Modelling floral induction for different apple tree cultivars: an innovative approach to disentangle the intertwined effects of hormonal signals, carbohydrate status and plant architecture

Benoit Pallas

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Context and state of art

- Alternate bearing is of key importance for apple tree production and is characterised by a low production in OFF years and a high production of too many fruits of poor quality in ON years.
- The use of chemical products reducing fruit set during ON years is going to be gradually forbidden.
- Growers are looking for alternative solutions to reduce alternate bearing.
- Preliminary analyses on a bi-parental population showed a large genetic variability in tree production pattern (irregular, biennial, regular bearing) (Durand et al., 2012)
- QTLs related to these production and flowering patterns were indentified (Guitton et al., 2012)

Main hypothesis and scientific questions

- The variability in production patterns is mainly related to the variability in floral induction occurring one year before flowering in apical and lateral meristems.
- Physiological determinants of floral induction variability are still largely unknown.
- 2 Hypotheses are proposed based on experimental results:
  - trophic competition for carbohydrate between growing fruits and meristems could decrease floral induction during ‘ON’ years (Nielsen and Denis, 2000)
  - gibberelins produced by fruit seeds could also lead to a decrease in floral induction (Bangerth, 2009) … but production patterns are also strongly correlated with plant architecture (Lauri and Trotter, 2004) (e.g. genotypes with long shoots display more regular bearing patterns)
- The respective effects of hormones, carbohydrate balance and architecture are difficult to disentangle using experimental approaches.

Using a modelling approach to better analyze the interactions between these different aspects of plant development and functioning.

Objectives and description of the project

- The main objective is to include in the Functional Structural Plant Model MAFlipet (Costes et al. 2008) simulating plant architecture over years a sub model to simulate hormonal and carbohydrate fluxes between leaves, fruits and meristems.
- This sub model will be developed in University of Queensland.
- A first model based on models developed at UQ (C-TRAM for carbohydrate fluxes (Cieslak et al., 2011); models for translocation of hormones (Renton et al., 2013)) will be implemented for the sub-unit composed of a bourse and a bourse shoot in which floral induction occurs.
- The model will be built in L-Systems with the plant modelling environment L-Studio (Karwowski and Prunuskiniewicz, 2004) and will then be integrated in MAFlipet to capture the variability in floral induction within plant structure and analyze the impact of plant architecture.
- The model will be calibrated and validated with experiments carried out in Montpellier.

First activities and results

- A first experiment was carried out in summer 2014 in Montpellier on a segregating population (X3263 x Belrène) with four B x B families.
- The objectives of the experiment were to:
  - define a sub-population displaying large variability in production patterns (biennial, irregular, regular) based on floral sequence analysis (Fig.7)
  - quantify hormonal contents in organs and plant trophic status (photosynthesis activity) for the genotypes with contrasting production patterns
- A first dataset useful for modelling activities is available. This dataset will be complemented in 2015.

References