LICENSE AGREEMENT OPPORTUNITY ON TWO PATENTS

APOMEIOSIS + PARTHENOGENESIS = APOMIXIS

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PATENTS

- **INRAE's Patent** : "Plants producing 2n gametes or apomeiotic gametes" – WO2010/079432
- **University of Georgia's Patent** "Artificial Induction of Parthenogenesis, a Component of Apomixis"

INVENTORS

- Drs. Peggy Ozias-Akins (https://hort.caes.uga.edu/people/faculty/peggy-ozias-akins.html) and Joann Conner (University of Georgia)
- Dr Raphaël Mercier (INRAE / working at the Max Planck Institute)

INTRODUCTION AND APPLICATIONS

A challenge for plant breeders is to quickly develop genetically pure lines of seeded (sexually reproduced) crops. Progeny of sexually reproduced crops, due to the nature of genetics, display variation. Apomixis is a naturally occurring asexual developmental process in minor crop species only, which generates progeny genetically identical to the mother plant. Mechanistically, apomixis is composed of two phenomena, the production of clonal gamete (apomeiosis) and embryogenesis without fertilization (parthenogenesis).

INRAE's researchers have discovered that by combining the inactivation of three genes, a genotype (MiMe) in which meiosis is replaced by mitosis without affecting subsequent sexual processes is generated. The resulting **apomeiotic gametes** are of interest for the production of apomictic plants.

Parthenogenesis, a component of apomixis, results from the spontaneous fertilization-independent development of the unreduced egg cell into an embryo (resulting in genetic clones of the maternal parent). **University of Georgia** researchers discovered a technique to artificially induce parthenogenesis via construction of transgenic plants expressing a single gene. Expression of this gene is a critical advancement for asexual seed formation in seeded crops (**apomixis**.)

ADVANTAGES OF APOMIXIS

These techniques, apomeiosis and parthenogenesis, are combined to develop apomictic plants, producing clonal seeds.

- Makes clonal populations possible for seeded crops expressing desirable polygenic traits;
- Makes breeding program more time and resource efficient;
- Quickly fixes desirable traits in F1 hybrids;

TECHNOLOGIES DESCRIPTION

1) **Apomeiosis**: Inactivation of OSD1, SPO11-1/PAIR1 and REC8 genes results in a genotype in which meiosis is totally replaced by mitosis without affecting subsequent sexual processes. This generates 2n gametes retaining all the parent's genetic information.

2) **Parthenogenesis** allows for the generation of an embryo retaining all the traits of the parent line and clonal propagation. This is of great interest for plant breeders whose goal is embryogenesis. This technology achieves this goal through transformation with the ASGR-BBML gene through genetic engineering.

The combination of these two techniques results in apomixis. An F1 hybrid can then be propagated through seeds, maintaining the hybrid vigor along generations, thereby providing a cost savings to plant breeding companies and the end consumer.

Combining apomeiosis (MiMe) and BBM1 was shown to induce apomixis at high frequency (Vernet et al, Nat com, 2022).

DEVELOPEMENT STAGE

INRAE's patent: *Proof Of Concept* demonstrated in rice. N.B the claims of the pending applications cover other species including corn concerning US 2021-0163972
University of Georgia: *Proof Of Concept* demonstrated in rice, maize, and sorghum.

INTELLECTUAL PROPERTY

INRAE:
Issued patents: US #10,883,112; CN201080007059.3
Pending applications: US 2021-0163972; EP 10702906.8 (published as EP2379726) ; Brazil PI 1006827-9
University of Georgia:
Issued patents: US #10,633,672, EP #3060651 - Hungary, Germany, France, Netherlands, Spain, Switzerland
Canada #2,927,848
Pending applications in Brazil, China, and 2 in US (continuation and continuation in part)

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REPRESENTATIVE PUBLICATIONS

- D' Erfurth, I., Jolivet, S., Froger, N., Catrice, O., Novatchkova, M., & Mercier, R. (2009). *Turning meiosis into mitosis*. PLoS biology, 7(6), e1000124. doi:10.1371/journal.pbio.1000124
- Conner, J.A., M. Muruganantham, H. Huo, K. Chae, and P. Ozias-Akins. 2015. *A parthenogenesis gene of apomict origin elicits embryo formation from unfertilized eggs in a sexual plant*. Proc. Natl. Acad. Sci. USA 112:11205-11210; https://doi.org/10.1073/pnas.1505856112.
- I. Khanday, D. Skinner, B. Yang, R. Mercier and V. Sundaresan. 2019. *A male-expressed rice embryogenic trigger redirected for asexual propagation through seeds.* Nature. https://www.nature.com/articles/s41586-018-0785-8
- A. Vernet, D. Meynard, Q. Lian, D. Mieulet, O. Gibert, M. Bissah, R. Rivallan, D. Autran, O. Leblanc, A.C Meunier, J. Frouin, J. Taillebois, K. Shankle, I. Khanday, R. Mercier, V. Sundaresan and E. Guiderdoni. 2022. *High-frequency synthetic apomixis in hybrid rice*. Nat com. https://www.nature.com/articles/s41467-022-35679-3
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