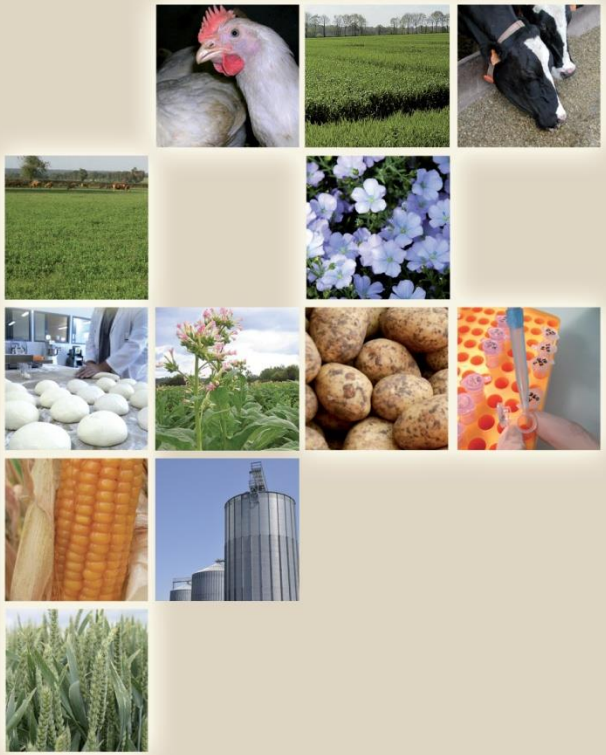

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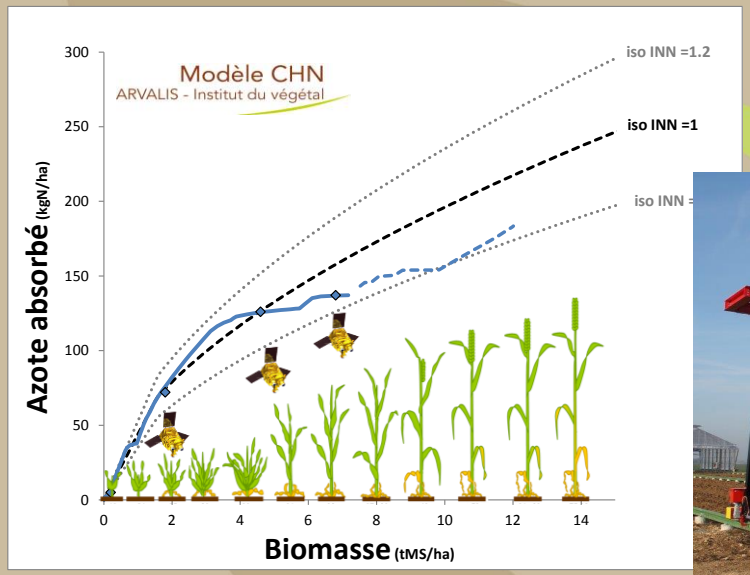

Wheat yield progress in Europe – practical examples from France

November 30th 2016

Jean-Pierre COHAN

Head of crop-physiology, biotechnology and crop phenotyping programs

jp.cohan@arvalisinstitutduvegetal.fr

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Several elements of this presentation have been provided by:
Jean-Charles Deswartes & Philippe Gate (ARVALIS)
Hélène Lucas (INRA)

ARVALIS, a brief overview

Basic Research

Applied Research

Extension

PUBLIC RESEARCH

INRA
IRSTEA
"Grandes Ecoles"
Universities/ CNRS

PRIVATE RESEARCH

Breeders,
Agrochemists,
Machinery companies,
Food and non-food companies

ARVALIS

Other technical institutes

LOCAL ADVISORS

(Public/regional, Private – Distributors/Coops)

FARMERS

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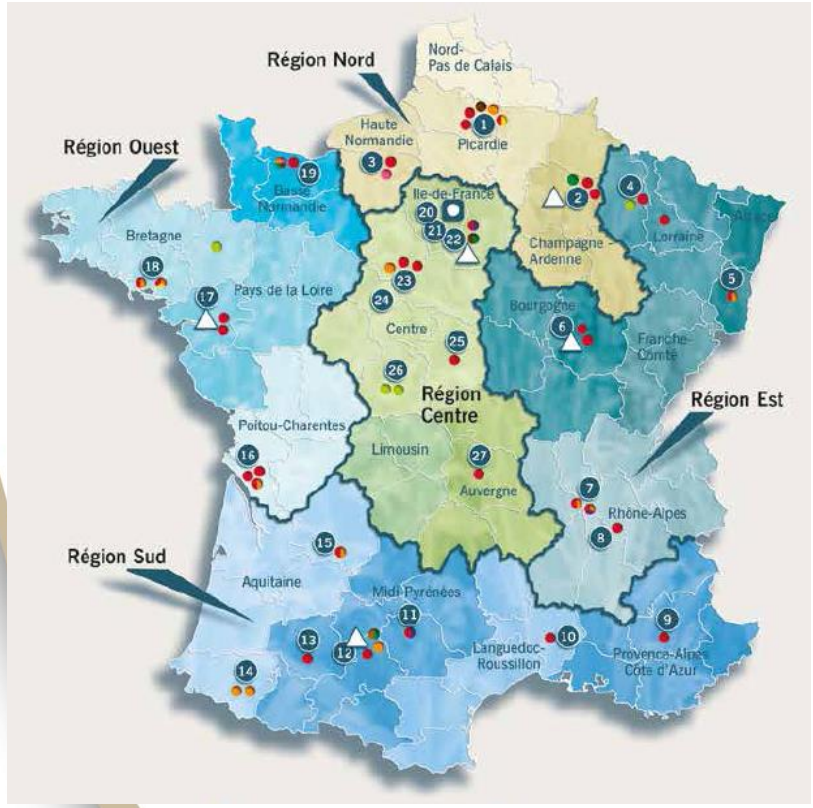
ARVALIS, a brief overview



- **An agricultural research Institute**
- **Funded by French farmers**
- **30 research stations and laboratories all over the country**
- **400 permanent people divided into 4 main departments:**

➔ Research and development

➔ Regional actions

➔ Scientific direction (material and methods, statistics)

➔Marketing and communication (newsletters, website, DMT, conferences)

- **Crops :** grain cereals, corn, grassland and forage, potatoes, flax, tobacco, cover-crops
- **Studies** from gene/seed to harvest quality for humans and cattle
- **Topics** including production, economics and environment

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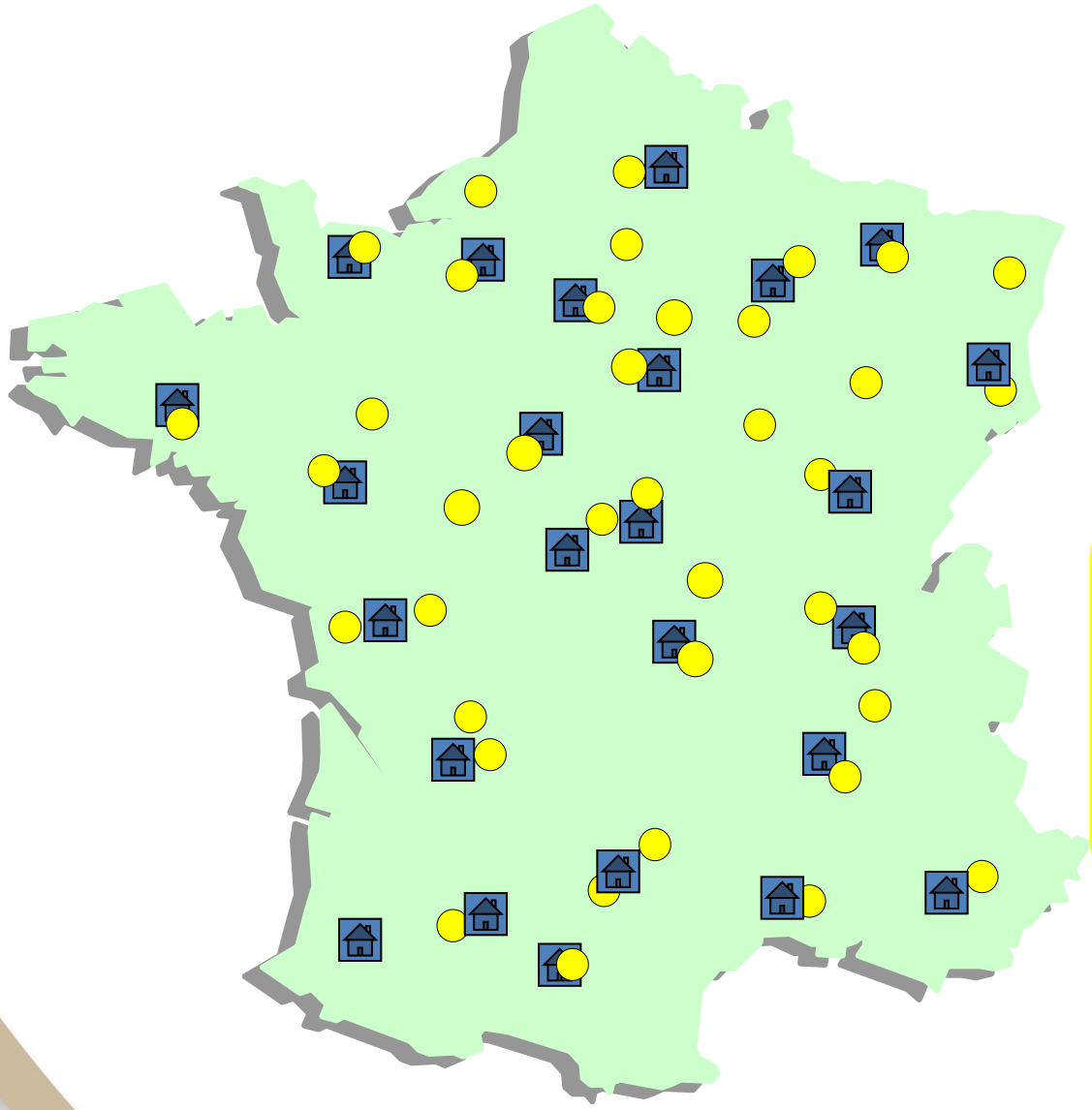
ARVALIS, a brief overview

Winter cereals: A national network of field trials



Research stations

Main Winter cereals Field trials

Topics:

- Varieties evaluation
- Crop nutrition
- Crop-physiology
- Biotechnology
- Crop protection
- …

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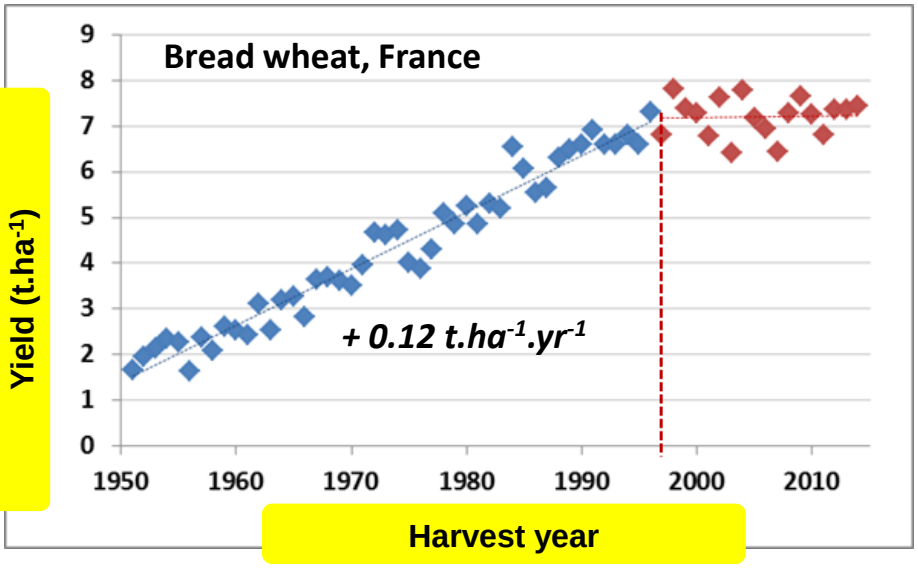
Stagnating wheat yields in France and Europe : the diagnosis



Data sources : SCEES

- No more systematic yield growth from year to year
- Observed in numerous European countries
- Especially for winter crops (not the case for maize and sugar-beet in France)

Why are wheat yields stagnating in Europe? A comprehensive data analysis for France

Nadine Brisson[a,*], Philippe Gate[b], David Gouache[b], Gilles Charmet[c], François-Xavier Oury[c], Frédéric Huard[a]

[a] INRA AGROCLIM 84914, Avignon Cedex 9, France
[b] ARVALIS Institut du Végétal, La Minière, 78280 Guyancourt, France
[c] INRA UMR GDEC, 234 av du Brézet, 63 100 Clermont-Ferrand, France

INRA SCIENCE & IMPACT

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Table 2
Results of the rising-plateau regression yield analysis throughout various European countries in terms of the year of stagnation and the significance of this evolution compared to the single sloping straight line (** very significant $P<0.01$, no star $P>0.05$). Source of data: FAO.

Country	Year of stagnation
Denmark	1995 (**)
France	1996 (**)
Germany	1999
Italy	1994
Netherlands	1993 (**)
Spain	1989
Switzerland	1990 (**)
United Kingdom	1996 (**)

Same trend in most European countries

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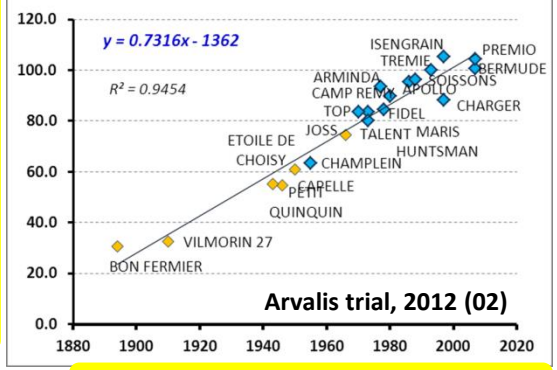
Brisson et al. 2010

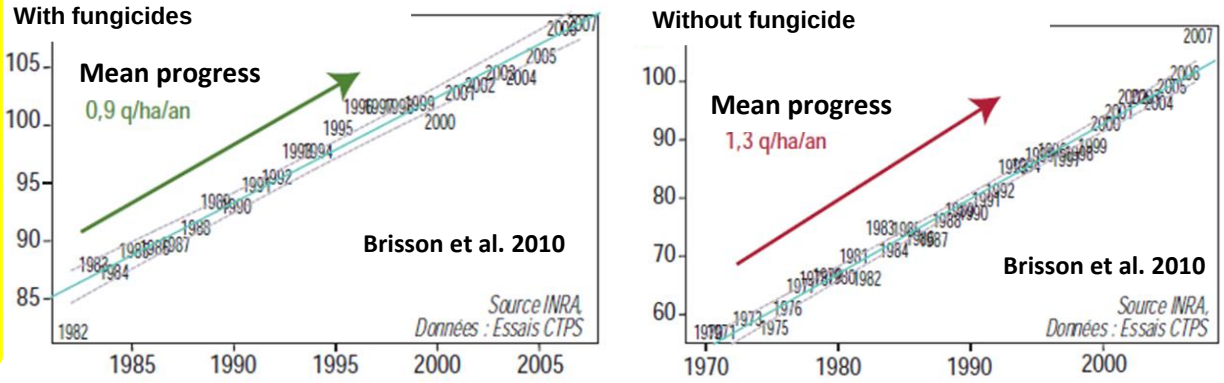
Stagnating wheat yields in France: why ?

Genetic progress ?

All genotypes in one trial



Genotypes registration chronicles ("year effect" removed)

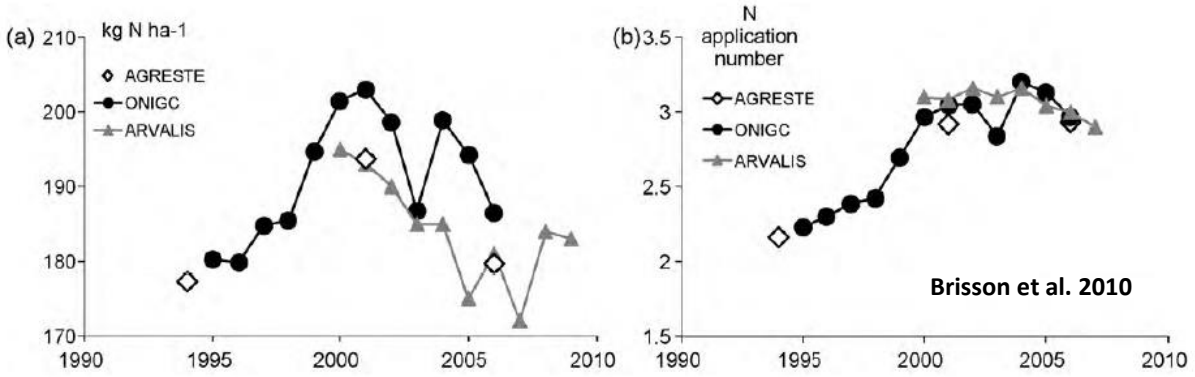


- Recent varieties are more productive than previous ones (+0.1 t/yr) ➔ **constant genetic progress.**
- Recent varieties are less susceptible to diseases than previously (higher genetic gain for "un-treated" set than for "treated" set)
- Varietal adoption is still an issue (slower than for maize) ➔ **genetic progress transferred to farmers**
- ➔ genetic progress prevents yields from falling. **If genetic progress ceased, yields would fall.**

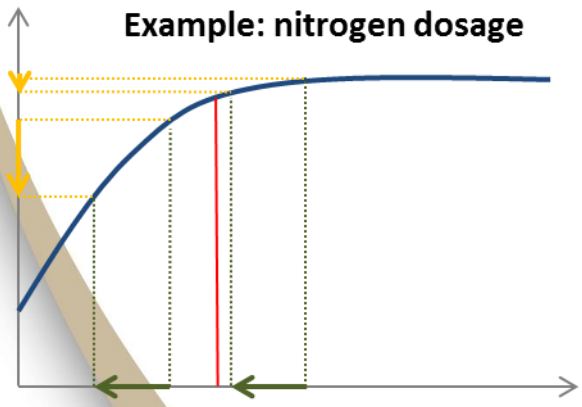
Stagnating wheat yields in France: why ?

Crop nutrition and soil fertility

N application practices



Brisson et al. 2010



Reduced dosage (regulatory repercussion), but adoption of more targeted inputs (split application, remote sensing tools…).

Impact of reduced dosage difficult to assess because of the non-linear response of yield to N
➔ impact probably undervalued

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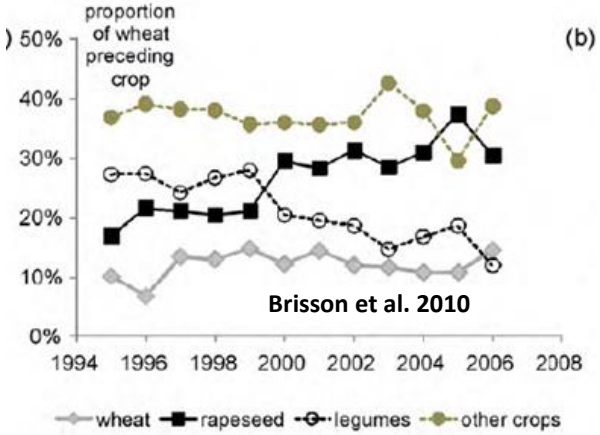
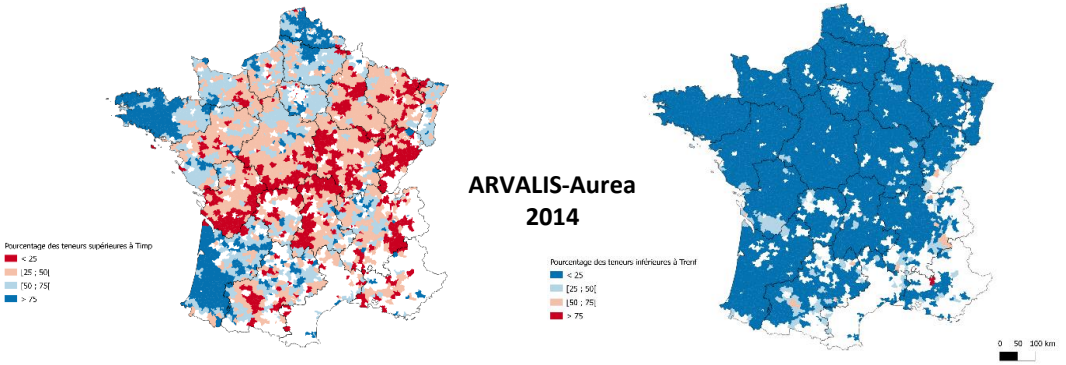
Stagnating wheat yields in France: why ?

Crop nutrition and soil fertility

Rotation : use of legumes



Soil fertility (P_2O_5 example)



- **Rotation:** use of the most beneficial preceding crops (legumes) has been reduced by half
- **Soil fertility:** disparate soil carbon (C) conditions (no general drop). Phosphorous (P) concentrations sometimes restrictive but only for sensitive crops (excluding wheat most of the time). Soil structure not assessed.

Diseases, pests and weeds ?

Fungicide: slight reduction in dosage (with major inter-annual fluctuations), but more effective products and less sensitive varieties
Weed-control: more and more complicated, difficult to assess
Pest: no assessed but probably not involved in the main trend

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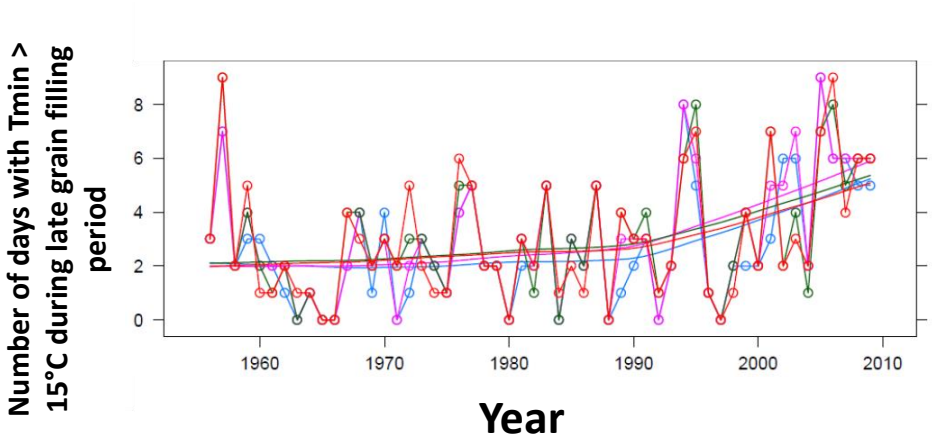
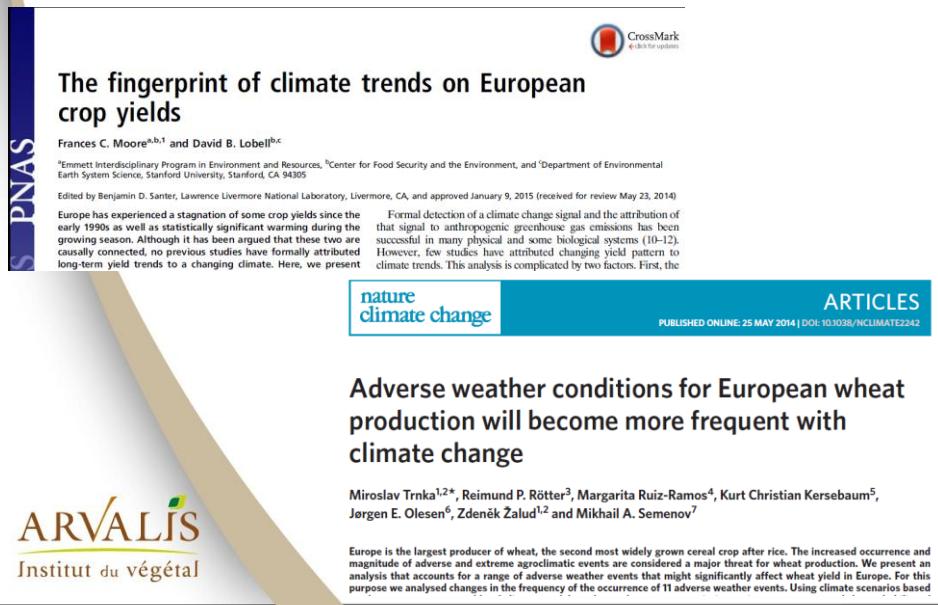
Stagnating wheat yields in France: why ?

Adverse weather conditions





CrossMark

The fingerprint of climate trends on European crop yields

Frances C. Moore[a,b,1] and David B. Lobell[b,c]

[a]Emmett Interdisciplinary Program in Environment and Resources, [b]Center for Food Security and the Environment, and [c]Department of Environmental Earth System Science, Stanford University, Stanford, CA 94305

Edited by Benjamin D. Santer, Lawrence Livermore National Laboratory, Livermore, CA, and approved January 9, 2015 (received for review May 23, 2014)

Europe has experienced a stagnation of some crop yields since the early 1990s as well as statistically significant warming during the growing season. Although it has been argued that these two are causally connected, no previous studies have formally attributed long-term yield trends to a changing climate. Here, we present

Formal detection of a climate change signal and the attribution of that signal to anthropogenic greenhouse gas emissions has been successful in many physical and some biological systems (10–12). However, few studies have attributed changing yield pattern to climate trends. This analysis is complicated by two factors. First, the

PNAS

nature climate change

ARTICLES

PUBLISHED ONLINE: 25 MAY 2014 | DOI: 10.1038/NCLIMATE2242

Adverse weather conditions for European wheat production will become more frequent with climate change

Miroslav Trnka[1,2*], Reimund P. Rötter[3], Margarita Ruiz-Ramos[4], Kurt Christian Kersebaum[5], Jørgen E. Olesen[6], Zdeněk Žalud[1,2] and Mikhail A. Semenov[7]

Europe is the largest producer of wheat, the second most widely grown cereal crop after rice. The increased occurrence and magnitude of adverse and extreme agroclimatic events are considered a major threat for wheat production. We present an analysis that accounts for a range of adverse weather events that might significantly affect wheat yield in Europe. For this purpose we analysed changes in the frequency of the occurrence of 11 adverse weather events. Using climate scenarios based

- Trend to warmer climate so shorter cycle ➔ slightly unfavorable
- "Threshold effect" of higher temperatures: more cases of 'scorching' temperatures
- More cases of unpredictable extremes (freezes, drought, heatwaves)

➔ Adverse weather conditions in the plural, not necessarily just one set of conditions

➔ No clear illustration, rather a body of collected evidence and knowledge

➔ Need to better understand wheat physiological traits involved

Not necessarily completely convergent with recent studies (Moore and Lobell, 2015): "average temperature" approach vs. "climatic incidents"

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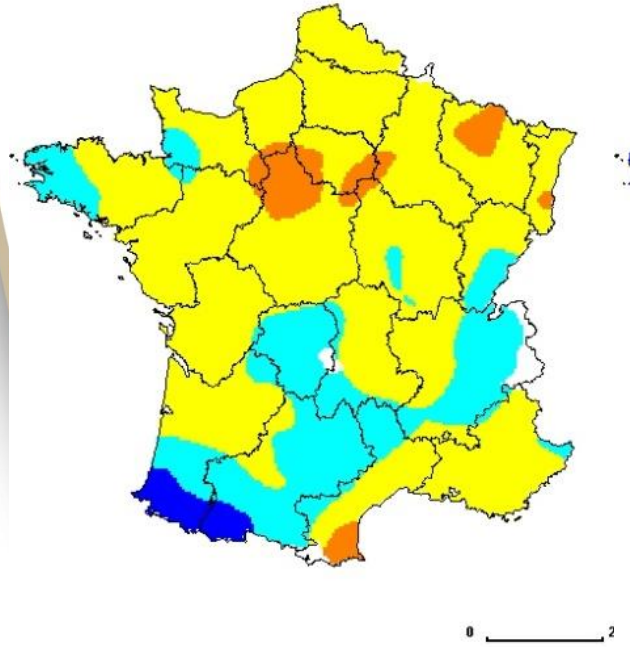
More and more exceptional meteorological events

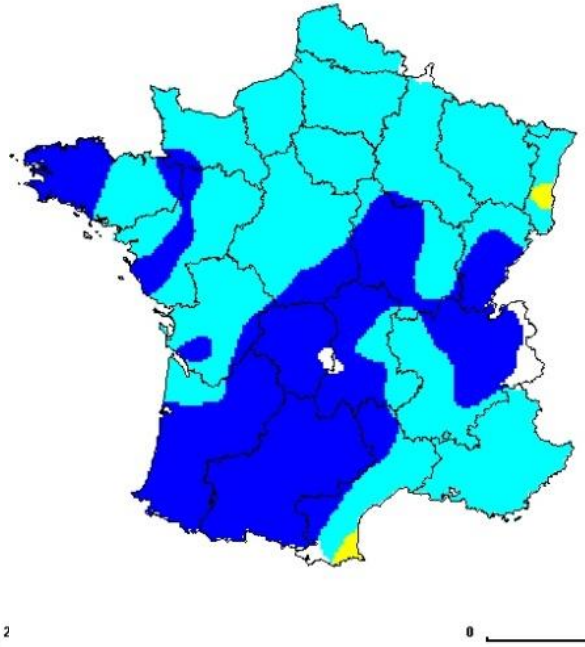
Example 1 : drought and bad N efficiency during 2011 spring

Number of days "suitable" to apply N fertilizer with a maximum efficiency

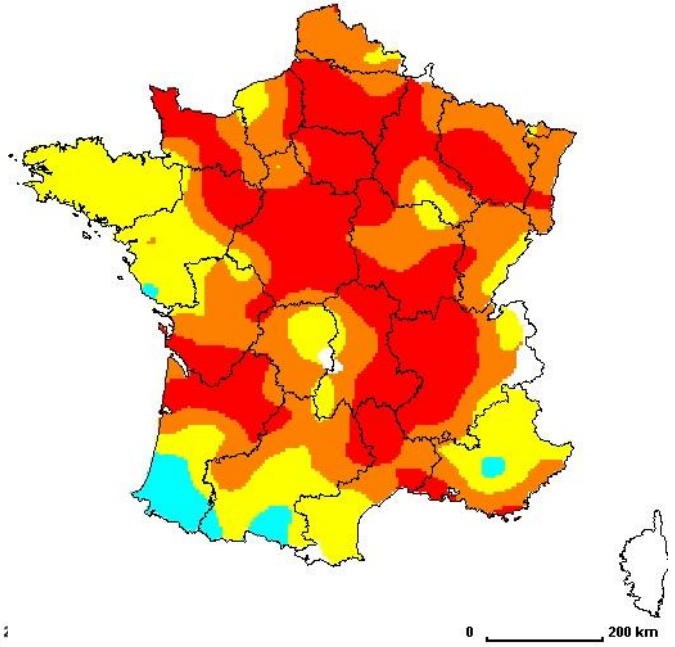
April – centile 2



April - Median



April - 2011



0 => 6 jours
6 => 12 jours
12 => 19 jours
19 => 25 jours
25 => 31 jours
Calcul impossible

Calculation and mapping: ARVALIS
Meteorological data sources: METEO-France, SRPV, Terres-Inovia, INRA, ARVALIS

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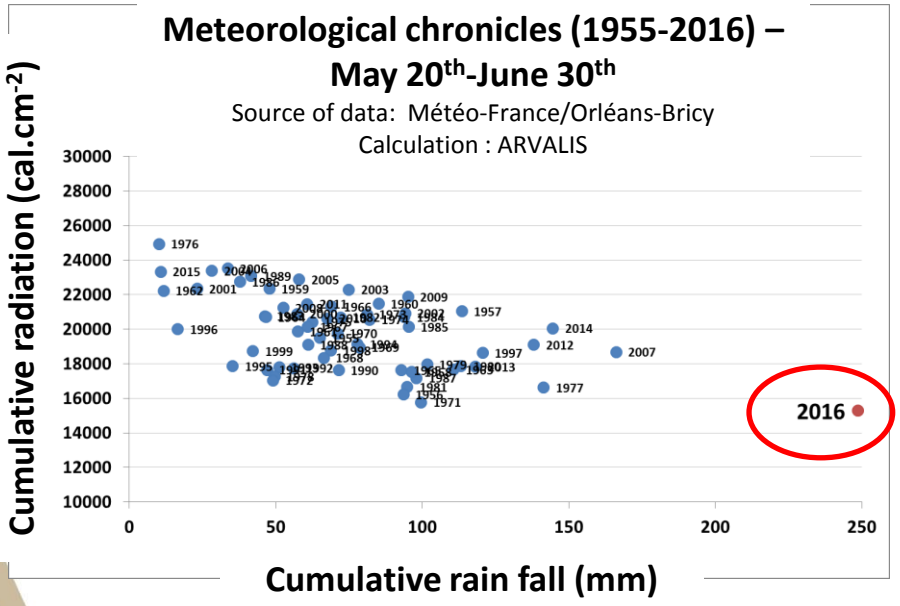
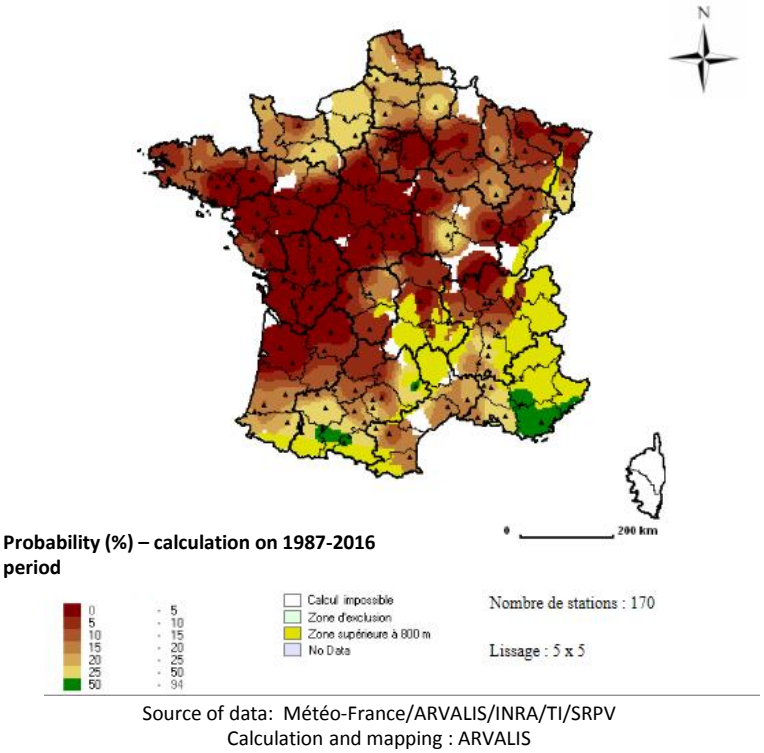
More and more exceptional meteorological events

Example 2 : Cumulative rain fall and lack of radiation during 2016 grain filling period



Probability to obtain a cumulative radiation under 2016 level during wheat grain filling



Source of data: Météo-France/ARVALIS/INRA/TI/SRPV
Calculation and mapping : ARVALIS

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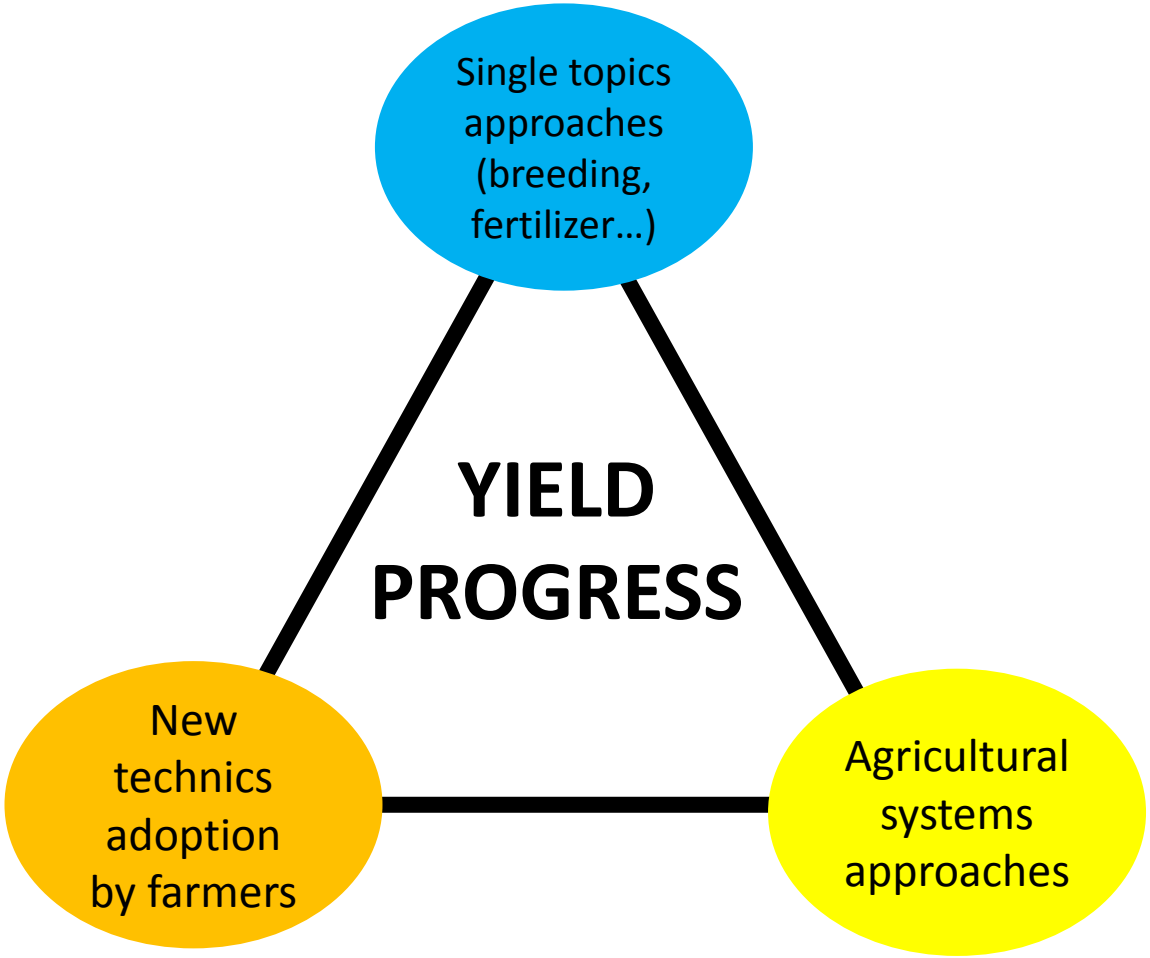
Wheat yield progress : build a multivariate response



Some examples are following

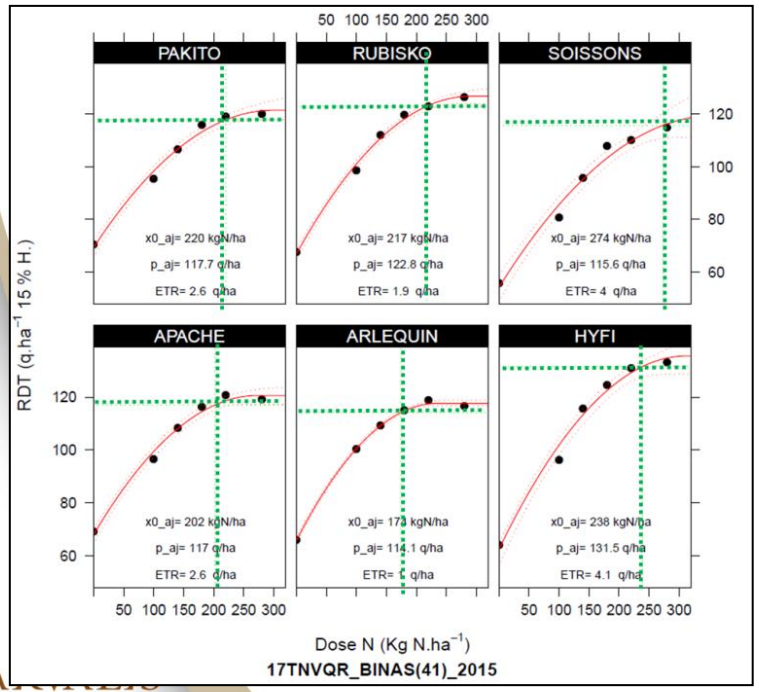
Wheat yield progress : increasing genotype performances

Key research projects

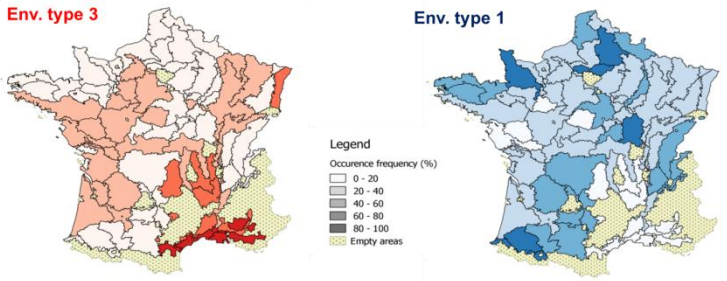
FSOV 2012-K project
FSOV 2014- N BW project

Improving NUE:
➔ Breeding program (new indicators and genetics)
➔ Registration process (new indicators)

Improving WUE:
➔ Breeding program (new indicators and genetics)



Significant differences for water-stress scenarios frequencies between wheat growing areas ➔ contrasting ideotypes to grow ?



Wheat yield progress : increasing genotype performances

Developing efficient new phenotyping tools

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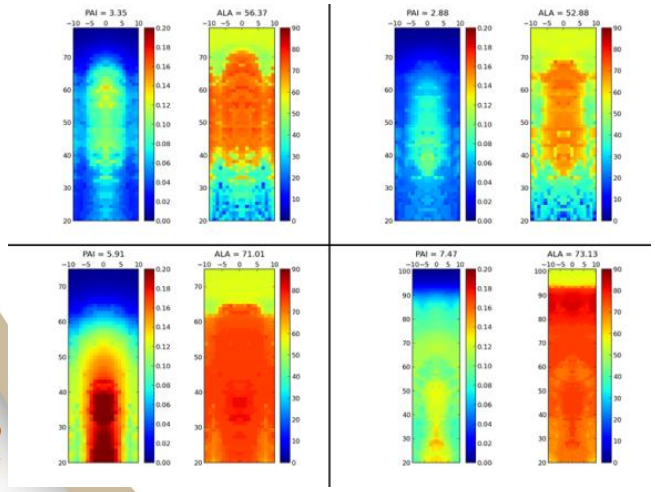
INRA SCIENCE & IMPACT

PHENOME Réseau Français Phénomique végétale FPPN

Phenomobile

Several innovative phenotyping tools held by INRA, Terres-Inovia and ARVALIS



Phenofield

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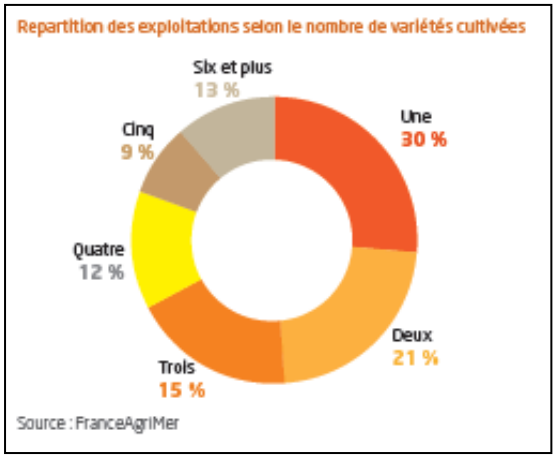
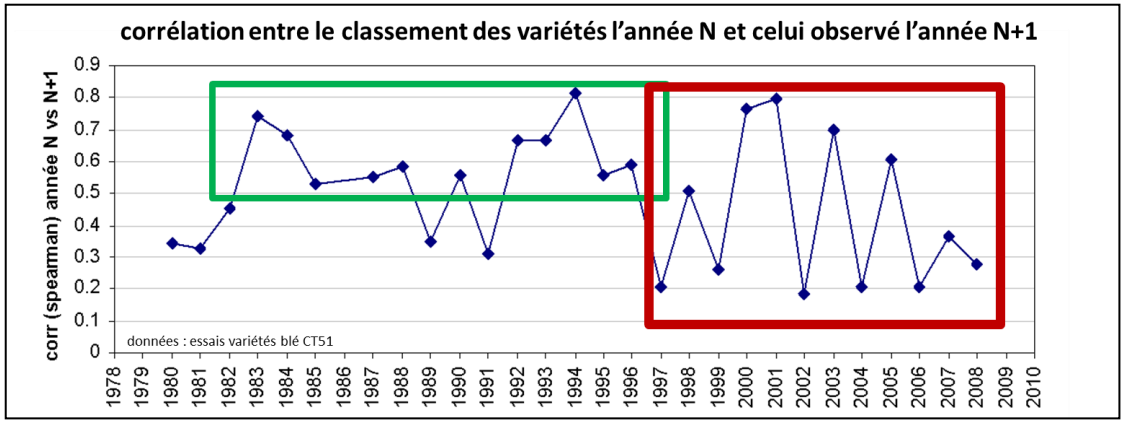
Wheat yield progress : increasing genotype performances

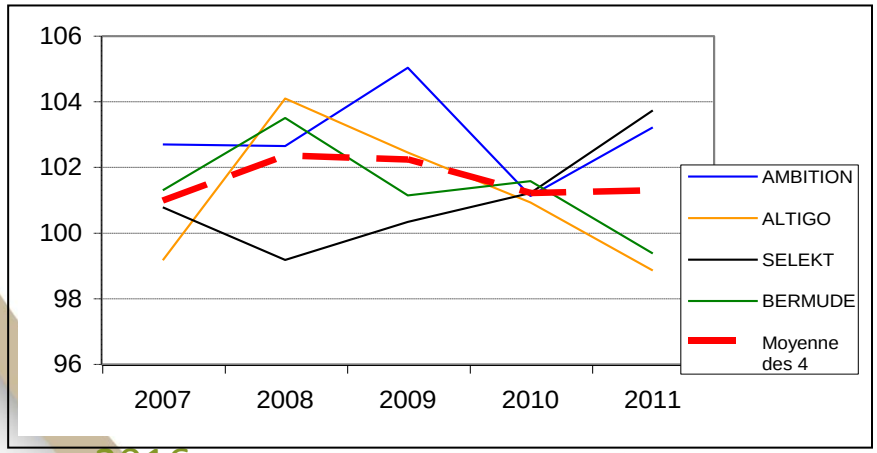
- **Practices adoption by farmers**

Panel of varieties on farms





- The **number of varieties per farm** is **limited**
- The **performance of a variety depends on the year**
- **Climate change increases the uncertainty** of the performance of a new variety
- The **panel of varieties contains old varieties,** not necessarily the most productive



Les dix premières variétés

Variétés	Année d'inscription	Avis meunerie 2015*	Classe technologique Arvalis
Rubisko	2012	BPMF	BP
Cellule	2012	BPMF	BPS
Apache	1998	VRM	BPS
Arezzo	2008	VRM	BPS
Boregar	2008	BPMF	BPS
Pakito	2011	VRM	BPS
Trapez	2009		BP
Bergamo	2012		BP
Oregrain	2012	VRM	BPS
Expert	2008		BP

*VRM = variété recommandée par la meunerie - BPMF = blé pour la meunerie française
Source : FranceAgriMer/ANMF/ARVALIS 2014

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Wheat yield progress : more precise nutrition management

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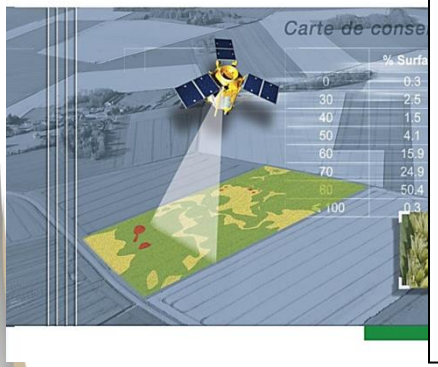
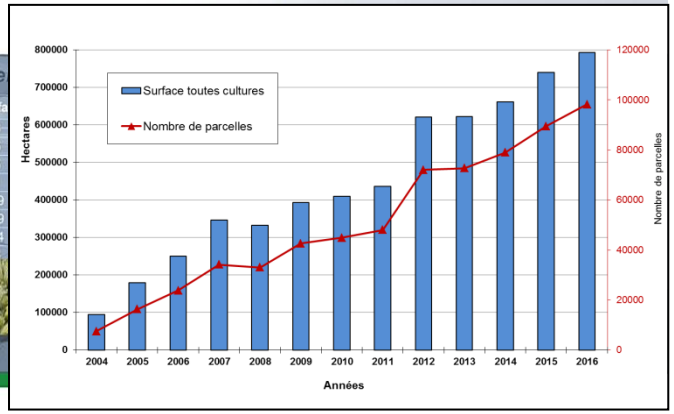
Terres Inovia l'agronomie en mouvement

AIRBUS DEFENCE & SPACE

FARMSTAR expert
Vos parcelles vues du ciel





Nitrogen Status Remote sensing tool

Example : satellite based FARMSTAR

793 000 ha monitored in 2016

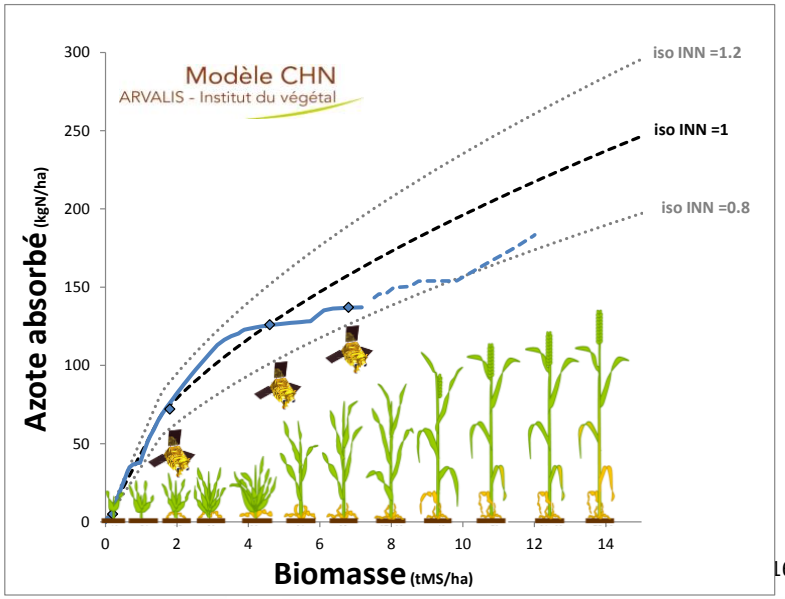
- ➔ Wheat : 484 000 ha
- ➔ Barley : 94 000 ha
- ➔ Oilseed rape: 212 000 ha
- ➔ Triticale : 3500 ha

Mixing remote sensing and model based tools

Example : ARVALIS CHN model

Operational model mixing high level scientific knowledges and the need to have a practical tool for different users

For technicians, researchers, breeders, stakeholders… (same “motor”, different “interfaces”)

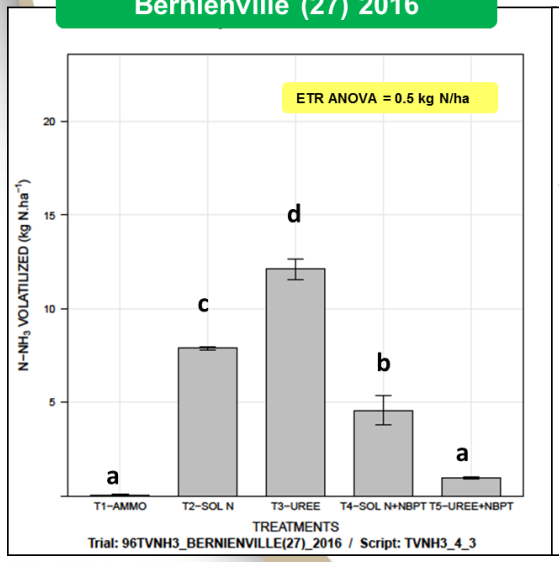


Wheat yield progress : new fertilizers assessments (Urea+NBPT example)

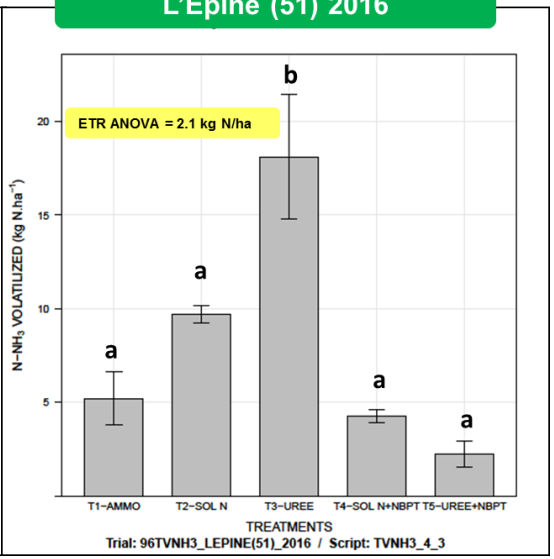
Name	Company	Regulation status	Availability in France	U/NH_4/NO_3 (% N-Total)	N-Total (% masse)	Urease inhibitor-1*	Urease inhibitor-2*
NEXEN	Koch Fertilizer Products	CE 2003/2003	2012	100/0/0	46	NBPT	
UTEC 46	Eurochem Agro France	CE 2003/2003	2013	100/0/0	46	NBPT	
NOVIUS	In Vivo	CE 2003/2003	2014	100/0/0	46	NBPT	
UREA+LIMUS	BASF	CE 2003/2003	Spring 2017	100/0/0	46	NBPT	NPPT

* Concentration according to CE 2003/2003

Bernienville (27) 2016



L'Epine (51) 2016

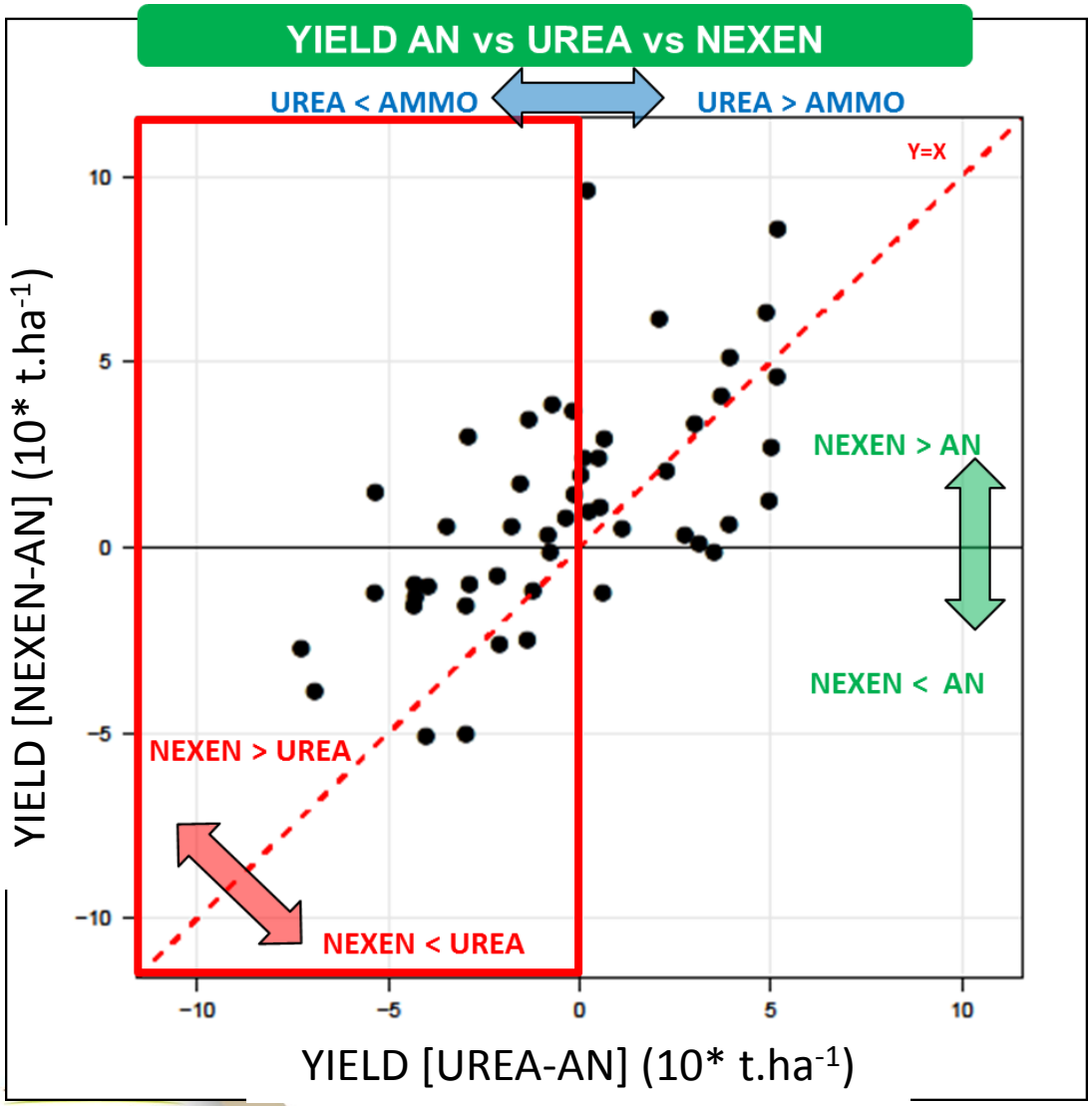


First results of ADEME EVAMIN project

Flux analysis method : INRA-ECOSYS/ARVALIS

SOL N + NBPT = UAN + Agrotain from Koch Fertilizer Products
UREE+NBPT = NEXEN from Koch Fertilizer Products
Letters = HG Tuckey tests

Wheat yield progress : new fertilizers assessments (Urea+NBPT example)



YIELD	All points	Points UREA < AN	Points UREA ≥ AN
[NEXEN] - [AN]	+1.0 q/ha**	-0.4 q/ha^{NS}	+2.9 q/ha***
[NEXEN] - [UREA]	+1.5 q/ha***	+ 2.3q/ha***	+0.4 q/ha^{NS}
[UREA] - [AN]	-0.4 q/ha^{NS}	-2.8 q/ha***	+2.5 q/ha***

Statistical tests : *** 1% significant; ** 5% significant; * 10% significant; ns : non significant

19 trials ARVALIS 2012-2016 (31, 32, 41, 45, 51, 55, 56, 67)

- Soils : Chalky soils (6 trials), loamy soils (13 trials)
- Species: 5 durum wheat trials , 14 bread wheat trials
- Comparisons made on all applications (53 points)

Similar results for UTEC 46 and UREA+LIMUS

The Wheat Initiative

An international research partnership for wheat improvement

- **Created in 2011 following endorsement by G20 Agriculture Ministries** to improve food security
- A framework to **establish strategic priorities**, **identify synergies and facilitate collaborations** for **wheat improvement** at the international level

www.wheatinitiative.org

Contact:
wheat.initiative@versailles.inra.fr



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The Wheat Initiative

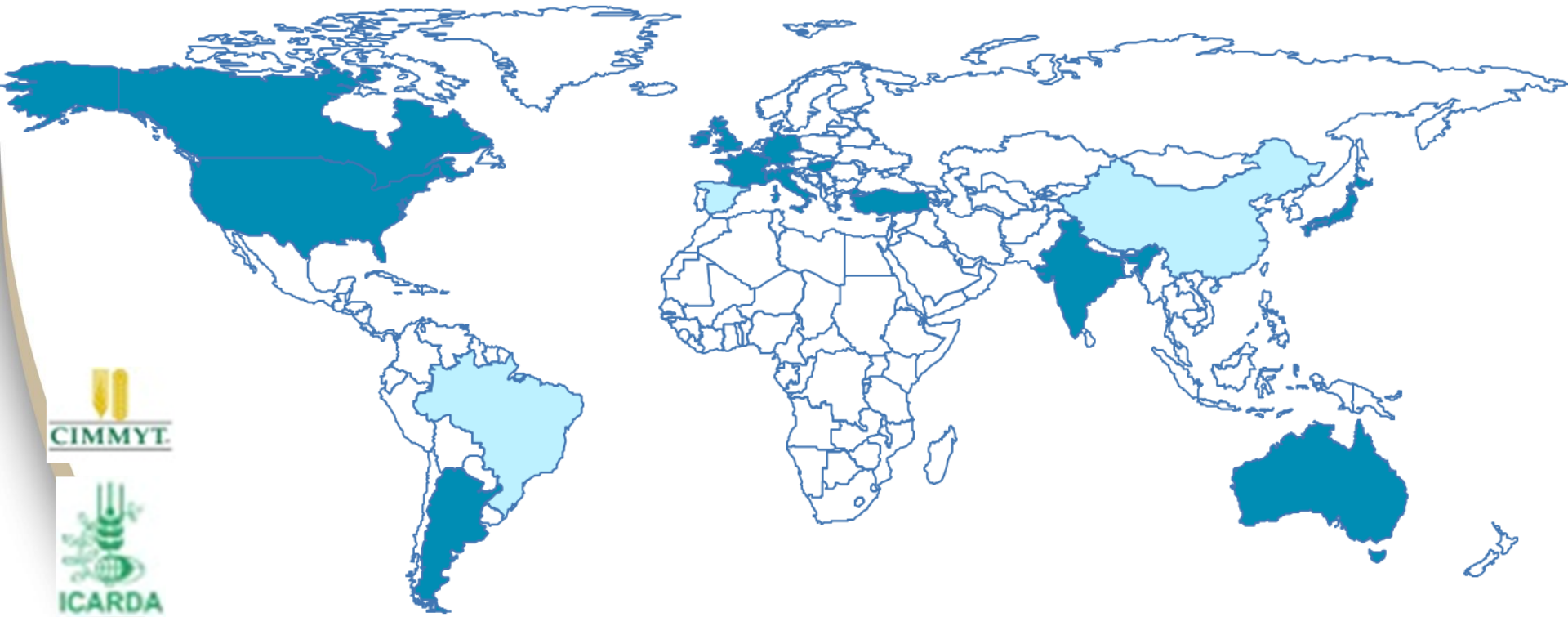
- **Vision:** a **vibrant global wheat research community** sharing resources, capabilities, data and ideas to improve wheat land productivity, quality and sustainable production

- **Mission:** develop a global Strategic Research Agenda and support its implementation through **coordinated actions, knowledge and resource sharing and efficient investment**

The Wheat Initiative

All countries and companies welcome!

16 countries, 9 private companies, 2 CGIAR Centres



CIMMYT

ICARDA

ARVALIS Institut du végétal

ARVALIS Institut du végétal

BAYER CropScience

FLORIMOND DESPREZ

KWS

Limagrain

MONSANTO

RAGT

SAATEN UNION

syngenta

The Wheat Initiative

Expert Working Groups
Any expert welcome !

Established

- Wheat Information System
- Genetics and genomics of Durum wheat
- Wheat breeding methods and strategies
- Wheat phenotyping to support wheat improvement
- Wheat plant and crop modelling
- Nutrient use efficiency

Developing

- Control of wheat pathogens and pests
- Adaptation of wheat to abiotic stress
- Global wheat germplasm conservation and use community
- Improving wheat quality for processing and health

Newly approved

- Agronomy

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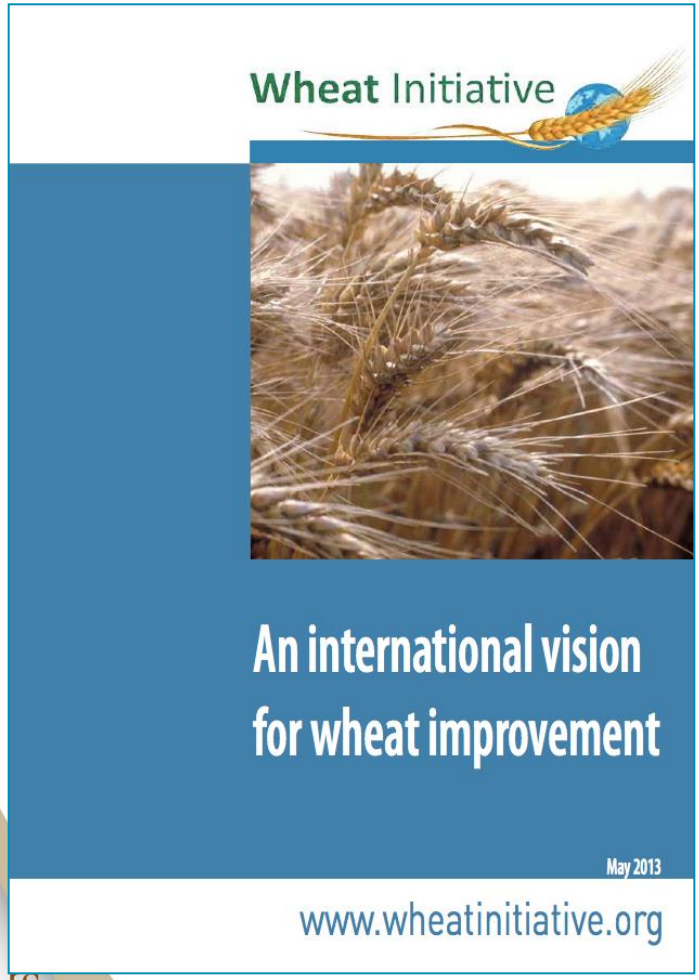
The Wheat Initiative

From an Vision Document to a Strategic Research Agenda



2013

2015

Thank you for your attention

ARVALIS
Institut du végétal