



Assessment of mango blossom gall midge management solutions from *in-silico* experiments : overview of an on-going modeling approach

Isabelle Grechi^{1,3,*}, Laurie Saint-Criq^{1,2}, Christian Soria^{1,3}, Alain Ratnadass^{1,3}, Frédéric Normand^{1,3}, Paul Amouroux⁵, Frédéric Boudon^{2,3}

¹ CIRAD, UPR HortSys, F-97455 Saint-Pierre, La Réunion, France

² CIRAD, UMR AGAP, F-34398 Montpellier, France

³ University of Montpellier, F-34090 Montpellier, France

⁵ Departamento de Fruticultura y Enología, Pontificia Universidad Católica de Chile, Santiago, Chile

* Corresponding author: isabelle.grechi@cirad.fr



1. Introduction



Mango (*Mangifera indica* L.), a major fruit production in tropical and subtropical regions, is facing many production constraints: mango yield is irregular across years, fruit quality is heterogeneous at harvest, and mango tree exhibits phenological asynchronisms within and between trees that result in long periods with phenological stages susceptible to pests and diseases. Among them, the mango Blossom Gall Midge (BGM, *Procontarinia mangiferae* (Felt)) is a major pest of mango. It can cause significant yield losses by damaging mango inflorescences. Management solutions to improve fruit yield and quality while reducing the use of pesticides are considered. A crop-pest model applied to the mango-BGM system is currently developed from experimental data and will be used for *in silico* assessment of BGM management levers (e.g. soil mulching and manipulation of mango phenology). The on-going modeling approach is presented.

2. The modelling framework

Model description

A mango-BGM model simulates the dynamics of inflorescence and BGM populations of an orchard at a daily time-step during the period of mango flowering (Fig.1). The orchard is structured into three patches (A, B and C) according to soil mulching treatments (Fig.2).

In a first approach, the model is defined at the patch scale and considers:

- ❖ **Inflorescence age-structured population dynamics within each patch**, accounting for natural development and BGM-induced mortality of inflorescences: steps 1 to 5
- ❖ **BGM stage-structured population dynamics within each patch**, differentiating the effect of soil mulching treatments on the BGM life cycle for each patch: steps 1 to 5
- ❖ **Orchard colonization and movements of BGM adult individuals between patches**, at constant rates or driven by inflorescence abundance in each patch: steps 1 to 2

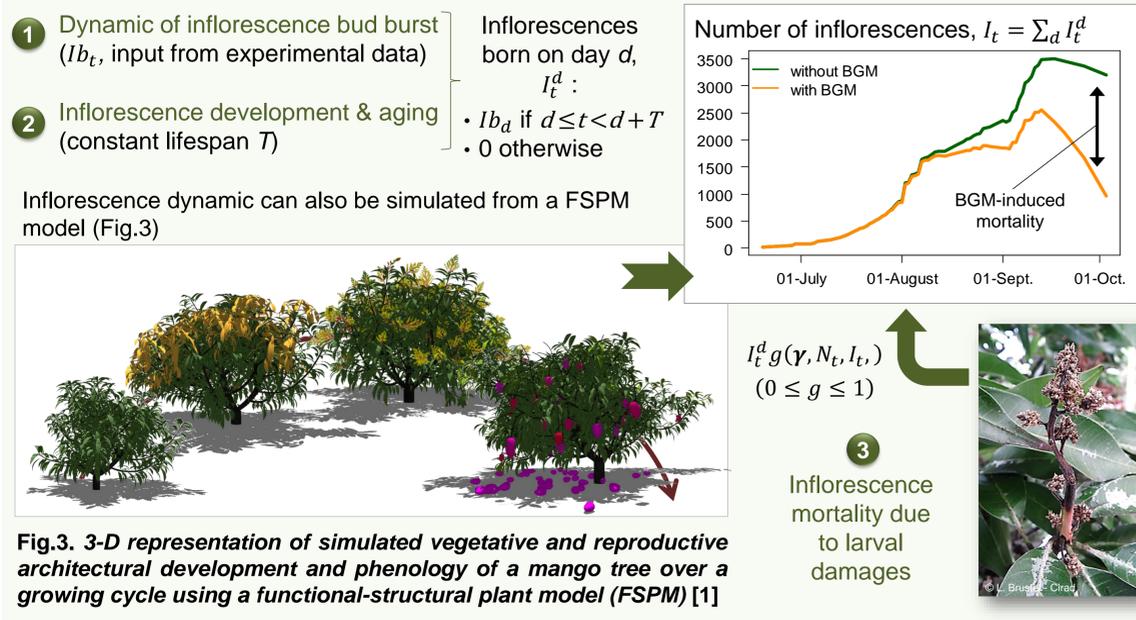


Fig.3. 3-D representation of simulated vegetative and reproductive architectural development and phenology of a mango tree over a growing cycle using a functional-structural plant model (FSPM) [1]

Model parameterization and simulations

- **Model parameterization** from existing knowledge [2] and experimental data [3] collected in Reunion Island on Cogshall cultivar (see experimental design; Fig.2)
 - Survival to soil mulching treatment, $\mu_{SM} = \mu_{SM1} \mu_{SM2}$: 1 for bare ground (patch A), 0 for tarpaulin mulching (patch B), and 0.11 for high weed cover (patch C).
- **Qualitative validation** based on experimental data and model simulations (Fig.4).

3. Future prospects: virtual experiments

Virtual experiments will be performed with the mango-BGM model to assess the effects of BGM management levers on flowering level and fruit yield, according to exogenous pest pressure.

Tested environmental and management levers and their corresponding variables will be :

- Exogenous pest pressure: λ_t
- Soil mulching treatment: μ_{SM}
- Manipulation of mango phenology: Ib_t
- Pesticide applications: μ_a (adult survival rate to pesticides)

4. Conclusion

- This first modeling approach at the population scale gave promising results. However, further investigations are required to assess the benefits of i) considering inflorescence phenological stages, and ii) changing from a population to an individual-based and spatially explicit modelling approach, using a mango FSPM [1] for instance.
- Furthermore, relying on the mango FSPM can be useful to assess the effects of cultural practices on mango tree flowering and their indirect effects on BGM dynamics. Eventually, the mango-BGM model should be used for the design of management solutions for a sustainable mango production.

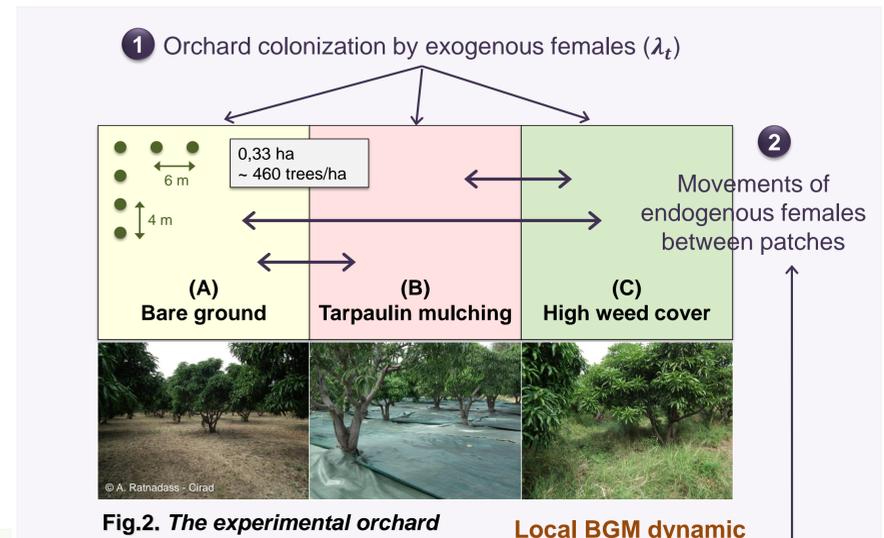


Fig.2. The experimental orchard

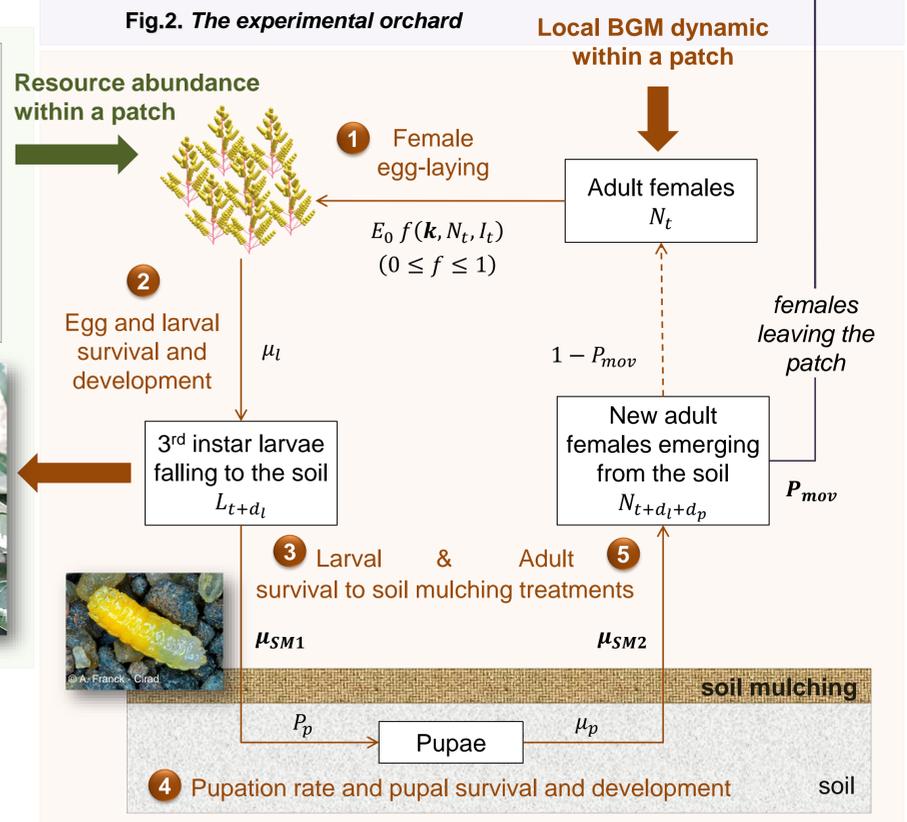


Fig.1. Schematic representation of the mango-BGM model (bold text: estimated parameters)

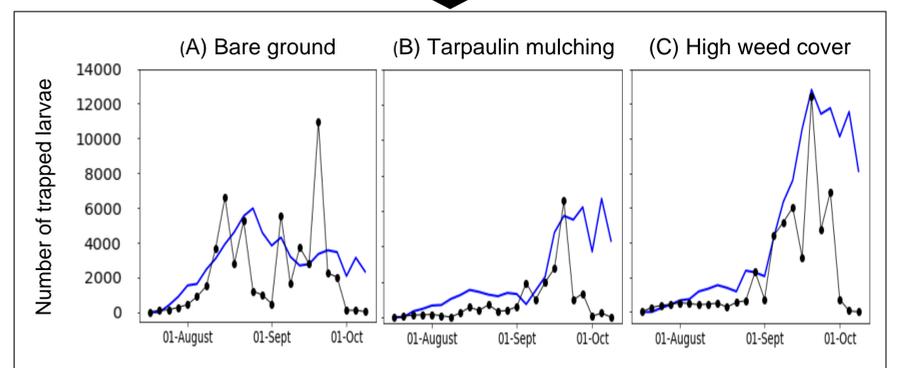


Fig.4. Simulated (blue lines) vs observed (black points) BGM dynamics, assessed by trapped larvae, in each of the three patches A, B and C

References: [1] Boudon et al. (2017). Acta Horticulturae, 1160: 83-90; [2] Amouroux (2013). PhD Thesis dissertation. University of La Réunion; [3] Brustel (2018). Master Thesis dissertation. Purpan.

