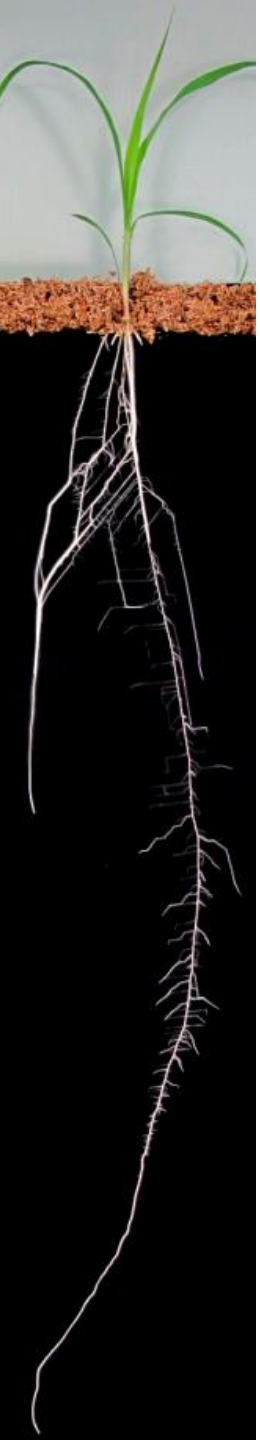


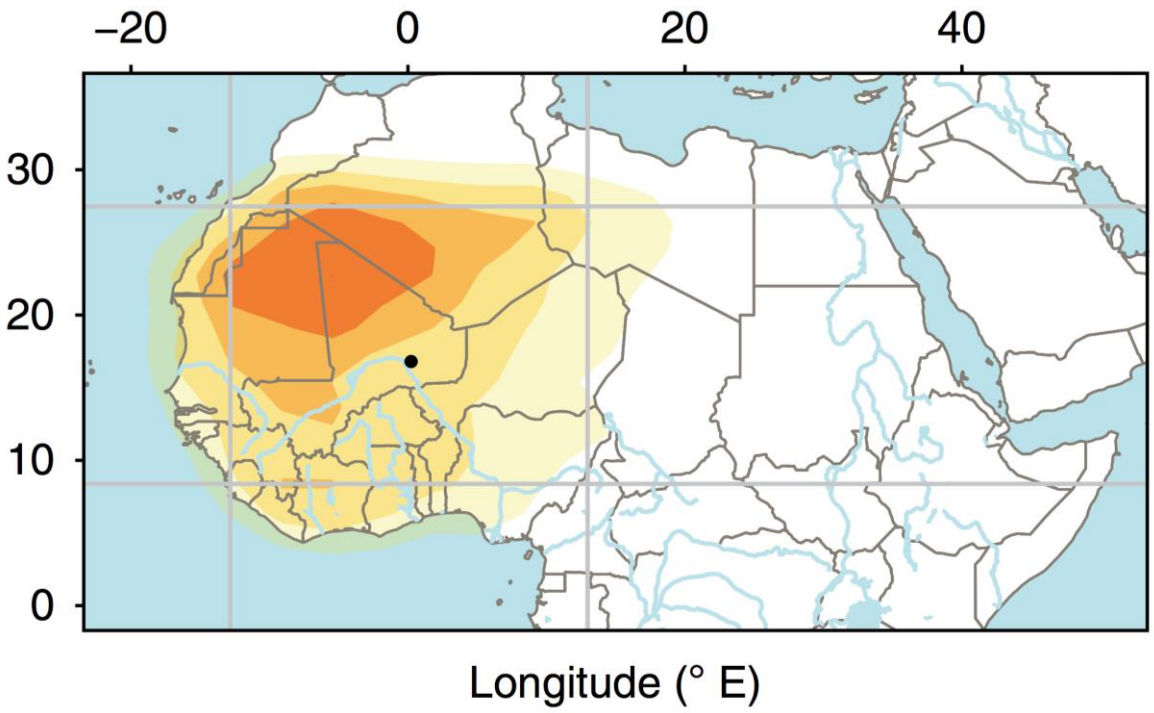
Vers une sélection variétale de la structure et des fonctions des microbiotes racinaires

Laurent Laplaze & Laurent Cournac

UMR DIADE & UMR Eco&Sols, Montpellier, France

Pearl millet

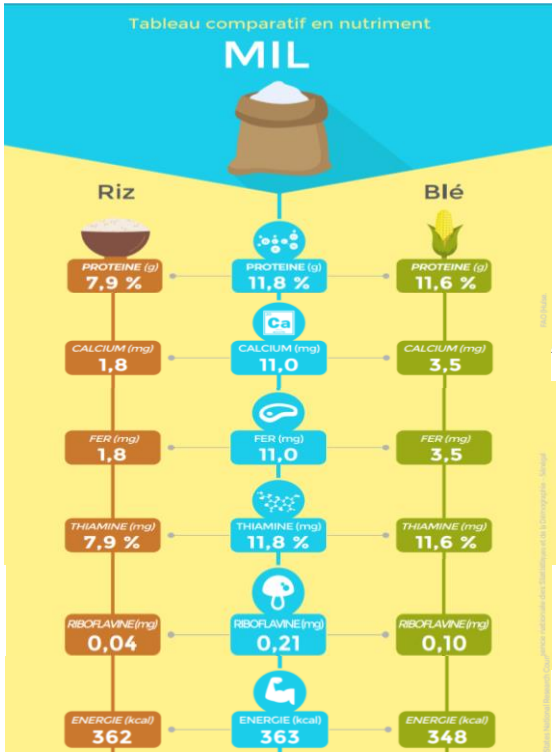
Pennisetum glaucum



Burgarella *et al*, Nat. Ecol. Evol. 2018

Pearl millet

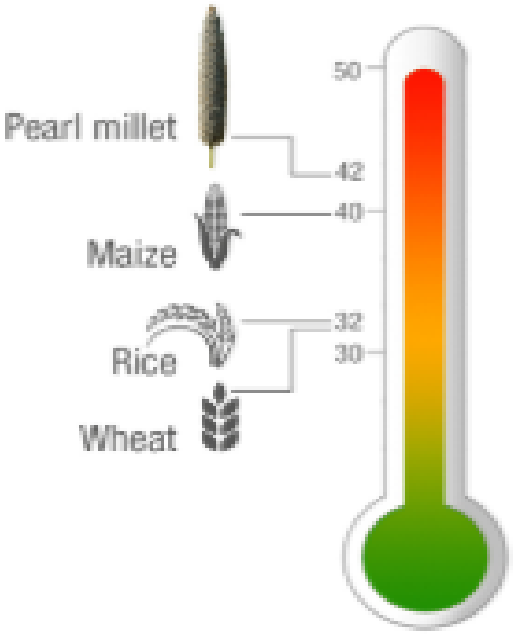
Pennisetum glaucum



Ref: Agritools (http://www.agritools.org/)

Pearl millet

One of the hardiest cereals



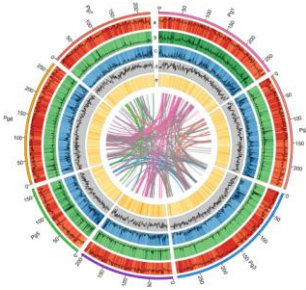
Ref: ICRISAT Newsletter (http://www.icrisat.org/)

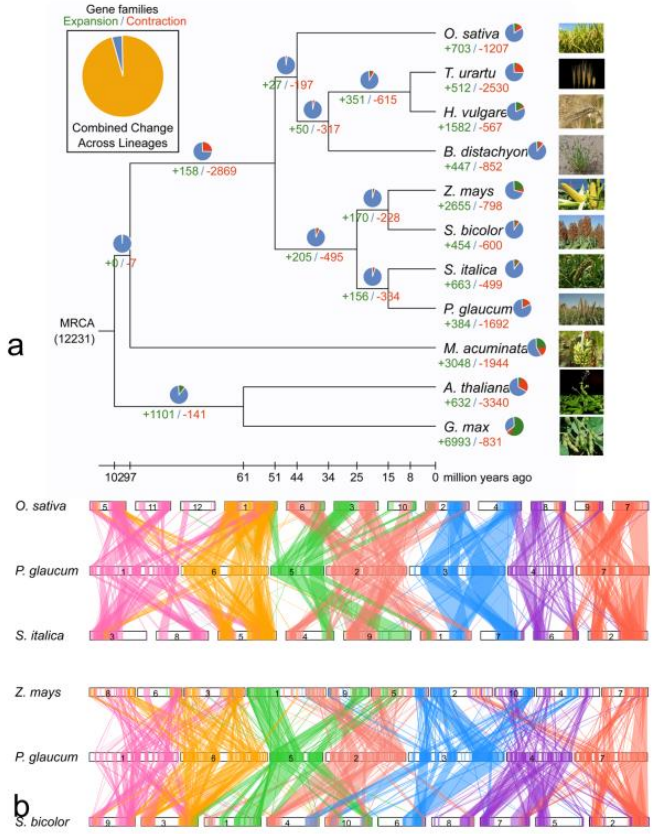
Picture: C.T. Hash (ICRISAT)

Picture: Y. Vigouroux (IRD)

Pearl millet

Genomic ressources





Varshney *et al*, Nat. Biotech. 2017

- Consortium ICRISAT/BGI/IRD
- Genome size: 1.79 GB
- 38 579 predicted genes
- High GC (47.9%) and TE (80%) content
- Expansion genes families for cutin/suberin and ABC transporters
- 994 lines fully resequenced

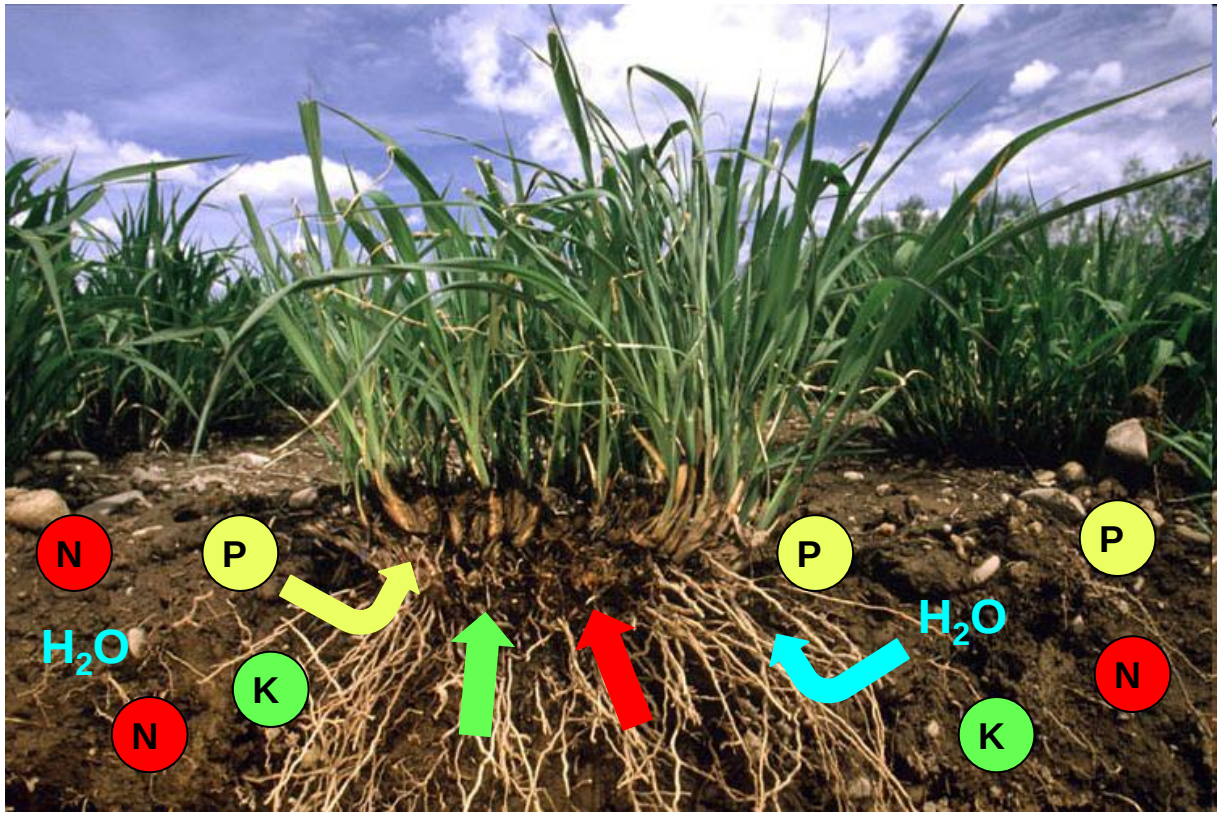
Pearl millet

Main limiting factors

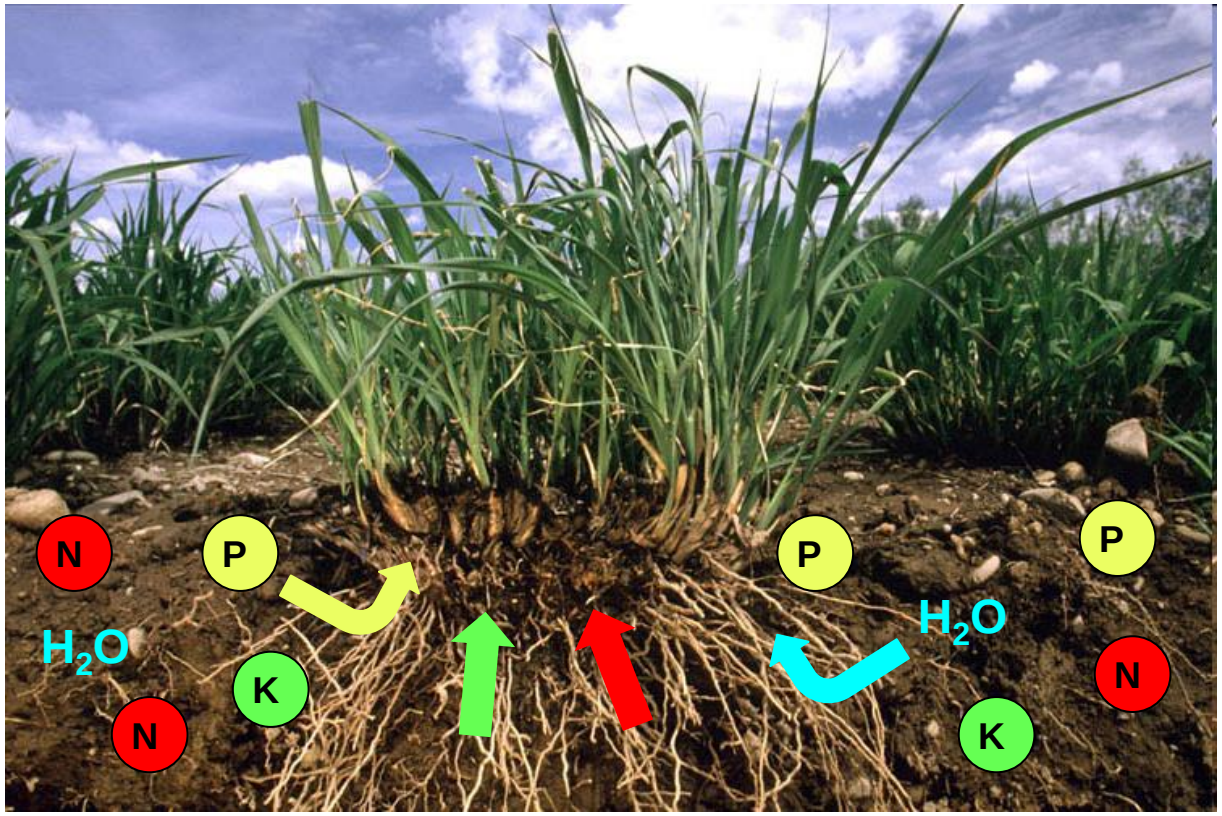
- **Abiotic stresses**
  - Drought
  - Low soil fertility (low P availability)
  - Heat stress
- **Biotic stresses**
  - Striga
  - Fungal pathogens
  - Insects & nematodes
  - Birds

Root systems: the hidden half

Root systems: the hidden half

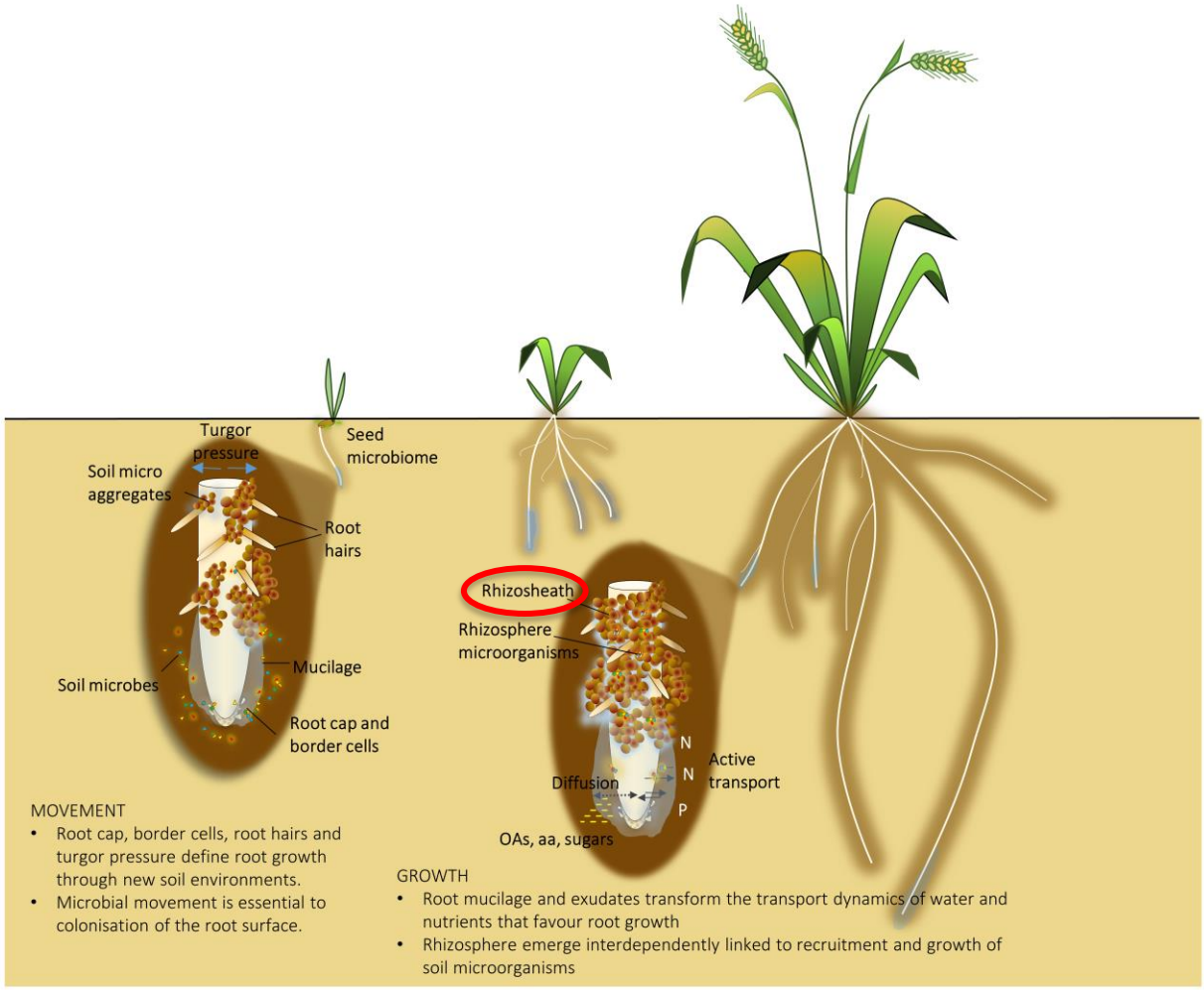


Objectives



⇒ ***Identify root traits that contribute to pearl millet adaptation to low water and low nutrients conditions***

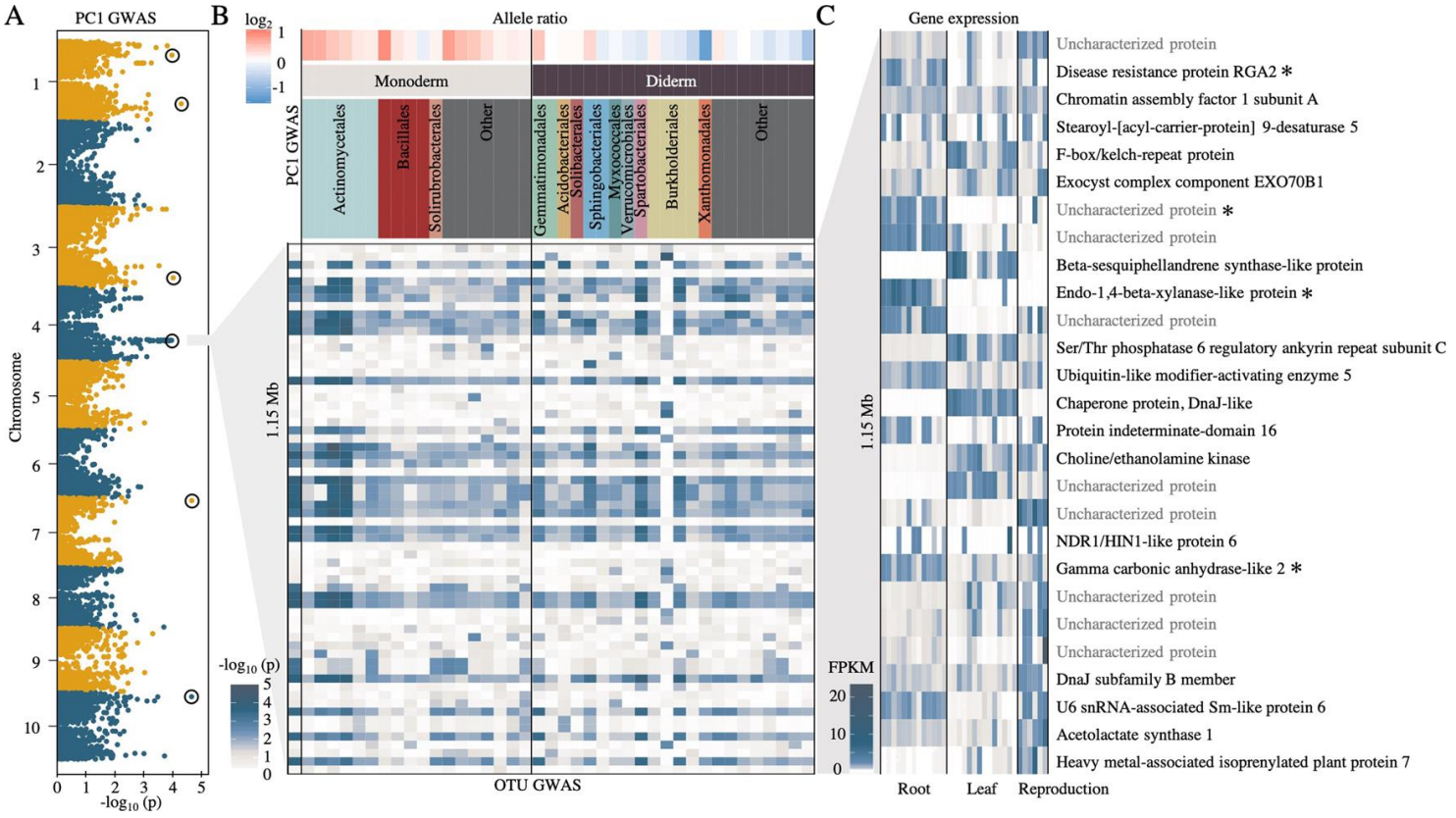
The rhizosphere: an extended plant phenotype



De la Fuente Canto, Simonin *et al*, 2020 Plant J.

The rhizosphere: an extended plant phenotype

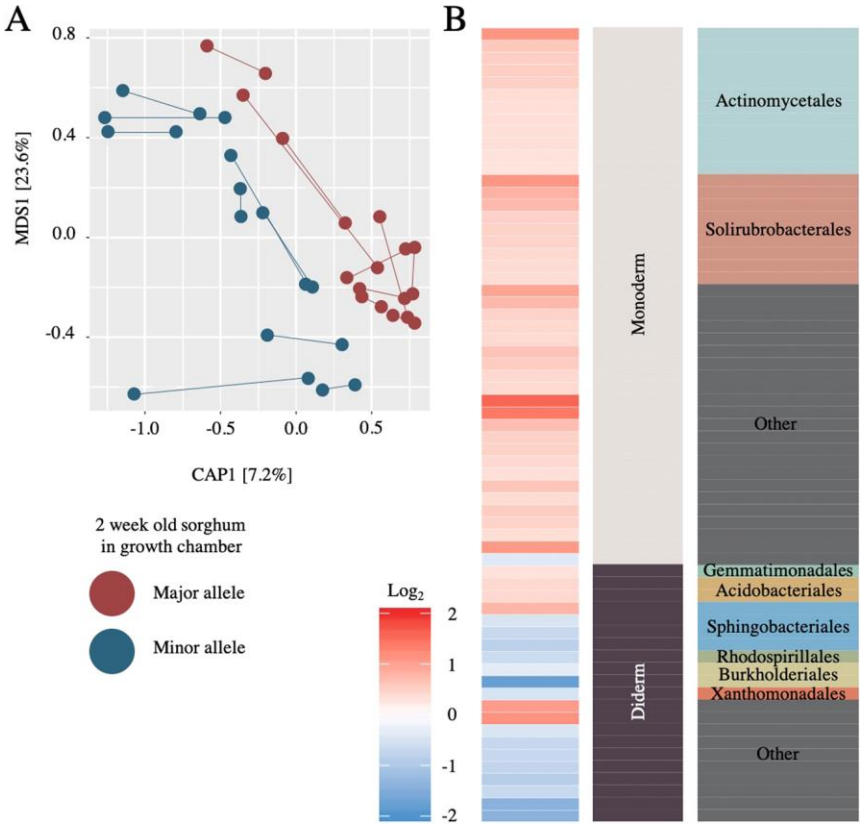
Identification of loci controlling the rhizosphere microbiome composition in sorghum



Deng *et al*, 2021 *ISME J.*

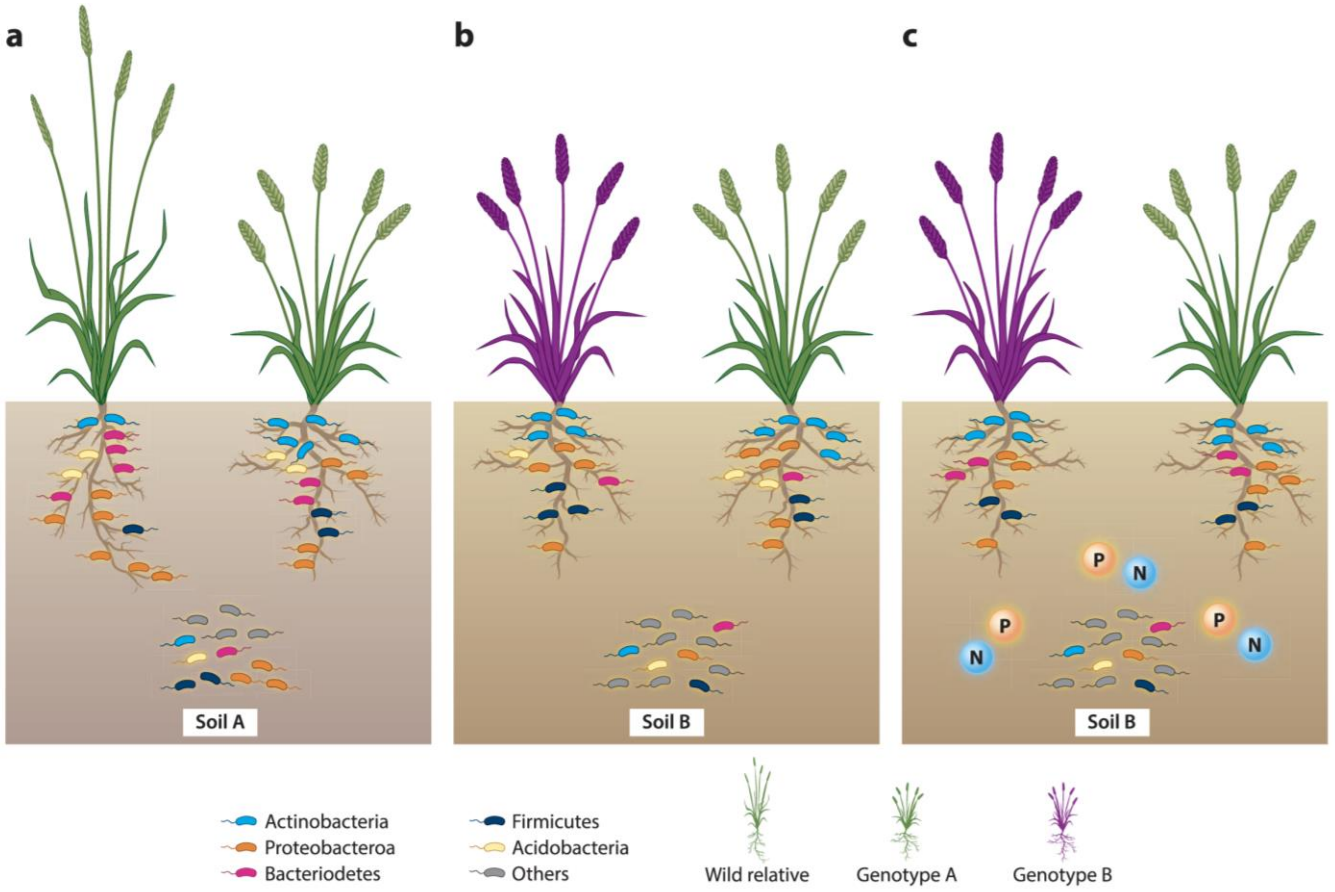
The rhizosphere: an extended plant phenotype

Sorghum genetic information can be used to predict rhizosphere microbiome composition under different growth conditions



Deng *et al*, 2021 *ISME J.*

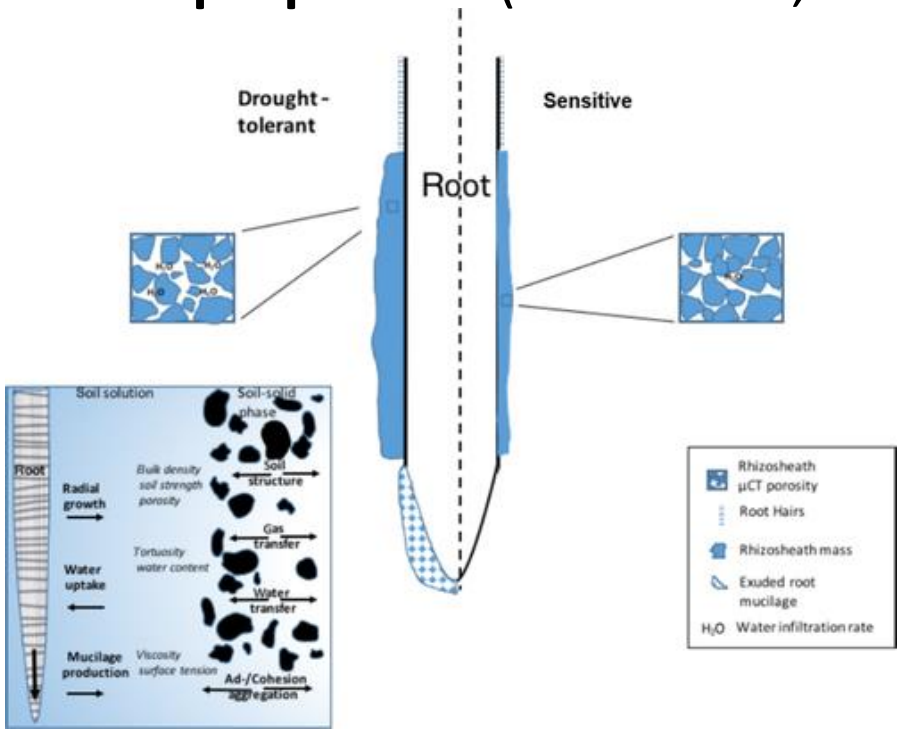
The rhizosphere: at the crossroad of plant genetics and environmental drivers



Escudero-Martinez & Bulgarelli, 2023 *Ann. Rev. Phytopath.*

Soil aggregation / rhizosheath

- **Changes in soil water transport and retention properties** (Rabbi *et al*, 2018)



Soil aggregation / rhizosheath

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- **Improved drought and low P tolerance** (Rabbi *et al*, 2018; George *et al*, 2014)

Soil aggregation / rhizosheath

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Soil aggregation / rhizosheath

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- **Found throughout angiosperms** (Brown et al, 2017)
- **Increased soil C content**

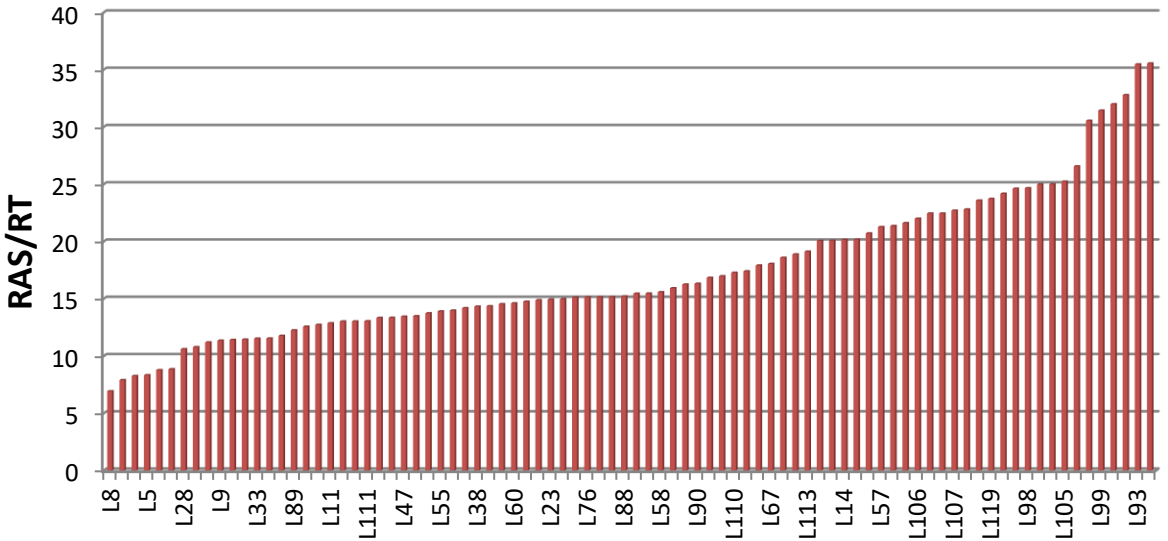
=> A potential selection target !

Soil aggregation in pearl millet

- diversity -

S. Ndour

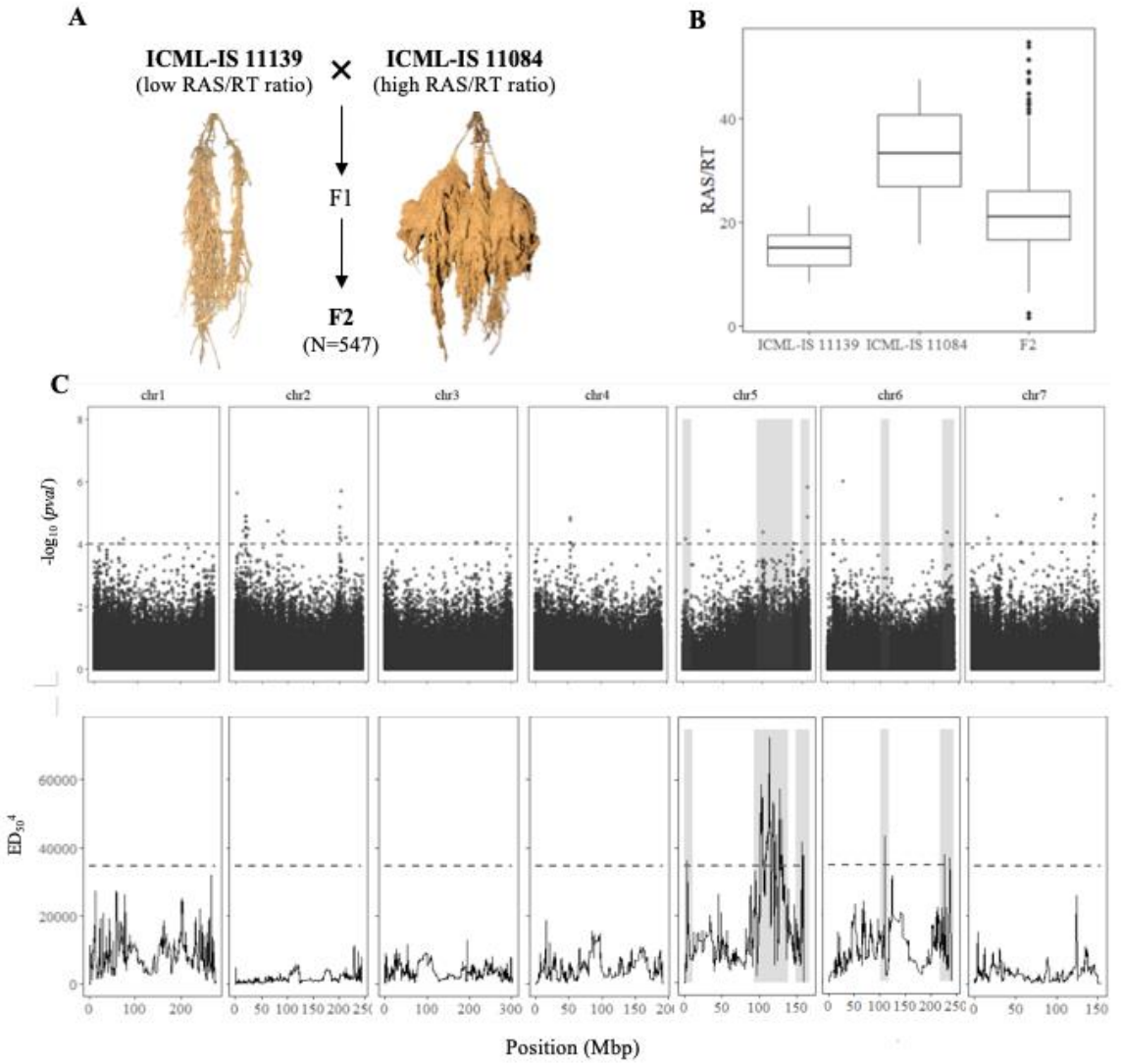
Panel inbred lines (181 IL, > 1400 plants)



- 1.2 < RAS/RT < 39.9 g soil.g root^{-1}
- H^2 = 0.72

Genetic dissection

C. de la Fuente



Soil aggregation in pearl millet
- GWAS -

M. Debieu

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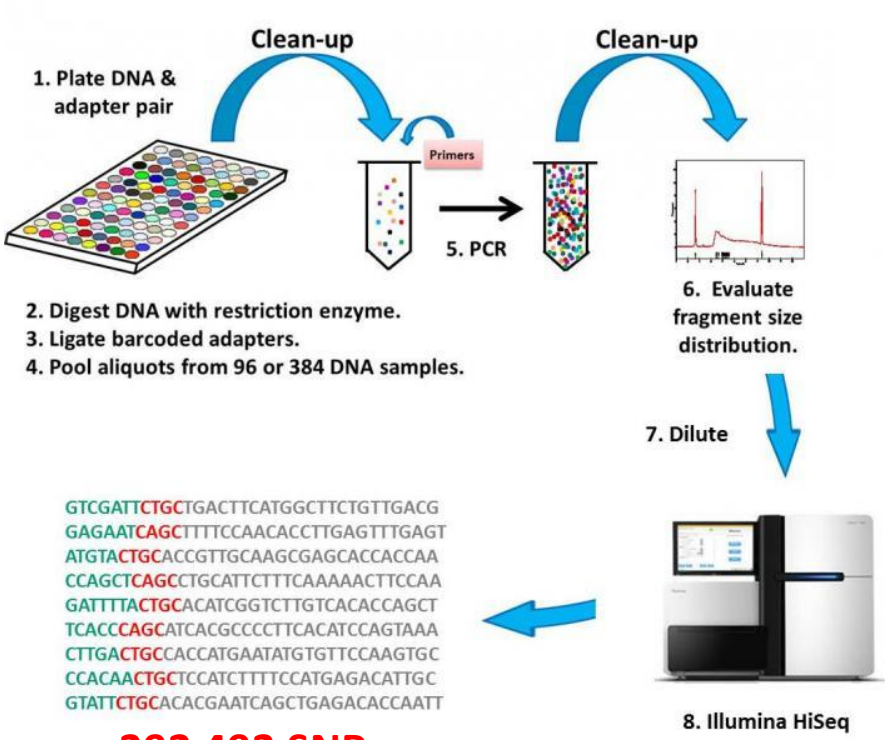


392 493 SNPs

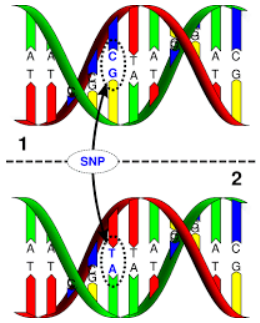
Seville, July 2019

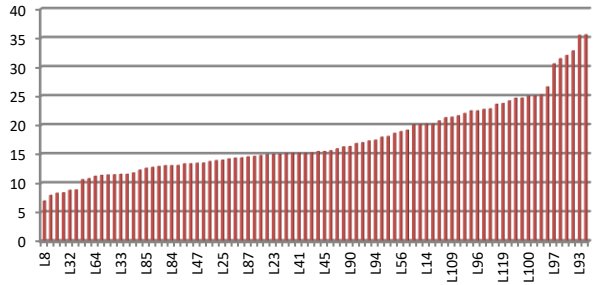
LAPSE
LMI Adaptation des Plantes et microorganismes associés aux Stress Environnementaux

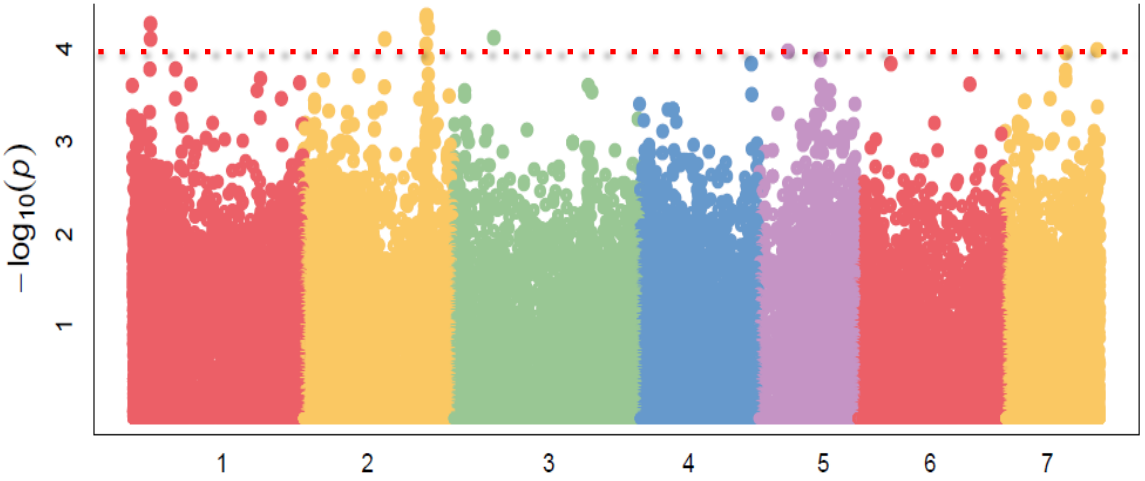
Soil aggregation in pearl millet

- GWAS -

M. Debieu







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QTL validation

Bulk segregant analysis

C. de la Fuente

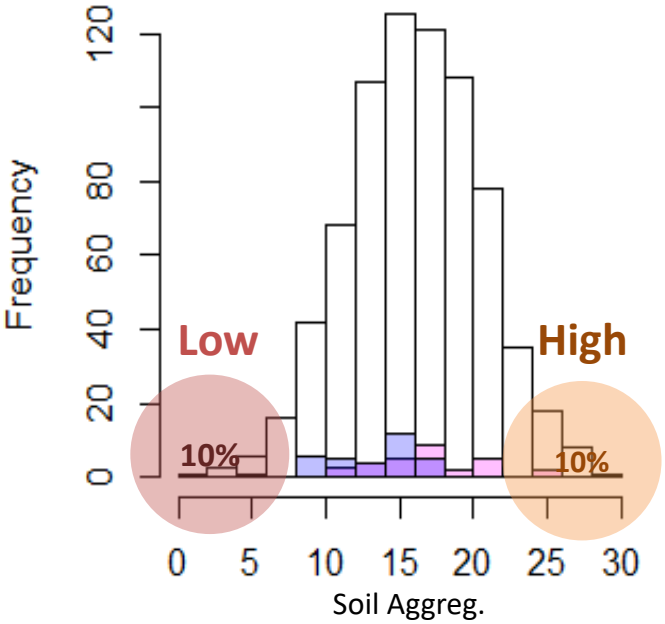
Low aggreg. parent

X

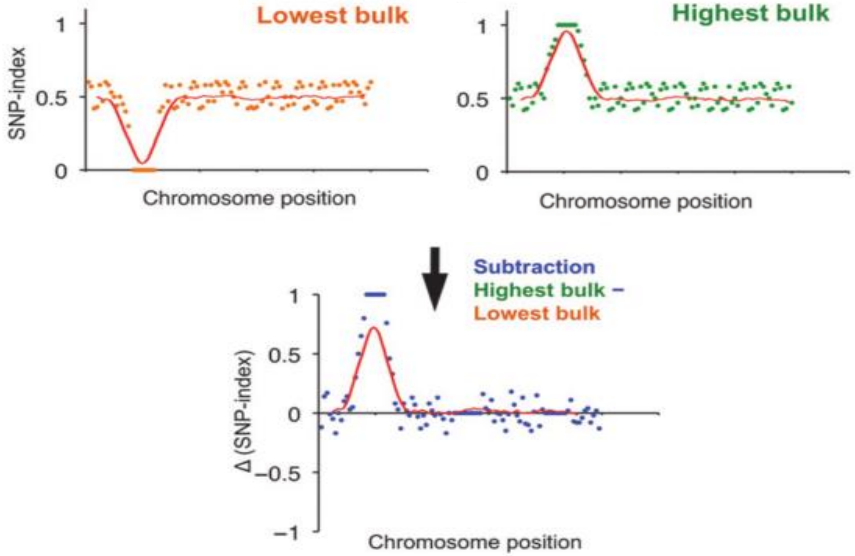
High aggreg. parent

→ F1 → (Self pollination) F2

- **F2 seedlings 132x220 cross** →
- **F2 seedlings 253x3 cross** →



Expected results…



Adapted from: Takagi et al. (2013) The Plant Journal, 74: 174- 183

Seville, July 2019

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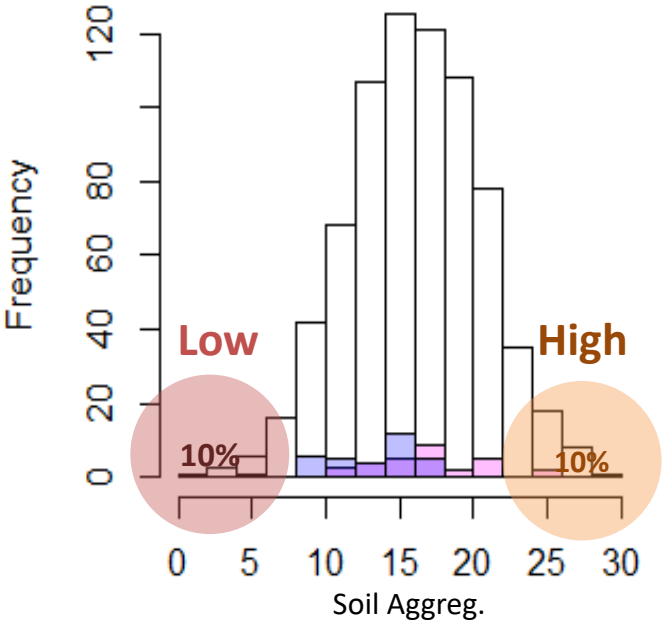

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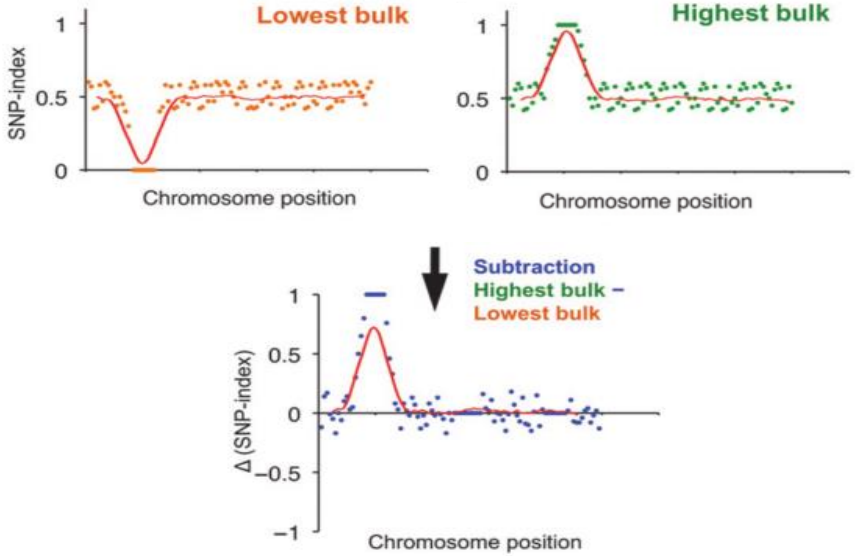

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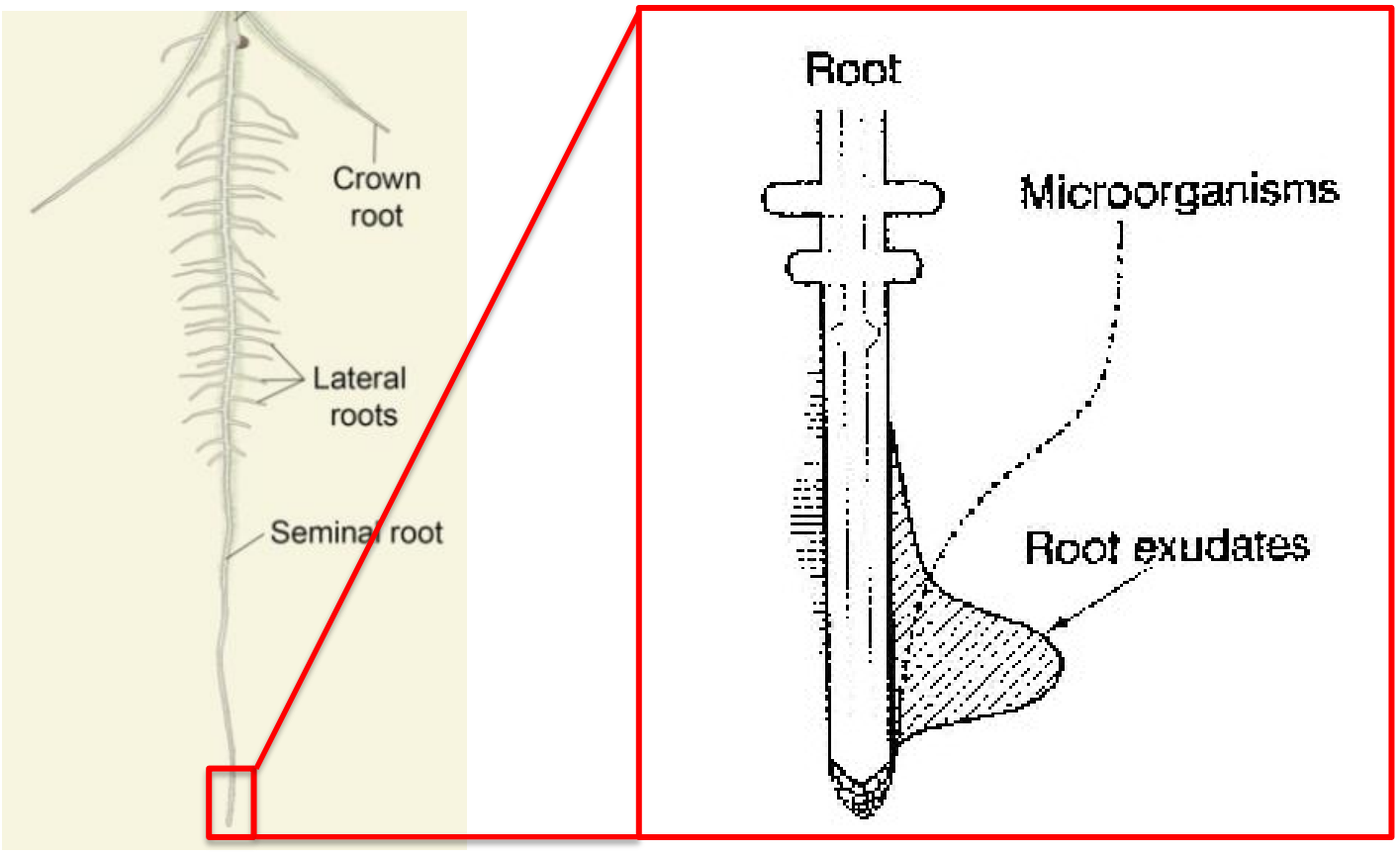
Seville, July 2019

Soil aggregation in pearl millet
- transcriptomics-

M. Debieu



Pattern of root exudation (Marschner, 1995)

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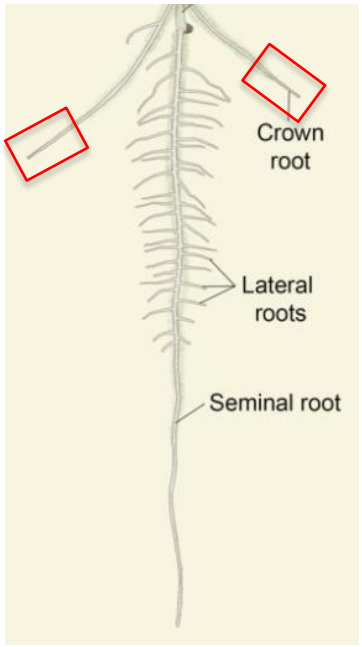
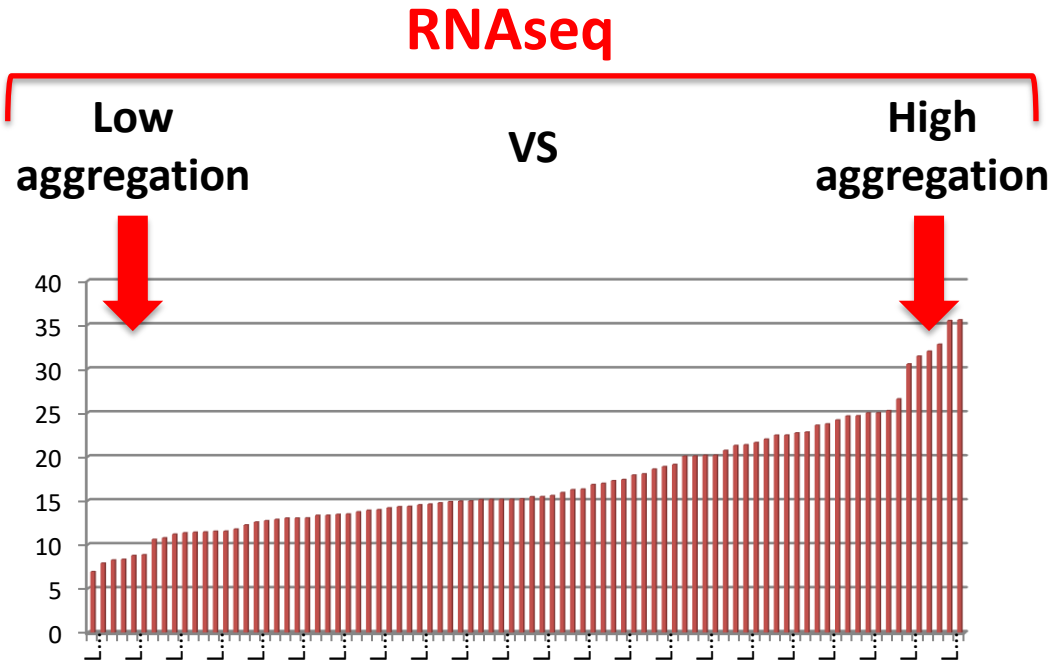
Soil aggregation in pearl millet
- transcriptomics-

M. Debieu





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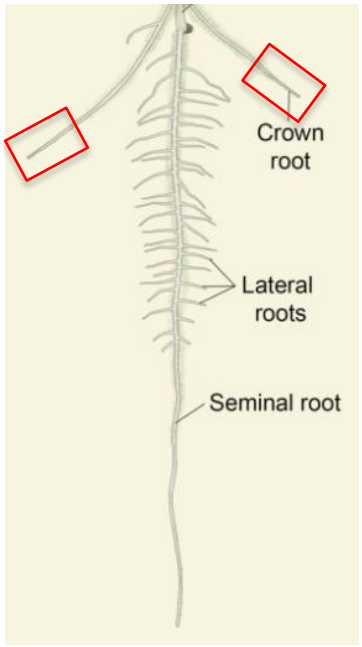
M. Debieu

A. Grondin



RNAseq

Low aggregation **VS** **High aggregation**

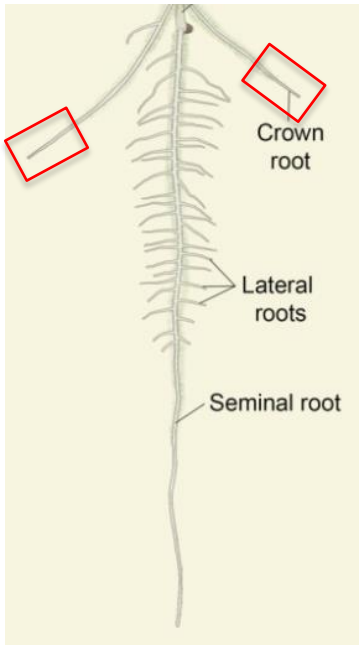
Montpellier MGX GenomiX

- 3 replicates
- single read 50 nt (Illumina HiSeq 2500)
- 1/3 reads not mapped to predicted CDS
- 3 stastical tests (EdgeR, DESeq & DESeq2)

Seville, July 2019

Soil aggregation in pearl millet
- transcriptomics-

A. Grondin



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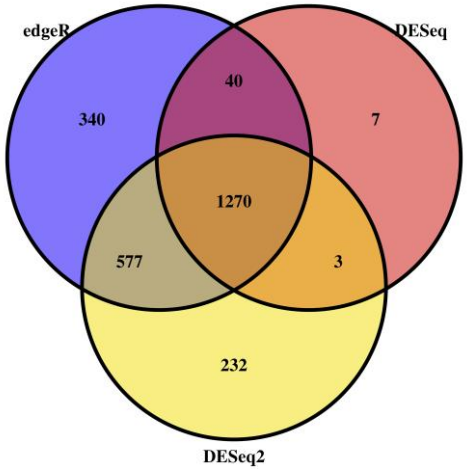

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LMI Adaptation des Plantes et microorganismes associés aux Stress Environnementaux

Soil aggregation in pearl millet
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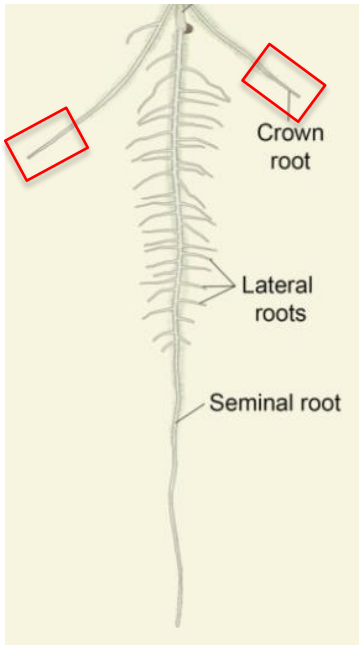

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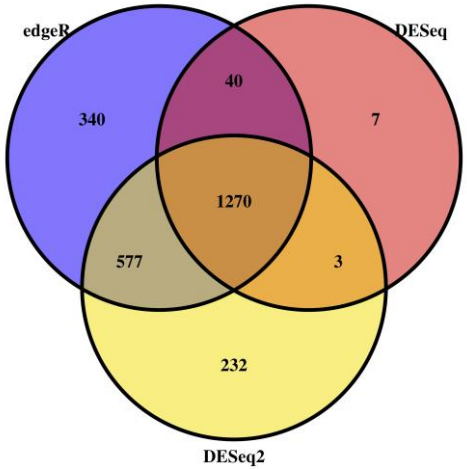

Enriched GO terms :

- Molecular interactions (binding)
- Enzymatic reactions
- Transporters
- Antioxidant activity

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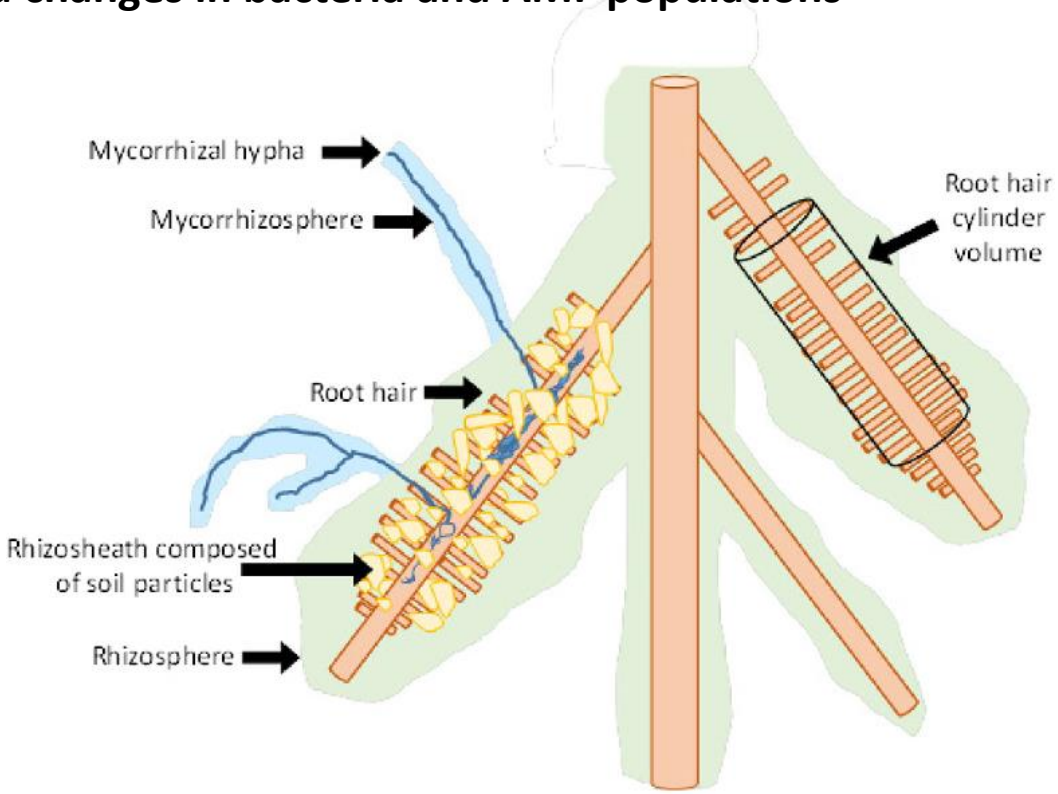
LMI Adaptation des Plantes et microorganismes associés aux Stress Environnementaux

Soil aggregation in pearl millet
correlations with other traits

M. Diouf

- **Rhizosheath formation associated with root hairs, exsudation and changes in bacteria and AMF populations**



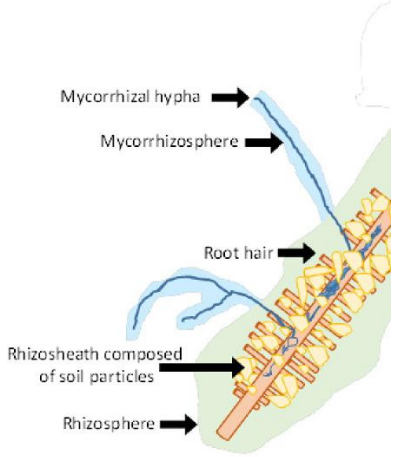
Pang *et al*, Plant & Soil 2017

Soil aggregation in pearl millet
correlations with other traits

M. Diouf

10 contrasted IL for soil aggregation

Growth in soil for 3 weeks



- **Soil aggregation**
- **Root system** (length, diameter, fine roots length, …)
- **Root hairs** (length & density)
- **AMF related traits** (frequency and intensity of infection, glomaline)

Soil aggregation in pearl millet
correlations with other traits

M. Diouf

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Growth in soil for 3 weeks

- **Soil aggregation**
- **Root system**
- **Root hairs**
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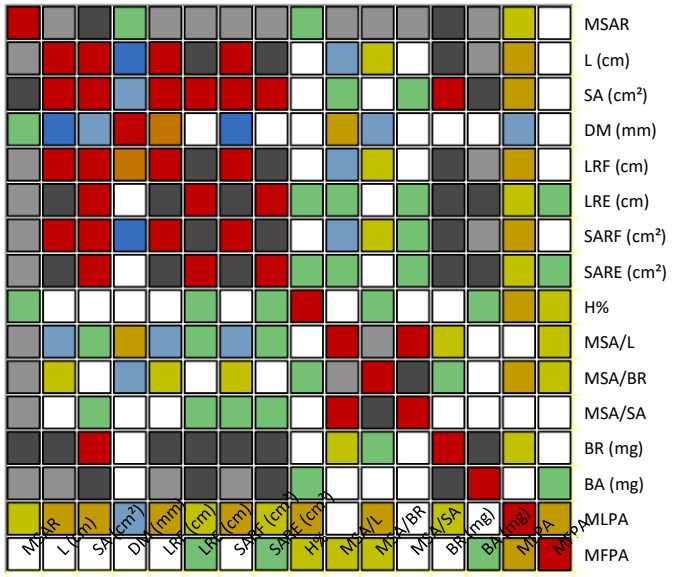

Soil aggregation in pearl millet
correlations with other traits

M. Diouf

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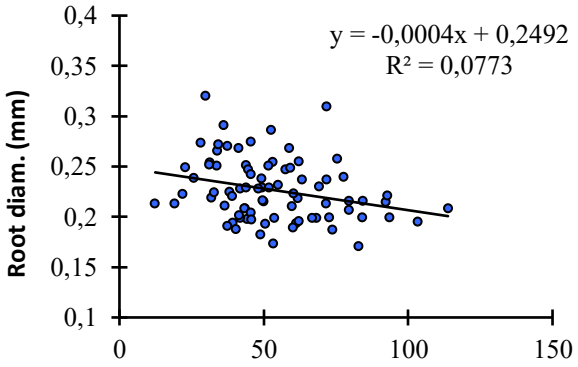

Soil aggregation in pearl millet
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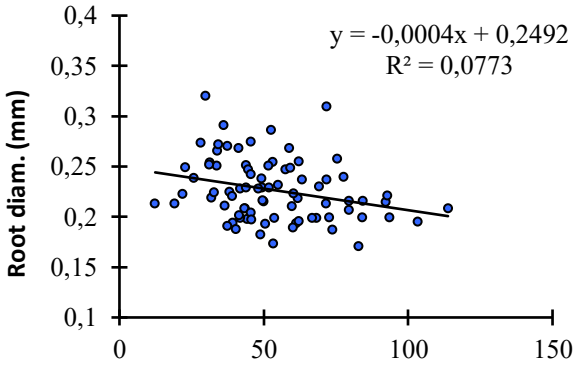
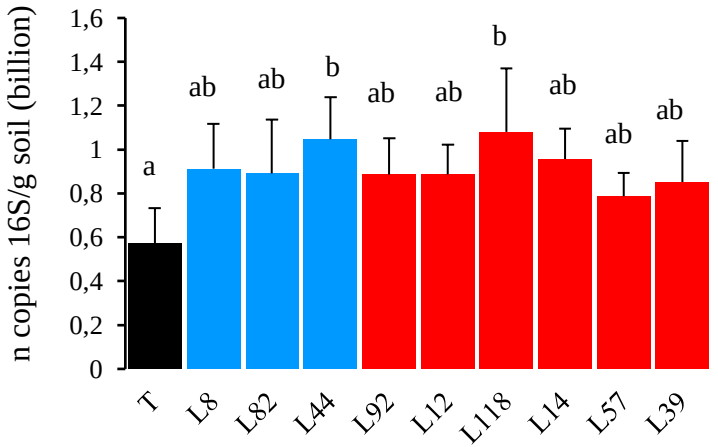


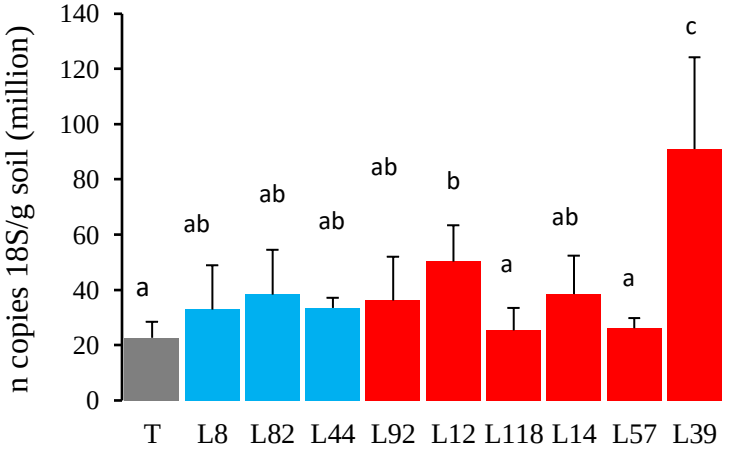
Soil aggregation
- Impact on microbiome -

S. Ndour

Bacteria



Fungi

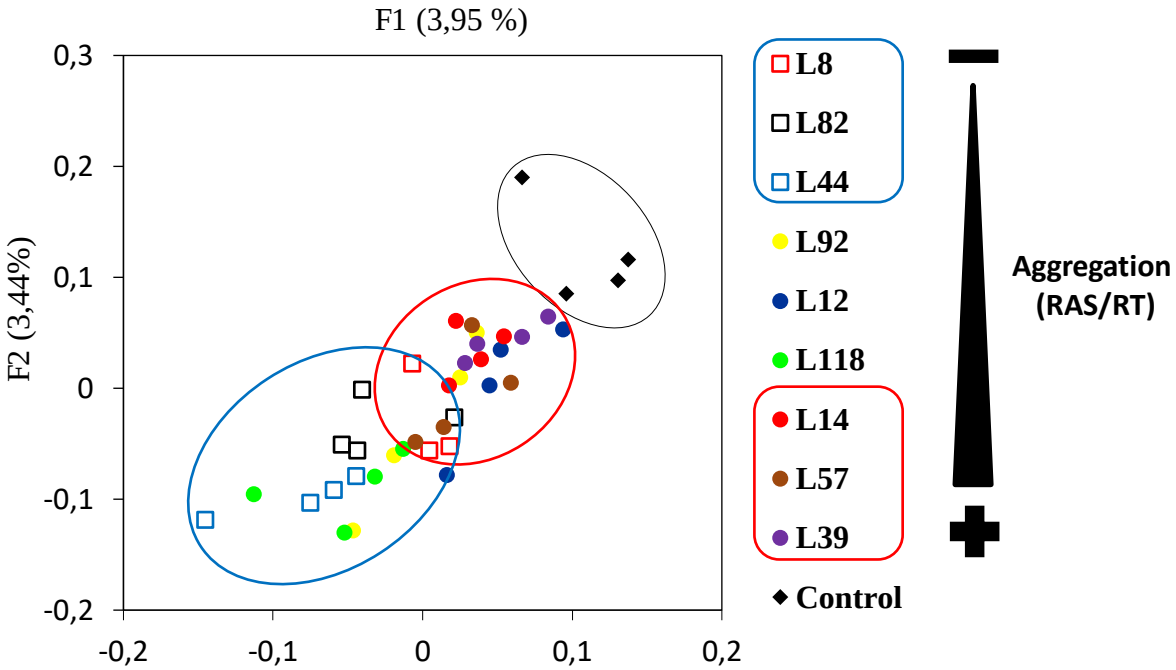


Ndour *et al*, Front. Plant Sci. 2017

➢ **Increased microbial communities and activity**

Soil aggregation
- Impact on microbiome -

S. Ndour

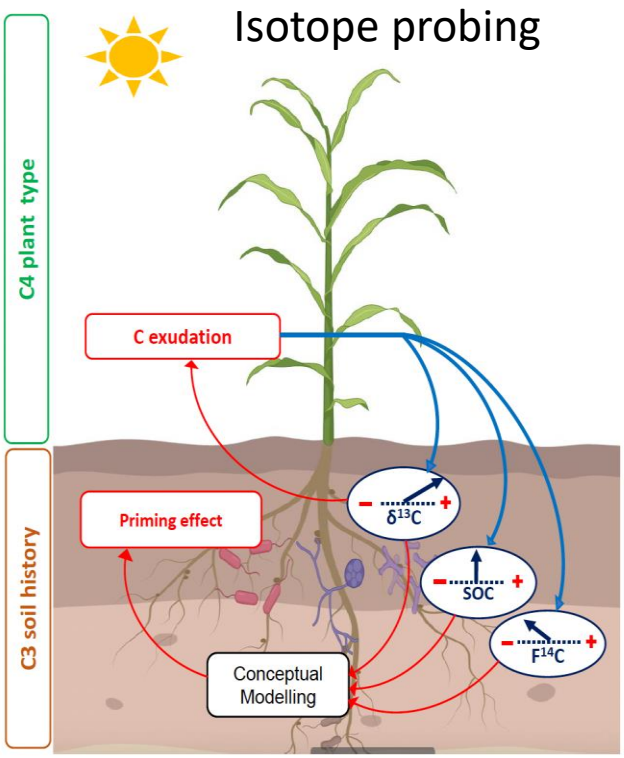


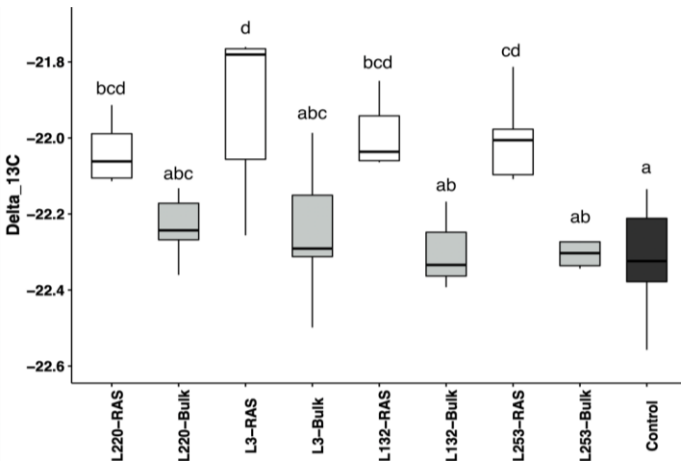
Ndour *et al*, Front. Plant Sci. 2017

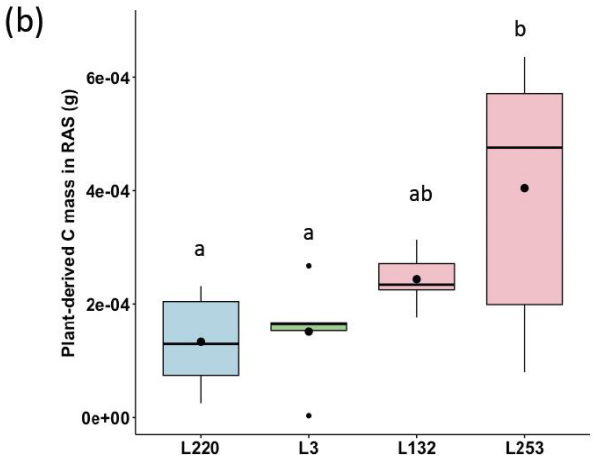
➢ **Decreased microbial diversity**

Soil aggregation
- Impact on rhizospheric C -

S. Ndour







Ndour et al., Soil 2022

- **Correlation between aggregation and C amount in millet rhizosphere**
- **Less priming effect for lines with high aggregation**

Soil aggregation in pearl millet

Ongoing tests

M. Diouf

Phenotypic characterization of backcrossed/selfed lines

=> Contrasted aggregation phenotype in an homogenous genetic background

Test of correlation of aggregation phenotype with

- **Water stress tolerance**
- **N and P deficiency tolerance**

Acknowledgments

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