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► **To cite this version:**

Meije Gawinowski, Jérôme Enjalbert, Paul-Henry P.-H. Cournède, Timothée Flutre. WHEAMM: a functional-structural model to study plant growth and interactions with neighbors in wheat variety mixtures. FSPM 2020: 9th International Conference on FUNCTIONAL-STRUCTURAL PLANT MODELS, Oct 2020, Hanovre (Virtual Conference), Germany. hal-02961398

HAL Id: hal-02961398

<https://hal.science/hal-02961398>

Submitted on 8 Oct 2020

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WHEAMM: A FUNCTIONAL-STRUCTURAL MODEL TO STUDY PLANT GROWTH AND INTERACTIONS WITH NEIGHBORS IN WHEAT VARIETY MIXTURES

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INTRODUCTION

Crop diversification was identified as a key leverage for the **agroecological transition**. In particular, increasing within-field diversity with **variety mixtures** for wheat may allow to stabilize yield and reduce the use of chemical inputs [Borg et al., 2018]. However, this technique is restrained in part because of a lack of practical rules for the assembly of varieties.

In order to study plant growth and interactions in mixtures, we chose an approach combining field experiment and **plant modeling**, with a main focus on **light competition** as plant interaction and **tillering** as a plastic response to this interaction. Even though, many wheat models already exist, none of them include light competition, accurate tillering dynamics and biomass production and allocation at the same time. WHEAMM (Wheat Model for Mixtures) is hence conceived as a combination of different existing models to assess mixture performance in terms of yield.

WHEAMM MODELING CONCEPT

WHEAMM is an individual-based FSPM. It is a combination of these different modeling methods:

- A **source-sink model** based on Greenlab-wheat for an individual plant [Kang et al., 2008]
 - Three organ types: leaf, stem and ear
 - Phenology, organ initiation, extension and senescence according to a thermal time calendar
 - Plant biomass computed with usual Beer-Lambert law based on light interception, plant leaf surface and radiation use efficiency
 - Biomass allocation between growing organs according to their sink strength

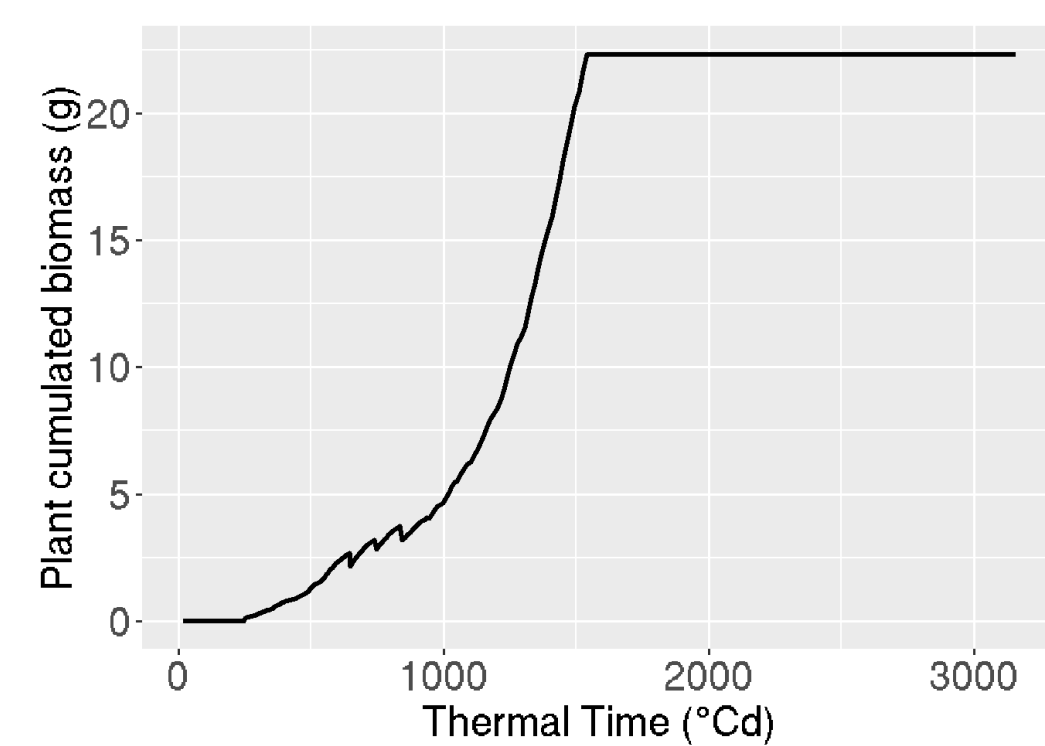


Figure 1: Simulation of plant biomass as a function of time with WHEAMM for one plant with arbitrary parameters

- More accurate **tillering dynamics** based on Ecomeristem model for regression phase [Larue et al., 2019]: allocation rules prioritizing tillers by age with simultaneous senescence processes

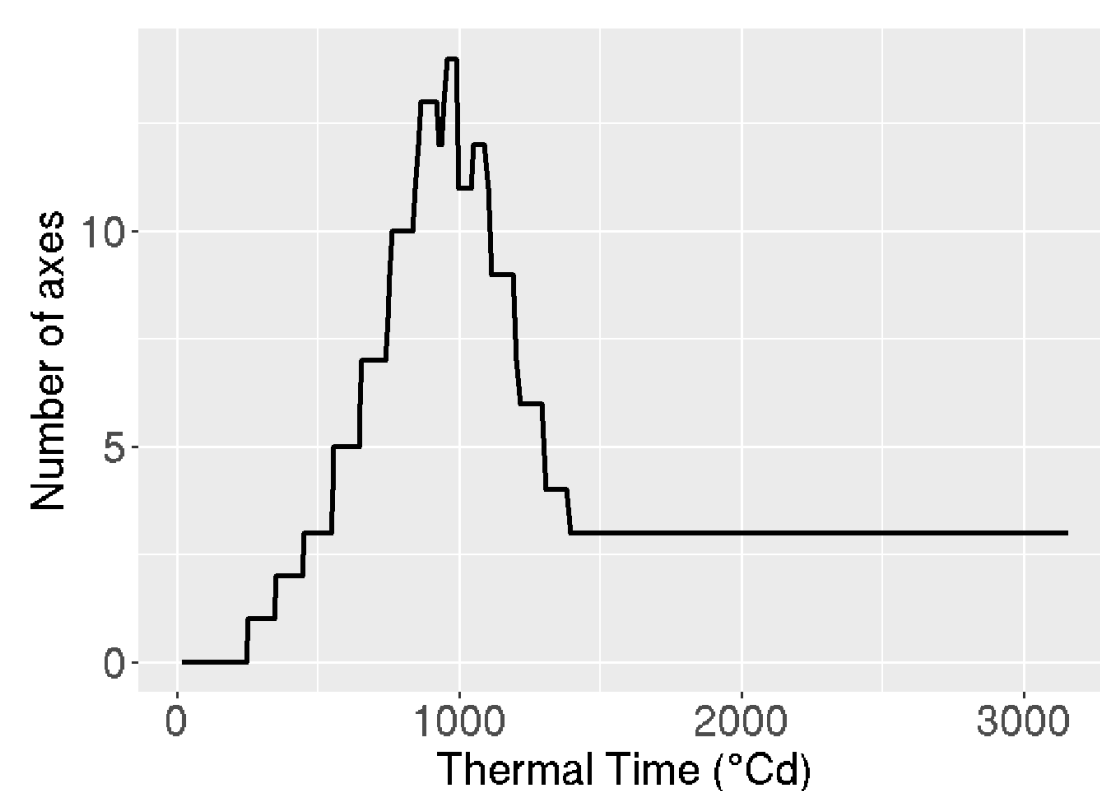


Figure 2: Simulation of the number of tillers as a function of time with WHEAMM for one plant with arbitrary parameters

NEXT STEPS:

Computation of **competition for light** in a plant population based on surface partition [Cournède et al., 2008]

- Determination of plant surface of influence S_p
- Partition of S_p surface according to neighbouring competitors into subsurfaces
- Computation of probabilities that a plant is covering a subsurface and is above the others
- Computation on actual exposed leaf surface accordingly to these probabilities

EXPERIMENTS FOR MODEL CALIBRATION

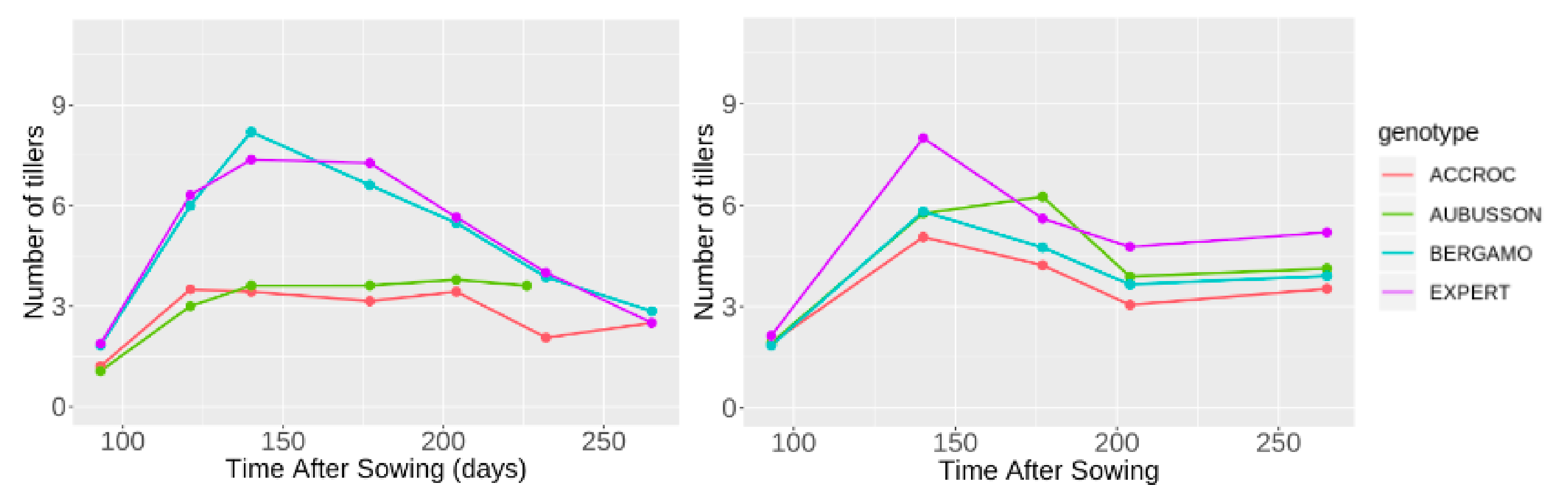
For WHEAMM calibration there is a need for data of individual plants during their growth. A field experiment was hence conducted in the frame of the PerfoMix project:

- 2 different balanced mixtures of 4 components of 264 plants, 2 replicates at density 160 and one replicate at density 250 and 8 pure stands for corresponding varieties at density 160
- Sowing on October, 30 2019 and harvest on July, 20 2020 at Le Moulon, Gif-sur-Yvette (France)
- Precision sowing for mixtures according to a determined and randomized spatial layout

Collected data for calibration:

Scoring	Stand	Number plants per point per stand	Number of scorings
Height, Tillers, Biomass	Pure	20-30	7
	Mixtures 250	20	1
		All	1 (harvest)
	Mixtures 160, rep1	30	1
All		1 (harvest)	
Tillers	Mixtures 160	All	5
Height	Mixtures 160	All	7
Ear biomass	Pure	20-30	3
	Mixtures	All	1 (harvest)

Table 1: Table of scorings for the PerfoMix 2019-2020 experiment during growth. Leaf number, weight and surface were also recorded for a few plants, and yield components were recorded for all plants in mixtures at harvest



A) Plants in pure stands at 160

B) Plants in mixture at 160, rep1

Figure 3: Number of tillers averaged by variety at each observation point in pure stands and in one mixture of the PerfoMix experiment 2019-2020

On Figure 3 we can see an important difference in tillering between pure stands of early varieties Accroc and Aubusson, and later varieties Bergamo and Expert. In the mixture of these four varieties, this gap is not as noticeable, as early varieties reach a higher tillering plateau.

NEXT STEPS:

- Renewal of PerfoMix experiment in 2020-2021
- Calibration in the Bayesian paradigm using a hybrid Metropolis-Hastings-Gibbs algorithm [Viaud, 2018].

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This work is supported by the FIRE PhD program with the support of Fondation Bettencourt Schueller, the PerfoMix project and the INRAE BAP department for PerfoMix funding and M. Gawinowski PhD funding.

