SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

How do drought related traits interact with major agronomic traits in Sorghum?

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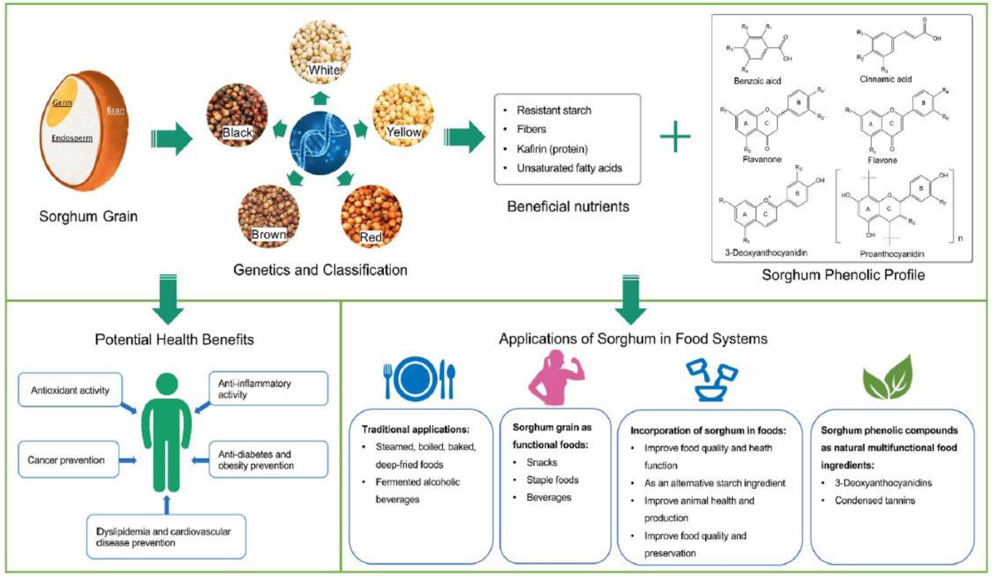
Outlines

- Background
- Genotype by enviroment interaction
- Genetic divetsity of sorghum
- Root system arcticture
- GWAS
- Physilogical and transcriptomics respose of sorghum
- Conclusion and recommendations

INTRODUCTION

Sorghum

- ❖ Grass family
- ❖ Diploid, self pollinated
- ❖ Fifth most important crop
- ❖ Food, feed and fuel



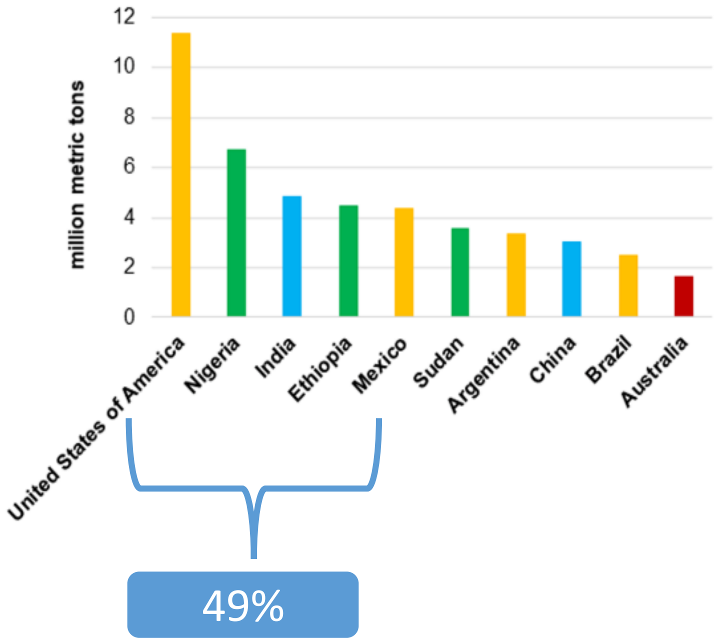
Introduction

- Why sorghum?
- Avital food security crop
  - High adaptability → (Borrell *et al.*, 2021)
  - Drought tolerance
  - Low input requirements, and
  - High nutritional value

- It has various interesting characteristics
  - C4 photosynthesis pathway
  - Bioenergy
  - A relatively small genome

Introduction...

- Global production was 61.4 MMT (FAOSTAT, 2021)



- Ethiopia is the fourth largest producer

17%

  - Utilized in the preparation of many traditional foods

- However, the productivity of sorghum is low due to several factors

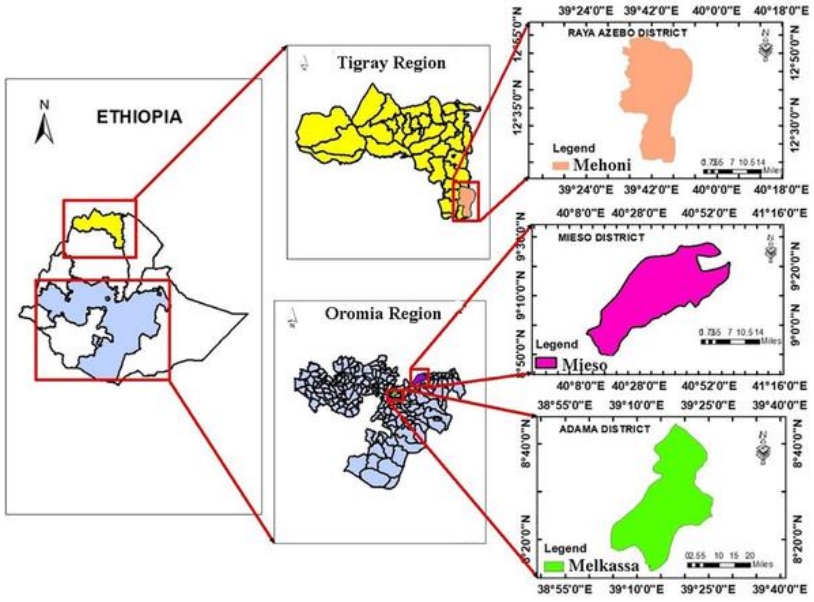
- Even though sorghum is a drought-tolerant crop, its production is still affected by drought stress

Genotype by enviroment interaction

- 324 Sorghum genotypes

  Argiti, ESH4 and
  Melkam and B35

- Three enviroments



- **Phenotype data**
  - ➢ DTF, PALH, PAWD, PH, PAWT and GY
  - ➢ CHLF, CHLM, GLN, FLA, SG, PAE and PDL

Data analysis

R & RStudio

Genstat

META-R

MEGA

High genetic variation in sorghum

- High variability were observed in sorghum genotypes for drought, yield and agronomic traits

- DTF, PALH, PAWD, PH and CHL, SG → **G**
- GY, PAWT, FLA, PDL and PE → **E and G×E**

- Therefore, MET is needed for taking care of G × E interaction

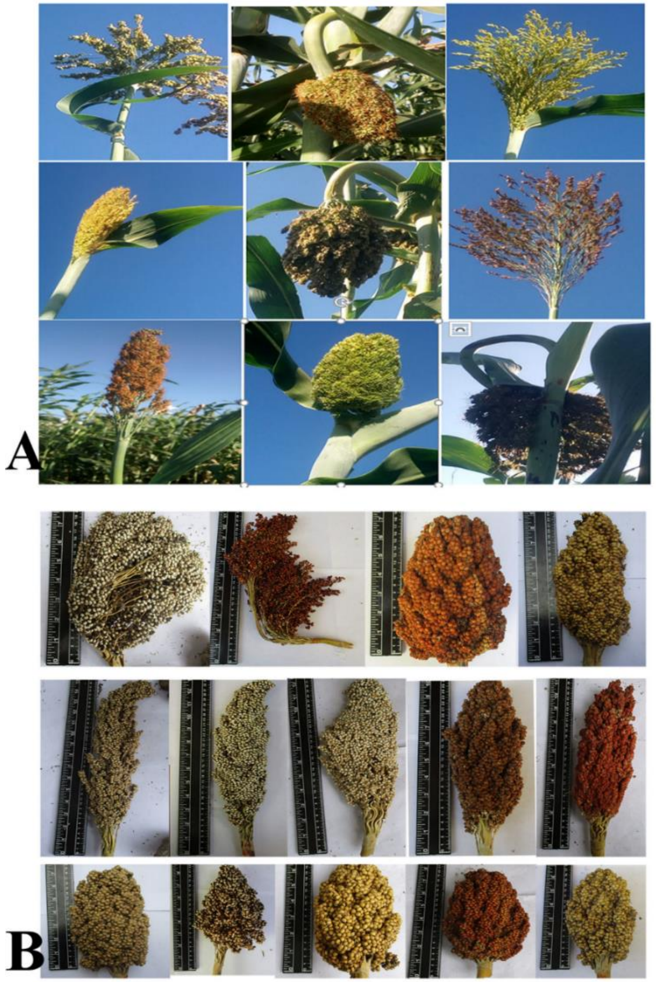
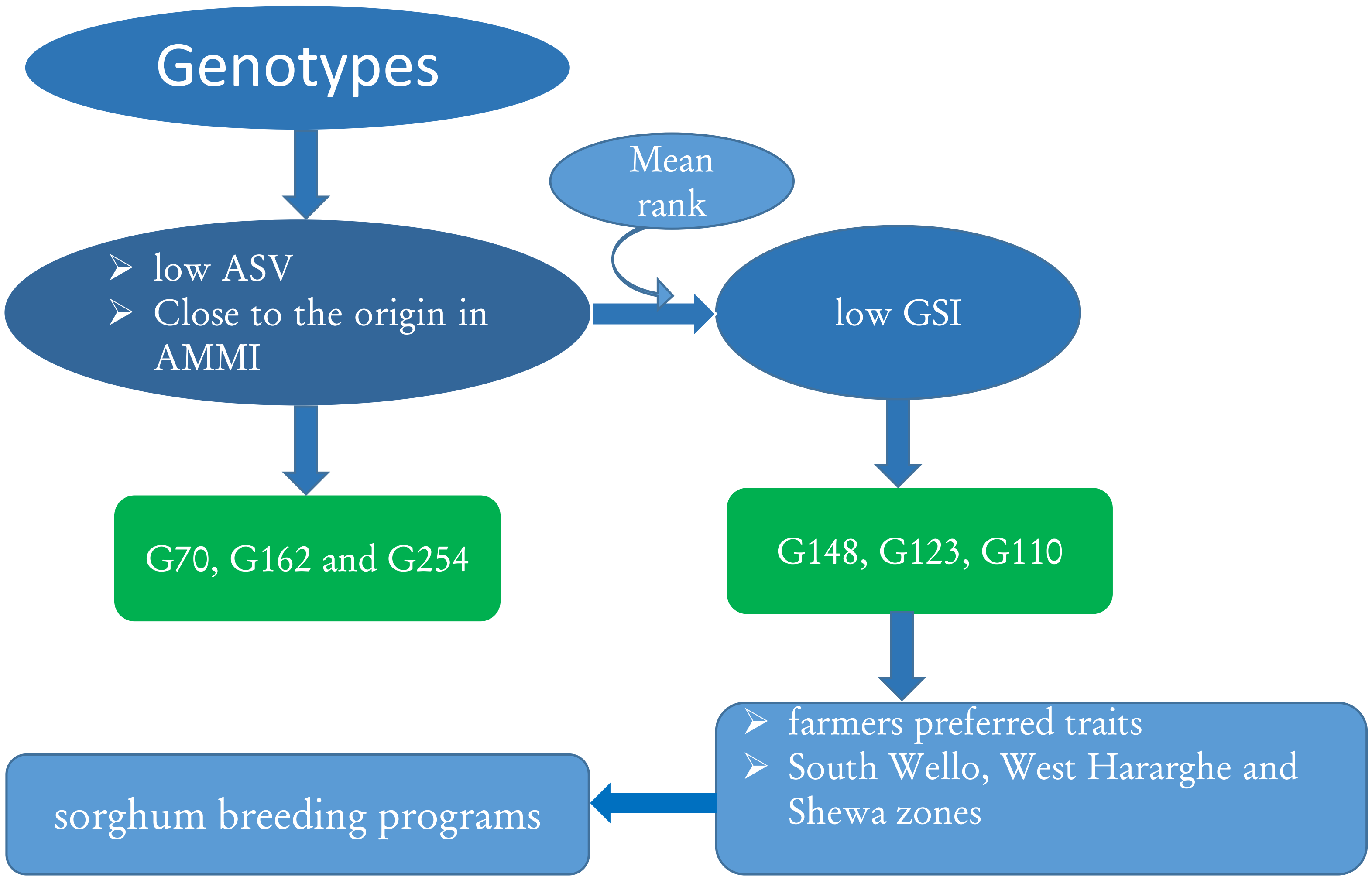
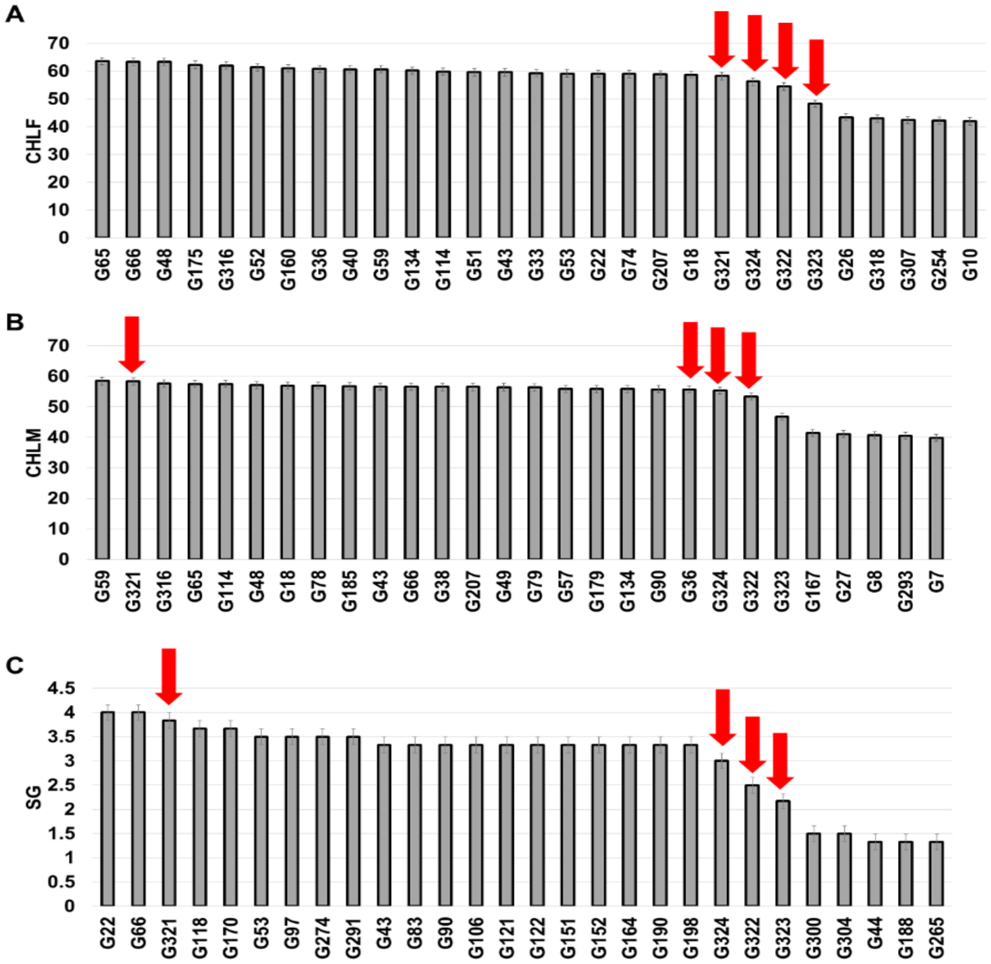


Figure 1 Diverse sorghum panicles A) at early grain filling and B) at maturity

Genotype performance and AMMI stability analysis

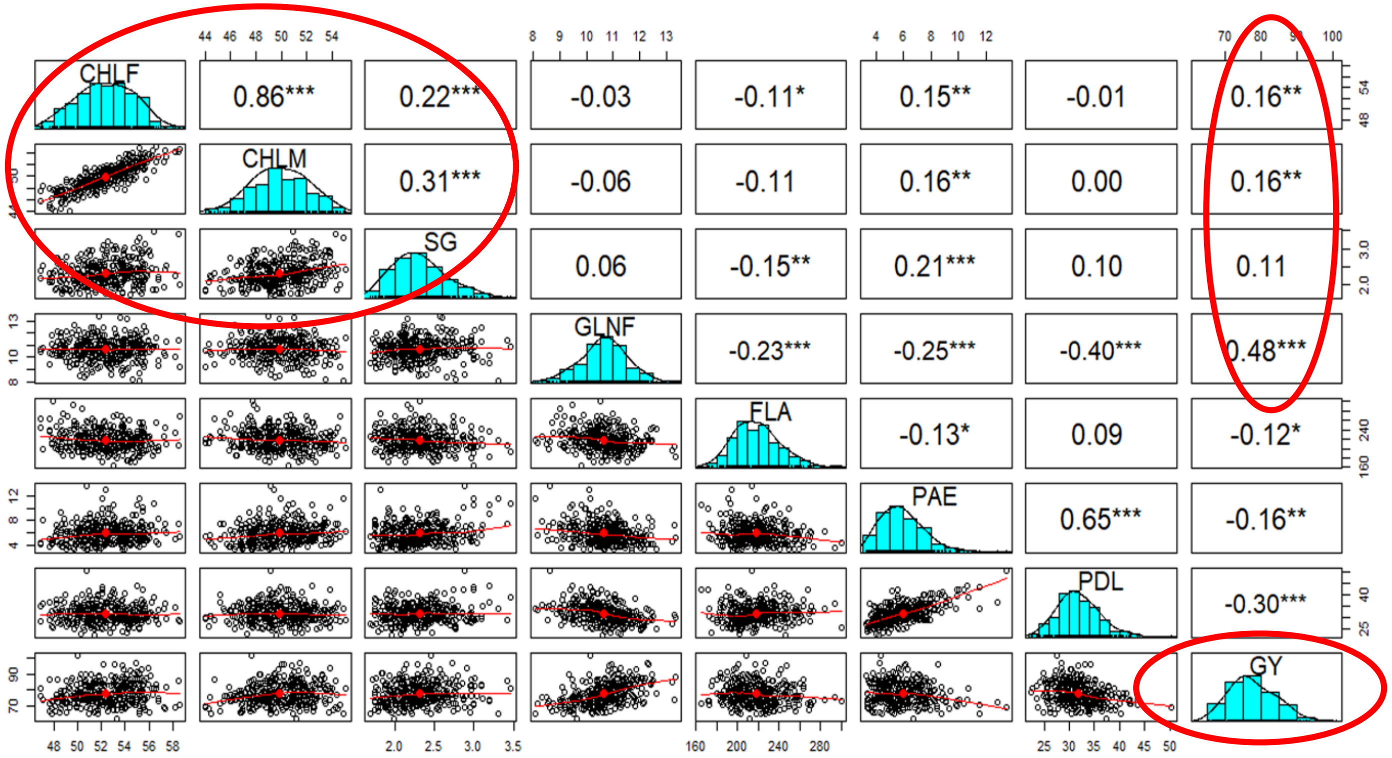


Novel sources of stay-green related trait



The landrace accessions that had better mean performance than the improved varieties with respect to their CHLF, CHLM and SG were considered as potential novel sources of drought tolerance.

Correlation among traits



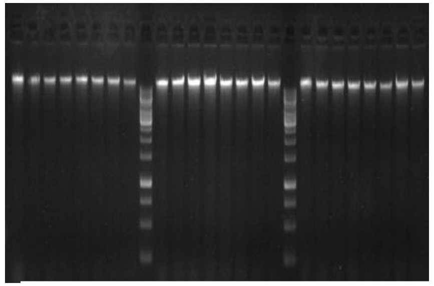
(Ezeaku and Mohammed, 2006; Amare et al., 2015).

Possibility of simultaneous improvement of both traits through effective selection

Genetic diversity of sorghum genotypes using SNP markers

- **Objectives**
- To investigate the genetic diversity of Ethiopian sorghum
- **Methods**
- 359 individuals → **24 Ethiopian sorghum landrace accessions**
- The accessions were selected to represent three agro-ecological zones
  - cool/subhumid,
  - cool/semiarid and
  - warm/semiarid
- Genomic DNA extraction

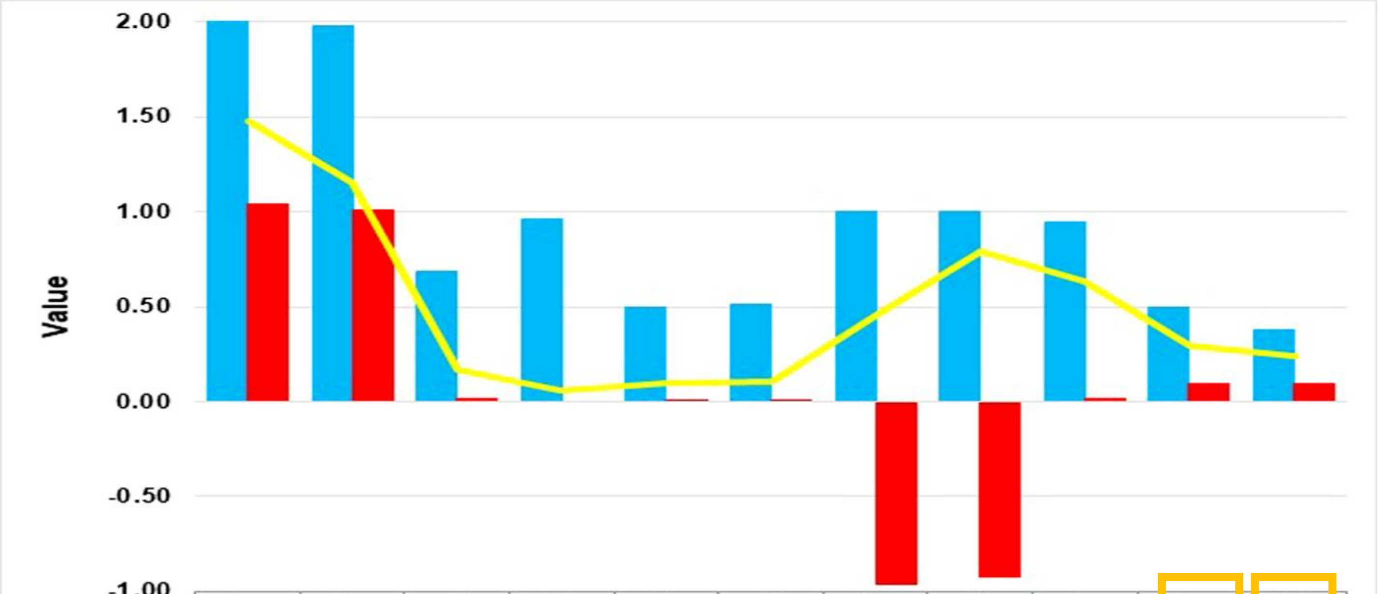
359 Sorghum



Genomic DNA

Genotyping

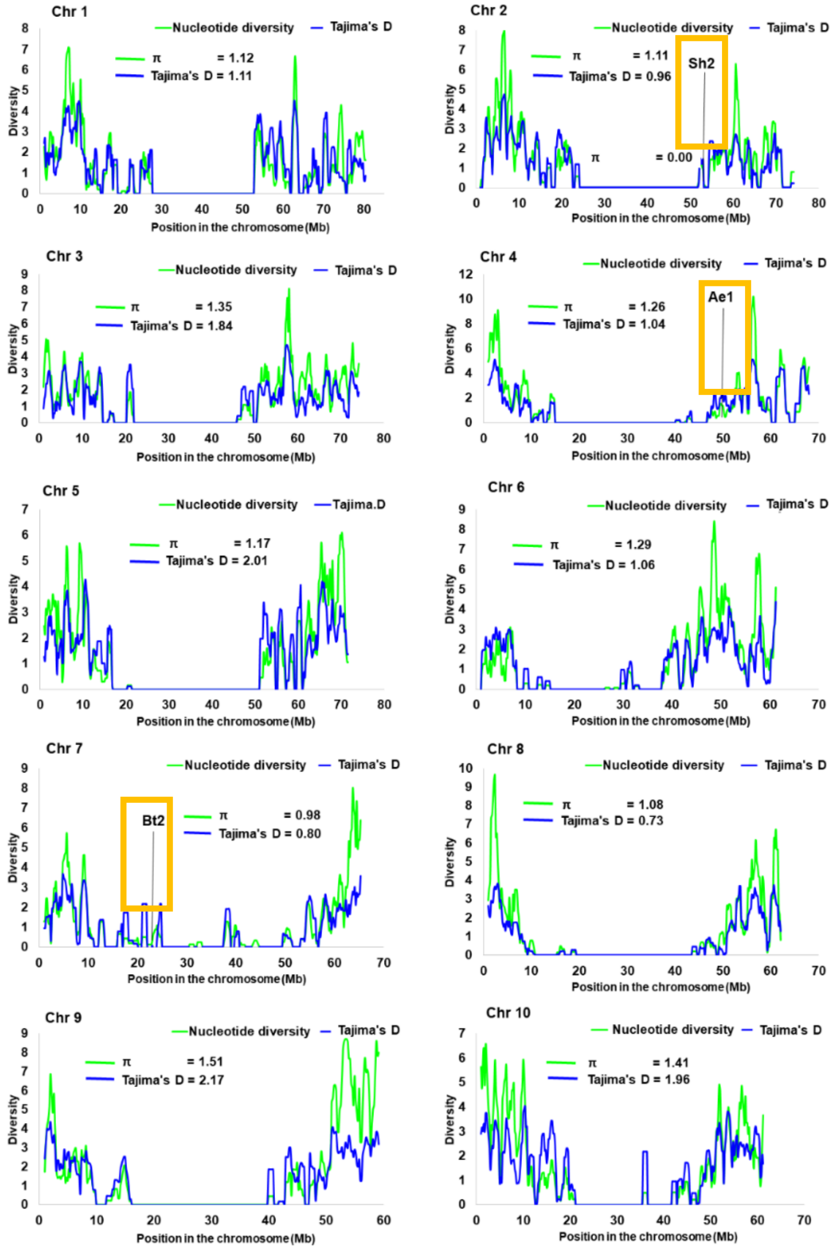
Polymorphism of markers



	Na	Ne	I	Ho	He	uHe	Fis	Fit	Fst	H	PIC
Max	2.00	1.98	0.69	0.96	0.49	0.51	1.00	1.00	0.95	0.50	0.38
Min	1.04	1.01	0.02	0.00	0.01	0.01	-0.96	-0.93	0.01	0.10	0.09
Mean	1.48	1.16	0.17	0.06	0.10	0.11	0.45	0.79	0.63	0.29	0.24

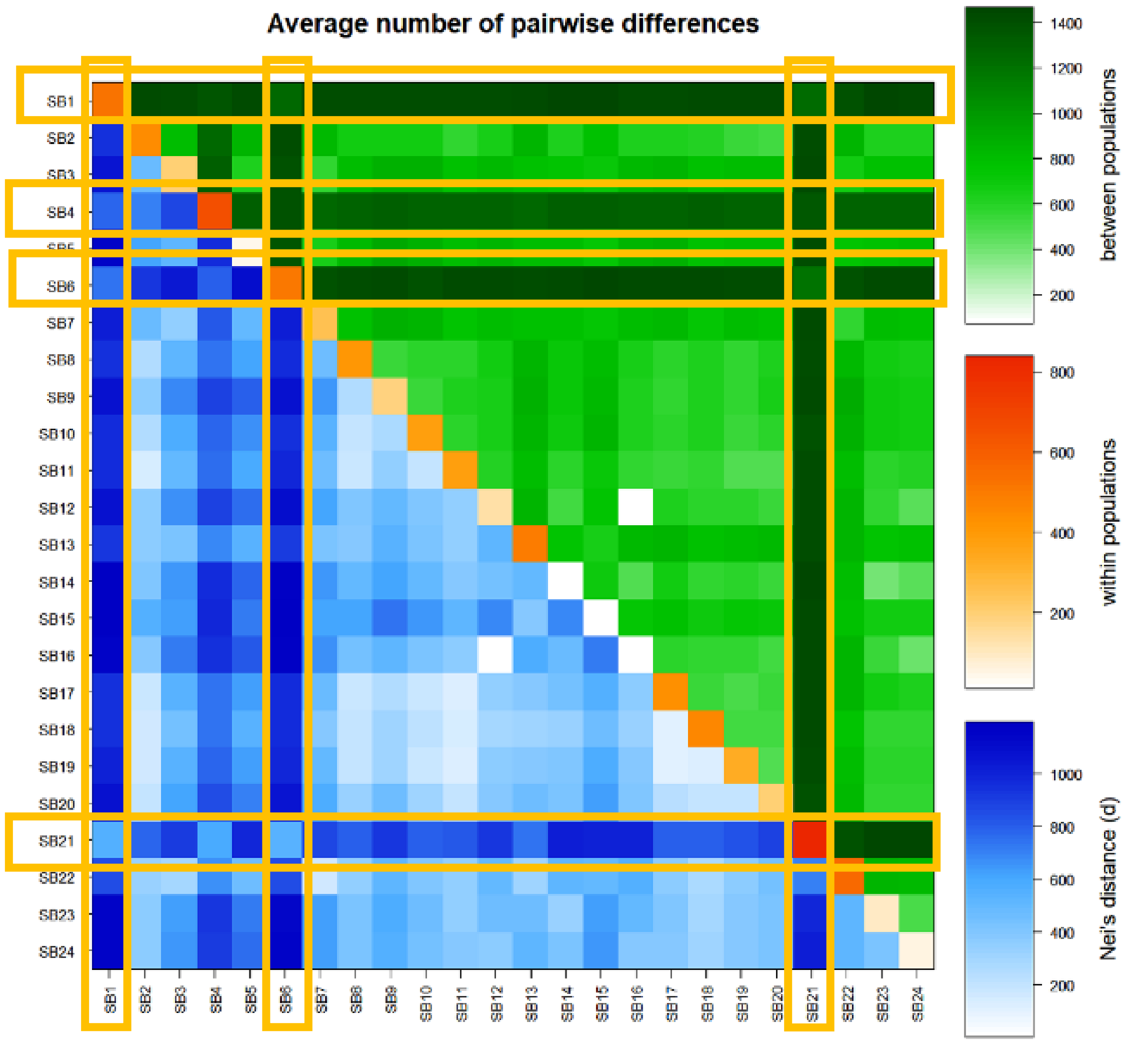
(Afolayan et al., 2019; Silva et al., 2021; Wondimu et al., 2021)

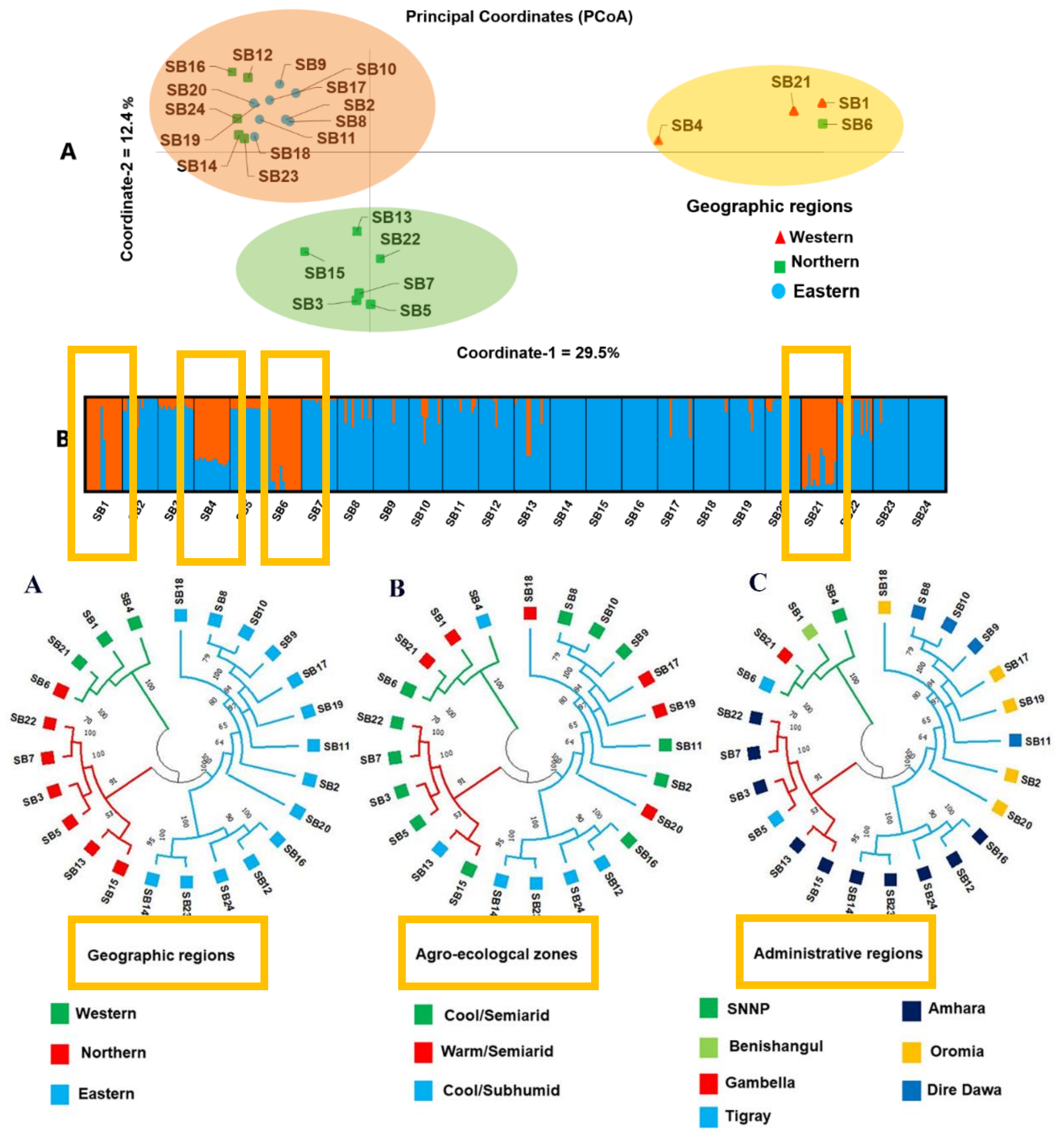
- ➢ 47% greater than 0.25



Genome-wide diversity

Genetic differentiation of accessions and cluster analysis





Root system architecture

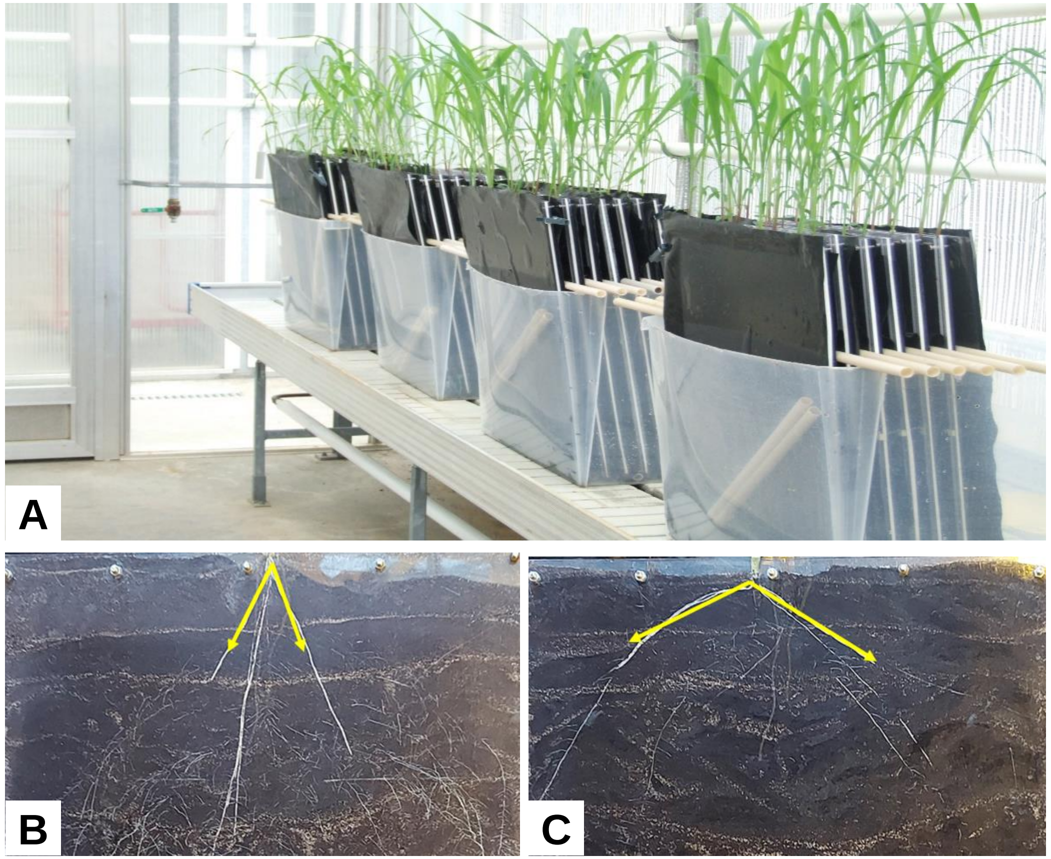
- RSA trait is one of the most important traits for extracting water and nutrient

- **Objectives**
- To characterize the RSA and shoot traits of Ethiopian sorghum landraces
- To identifying promising genotypes for key RSA and shoot traits for sorghum breeding programmes

- **Methods**
- 160 genotypes
- Grown in root chamber
- RSA traits such as NRN, NNR, RL

Root system architecture

- highly variation among genotypes
- H^2 ranged from 44.8% for RSR to 85.2% for NNR.
- ranging from 16.3^o to 53.0^o and heritability (63.1%) of the nodal root angle
- Enhance acquisition of available water by roots



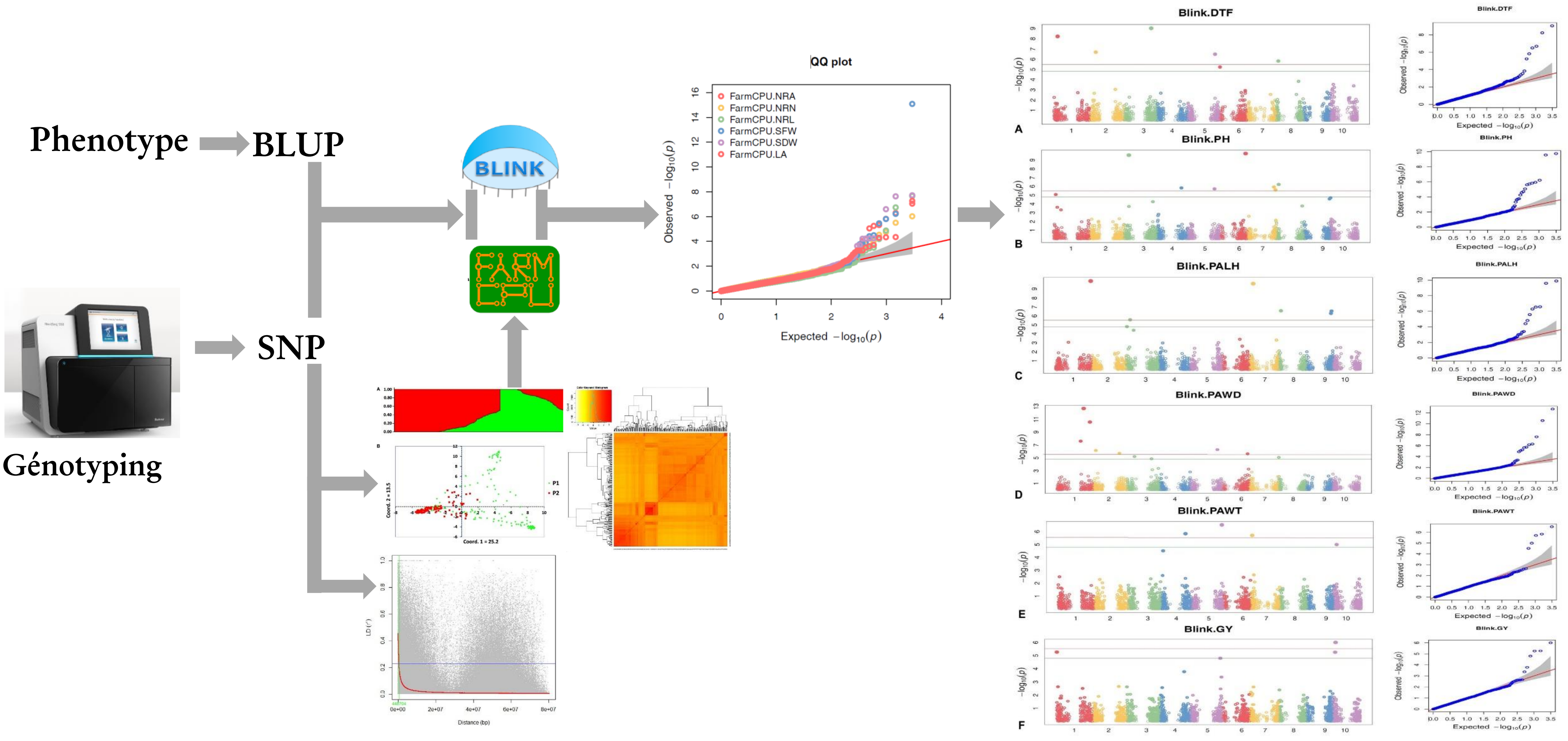
Narrow root angle

- ➢ deep in the soil
- ➢ Dry low/drought stress land area

Wide root angle

- ➢ shallow soil layers
- ➢ skip row agriculture

Genome wide association mapping



Physiological and transcriptomics analysis

- Gene expression studies
  - microarray
  - RNA-Seq
- Most of transcriptome researches in sorghum have focused on a single growth stage separately at seedling Eg. Amoah and Antwi-Berko, 2020; Rajarajan et al., 2021)
  - Growth stage 3 (30 to 40 days)
  - Reproductive stage

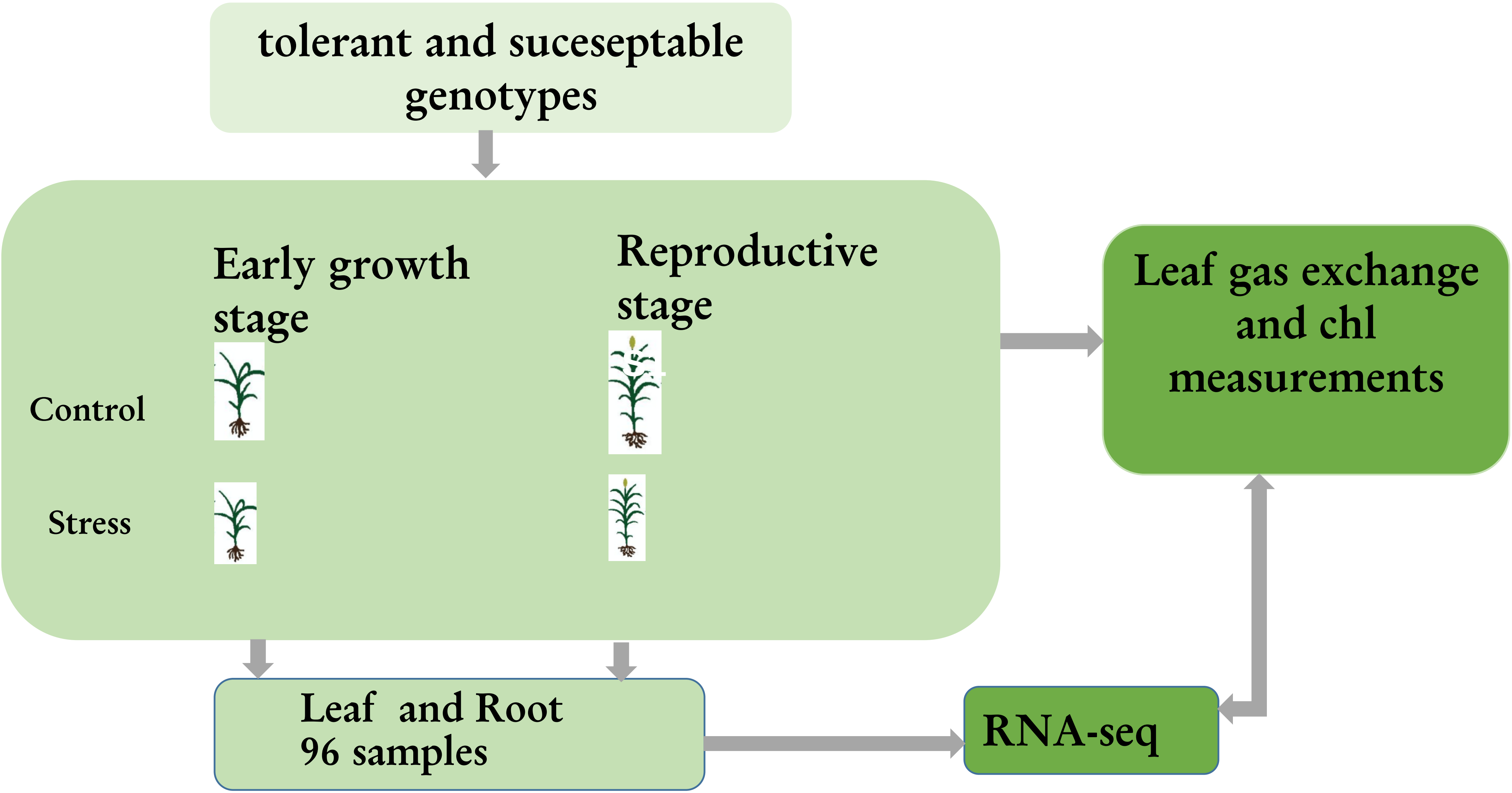
Drought sensitive stages

- No much transcript study on leaf and roots responsive to drought stress during these growth stage

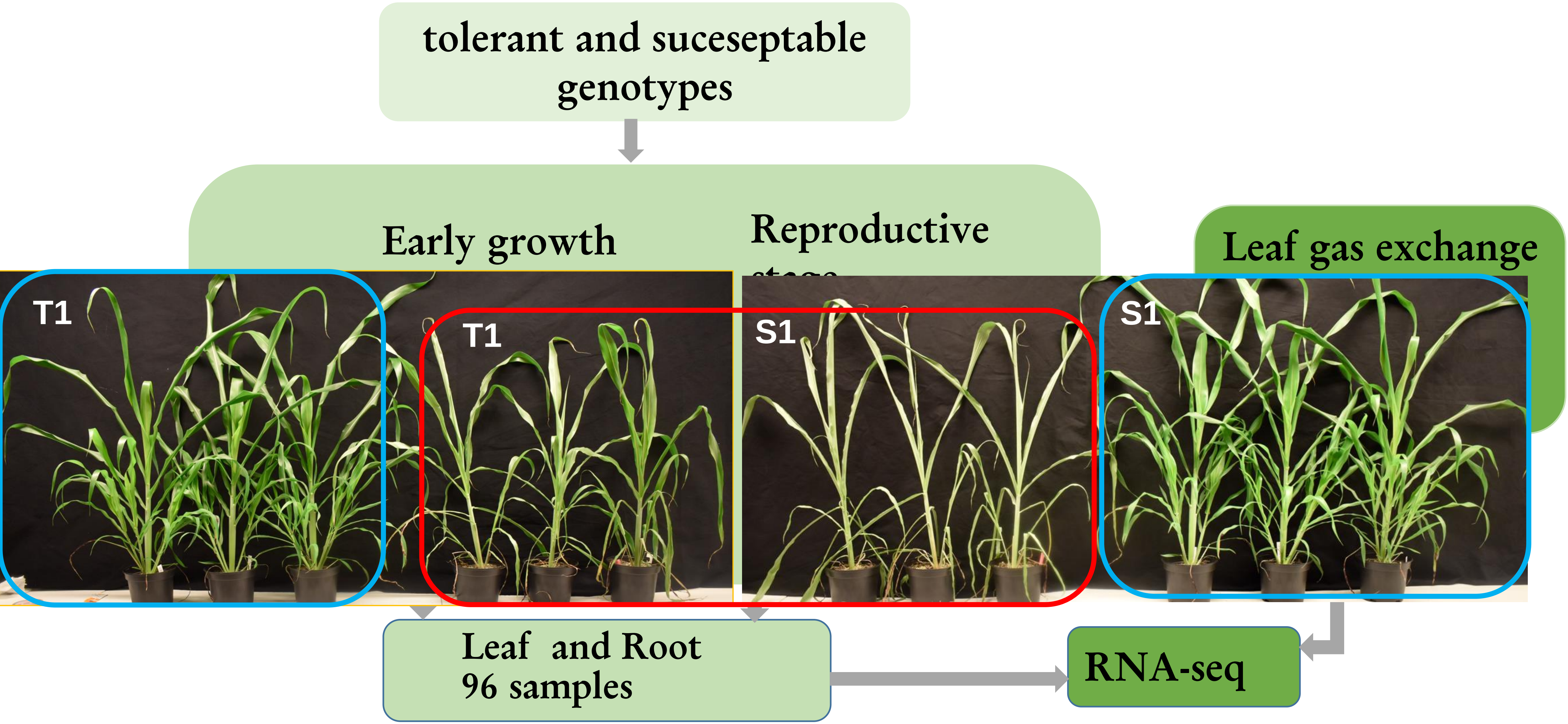
Objectives

- To investigating the physiological and transcriptomic responses of sorghum
  - different growth stages
  - tissues

Physiological and transcriptomics analysis



Physiological and transcriptomics analysis



Conclusion and recommendations

- Ethiopian sorghum landraces are key genetic resources that contain a large variation
  - Grain yield, agronomic
  - Drought related
  - Root system architecture traits
- The genetically rich Ethiopian sorghum gene pool should be
  - sustainably conserved and utilized for its improvement
- The identified stable and high yielding and drought tolerant genotypes
  - Should be incorporated into sorghum improvement programs targeting drought-stress environments.

- Selected sorghum genotypes should be screened both under controlled environments
    - to compare their performance with that of drought-stressed field conditions.

- A number of novel and previously known genomic regions that are associated with the studied traits were identified.
    - Further investigation and validation of QTLs identified

- The identified genotypes which had narrow and wide root angel suitable as donors to improve these traits.

Publications

- **Enyew, Muluken**, Tileye Feyissa, Anders S. Carlsson, Kassahun Tesfaye, Cecilia Hammenhag, Amare Seyoum, and Mulatu Geleta. "Genome-wide analyses using multi-locus models revealed marker-trait associations for major agronomic traits in *Sorghum bicolor*." **Frontiers in Plant Science,** 13 (2022).
- **Muluken Enyew**, Anders S. Carlsson, Mulatu Geleta, Kassahun Tesfaye, Cecilia Hammenhag, Amare Seyoum and Tileye Feyissa. “Novel sources of drought tolerance in sorghum landraces revealed via the analyses of genotype-by-environment interactions”. **Frontiers in Plant Science**, 13 (2022).
- **Enyew, Muluken**, Tileye Feyissa, Anders S. Carlsson, Kassahun Tesfaye, Cecilia Hammenhag, and Mulatu Geleta. "Genetic Diversity and Population Structure of Sorghum [*Sorghum Bicolor* (L.) Moench] Accessions as Revealed by Single Nucleotide Polymorphism Markers." **Frontiers in Plant Science,** 12 (2022).
- **Enyew, Muluken**, Tileye Feyissa, Mulatu Geleta, Kassahun Tesfaye, Cecilia Hammenhag, and Anders S. Carlsson. "Genotype by environment interaction, correlation, AMMI, GGE biplot and cluster analysis for grain yield and other agronomic traits in sorghum (*Sorghum bicolor* L. Moench)." **Plos one,** 10 (2021).
- Abreha, Kibrom B., **Muluken Enyew**, Anders S. Carlsson, Ramesh R. Vetukuri, Tileye Feyissa, Tiny Motlhaodi, Dickson Ng’uni, and Mulatu Geleta. "Sorghum in dryland: morphological, physiological, and molecular responses of sorghum under drought stress." **Planta,** 255 (2022).

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Thank you!!!


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