BREEDWHEAT
Wheat production is facing great challenges

- Provide consistently sufficient, high quality food and feed products as well as non-food products through a sustainable agricultural system while

  - Increasing demand (population, urbanization) = need to increase production by 2%/year until 2050 (FAO)
  - Yield stagnation in the past 10 years in main producing areas
  - Climate change, reduced and unevenly distributed water resources, limited expansion of arable lands
  - Need to reduce environmental impact of agricultural production (e.g. ECOPHYTO 2018)
  - Increasing competition between food and non food uses (products and areas)
  - Agricultural policies difficult to coordinate, agricultural research is not a priority
Wheat is essential for the French economy

- France ranks 1st in the EU/5th in the world for both production and export
- A positive balance of 6.6 billion € (2007)
- ~58% of the production is exported (mostly for milling)
BREEDWHEAT
Breeding for economically and environmentally sustainable wheat varieties: an integrated approach from genomics to selection

Objective
Develop a sequence-based tool box for the wheat genome, exploit and develop new phenotyping capabilities and combine those to:

• decipher the genetic and ecophysiological basis of key traits for wheat improvement e.g. abiotic and biotic stress tolerance, yield components and quality,
• expand and facilitate the use of genetic resources to increase allelic variability in the elite gene pool and,
• develop and deploy new breeding methods

to select improved bread wheat varieties that meet the breeders, growers and consumers needs thereby enabling a competitive and sustainable wheat production in France.
The future is an integrated toolbox

**Genetic material**
- Mapping populations (RILs, NAM, MAGIC, RH....)
- Association panels
- Exotic germplasm
- Mutant populations

**Genetic and genomics resources**
- Genetic maps
- Genome sequences (Ref and others)
- HT DNA markers/platforms
- HT gene expression platforms all “omics”

**Phenotyping**
- HT in controlled conditions
- HT in the fields
- Imaging technologies

**Methodologies**
- Modeling/prediction
- GM approaches
- Breeding methods

**Allele mining**

**Gene and QTL mapping**

**Map-based cloning**

**Candidate genes**

**Perfect markers**

**Improved Triticeae germplasm**
WP1: Sequencing and marker development for high throughput genotyping and candidate genes isolation

WP2: Genetics and ecophysiology of wheat adaptation to biotic and abiotic stress

WP3: Characterization and exploitation of natural and induced genetic variability

WP4: Design, implementation and evaluation of novel breeding strategies

WP5: Bioinformatics for gene discovery, data integration and dissemination

WP6: Outreach

WP7: Management
BREEDWHEAT: timeline

High throughput technological developments: genotyping, phenotyping, bioinformatics (EQUIPEX, Infrastructures calls)

2011 Phase I

Data production on existing genetic material, integration of ongoing project data

Systemic analysis, evaluation and design of phase II

2014 Phase II

Data production and analysis on new panels and populations and with new genotyping and phenotyping capacities

2019

Dissemination (WP6) and management (WP7)
**BREEDWHEAT** - Partnership (26)

**Public partners:**
- INRA (12 centres)
- ISIMA
- INRA Transfert

**Competitiveness Cluster**
- Cereales Vallées

**Private partners / Technical institutes:**
- Agri Obtention
- Arvalis
- Bayer
- Biogemma
- Bioplante
- Caussade semences
- GEVES
- Limagrain
- Momont
- RAGT
- Secobra
- Syngenta

- 124 permanent staff
- 54 non permanent staff
### Partners and Total Cost

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**TOTAL** | **39 113 561** | **10 017 995** | **2 667** | **1 163**

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**WP1** | **WP2** | **WP3** | **WP4** | **WP5** | **WP6** | **WP7**
---|---|---|---|---|---|---
**2 999 919** | **3 000 000** | **1 305 000** | **1 300 000** | **648 030** | **299 800** | **450 000**

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**Total cost: 39 M€**

**Grant: 9 M€**

➢ Complete with France Agrimer and private partners
**WP1: Sequencing and marker development for high throughput detection of polymorphisms and target trait candidate genes isolation (E. Paux, INRA GDEC)**

**Objectives:**
- Develop **high throughput and innovative molecular resources** to support efficiently the genetics studies undertaken in the BREEDWHEAT project and
- Contribute to **maintain France leadership** in the international wheat genomics projects.

**Budget:** 3 M€

**4 tasks**

- Chromosome 1B sequence
- 15’000 SNPs (5500 genetically and physically mapped)
- Genotyping of 7500 SNPs on 19 900 lines (33 million SNP data points)
- Sequencing/annotation of 300 BAC contigs for positional cloning of 5 target traits

**Sequencing**
(1B, WGS, target contigs)

**Marker development**
(ISBP, candidate genes) from 96 accessions
(Sequence capture)

**Genotyping Mapping**
(WP2, 3, 4)
WP2: Genetics and ecophysiology of wheat adaptation to biotic and abiotic stress (J. Le Gouis, INRA GDEC)

Objectives:
• Develop integrative approaches to decipher the ecophysiological, genetic and molecular basis of key factors impacting important agronomic traits such as yield and quality in the context of sustainable systems and climate changes

Budget: 3 M€

5 tasks

Modeling (plant architecture, development)

Association Genetics = Genotyping + Phenotyping (48’000 plots)

• Yield
• Water use efficiency
• Heat stress
• Disease resistance

Data integration

- A structure-function model to assess ideotypes maximizing grain yield and quality
- A list of 2000 candidate genes for target traits
- New marker-trait associations for yield and quality traits under major biotic and abiotic stresses
- Fine mapping and positional cloning of 5 loci
WP3: Characterization and exploitation of natural genetic variability (A. Murigneux, Limagrain)

**Objectives:**
Broaden the genetic diversity present in modern French cultivars through the introduction of novel sources of diversity that contains favourable alleles for abiotic and biotic stresses

**Budget:** 1.3 M€

2 tasks

- Genotyping of 5000 wheat lines from INRA collection with 1000 SNPs
- Phenotyping of selected panels (2 x 250)
- Identification of new sources (adapted material from other programs, synthetics) of abiotic and biotic stress tolerance
- Introduction into French germplasm

- Detailed description and on line database access of the INRA collection
- Adapted panels (250) for abiotic and biotic stress
- Novel European Elite Germplasm with improved stress tolerance (2 x 9 Advanced Back crossed populations)
WP4: Design, implementation and evaluation of novel breeding strategies (G.Charmet, INRA GDEC)

Objectives:
• Develop innovative tools and methodologies to better exploit natural and induced variability in breeding programmes and accelerate genetic progress.
• Test the effectiveness of newly developed ideotypes to increase sustainability and profitability

Budget: 1.3 M€

4 tasks

➢ An integrated pipeline of softwares to estimate marker-based breeding values, and maximize genetic progress
➢ Comparisons between classical, genomic or marker-assisted selection schemes
➢ Identity cards and agro-climatic atlas of adaptation of new ideotypes
➢ Evaluation of economic impact of new breeding methods
Objectives:

- **Integrate data** from others WPs, as well as publicly available information (BIS)
- Develop **new tools to integrate new polymorphisms and automate association studies**
- Establish a **Breeder’s oriented** portal

**Budget:** 0.65 M€
Phenotyping • > 60 field assays (1000 parcels each) on N, Drought, fusarium and septoria in > 15 locations over 9 years

Genotyping • ≥ 33 million SNP assays (Gene and ISBP based) on ~20 000 lines

Ecophysiology • Modeling (N economy, Phyllocron /T°, leaf optical properties, radiative transfer Septoria and fusarium)

Characterization of genetic resources and new alleles

Physical and genetic mapping

Association genetics studies

Pre competitive breeding program

New core collections

New AB QTL lines

Chromosomal regions underlying agronomically important traits

Candidate genes

Markers for MAS and genomics selection

New breeding methods evaluated

Socio economic impact of innovative breeding methods and agricultural practices

BREEDWHEAT
**Objectives:** Disseminate the results of the BRREDWHEAT to scientists, breeders, farmers and consumers and develop interactions with international initiatives

**Budget:** 300 K€

**4 tasks**

- Website
- Leaflets and newsletters
- 6 Booklets
- 5 Training courses
- BREEDWHEAT conferences
**WP7: Management** (C. Feuillet/E. Lagendijk, INRA GDEC)

**Objectives:**
Ensure a **timely development** of the project, reaching the goals and achieving the **deliverables** on time, ensure **good practice** in resources management, guarantees financial **good practice** at the managerial level

**Budget:** 450K€

**6 tasks**

- Project management
- Project reporting (scientific and financial)
- Meetings
- Intellectual Property
- Interactions with international initiatives and stakeholders
BREEDWHEAT: partnership with international initiatives

- *TriticaceaeCAP* (5 years, 25M$, 55 labs, Wheat-Barley)
- SeeD, 3M$/year for wheat, 7 years, CIMMYT and collaborators
- Wheat Yield Consortium 7M$, 6 years, CIMMYT and collaborators
- WISP (5 years, 11M$, 5 institutes, 6 years, Wheat)
- BREEDWHEAT (9 years, 13M$, 26 partners, wheat)
Les blés du futur en germe à Clermont