Sorghum in Argentina: Trends and new challenges

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Contents

- Sorghum production in Argentina
- Photosynthesis and transpiration efficiency
- Salinity/Alkalinity tolerance

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Sorghum breeding program – INTA

- 60 years breeding
- Sorghum types: grain, forage and sweet (biofuel)
- Germplasm collection
- Research and extension

Grain

Sudan

Sileage

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Sorghum in Argentina

Country	Production (Mill. Ton)	Area (Mill. Ha)	Yield (Ton/Ha)
USA	9.47 (1)	2.06 (6)	4.59 (4)
Nigeria	6.9 (2)	5.9 (2)	1.17 (12)
Ethiopia	5.2 (4)	1.85 (7)	2.81 (9)
Sudan	5 (5)	7 (1)	0.71 (21)
India	4.74 (6)	4.1 (4)	1.16 (13)
Mexico	4.3 (7)	1.3 (10)	3.31 (7)
China	3.55 (8)	0.73 (15)	4.86 (3)
Argentina	3.2 (9)	0.73 (14)	4.38 (5)
Brazil	2.1 (10)	0.75 (13)	2.8 (10)
Burkina	1.9 (11)	1.8 (8)	1.06 (15)
Niger	1.9 (12)	3.7 (5)	0.51 (23)
Mali	1.5 (13)	1.5 (9)	1 (17)
Australia	1.45 (14)	0.51 (16)	2.84 (8)
Cameroon	1.4 (15)	0.85 (11)	1.65 (11)
European Union	1.02 (16)	0.2 (21)	5.1 (2)

	2017-18	2018-19	2019-20	2020-21
Exports				
Argentina	473	254	426	1,000
Australia	449	91	107	500
Ethiopia	75	75	75	75
India	123	53	31	50
Kenia	136	53	31	80
Nigeria	100	100	50	50
USA	4,839	2,437	5,480	7,600

Sorce: USDA

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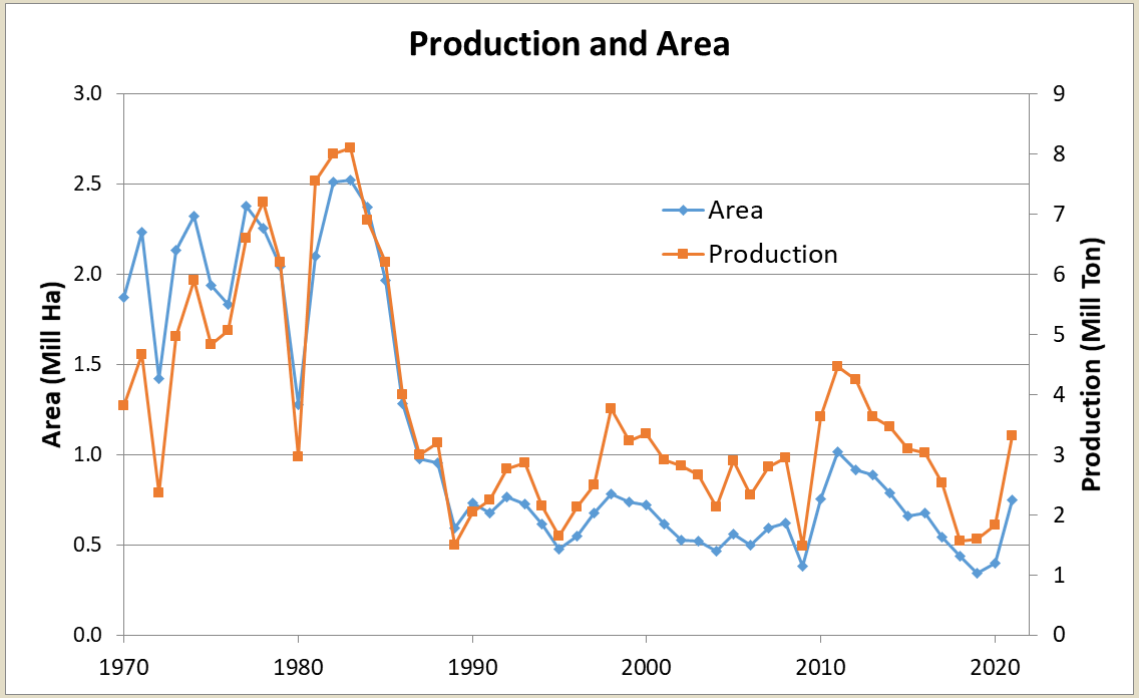
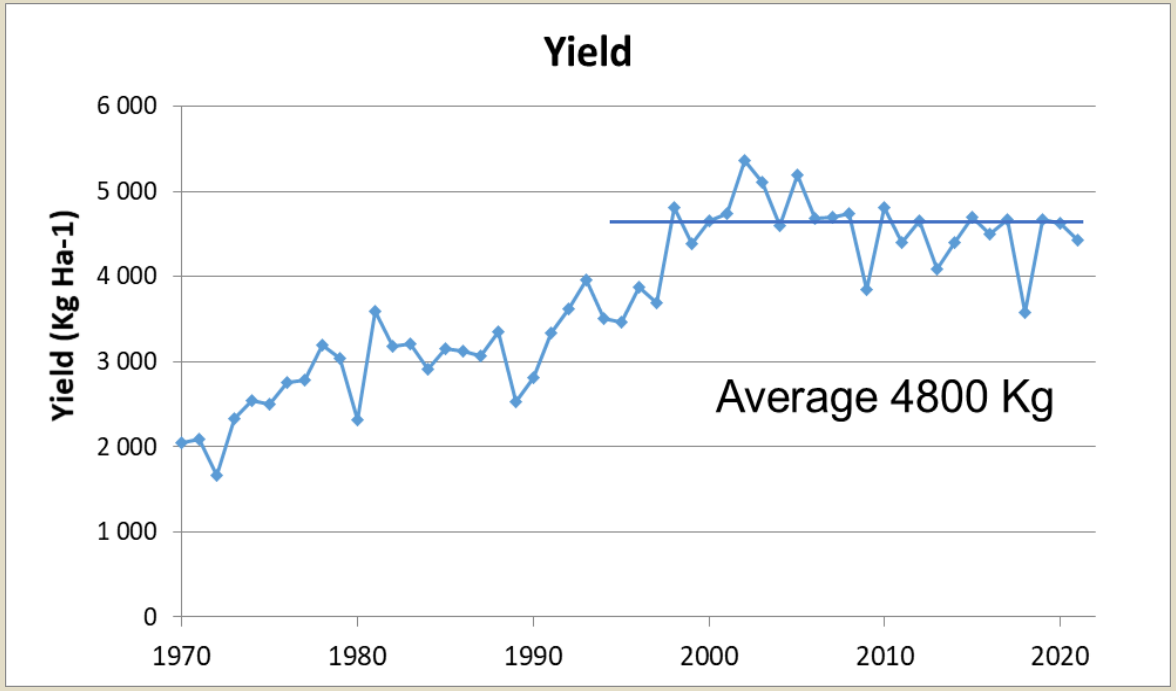
Historical trends





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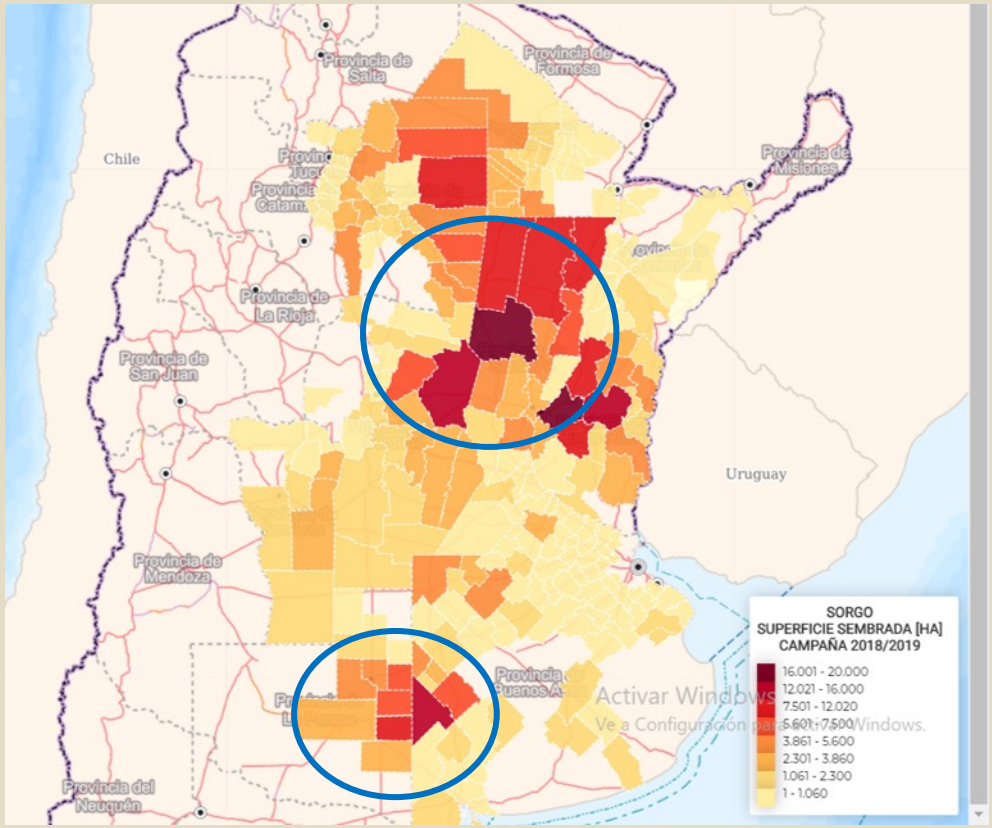
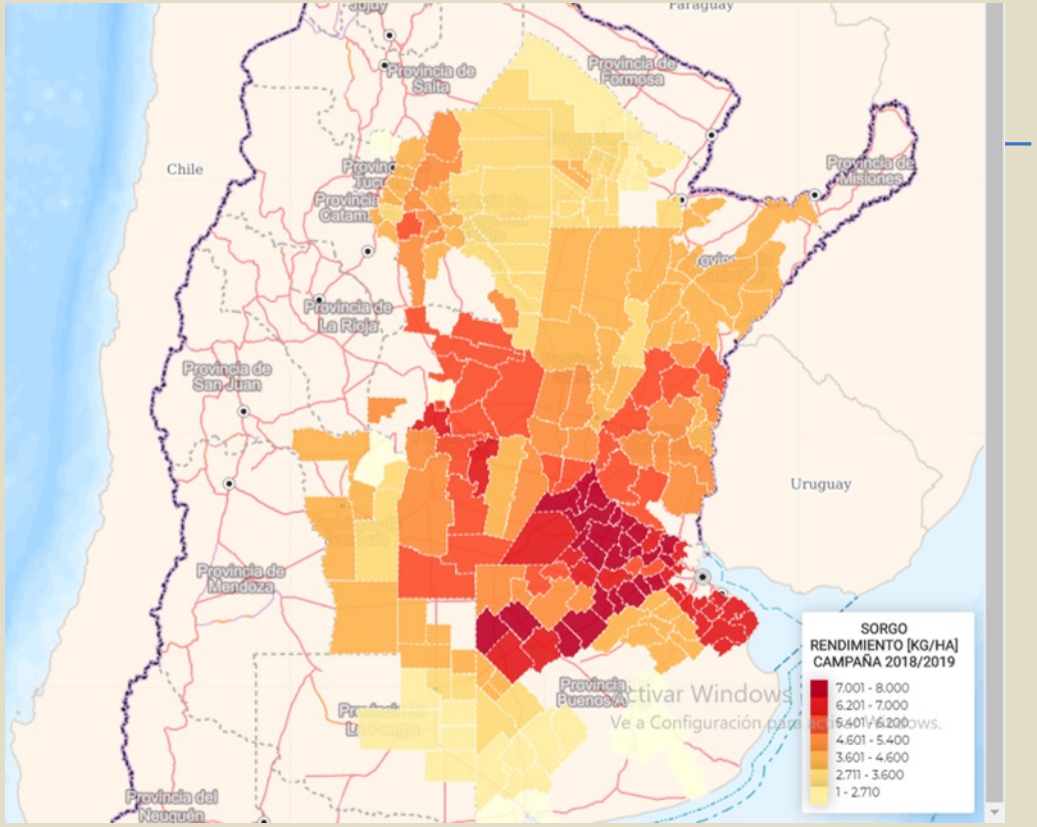
Sorghum regions in Argentina

Area



Yield



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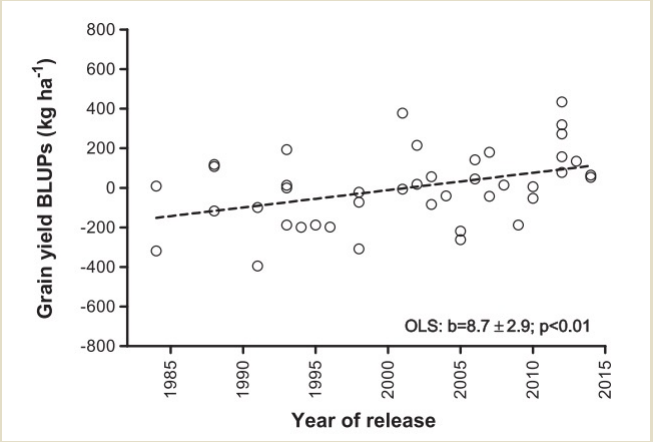
Grain Sorghum

- High grain yield: 4-12 Tn/Ha
- Tannins
- Height: 1.1 a 1.8 m
- Stay green
- Resistance to biotic (lodging, ergot, mildew) and abiotic factors (drought, cold and salinity)
- Test Weight (Hectolitre Weight)



Gizzi and Gambin (2015)

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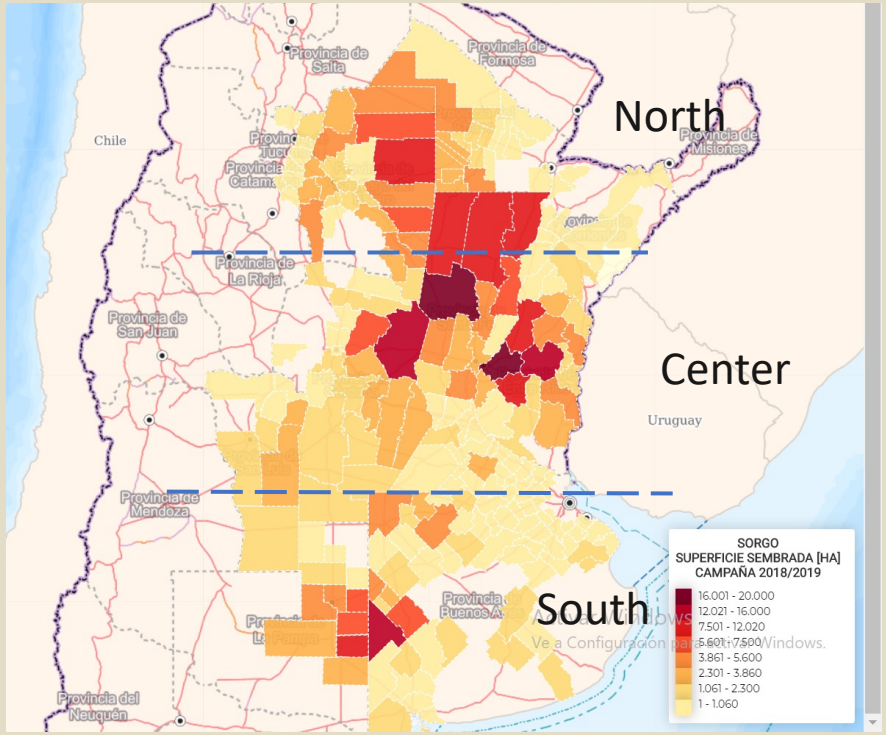
Defining ideotypes for each region



North

- Variability in planting dates
- All maturity types
- Disease and pest pressure
- Tannins (birds)

Center

- Short and intermediate maturity
- Disease and pest pressure
- Humid fall (grain mold and sprouting)
- Tannins (birds)

South

- Short growing period
- Cold tolerance (early stage)
- Low bird pressure

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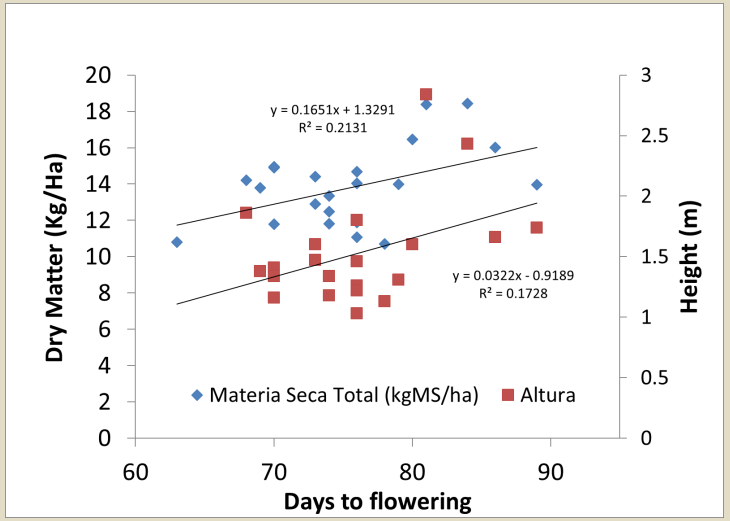
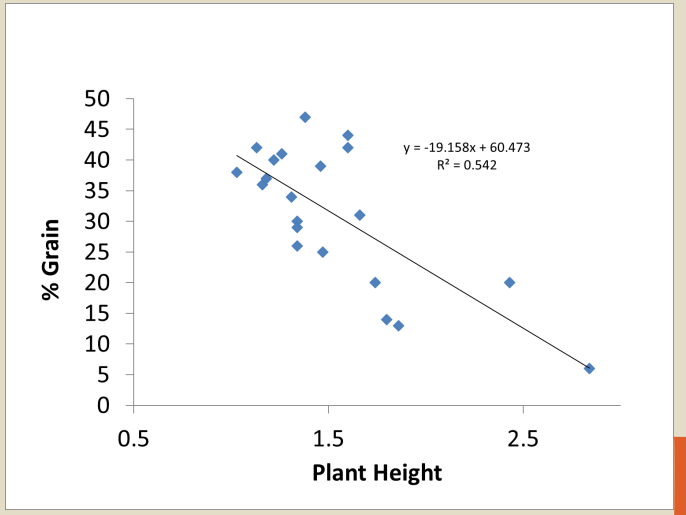
Sileage Sorghum

- Biomass production
- Higher grain proportion
- Sileage and dual purpose (grain/sileage)
- Largest variability in plant types
- Stay green and sugars in stems: problems with harvesting time





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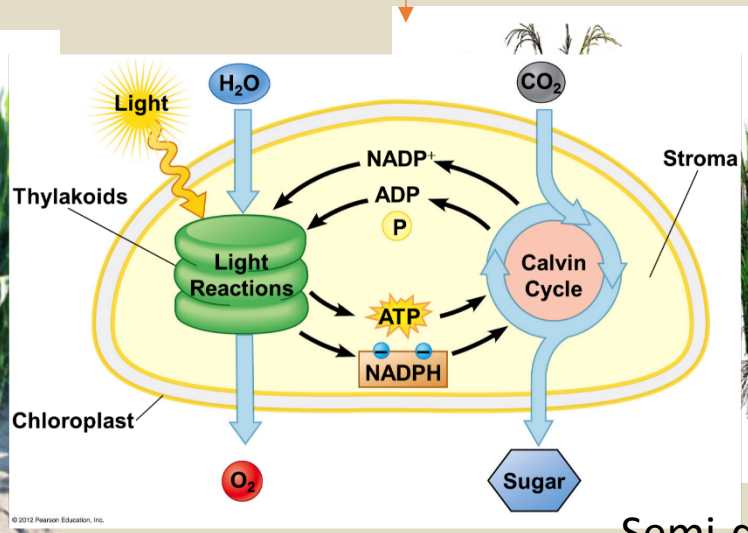
Why is it important to study photosynthesis?

YIELD = Radiation × Interception efficiency × Conversion efficiency × Harvest Index

Monteith (1977)

Leaf angle in maize



Photosynthesis

Semi-dwarf rice and wheat

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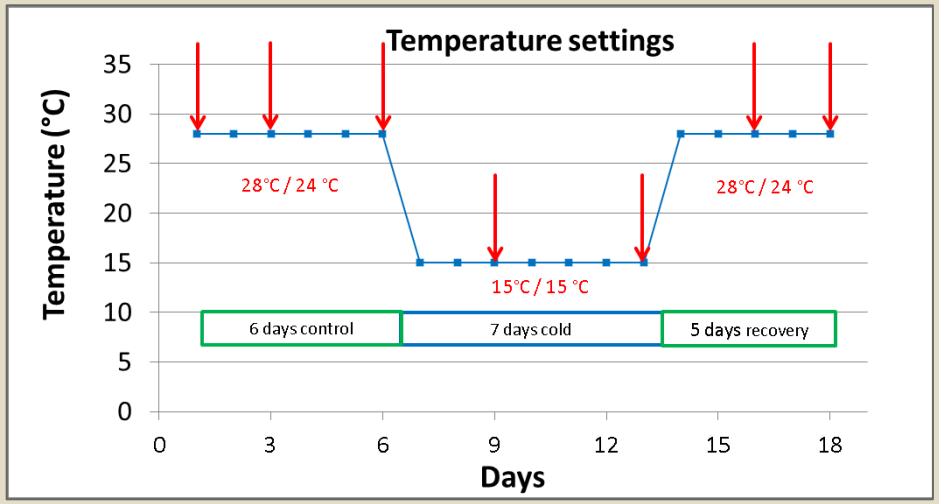
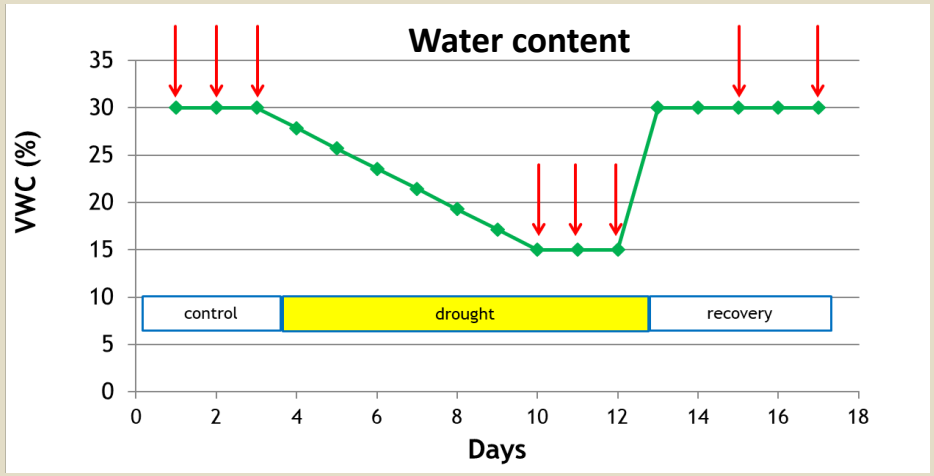
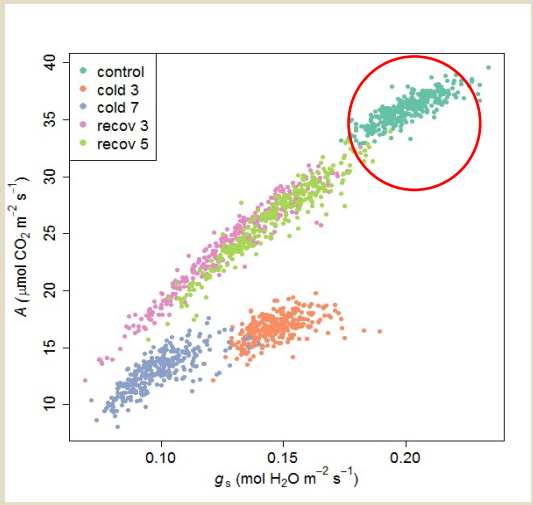
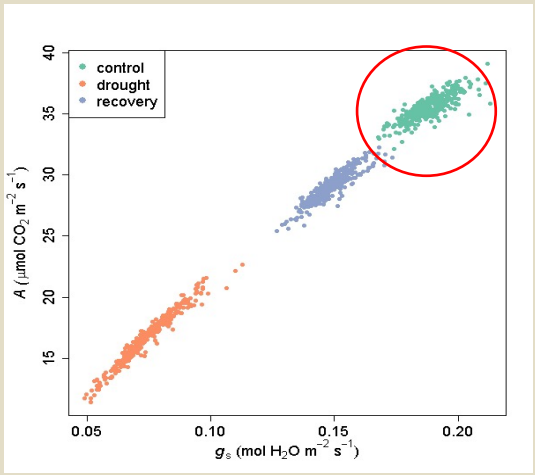
Photosynthesis – response to stress





Photosynthesis vs stomatal conductance





Results

- Natural variation in photosynthesis in sorghum
- Loci for non-stress, cold and drought conditions
- Genomic regions identified in multiple traits
- Candidate genes
- Irrigation system for drought experiments

Ortiz et al (2017) ; Ortiz and Salas Fernandez (2021) accepted

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Natural variation in photosynthesis

Belén Rosas (Conicet)

Year 1	Year 2	Year 3
Field	Field	Greenhouse
334 genotypes	304 genotypes	150 genotypes

Measurements

- Efficiency of energy captured (Fv´/Fm´)
- Effective quantum yield of PSII (Φ_{PSII})
- Plant Height (ALT)
- Chlorofill content (SPAD)
- Stomatal density (DE)
- Specific leaf area (AFE)
- Stomatal conductance (only in year 3)

Field experiment (2020)

Greenhouse experiment (2021)

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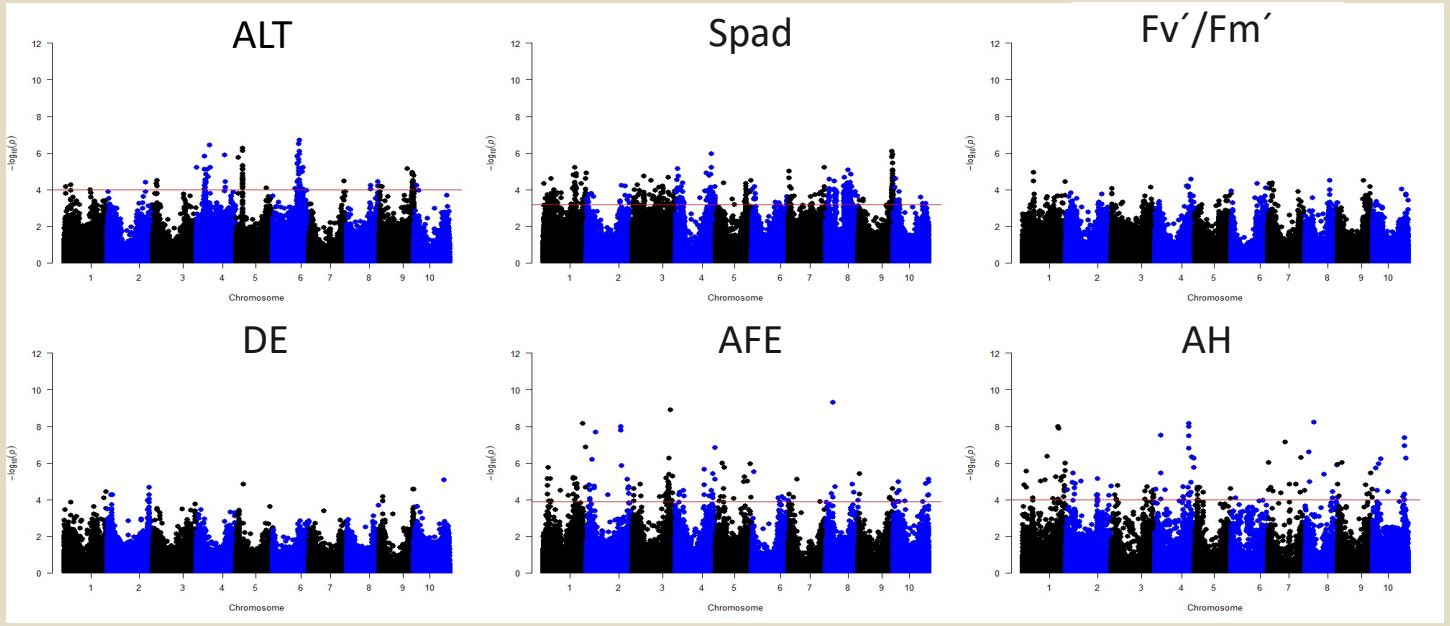
Results



- Multiple markers in important traits
- GxE interaction
- Interesting trait correlations:
  - Plant height : chlorophyll content (-0.36)
  - Specific leaf area: chlorophyll content (-0.20)
- Next: Study physiological mechanisms in contrasting genotypes

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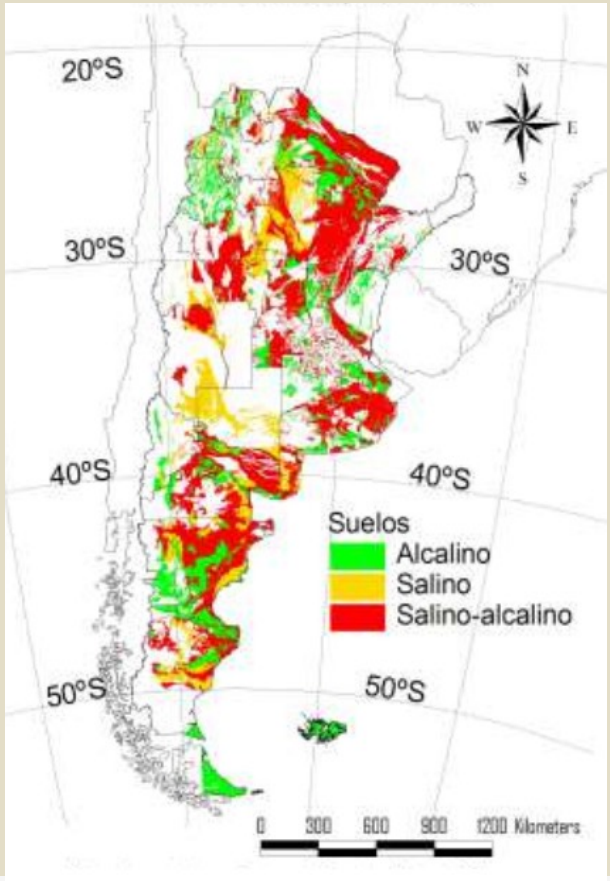
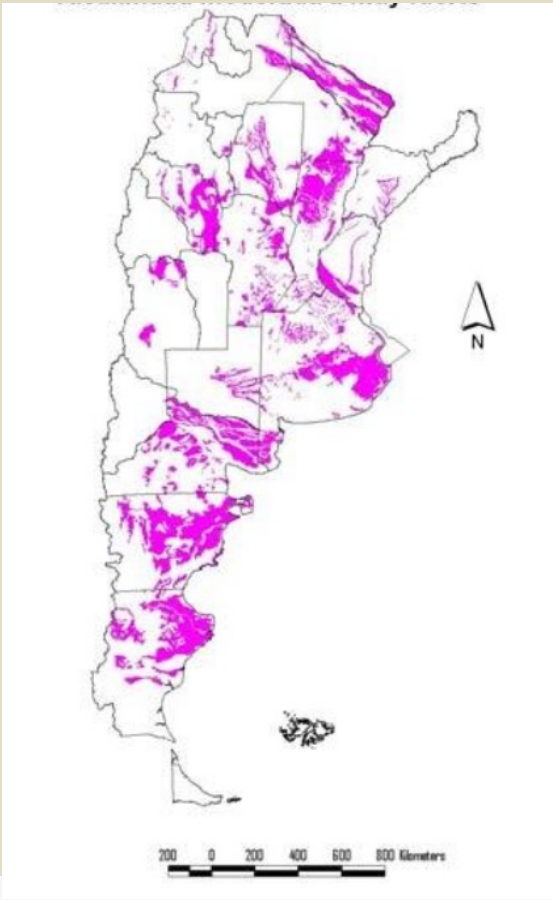
Salinity/alkalinity tolerance

Soil salinity and alkalinity



Soil alkalinity



- Extensive regions with salinity and alkalinity problems in Argentina
- Sorghum can grow under these conditions and produce biomass and grain
- Soil recovery

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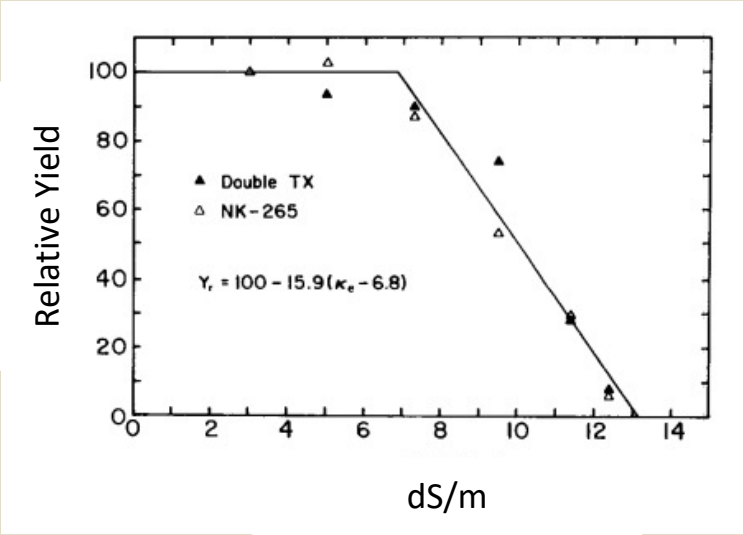
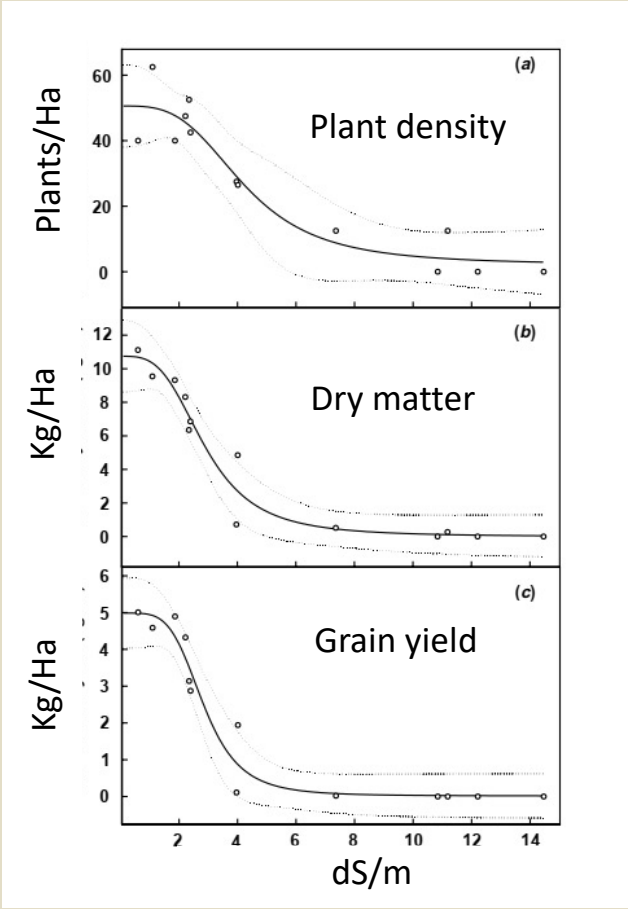
Salinity/alkalinity tolerance

Controlled conditions



Francois et al (1984)

Field conditions



Daniells et al (2001)

- Germination is key
- Sorghum is sensitive in Initial stages

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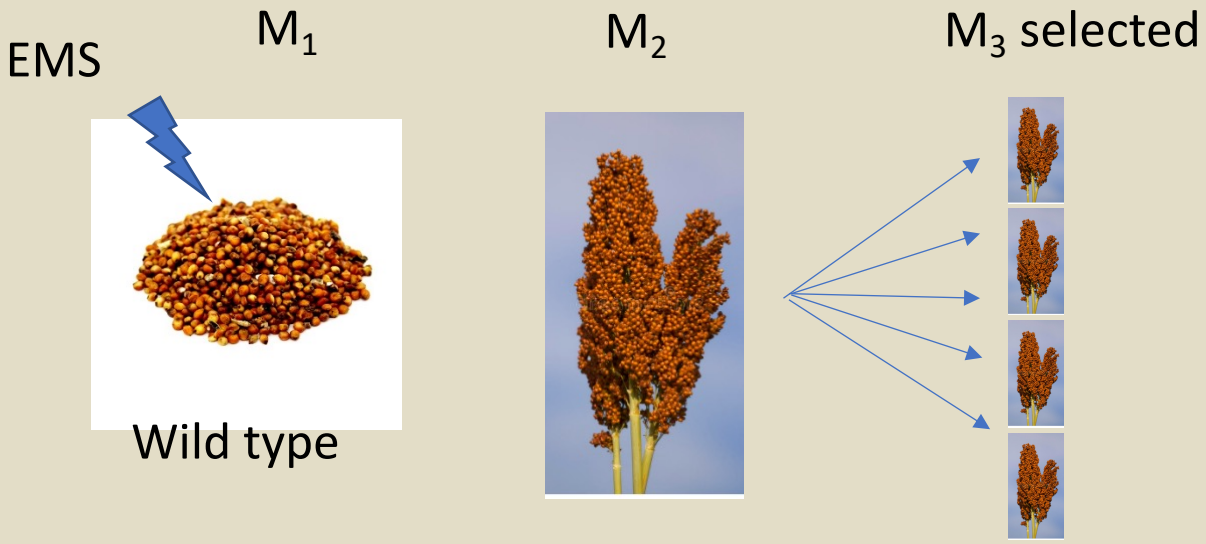
Mutagenesis

- Mutagenesis of elite line via EMS (Lucio Lombardo y Celina Ghione)
- Mutant population (350 M lines)
- Selection in the field (germination)



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Salinity/alkalinity tolerance

M3 selection

Derived hybrid selection

	pH	CE (dS m)
0-20	8.1	4.5
20-40	8.0	8.3

- Up to 80% germination
- Up to 3000 Kg/Ha yield

Saira (Córdoba)

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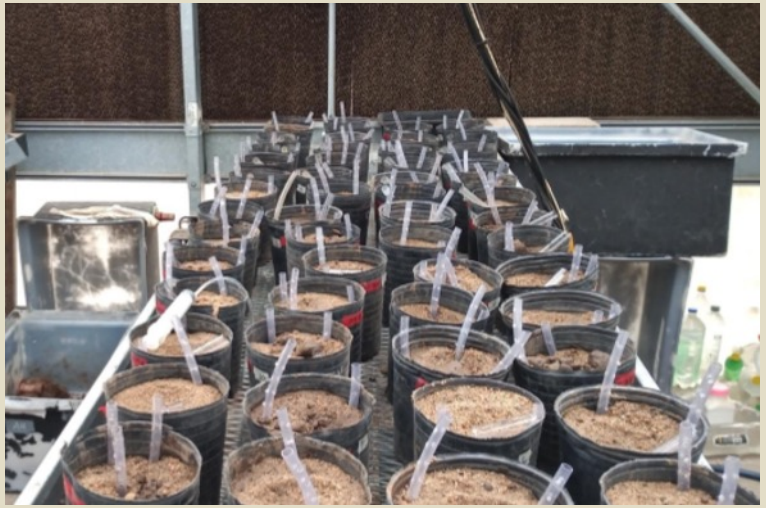
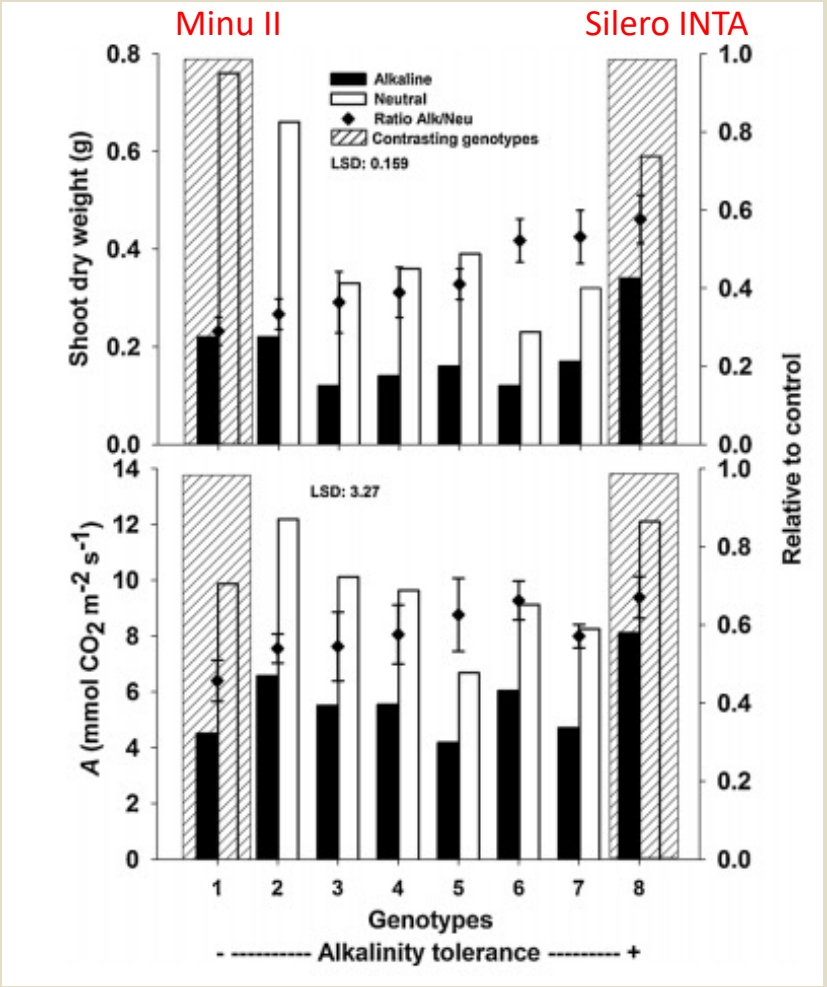
Response to alkalinity

Plants grown in hidroponic system



Dolores Bustos and Fernando Luna
IFRGV INTA



- System allowed to differenciate contrasting genotypes
- Differences in photosynthesis
- Differential expression of phytosiderophore genes (Fe defficiency)
  Next step: association mapping

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Concluding remarks

- Sorghum production is growing in Argentina in response to exports (China)
- Important to define ideotypes by region and use
- Grains with tannins are still used
- Public programs need to work on pre-breeding to provide adapted germplasm
- Sorghum breeding program at INTA works on abiotic stress tolerance
- Interest in research in photosynthesis for increasing yield potential

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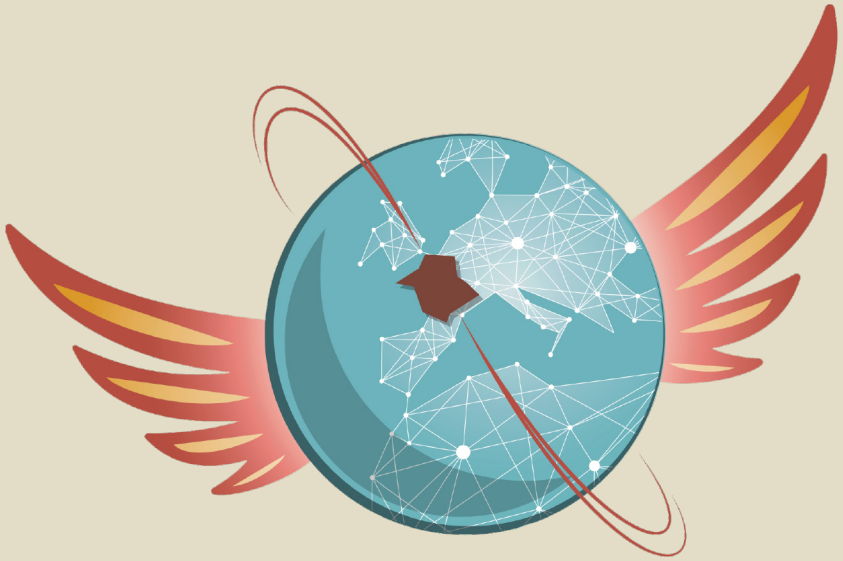

Thank you

Partners

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