

Genome ENgineering Improvement for Useful plants of a Sustainable agriculture

Fabien Nogué⁽¹⁾, Philippe Vergne⁽²⁾, Anne-Marie Chèvre⁽³⁾, Jean-Eric Chauvin⁽³⁾, Oumaya Bouchabké⁽¹⁾, Annabelle Déjardin⁽⁴⁾, Elisabeth Chevreau⁽⁵⁾, Laurence Hibrand-Saint Oyant⁽⁵⁾, Marianne Mazier⁽⁶⁾, Pierre Barret⁽⁷⁾, Emmanuel Guiderdoni⁽⁸⁾, Luc Mathis⁽⁹⁾, Christophe Sallaud⁽¹⁰⁾, Mireille Matt⁽¹¹⁾, Jean-Philippe Pierron⁽¹²⁾, Eric Bonnel⁽¹³⁾, Séverine Foucrier⁽¹⁴⁾, Alain Toppan⁽¹⁵⁾, Laure Trannoy⁽¹⁶⁾, Peter Rogowsky⁽²⁾.

The Context

World agriculture needs to guarantee food security, replace fossil resources, decrease environmental impact and adapt to global climate change. Whereas France and other European countries presently choose to meet the genetic aspect of these challenges by the sole use of genome breeding, an increasing number of agriculturally important countries enlarge the available gene pool

via transgenesis. Despite a certain political reserve transgenesis is already an indispensable technology for French seed companies and public scientists to remain competitive at an international level. Recent scientific advances in the field of transgenesis now provide answers to certain misgivings of citizens and blur the border between breeding and transgenesis. In

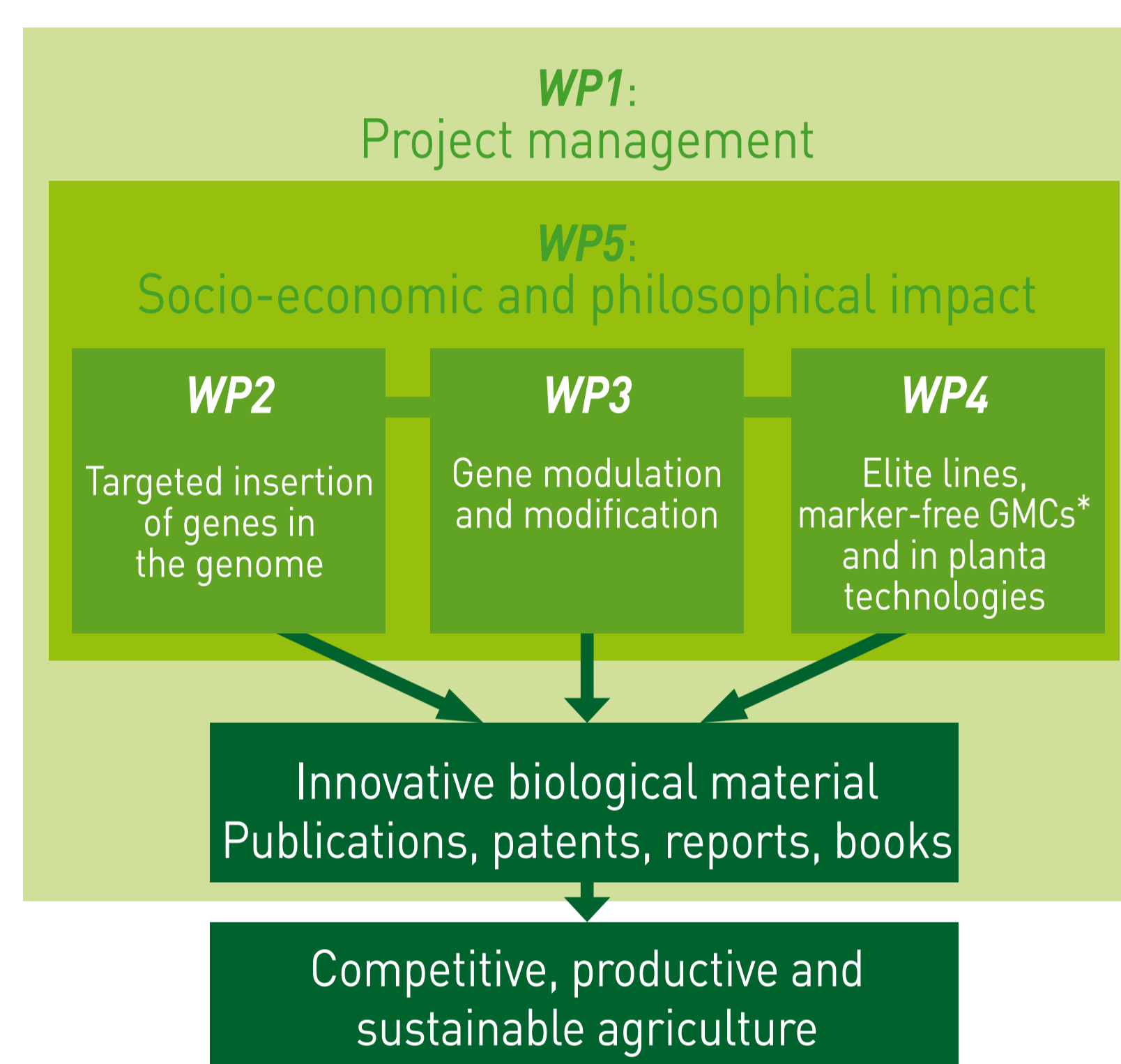
particular the advent of nuclease technology opens the way to extremely precise modifications of plant genomes at pre-determined sites. In this context it is strategic to reinforce top-level know-how in transgenesis in France, to actively participate in the debate of these new breeding technologies and to demonstrate their applicability in a wide range of crop species.

The Project

Objectives

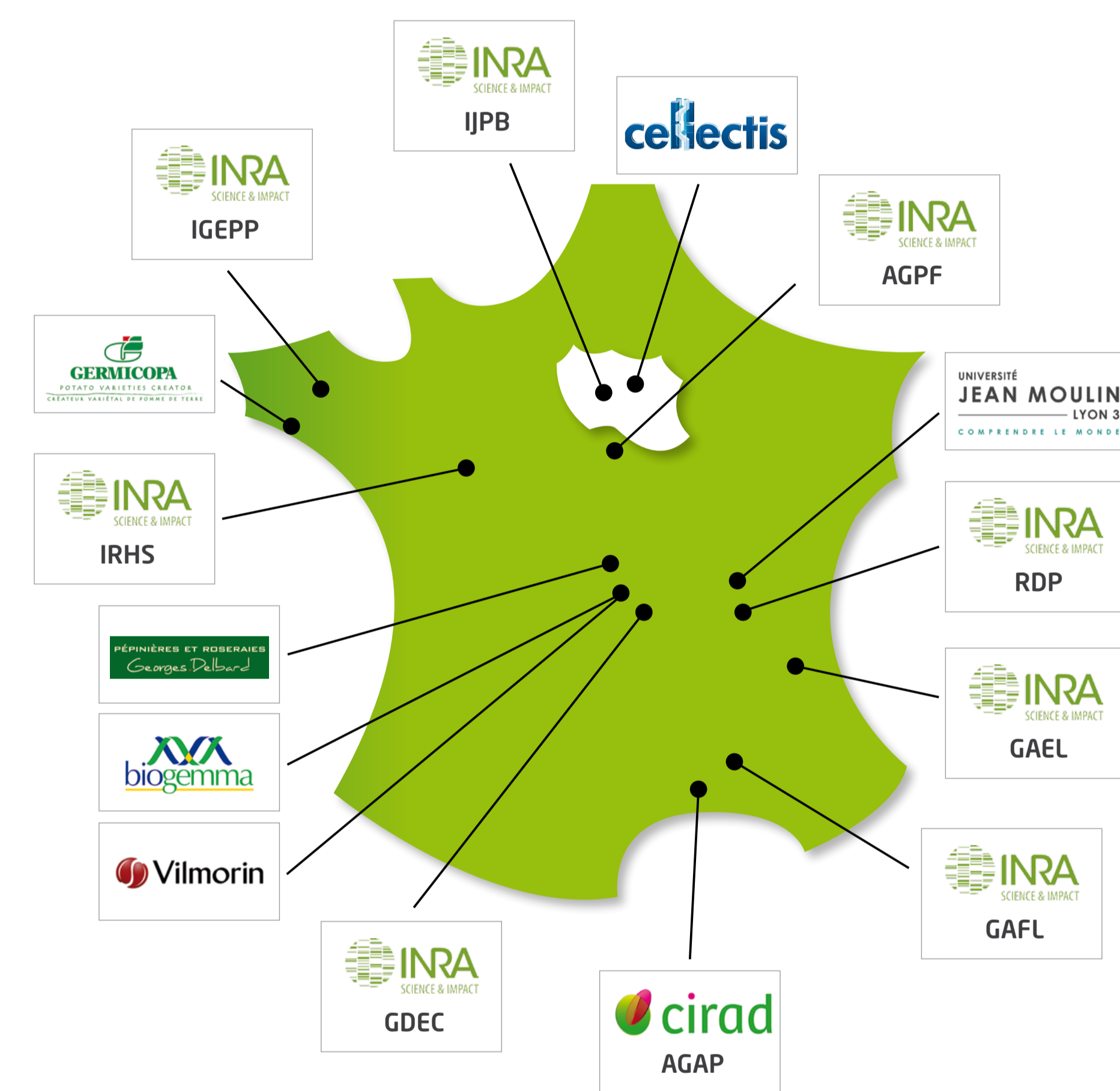
- Implement novel transformation technologies for nine crops (wheat, maize, rice, oilseed rape, tomato, potato, poplar, apple, rose) and the model species *Brachypodium*.
- Improve the efficiency and throughput of existing transformation methods.
- Provide proof of concept by the introduction or modification of genes of agronomic interest (resistance and yield traits) via novel or improved transformation methods.
- Allow French researchers to acquire and maintain high level technical know-how and expertise in the field of genome engineering.
- Assess the economic, ethical and legal impact of novel breeding techniques.

Workflow



The Partners

GENIUS has assembled a consortium of 15 public and private partners. Its ambition is to create synergy between species-oriented labs and to give rise to a technology-oriented community.



The Work Packages

• Work Package 1: Project management

Objectives: monitor progress and adapt GENIUS to scientific evolutions in the field.

Assure an efficient valorisation/exploitation and diffusion of the results and manage adjustments of the project in a transparent and efficient way.

• Work Package 2: Targeted insertion of genes in the genome (meganucleases/TALENs)

Objectives: implement efficient methods for the targeted insertion of genes into plant genomes using site-specific nucleases (meganucleases or TALENs).

Central to the work is the creation of transgene 'landing pads', sites in which transgenes can be routinely inserted for stable, reliable expression and predictable recombination rates. Landing pads will be established in the crop species wheat, maize, rice, tomato, potato, oilseed rape, the crop species poplar and the model species *Brachypodium distachyon*. The use of 'landing pads' to control gene flow from oilseed rape to wild turnip and wild radish will also be evaluated.

• Work Package 3: Gene modulation and modification (amiRNA, TALENs)

Objectives: set up efficient methods for the targeted regulation or modification of plant genes ; use these techniques for the generation of new traits in important crops.

The first part of this work package will consist in the set up of efficient artificial microRNA (amiRNA) systems for gene disruption in maize, wheat, oilseed rape, apple and rose. The second part of this work package will implement the use of nucleases for gene disruption in maize, rice and potato, and gene replacement in rice and tomato. The traits targeted in case studies are yield, architecture and resistance to biotic and abiotic stress.

• Work Package 4: Elite lines, marker-free genetically modified crops and in planta technology

Objectives: adapt transformation techniques to recalcitrant elite genotypes, implement marker-free technology and develop innovative in planta transformation methods.

The first activity concerns the development of efficient methods for the regeneration of commercial genotypes of crop (maize) and horticultural species (apple and rose). The second activity aims to develop efficient transformation protocols for elite lines of these three species and to establish marker-free technology on apple. The third activity will demonstrate the usefulness of gene disruption nuclease technology for the creation of a trait of interest in potato. The fourth activity is centred on innovative in planta transformation methods to produce transgenic plants easily, rapidly and at low cost. Based on reports on flower or seed transformation in model species, technology transfer to maize, rice and poplar will be undertaken.

• Work Package 5: Socio-economic and philosophical impacts

Objectives: anchor GENIUS in the French socio-economic context.

A first action is the widest possible dissemination of the objectives and results of the project to the scientific community, specialised organisations and the general public. On the economic front, the project itself will be an object of research for the analysis of public sector technology transfer mechanisms to private companies. Risk assessment and sustainability are at the heart of the philosophical questioning. Finally, the status of the regulatory framework will be monitored and updated on a regular basis.

Key numbers

Duration: September 1st, 2012 to December 31st, 2019 (7 years and 4 months)

Funding: 6 M€ by the Investment for the Future ANR program "Biotechnology and Bioresources" for a total cost of 21.3 M€.

Partnership: 89 permanent scientists in 19 research labs belonging to 8 institutions/companies.

www.genius-project.fr

This project is endorsed by

