Maize architectural adaptation in intraspecific competition

Serouart Mario, Raul Lopez Lozano, Gaetan Daubige, Benoit de Solan, Frédéric Baret

MAIZE ARCHITECTURAL ADAPTATION IN INTRASPECIFIC COMPETITION

12th May 2022 CAPTE WORKSHOP

SEROUART Mario

PHENOTYPIC VARIANCE

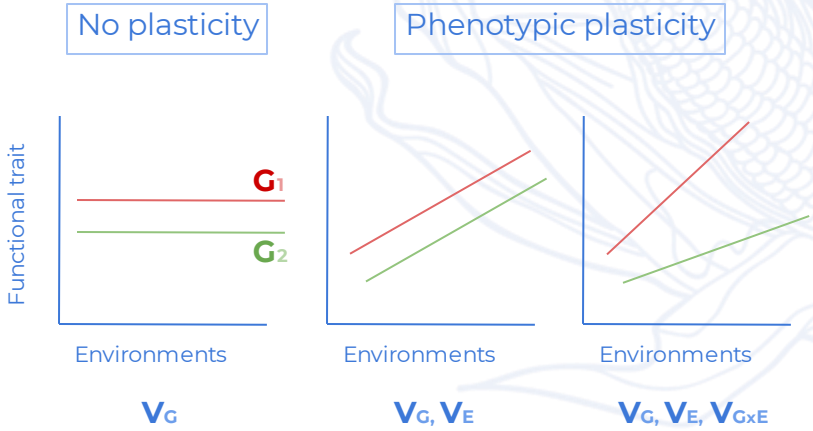
$$V_P = V_G + V_E + V_{GxE}$$

V_P : Total phenotypic variance of a trait

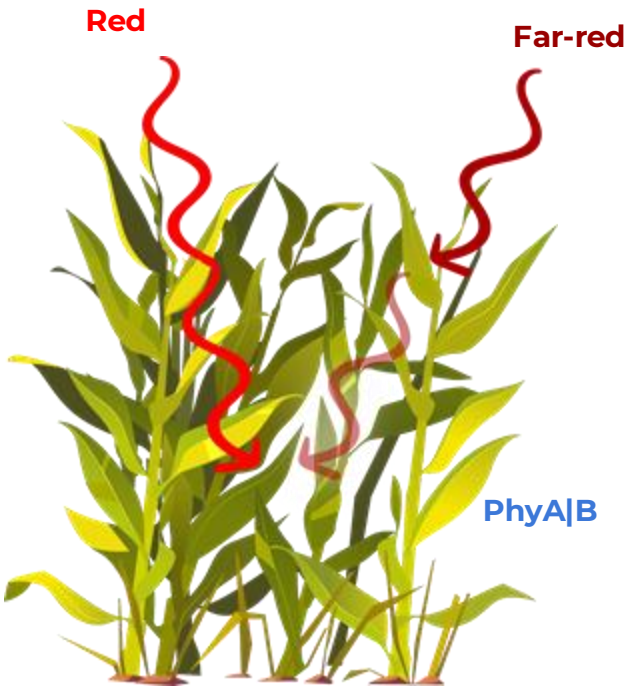
V_G : Proportion of phenotypic variance explained by genetic variance

V_E : Proportion of phenotypic variance explained by environmental variance

V_{GxE} : Genotype by environment interaction (plasticity depending on genotype)

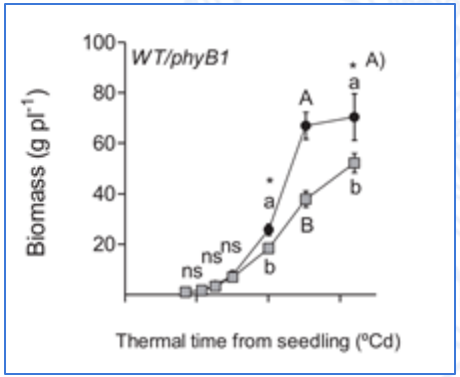


PLASTICITY



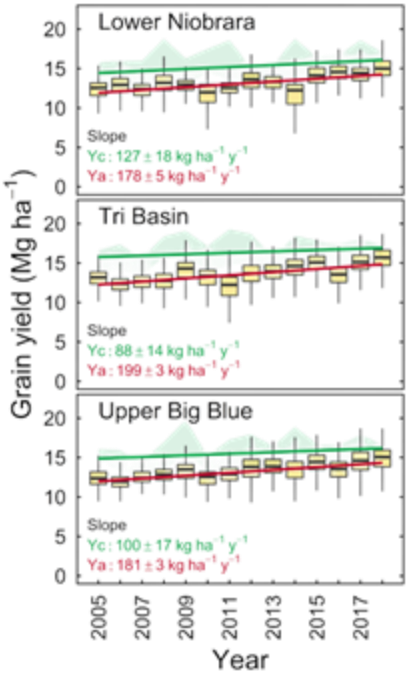
[plasticity]

« The ability of an organism to change its phenotype in response to different environments. »

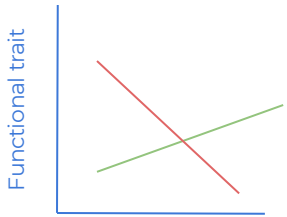


Wies G, Mantese AI, Casal JJ, Maddonni GÁ. Phytochrome B enhances plant growth, biomass and grain yield in field-grown maize. *Ann Bot*. 2019;123(6):1079-1088. doi:10.1093/aob/mcz015

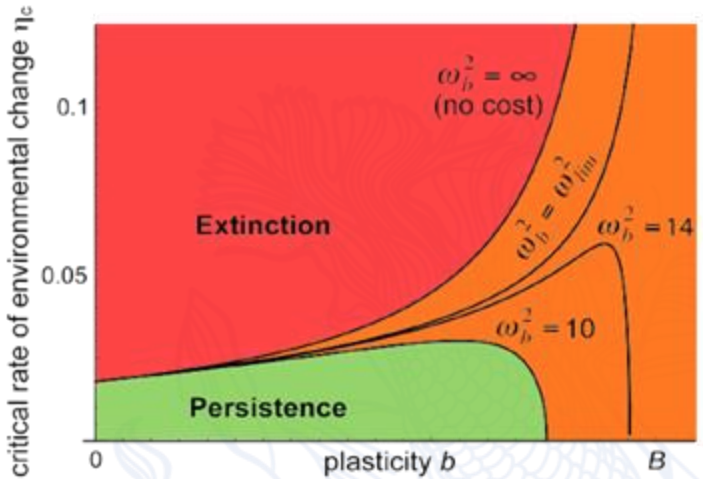
SOTA



Rizzo G, Monzon JP, Tenorio FA, et al. Climate and agronomy, not genetics, underpin recent maize yield gains in favorable environments. Proceedings of the National Academy of Sciences of the United States of America. 2022 Jan;119(4). DOI: 10.1073/pnas.2113629119 PMID: 35042796; PMCID: PMC8795556



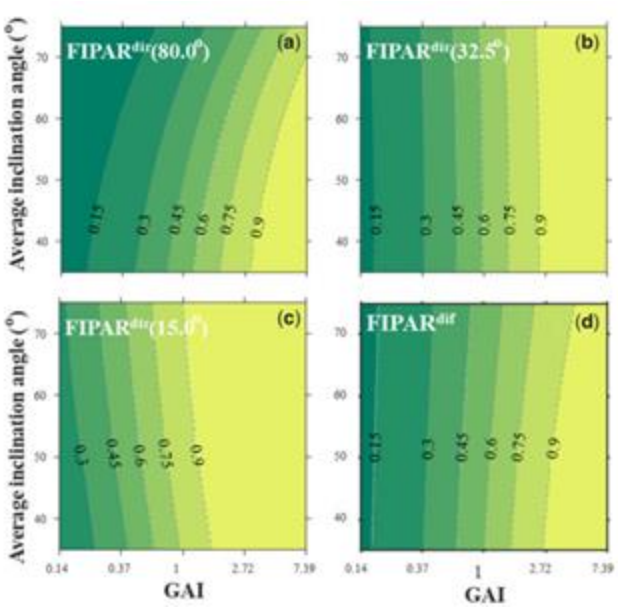
V_G, V_E, V_{GxE}



Chevin LM, Lande R, Mace GM. Adaptation, plasticity, and extinction in a changing environment: towards a predictive theory. PLoS Biol. 2010 Apr 27;8(4):e1000357. doi: 10.1371/journal.pbio.1000357. PMID: 20463950; PMCID: PMC2864732

SOTA

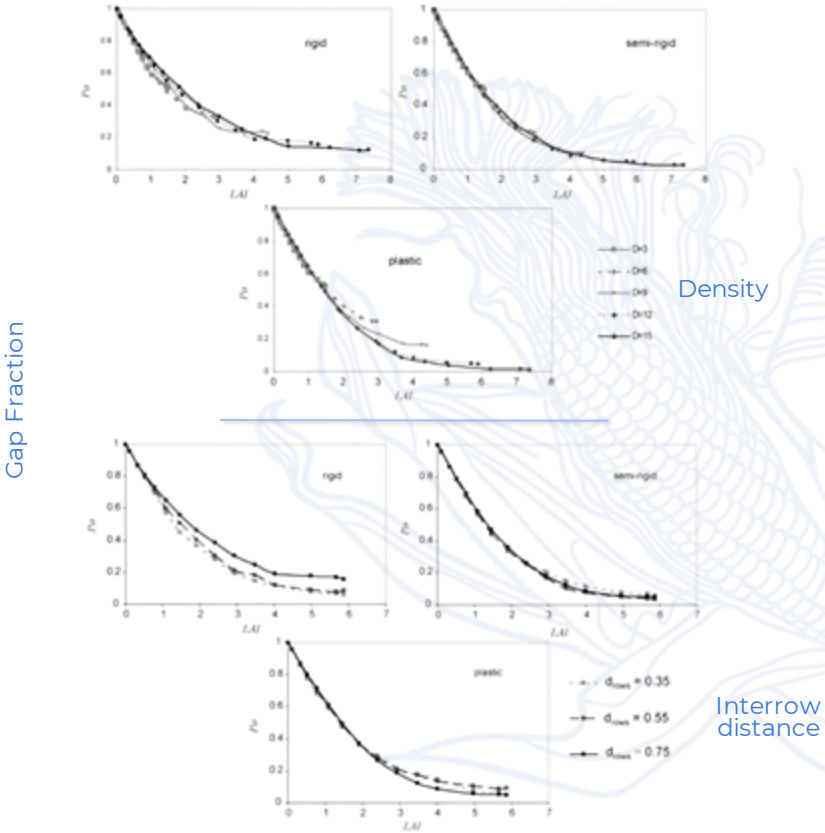
Average Leaf Angle



Shouyang Liu, Frédéric Baret, Mariem Abichou, Loic Manceau, Bruno Andrieu, et al.. Importance of the description of light interception in crop growth models. Plant Physiology, American Society of Plant Biologists, 2021, 186 (2), pp.977-997. ff10.1093/plphys/kiab113ff. ffhal-03222455

Azimuth Angle

R. Lopez-Lozano, Frédéric Baret, Michaël Chelle, N. Rochdi, M. España. Sensitivity of gap fraction to maize architectural characteristics based on 4D model simulations. *Agricultural and Forest Meteorology*, Elsevier Masson, 2007, 143 (3-4), pp.217-229. (101016/j.agrformet.2006.12005). (hal-01192023)



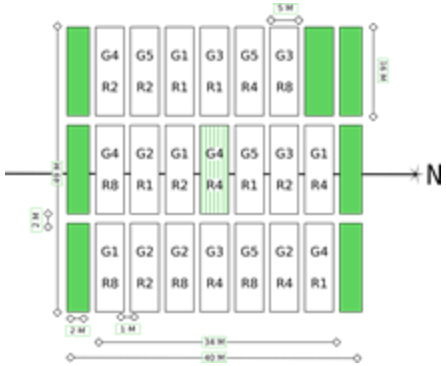
SOTA

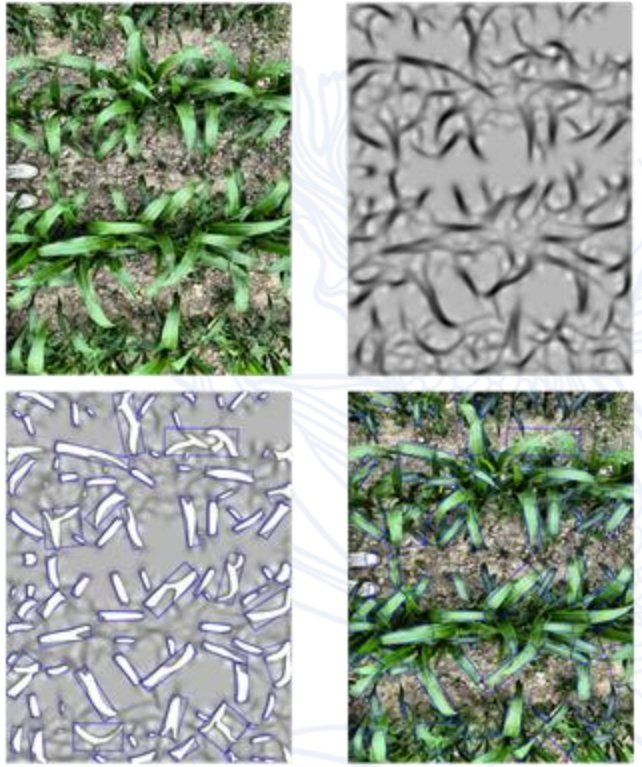
Etienne David. The challenge of robust trait estimates with Deep Learning on high resolution RGB images. Agronomy. Avignon Université, 2021. English. (tel-03431192)

Atlin, Gary N.; Cairns, Jill E.; Das, Biswanath (2017). *Rapid breeding and varietal replacement are critical to adaptation of cropping systems in the developing world to climate change.* Global Food Security, 12(), 31–37. doi:10.1016/j.gfs.2017.01.008

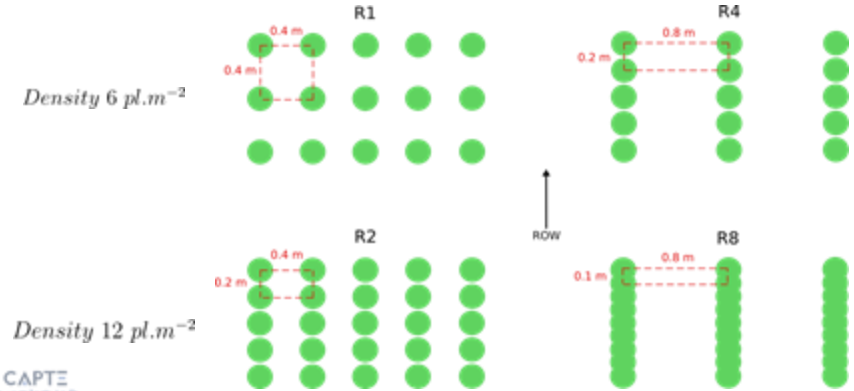
Crop	Country	Average age of variety (years)	Weighting basis	Year of estimate	Source
Hybrid maize	US	3	Area	2016	Brooks (2009)
Hybrid maize	Kenya	17	Area	2010	Smale and Olaiwande (2014)
Rainfed rice	India	28	Area	2014	IRRI, unpublished data
Wheat	India	13	Seed production	2008	Krishna et al. (2014)

AVIGNON EXPERIMENT

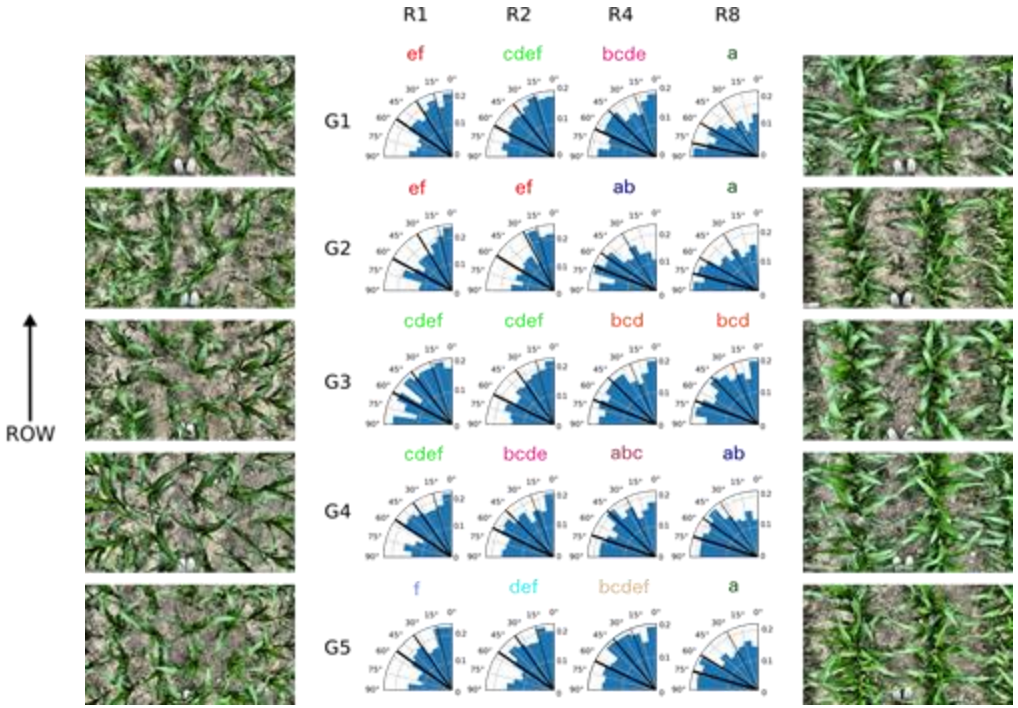




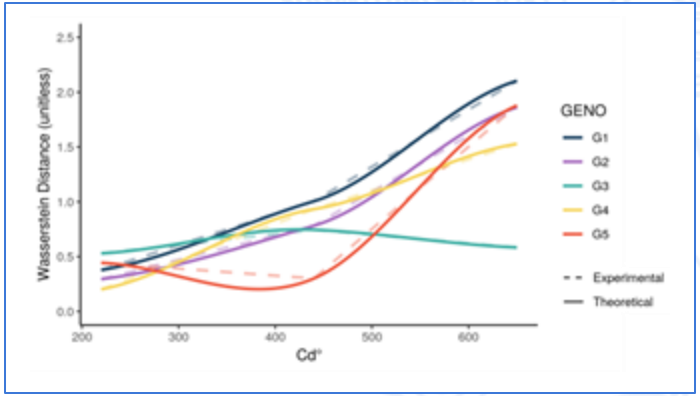
RECTANGULARITY



AZIMUTH



WASSERSTEIN DISTANCE



AZIMUTH

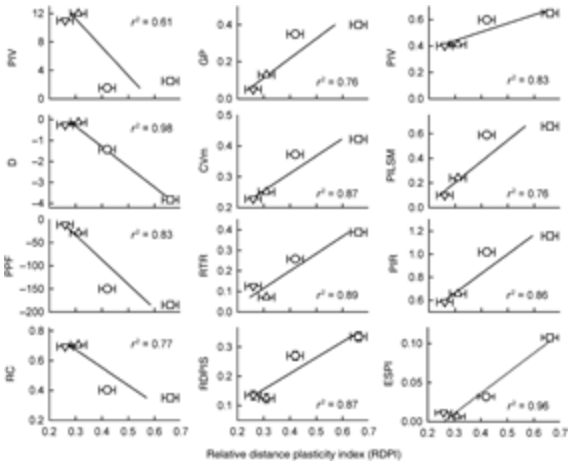
Relative Distances Plasticity Index

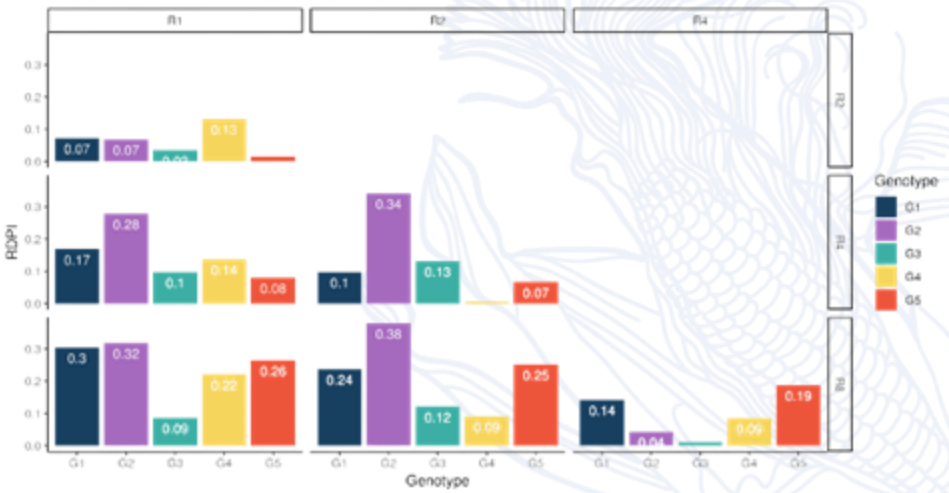
Ranking species according to their plasticity

$$RDPI = \sum \frac{|X_{ij} - X_{i'j}|}{(X_{ij} + X_{i'j})} \times \frac{1}{n}$$

Where

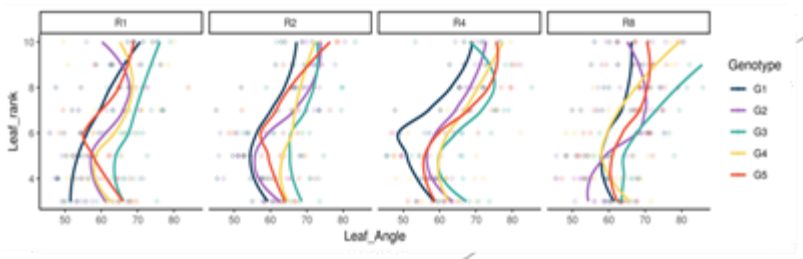
- **i** referred to a given level of the environment treatment
- **i'** another given environment different from i.
- **j** referred to a given genotype.
- **X**ij is the phenotypic value.
- **n** is defined as the number of pairwise environments.



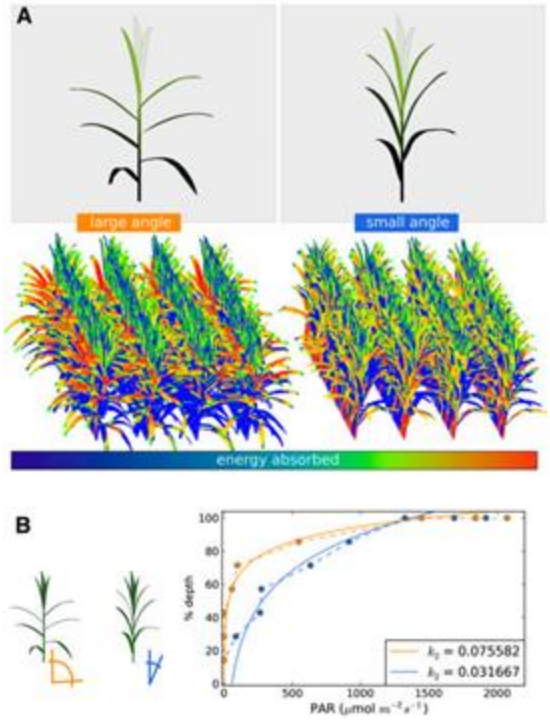


Valladares F, Sanchez-Gomez D, Zavala M a. (2006) Quantitative estimation of phenotypic plasticity: Bridging the gap between the evolutionary concept and its ecological applications. J Ecol 94:1103–1116 . doi: 10.1111/j.1365-2745.2006.01176.x

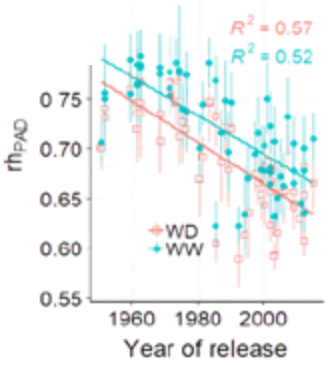
VERTICALITY



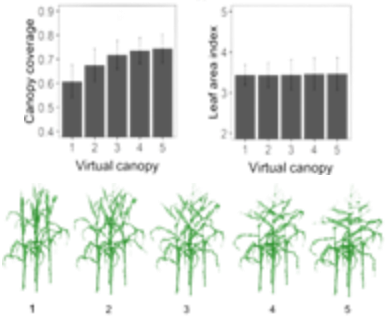
LIGHT INTERCEPTION



Truong, Sandra & Mccormick, Ryan & Rooney, William & Mullet, John. (2015). Harnessing Genetic Variation in Leaf Angle to Increase Productivity of Sorghum bicolor. Genetics. 201. 10.1534/genetics.115.178608.

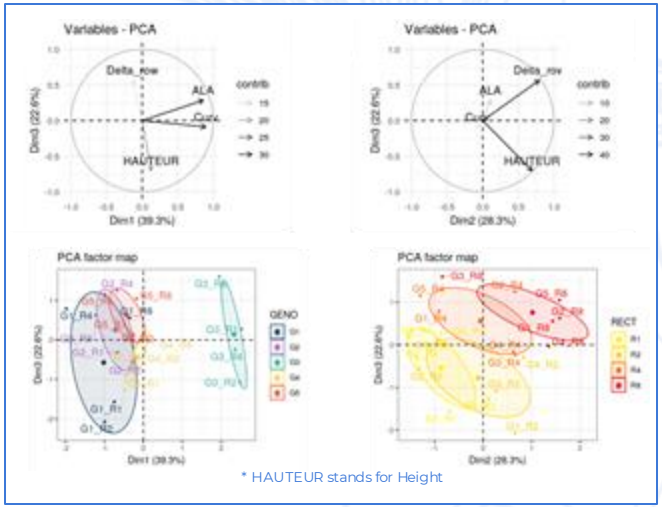


Raphael Perez, Christian Fournier, Llorenç Cabrera-Bosquet, Simon Artzet, Christophe Pradal, et al.. Changes in the vertical distribution of leaf area enhanced light interception efficiency in maize over generations of selection. Plant, Cell and Environment, Wiley, 2019, 42 (7), pp.2105-2119. ff10.1111/pce.13539ff. ffhal-02228393f



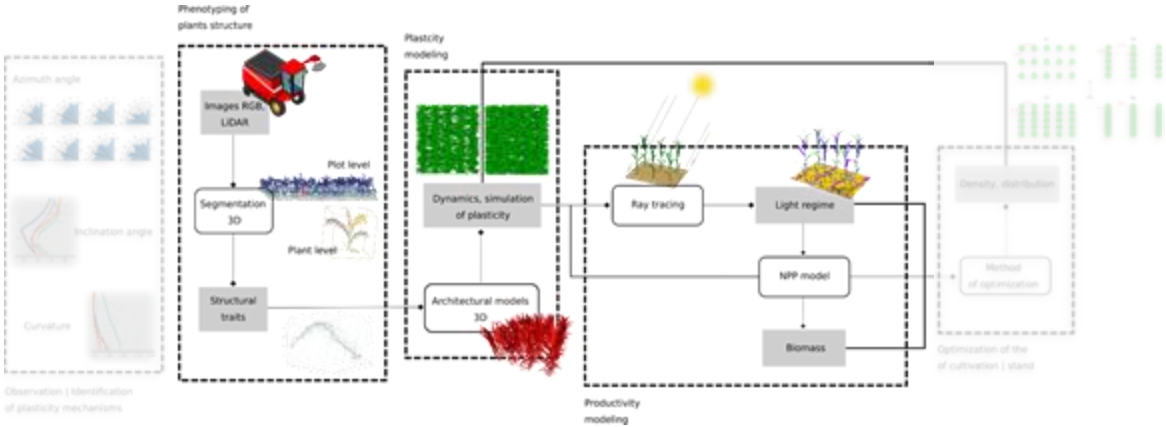
Liu F, Song Q, Zhao J, Mao L, Bu H, Hu Y, Zhu XG. Canopy occupation volume as an indicator of canopy photosynthetic capacity. New Phytol. 2021 Oct;232(2):941-956. doi: 10.1111/nph.17611. Epub 2021 Aug 3. PMID: 34245568.

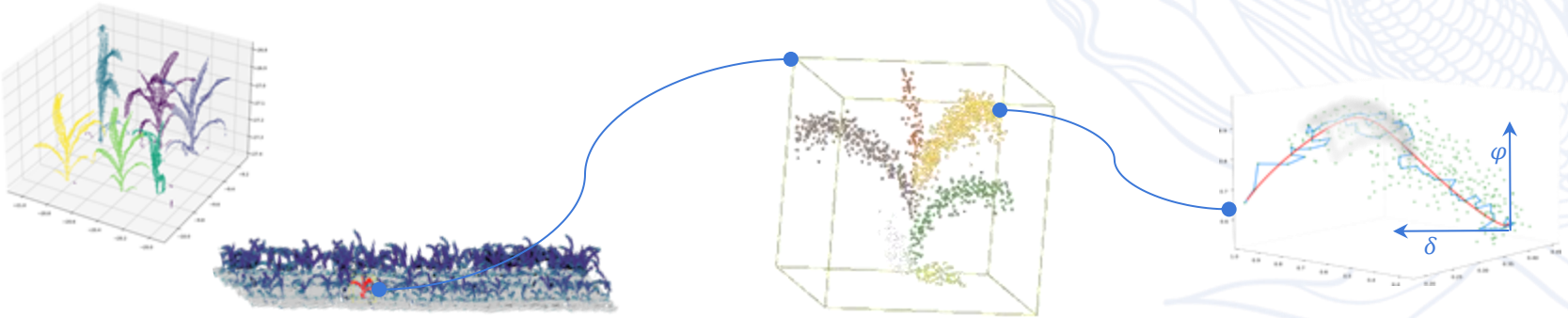
Functional trait space



* HAUTEUR stands for Height

PERSPECTIVES





Plot level segmentation in field

Plant level segmentation

Traits extraction