevant breeding scheme towards the development of varieties suitable for the soudano sahelian region. The aim of this study was to characterize the parental lines of a BCNAM multiparental design for their main stem composition and histological properties in order to:

- Assess the relevance of this genetic design to reach a better understanding of the genetic bases of these traits
- Evaluate the effect of the sowing dates, and height diversity on the biochemical composition of the stems
- Have a first image of the relationships between stem histological and biochemical traits

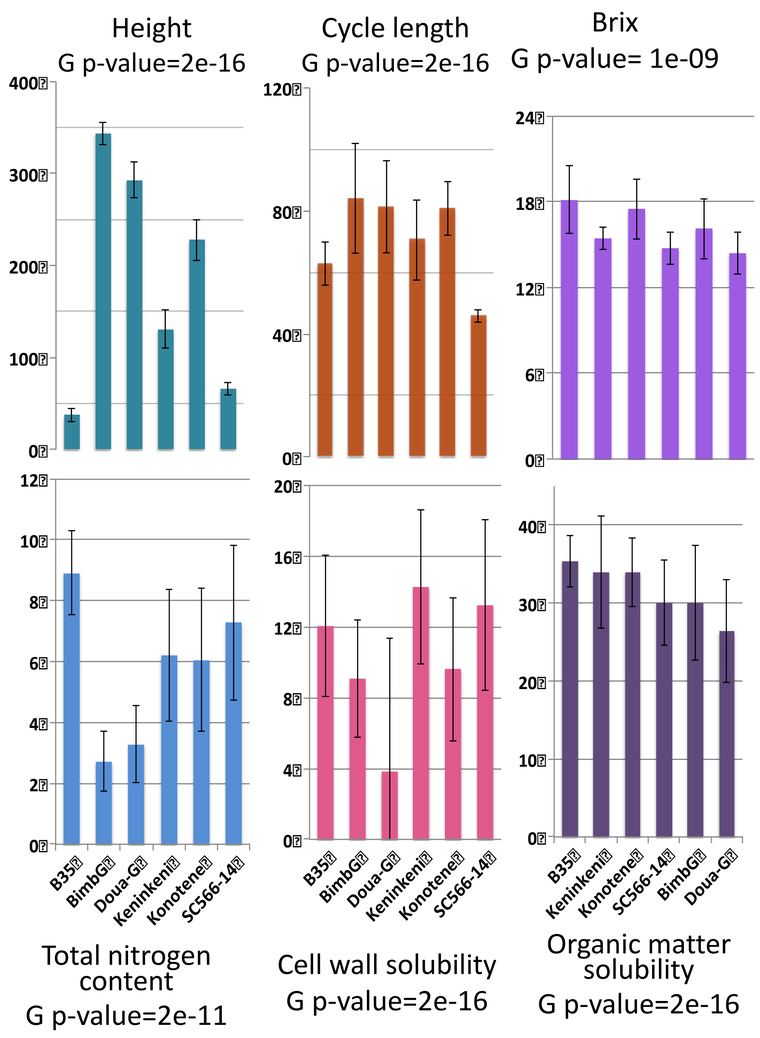


Generation Challlenge programme BCNAM design : RP in orange, common DP in blue (crossed with 2 RP) and green (crossed with 3 RP) and specific DP in yellow)

Methods

Thirty three parental lines were characterized in 2014 in a split-plot design combining the genetic effects and sowing dates (June 16th and July 16th) in Sotuba (Mali). Agromorphological traits, sugar content (BRIX) and stem biochemical composition were assessed at the grain physiological maturity. Histological traits were evaluated only for a subset of 22 parents for the second sowing date.

1 Strong genetic effects on biomass production, stem biochemical composition and histological traits



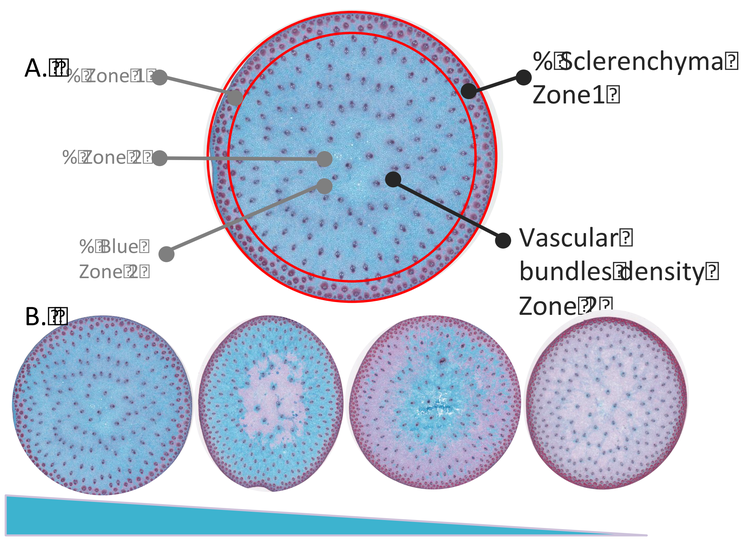
Total nitrogen content
G p-value=2e-11

Cell wall solubility
G p-value=2e-16

Organic matter solubility
G p-value=2e-16

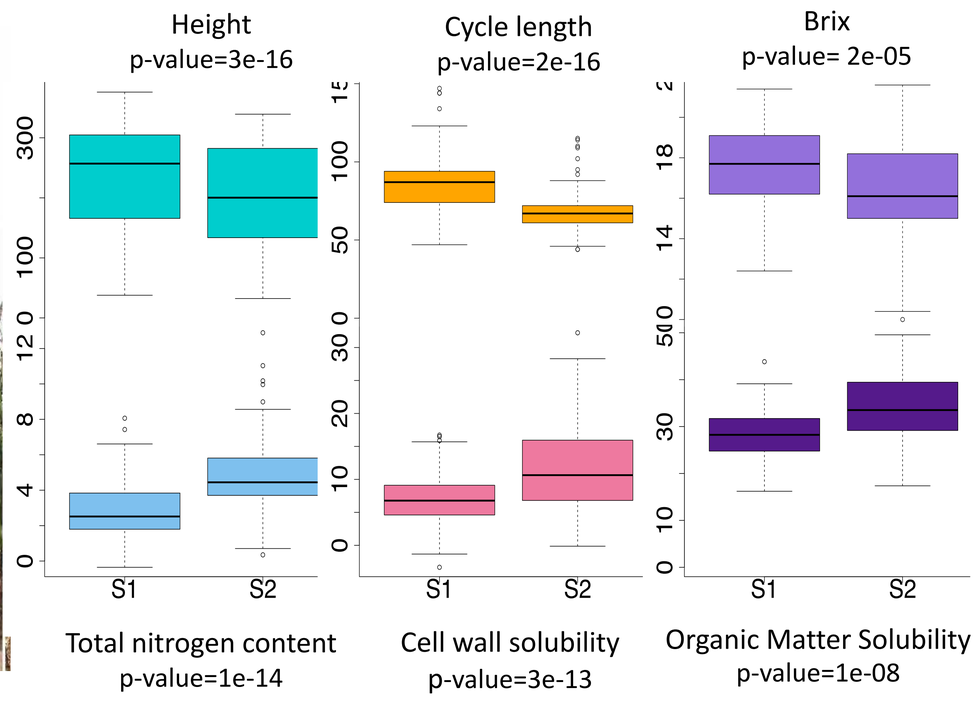
Significant genetic effects were detected for the biomass production traits (height and cycle length). Strong genetic effects were also observed for the biomass composition related traits. The graphics illustrate for 6 traits and 6 parental lines, encompassing different photoperiod sensitivities, their genetic variability. These results combined with the phenotypic variations observed (average coefficient of variation of 34% for growth related traits and 40% for biomass composition related traits) suggest that important genetic gains can be obtain for biomass production and composition.

Tissue proportions of the internodes and their « potential » biochemical composition vary among parental lines. A: Grey traits present genetic effects with a p-value lower than 0.05 and black traits present genetic effects with a p-value lower than 0.005 B: Variability observed between 4 parental lines for the percentage of blue in the zone 2 (mainly related to the polysaccharide content of the cell wall).



2 Sowing date impacts biomass yield and quality

Sowing1 Sowing2



The yield, and quality related traits are significantly impacted by the sowing date (S1 vs S2). Biomass production (cycle length and plant height) and the sugar content (Brix) significantly decreased when sowing was delayed. Opposite trends, leading to an improvement of biomass quality, were observed for the 3 key biomass composition related traits presented above.

3 Simultaneous selection of biomass yield and quality is possible

Weak correlations between plant height (HTIG) and quality related traits suggest the possibility of concomitant selection for yield and quality.

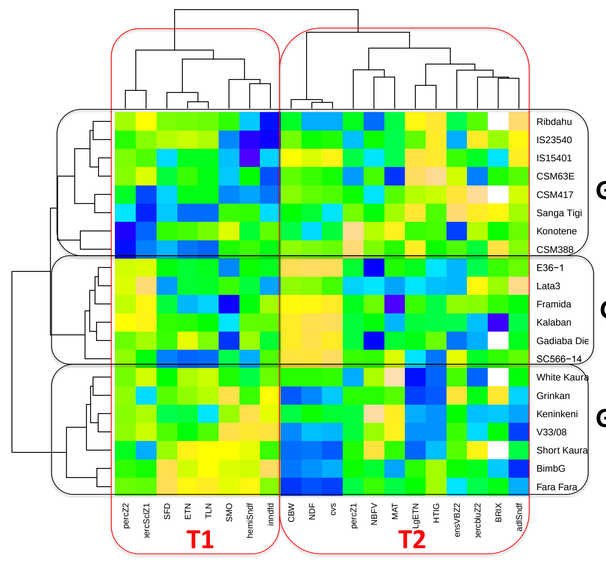
The medium to high correlations observed between cycle length and quality related traits like fiber content (NDF) and Organic Matter solubility (SMO) indicate that the phenology has to be considered during the selection process

Traits	SFD	HTIG
HTIG	0,525	
BRIX	-0,143	0,215
NDF	-0,573	-0,138
SMO	0,432	-0,047
adlSndf	-0,169	0,399
inndfd	0,206	-0,334
percZ1	-0,133	0,114
densVBZ2	-0,355	-0,094

Traits	BRIX	NDF	SMO	adlSndf	inndfd	percZ1
NDF	-0,225					
SMO	0,087	-0,908				
adlSndf	0,467	0,311	-0,417			
inndfd	-0,382	-0,496	0,590	-0,888		
percZ1	0,343	-0,238	0,199	0,244	-0,120	
densVBZ2	0,430	0,070	-0,095	0,041	-0,142	-0,373

Green: strong positive correlation, Yellow: weak correlation
blue: strong negative correlation

Correlations between biomass quality related traits. The solubility of the cell walls (inndfd) is strongly negatively correlated to the lignin content (adlSndf). With the exception of the BRIX wich presents positive correlations with the vascular bundles density and the percentage of Zone1, only weak correlations have been observed between histological and biochemical traits.



Clustering analysis based on the yield and quality related traits for the 22 parental lines identified two groups of traits. The first one (T1) includes traits related to cycle length, cell wall solubility and percentage of lignified tissues. The second one (T2) encompass traits related to the content of the biomass in fibers, the plant height, the BRIX and the vascular bundles density.

In terms of varieties, the clustering analysis allowed the identification of three main groups characterized by : photoperiod sensitive tall varieties (G1), slightly photoperiod sensitive medium size varieties (G2) and slightly photoperiod sensitive tall varieties (G3)

GCP BCNAM design : merging genetic analysis and breeding towards multi-prurpose sorghum

A large genetic diversity in terms of biomass production, stem biochemical and histological quality related traits was observed among the parental lines of the GCP BCNAM design. Sowing date has a very strong effect on the production and composition of biomass. Our results showed the absence of antagonistic correlations between biomass yield and quality related traits which makes possible the simultaneous selection of these traits. This work also highlighted the high relevance of this genetic design to explore the genetic determinism quality related traits which are key players in the context of multi-purpose sorghum breeding.

Acknowledgments: This work is supported by the BIOSORG project funded by the Agropolis (Labex Agro) and Cariplo foundations. Special acknowledgements to the Generation Challenge programme which supports the development of the BCNAM design (GCP BCNAM project).