The virtual fruit: towards a tool to design ideotypes for substainable production systems

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towards a tool to design ideotypes for sustainable production systems

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Context

Controlling storage disease is a priority
to reduce fruit residues and increase safety

Critical question : finding the best combinations of genetic resources and cultural practices adapted to, and respectful of specific environments

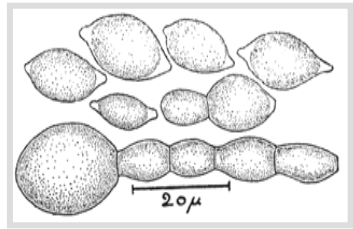
Monilinia

• brown rot caused by *Monilinia* species, can provoke as much as 30 to 40% of crop losses

• no other alternative than chemical treatment is available : fungicide applications are generalized and occur till pre-harvest

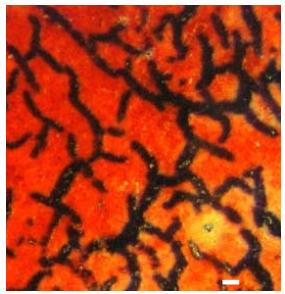
• all cultivated peaches are more or less sensitive to brown rot

• mechanisms of resistance may be complex and largely linked to fruit characteristics including fruit craking

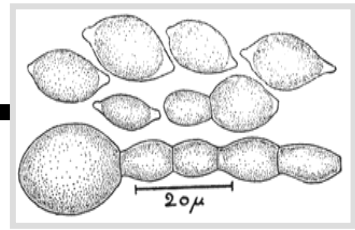


Monilinia laxa

Cracking and practices

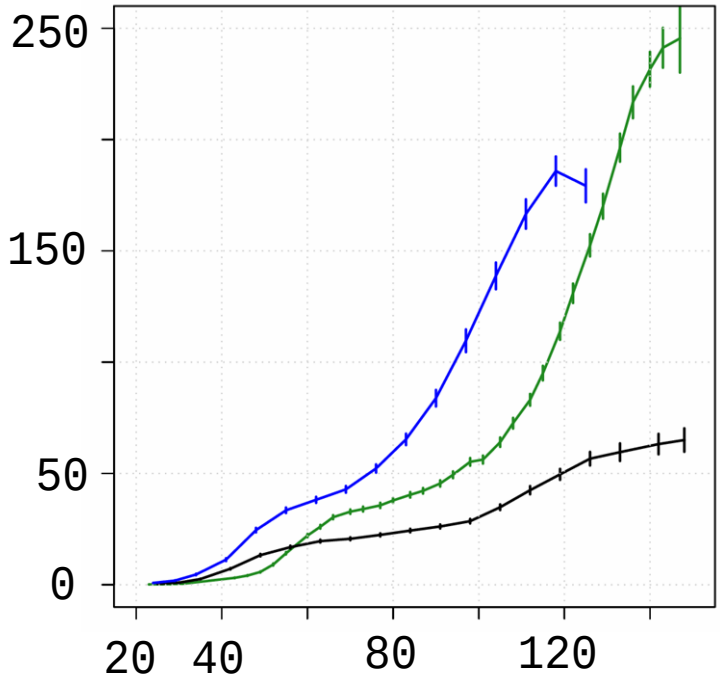


cuticular cracks



Monilinia laxa

Fruit mass (g)

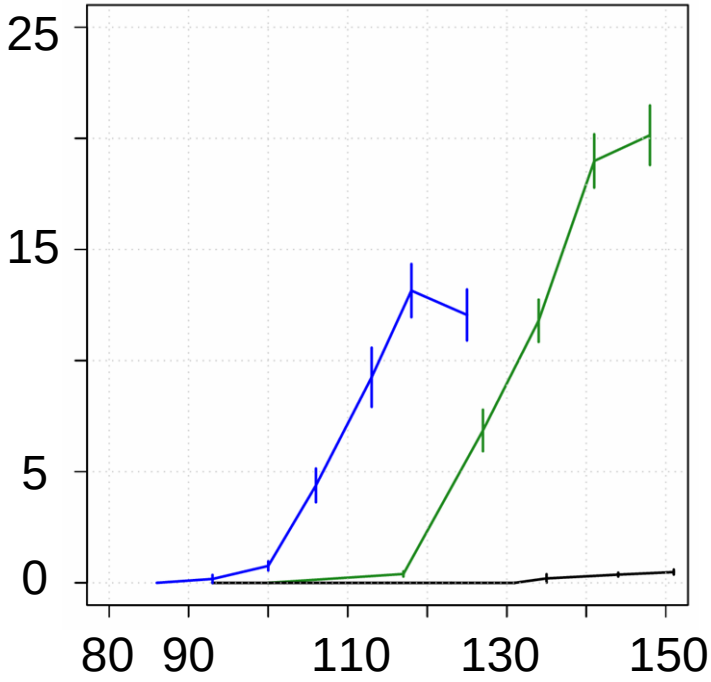


Low load

Trees in container

High load

$S_{cracking}$ (cm^2)



Days after bloom

Cracking and practices

cultivars

- **crack occurrence sensitivity**
- **growth and quality characteristics**

thinning

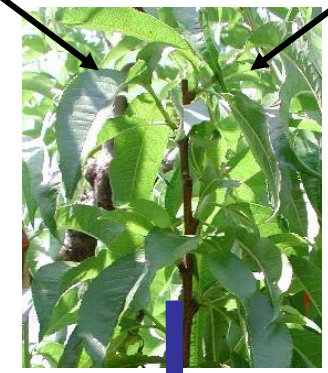
irrigation

Practices

Genotype

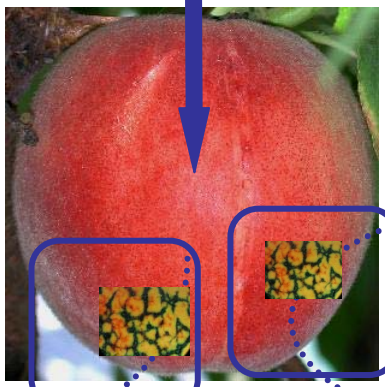
humidity
temperature
radiation

Climate

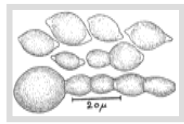


fruit growth
(carbon and water)

sugar partitioning



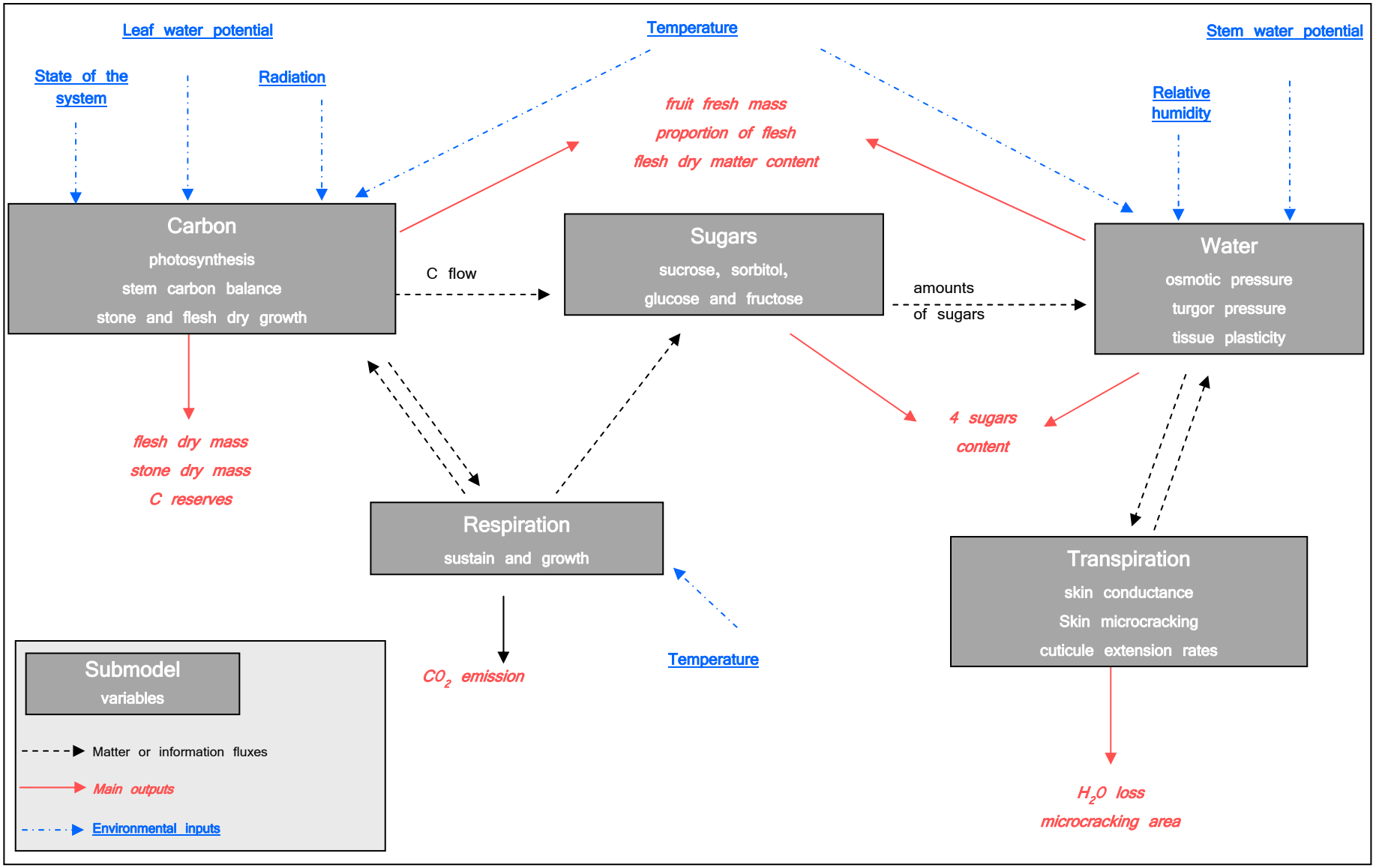
infection



transpiration

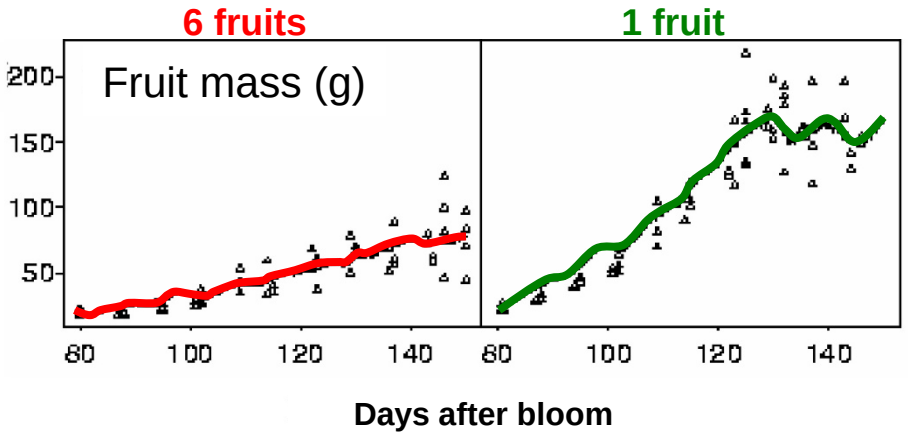
cuticular cracking

Models

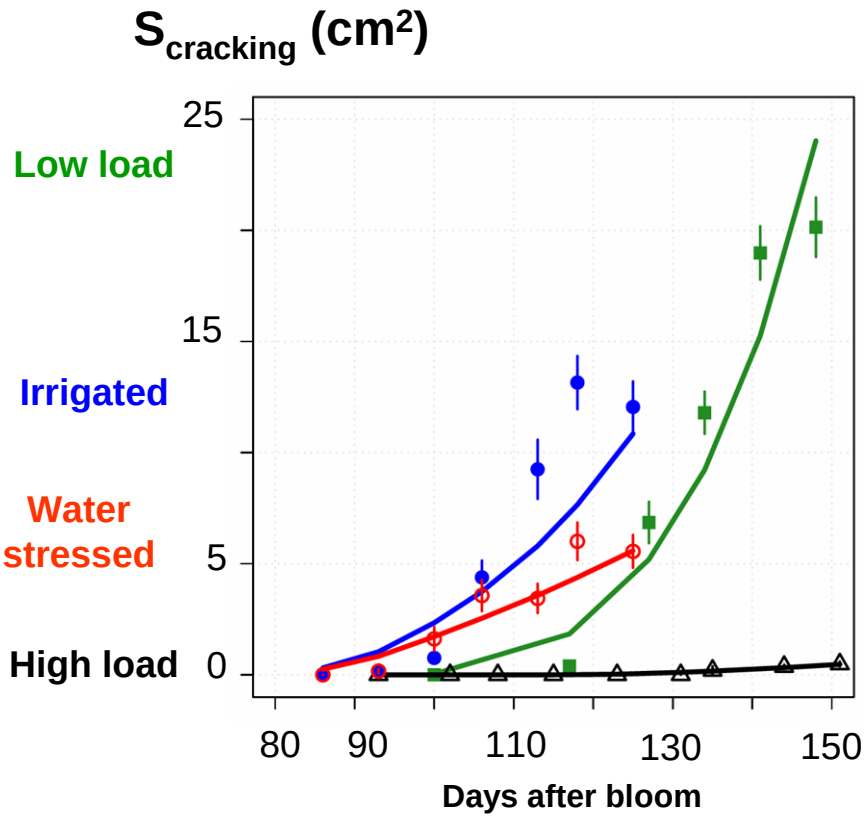


Adapted from Bertin et al, 2010

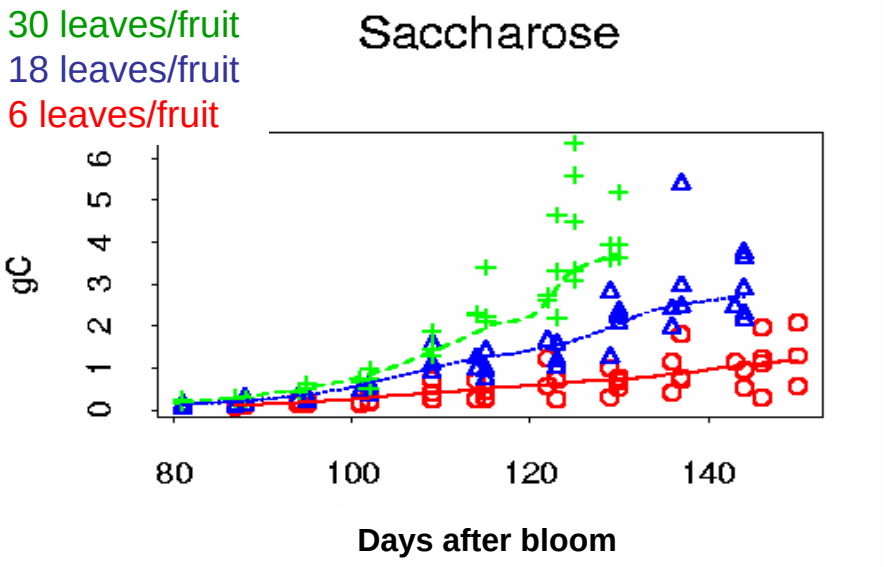
Fruit growth variations between tree load



Cuticular cracking for different scenarii

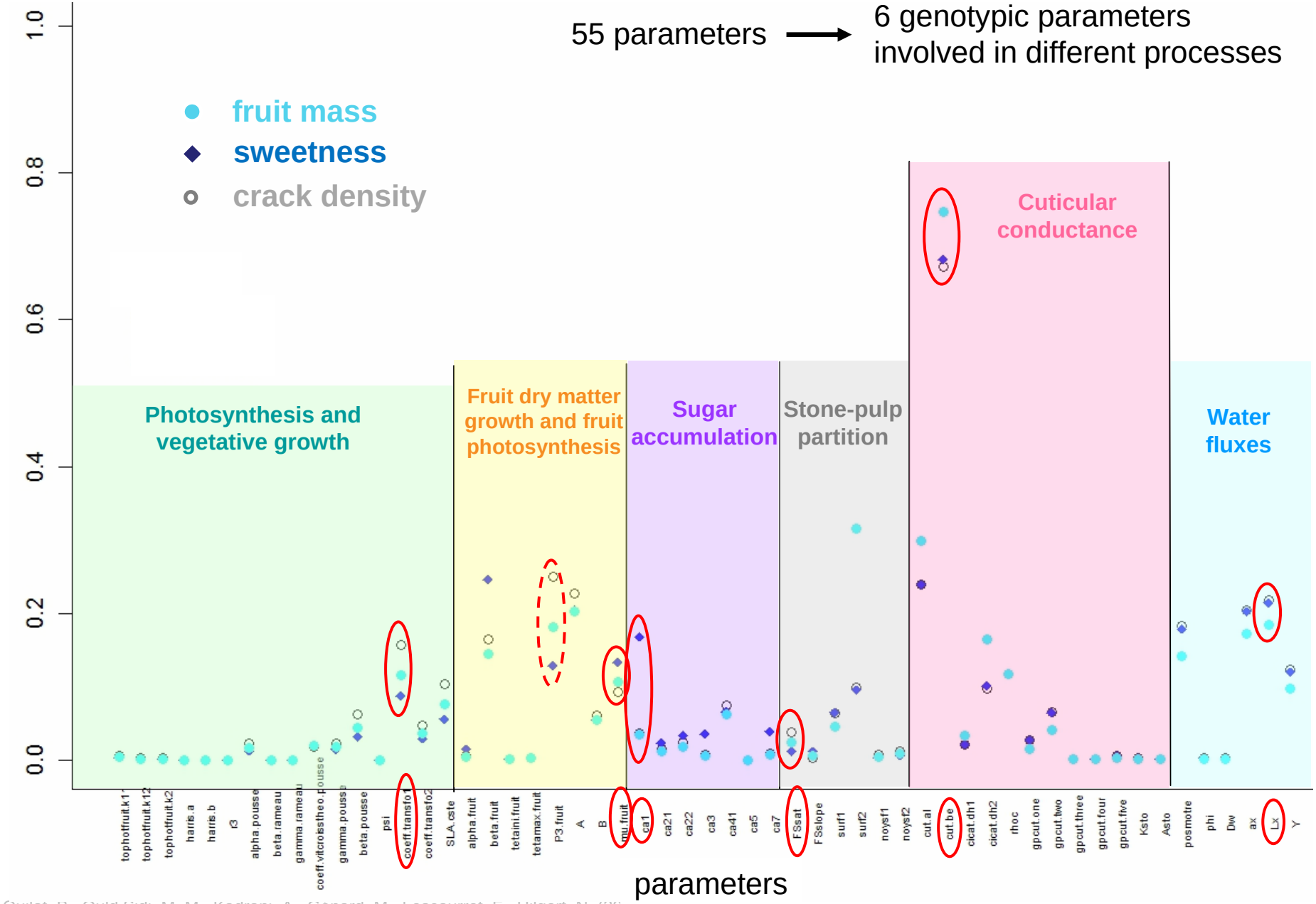


Sucrose accumulation for different tree loads



Sensibility analysis

55 parameters → 6 genotypic parameters involved in different processes



Genetic parameters

PARAMETERS	DEFINITION	PROCESSES	REFERENCE	MINI	MAXI
coeff.transfo1	Part of the leaves in the structural part of the leafy shoots	Vegetative structure	0.766	0.672	0.842*
MuF	Initial relative fruit growth rate	Fruit demand	0.0035	**0.001**	**0.01****
ca1	Proportion of carbon as sucrose in phloemic sap	Sugar metabolism	0.347	**0.23**	**0.54*****
FSsat	Parameter of the relationship between stone dry mass and total fruit dry mass	Stone-pulp partition	6.78	**6.10**	**7.46****
cut.be	Parameters of the equation of the relative elongation rate of the cuticle	Transpiration	1.26	1.134	1.386*
Lx	Conductivity of the composite membrane for water transport	Water fluxes	0.23328	**0.0769**	**0.667****

*** ± 10 % variations**

**** Observed variability within BC2 population (Quilot et al 2005)**

***** Extreme values from litterature**







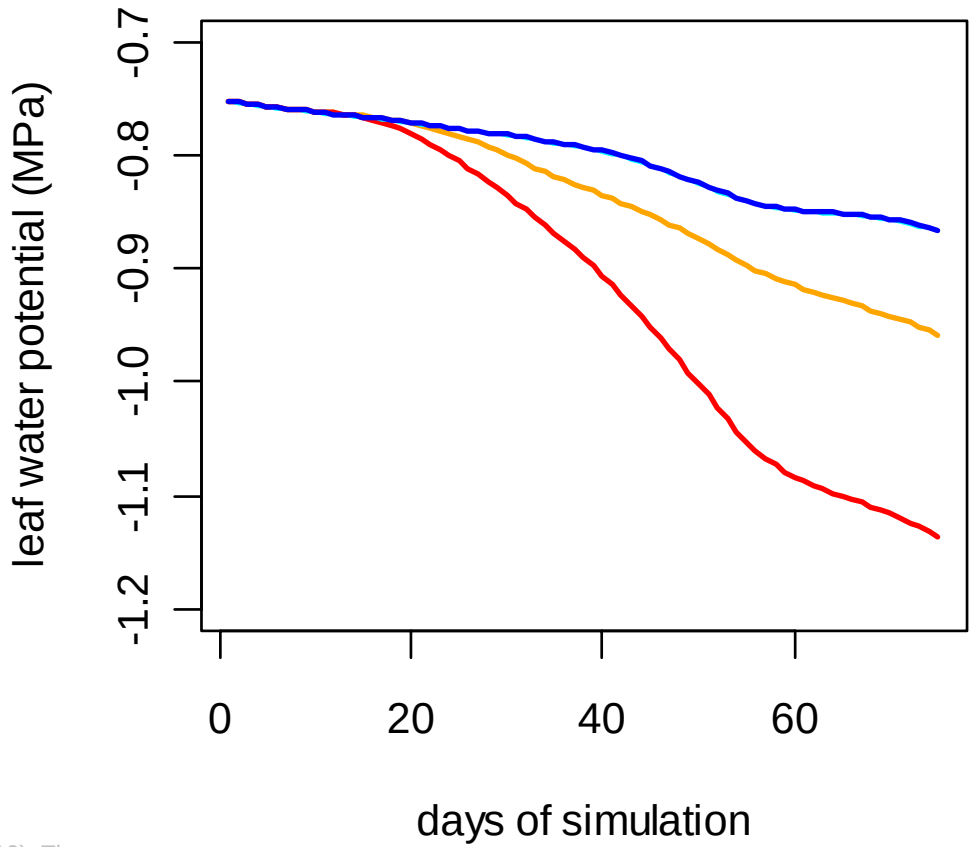
Criteria to optimize

CRITERIA	OPTIMISATION	MINI	MAXI
Fruit mass (g)	maximiser	50	300
Sweetness (%)	maximiser	4	20
Crack density (%)	minimiser	0	20

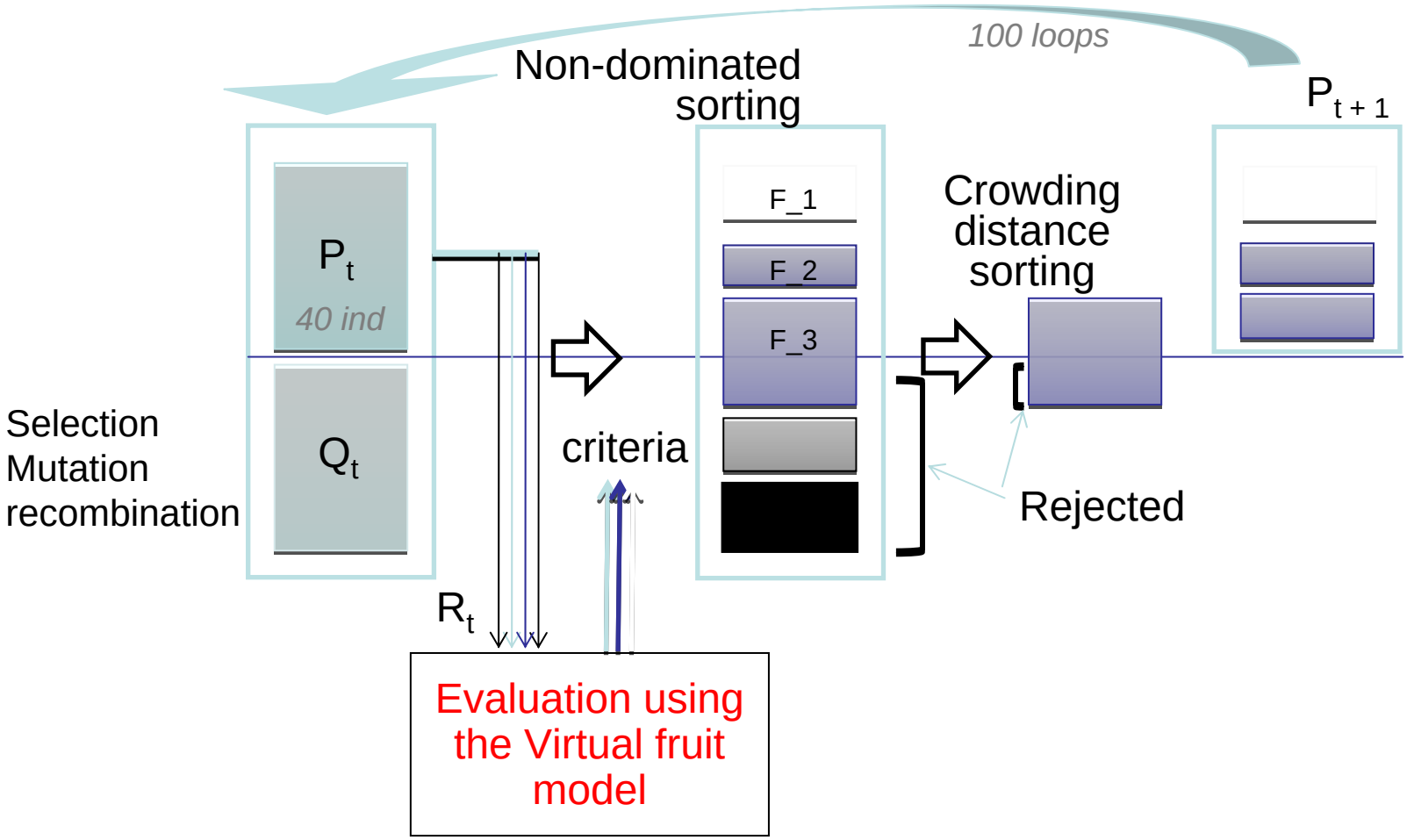
8 scenarii

CLIMATE	IRRIGATION	FRUIT LOAD
Avignon	Well irrigated (WI)	4 fruits/stem LC
		20 fruits/stem HC
	Water deficit (WD)	4 fruits/stem LC
		20 fruits/stem HC

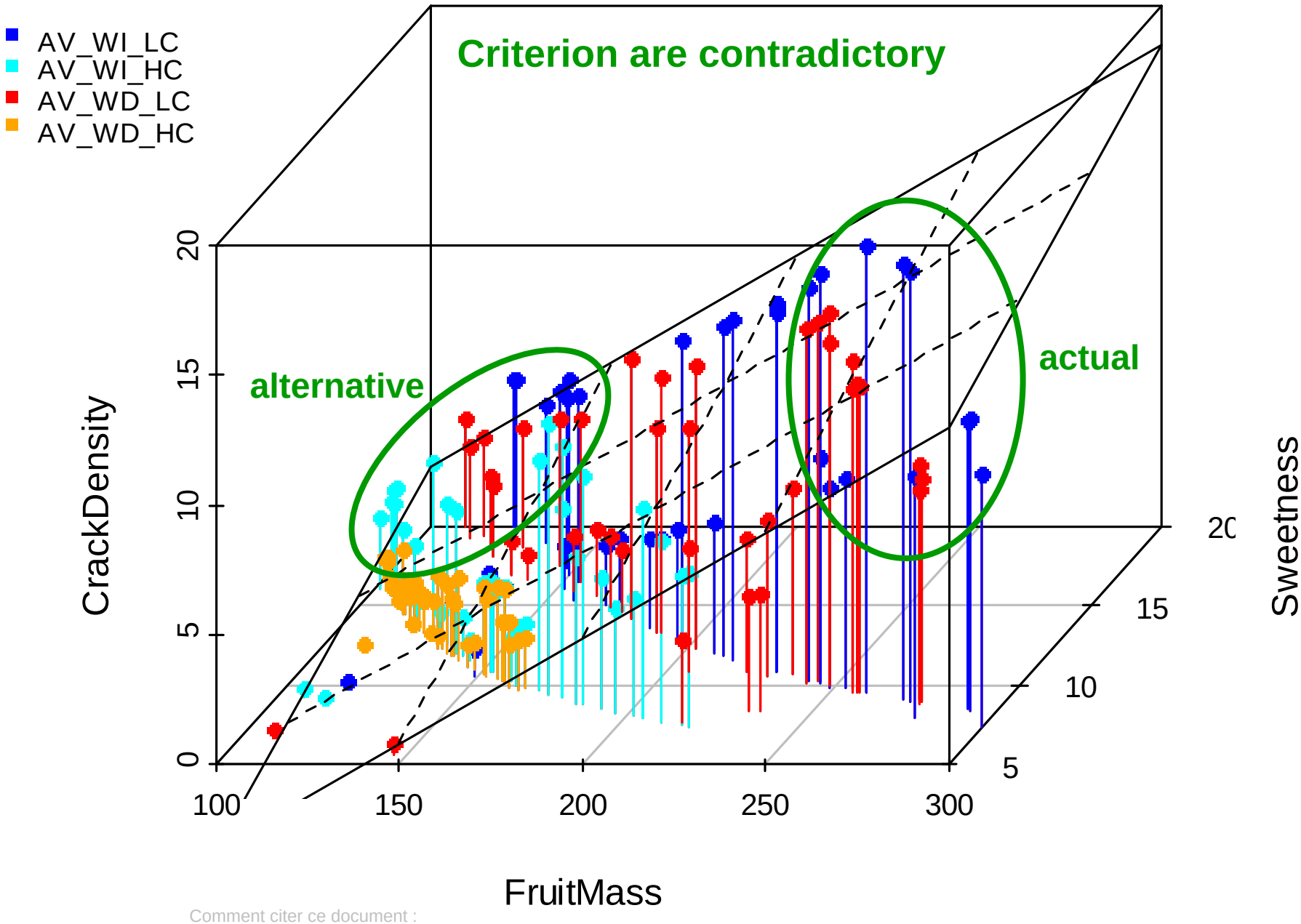
same for Bordeaux



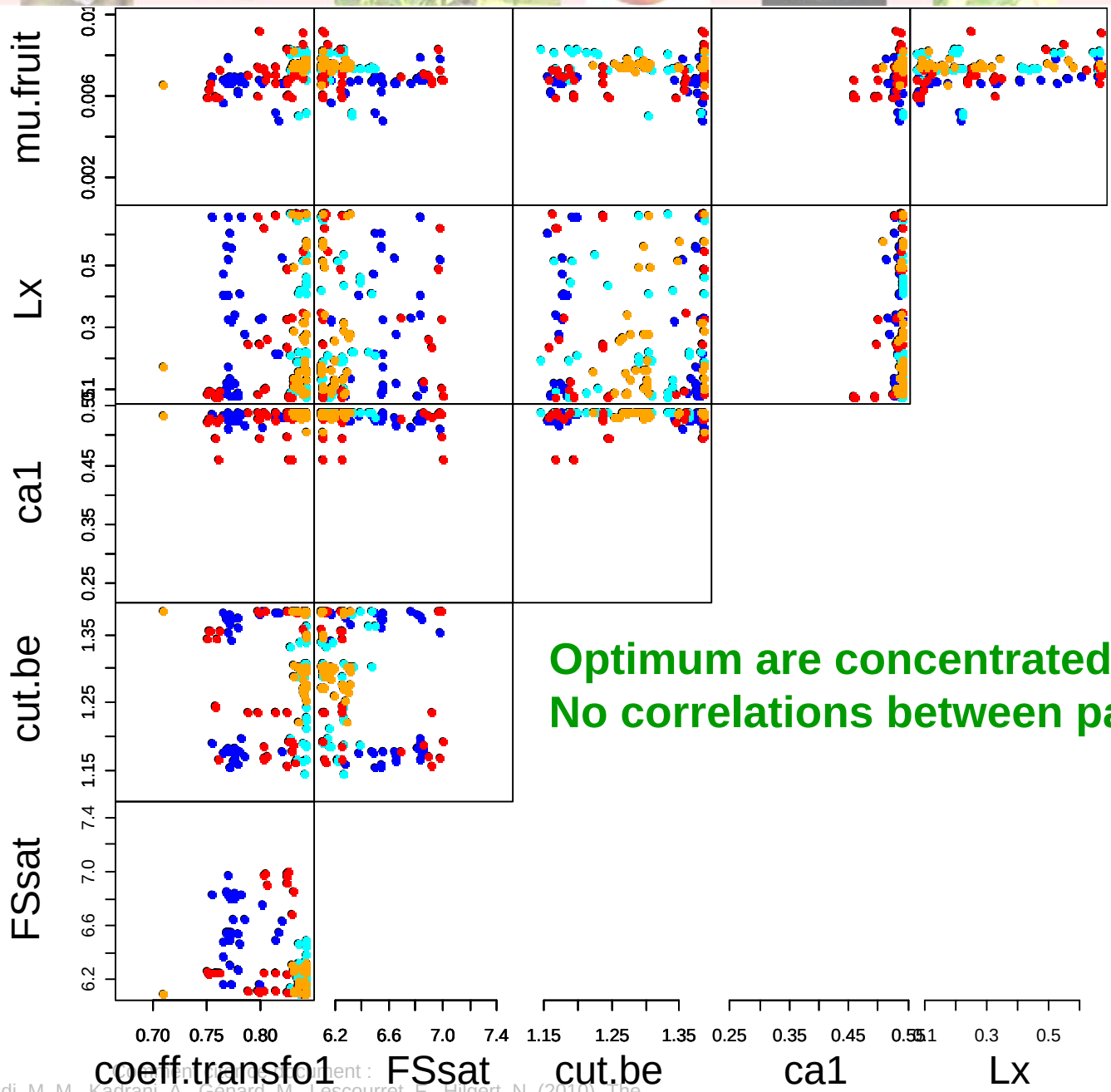
NSGA-II : a multiobjective evolutionary algorithm, a Pareto approach



Dominance relation between solutions
A large choice of solutions:
40 optimum genotypes over 4000 tested per scenario

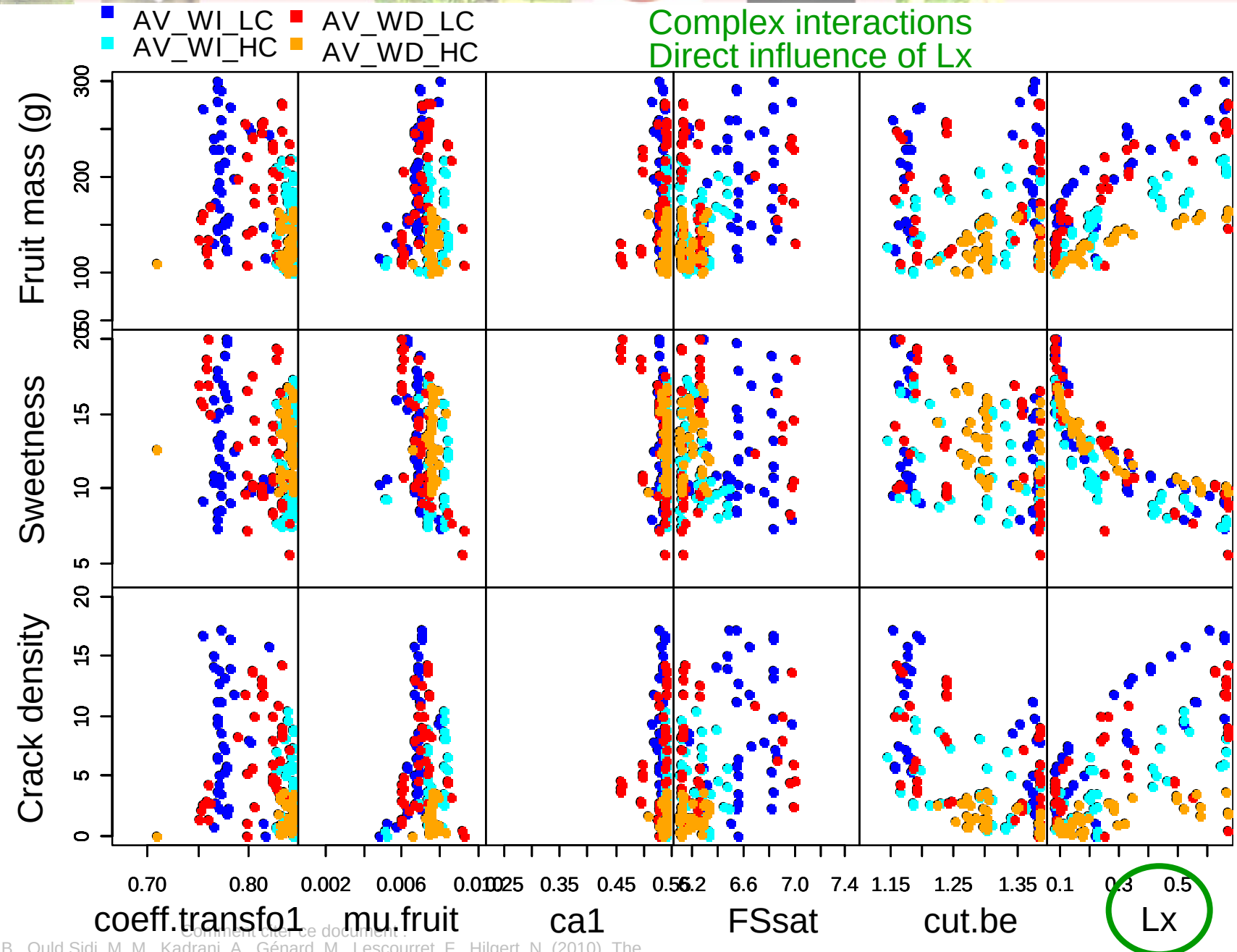


Parameter correlations

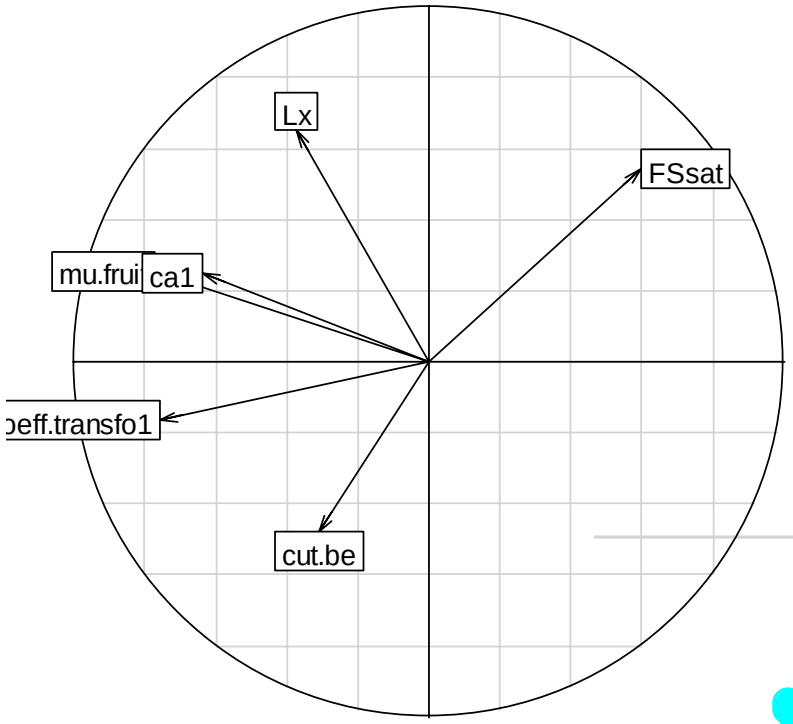


Optimum are concentrated in the space
No correlations between parameters

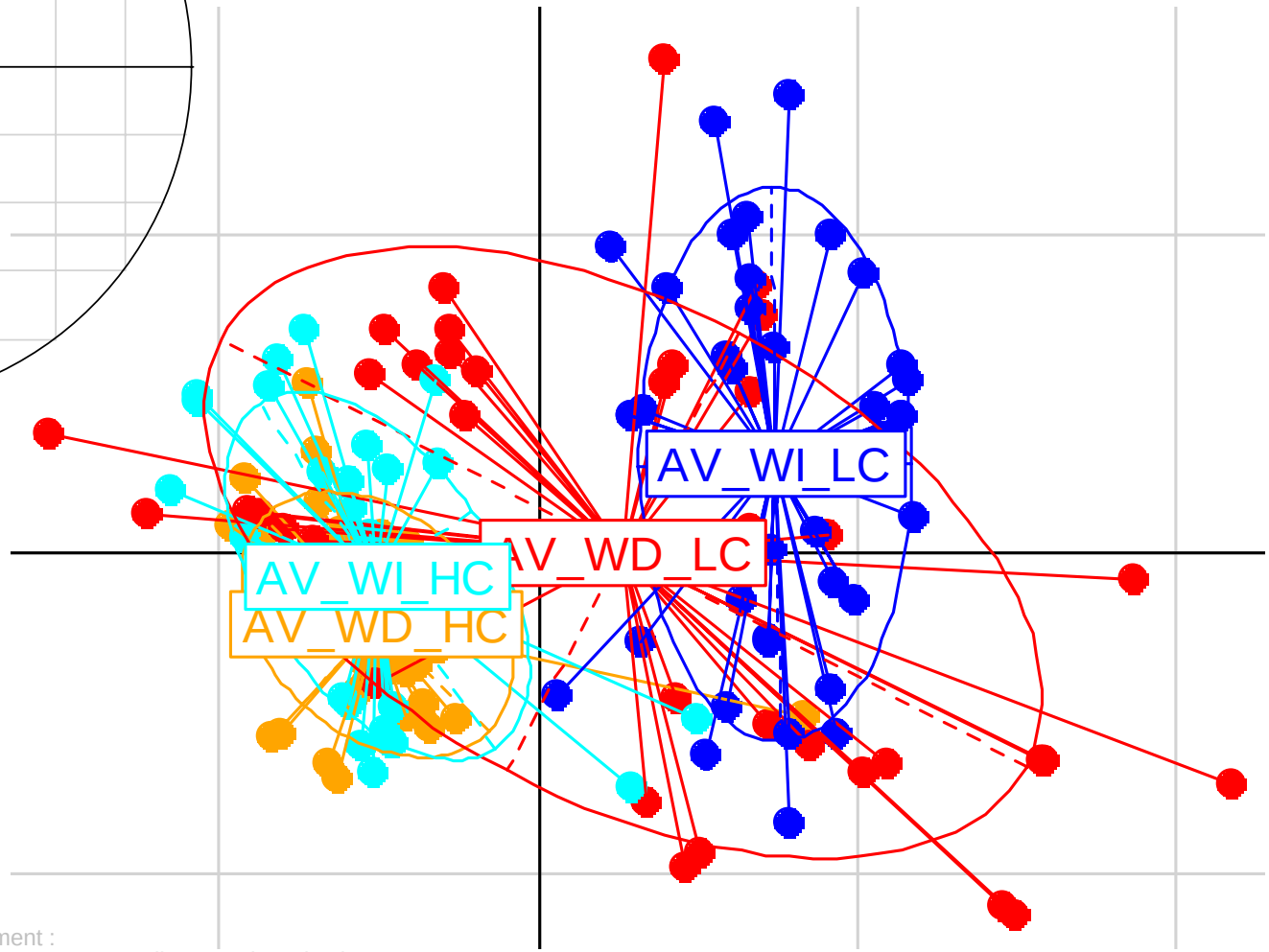
Criteria and parameters



Conclusions



Specific genotypes for high crop load
High variability of ideotypes for WD_LC



Perspectives

- explore genotypes selected in Bordeaux climate

- test the best genotypes of one scenario in the other scenarii:
  - are their genotypes good in different scenarii ?

- try to develop methods from Operations Research and compare results with those from Artificial Intelligence methods (NSGA)

Thank you for your attention