Plant Ideotypes for climate change

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Climate Change (Projected Trends)

CO_2	379ppm in 2005	↑	450 ppm in 2050
Temperature	Avg 0.74°C since 1906 Min 0.5°C since 1906	↑ ↑	Avg 1.8°C in 2100 Min 1.3-1.7 °C in 2050
Solar Radiation		↓	Reduction in solar radiation
Rainfall (Total and distribution)		↑ ↓	Increase in high latitudes and decrease in low latitudes

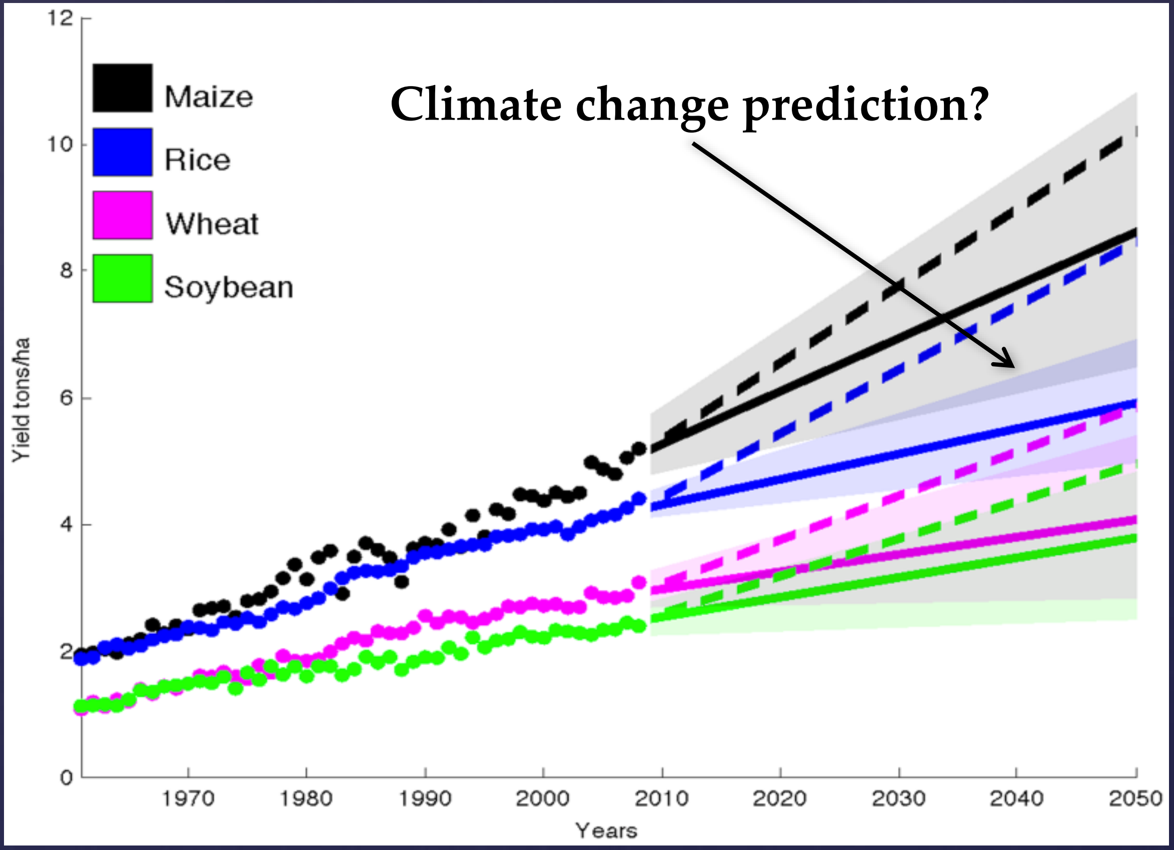
IPCC 2013

Global climate is changing and rice production will have to adapt to ensure sustainability

Food security

In the future large imbalance between rice supply and demand

-Population growth up to 9 billion by 2050
-Urbanization improving living standards

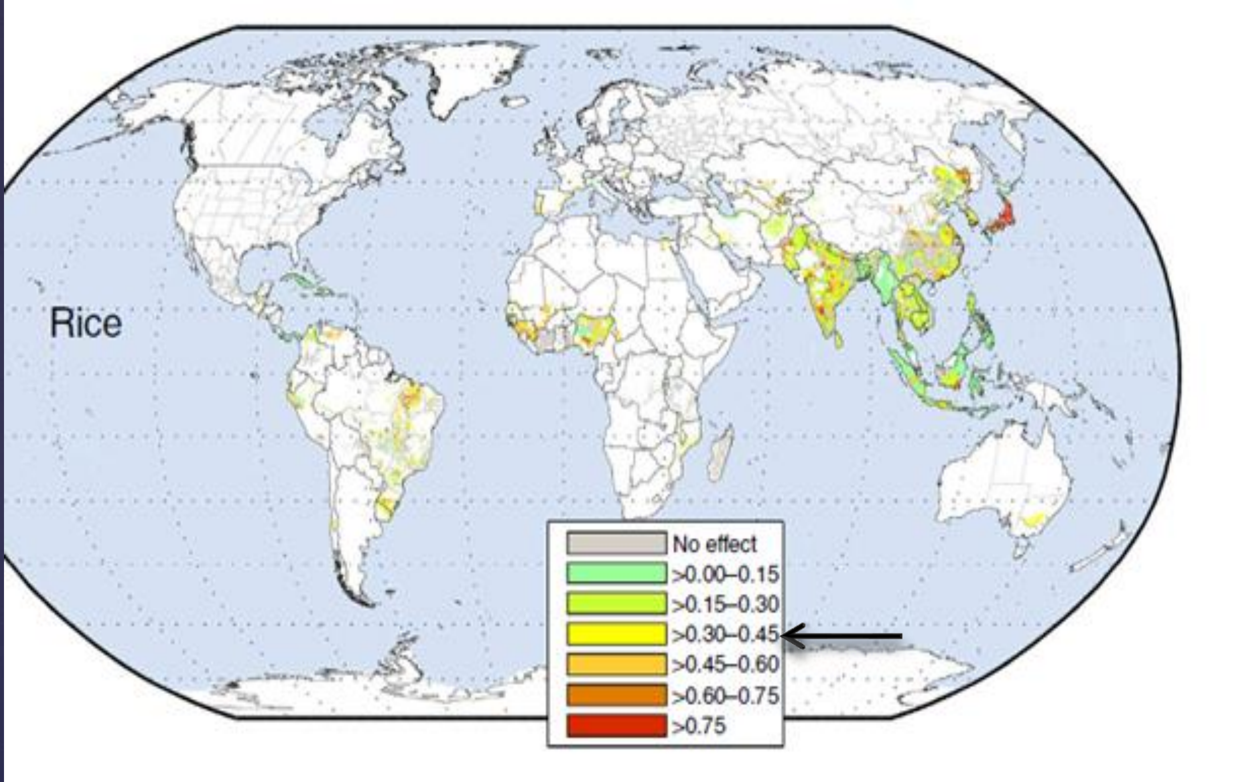


Ray et al, 2013

Climate variability and yield

-Climate variability explains ~32% of rice yield variability globally.

-25% to 38% in South America (precipitation and temperature)

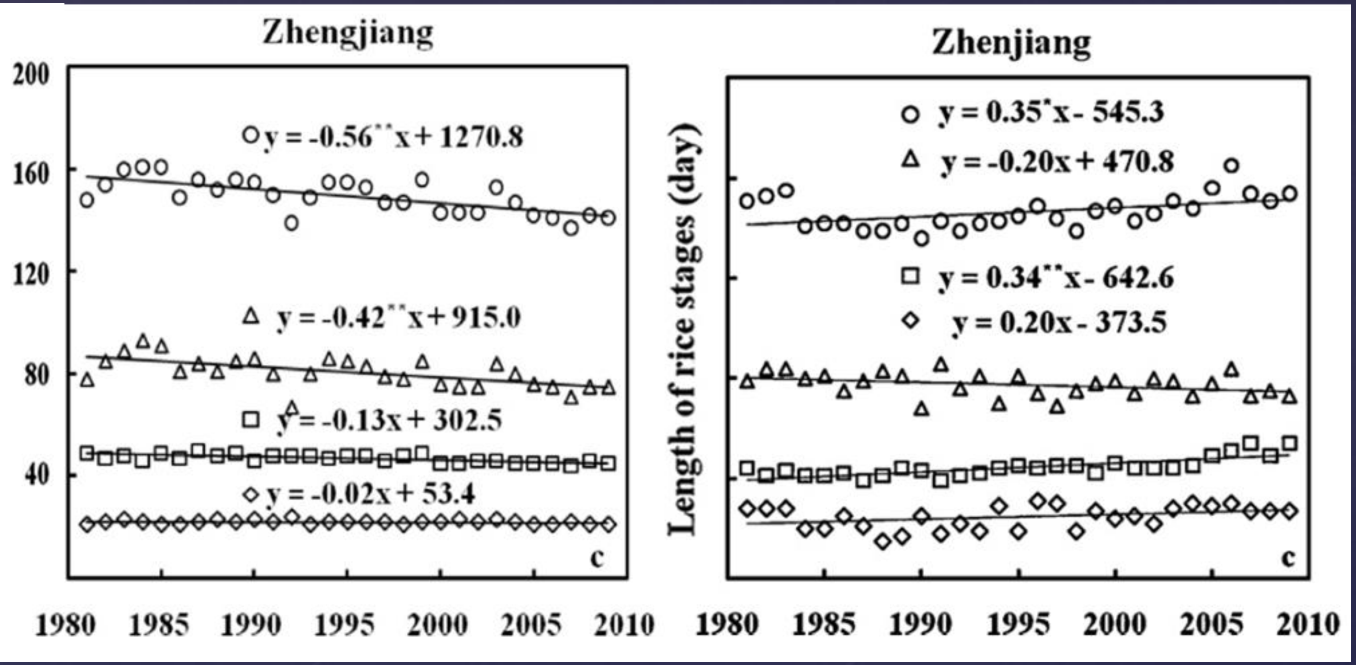


Ray et al, 2015

Rice production is highly sensitive to climate conditions :
-Facts from empirical modeling (Jimenez et al) : different varietal responses to climate variability.

Potential mitigating impact of varietal changes

Simulated Observed



-Facts from mechanistic modeling (Liu et al, 2012)

The idea behind "ideotype for Climate Change"" is to adapt agriculture to global change with emphasis on crop improvement

Breeding tools improving yields in current climate scenarios might contribute to mitigate climate change effects on yields

Breeding tools

Under abiotic constrains yield has low heritability, breeding needs the inclusion of secondary traits

Biomass (high NUE, WUE, RUE) × **Harvest Index** **Grain Yield**

Partitioning (Source,Sink) is a dynamic process and the result of source-sink relationships in the different growth phases of the crop.

All processes (resource acquisition, conversion and partition) are under genetic control and will interact with the environment determining the final plant type

Breeding tools: secondary traits

…..Little evidence of inclusion in breeding programs

- ✓ Improved knowledge of secondary traits conferring adaptation
- ✓ Genotyping techniques
- ✓ Phenotyping techniques

Lack of knowledge on:
-Compensation among plant traits
-Genotypic variability and predominant genetic control
-Trait behavior in different environments

Breeding tools: Plant Ideotypes

Martre et al (2014) combination of morphological and physiological traits (or their genetic basis) conferring to a crop a satisfying adaptation to a particular biophysical environment, crop management and end use

Donald (1968) : a biological model which is expected to perform or behave in a predictable manner within a defined environment

Environment

- Climate, management, cropping systems, soils …
- The importance of a trait may vary depending on the environment

Genes

- Trait definition, Phenotypic tools
- Identify compensation among traits, genetic variance, genetic control

Climate variability

Plant Ideotypes

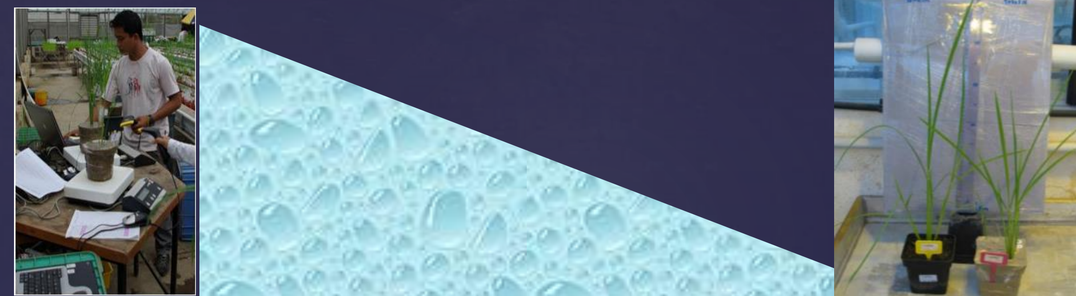
Climate change

An ideotype for climate change is the combination of traits (genes) that confers the crop a satisfying adaptation to climate variability and extreme events in specific environments and under specific cropping systems

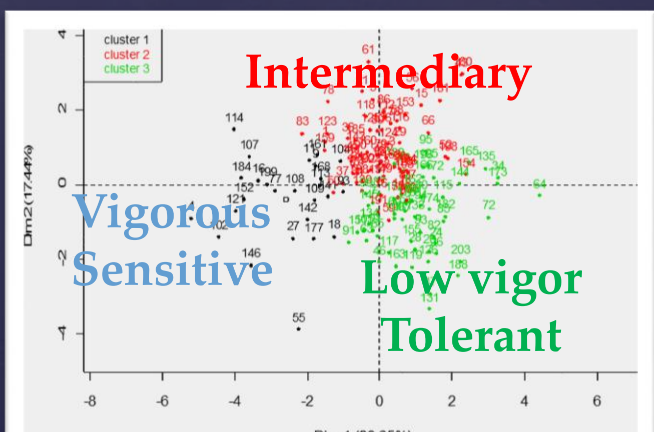
Ex 1 :Early vigor and drought tolerance

Ideal trait association for high early vigor:
High Shoot Biomass with
High Leaf Nb
Low Leaf dimension
High Tiller Nb

6th leaf stage FTSW = 0.2

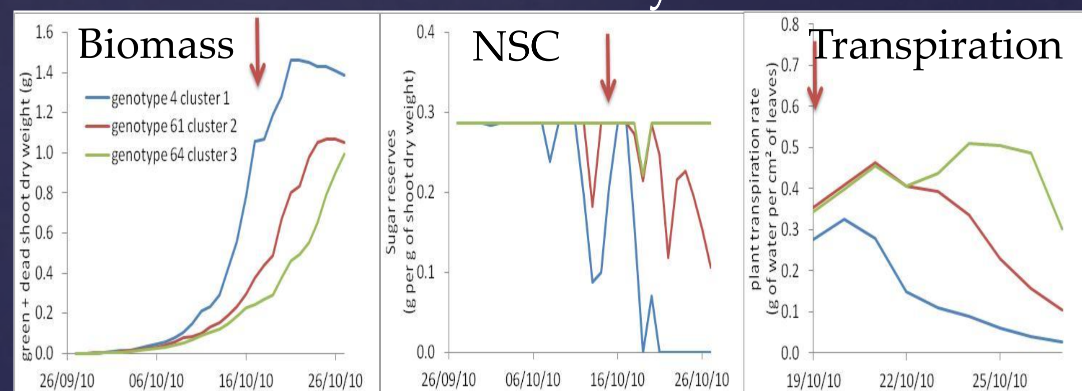


Rebolledo et al, 2013



Pallas et al, 2014

30d model simulation Dry-down at 17d



Ideal trait association showed less tolerance under drought

- **The study of secondary traits contributed to understand the trade off between early vigor and drought tolerance**
- **Need to define the drought type to define the trait value**

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Ex.3 Site specific climate variability

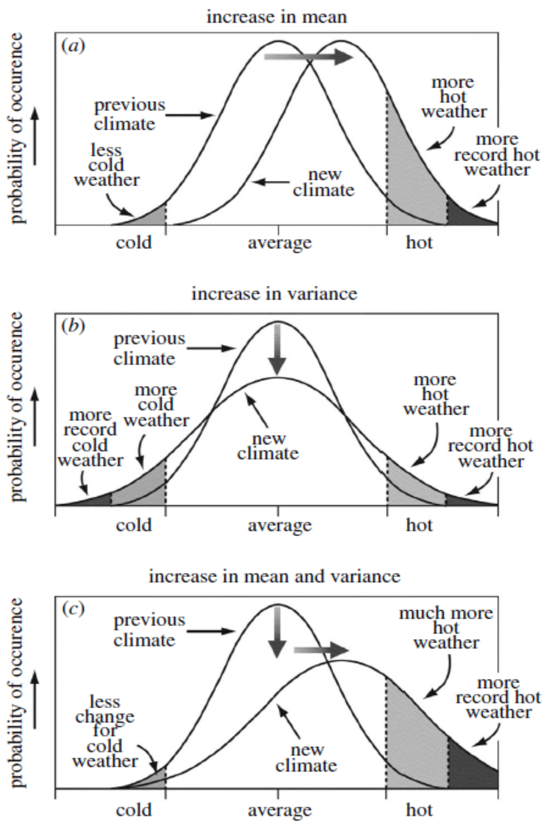


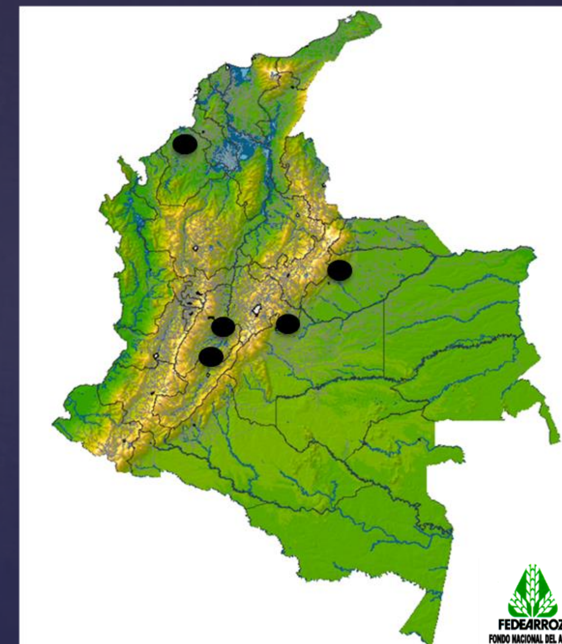
Figure 9. Postulated changes in the distribution of temperatures involving changes in their (*a*) mean, (*b*) variance and (*c*) both on the frequency of occurrence of extreme conditions (IPCC 2001).

Porter and Semenov, 2005

Weather variability comes from three sources, change in:

- mean weather
- distribution of weather (more frequent extreme events
- A combination of changes to the mean and its variability

⇒ How changes in the climate variability are mirrored in changes in the variability of crop production?

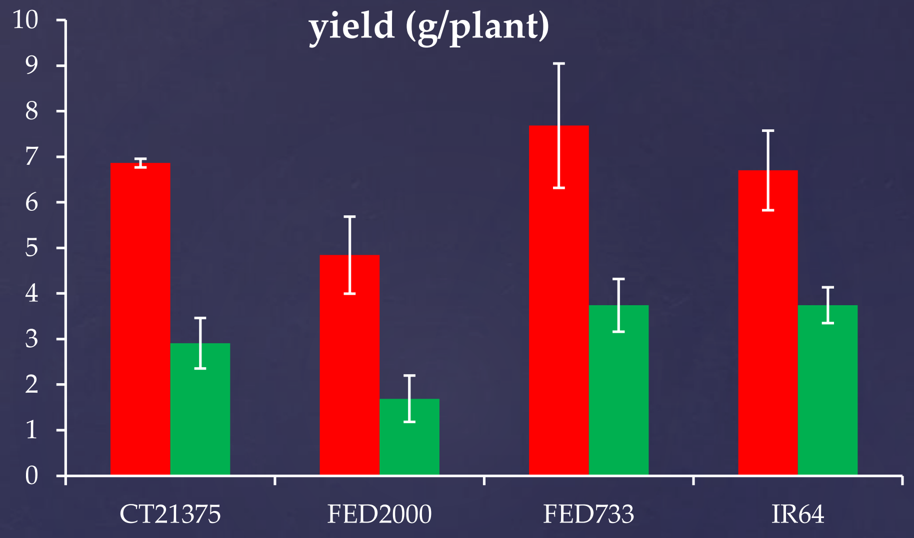


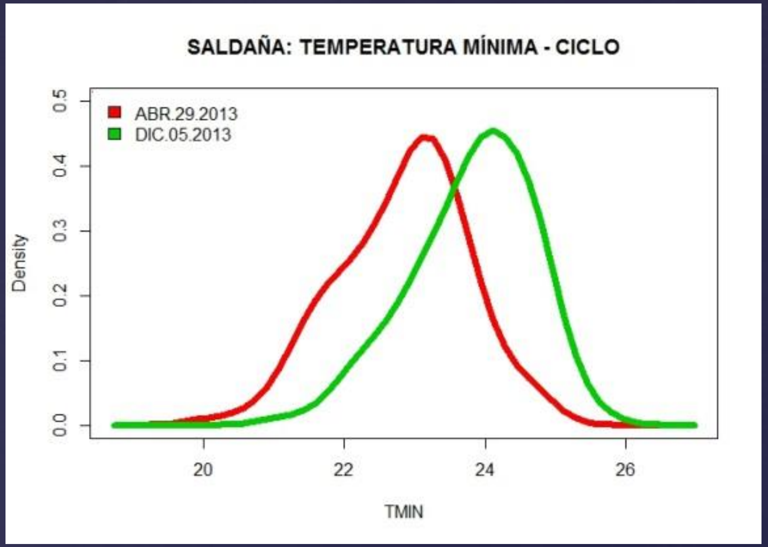
Detailed MET to dissect traits of interest and ideotypes for an specific region

It is important to represent changes in both the mean and variability of climatic conditions in order to predict the impact of climate change on crop development and yield

Saldana – Tolima (Colombia) Case study

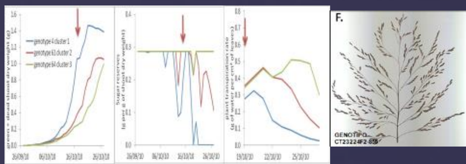
1. Climate limiting factors and traits of interest



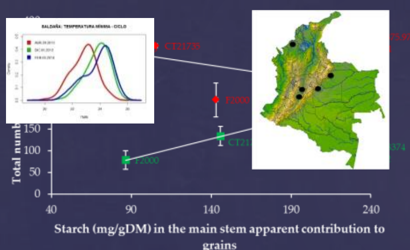


1°C increase in the average of minimum temperature reduce yields in the second sowing in Saldana.

Can we use actual climatic variability in specific regions to dissect traits that might be important in future climate scenarios?



=> a single trait will not improve plant performance in all scenarios of climate variability, in all cropping systems



=> a single genotype will not cope with all the existing climatic (temporal) variability

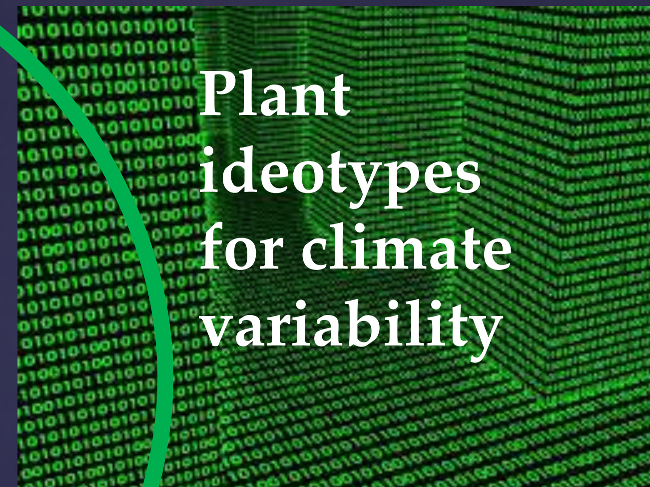
=> define the environment , cropping system and target areas will speed up the adaptation of the ideotype

Summary

Site characterization
-Climate
-Soils
-cropping system
-management
-End use

Traits of interest
- Trait dissection
- Trade-offs

Genes
- Genotypic variance
- diversity
- Genotyping and phenotyping tools
- Local genetic background



Empirical and Mechanistic modelling + Future spatial and temporal climate

Plant ideotypes for climate change

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IDEOTYPE: A SET OF TRAITS FOR EACH ENVIRONEMENT

Putting together the technology to fit on the actual climate variability on a specific site will increases our chances to be prepared for future climate change conditions