# Phenotypic characterization of French elite germplasm in response to drought and heat stress.

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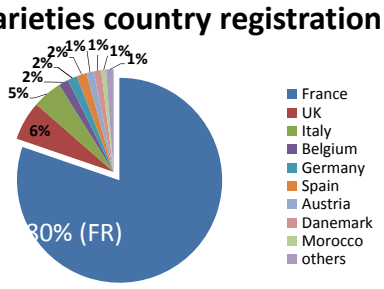
## Context

**Water deficit** is one of the main abiotic stresses **limiting wheat growth**

**European temperate climate** seems to be less subject to **drought**. However, recent studies show that **water deficit** events have **led to reduced yields** for at least two decades [1]. This is why, several **French research** and **breeding** programs have devised a trial network for understanding the **physiological** and **genetic** bases of **response to drought stress**.

## 280 Bread wheat varieties

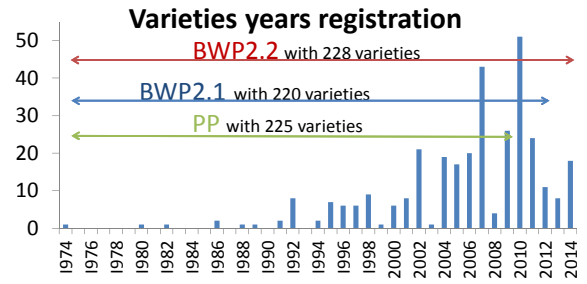
**Varieties country registration**




**Three connected panels with:**

- Varieties following the evolution of the current market.
- 80% of French varieties.
- The first panel (PP) was used in project « Genoplante ».
- Second and third (BWP2) were used in PIA BreedWheat.

**Varieties years registration**




## Trial network

### Field experiments

**Rainfed :** 20 trials between 2008/2014

**Rainfed vs irrigated :** 12 trials between 2012/2017


**Field analysis :**
Augmented designs with two replicates.
Spatial trend modeled by means of 2D P-splines [2]

### Semi-controlled platforms

**Mobile shelter** that can be **deployed if it rains** which allows the **management of drought stress**.

**Rain-out vs irrigated** 2 trials in 2016.
Phenofield® : Ouzouer-le-Marché (41), France
Phéno3C : Clermont-Ferrand (63), France

### Controlled platforms

1 : Study **physiological** responses to **high-temperature** (29°C) occurring at **grain filling stage**.

2 : Study finely the **root architecture** at the **juvenile stage** in a contrasted **water regime.**

## Phenotypic trait

➡ **For each trial, basic traits** have been collected : **phenology** (heading date…), **yield** and **yields components**.

➡ **For some trials**, **fine traits** have been collected :
- **kinetic senescence** by visual scoring or NDVI.
- **Morphological kernel** characterization by using image analysis.

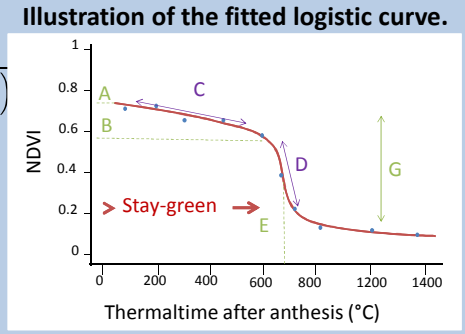
➡ **Fully automated phenotyping** system :
-RGB camera, multispectral spectrometry, LIDAR, thermal camera…

Modelize the **kinetic senescence** and estimated the **stay-green** trait.

$$NDVI = A + B.\left(1 - exp\left(\frac{-C.Tt}{B}\right)\right) + \frac{G}{1 + exp\left(\frac{-4.D.(Tt - E)}{G}\right)}$$

With:
NDVI : normalized difference vegetation index
Tt = Thermal-time after anthesis (base 0°C)
A = score max at anthesis
B = score at the end of slow phase
C = maximal rate of NDVI during slow phase
D = maximal rate of NDVI during rapid phase
E = thermal-time when D is reached
G = indicator of NDVI loss

**Illustration of the fitted logistic curve.**



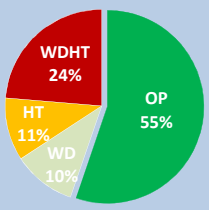

## Environmental characterisation

**Ecophysiological models** (CNH) [3] were run to **identify the timing, intensity and history of stress**

➡ **Soil characterization** was recorded in each trial and **connected to a database** (Arvalis), which regroups soils per French region.

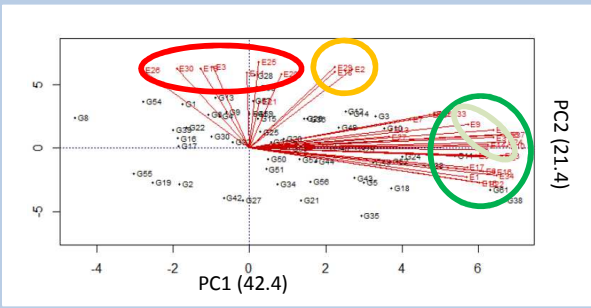
➡ **Weather data** was collected and imputed with a database (Arvalis) based on 250 sites in France.

Define **water-stress** and heat-stress patterns to cluster the trial net-work.




4 scenarii :
- OP : Optimal condition.
- WD : Water deficit.
- HT : High temperature
- WDHT : High temperature and water deficit

Bi-plot of Genotype–environment interactions for yield in the trial net-work (62 lines in the 47 trials)




## Conclusion & Perspectives

1. Traits selection will be our main goal to enhance genetic progress of yield in response to environmental stress.
2. Genome-wide association study of this panel will be performed exploiting all phenotypic data collected.
3. Physiological and genetic approach will lead us to explain the GxE (genetic x environmental) interaction and select the best strategies for wheat adaptation of drought and heat stress.

[1] Brisson, N., Gate, P., Gouache, D., Charmet, G., Oury, F.-X., Huard, F., (2010.) Why are wheat yields stagnating in Europe? A comprehensive data analysis for France. Field Crops Research 119, 201–212.
[2] Rodriguez-Alvarez, M.X., Lee, D.-J., Kneib, T., Durban, M., and Eilers, P.H.C. (2015). Fast smoothing parameter separation in multidimensional generalized P-splines: the SAP algorithm. Statistics and Computing 25, 941 – 957.
[3] *Soenen B., Le Bris X., Laberdesque M., Cohan J.-P., Laurent F., Bouthier A., Gouache D., Garcia C.* (2016) "CHN", a crop model to jointly manage water and nitrogen on winter wheat. (2016). ARVALIS - Institut du végétal. https://www.researchgate.net/publication/299515014 ,DOI: 10.13140/RG.2.1.3747.2400

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