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SORGHUM, A KEY TO BUILD OUR FUTURE.

cirad agAP INSTITUT
Amélioration génétique et adaptation des plantes méditerranéennes et tropicales

CHALLENGES FOR CROP PHYSIOLOGY AND MODELLING TO SUPPORT SORGHUM BREEDING FOR DROUGHT PRONE ENVIRONMENTS

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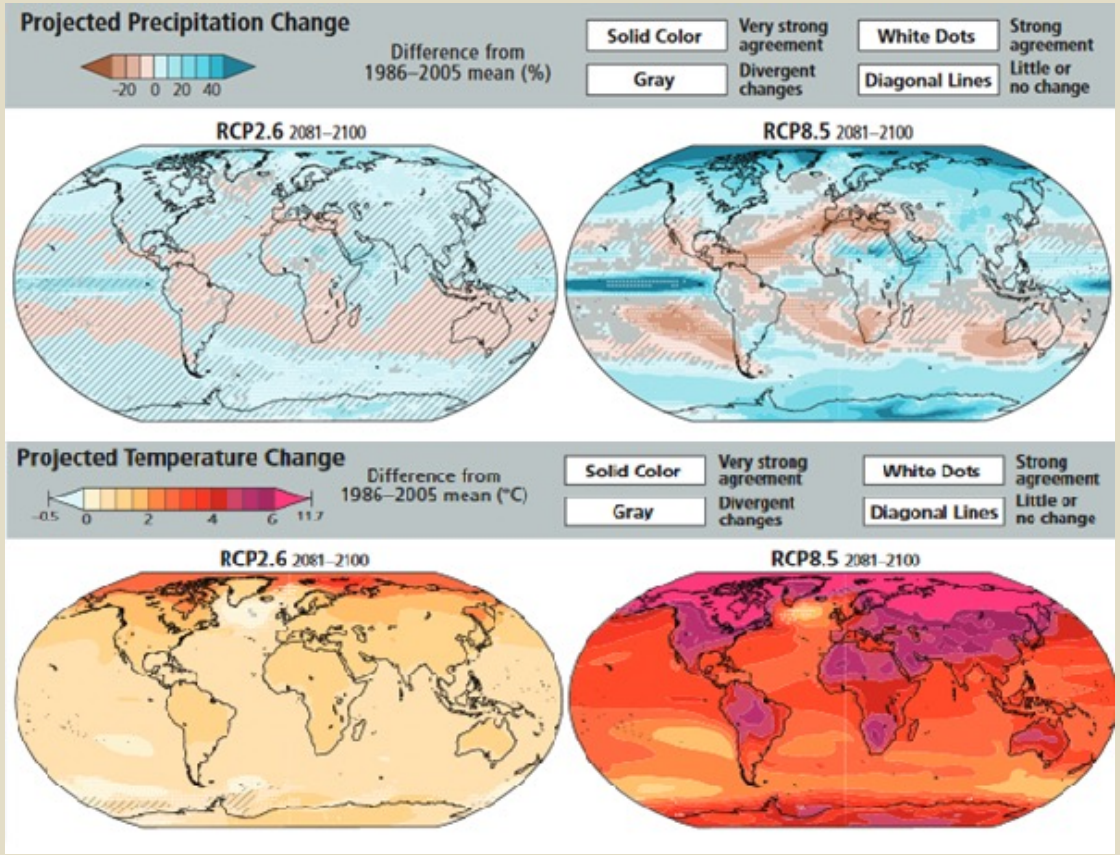
Sorghum in West Africa and Europe

Convergence of challenges for crop physiological researches

- Increasingly frequent, severe drought
- Adaptation to climate change mitigation
- Sorghum a key player
  - Drought tolerance
  - End-use diversification (grain, biomass, C seq.)
  - Agroecological contexts

=> Exploring and understanding the adaptive value of soghum genetic diversity



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Talk structure

1. Multiplicity of ideotypes for multiplicity of drought patterns & demands
2. Why and how crop modelling and physiology can help in a complementary way
3. Model based characterization of drought types for sorghum
4. Which traits to breed for ?
5. Phenotyping challenges
6. Toward model assisted ideotype design?
7. Conclusions

Delphine Luquet

Myriam Adam

Florian Larue

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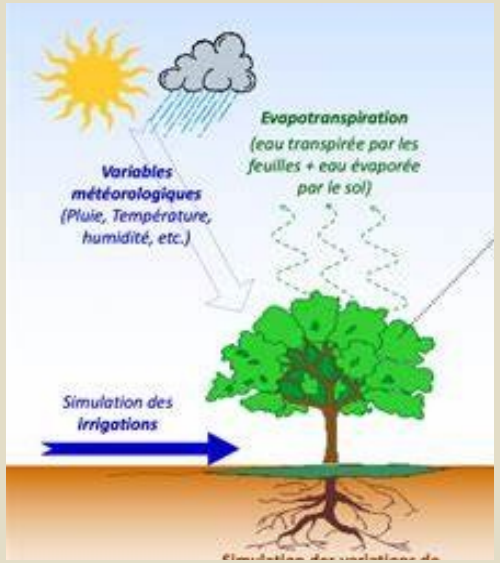
1. Multiplicity of ideotypes for a multiplicity of drought patterns

Convergence of challenges for crop physiological researches

Drought experienced by the crop is the result of interactions between:

- Climate
- Soil (depth, structure…)
- Practices (sowing, input…)
- Genotypes (cycle, architecture, rooting, vigor, water use…)



⇒ **Variability of drought essential to characterize for**

- Identifying adaptive traits of interest for breeding
- Seeking for relevant genetic diversity
- Defining locally ideotypes (no miracle / universal ideotype)

⇒ **Role for crop modelling**

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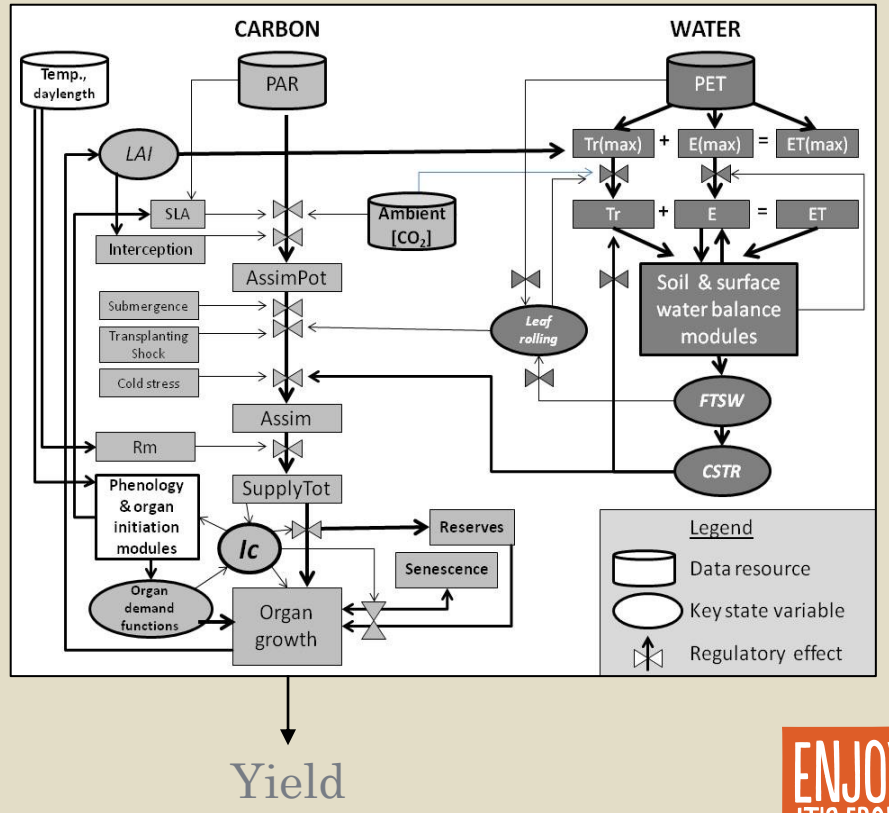
2. Why and how crop modelling and physiology can help

What are crop models ?

- **Knowledge on biological processes & their response to the environment**
- **Dynamics of yield elaboration (biomass, grain..)**
- **Interactions, trade-offs among processes difficult to look at experimentally**
- **Genotype X Environment X Management (GxExM)**
- **Yield & intermediates variables (stress indices: water, N...)**



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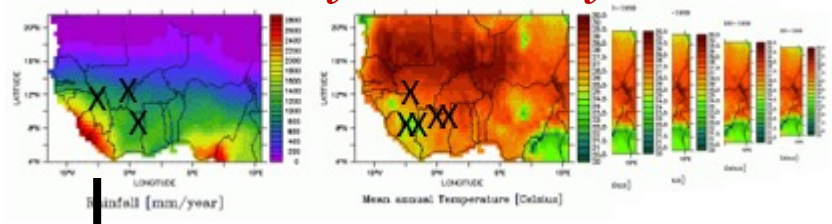
2. Why and how crop modelling and physiology can help

Typology of drought

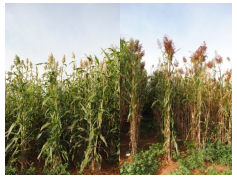
Climate data by site/multi-year

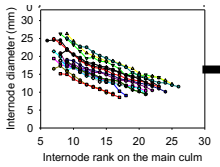


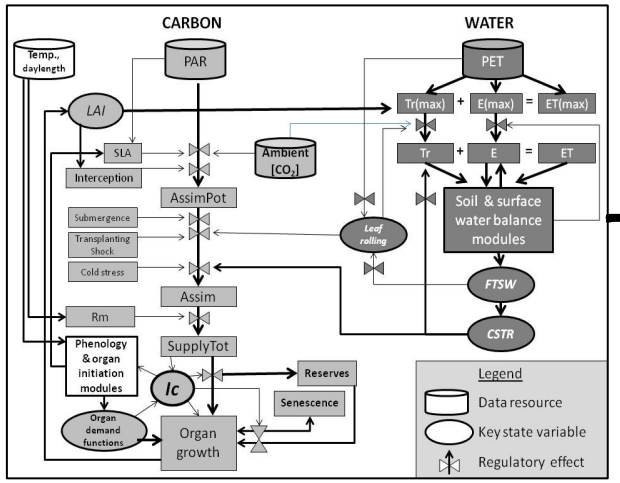
X years

Agro-environments (soils and management)

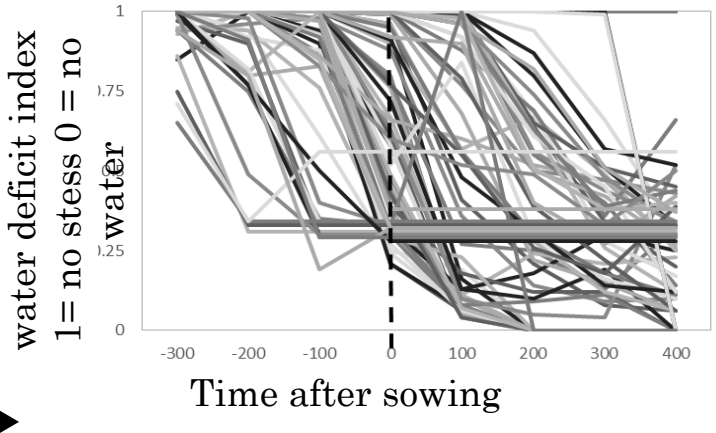
Reference genotype (validated model)



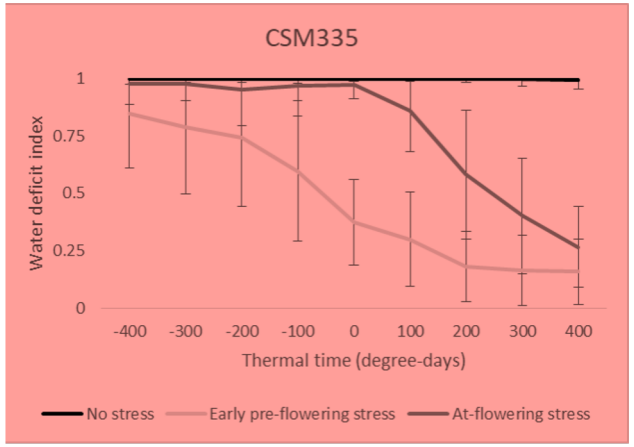




e.g. Simulations of water deficit index in Mali (site X year – 1 genotype)



Clustering of sites (3 stress type groups - TPE)



(Diacoumba 2020)

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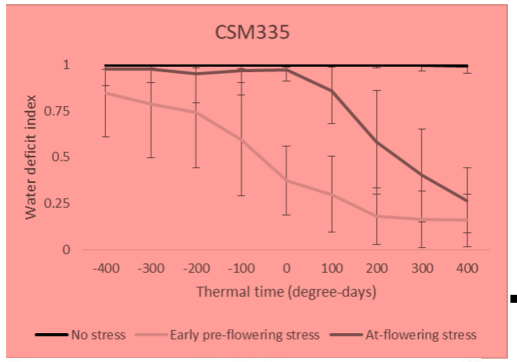
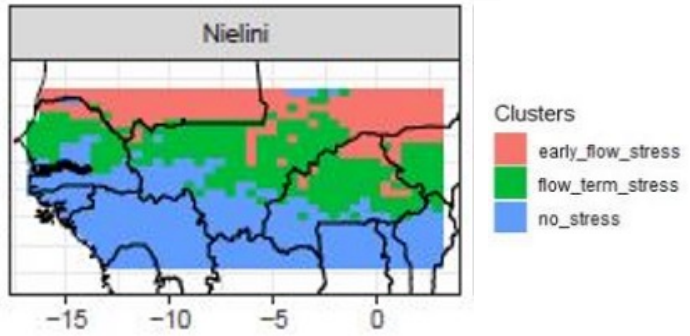
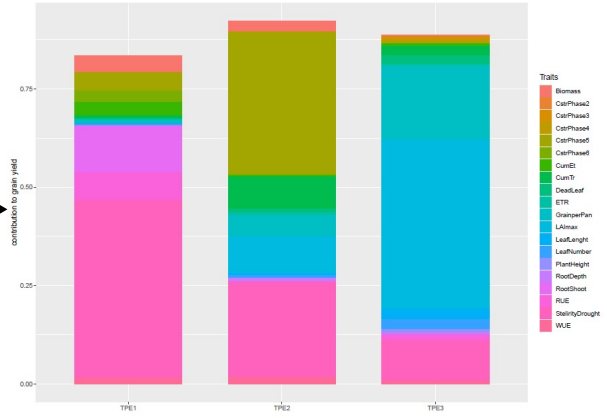
2. Why and how crop modelling and physiology can help
Adaptive trait identification and ideotype exploration

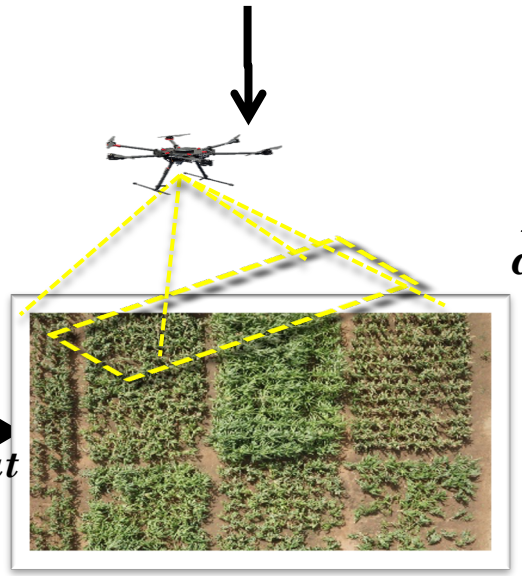
Target population of environments





Model & experiment-based Trait identification

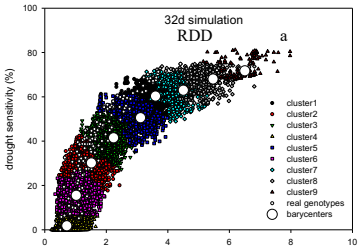


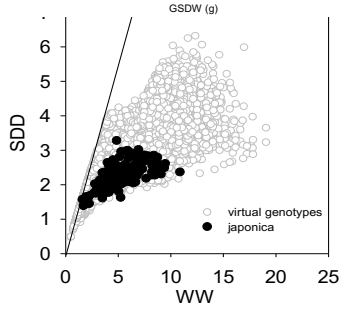


High-throughput phenotyping

Integration of sorghum physiology and diversity in crop models

Model virtual experiments





tillering Plant height

Optimal trait combination

Ideotype

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3. Model based characterization of drought types for sorghum

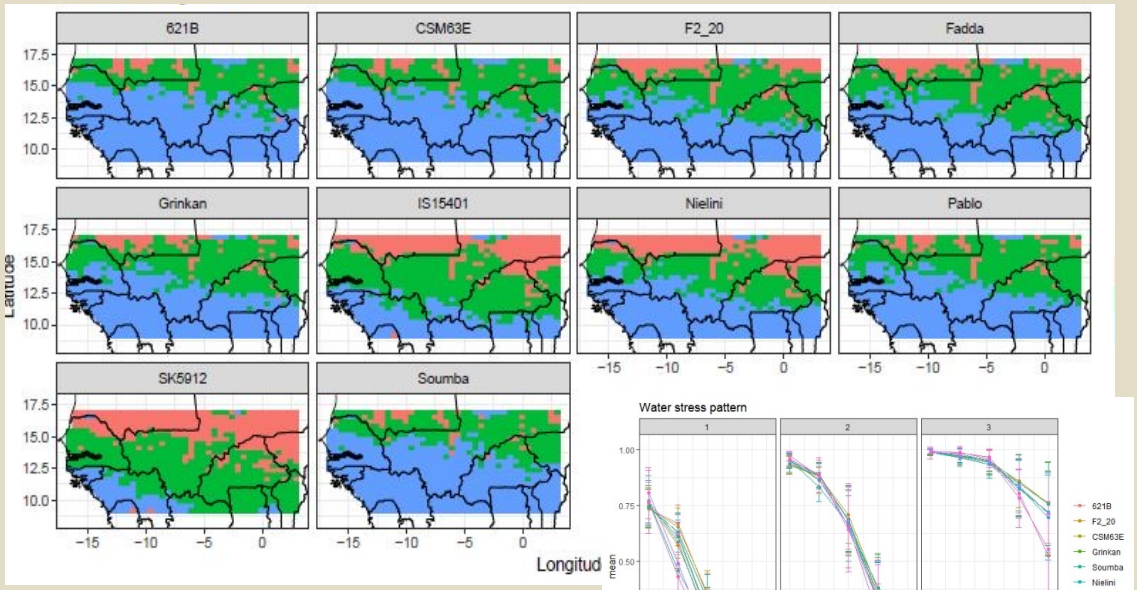
Where are we ? Modeling to guide varietal selection in West Africa

Identification of limiting factors by models according to different management practices (varieties, fertilisation, sowing density…)

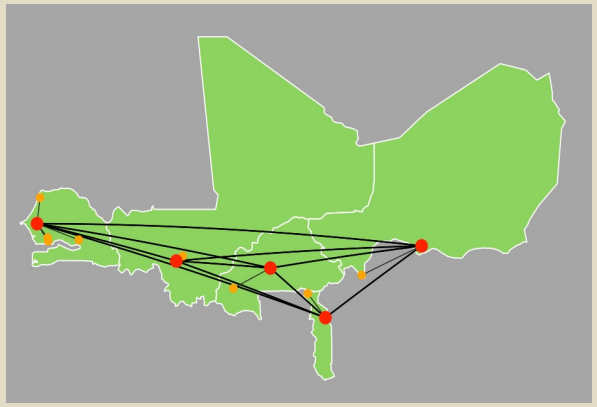
Reflect semi arid zone crop types/ environments/ situation

⇒ **Optimization of crop management**

⇒ **Target traits to guide breeding**



Adam et al. In prep



ABEE project-West Africa
(DeSira EU funding)
Breeding Networks & Extension Empowerment

1. **A network of concerted breeders working together**
2. **Data (field based) & Tools (model) to characterize the diversity of environments and stresses for breeding targets**

→ **Considering drought together with other constraints**
→ **Targeting sorghum & other crops**
→ **Perspective of considering a diversity of cropping systems (intercropping)**

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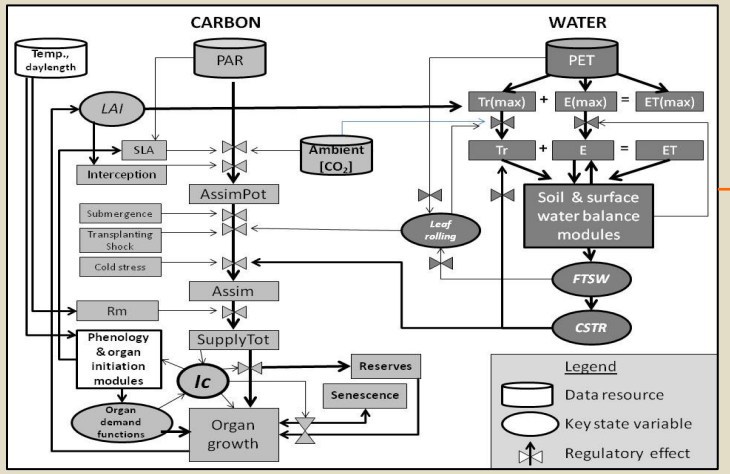
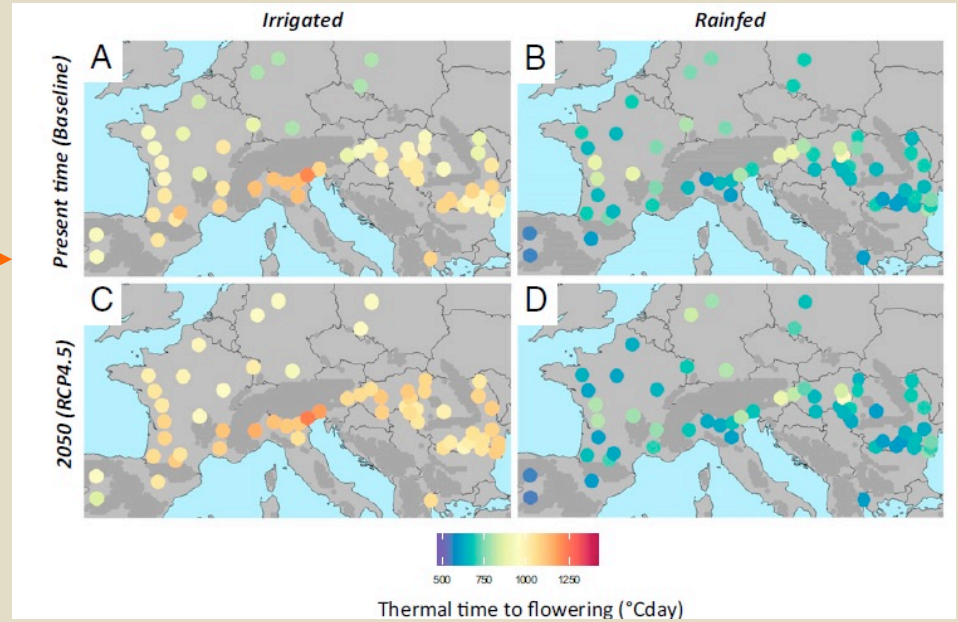
3. Model based characterization of drought types for sorghum

Where we go? Case of European conditions

- **Crop models available for sorghum (INRAE, CIRAD: STICS, SAMARA…)**
- **Data available for EU conditions: Soil & climate data bases, recent field experiments (CIRAD, RAGT, Euralis)**
- **Time and money is missing: project context, postdoc?**





Parent et al. 2018, PNAS

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4. Which traits to breed for ?

Challenges to be tackled

- End-use diversification: biomass, grain quantity & quality & their regulation (drought, climate)
- Adaptation to droughts: e.g. rooting, stay-green… & related stresses (heat!)
- & Adaptation to novel practices (agroecology, intercropping…)

⇒ True for European and West African contexts

⇒ Provide geneticists / breeders with 'packages of traits' for multicriteria approaches

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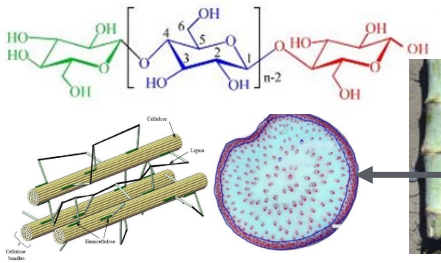
4. Which traits to breed for ?
e.g. of biomass sorghum

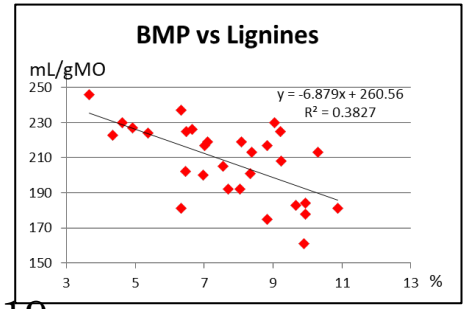
BFF (ANR): public / private, France, INRAE coord.
Biosorg (Agropolis / cariplo): French/Italian /W. African. CIRAD coord.

1. Link physiology to end-uses & production



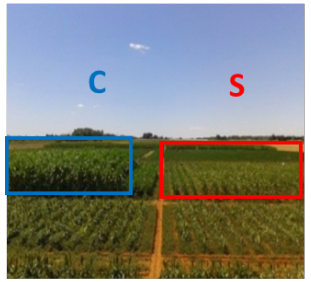
- Digestibility
- BMP (Methane)
- Elasticity...

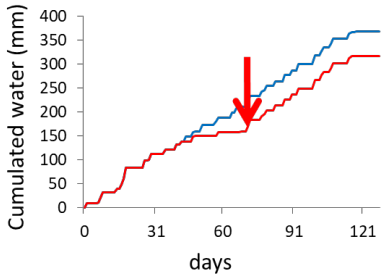
Biochemistry
Histology
Morphology...



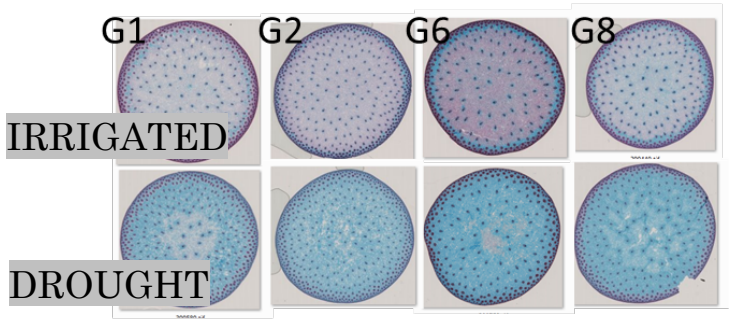
e.g. Thomas et al 2019

2. Understand Genotype & Environment (drought) variability





Few contrasted genotypes & water treatments



Internode cross-sections

Perrier et al. 2017, Luquet et al. 2019

3. Orient Phenotyping: cf. new tools at CIRAD (NIRS, histology)
4. Crop model improvement and use to explore ideotypes

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SELMET

PHIV

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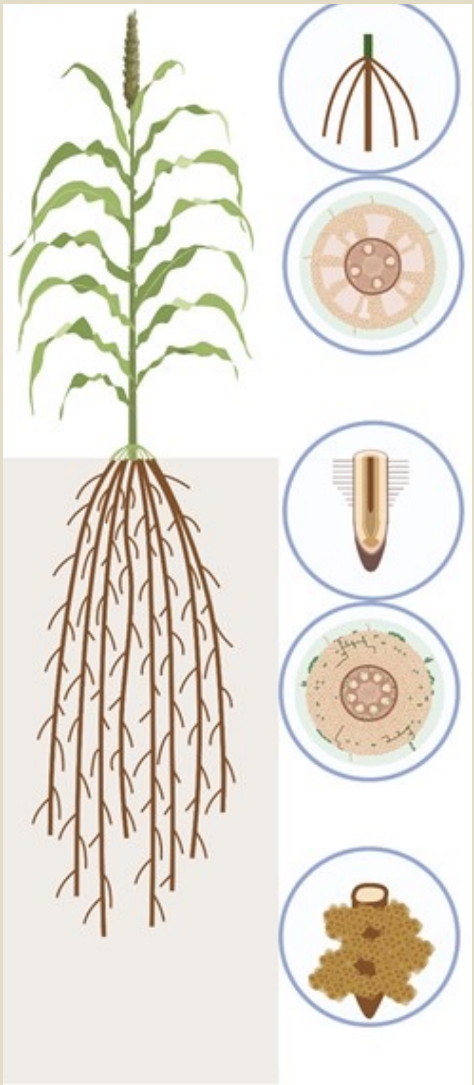
4. Which traits to breed for ?
e.g. root traits

HORIZON EU CL6-2021-BIODIV-01-13: breeding for resilience – focus on root-based traits

New avenues for plant breeding based on root and rhizosphere traits to create new robust cereal crop varieties (resource use efficiency, stresses, soil C…)



1. **Look at root architecture, microbiome interactions & impact on crop production & C seq.**
2. **Using modelling and field trials**
2. **genetic of traits & genomic selection models**
3. **Focus on Europe and West Africa**

⇒ **Partners:**

- ⇒ **IRD, CIRAD, INRAE (France)**
- ⇒ **AIT, CREA, ETH, FJZ, ILVO, ISRA, KU, UCLouvain, UniBo, Unott, UFZ, WUR**

⇒ **Private partners:**

- ⇒ **Eurosorgho, KWS, RAGT, LIDEA**

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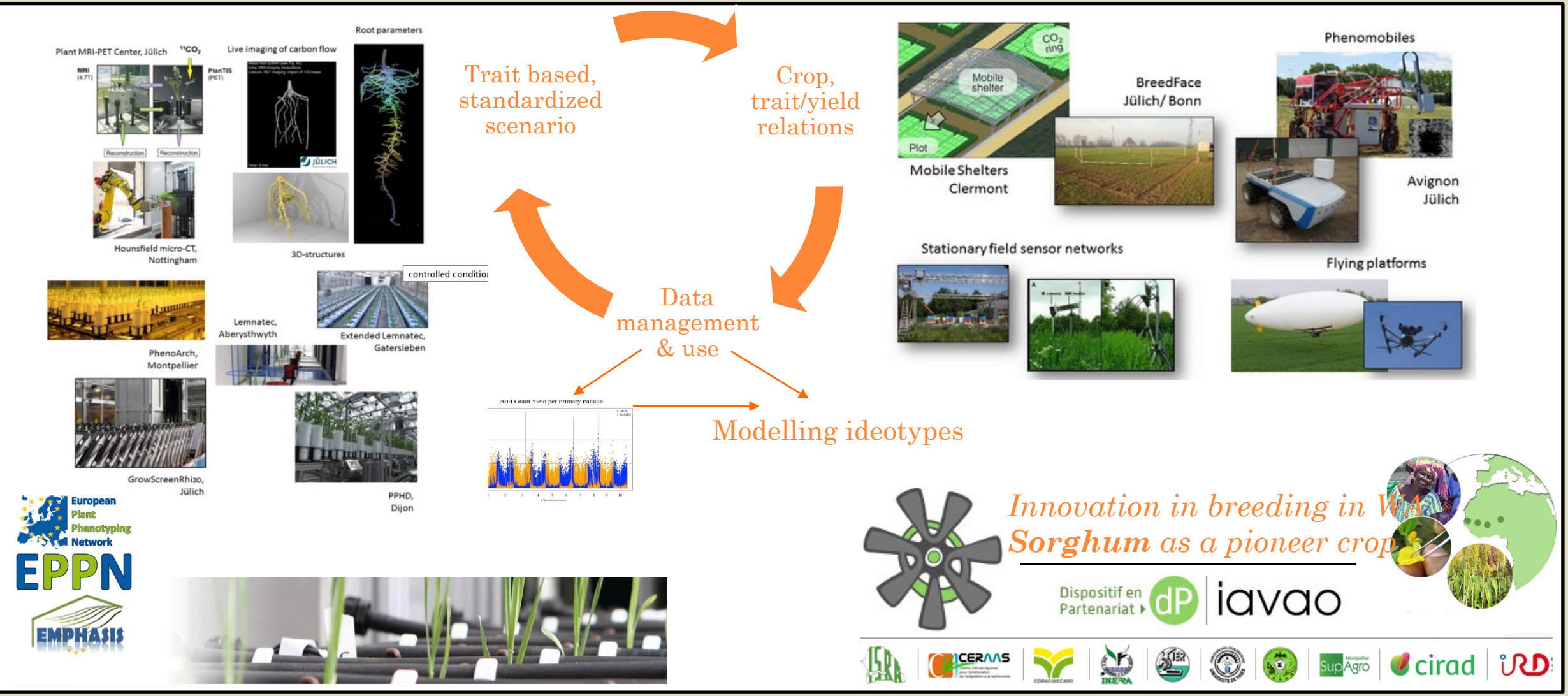
5. Phenotyping challenges

3RD EUROPEAN SORGHUM CONGRESS



European Plant Phenotyping Network
EPPN
EMPHASIS

Innovation in breeding in W
***Sorghum** as a pioneer crop*

Dispositif en Partenariat
dP | iavao

CERAAS · CORAF/WECARD · INERA · SupAgro · cirad · IRD

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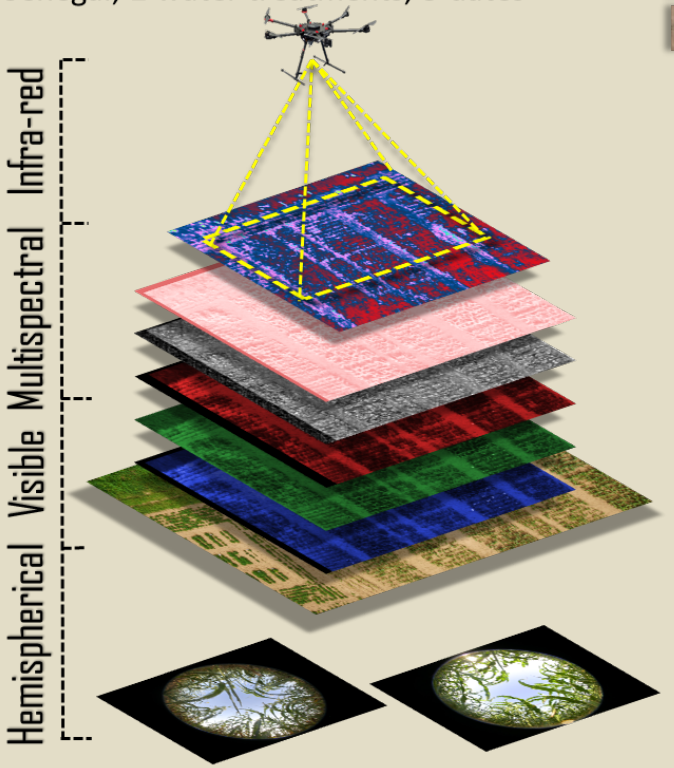
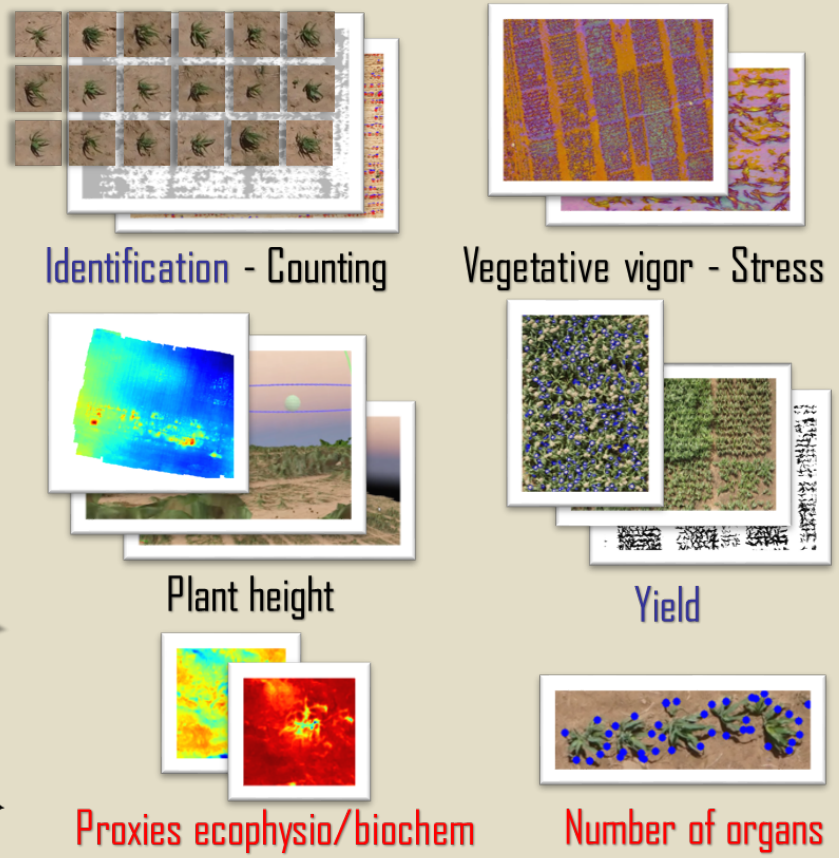
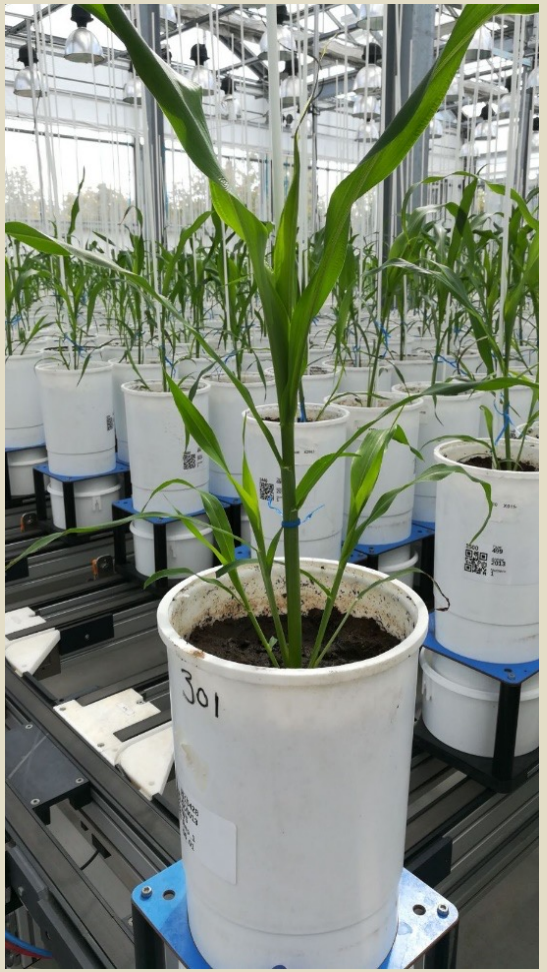
5. Phenotyping challenges
e.g. SGT project

SGT Project 2016-2019
300 accessions of african sorghum
Sénégal, 2 water treatments, 5 dates







Gano et al. 2021 Agronomy

Larue (2021)

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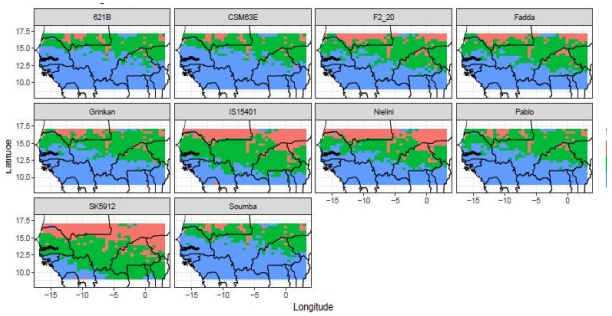
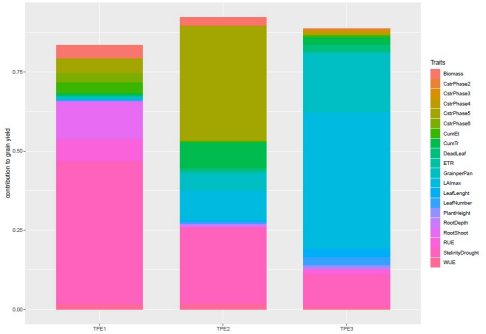
6. Toward model assisted ideotype design

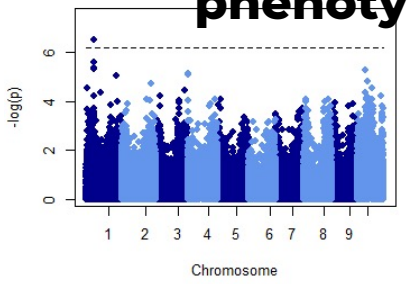
Drought types



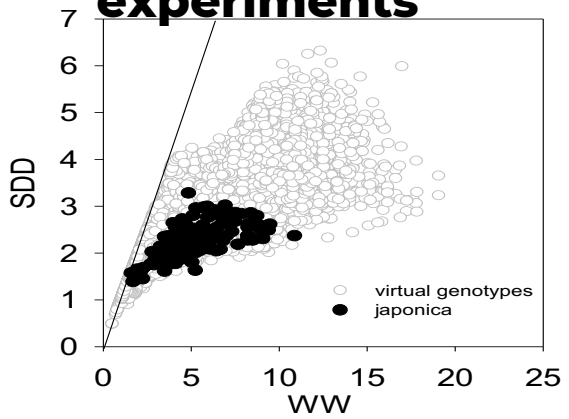
Identified traits

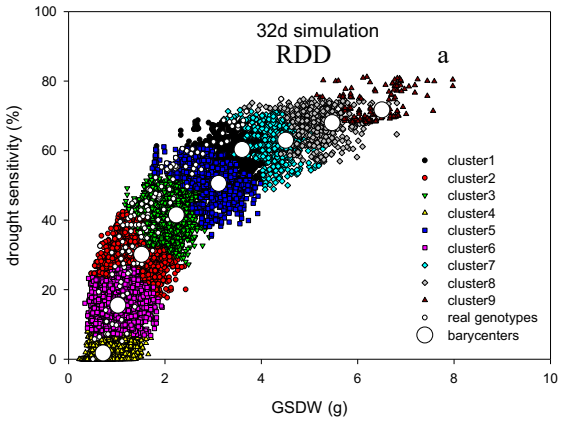


Genotype to phenotype



Model virtual experiments





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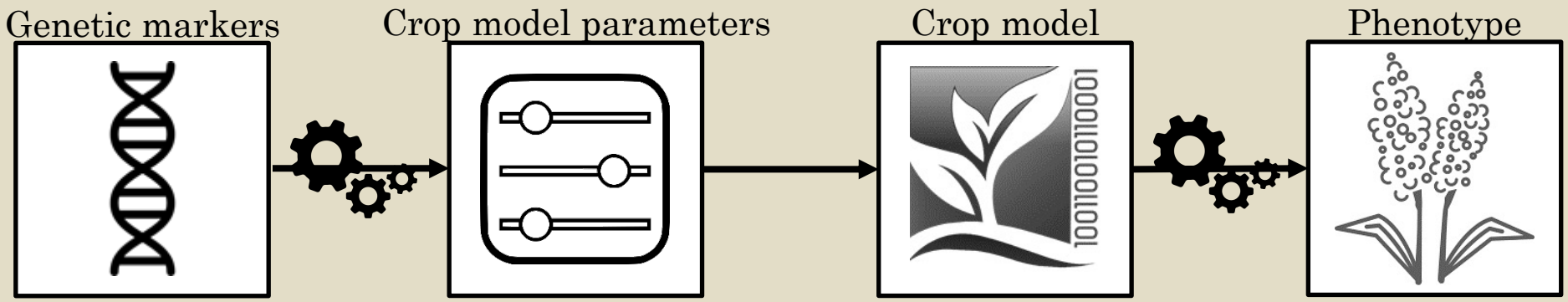
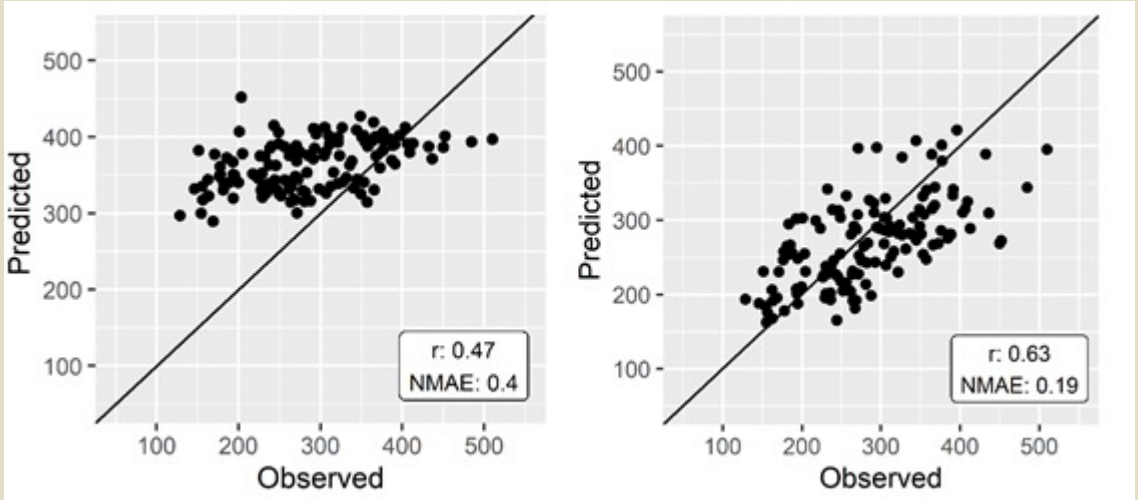
6. Toward model assisted ideotype design

integrating genetics into crop models



Bayes C **Crop model – Genomic Prediction**



Larue et al. in prep

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Conclusion

Drought is multiple, ideotypes are multiple

Sorghum end-use diversification: adaptive traits, quality traits (biomass, grain)

Breed for new traits adapted to changing contexts (agroecology, climate) (eg. rooting…)

Design and combine novel phenotyping tools (NIRS, drone based…)

Crop modelling as an integrative tool to design ideotypes

Develop collaborations: complementarity of expertises to valorise sorghum diversity

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