Demonstrating the functional role of traits for plant performance: a mechanistic modeling approach.

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▶ **To cite this version:**

Nicolas Gross, Vincent V. Maire, Raphaël Martin, Jean-François J.-F. Soussana. Demonstrating the functional role of traits for plant performance: a mechanistic modeling approach.. British Ecological Society, annual Meeting, British Ecological Society (BES). GBR., Sep 2008, Londres, United Kingdom. 20 p. hal-02750769

HAL Id: hal-02750769
https://hal.inrae.fr/hal-02750769v1

Submitted on 3 Jun 2020

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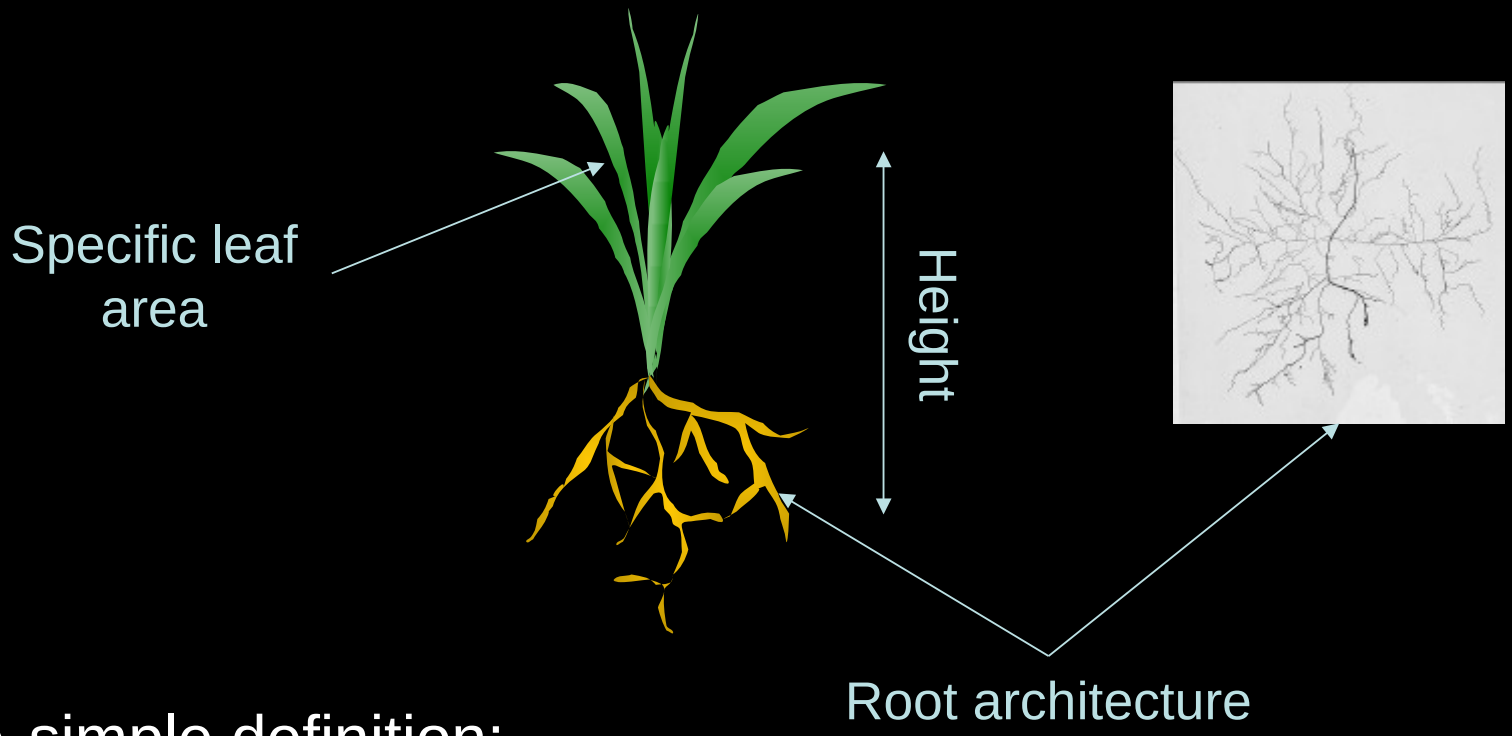
British Ecological Society September 2008

Demonstrating the functional role of traits for plant performance: a mechanistic modeling approach

Gross N, Maire V, Hill D, Martin R, Soussana JF

What are plant traits?



A simple definition:

Morphological or physiological characteristics with a function for plant to subsist in its local environment

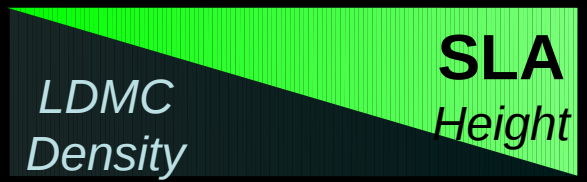
→ Response traits (Lavorel et al. 2007 for review)

Traits co-vary along axis of specialization:

Notion of trade-off and trait syndrome

Conservative syndrome

Exploitative syndrome

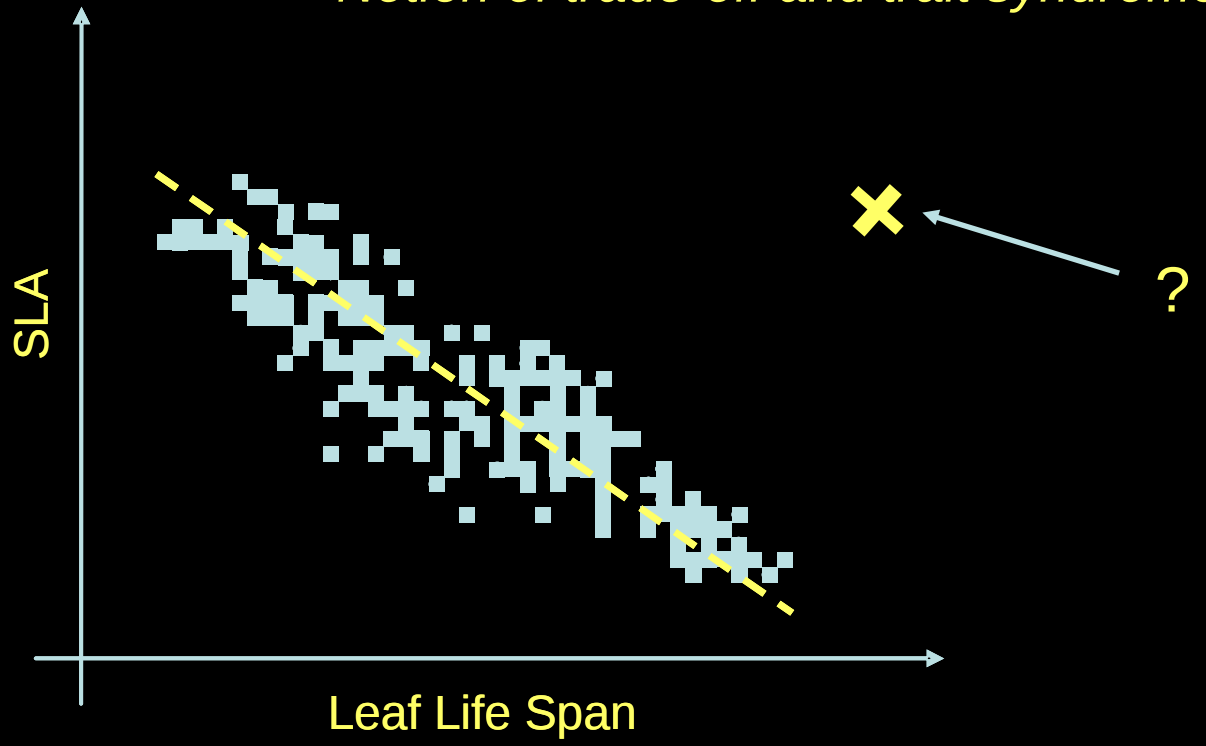


Axis of specialization

Diaz et al. 2004

Traits co-vary along axis of specialization:

Notion of trade-off and trait syndrome



Difficulty to test effect of particular trait
on plant performance due to trade-off among traits

A modeling approach to isolate trait effect on plant performance

GEMINI

(*Grassland Ecosystem Model with INdividual centered Interactions*)

Environmental variables

Demographic models

Ecophisiologic biochemstry models

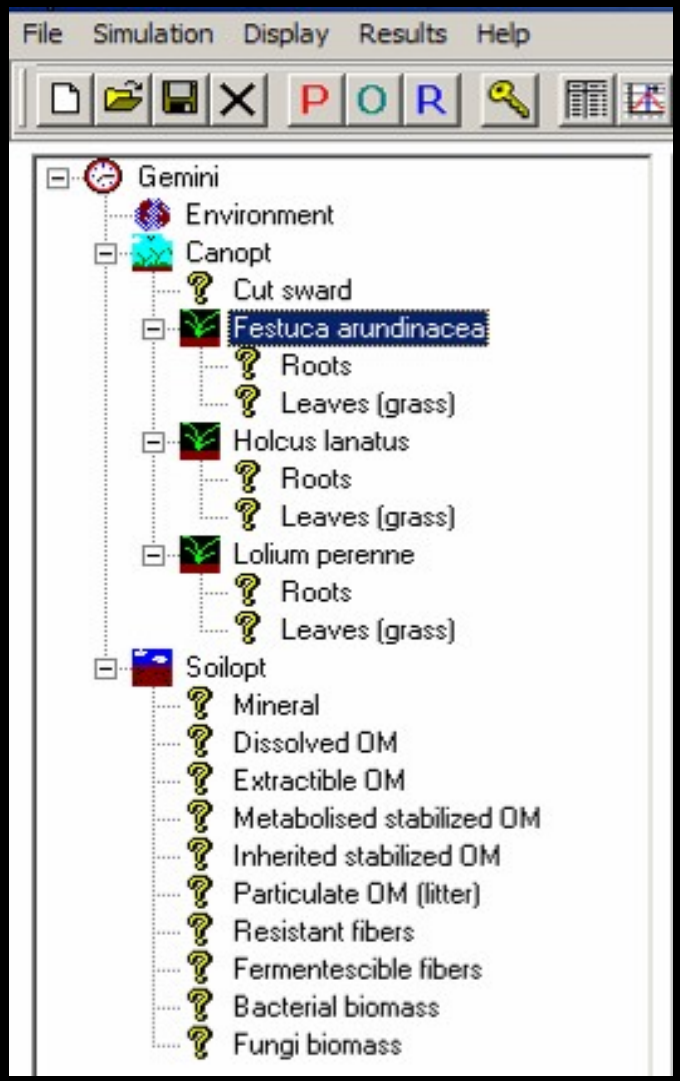
Individual centred Model

Demography & Morphology

Population Dynamics
Level of biodiveristy

Flux Models
C, N, H_20

Acquisition and Utilisation



GEMINI is composed by different submodels

Overall 74 physiological and morphological parameters are needed for plants

Parameterized and evaluated on 13 grasses species (monoculture) grown in 2003-2004
Maire et al. in prep

More informations see: www2.clermont.inra.fr/discover/gemini/model.htm & www.the-jena-experiment.de

Testing traits effect on plant performance using a sensitivity analysis

4 traits were selected

two leaf traits (LDMC, Ph0) and two stature traits (D0, L0)

Hypothesis

Strong linkages within leaf traits (D0 and L0) and within stature traits (LDMC, Ph0) (Wright et al. 2004)

Independence between Leaf traits and stature traits (Ackerly 2004, Gross et al. 2007)

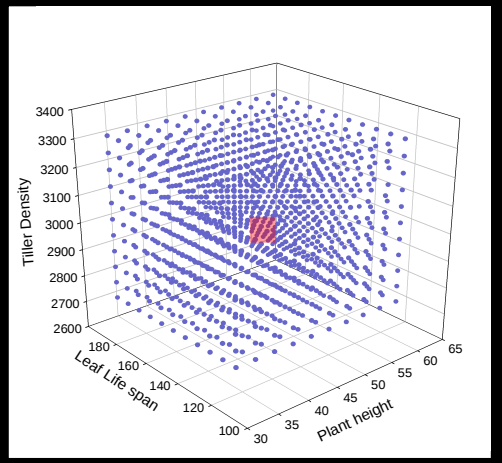
Testing traits effect on plant performance using a sensitivity analysis

12 grasses species were used

Tested only effect of morphological traits
Monoculture at equilibrium
No Reproductive stage
No water limitation
Environnement 2003-2004

Traits space exploration

10 value of traits per species
in a full factorials design



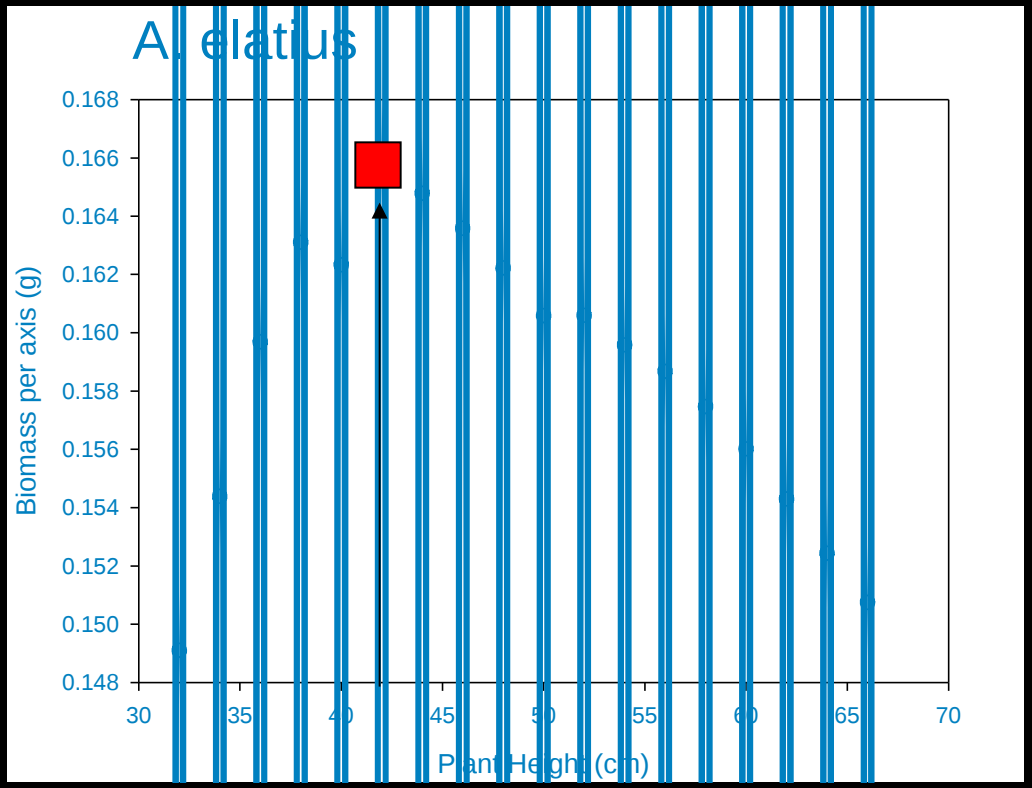
In total

12 species x 10 value ^4 traits x 2 N conditions = 240 000 simulations ran with monoculture growth conditions 2003/2004

Trade-off at inter-specific level

Plant biomass in function of traits value (Plant Height)

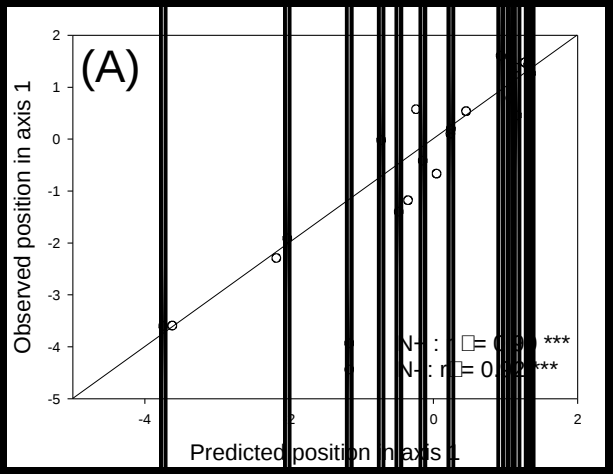
all other parameter are fixed

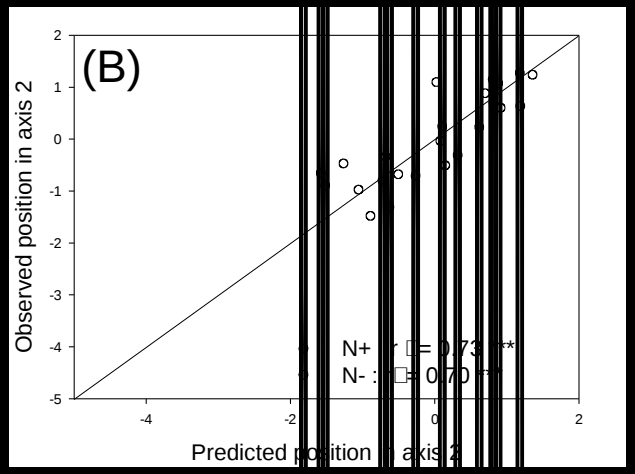


One trait value maximize plant performance

In the 4D space traits:

traits combinations which maximize plant performance





(variance explained >80 %)

Traits combinations which maximize plant performance are in accordance with current plant schema (Grime 1977, Westoby 1998)

Trade-off among traits and among species is well predicted by the model

Some insight coming from the modeling approach

→ Plant traits observed in the field maximize resource utilization and plant performance

Best light interception, N absorption, N leaf concentration predicted in the model

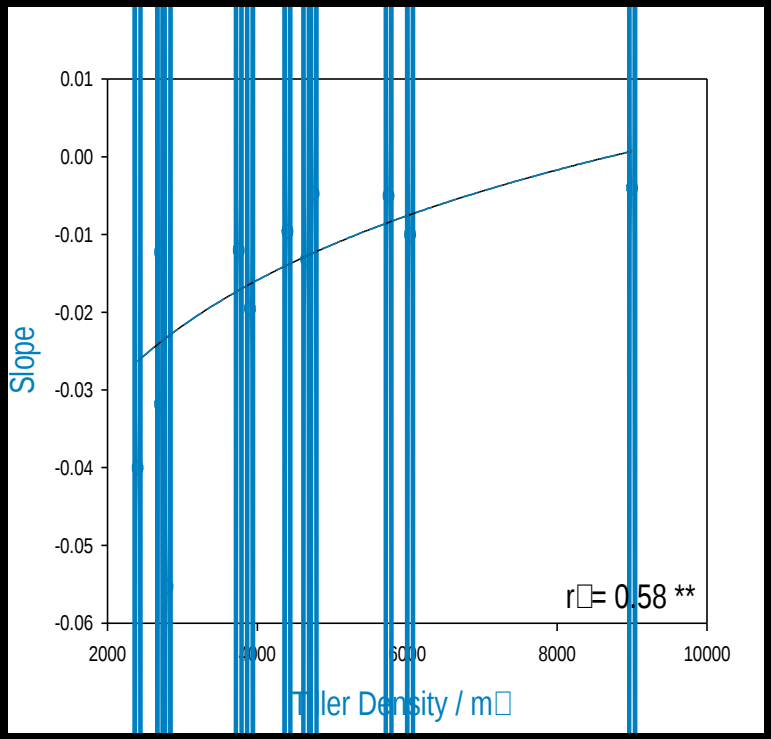
→ Each species can be view has an island, a particular traits combination which locally maximize plant fitness in the traits space

→ Our study did not show why species differed in traits syndrome (Selection along ecological gradients…), but can explain why trade-offs among traits exist (all combinations are not equal)

Trade-off at intra-specific level

and interaction among traits

Interaction between tiller density and plant height



Ridge which maximize plant performance

Consistently with our hypothesis there is a negative trade-off between tiller density and plant height

Constraint between traits change depending on plant syndrome

Conclusion

→ By using a modeling approach we demonstrated the functional role of traits for plant performance

→ Species are organize along trade-off of traits where species maximize their performance

→ Trade-off exist both between and within species but are not necessarily the same

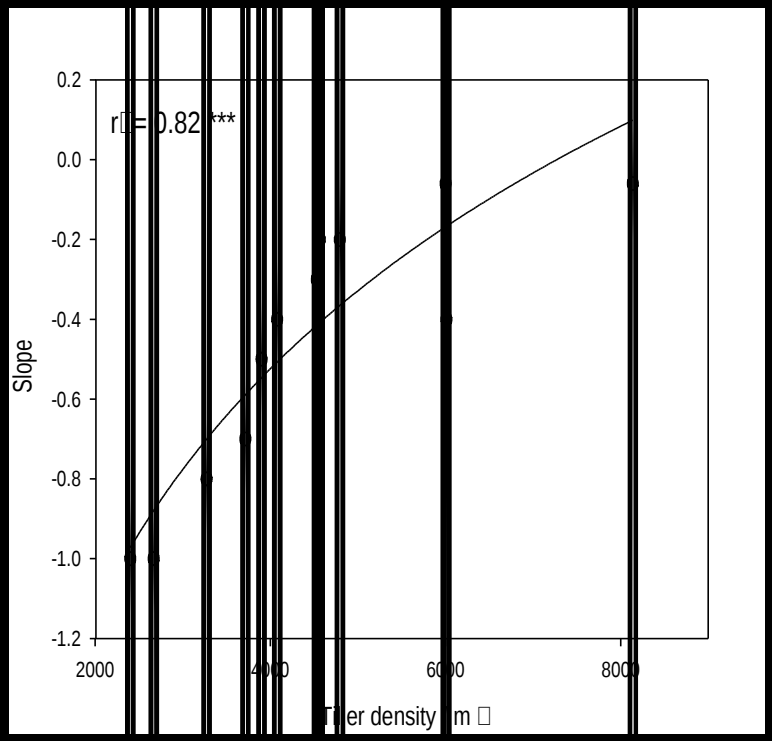
Perspective

Studying the impact of plant plasticity in response to change in abiotic conditions

Linkage between species interactions and plant traits: Plasticity, convergence, divergence…

Thank you!!!

Interaction between tiller density and LDMC



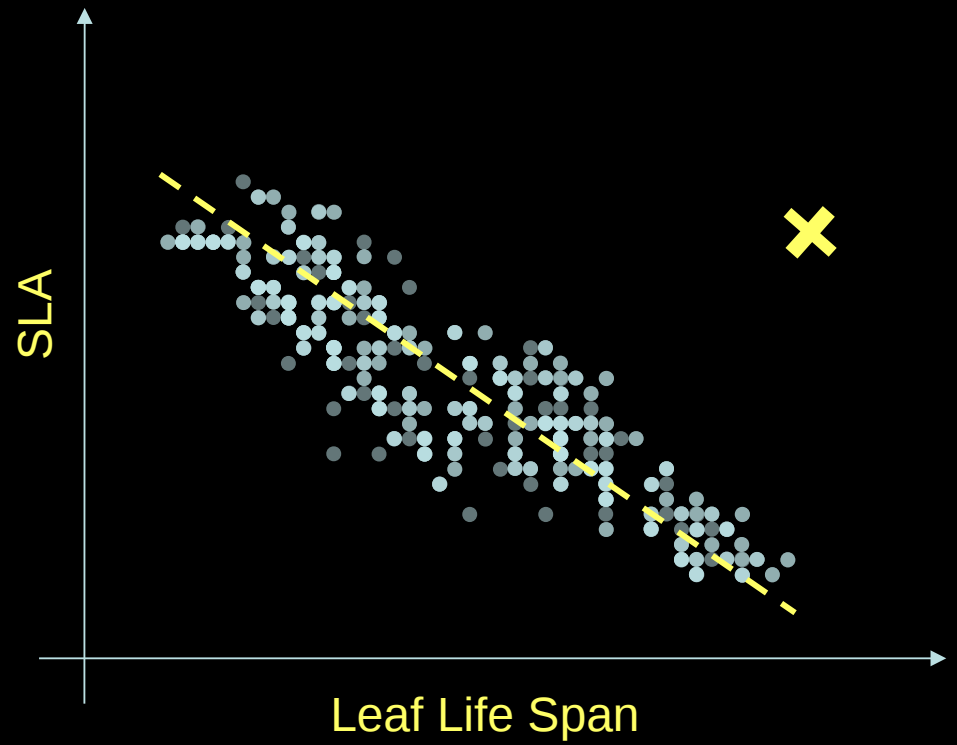
Within species there is a strong linkage between LDMC and tiller density

Not necessary observed at inter-specific level

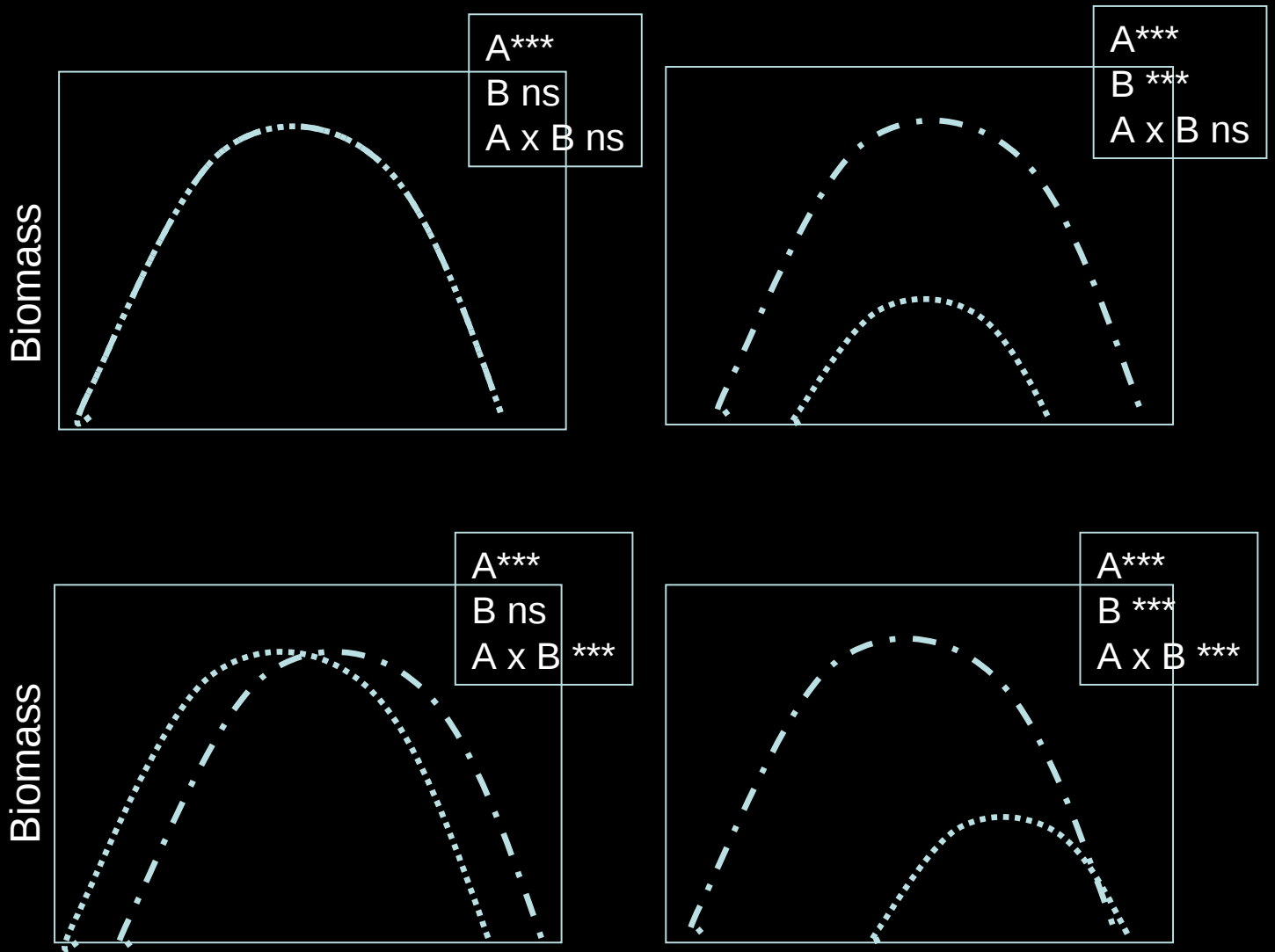
Constraint between traits change depending on plant syndrome

Some combinations in the traits space are equivalent

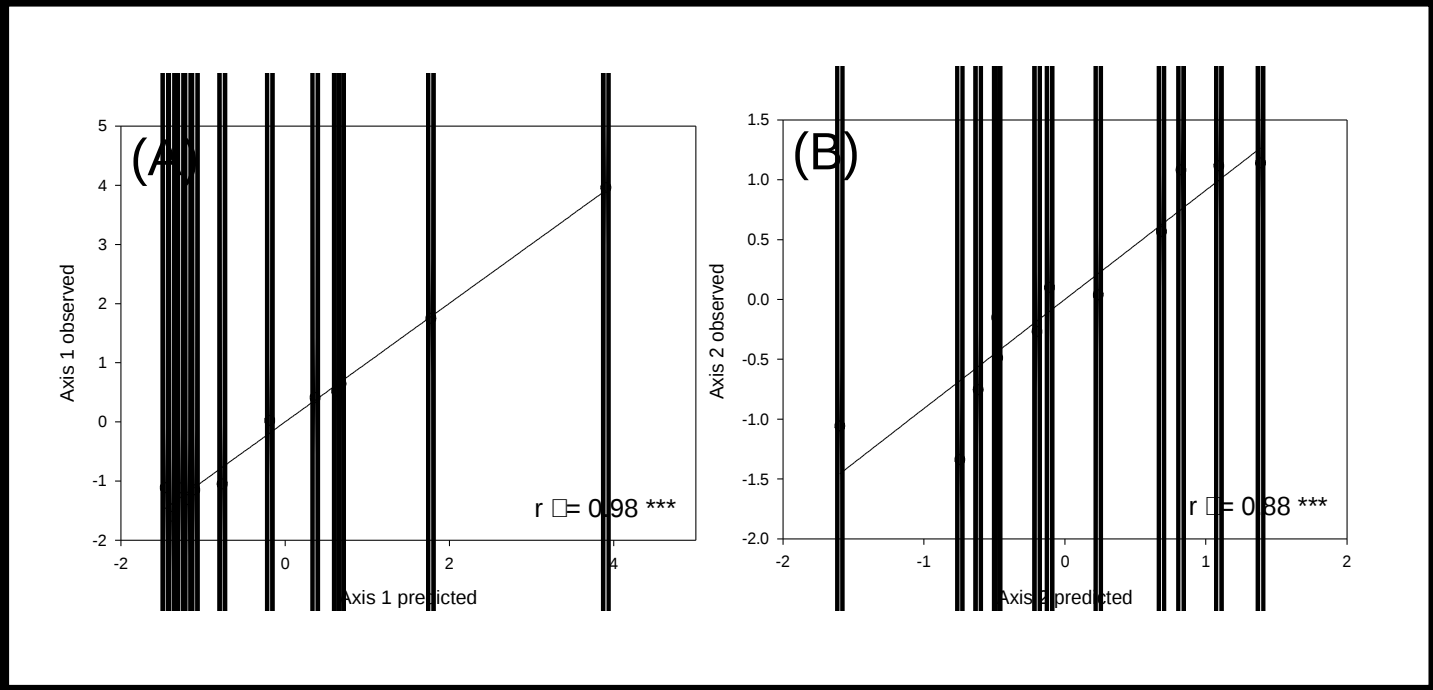
→ Not same level of plasticity in function of traits syndromes


SLA
Leaf Life Span

Interactions between two traits: Four possibilities



In the 4D space traits: traits combinations which maximize plant performance



Trait max predict by the model are strongly related with observed traits measured in the field

This ACP concordant with the Grime Model CSR (1977)