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A modeling approach of carbon and hormones fluxes

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Context

The alternate bearing in apple trees consists in a high fruit production in ON years followed by a low production in OFF years (Fig. 1) and represents a major problem in fruit industry.



Fig 1: Trees in ON (left) and OFF (right) years.

Main hypotheses

Floral induction (FI) variability between successive years is caused by:
Competition for carbohydrates between fruits and vegetative organs (Monselise et Goldschmidt, 1982)
Inhibition by gibberellins (GA) coming from the fruits seeds (Nielsen and Dennis, 2000)
Tree architectural variability (Lespinasse et Delort, 1986)

Previous results

- Analyzes of transcript differentially expressed in terminal buds of 'ON' and 'OFF' trees show starvation for carbon and stress hormonal metabolism in 'ON' trees (Guitton et al., 2016)

Previous results

- Genetic variability in bearing behavior associated with a strong genetic determinism (Guitton et al., 2012)
- Genotypes can be classified for bearing behavior in three classes (irregular, biennial, regular) (Durand et al., 2013)

Objectives

- Understanding the physiological processes controlling FI in apple trees
- Modeling and simulating carbon and hormone fluxes within the trees and their consequences on FI
- Integrating genotypic variability in the modelling approach to account for the variability in bearing patterns

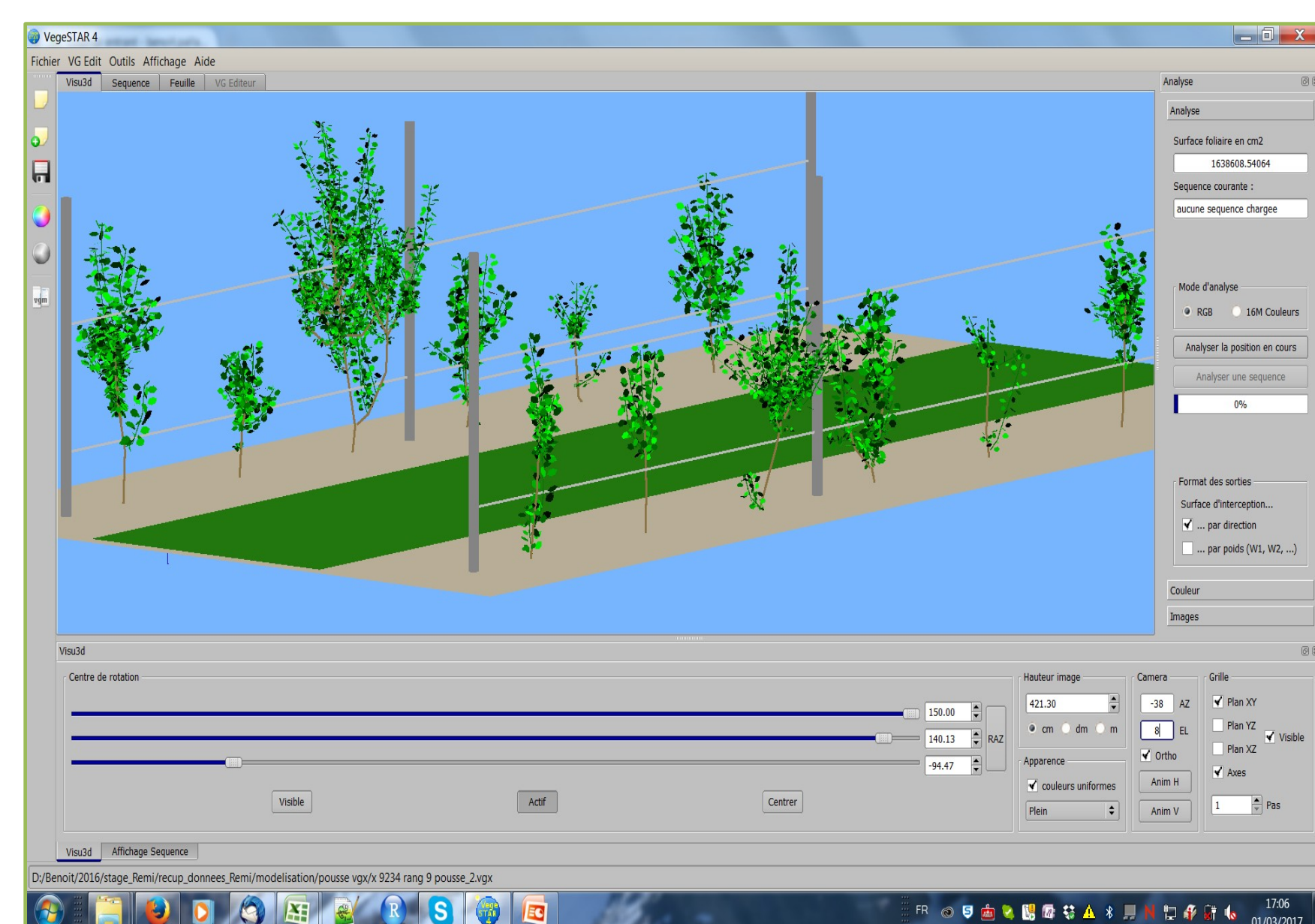


Fig 3: 3D representation of a subset of genotypes in the French apple core collection (planted in 2014)

Experimental design

- First experiment (2015-2017): Leaf and fruit removal at different scales (shoot, branch and Y shape-trees; Fig. 2) to locally modify Carbon source/sink relations and GA content

- Second experiment (2017-2018):

Characterizing the genotypic variability in production patterns and architecture on a subset of genotypes selected in an apple tree core collection (Fig. 3)

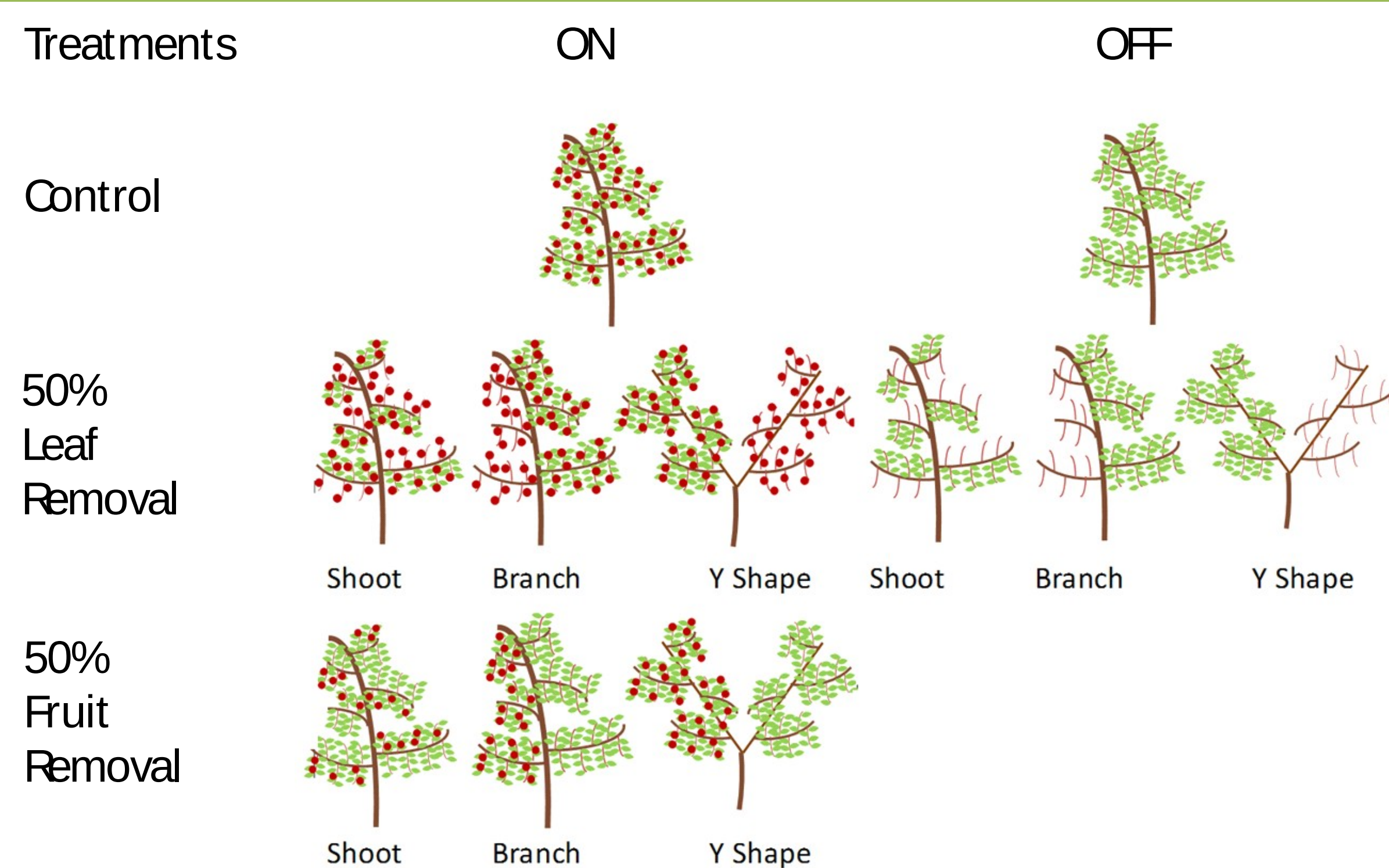


Fig 2: Experimental design for local leaf and fruit removal on 10 year-old 'Golden' trees

Measurements

- Digitizing trees to get 3D representations
- Flowering and fruit production and their within tree distributions
- Non structural carbohydrates and gibberellins concentration before bud break, at FI and fruit maturity
- Photosynthetic activity of leaves at the FI period

Analyses

- Quantifying the effect of distances on FI and calibration of the flux models
- Analyzing the relationships between architecture, functioning and flower induction on the subset of genotypes of the core collection

Modeling

- Calibrate two flux models:
 - Musca for multi-scale (metamer, shoot, branch) carbon allocation (Reyes et al, 2015)
 - Model for hormones bi-directional transport (Pallas et al, 2016)
- On the trees with modified architecture and on the genotypes of the core collection
- Integrate these two sub-models in the MappleT model which simulates plant architectural development (Costes et al, 2008, Fig. 4)

Expected final output

Development of a decision support model to help breeders managing fruit thinning and crop load

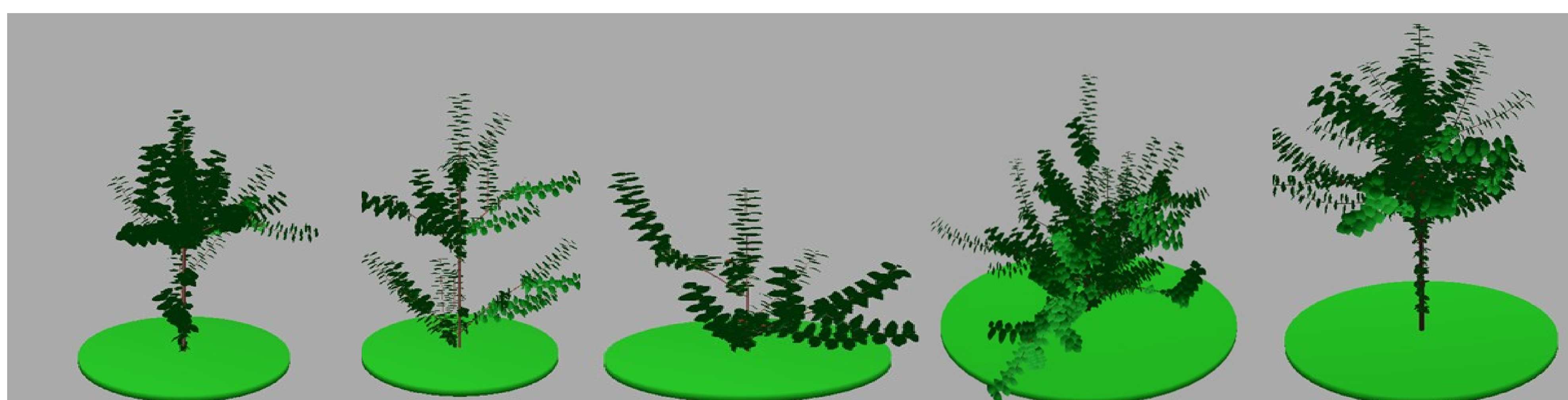


Fig 4: Different architectures of trees simulated by MappleT model (Costes et al, 2008)

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References

Costes E, Smith C, Renton M, Guédon Y, Prusinkiewicz P, Godin C. 2008. *Funct. Plant Biol* 35 936-950; Durand J-B, Guitton B, Peyhardi J, Holtz Y, Guédon Y, et al. 2013. *J Exp Bot* 64: 5099-5113; Guitton G, Kelner J-J, Velasco R, Gardiner SE, Chagné D, et al. 2012. *J Exp Bot* 63: 131-149; Guitton B, Kelner J. J, Celton J. M, Sabau X, Renou J. P, Chagné D and Costes E. 2016. *BMC Plant Biol* 16:55; Lespinasse, J.M. and F. Delort. 1986. *Acta Hort.* 160:120-155; Monselise SP, Goldschmidt EE. 1982. *Hortic Rev* 4: 128-173; Nielsen JC, Dennis FG. 2000. *Acta Hort* 527: 137-146; Pallas B, Costes E & Hanan, J. 2016. *FSPMA, International Conference on IEEE*.p. 150-157. Reyes F, Pallas B, Pradal C, and Costes E. 2015. In *International Symposium on Modelling in Fruit Research and Orchard Management*.