LOUISIANA STATE UNIVERITY
College of Agriculture
School of Plant, Environmental, and Soil Sciences
AGRO 7076 HTP in Plant Breeding

Enviromics

Prof. Roberto Fritsche-Neto
Dr. Germano Costa-Neto

rfneto@agcenter.lsu.edu

Baton Rouge, Mar 6th, 2024

Prediction-based model

$$RS = \frac{i.r_{aP}.\sigma_a}{T} \qquad r_{aP} = \sqrt{h_a^2}$$

$$y = u + X\beta + Zg + Wge + \varepsilon$$

Envirotyping (W):

- **Virtually increase the MET**
- **Allows to better predict gxe**
- **Optimize cultivar recommendation**
- **Thus, increase h**

Current challenges:

1. **Obtain high resolution data**
2. **Translate information**

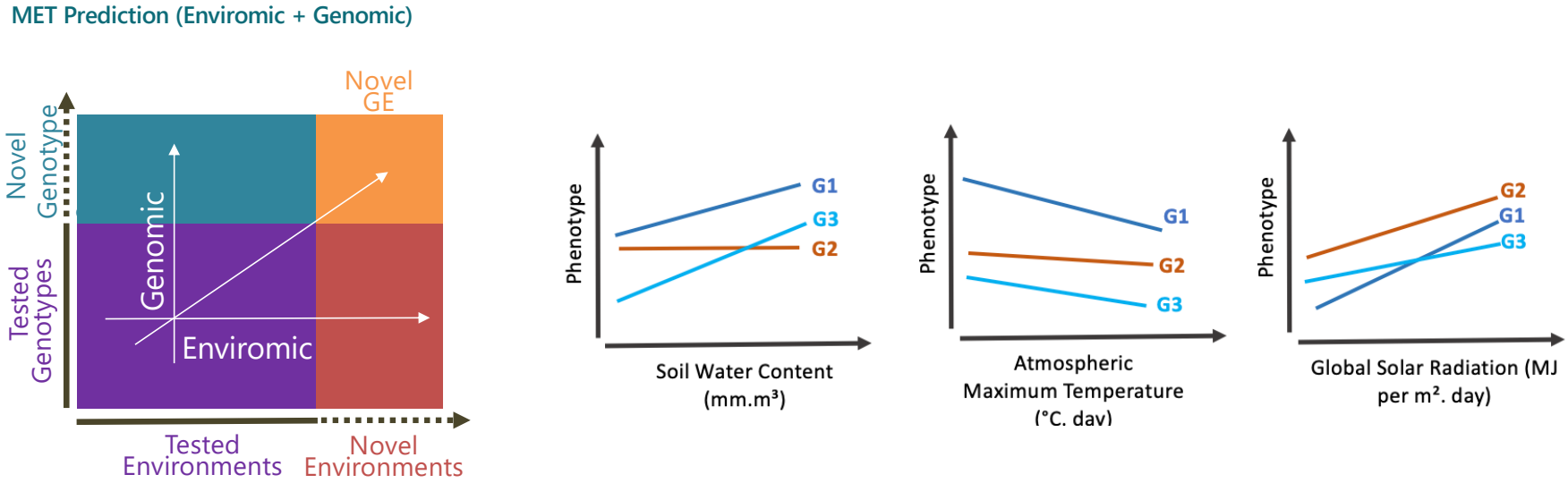
Heredity
https://doi.org/10.1038/s41437-020-00353-1

the geneticssociety

ARTICLE

Nonlinear kernels, dominance, and envirotyping data increase the accuracy of genome-based prediction in multi-environment trials

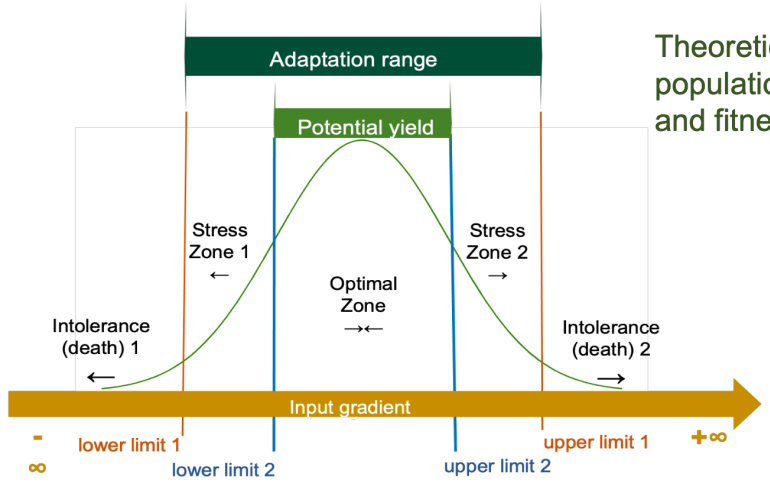
Germano Costa-Neto[1] · Roberto Fritsche-Neto[1] · José Crossa[2]

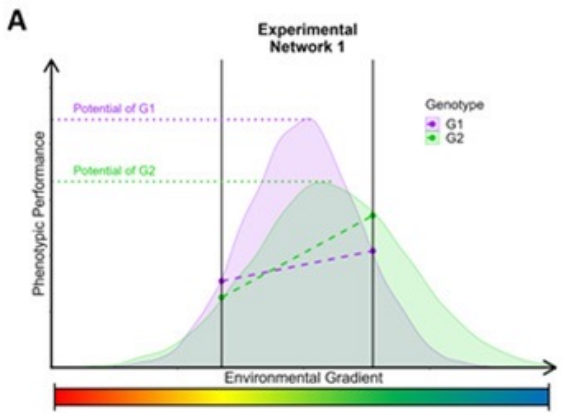


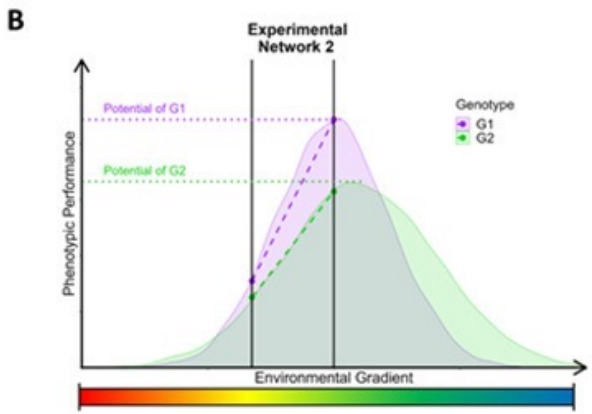
Shelford (1931, 1932)
Tolerance Limits and adaptation

Theoretical population diversity and fitness

Theoretical gradient of some continuous environmental factor







frontiers in Plant Science

ORIGINAL RESEARCH
published: 07 October 2021
doi: 10.3389/fpls.2021.717552

Enviromic Assembly Increases Accuracy and Reduces Costs of the Genomic Prediction for Yield Plasticity in Maize

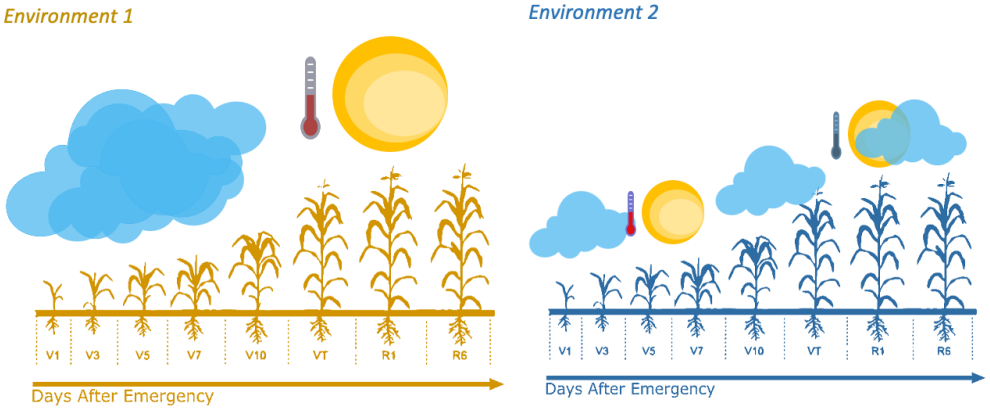
Germano Costa-Neto [1,2], Jose Crossa [3,4†] and Roberto Fritsche-Neto [1,5]*

- Cardinals must weight EC
- Not all EC are important:

- for all traits or

- during the whole cycle

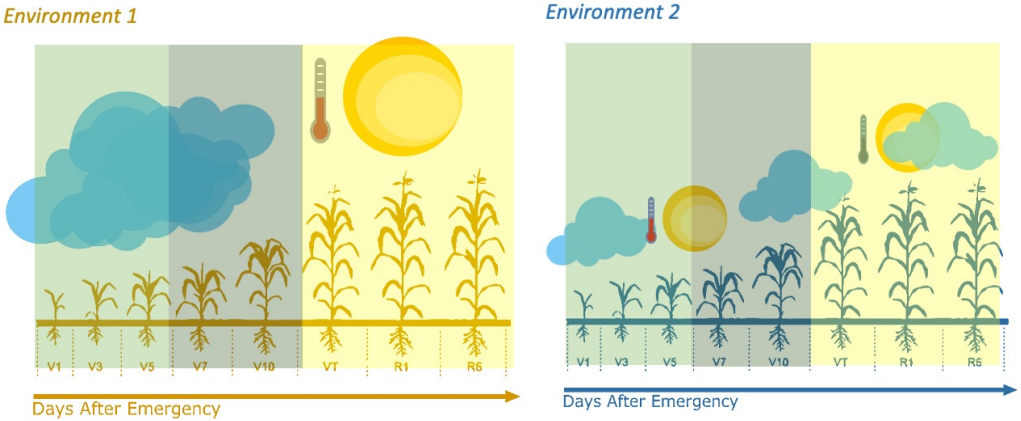
Cumulative values per croplife (poor description)



- Precipitation: 560 mm/cycle
- Temperature: 962 °C/cycle
- Radiation: 724 MJ m2/ cycle

- Precipitation: 560 mm/cycle
- Temperature: 962 °C/cycle
- Radiation: 724 MJ m2/ cycle

Cumulative values per stage (better)



- Precipitation (mm): 300 (T1); 260 (T2); 0 mm (T3)
- Temperature (°C): 150 (T1); 100 (T2); 712 (T3)
- Radiation (MJ/m2): 144.8 (T1); 115.8 (T2); 463.4 (T3)

- Precipitation (mm): 224 (T1); 168 (T2); 168 (T3)
- Temperature (°C): 150 (T1); 100 (T2); 712 (T3)
- Radiation (MJ/m2): 144.8 (T1); 115.8 (T2); 463.4 (T3)

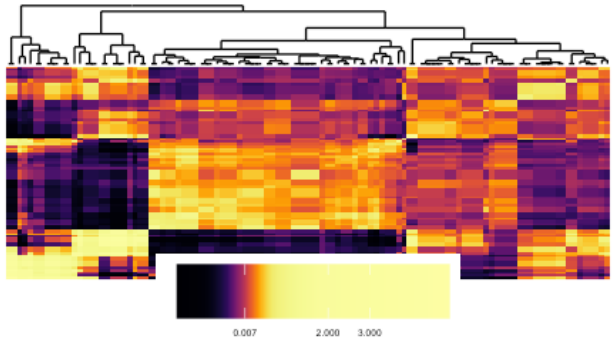
- **Crop-specific tune**
- Tbase1 = 12,
- Tbase2 = 24,
- Topt1 = 33,
- Topt2 = 37,
- Alt = 540

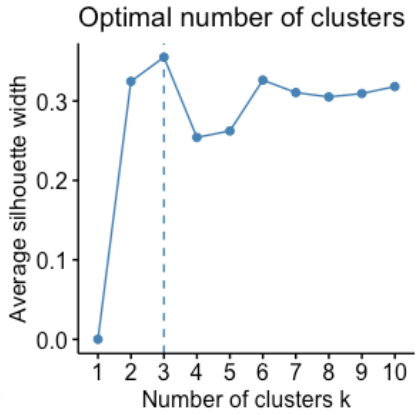
- **Temporal variations**

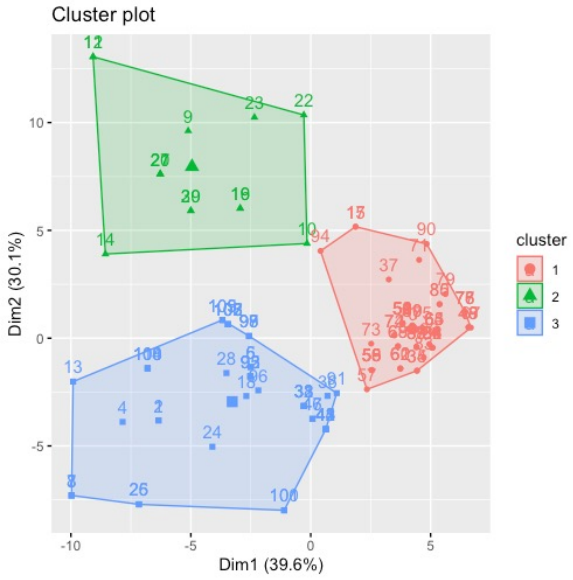
- From 0 DAE (emergence day) to 14 DAE (appearance of the first leaf, V1).
- From 15 DAE (V1) to 35 DAE (appearance of the fourth leaf, V4).
- From 36 DAE (V4) to 65 DAE (tasseling stage, VT).
- From 66 DAE (VT) to 90 DAE (kernel milk stage, R3).
- From 91 DAE (R3) to 120 DAE (physiological maturity).

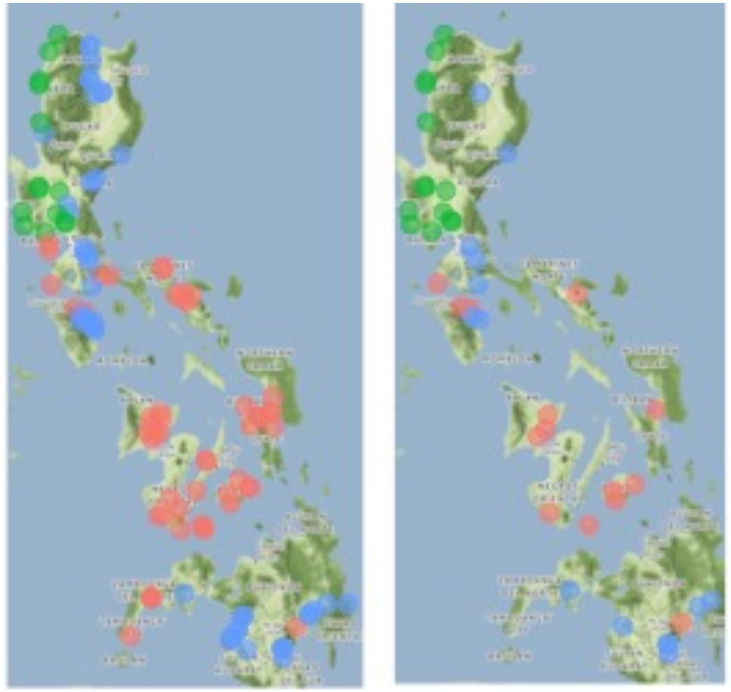
Source	Environmental factor	Unit
NASA Power	Top-of-atmosphere insolation	MJ m^{-2} d^{-1}
	Average insolation incident on a horizontal surface	MJ m^{-2} d^{-1}
	Average downward longwave radiative flux	MJ m^{-2} d^{-1}
	Wind speed at 10 m above the surface of the earth	m s^{-1}
	Minimum air temperature at 2 m above the surface of the earth	°C d^{-1}
	Maximum air temperature at 2 m above the surface of the earth	°C d^{-1}
	Dew-point temperature at 2 m above the surface of the earth	°C d^{-1}
	Relative air humidity at 2 m above the surface of the earth	%
	Rainfall precipitation (P)	mm d^{-1}
Calculated[a]	Effect of temperature on radiation-use efficiency	–
	Evapotranspiration (ETP)	mm d^{-1}
	Atmospheric water deficit P-ETP	mm d^{-1}
	Deficit of vapor pressure	kPa d^{-1}
	Slope of saturation vapor-pressure curve	kPa C° d^{-1}
	Temperature range	°C d^{-1}
	Global solar radiation based on latitude and Julian Day	MJ m^{-2} d^{-1}

E.g., DS in The Philippines









cluster 1 2 3

45 14 51

Using enviromics, we can:

- **Reduce the total number of trials and cost**
- **Better allocate the resources**
- **Define the optimal MET in advance**
- **Identify genomic regions associated with EC responsiveness**
- **Select more resilient genotypes for future scenarios**

OXFORD G3 Genes | Genomes | Genetics

G3, 2021, 11(4), jkab040
DOI: 10.1093/g3journal/jkab040
Advance Access Publication Date: 6 February 2021
Software and Data Resources

EnvRtype: a software to interplay enviromics and quantitative genomics in agriculture

Germano Costa-Neto [1]*, Giovanni Galli, [1] Humberto Fanelli Carvalho [1], José Crossa [2] and Roberto Fritsche-Neto [1,3]

Received: 30 March 2023 | Accepted: 8 May 2023
DOI: 10.1002/agj2.21383

Agronomy Journal

SPECIAL SECTION: MACHINE LEARNING IN AGRICULTURE

SoilType: An R package to interplay soil characterization in plant science

Roberto Fritsche-Neto