Using simple cultivar phenotyping and photothermal algorithm to explore the suitability of spring-sown grain legumes in France

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Background & Aims

Improving grain legume production in Europe under climate change needs a good prediction of cultivar phenology under different temperature and photoperiod conditions. For that purpose, the **Simple Phenology Algorithm (SPA)** was developed on soybean (Schoving *et al.*, 2020 ; Bourgeois *et al.*, 2023) then extended to 3 spring-sown legumes: chickpea (*Cicer arietinum*), faba bean (*Vicia faba*), and field pea (*Pisum sativum*). Before being applied, the generic 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 for chickpea, faba bean and pea varieties on 2 cultivars for each species.

SPA algorithm

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

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

- 3 parameters - thermal function F(T): minimum T0, optimum Topt, and maximum Tmax
- 3 parameters - photoperiodic function F(P) : optimal (Popt) and critical (Pcrt) daylength for development, and S sensitivity coefficient
- 1 parameter - maximal development rate: optimal Physiological Development Days to complete a given phenological phase (PDD opt)

Phenotyping of F(T) parameters

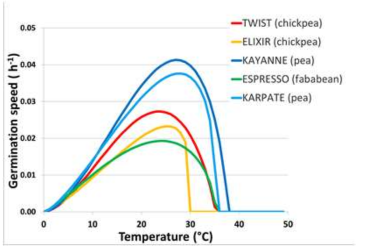
- Experiment in controlled conditions
- Determination of the rate and speed of seed germination

EXP 1 : Climatic chambers

4 x 25 seeds ; 11 temperatures

Fitting of germination speed according to Yin *et al.* (1995) for 50 % of germination rate

$$\frac{1}{tG} = EXP(\alpha) \times (T - T_0)^{\beta} \times (T_{max} - T)^{\gamma}$$



Phenotyping /optimization of F(P) parameters

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

Exp 2 : Heliaphen platform

3 species x 2 cultivars (2022)

5 planting dates (from March to July)

Observed day of appearance of a main stage (*e.g* R8)

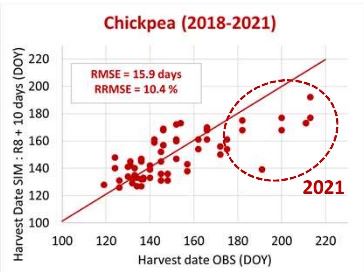
Daily or hourly air temperatures tested as input data for parameterization

SPA parameterization

	Topt	Tmax	Pcrt	Popt	S	PDDopt	RMSE
	°C	°C	h	h		d	d
Espresso	25.2	35.5	7.5	18.0	1.00	52.6	2.87
Victus	23.6	35.2	7.5	18.0	2.34	67.8	0.25
Elixir	24.0	32.0	11.0	21.0	1.00	34.1	5.89
Twist	26.0	35.2	11.0	21.0	1.00	33.9	3.50
Karpate	27.7	35.9	19.6	12.0	1.00	23.0	1.91
Kayanne	28.3	37.6	20.9	12.0	1.00	28.3	3.54

SPA Evaluation

- Multi-environment trials at France level
- Hourly or daily temperatures for PDD optimisation

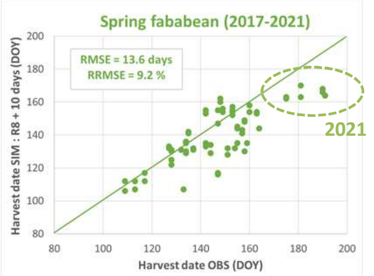


Simulation of harvest date with daily temperatures applied on the post-registration network of Terres Inovia

Wet conditions in 2021 delayed the harvest dates

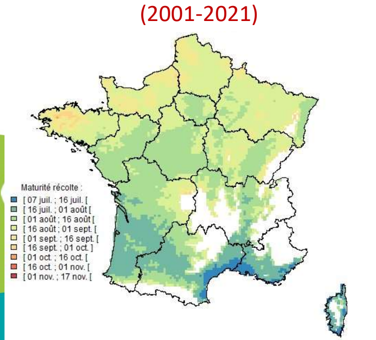
Cv Elixir & Twist

Cv Espresso & Victus



SPA Application

Harvest date (8 years on 10) of chickpea (cv Twist) sown on 15/01 (2001-2021)



Conclusion & perspectives

- This approach - simple cultivar phenotyping and photothermal algorithm – first developed on soybean was successfully applied to three other grain legumes and will be reproduced on other spring and winter-sown legumes
- The SPA could be improved by better predicting the emergence and grain desiccation phases and introducing the effect of water stress on development acceleration.
- Exploiting the variety trials at national level to calibrate photoperiod response as a function of latitude could be an alternative to EXP2 approach.

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