Analysing the architecture of *Corylus avellana* and parametrizing L-HAZELNUT FSPM

Francesca Grisafi[1], Sergio Tombesi[1], Daniela Farinelli [2], Frederic Boudon[3,4], Jean-Baptiste Durand[5], Evelyne Costes[3]

[1]*Department of Sustainable Crop Production, Università Cattolica del Sacro Cuore, Piacenza, Italy*
[2]*Department of Agricultural, Food and Environmental Sciences, Università degli studi di Perugia, Perugia, Italy*
[3] *UMR AGAP Institut, Univ Montpellier, CIRAD, INRAE, Institut Agro, Montpellier, France,*
[4] *CIRAD, UMR AGAP Institut, Montpellier, France,*
[5] *Univ. Grenoble Alpes, Inria, CNRS, Grenoble INP, LJK, Inria Grenoble Rhône-Alpes, France*

For correspondence: francesca.grisafi1@unicatt.it

Keywords: hazelnut, Lpy, modelling

Introduction

Tree architecture is a fundamental part of a functional structural plant model. This is particularly evident in perennial tree crops where the structure of the plant influences the position of source and sink organs, as well as light interception inside the canopy, and serves as storage pool for exceeding carbohydrates. Therefore, a precise description of tree 3D structure is essential to realistically allocate carbohydrates in a FSPM (Costes et al., 2006). Hazelnut tree architecture has different characteristics compared to other fruit tree crops that have been modelled (i.e., peach, mango, apple, and kiwi). It is a monoecious species. Female flowers are grouped into inflorescences located into mixed buds, while male flowers are arranged into inflorescences in the apical position of sylleptic shoots. Each node could bear more than one bud and, the following year, the new shoots are much shorter than the shoots from which they were born. The present study aimed to analyse hazelnut one-year-old shoots 'architecture in order to build the structural part of L-HAZELNUT: a functional structural plant model of hazelnut (*Corylus avellana*).

Material and Methods

Own-rooted tree clones of *C.avellana,* cultivar "Tonda di Giffoni", were chosen, during winter, in 2020 and 2021 in Deruta (Italy). Plants were normally irrigated and fertilized. No pruning occurred during the two years. 104 one-year-old proleptic shoots were sampled according to four length categories: short (Sh) when shorter than 5 cm, medium (Me) when they were between 5 and 20 cm, long (Lo) when they were between 20 and 40 cm, and very long (VLo) when longer than 40 cm. For each shoot, diameter, length, and number of nodes were recorded. From the base of the shoot to its tip, the fate of each node was noted. Four fates are distinguished in *C.avellana*: blind nodes, vegetative buds, sylleptic shoots and mixed buds. In the year subsequent to sampling, the same measurements were repeated on the lateral shoots that were born from the buds.

Statistical analyses were done in 2022, using packages from RStudio. First, exploratory analyses were performed to investigate the distribution of the bud types or sylleptic shoots depending on the rank node along the one-year-old proleptic shoots and thus, to address if there were some homogeneous zone (i.e., zones characterized by a stable distribution of the possible bud fates (Guédon et al., 2001)). This led us to draw a flux diagram (Figure 1). Each part of the diagram corresponds to specific logical connections, between FSPM components, which were addressed using specific probabilistic models, inferred from the collected data set.

Results and Discussion

During this study new knowledge regarding the architecture of *C.avellana* was acquired. Even though male flowers were stated to be located on proleptic shoots ‘nodes (Botta & Valentini, 2018), we instead highlighted the presence of male flowers in the apical position of sylleptic shoots. It was also observed that hazelnut has a sympodial growth. Each statistical model, associated with the FSPM components, was used to define functions to answer each of the questions addressed in the flow diagram. All the functions were coded in L-py (Boudon et al., 2012) to build a L-system program able to generate the architecture of hazelnut (Figure 1).

Conclusion

This led to a first coarse FSPM named L-HAZELNUT, in reference to some previous FSPM for fruit tree crops (Lopez et al., 2010). It simulates the growth of a hazelnut tree over two successive years. The conception of an FSPM is a long and meticulous process that requires having in mind a clear scheme that describes the growing and branching processes. Such a scheme can be acquired by appropriate observations and analyses of how the plant grows and develops. However, as many aspects of the plant have to be considered, the accuracy of the presented 3D structure has still to be evaluated and further studies will be necessary to validate them. Moreover, L-HAZELNUT model should be complemented in the next future with a functional part describing carbon acquisition and partitioning within the tree.

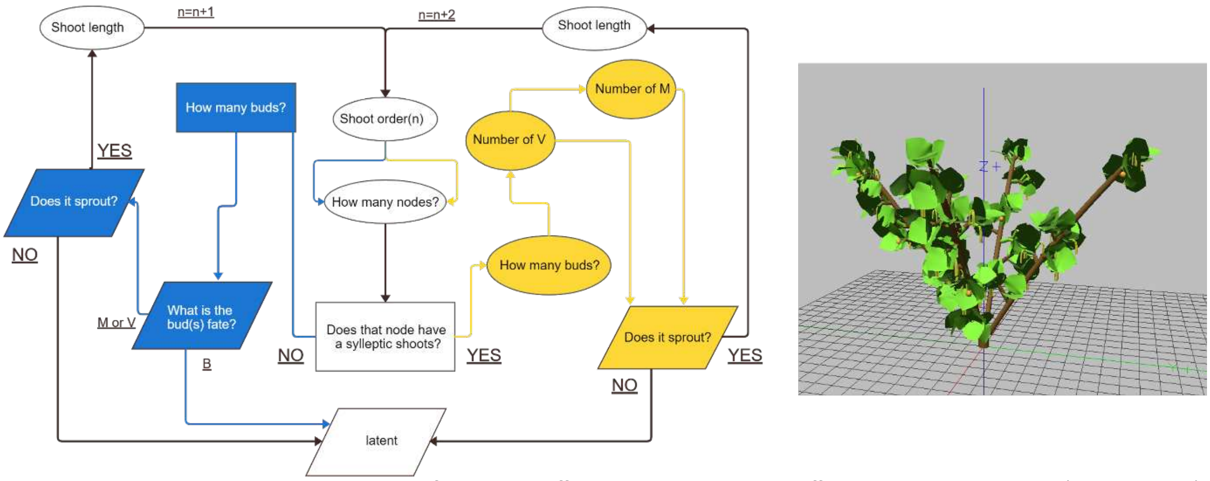

Figure 1: On the left: Logical diagram of the architectural model. Each box represents a model component that had to be coded in L-py to draw the architecture of hazelnut. Different shapes represent different scales: shoot scale (circled boxes), node scale (squared boxes) and bud scale (rhomboid boxes). The blue and yellow colours represented proleptic and sylleptic shoots, respectively. On the right first 3D output of : L-HAZELNUT architectural model, viewed in PlantGL.

References

Botta, R., & Valentini, N. (2018). *Il nocciolo. Progettazione e coltivazione del corileto*. https://iris.unito.it/bitstream/2318/1706485/1/NEW_BUSINESS_MEDIA_Richiesta_deroga.pdf

Boudon, F., Pradal, C., Cokelaer, T., Prusinkiewicz, P., & Godin, C. (2012). L-Py: An L-system simulation framework for modeling plant architecture development based on a dynamic language. *Frontiers in Plant Science*, *3*(MAY), 76. https://doi.org/10.3389/fpls.2012.00076

Costes, E., Lauri, P. E., & Regnard, J. L. (2006). Analyzing fruit tree architecture: implications for tree management and fruit production. In J. Janick (Ed.), *Horticultural reviews* (Vol. 32, Issues 1–61). John Wiley & Sons, Inc. https://doi.org/10.1002/9780470767986.ch1

Guédon, Y., Barthélémy, D., Caraglio, Y., & Costes, E. (2001). Pattern analysis in branching and axillary flowering sequences. *Journal of Theoretical Biology*, *212*(4), 481–520. https://doi.org/10.1006/jtbi.2001.2392

Lopez, G., Favreau, R. R., Smith, C., & DeJong, T. M. (2010). L-PEACH: a computer-based model to understand how peach trees grow. *HortTechnology*, *20*(6), 983–990. https://doi.org/10.17660/ActaHortic.2018.1228.2