

## Climate change impacts and possibilities of adaptation for soybean cultivation in France

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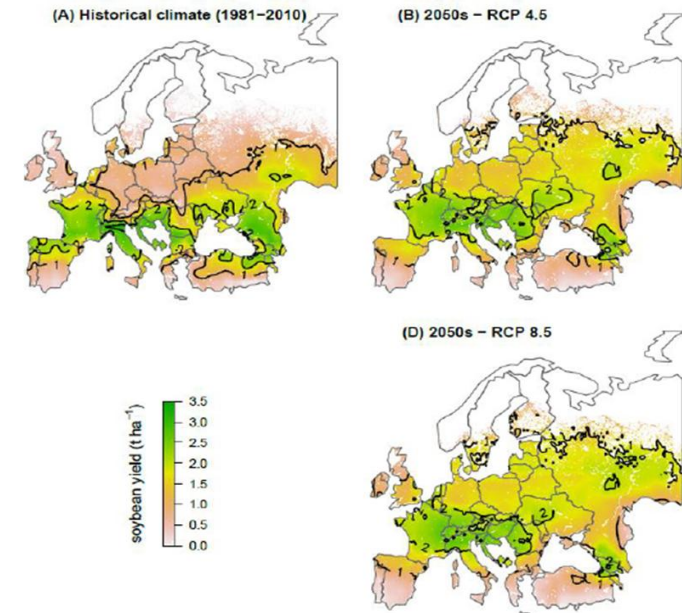
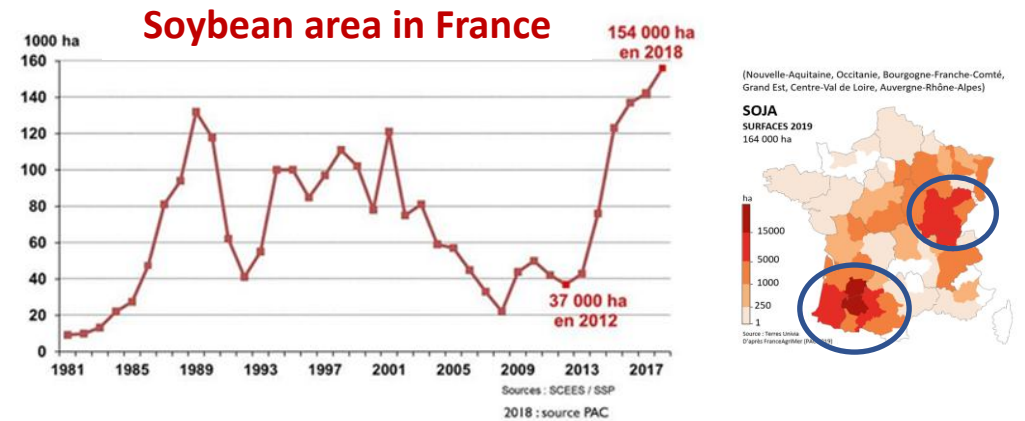
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Toulouse (France)

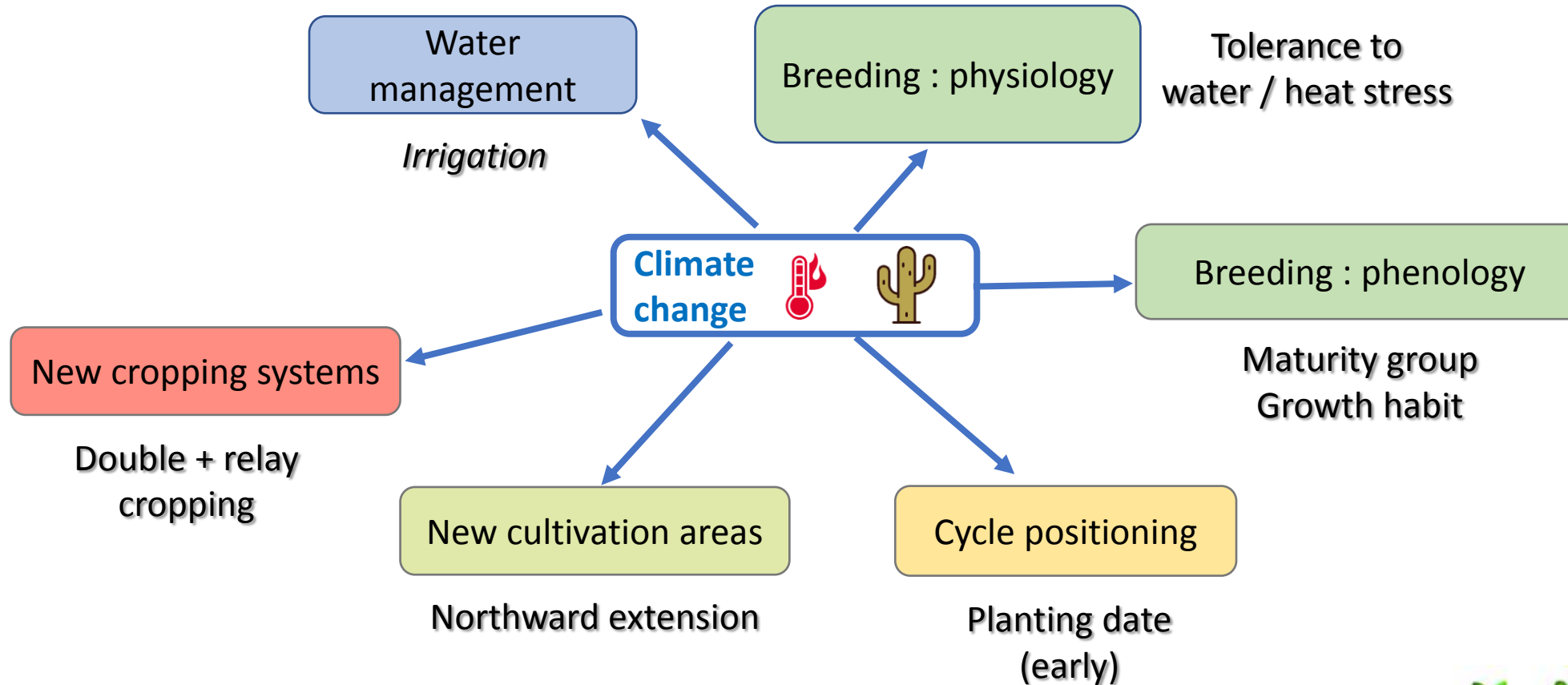
## ➤ A strong opportunity for soybean development in Europe

In 2020 : 186 000 ha (France), 921 000 ha (EU-27)  
29 % under organic farming in France

- ❑ Agronomic and environmental benefits :  
N fixation, GPC ~42 % DM, TFI < 2
- ❑ Secured outlets on feed (~80%) and food markets
- ❑ A certified and sustainable non-GM value chain
- ❑ EU and national policies for protein self-sufficiency  
(EU : 5 % for soya ; 42 % for sunflower ; 79 % for rapeseed))
- ❑ Climate change could promote the northward expansion  
of soybean in Europe and double cropping in the South



# ➤ Options for adapting soybean crop to climate change



# ➤ Phenotyping and ideotyping for varieties adapted to drought



Transpiration and leaf expansion responses to soil water deficit

*Outdoor automated platform (Heliaphen)*

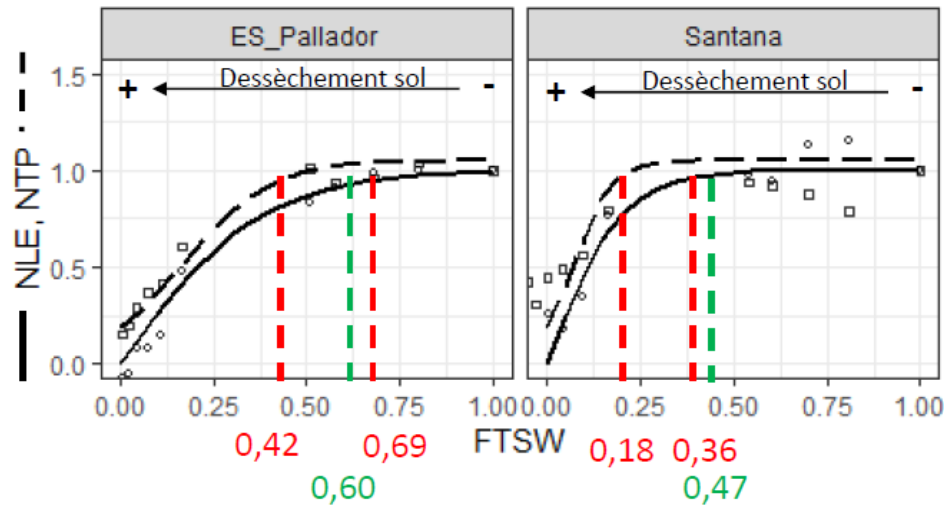


Early root growth

*Mini-rhizotrons*

Ideotype of root system for drought adaptation

2017



Schoving (2020), PhD

- Root biomass +
- Root length +
- Root diameter -
- Volume & area +

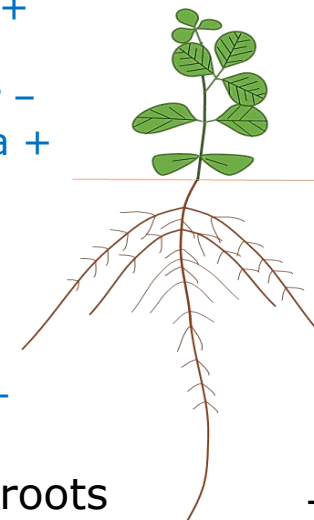
-> Resource acquisition

- Nb root tips +

-> More lateral roots

- Aerial growth +
- Stem length +

-> Plant vigour



- Root angle (> 60°)
- Root growth in depth +
- Lateral root growth -

-> Deeper root system

Dayoub *et al* (2021), *Agronomy*



INRAE

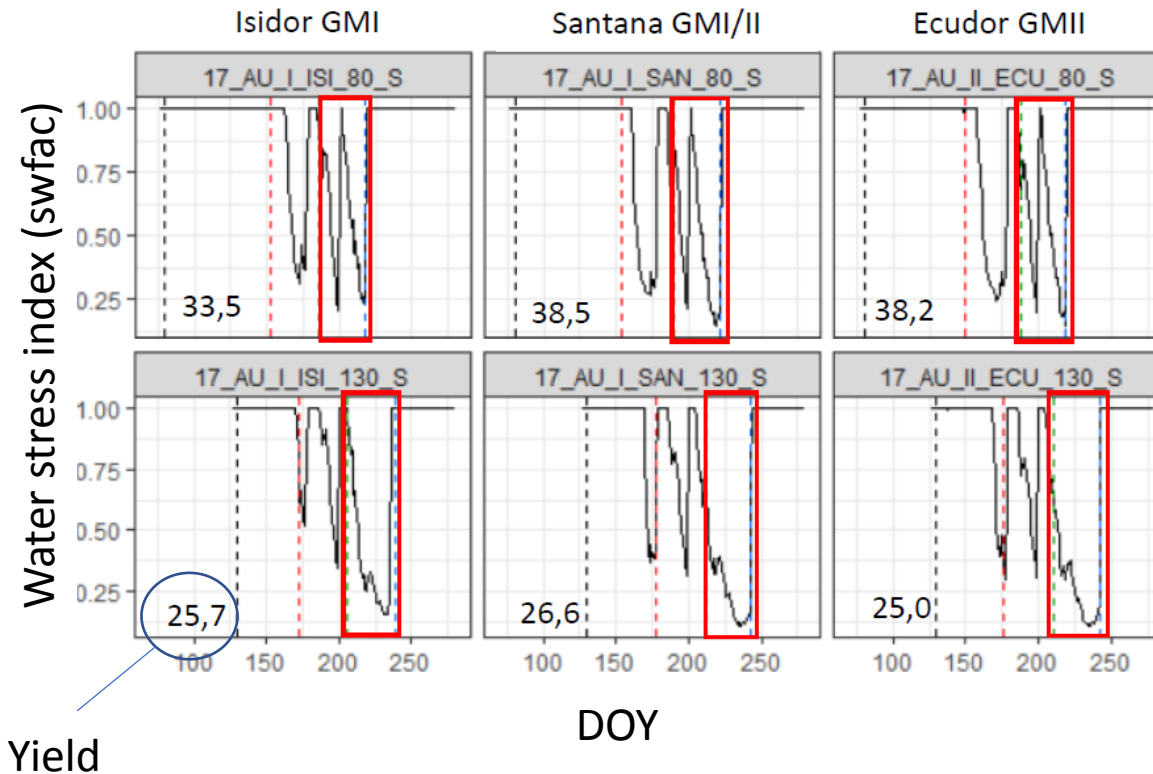
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# ➤ Early sowing for escaping water and thermal stresses

Early sowing  
(~ mid-March)  
**ES**

Conventional  
(~ mid-April)  
**CS**



Auzeville 2017 - rainfed

Water stress less intense and shorter during grain filling with early sowing (escape strategy)

## 2010-2018 (SOJAMIP)

Grain yield **ES < = CS**

Grain protein **ES > CS**

Grain oil **ES = CS**

Irrigation **ES < CS**



Schoving *et al*, *EJA* (submitted)



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# ➤ New cropping systems for introducing more soybean in the rotation

Intercropping, Relay Cropping or Double Cropping



Agroecology



← Opportunities due to climate change (temperature) →



Water resource for irrigation could be more limited in the future

New ideotypes for breeding

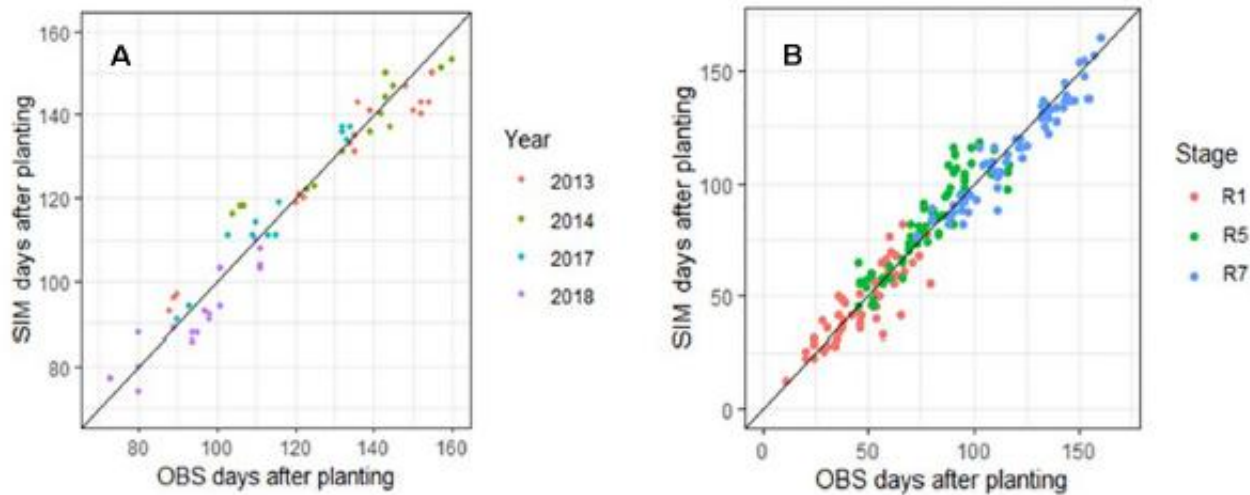


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# ➤ Developing models for soybean crop suitability

## Simple Photothermal Algorithm (SPA)

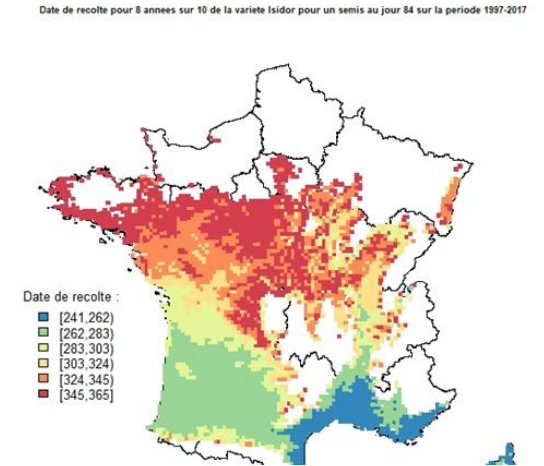
Schoving *et al* (2020), *FPS*



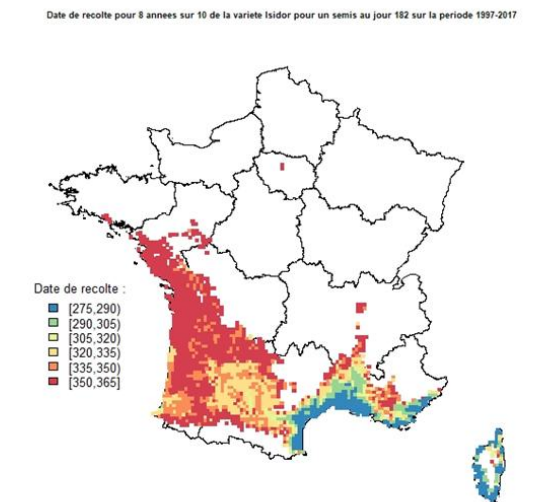
Phase	MBE (d)	RMSE (d)	RRMSE	EF (%)
VE-R7	-0,70	5,61	0,05	94
VE-R1	-0,71	8,22	0,17	75
R1-R5	4,02	9,40	0,13	80
R5-R7	-3,54	7,37	0,06	90

Harvest date for  
cv Isidor (I)

early sowing  
(20/03)



late sowing -  
double crop  
(01/07)



Duchalais (2020)



# ➤ Developing models for soybean yield prediction (1)

## Simulation model improvement

Previous STICS version for soybean (Schoving, 2020):

- good performance in aboveground biomass prediction
- **poor results on grain yield** and protein concentration

Improve prediction of final grain yield:

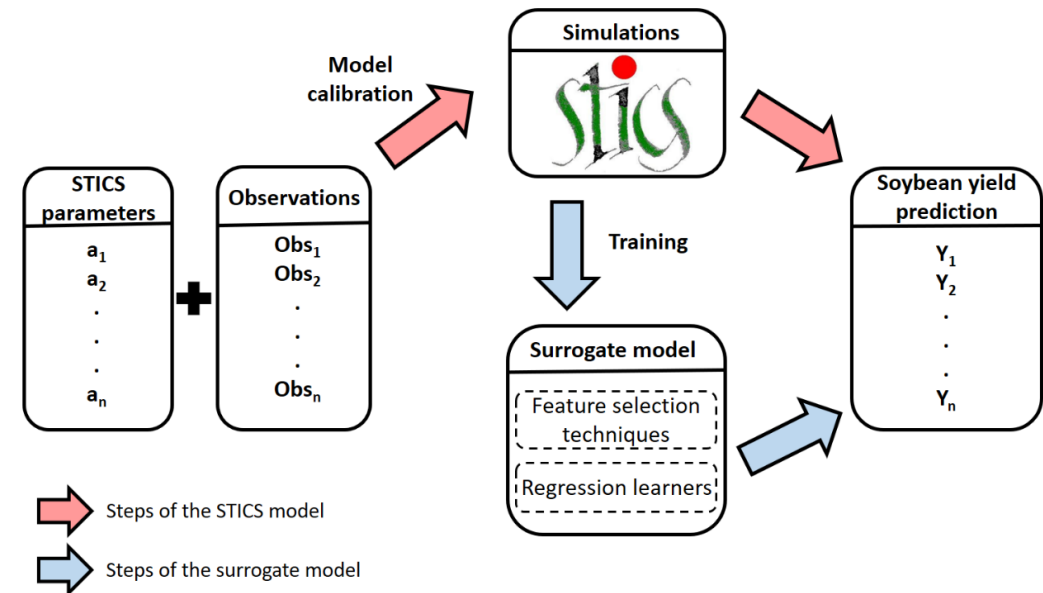
➔ **hybrid model** combining STICS with a statistical model generated through **feature selection techniques** and **regression models**

Southern France

Models	Statistical criteria	
	R <sup>2</sup>	RMSE
RFE-SVR	0.710	0.645
RFE-LR	0.691	0.693
<b>(Schoving, 2020)</b>	0.040	1.320

Corrales-Munoz et al.

*Computers and Electronics in Agriculture (submitted)*



*Hybrid model to predict soybean yield*

**Enhancing model genericity for soybean over more EU areas**

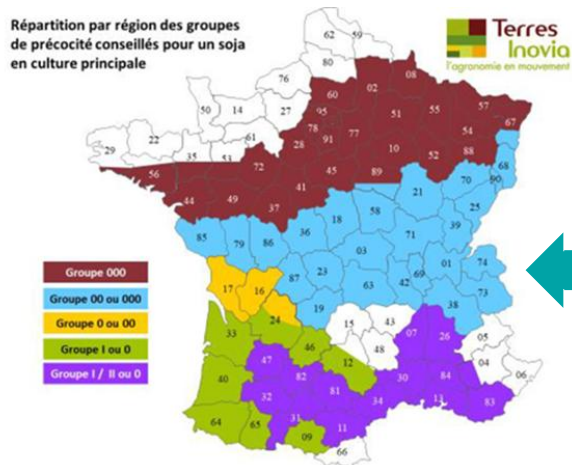
- **Interpretable model to predict yield soybean in Europe (yield observations from North-East EU, ZALF collab.)**
- **Decision tree learners : CUBIST rule-based model**  
➔ R<sup>2</sup> 0.77; RMSE 0.57



# ➤ Developing models for soybean yield prediction (2)

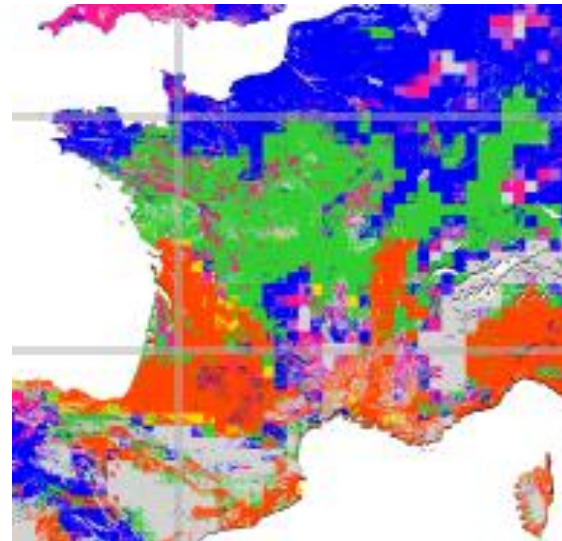
Explore the potential productivity of soybean across Europe under current and future climate (collab. ZALF)

Current recommendations  
from Terres Inovia

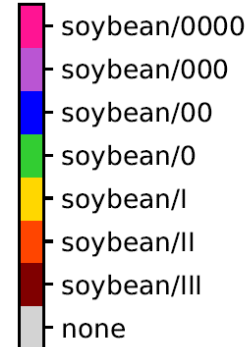
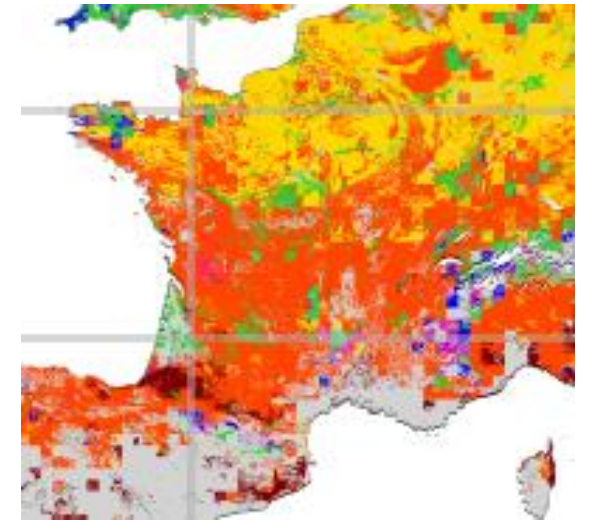


Maturity groups achieving the highest yield (25 Km x 25 km)

Rainfed - baseline



Rainfed – 2050 RCP 4.5



## ➤ Concluding remarks and perspectives

→ We illustrated the added value of an integrative approach combining controlled and field experiments plus crop modeling to support the development of a new legume crop as soybean within the European agricultural « landscape »

→ This framework is continuously consolidated by new research :

Ex. coupling a model of crop establishment (SIMPLE) with STICS to better explore the opportunity to grow soybean in some cool or dry environments in Europe (cf Lamichhane et al., 2020, *EJA*)

Ex. evaluation of the agronomic and environmental performances of soybean grown as a relay-crop or double crop (3C2A – Iphard ; collab with China – Thesis of Lin Kang)



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CasDAR 3C2A : Ministère de l'Agriculture et de l'Alimentation

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