

# Itemaize

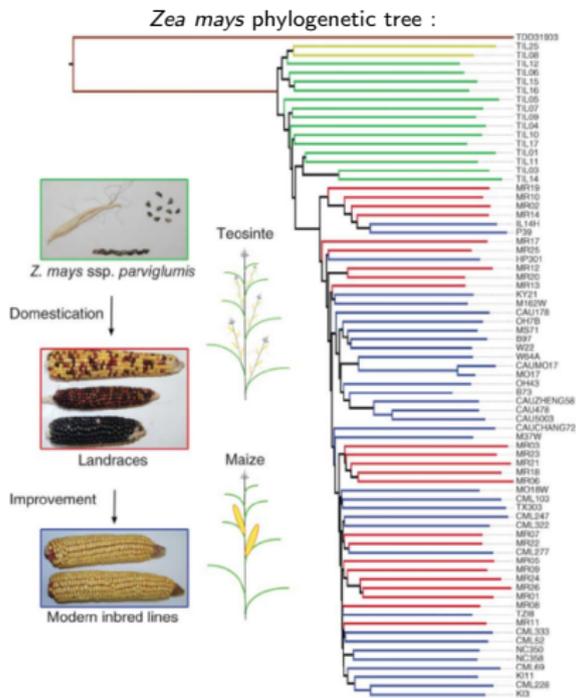
## Integrative approaches of flowering time variation in maize

C. Dillmann, B. Andrieu, A. Lerouzie



November 13, 2016

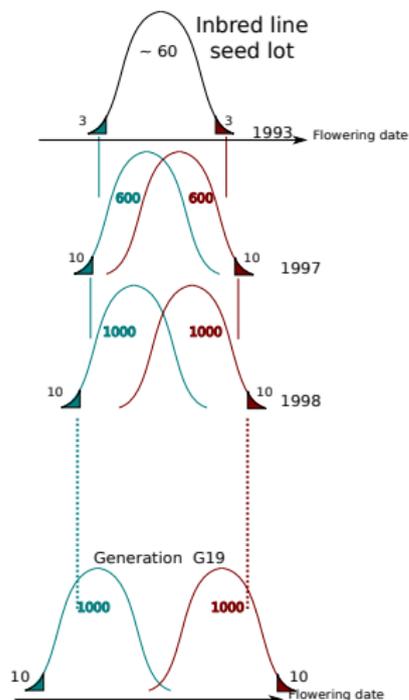
# Maize : breeding material are (homozygous) inbred lines



Current issues (climatic changes) :

- Life-cycle shifts as avoidance strategies ?
- Genetic and environmental determinants of phenology ?
- Better understanding of growth and development ?

# Divergent selection experiments (DSEs)



**Starting point:**  
**Plants from a single inbred seed lot.**

**G1: one Early population + one Late population**

$$Y_{pop,plant(g)} = \mu_{pop(g)} + \epsilon_{pop,plant(g)} \approx \mathcal{N}(\mu_{pop(g)}, \sigma_{G(g)}^2 + \sigma^2)$$

Response to selection:

$$R_{(g+1)} = h_{(g)}^2 \cdot S$$

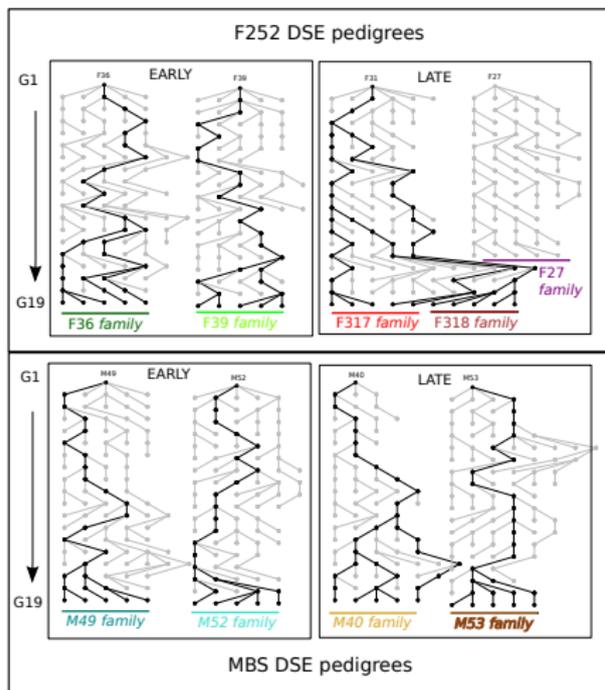
Additive genetic variance:

$$\sigma_{A(g)}^2 = \left(1 - \frac{1}{N_{e(g-1)}}\right) \sigma_{A(g-1)}^2 + \sigma_m^2$$

*Residual heterozygosity + new mutations*

**Starting from a narrow genetic basis, how far can we change flowering time ?**

# DSE selfing pedigrees



4 populations from 2 genetic backgrounds,  
2/3 independent families/population

Ancestor	Pop	Families
F252 inbred	Early	F36, F39
	Late	F317, F318, (F27)
MBS inbred	Early	M49, M52
	Late	M40, M53

- 10 progenitors/population/generation.
- Family structure: **two independent families** per population.
- Each G19 family derives by selfing from a single G0 plant.
- F27 (very late) representatives were discarded after G14.
- F317 and F318 derive from a single plant from G3.

*Each progenitor is characterized by the flowering date of the  $\approx 12$  most extreme plants (8109 individual records).*

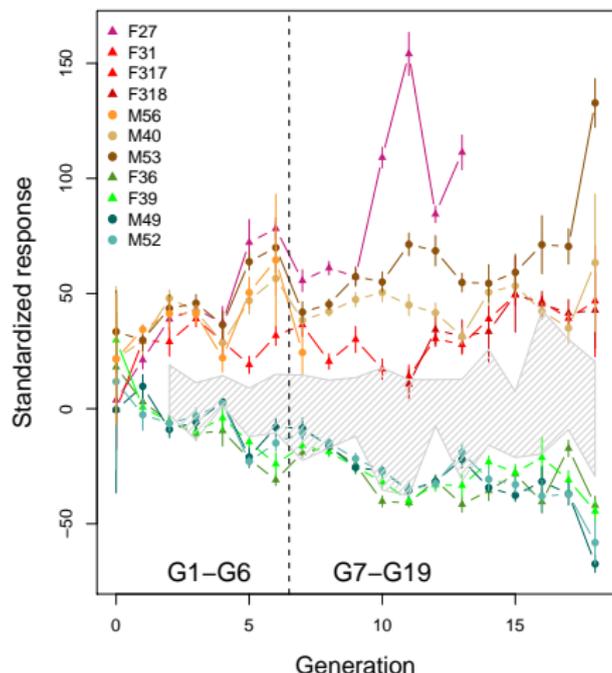
# Response to selection

- Control = plants from the initial seed lots.
- Average family mean (thermal time) centered on the median control mean in each genetic background (MBS and F252).
- Dashed area = 95% CI for control individual plants.

**Early families:** Linear response.

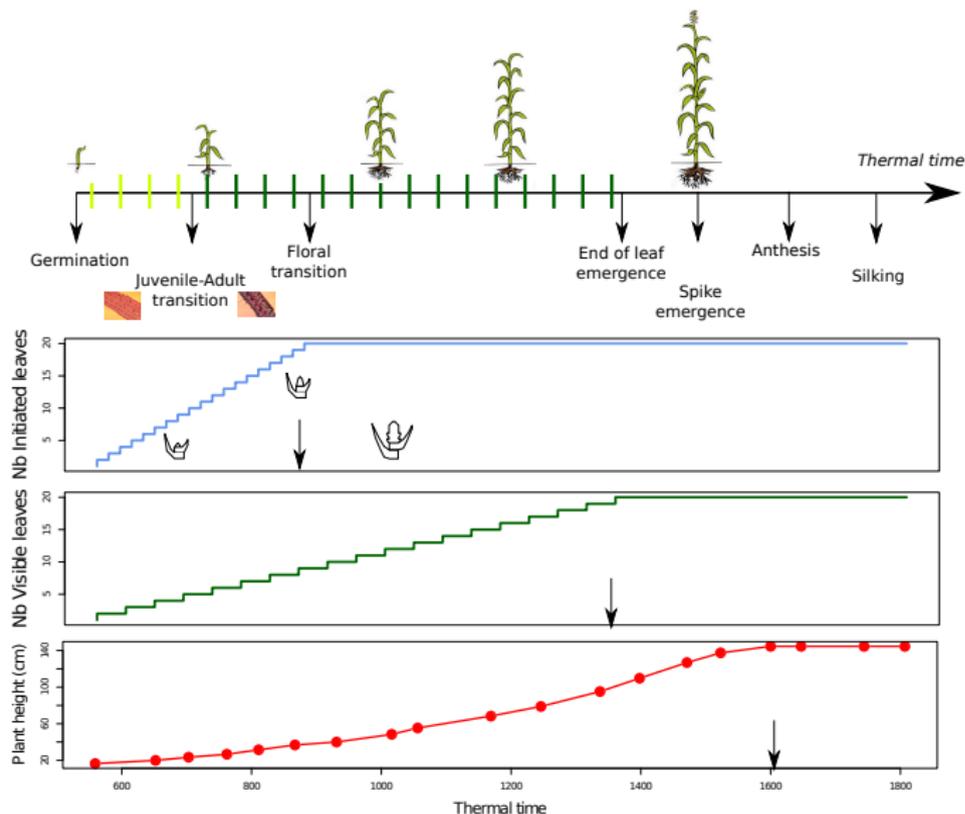
**Late families:** Significant response, non linear dynamics.

Similar dynamics in the **MBS** and **F252** genetic backgrounds.



**Residual heterozygosity + Constant Mutational input ?**

# Which traits were targeted by selection ?



Transitions times *versus* growth rates ?

## Maize life cycle

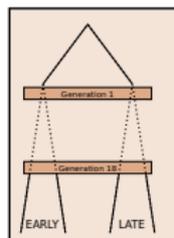
**Floral transition** marks the end of leaf initiation.

**Phyllochrone** : newly formed leaves continue to grow inside the plant until they become visible.

At the **end of leaf emergence**, plant height still increases through internode elongation.

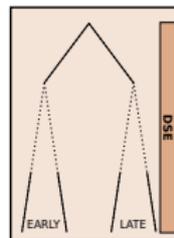
# The Ite maize project

## Integrative approaches of flowering time variation in maize



Comparing Early *versus* Late progenitors from the same generation.

- Which traits were targeted by selection ?
- Modeling the interplay between growth and development ?

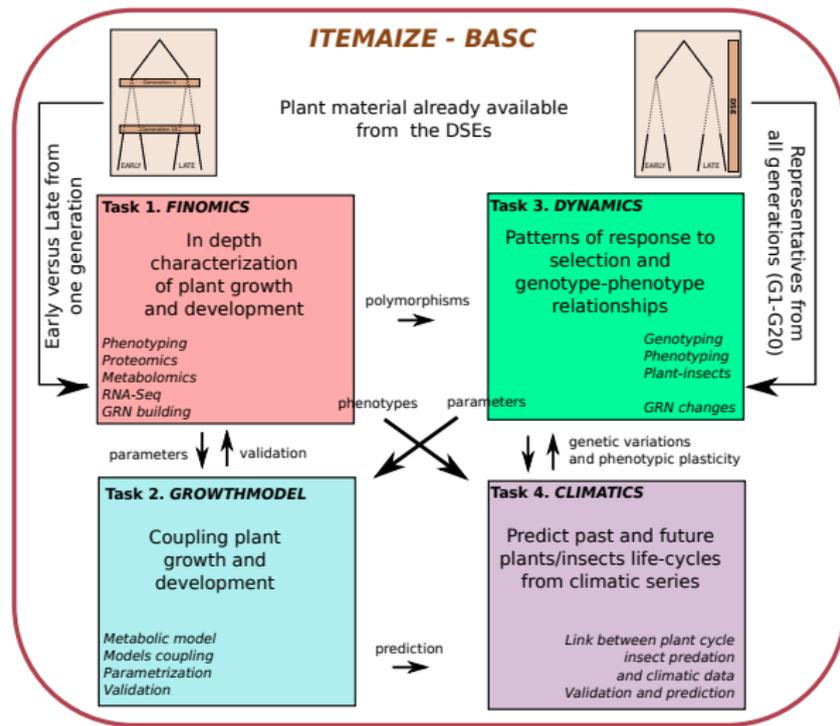


Studying changes through time within populations.

- Dynamics of the response to selection ?
- Link with environmental changes (including plants/insects) ?

Use the original available plant material to better understand the determinants of flowering time variation AND the dynamics of the response to selection.

# Itemaize workpackages



# Itemaize consortium

Modèles mathématiques



Ecophysiologie, agronomie



Physiologie, développement



Evo/dévo



Génétique quantitative



Evolution, adaptation

Fondation mathématique



*des plates-formes de biologie performantes,*



*Un matériel génétique original,*



*et des terrains expérimentaux de proximité*

## UMR ECOSYS

*agronomie/ecophysiologie*



Bruno Andrieu  
Alain Fortineau  
Tiphaine Vidal (postdoc BASC)

## UMR MaIAGE

*Modélisation statistique*

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Sylvie Huet  
Sandra Plancade  
Marie-Luce Taupin  
Olivier David

*Modèles dynamiques*

Béatrice Laroche

*Bibliome*

Claire Nedellec  
Estelle Chaix  
Philippe Bessieres

## UMR GQE-Le Moulon

*génétique quantitative*

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Adrienne Ressayre  
Elodie Marchadier  
Dominique de Vienne  
Michel Zivy  
Maud Tenaillon  
Martine Le Guilloux  
Hélène Corti  
Aurélie Bourgas  
Mostapha Shehadi (postdoc IMSV)  
X (TR BASC)



## UMR EGCE

*Biologie évolutive*

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Andréas Odorico (PhD)

*Plantes-insectes*

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Frédéric Marion-Poll  
Paul-André Catalayud  
Elisée-Emmanuel Dabdré (PhD)  
Rémi Jeanette



## IJPB

*Génétique, physiologie*

Fabien Chardon  
Sylvie Dinant  
Bertrand Hirel



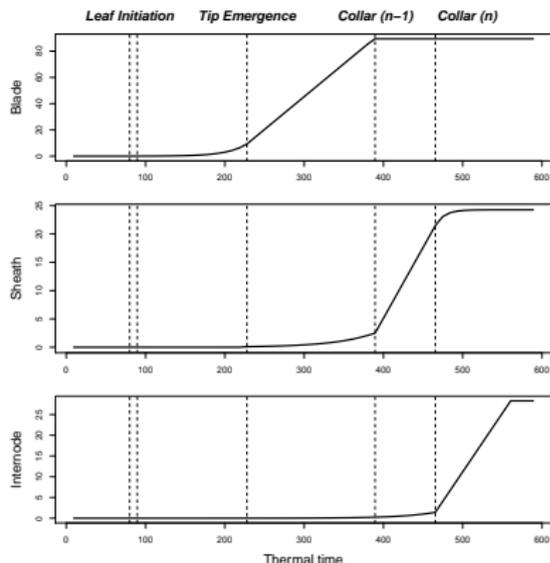
## UMR ESE

*Développement*

Béatrice Albert



## Task2. Growthmodel

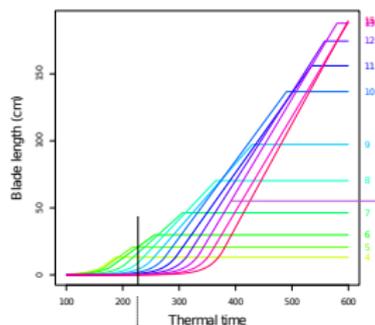


Plant developmental units are called **phytomers** and comprise a leaf, an internode and an axillary bud. A leaf is composed of a blade and a sheath, that ensure the rigidity of the stem. During growth, each organ begins with an **exponential phase** merely determined by cell divisions, and a **linear phase** that also comprises cell elongation. Growth is coordinated between organs (Zhu et al, 2014).

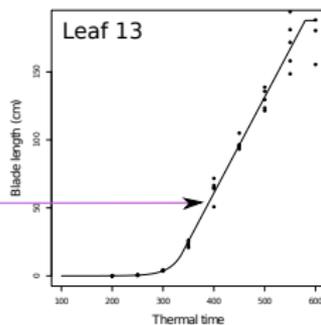
Integration of the ODE system (coll. J. Moreno, invited professor) + Experimental measurements of growth rates (dissections, spring + summer 2016, 5 L2 and M1 students). B. Andrieu, A. Ressayre, C. Dillmann, E. Marchadier

# Task2. Growthmodel : Parameter estimation

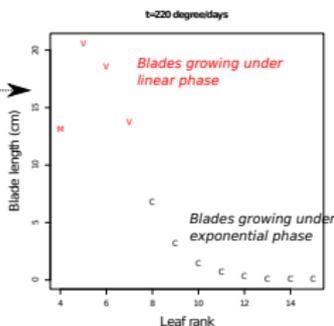
MODEL



EXPERIMENT



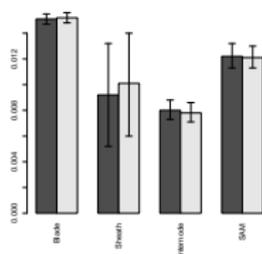
Plant dissections  
at regular time points



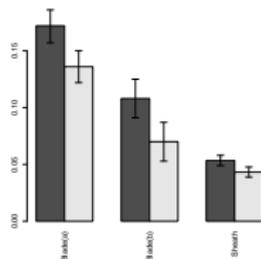
One time-point :  
allometry relationships

## Task2. Growthmodel : Preliminary results

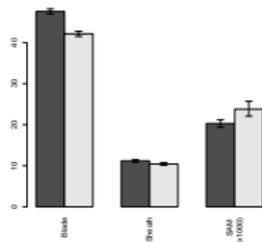
In 2016, plants from the Early M52 (grey bars) and the Late M40 (black bars) families were dissected at regular intervals. All organ's sizes were recorded. For each phytomer rank, coordination rules (Leaf emergence, collar) were used to assess the developmental phase of each organ. Data allowed to estimate growth rates and final heights.



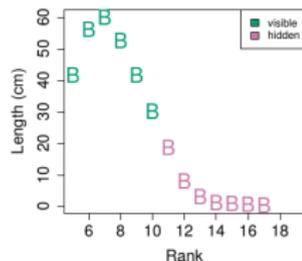
**Exponential growth rates** are of the same order of magnitude for the two progenitors for Blade, Sheath, Internode and SAM.



**Linear growth rates** are higher in the Late M40 than in the Early M52 in Blade and Sheath.



**Final heights** : Final blade length is higher in the Late M40. Higher SAM height in the Early M52 = higher cell volume ?

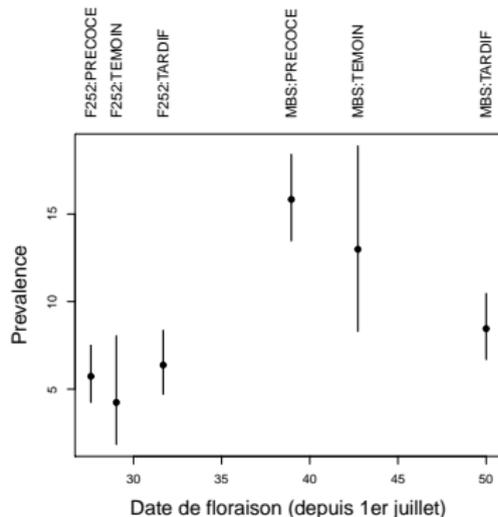


**Single plants dissections** seem to give valuable informations.

# Task4. Climatiks

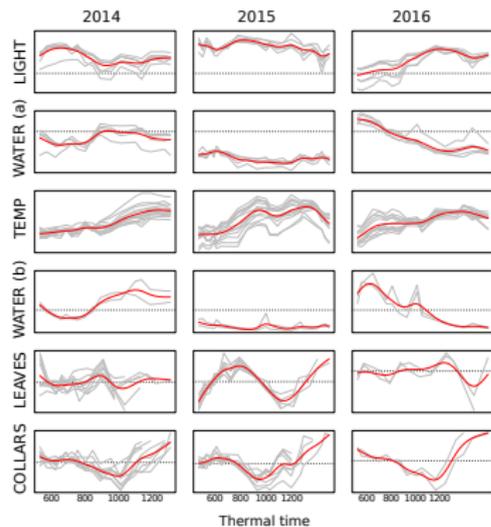
Average prevalence (stem diseases) in august 2016, by population.

coll. UMR EGCE, Gif sur Yvette



*Phenological shifts change the sensitivity to herbivorous insects. Early MBS development seems coordinated with the insect's 2nd generation egg-laying season.*

## Task4. Climatics : Ongoing work



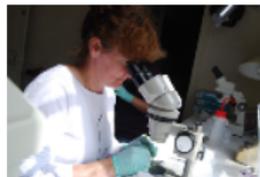
- **Role of climatic variables on plant life-cycle**  
Ongoing work to analyse experimental data on phyllochrone. E. Marchadier, C. Dillmann, S. Plancade, S. Huet
- **Plant/insects** Dissection of mature plants and prevalence measurements from the G20 DSE experiment. GQE-Le Moulon + EGCE
- **PhD** E. Dabré ? C. Dillmann, F. Marion-Poll

# The input from BASC



- ① Project funding (BASC phase1 : RNASeq from SAM during floral transition) – > proof of concept.
- ② New collaborations between BASC teams (ECOSYS - GQE Le Moulon - ESE) – > Measurement of meristems temperatures in ESE climatic chambers using material and methods from ECOSYS (A. Fortineau).
- ③ Maturation seminar – > Plant/insects part of the project.
- ④ Project dynamics – > DSE parental seed lots included in the Amaizing panel to build a maize gene atlas of early growth.
- ⑤ Project dynamics – > Integration of proteomic data into whole-genome leaf metabolic model (Itemaize - Amaizing - IMSV postdoc).

# Thanks



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Hélène Corti  
Martine Leguilloux  
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Denis Coubriche  
Cyril Bauland  
Anthony Venon  
>40 students

