Recherches conduites dans l'équipe AFEF

Equipe INRA-Montpellier SupAgro

Architecture et Fonctionnement des Espèces Fruitières

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UMR DAP (Développement et Amélioration des Plantes)

Research Axes

➢ Caracterisation of tree architecture and functions in a range of cultivars

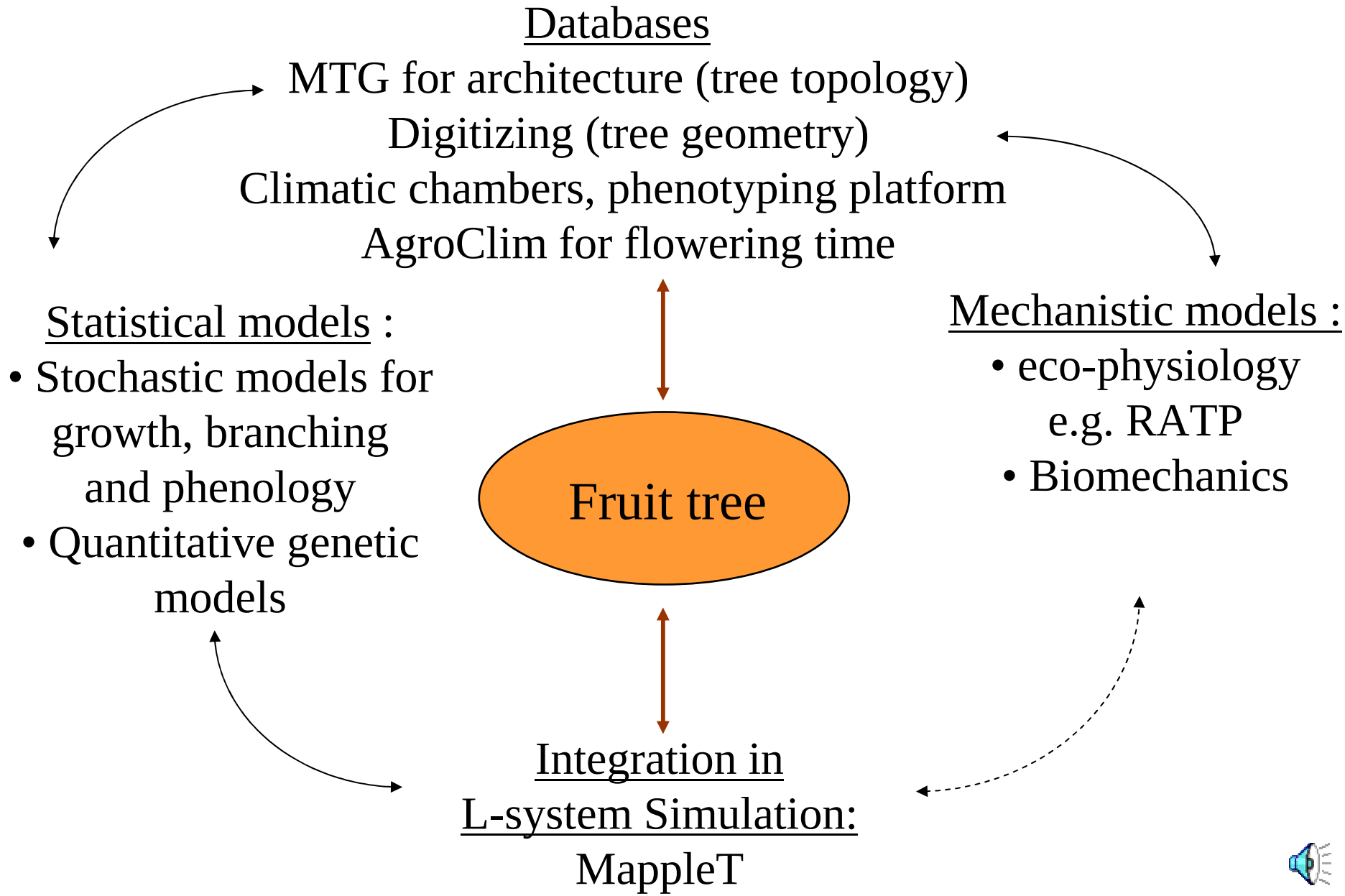
- Changes in flowering time in response to global warming
- Growth and branching – Reactions to tree manipulation
- Estimation of physiological capacities of trees (transpiration, photosynthesis) in response to environmental conditions
- Modelling and simulation of 3D tree development and physiology over years

➢ Genetic determinisms of tree architecture and functions

- Tree morphology and architecture
- Leaf functions and tolerance to abiotic stress (air vapour pressure deficit, water stress)

–> QTL mapping, candidate genes

Methods


Databases
MTG for architecture (tree topology)
Digitizing (tree geometry)
Climatic chambers, phenotyping platform
AgroClim for flowering time
Statistical models :
• Stochastic models for growth, branching and phenology
• Quantitative genetic models
Mechanistic models :
• eco-physiology
e.g. RATP
• Biomechanics
Fruit tree
Integration in
L-system Simulation:
MappleT

Une plante 3D obtenue par digitalisation

Digitalisation
au champ

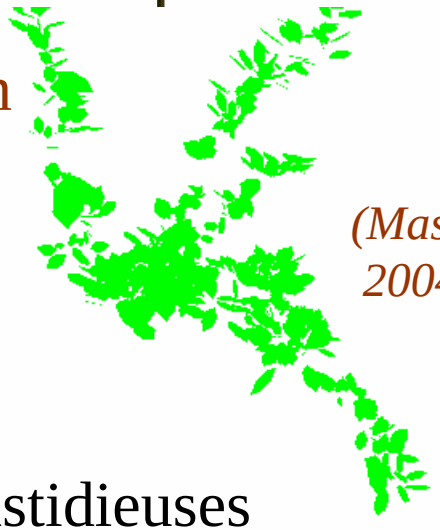
Reconstruction +/-
simplifiée par PlantGL

observation

Mesure des axes
ligneux

(Godin et al., 1999;
Costes et al., 1999)

Mesure de la distribution
3D du feuillage



(Massonet et al.,
2004)

Avantages: Opérationnel
Fiable

Inconvénients: Mesures longues et fastidieuses

Results Axis 1 Tree architecture and alternate bearing: a positive relationship between return-bloom and low branching density

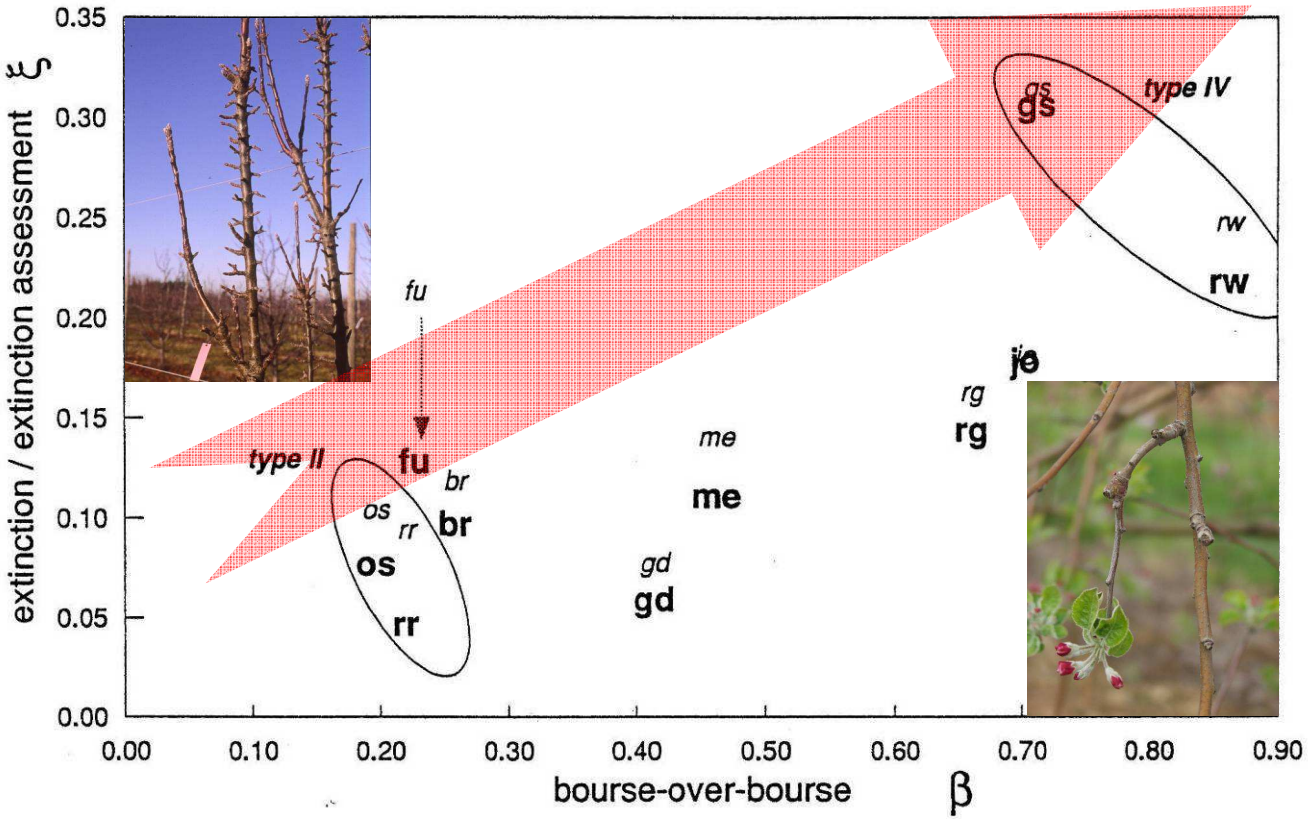
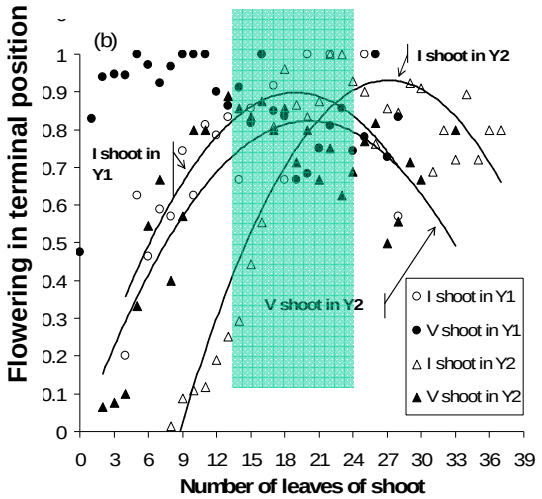


FIG. 4

Relationship between the bourse-over-bourse (β), and the extinction (in italic and small size) and extinction assessment (in thick character; ξ), for the various cultivars. The cultivar abbreviation shows the mean value of each index for the couples of years 1–2 and 2–3. (See Fig. 2 for cultivar abbreviations).

(Lauri *et al.*, 1997)



(Lauri and Trottier, 2004)

The interest of apple genotypes with medium-length branches.

The interest of training protocols which homogenize the length of branches.

↳ young spur thinning (*artificial extinction*)

Results Axis 1

Implications for tree training and pruning

manipulation of tree architecture to improve:

1 – fruit quality and regularity of bearing

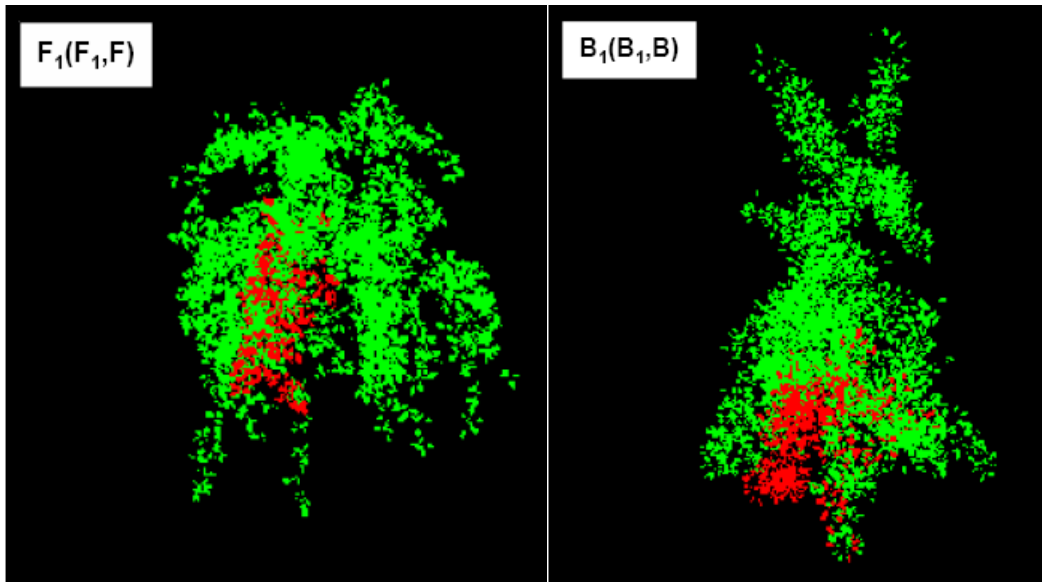
2 – control of pests and diseases in the context of ICP (PFI)

Tree with classical training and pruning: a dense within-tree canopy

Centrifugal-trained tree

A tree with a high porosity to light, to enhance and homogenize fruit quality, and decrease pest and disease incidence

Effet relatif de la répartition 3D du feuillage et des capacités d'échanges gazeux des feuilles chez deux cultivars Fuji et Braeburn



	Mean (see)	Struc.	Func.	SxF
Transpiration (mol H_2O m^{-2} day^{-1})				
(F, F)	104.0 (28.2)			
(B, B)	84.3 (22.2)	**	**	ns
(F, B)	87.8 (23.6)			
(B, F)	100.2 (26.7)			
Photosynthesis (mmol CO_2 m^{-2} day^{-1})				
(F, F)	469.7 (111.3)			
(B, B)	404.2 (91.8)	**	**	ns
(F, B)	422.9 (101.6)			
(B, F)	450.5 (101.0)			

Leaf functions:

-stomatal regulation:
higher g_{smax} and more rapid g_s response to VPD in 'Fuji' than in 'Braeburn'
- higher leaf respiration (R_d) in 'Fuji'
- photosynthetic capacities (V_{cmax}, J_{max}) not significantly different

Usefulness of FSPM in silico scenarii

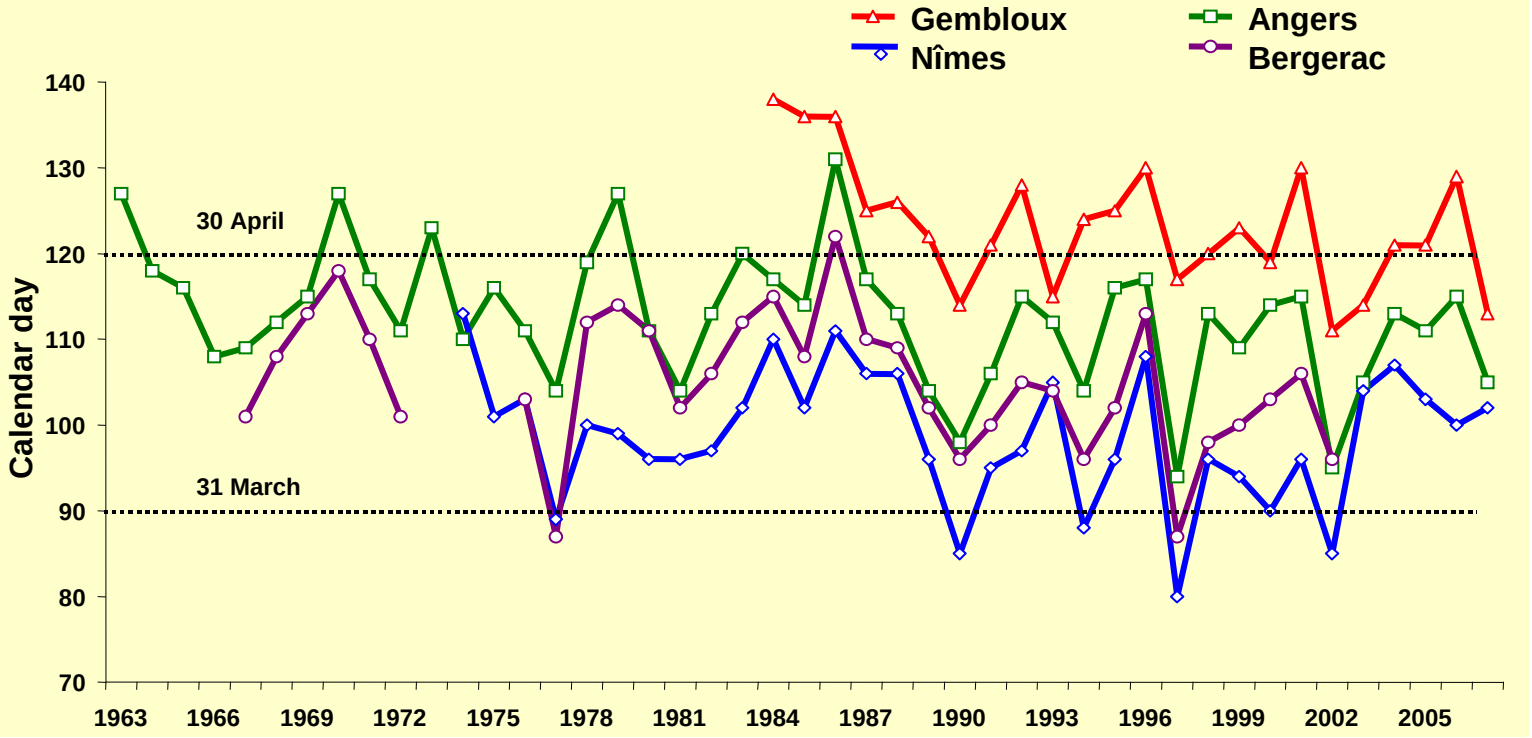
Additive combination of structural and functional effects at both branch and tree scales.

Massonnet *et al.*, 2008

Results Axis 1 Changes in tree phenology : towards precocity in flowering time

Time-course variation of apple F1 dates (10% of flowers opened)

'Golden Delicious' at four locations



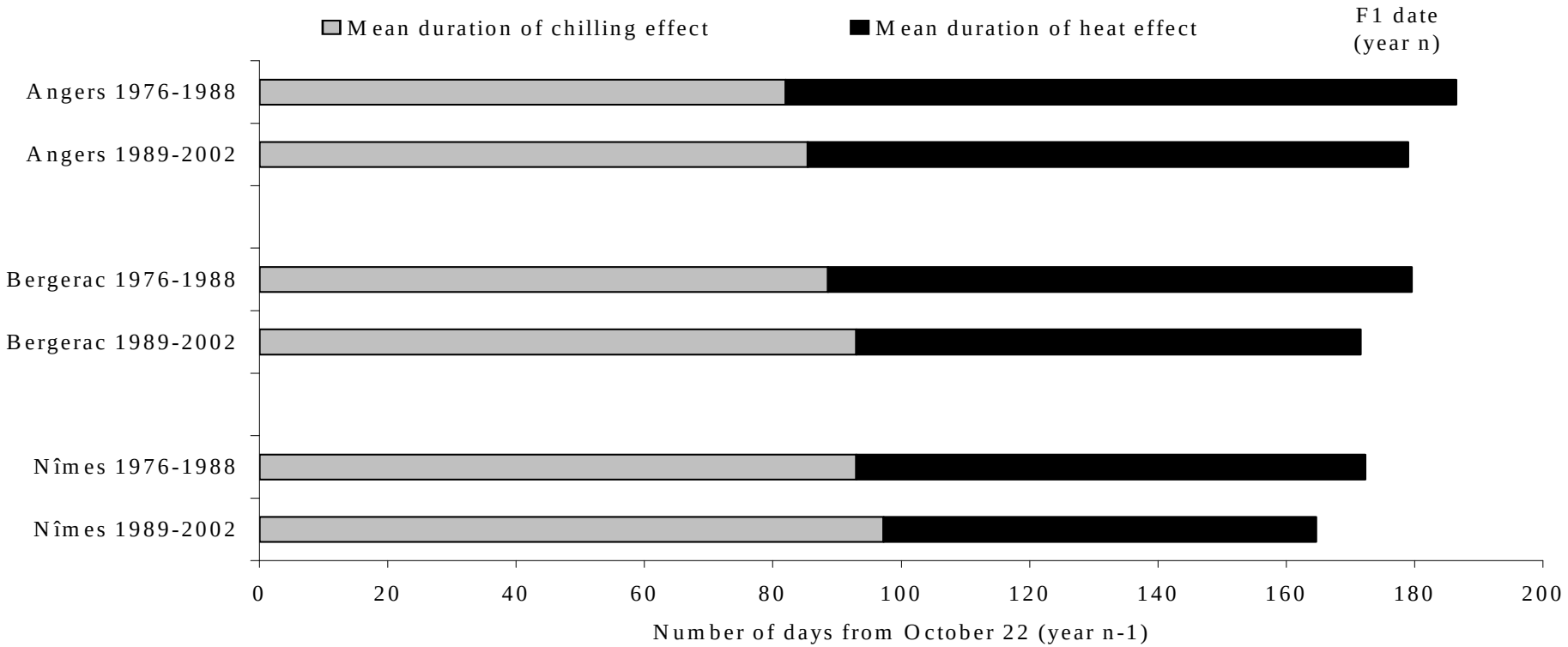
	Mean F1 date	
	Angers	Nîmes
1989-2002	18 april	4 april
1976-1988	25 april	11 april

Advances in F1 date by 7-8 days

Legave *et coll.* (2008)

Results Axis 1

Modelling chilling and warming requirements to understand changes in flowering time



Two effects of global warming may explain the flowering advance (7-8 d), since the end of years 80 :

- a slight increase in the duration of chilling effects (3-5 d) and
- a more marked decrease in the duration of heat effects (10-13 d) whatever locati

Un modèle structure fonction basé sur la dynamique du développement architectural

❖ *Développer une démarche de modélisation "mixte", alliant modèles stochastiques et mécanistes*

✓ *Développer un modèle réactif, pour prendre en compte les réactions de l'arbre aux manipulations en verger*
Thèse cifre en cours

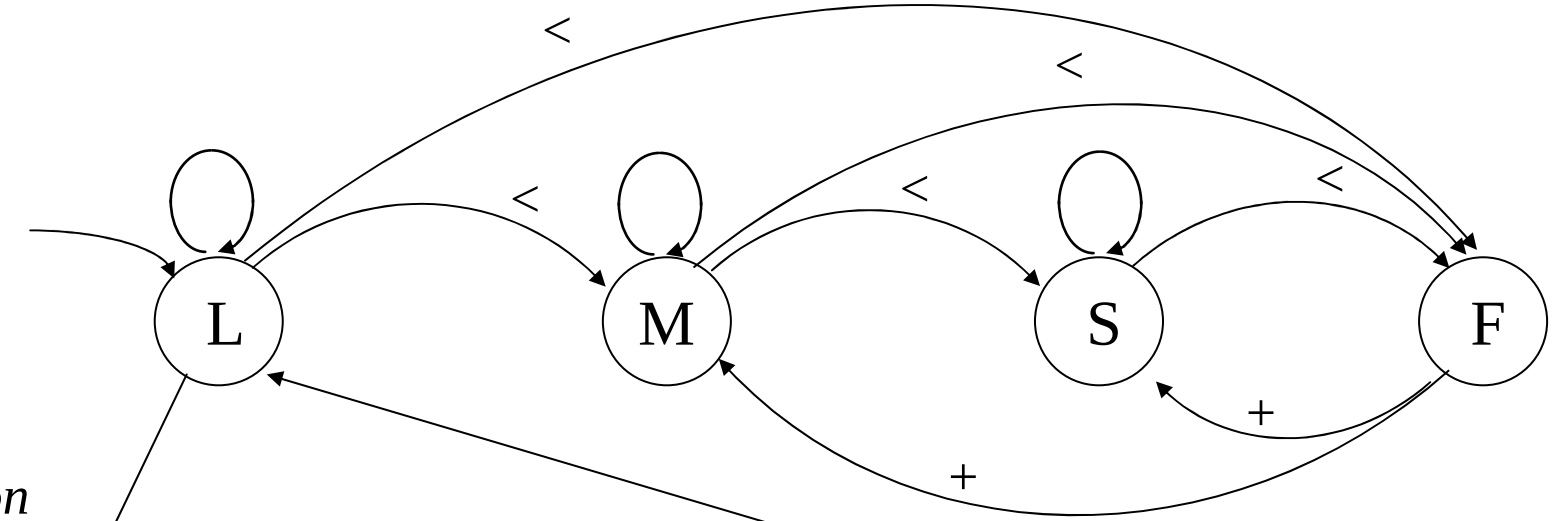
✓ *Coupler un modèle de flux d'eau et de carbone à la dynamique de développement architectural (par exmple L-Peach)*

❖ *Introduire des effets de rétro-action entre les modèles élémentaires : géométrie – topologie – environnement*

A hierarchical model for tree topology

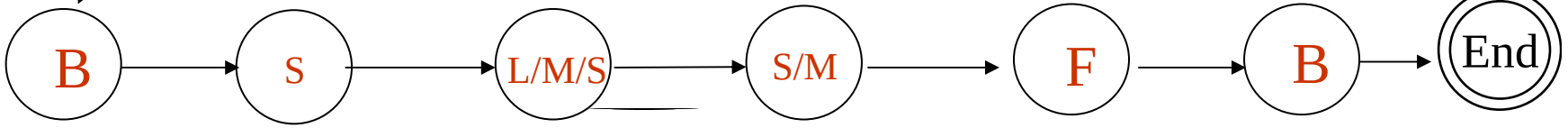
GU scale

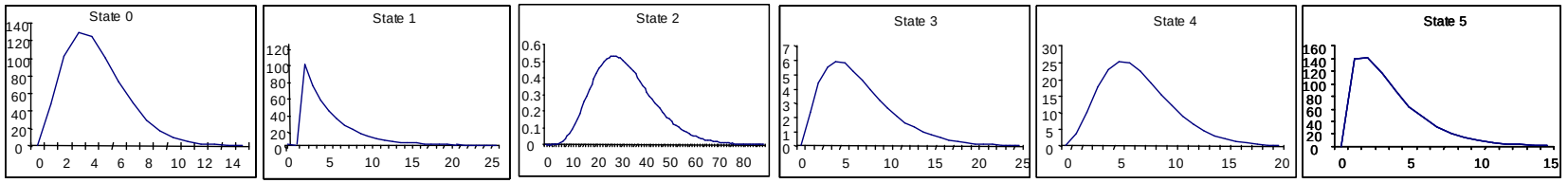
< succession
+ branching



Metamer scale

Axillary bud fates are organised in zones

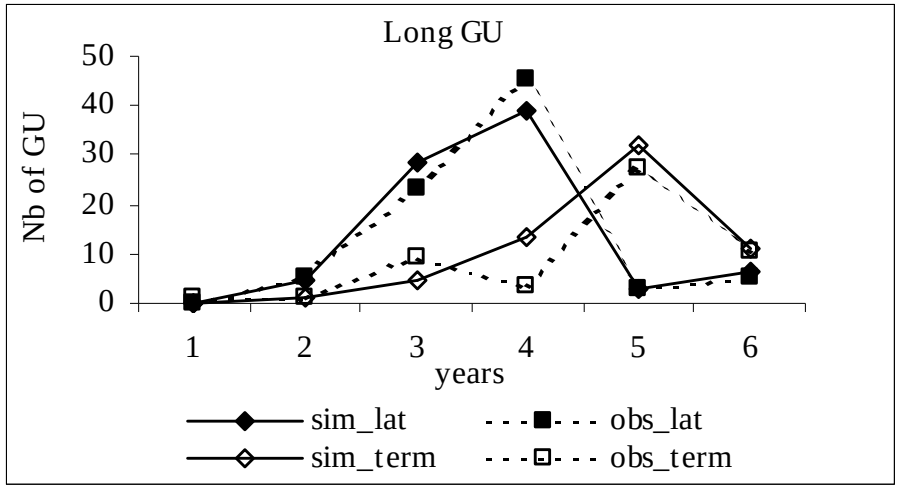


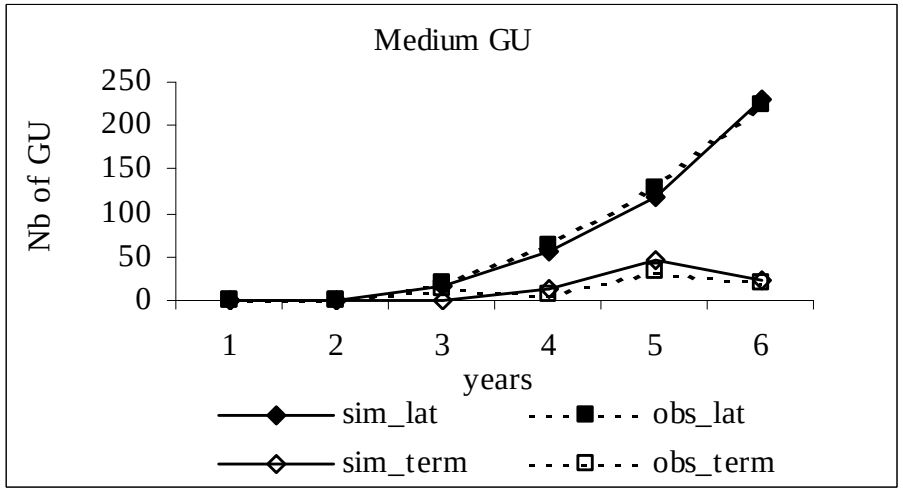


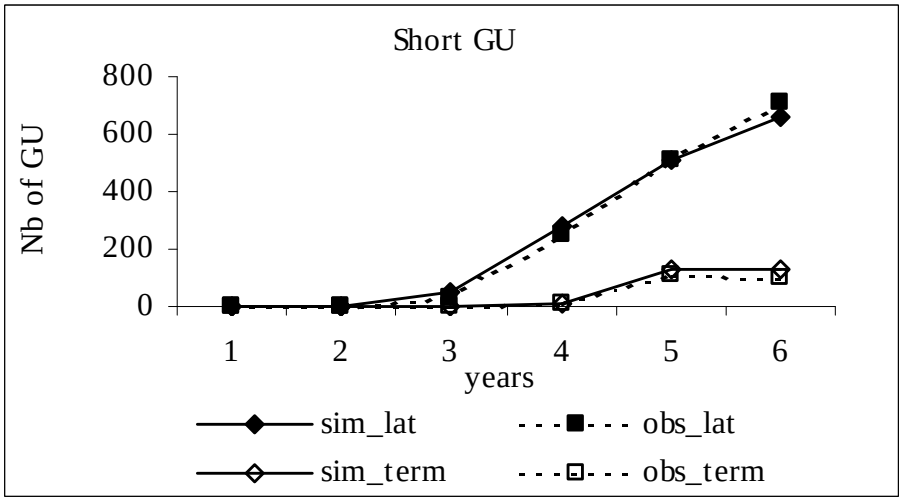
Hidden semi Markov Chain

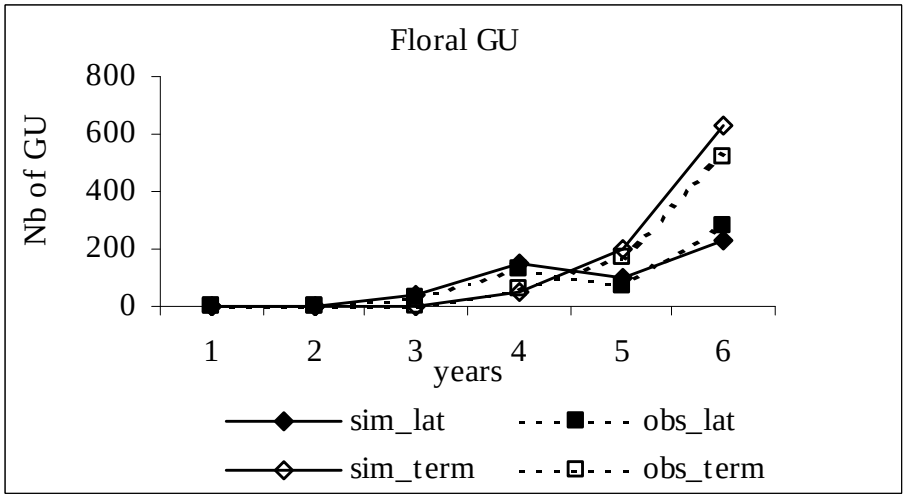
From Renton et al., 2006

Comparing simulation output to digitised trees: Counting GU at the whole tree scale

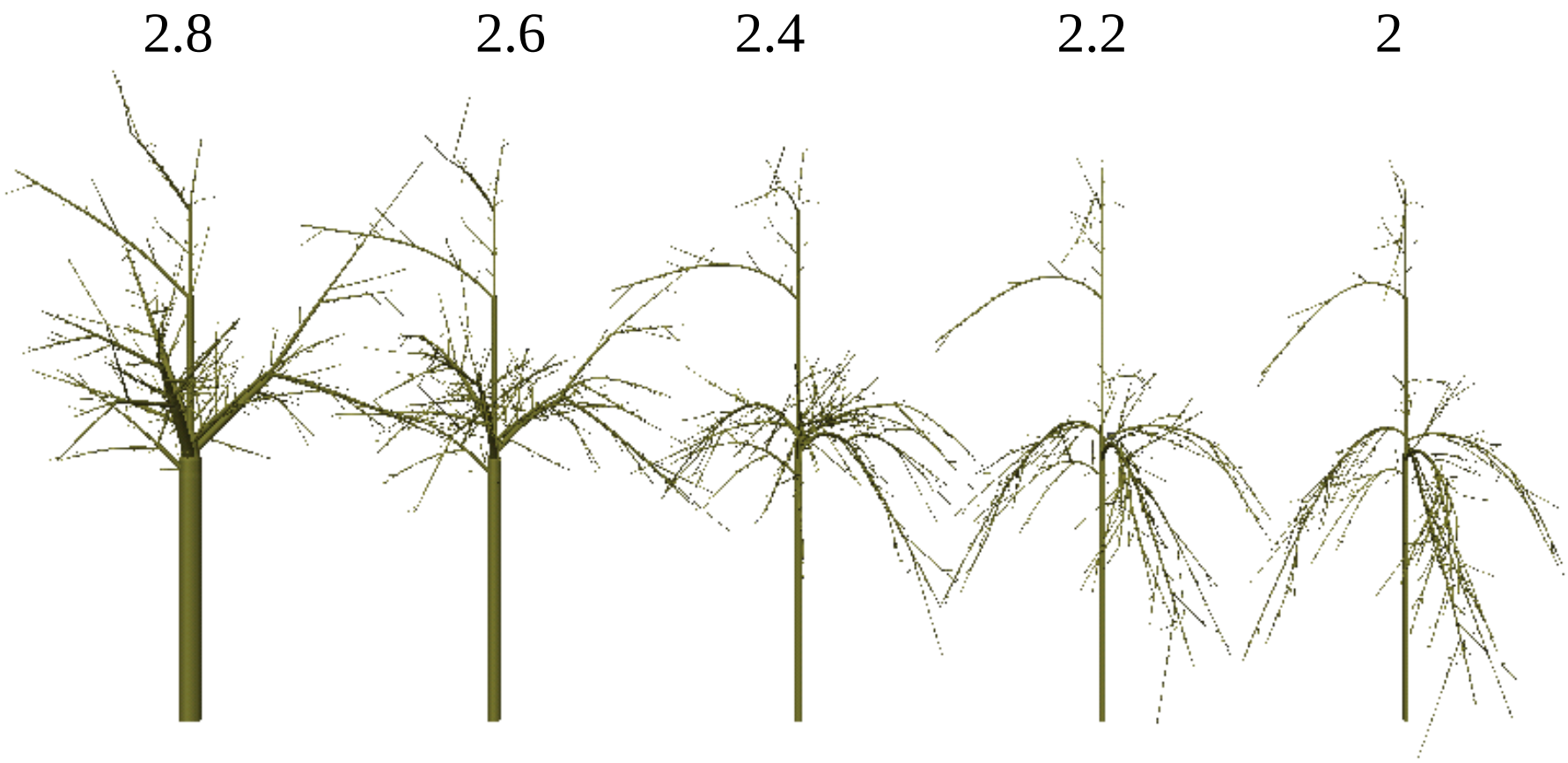






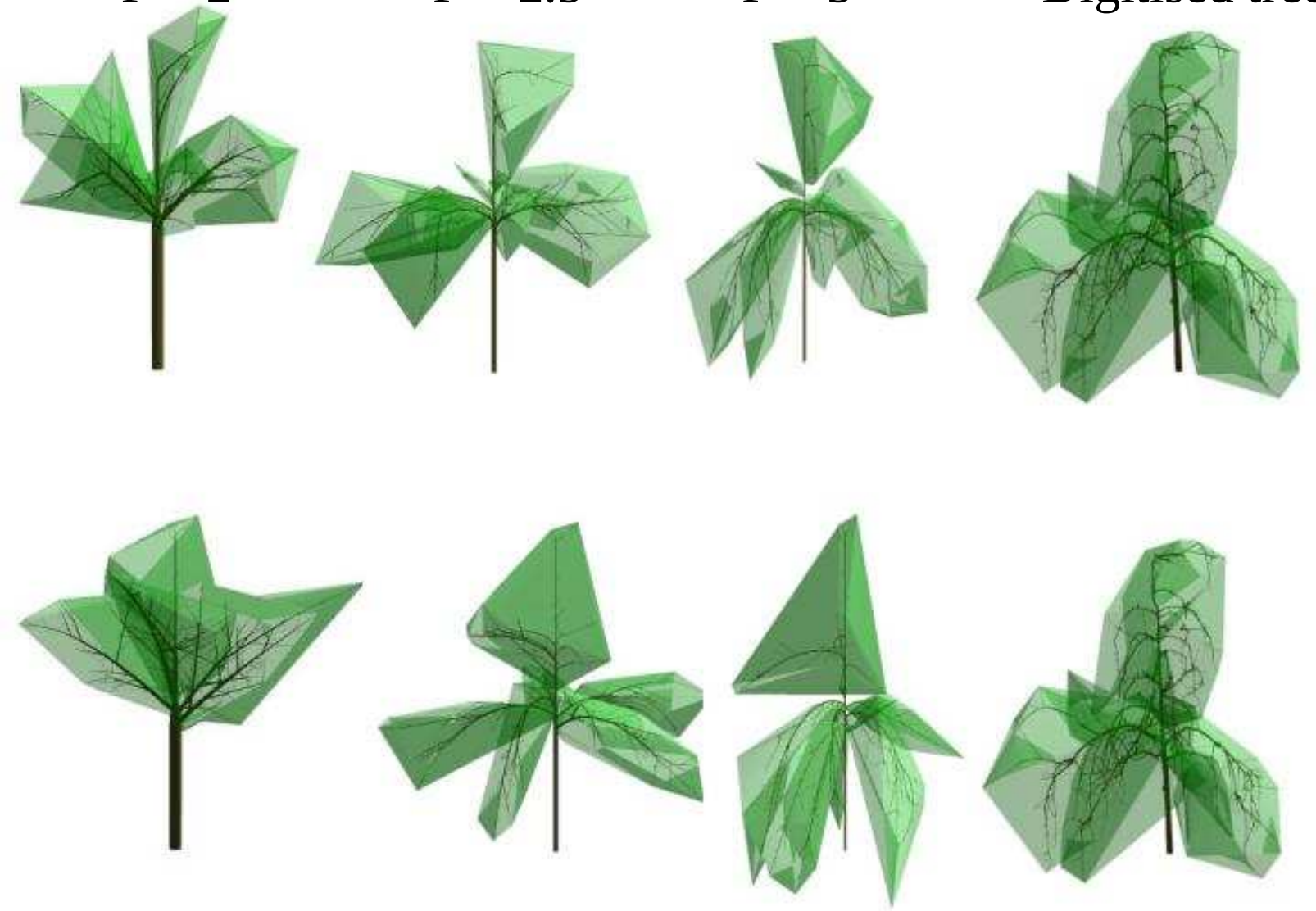


Sensitivity analysis of the tree shape to the pipe model exponent

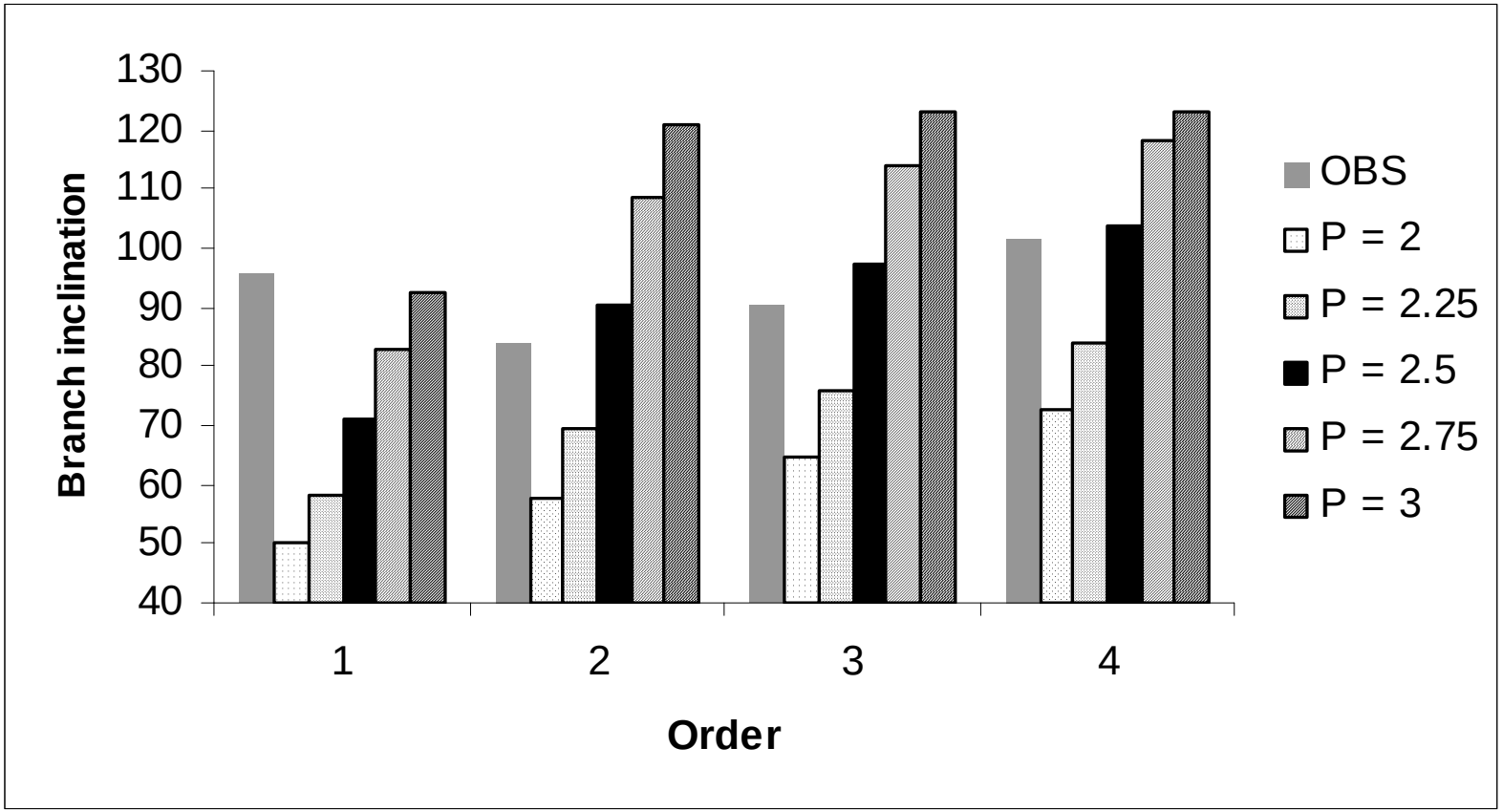


Comparing simulation output to digitised trees: Envelop calculation on fruiting branching systems

P = 2 | P = 2.5 | P = 3 | Digitised tree



Comparing simulation output to digitised trees: Numerical outputs



Variation of average branch inclination with respect to the pipe model exponent by branching order (default value P = 2.49)

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