Phenotyping of soybean phenology to temperature and photoperiod

Pierre Maury, Béatrice Quinquiry, Dorian Bourgeois, Neila Ait-Kaci, Lin Kang, Céline Schoving, Philippe Debaeke

INRAE
TOULOUSE INP Ensat L'AgroToulouse

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P. Maury[1], B. Quinquiry[1], D. Bourgeois[2], N. Ait-Kaci[1], L. Kang[2], C. Schoving[2,3], P. Debaeke[2]

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Background & Aims

Improving soybean production in Europe under climate change needs a good prediction of cultivar phenology under different temperature and photoperiod conditions. For that purpose, a **Simple Phenology Algorithm (SPA)** was developed (Schoving et al., 2020). Before being applied, SPA requires the calibration of 7 genotypic parameters. Therefore, a **simple phenotyping method** was designed and set up under natural and controlled conditions to determine these parameters.

SPA algorithm

- Formalism of development rate (Rdev)
- 7 genotypic parameters

$$R_{dev} = R_{dev.max} \cdot f(T) \cdot f(P)$$

3 parameters for the thermal function F(T): minimum T0, optimum Topt, and maximum Tmax

3 parameters for the photoperiodic function F(P) : optimal and critical daylength for development, and S sensitivity coefficient

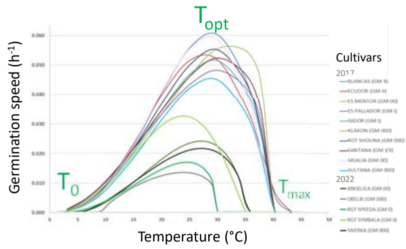
1 parameter for the maximal development rate: optimal Physiological Development Days to complete a given phenological phase (PDD opt)

Phenotyping of F(T) parameters

- Experiment in controlled conditions
- Determination of the rate and speed of seed germination

Climatic chambers

4 x 25 seeds ; 11 temperatures



Fitting according to Yin *et al* (1995)

Mean cardinal temperatures (T0, Topt, and Tmax) for germination were *ca.* 2.6 , 28.8, and 38.7°C, respectively with significant differences among cultivars (GM 000 to II)

Phenotyping /optimization of F(P) parameters

- Experiment in natural climatic conditions
- Recording of main phenological stages (VE, R1, R5, R7, R8)

Heliaphen platform

(10 and 6 cultivars in 2017 and 2022)

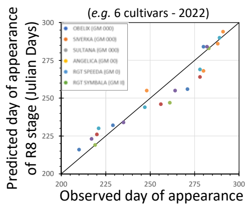
4 to 6 planting dates (from March to September)

Observed day of appearance of a main stage

Daily or hourly air temperatures were tested as input data for parameters optimisation

SPA Calibration

(*e.g.* 6 cultivars - 2022)

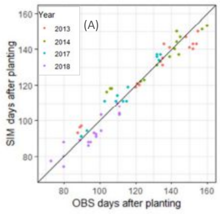


S and PDD opt were set by optimisation, i.e. minimize the RMSE between predicted and observed day of R8 stage for all planting dates of a given cultivar

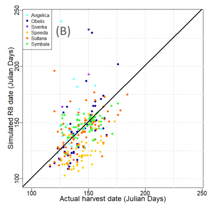
SPA Evaluation

- Multi-environment trials: SW France and France levels
- hourly or daily temperatures for PDD optimisation

2013-2018 (4 years) – SW France



2010-2021 (12 years) – France



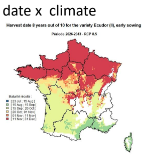
Observed (OBS) and predicted (SIM) days after planting for maturity (R7) in SW France trials (A) days of year for maturity R8 of Post-registration trials at France level (B).

Indicators of performance of SPA during its field evaluation

Multi-environment trials/ temperatures input for optimisation	MBE (days)	RMSE (days)	RRMSE (%)
SW France (R7 prediction)	-0,70	5,61	5
France level (R8 prediction)			
Daily temperature	12,50	23,50	16
Hourly temperature	-2,40	19,70	14

SPA Application

e.g. Areas suitable for a soybean cultivar x sowing date x climate



Conclusion & perspectives

A simple cultivar phenotyping method was designed and applied on a first set of 15 cultivars commonly grown in France.
The optimization of the PDD plant parameter from hourly temperature values instead of daily values improved the prediction of phenology by SPA.
This approach - simple cultivar phenotyping and photothermal algorithm - is currently evaluated on several grain legumes to design more diversified and agroecological cropping systems.

UMR AGIR – INRAE Toulouse,
24 chemin de Borde-Rouge
31320 Castanet-Tolosan
https://www6.toulouse.inrae.fr/agir

References
Schoving C *et al.*, 2020. *Frontiers in Plant Science 10: 1755*

[1] *INP-ENSAT, Université de Toulouse, UMR AGIR, France*
[2] *INRAE, Université de Toulouse, UMR AGIR, Castanet-Tolosan, France*
[3] *Terres Inovia, Baziège, France*

Contacts :
pierre.maury@ensat.fr
philippe.debaeke@inrae.fr

AMBASSADE DE FRANCE EN CHINE
Terres Inovia l'agronomie en mouvement
INSTITUT CARNOT Plant2Pro
ECODIV Project
UMT Pactole