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

Bénédicte Quilot



Mohamed Ould Sidi  
Abdeslam Kadrani  
Michel Génard  
Françoise Lescourret



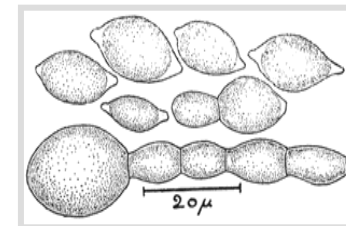
Nadine Hilgert

MISTEA

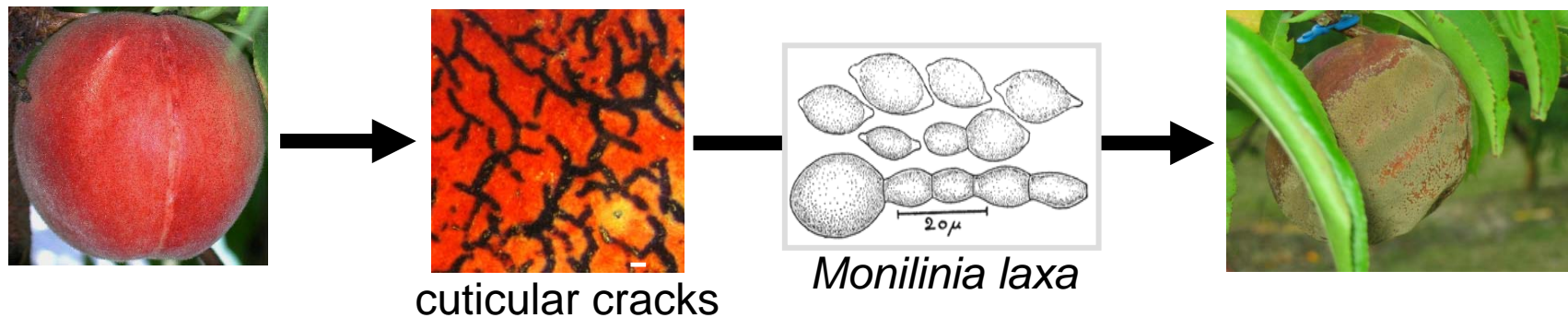
Controlling storage disease is a priority  
to reduce fruit residues and increase safety

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

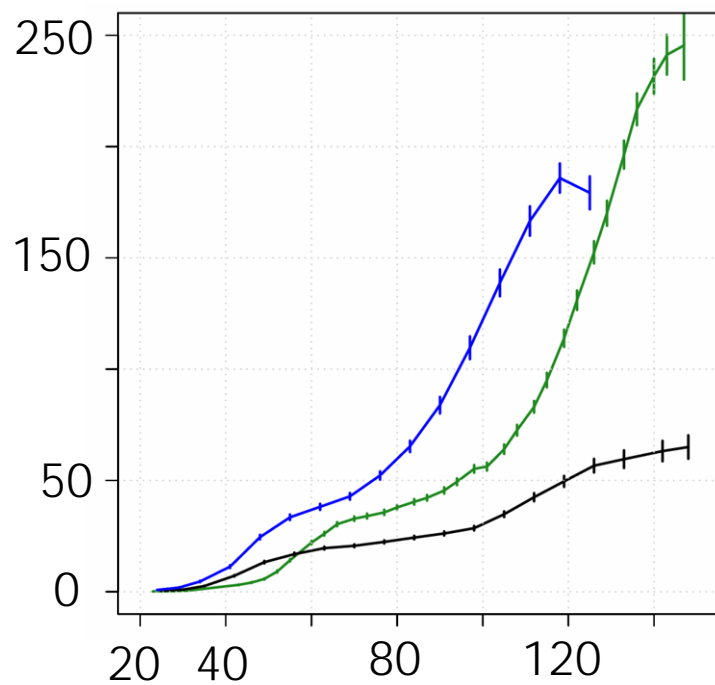
- brown rot caused by *Monilinia* species, can provoke as much as 30 to 40% of crop losses
- no other alternative than chemical treatment is available : fungicide applications are generalized and occur till pre-harvest
- all cultivated peaches are more or less sensitive to brown rot
- mechanisms of resistance may be complex and largely linked to fruit characteristics including fruit craking



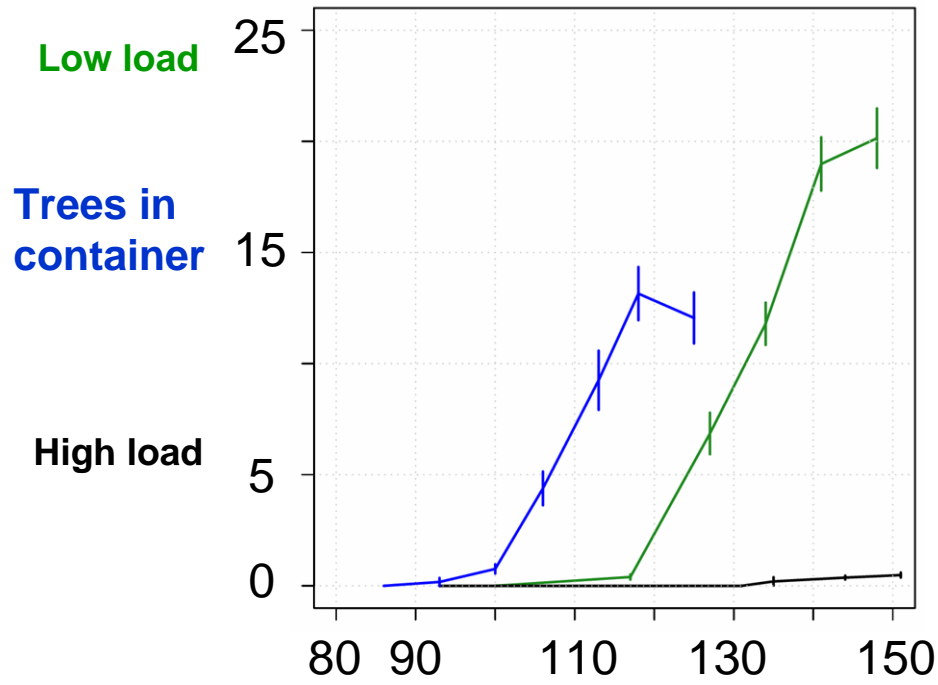
*Monilinia  
laxa*



Fruit mass (g)



$S_{\text{cracking}}$  (cm<sup>2</sup>)



Days after bloom

## cultivars

- crack occurrence sensitivity
- growth and quality characteristics

## thinning

## irrigation

## Practices

## Genotype

humidity  
temperature  
radiation

## Climate

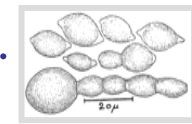
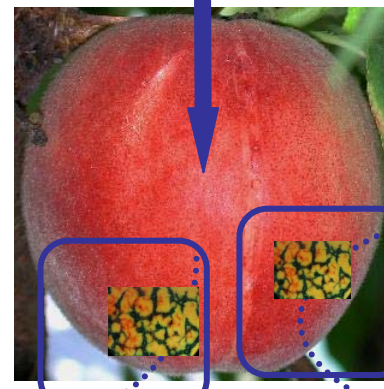
## Models

fruit growth  
(carbon and water)

sugar  
partitioning

transpiration

cuticular cracking

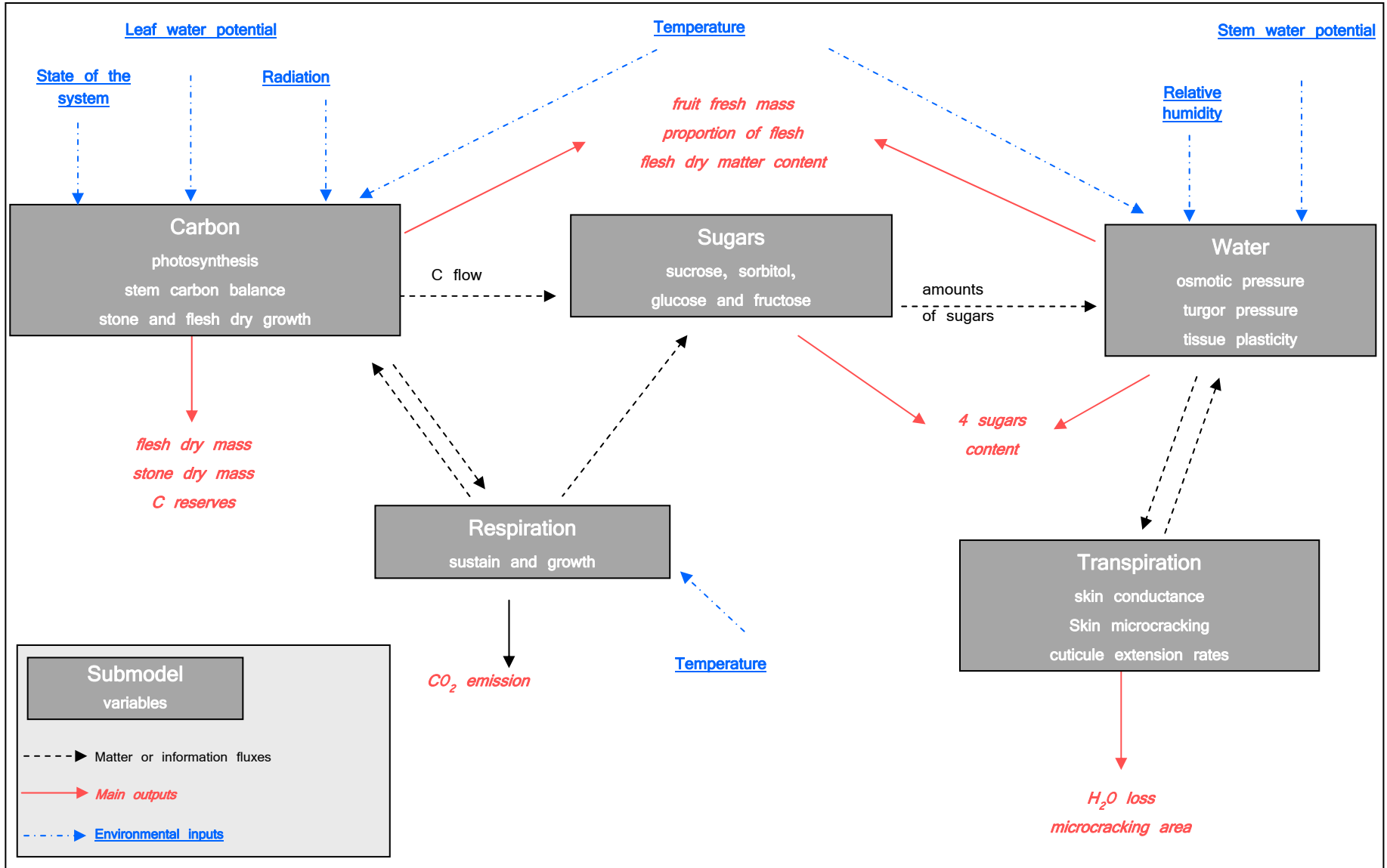


infection





# Virtual fruit



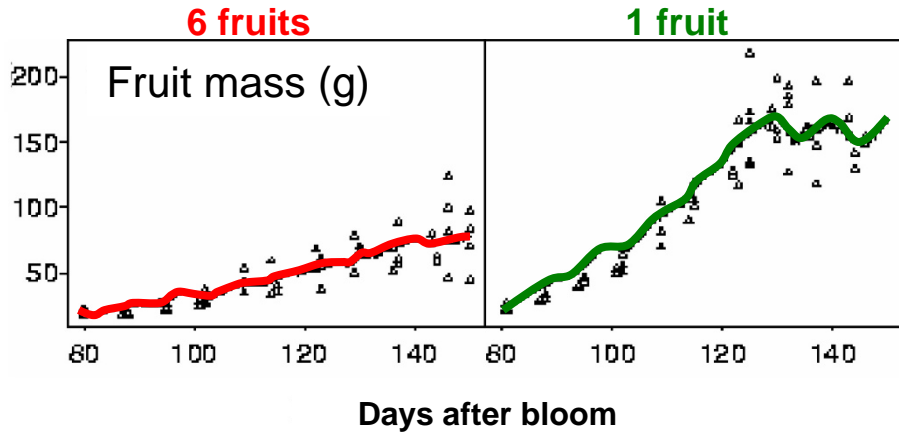
Adapted from Bertin et al, 2010

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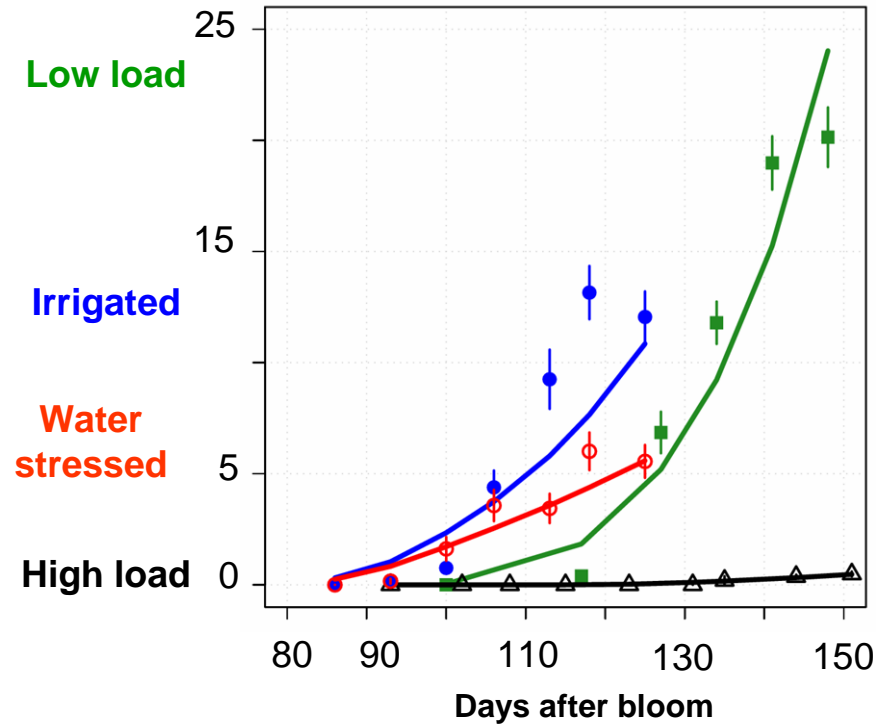
*Virtual fruit*

Fruit growth variations between tree load

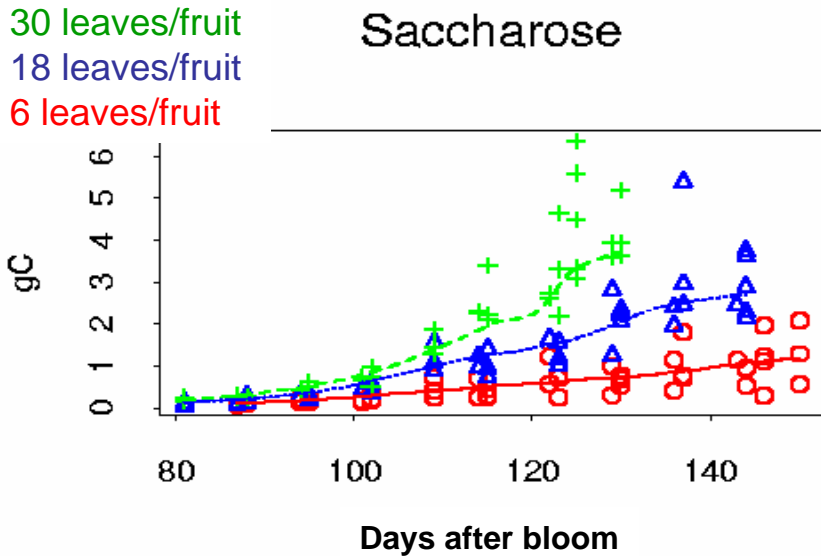


Cuticular cracking for different scenarii

$S_{\text{cracking}}$  (cm<sup>2</sup>)



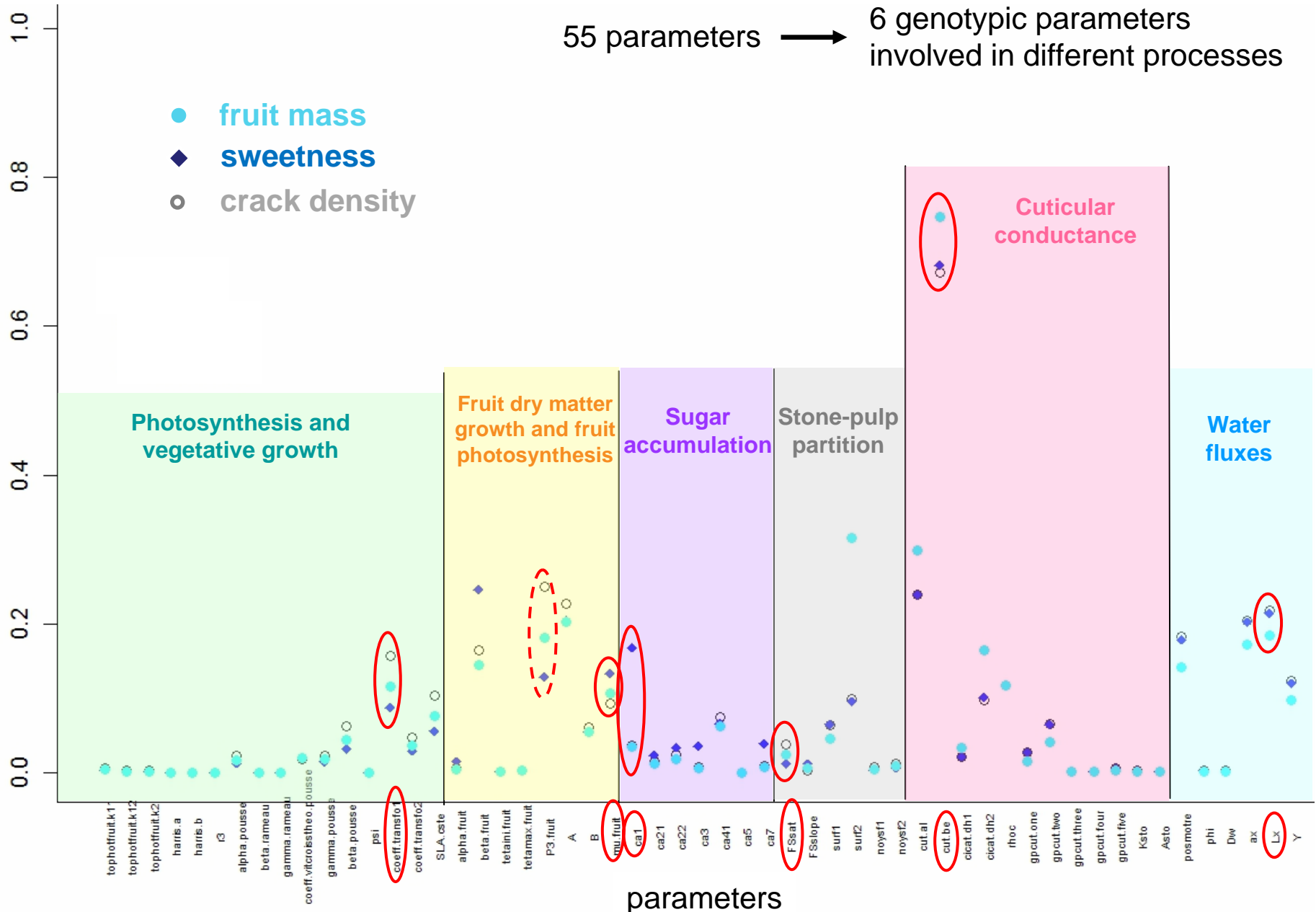
Sucrose accumulation for different tree loads





# Sensibility analysis

55 parameters → 6 genotypic parameters involved in different processes



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	<b>0.001</b>	<b>0.01**</b>
ca1	Proportion of carbon as sucrose in phloemic sap	Sugar metabolism	0.347	<b>0.23</b>	<b>0.54***</b>
FSsat	Parameter of the relationship between stone dry mass and total fruit dry mass	Stone-pulp partition	6.78	<b>6.10</b>	<b>7.46**</b>
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	<b>0.0769</b>	<b>0.667**</b>

\*  $\pm 10\%$  variations

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

\*\*\* Extreme values from literature

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## Criteria to optimize

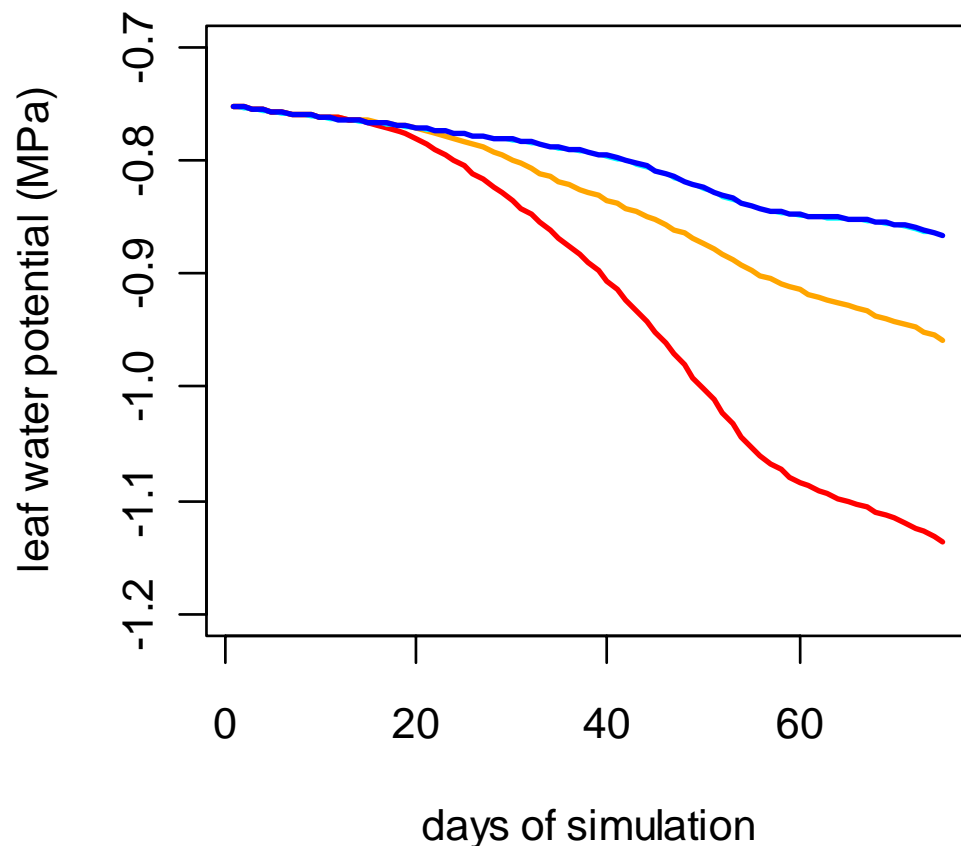
CRITERIA	OPTIMISATION	MINI	MAXI
Fruit mass (g)	maximiser	50	300
Sweetness (%)	maximiser	4	20
Crack density (%)	minimiser	0	20



# 8 scenarii

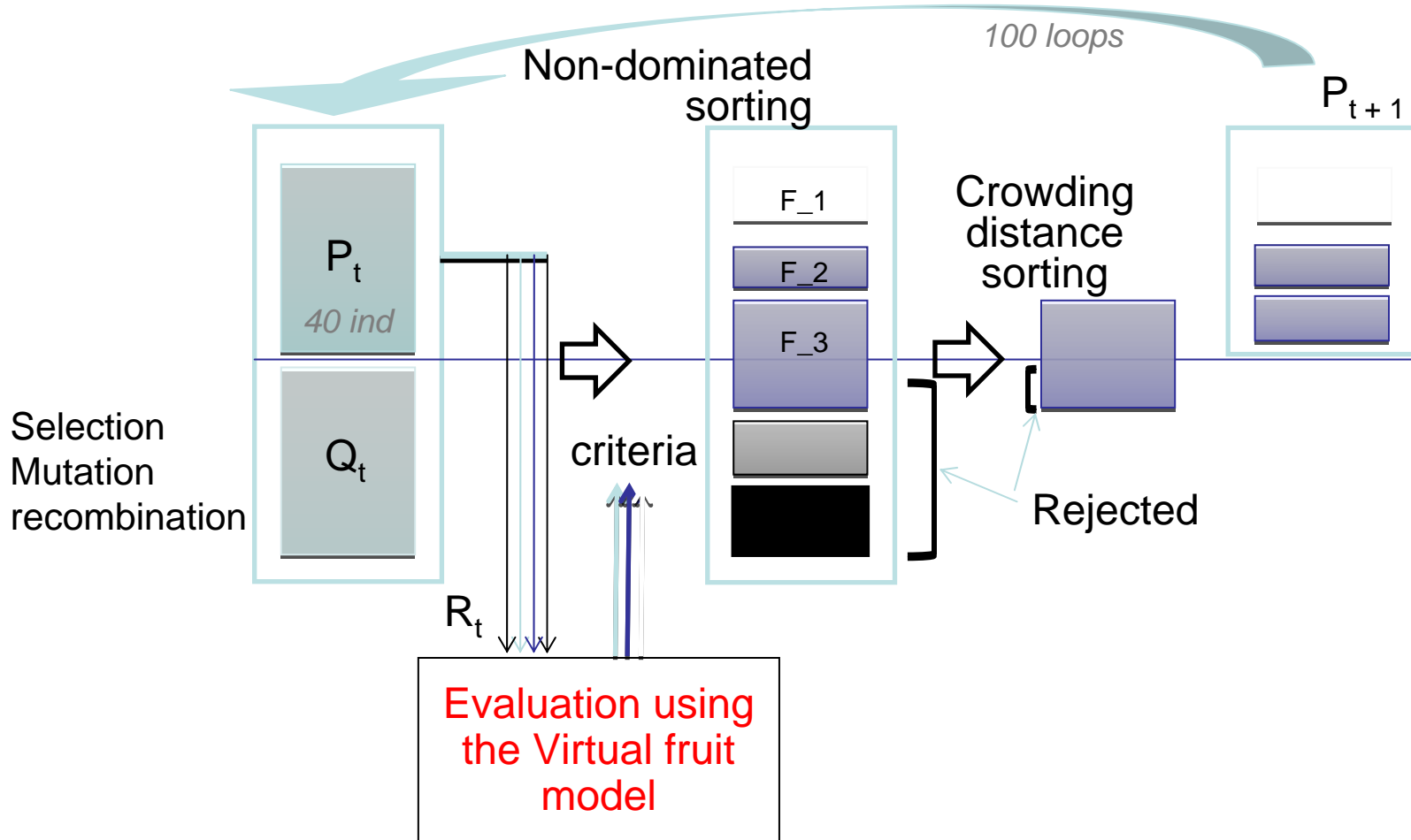
CLIMATE	IRRIGATION	FRUIT LOAD
Avignon	Well irrigated (WI)	4 fruits/stem LC
		20 fruits/stem HC
	Water deficit (WD)	4 fruits/stem LC
		20 fruits/stem HC

same for Bordeaux



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

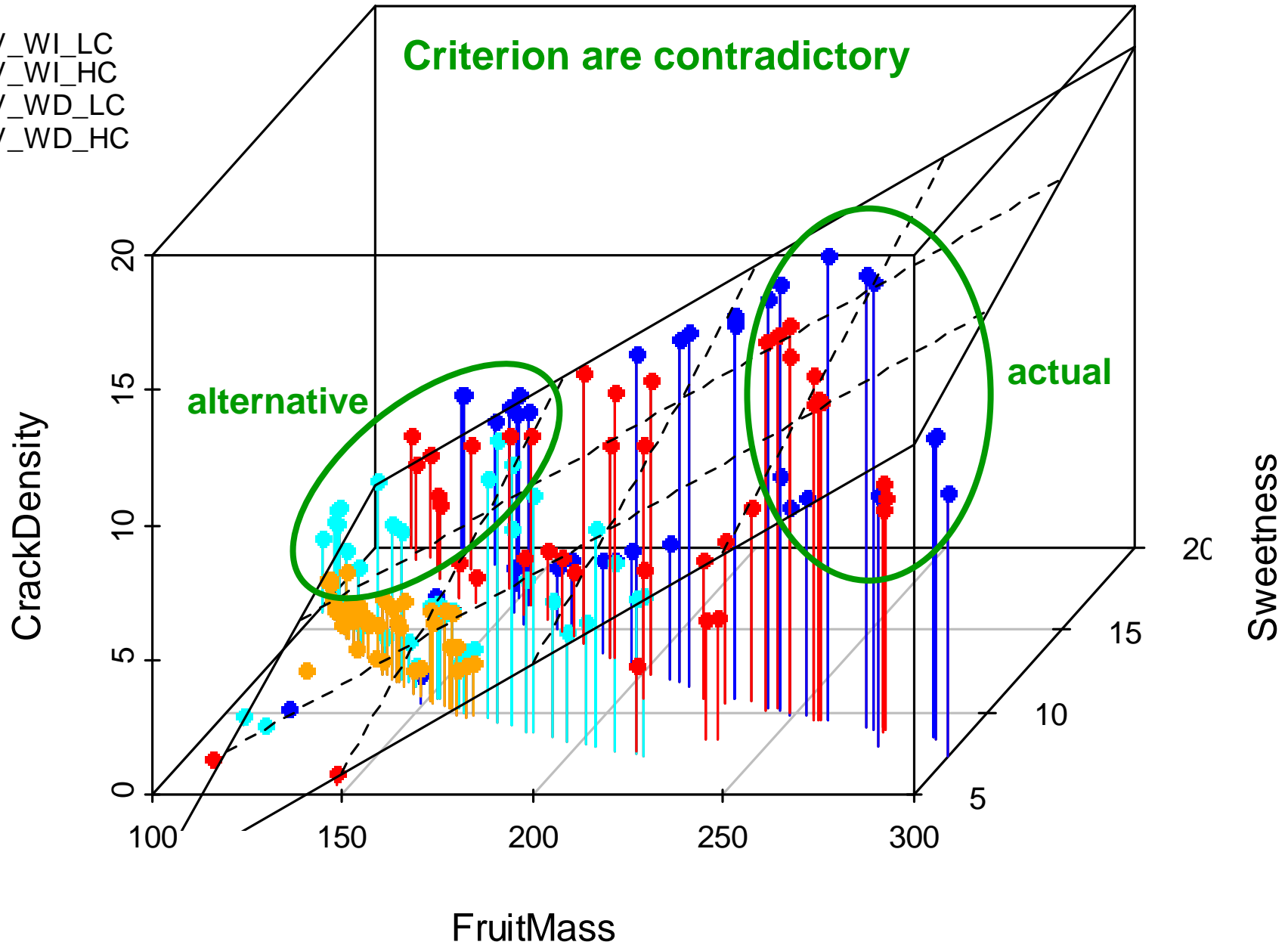


**Dominance relation between solutions**

**A large choice of solutions:**

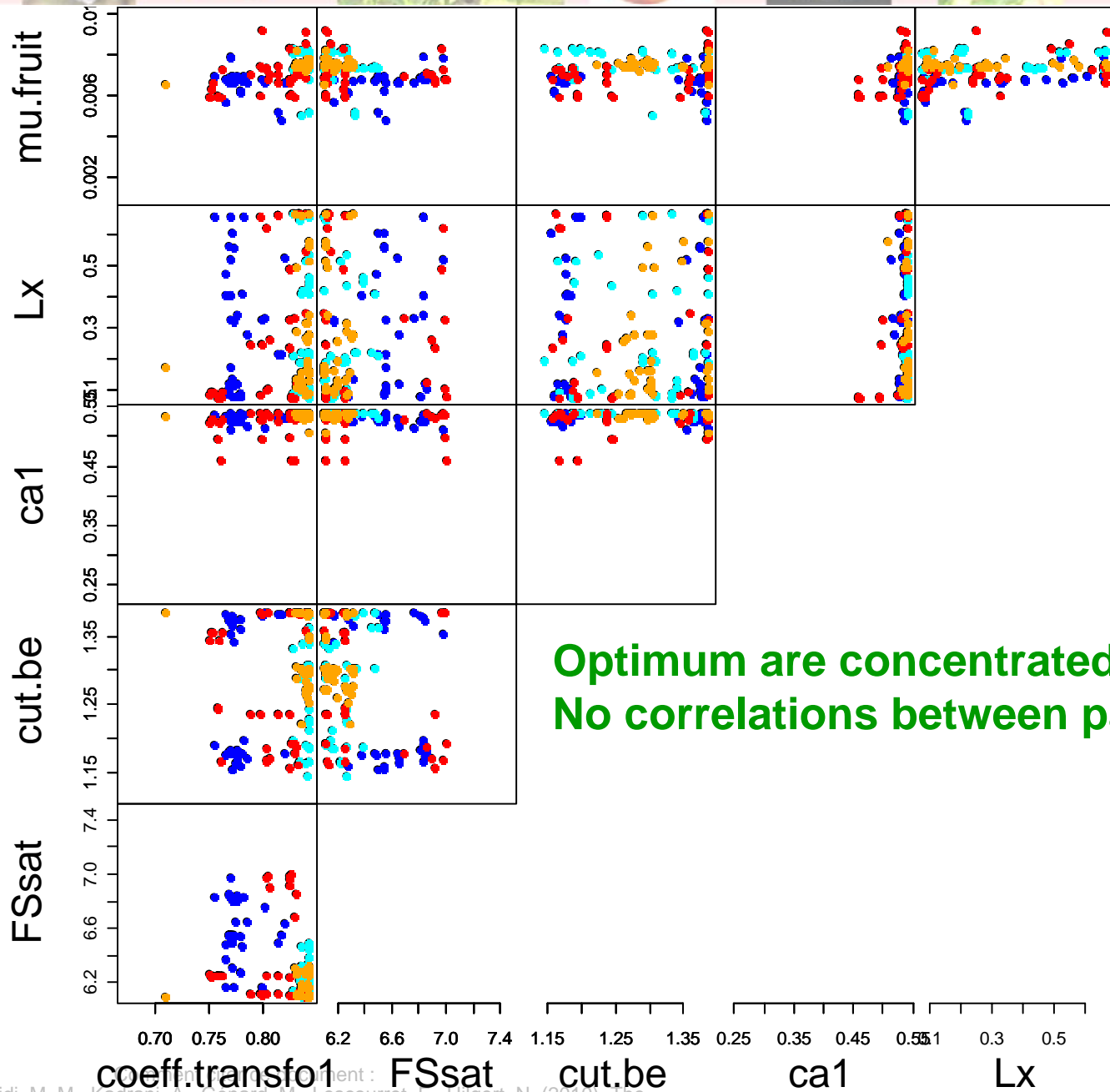
**40 optimum genotypes over 4000 tested per scenario**

- AV\_WI\_LC
- AV\_WI\_HC
- AV\_WD\_LC
- AV\_WD\_HC





# Parameter correlations



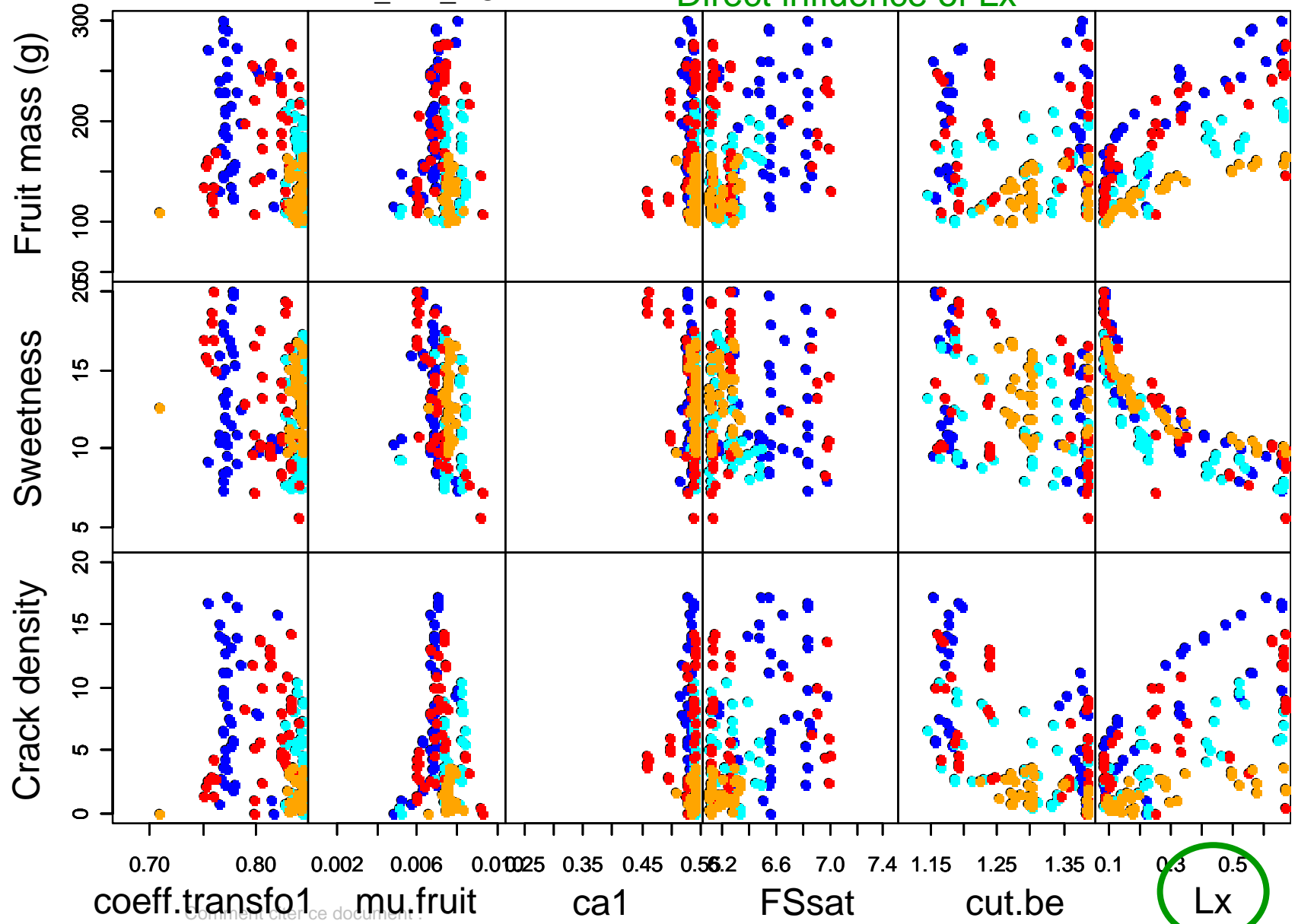
Optimum are concentrated in the space  
No correlations between parameters

- AV\_WI\_LC
- AV\_WI\_HC
- AV\_WD\_LC
- AV\_WD\_HC



- AV\_WI\_LC    ■ AV\_WD\_LC
- AV\_WI\_HC    ■ AV\_WD\_HC

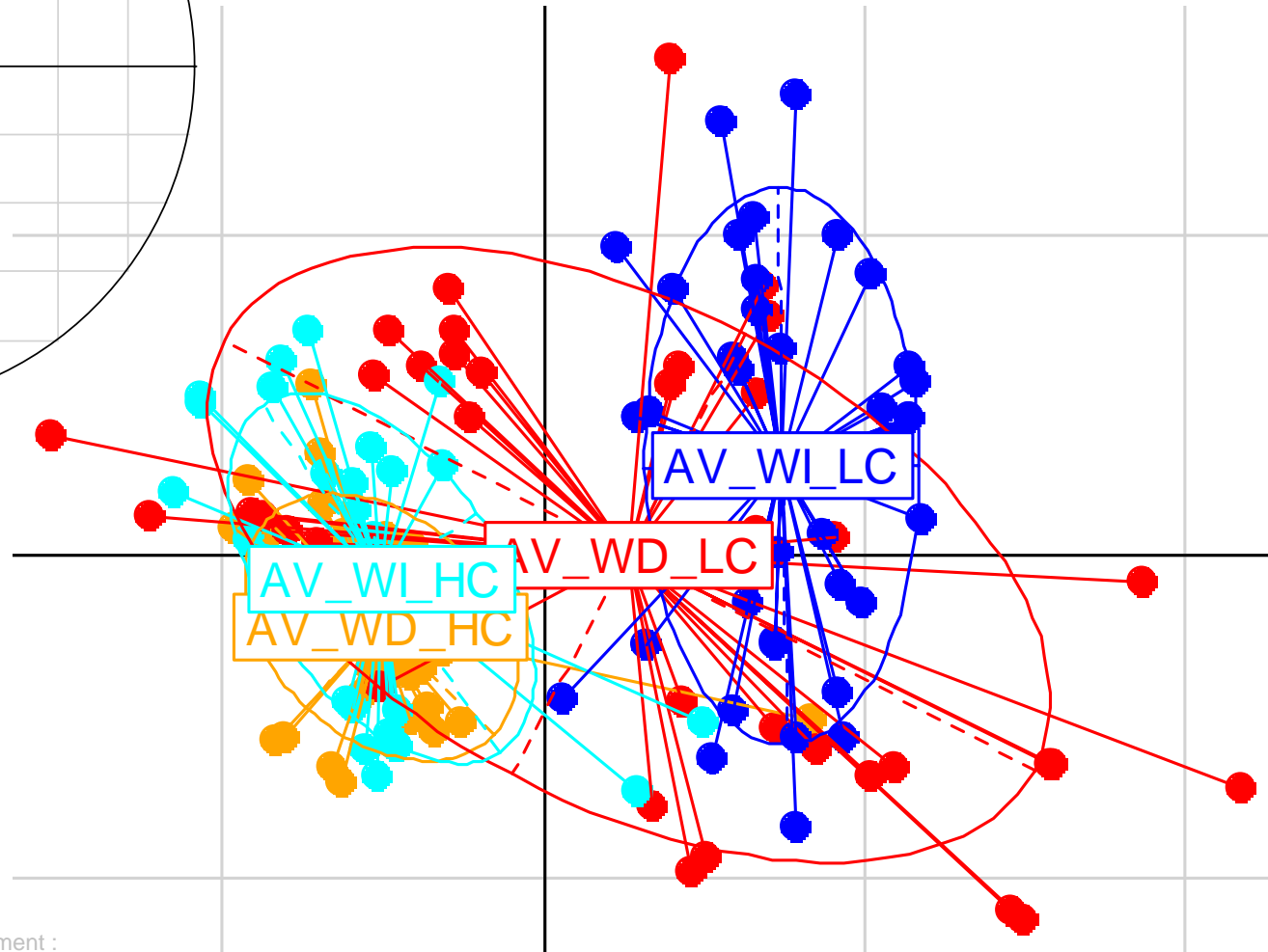
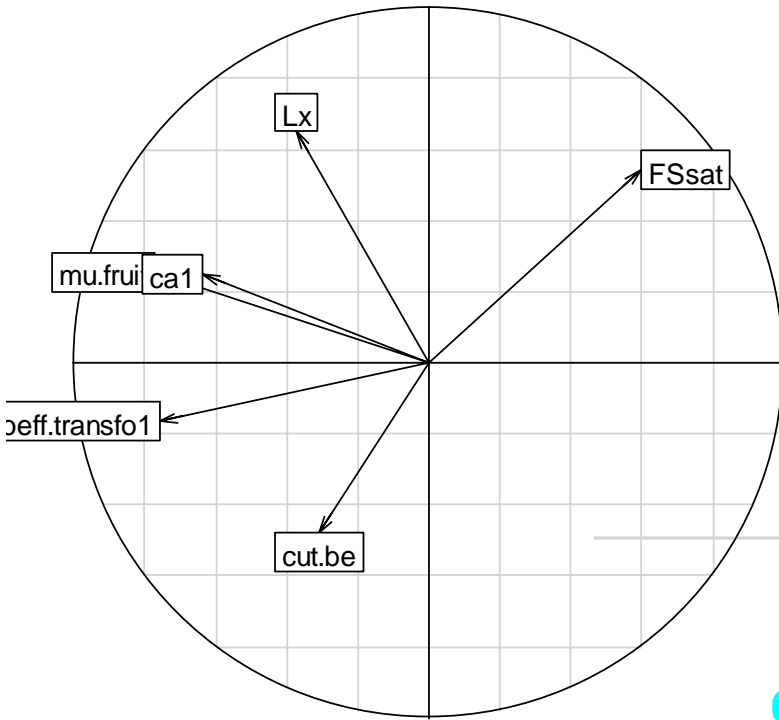
Complex interactions  
Direct influence of Lx





# Conclusions

**Specific genotypes for high crop load**  
**High variability of ideotypes for WD\_LC**



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- 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