

MODEL CALIBRATION ON TWO OILSEED RAPE VARIETIES (*BRASSICA NAPUS* L.), COMPARISON AND PERSPECTIVES

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Introduction

Plant plasticity is the capacity of a plant to adapt to its environment. Better understanding this plasticity may help explain and predict plant functioning in changing environments. Winter Oilseed Rape (WOSR) is a plastic plant as its architecture can vary significantly depending on the growth conditions such as crop density or nitrogen availability. Functional-Structural Plant Models (Fourcaud *et al*, 2008) are interesting tools to study plant plasticity. They provide a representation of the plant architecture combined with functional modules.

In this work, we use the GreenLab model (Cournède *et al*, 2006) to compare WOSR varieties with different architecture: a hybrid variety called Exocet and a line one called Pollen. Exocet has a more vigorous vegetative growth and in average more leaves and branches. The aim of the current work is to estimate Exocet parameters and compare them to Pollen parameters (Jullien *et al*, 2010). Comparing these sets of parameters may help to distinguish genetic parameters to environmental ones, and later use the model to reproduce plant plasticity.

Materials and Methods

Field trials

Measurements were carried out on the two varieties in the same field (Grignon, France, 2007-2008). The crop was sowed on the 4 September 2007 at a density of 50 seeds.m⁻². Jullien *et al* (2010) give a detailed description of the experimental protocol. A set of median plants were regularly recorded so as to compute the parameters of the dynamics of organ setting: date of appearance and death of organs (leaves, internodes and pods) and length of organs. In parallel, at eight dates between November 12th and June 24th, destructive measurements were carried out with dry weights of individual organs.

The GreenLab model

The GreenLab model outputs a mock-up with topologically connected organs and reproduces the dynamics of biomass production and partitioning among organs. In this paper, we give the main equations but we refer to (Cournède *et al*, 2006) for a complete description. Plant growth and its architecture are described by a dynamic system; the time step of the model is based on the phyllochron. The following events take place in one time step: appearance of the new organs, production of biomass by photosynthetic organs, allocation of this biomass to the growing organs. In WOSR modelling, the following organs are considered: leaves, internodes, pod envelopes and seeds. They are gathered in categories, called physiological ages (PA), depending on their functional characteristics (Barthélémy and Caraglio, 2007). In the simulated WOSR, the organs of the rosette stage are of PA 1, long phytomers of the main stem and the ramifications are respectively of PA 2 and 3. Inflorescences of the main stem and the ramifications are respectively of PA 4 and 5. The biomass $Q(t)$ produced at time step t is computed with an empirical equation, based on the Monteith model:

$$Q(t) = E(t) \square S_p (1 - e^{-k S(t)/S_p}) \quad (1)$$

$E(t)$ is the cumulated photosynthetically active radiation received by the plant during the time step. \square and S_p are function parameters, k is the extinction coefficient by analogy with the Beer-Lambert law (0.7 for WOSR). $S(t)$ is the leaf surface area of the plant. The latter is computed in the equations of biomass allocation to organs. During its life time, an organ has a sink value varying with its age according to two parameters a and b . It receives an amount of biomass proportional to this sink value multiplied by the biomass available ($Q(t)$) and divided by the plant demand, the last one being the sum of the sink value of all the organs. Storage is neglected but internodes can demobilize a part of their biomass.

Parameter estimation

Jullien *et al* (2010) describe the methodology to compute each type of parameters. The morphological parameters (number of organs, expansion duration of functioning duration of organs) were statistically estimated on the experimental data. The parameters of source-sink equations were estimated by model calibration with a least square method.

Results

Estimation of the topological parameters

The phyllochron was estimated using a piecewise linear relationship between the number of leaves and the thermal time from germination to first pod setting. The breakpoint was 627°CJ corresponding to mid-January. The phyllochron was 27.60°CJ during the rosette stage, before breakpoint, which is quite similar to the value computed for Pollen (28.53°CJ). During the second stage, the Exocet phyllochron was 9.93°CJ, a little shorter than for Pollen (11.75°CJ). Exocet plants bore in average 35 leaves on the main stem and 12 fertile ramifications.

Calibration of the Exocet variety

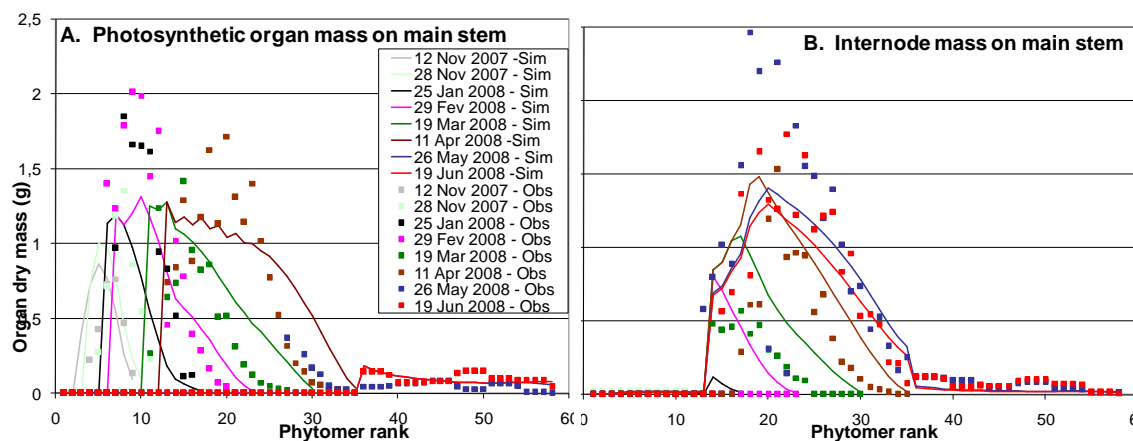


Fig 1. Photosynthetic organs (A) and internode (B) dry masses of the individual phytomers of the main stem. Lines (Sim) are the simulation of the model, filled squares (Obs) are the measured data.

The adequacy between model and measured masses is satisfying regarding individual organs on main stem (Fig.1). The heavier phytomer masses are underestimated whereas the leaf masses of the lightest ones (rank 27 to 35) are overestimated. Regarding ramifications, simulated and observed mass are compared for all the organs of a give type (Fig.2). Estimated parameters are given in Table 1. Sink strengths are greater for the first two physiological ages, *i.e.* main stem. Parameters a and b of

the sink functions drive the shape of the variations of the sink strength of an organ (Jullien et al, 2010). This function is almost symmetric for photosynthetic organs and internodes but seed sink strength increases quickly and reach its maximum value at 20% of its duration of growth. Figure 3 shows the measured and simulated dynamics of three compartments masses (stems, photosynthetic organs and seeds). The model reproduces the dynamics but Exocet final internode mass is overestimated of 30%.

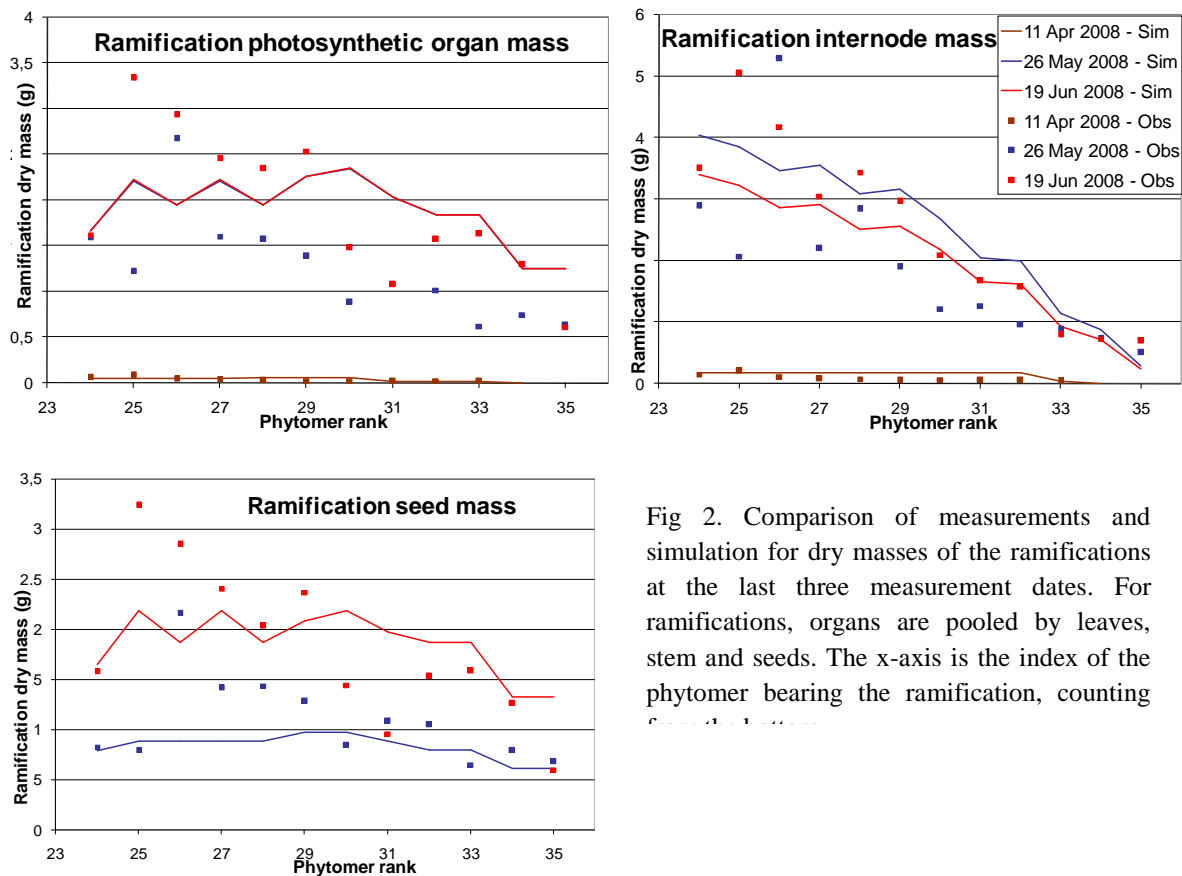


Fig 2. Comparison of measurements and simulation for dry masses of the ramifications at the last three measurement dates. For ramifications, organs are pooled by leaves, stem and seeds. The x-axis is the index of the phytomer bearing the ramification, counting from the bottom.

Comparison of Pollen and Exocet

Regarding topological parameters, the photosynthetic period of a leaf is similar for the two varieties, but organs grow during a longer period in Exocet plant. In our experimental conditions, Pollen median plant is heavier than Exocet median plant. It is coherent with the initial local plant density (Exocet: 50 plants/m², Pollen: 42 plants/m²) but final plant densities are similar. Patterns of compartment dynamics are different (Figure 3). Blades start to grow later but faster for Pollen. Both explain the difference for parameters \square et S_p of equation 1. Internode sink is greater for Pollen than Exocet as is the internode total mass. Pod envelopes and seeds (PA 4 and 5) have smaller sink strength in Pollen than Exocet .

Table 1. Estimated functional parameters for Exocet and Pollen (Jullien et al, 2010).

	physiological age	EXOCET			POLLEN		
		Photosynthetic organ	Internode	Seed	Photosynthetic organ	Internode	Seed
sink	1	1	0.03		1	0.03	
strength	2	0.89	1.06		0.95	3.13	
	3	0.39	2.29		0.67	3.57	
	4	0.25	0.08	0.50	0.10	0.10	0.22
	5	0.40	0.09	0.65	0.17	0.19	0.35
Sink functions	a/(a+b)	0.53	0.56	0.22	0.67	0.62	0.41
	a	1.62	1.67	1.56	2.43	21.71	2.76
Photosynthetic efficiency			11.9			7.04	
Projection Surface Sp			0.02			0.05	

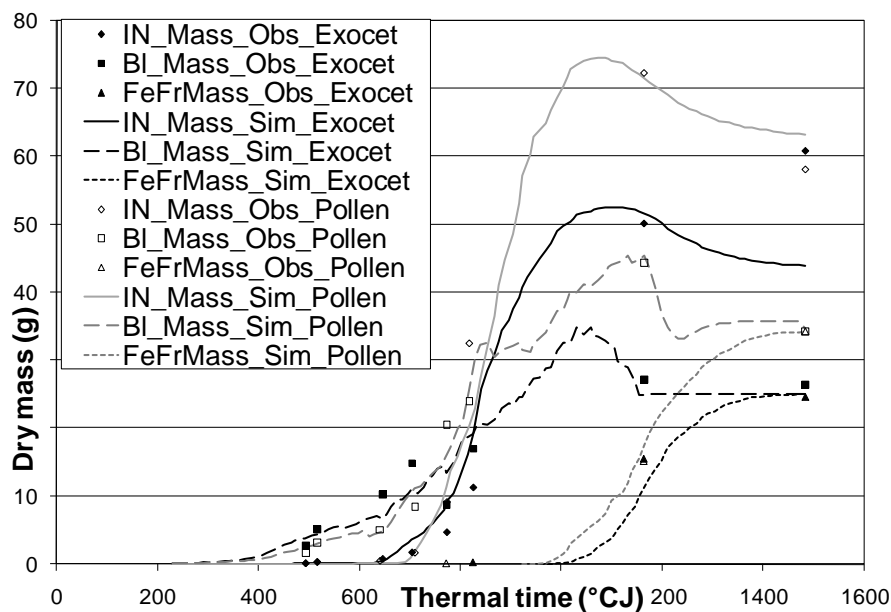


Fig 3. Measured (Obs) and simulated (Sim) dynamics of dry masses of photosynthetic organ (BI_Mass), internode (In_Mass) and fruit (FeFr_Mass) compartments for the median plants of the two varieties according to thermal time since germination. Lines is the simulated dynamics whereas symbols represent the measurements.

Discussion

This study was a first step towards using the architectural GreenLab model to compare oilseed rape varieties. The two selected varieties have different dynamics of growth which translates into different parameters in the source equation and in sink variation functions. Parameters related to the source equations are the more different ones followed by the internode sink strength. It may be a consequence of the different architectural patterns observed for these varieties. However, the choice of the median plant and the environmental effects need to be widened. To continue this work, a sensitivity analysis of the model will be carried out to determine the parameters to which the model is more or less sensitive and accredit the estimated differences in estimated parameters. A long-term objective is to decipher parameters that are purely genetic to parameters highly related to

environment (Bertin et al, 2010). Such a model will allow simulating plant plasticity under various constraints.

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