# Soybean seedling emergence under current and future climate across Europe and the possibility for sowing date adaptations

Jay Ram Lamichhane, Imen Ben-Hamouda, David Camilo Corrales, Helene Raynal, Philippe Debaeke, Etienne-Pascal Journet

# Soybean seedling emergence under current and future climate across Europe and the possibility for sowing date adaptations

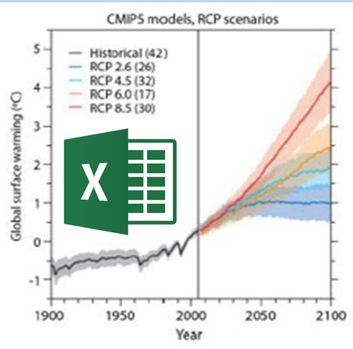
J. R. Lamichhane[1*], I. Ben-Hamouda[1], D. C. Corrales[1,2], H. Raynal[1], P. Debaeke[1], E-P. Journet[1,3]

Soybean (*Glycine max* (L.) Merr.) has potential to improve sustainability of agricultural systems due to several advantages, including its capacity to fix atmospheric nitrogen (Watson et al., 2017). In Europe, this crop is much less reliant on conventional pesticides compared to its leguminous counterparts (*e.g.* pea). The introduction of this crop into European cropping systems not only offers their diversification but also helps increase the protein self-sufficiency of the continent thereby reducing import dependency (Guilpart et al., 2022). However, little is known to date about i) the areas suitable for soybean emergence and seedling establishment across Europe, ii) how ongoing climate change will affect the distribution of these suitable areas, and iii) the possibility of adaptation of soybean crop by shifting sowing dates. This study aimed to respond to these questions.

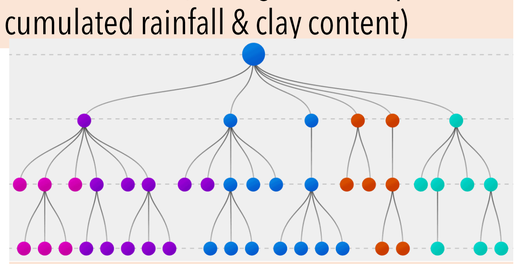
## Materials and methods

A simulation study was conducted by coupling climate change scenarios (historical: 1980-2010 and RCP 4.5: 2040-2069; Webber et al., 2018), machine learning algorithms, a soil-crop model (STICS), and a crop emergence model (SIMPLE). A soybean variety belonging to a late maturity group (ES Pallador), commonly grown across southern France, and six sowing dates (from early to late) were considered.

**European soil & climate database:**
- 1980-2010
- Baseline & RCP 4.5




Decision tree: clustering homogeneous groups according to key agro-climatic indicators (average temperature, cumulated rainfall & clay content)



~ 100 000 initial study sites

Elimination of redundant study sites & selection of relevant study sites across Europe

- Tav : <6 ; >6<10 ; >10<15 & >15 °C
- RRcum : <20 ; >20<40 ; >40<60 & >60 mm
- Clay : <15 ; >15<25 ; >25<35 & >35%

~ 10 000 final study sites

STICS-Soil: generating daily average temperature and moisture data at 0-10 cm soil depth

WinSIMPLE

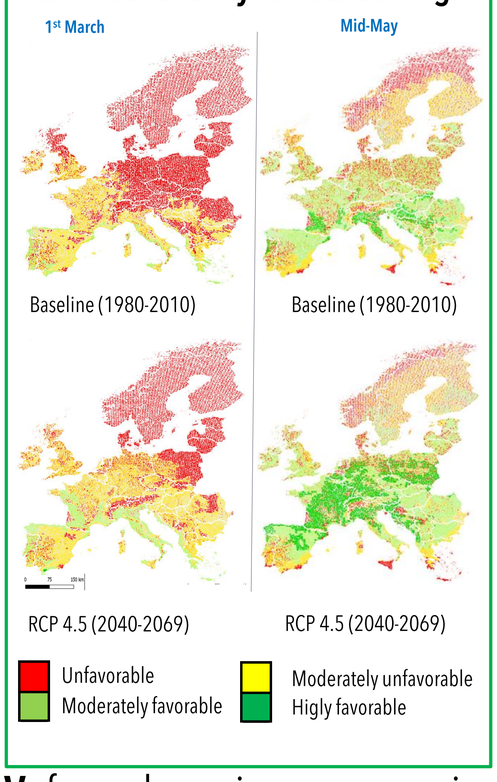
Simulation of soybean emergence across Europe in relation to six sowing dates: 1st March, mid-March, 1st April, mid-April, 1st May & mid-May

Feeding STICS-Crop with emergence rates as input variable for yield-gap simulations

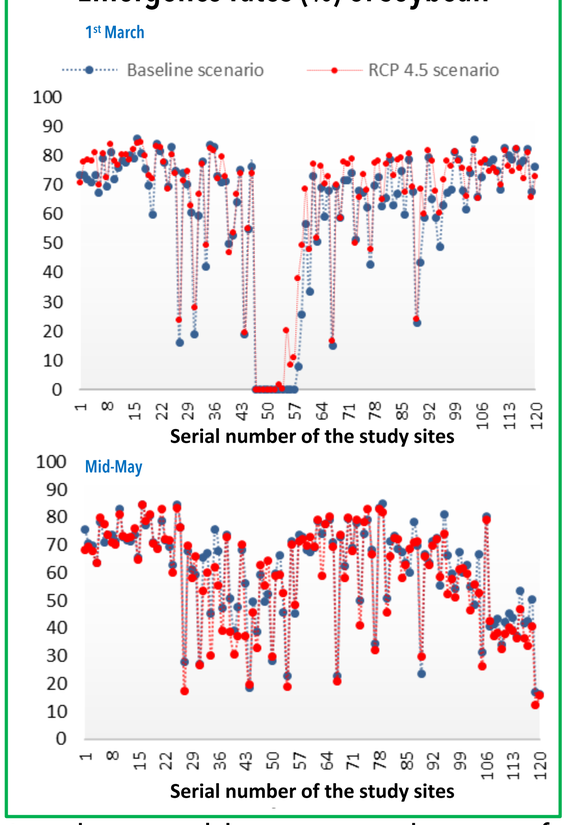
## Results

**I:** a significant shift was observed in seedbed climatic conditions across Europe under climate change, especially due to an increased seedbed temperature. For late sowing dates, previously unsuitable areas resulted suitable for soybean establishment across boreal and northern continental regions but the opposite was observed across southern Mediterranean areas. In contrast, early sowings result favorable for soybean seedling establishment in Northern France, the southern Mediterranean, Alpine and southern continental regions.

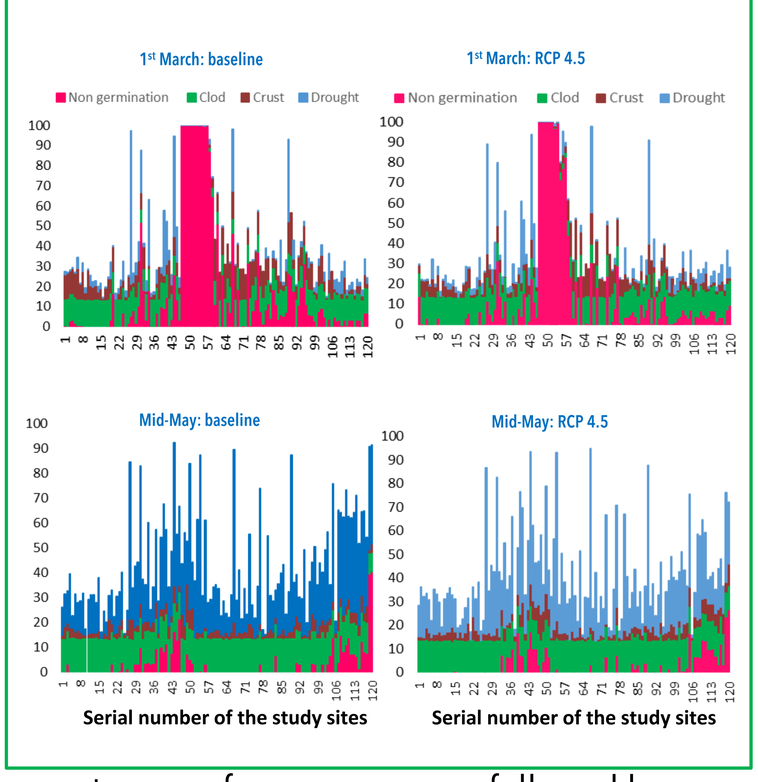
**Evolution in seedbed weather conditions: early vs. late sowings**




**Emergence rates (%) of soybean**




**Non-emergence rates (%) and their causes**




**II:** when unfavorable sites were discarded, in most cases, mean soybean emergence rates were >50%, independent of sowing dates and climate scenario.

**III:** for a given study site, soybean emergence rates for RCP 4.5 scenario were higher than the baseline.

**IV:** Higer risks of emergence failures for early sowing dates were observed compared to late ones.

**V:** for early sowing, non germination due to cold stress was the most frequent cause of non-emergence followed by seedling mortality due to clods, a soil surface crust and drought, independent of the climate scenario.

**VI**: for late sowing, drought was the key stress affecting seed germination and seedling emergence, independent of the climate scenario.

## Discussion and perspectives

- Possibility of anticipating sowing dates across southern Europe, shifitng from traditional sowing dates of late April to earlier sowing dates, that allows to escape summer drought during soybean flowering, which is the key limiting factor for soybean production across southern Europe.

- Requirement for a broad number of soybean varietties, especially those belonging to early maturity groups that may better establish across central and northern Europe compared to cv. ES Pallador used in this study.

- Need for an in-depth investigation on benefits vs. risks of early soybean sowings in relation to the crop yield potentials.

**References:** Guilpart, N. et al., 2022. Data-driven projections suggest large opportunities to improve Europe's soybean self-sufficiency under climate change. Nat. Food. https://doi.org/10.1038/s43016-022-00481-3.

Watson, C.A. et al., 2017. Chapter Four - Grain Legume Production and Use in European Agricultural Systems, in: Sparks, D.L. (Ed.), Advances in Agronomy. Academic Press, pp. 235–303. https://doi.org/https://doi.org/10.1016/bs.agron.2017.03.003.

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[1]AGIR, University of Toulouse, INRAE, Castanet-Tolosan, France; [2]TWB, INRAE, 135 Avenue de Rangueil, 31077 Toulouse, France; [3]LIPME, University of Toulouse, CNRS, Castanet-Tolosan, France; ***E-mail:** jay-ram.laichhane@inrae.fr

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