Characterization of mango tree patchiness using a tree segmentation/clustering approach

Pierre Fernique, Anaëlle Dambreville, Jean-Baptiste Durand, Christophe Pradal, Pierre-Éric Lauri, Frédéric Normand, Yann Guédon
pierre.fernique@inria.fr

Research focus: Like many other tropical trees, mango tree is characterized by strong phenological asynchronisms between and within trees, entailing patchiness. Patchiness is characterized by clumps of either vegetative or reproductive growth units (GUs) within the canopy: while some parts of the tree canopy develop vegetative GUs, others may remain quiescent or produce inflorescences at the same time. These asynchronisms concern more or less large branching systems. The objective of this study was to define statistical methodology to identify and characterize patchiness patterns.

Methods: Tree-indexed data are used as plant architecture representation and it is assumed that patches can be assimilated to a partition of tree-indexed data into subtrees. It is therefore assumed that there are subtrees within which the characteristics of the GUs follow the same or nearly the same distribution, and between which these characteristics have different distributions. The detection of such subtrees can thus be stated as tree-indexed data segmentation. The output of the segmentation procedure is a partition of trees such that two non-adjacent subtrees can be very similar in terms of GUs charateristics. We therefore propose in a second stage a clustering of subtrees based on a mixture model in order to group non-adjacent similar subtrees. This theoretical framework was applied to young mango trees that were fully described at the GU scale during two growing cycles. These trees were located in an experimental orchard of the CIRAD research station in Saint-Pierre, Réunion Island. Five mango trees were described for 7 cultivars, Cogshall, José, Kensington Pride, Irwin, Kent, Nam Doc Mai and Tommy Atkins.

Results: The patches detected using the tree segmentation/clustering algorithm had various compositions and sizes. The empirical distributions of patch size (in number of GUs) were used to compare cultivar behaviours. Irwin had the largest patches, in contrast to Tommy Atkins that had the smallest patches. José was the cultivar with the most variable patch sizes. A posteriori assignment of subtrees to clusters yielded information about patch composition (i.e. patches containing mostly vegetative, flowering or quiescent GUs). The most marked differences concerned Tommy Atkins, which had only 2 categories of patches, with flowering patches being quasi-absent and partly compensated by a significant proportion of inflorescences in quiescent patches.

Conclusions: We proposed a new approach for characterizing tree canopy patchiness using the mango tree as an example. This enabled us to compare the phenology and architecture of mango cultivars on a more objective basis. The strength of this approach was the representation of non-local dependencies within tree-indexed data. This is a mandatory property for identifying patchiness patterns at various scales within trees and we expect numerous applications of this new paradigm for analysing tree-indexed data.