

# Scientific Press release

2019, September 30<sup>th</sup>

## **Highly complex genome of the devastating soybean disease *Phakopsora pachyrhizi* unraveled by a unique consortium of private and public partners.**

Asian soybean rust caused by the obligate biotrophic fungus *Phakopsora pachyrhizi* is a critical challenge for soybean growers, especially in Latin America where 192 million metric tons are produced (USDA, 2019), representing a gross production value of U.S. \$ 61.4 billion per year (CONAB, 2019).

This devastating disease can lead to yield losses of up to 90% if not controlled. Management costs for farmers exceed U.S. \$2 billion per season in Brazil alone. The pathogen is highly adaptive, but the number of practical solutions for controlling the disease is limited. To accelerate innovation, develop new traits and discover novel modes of action against *P. pachyrhizi*, a high quality genome was required. This was not achieved so far because of the exceptional size and complexity of this pathogen's genome which was estimated to be around 1 Gbp.

To tackle this crucial challenge, a unique international consortium representing 12 public and private entities was established. This joint effort comprises the 2Blades foundation, Bayer, the Brazilian Company of Agricultural Research (Embrapa), the German University of Hohenheim, l'Institut National de la Recherche Agronomique (INRA) and Université de Lorraine, the U.S. Department of Energy (DOE) Joint Genome Institute (JGI, USA), KeyGene, the German University of RWTH Aachen, The Sainsbury Laboratory, Syngenta and the Federal University of Viçosa (Brazil).

This consortium today announces the completion of the sequencing and assembly of not just the genome of one, but three *P. pachyrhizi* isolates. A panel of high-end, next-generation sequencing technologies were used providing either small (Illumina) or long reads (PacBio). For one isolate, the consortium benefited from the JGI's expertise through their Community Science Program. For another isolate, KeyGene made their latest long-read sequencing platform, Promethion from Oxford Nanopore, available *pro bono* supporting the improved assembly of one of the genomes. This resulted in a 10-fold reduction of scaffolds for this isolate and a chromosome level assembly. For a third isolate, remarkable bioinformatics inputs were supported by Syngenta. All these new technologies have been key to the success of the initiative to tackle the complex nature of the genome. Additionally, the JGI is providing the platform to host and make publicly available these genomic resources to the scientific community. All available data can be found at <https://mycocosm.jgi.doe.gov/Phapa1>.

The assembled *P. pachyrhizi* genome encompasses 1.057 Gb, representing one of the biggest genomes amongst fungi and indeed plant pathogens in general. The sequencing revealed that the genome is extremely rich in sequence repeats and non-coding DNA, roughly making up about 90% of all sequences. The genome also harbors several families of transposons, elements that may enable the pathogen to rapidly adapt to new environments. Despite the large genome

size of *P. pachyrhizi*, the number of genes in its genome is about 20,700 which is similar to the number found in other rust fungi.

To better understand which parts of the genome are active at various stages of the pathogens' life cycle, the consortium has also generated a transcriptome atlas of all fungal structures and infection stages of the pathogen. This knowledge will contribute to improve annotation and extend the knowledge of the molecular mechanisms exploited by *P. pachyrhizi* during soybean infection.

With the complete sequencing of the *P. pachyrhizi* genome, substantiated by the analysis of gene expression and resequencing of isolates, the consortium hopes to leverage this information with the scientific community to decipher the biology of the fungus and understand, on the molecular level, its complex interaction with its host.

*"The completion of the sequencing and genome assembly in an open innovation way is a great news for the whole scientific community. It will broaden the understanding of P. pachyrhizi's adaptability, evolution, and genetic diversity thus paving the way to knowledge-based strategies for Asian soybean rust control"*, said the EMBRAPA Soybean researcher Francismar C. Marcelino-Guimarães.

### ***Details about the international consortium partners***

#### **About the DOE Joint Genome Institute**

The U.S. Department of Energy Joint Genome Institute (JGI), a DOE Office of Science User Facility at Lawrence Berkeley National Laboratory, is committed to advancing genomics in support of DOE missions related to clean energy generation and environmental characterization and cleanup. JGI, headquartered in Walnut Creek, Calif., provides integrated high-throughput sequencing and computational analysis that enable systems-based scientific approaches to these challenges. Follow @jgi on Twitter.

DOE's Office of Science is the largest supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time. For more information, please visit [science.energy.gov](http://science.energy.gov).

#### **About INRA**

INRA is the largest agricultural research institute in Europe, with around 10 000 employees in 2018, and is the second largest producer of agricultural science publications worldwide. INRA develops knowledge and innovation in the fields of food, agriculture and the environment, through a research network unique in Europe - 184 research units and 42 experimental units located throughout France. INRA's main goal is to contribute to the development of competitive and sustainable agricultural and forestry systems producing healthy and high-quality food as well as biomass for the bioeconomy, while actively participating to the global efforts to protect the environment and natural resources.

#### **About Bayer**

Bayer is a global enterprise with core competencies in the life science fields of health care and nutrition. Its products and services are designed to benefit people by supporting efforts to overcome the major challenges presented by a growing

and aging global population. At the same time, the Group aims to increase its earning power and create value through innovation and growth. Bayer is committed to the principles of sustainable development, and the Bayer brand stands for trust, reliability and quality throughout the world. In fiscal 2018, the Group employed around 117,000 people and had sales of 39.6 billion euros. Capital expenditures amounted to 2.6 billion euros, R&D expenses to 5.2 billion euros. For more information, go to [www.bayer.com](http://www.bayer.com).

### **About Embrapa**

The Brazilian Agricultural Research Corporation (Embrapa) was created on April 26, 1973 and is linked to the Ministry of Agriculture, Livestock and Supply (Map). Since its inception, it has taken on a challenge: to develop, together with our partners in the National Agricultural Research System (SNPA), a model of genuinely Brazilian tropical agriculture and livestock, overcoming barriers that limit food, fiber and energy production in the country.

This effort helped transform Brazil. Today Brazilian agriculture is one of the most efficient and sustainable in the world. We incorporated a large area of degraded land from the cerrado to the productive systems. A region that today accounts for almost 50% of our grain production. We quadrupled the supply of beef and pork and expanded the supply of chicken by 22 times. These are some of the achievements that have made the country from being a staple food importer to being one of the world's largest producers and exporters. Embrapa's mission is to enable research, development and innovation solutions for the sustainability of agriculture, for the benefit of Brazilian society.

<https://www.embrapa.br/en/international>

### **About the 2Blades Foundation**

The 2Blades Foundation, based in Evanston, Illinois, is a 501(c)(3) charitable organization dedicated to the discovery, advancement, and delivery of durable disease resistance in crops. 2Blades establishes and manages development programs addressing significant unsolved crop disease problems in collaboration with leading research institutions around the world and at the 2Blades Group in The Sainsbury Laboratory, Norwich, UK. 2Blades manages a portfolio of specific traits and enabling technologies that it implements in its own programs and out-licenses for broad use. Visit the 2Blades website at [www.2blades.org](http://www.2blades.org) and follow 2Blades on twitter at @2blades.

### **About The Sainsbury Laboratory**

The Sainsbury Laboratory (TSL) is a world-leading research centre focusing on making fundamental discoveries about plants and how they interact with microbes. TSL not only provides fundamental biological insights into plant-pathogen interactions, but is also delivering novel, genomics-based, solutions which will significantly reduce losses from major diseases of food crops, especially in developing countries. TSL is an independent charitable company and receives strategic funding from the Gatsby Charitable Foundation with the balance coming from competitive grants and contracts from a range of public and private bodies, including the European Union (EU), Biotechnology and Biological

Sciences Research Council (BBSRC) and commercial and charitable organisations [www.tsl.ac.uk](http://www.tsl.ac.uk).

### **About The Federal University of Viçosa**

The Federal University of Viçosa (UFV; Portuguese: Universidade Federal de Viçosa) is a Federal University with the main campus located in the city of Viçosa, state of Minas Gerais, Brazil. UFV offers 47 different undergrad courses in many areas, including engineering, agronomy, medicine, veterinary medicine, animal husbandry, and other areas related to science. The university has a highly reputed Graduate School as well, offering 36 Master's degree programs and 24 for at PhD level. It is considered one of the best universities in Brazil, and in the General Index of Institution Courses (IGC) made by the Ministry of Education in 2009 was elected the 2nd best in Brazil and the 1st in the state of Minas Gerais

### **About Syngenta**

Syngenta is one of the world's leading agriculture companies. Our ambition is to help safely feed the world while taking care of the planet. We aim to improve the sustainability, quality and safety of agriculture with world class science and innovative crop solutions. Our technologies enable millions of farmers around the world to make better use of limited agricultural resources. With 28,000 people in more than 90 countries we are working to transform how crops are grown. Through partnerships, collaboration and The Good Growth Plan we are committed to improving farm productivity, rescuing land from degradation, enhancing biodiversity and revitalizing rural communities. To learn more visit [www.syngenta.com](http://www.syngenta.com) and [www.goodgrowthplan.com](http://www.goodgrowthplan.com). Follow us on Twitter at [www.twitter.com/Syngenta](https://www.twitter.com/Syngenta) and [www.twitter.com/SyngentaUS](https://www.twitter.com/SyngentaUS).

### **About the University of Hohenheim**

The University of Hohenheim (UHOH) was founded as a school for agronomy in 1818 as a reaction to the devastating losses in agricultural production in Germany that came as a consequence of the eruption of the volcano Tambora in Indonesia in 1815. UHOH has developed considerably and today hosts almost 10,000 students, 145 professors and around 2,000 staff. UHOH is progressive in research, maintains a broad network, provides global perspectives, and is highly innovative. The width of study programs, the vicinity of the Faculty of Agricultural Sciences to the Faculty of Natural Sciences and the Faculty of Business, Economics and Social Sciences as well as the interdisciplinary research centres and multiple research foci are unique. UHOH ranks first in Agricultural Sciences in Germany, eighth in Europe, and 15<sup>th</sup> in the world. UHOH covers all different aspects of agriculture with a special focus on Microbiota-Livestock Interaction, Climate Change, Bioeconomy and Organic Farming.

### **About KeyGene**

The crop innovation company KeyGene is the go-to AgBiotech company for higher crop yield & quality. With our intellectual capital, solution driven approach and collaborative spirit, we work for the future of global agriculture with partners in the AgriFood sector. Using our proprietary technologies and non-GM approaches, we support customers with the development of new and improved

crops. Our goal is to help organizations with their toughest R&D challenges, combining our cutting edge breeding technologies, bioinformatics & data science expertise and plant-based trait platforms. At KeyGene, we work in an international environment with more than 140 professionals from all over the world. Our company is based in Wageningen, Netherlands and Rockville, MD, USA. [www.keygene.com](http://www.keygene.com)

### **About the RWTH Aachen University**

The Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen was founded in 1870. Today, almost 40,000 students are enrolled at RWTH. The university has nine faculties with 260 departments that are managed by 564 professors, 5,700 scientists, and 3,000 other staff. RWTH established a unique educational and networking research environment that embraces the convergence of knowledge, approaches, and insights from the humanities, economics, engineering, natural, and life sciences. Research foci include sustainable synthetic fuels, biotechnology, data mining, computational science, production technology, high-performance materials, health, renewable resources, and mobility. The so-called RWTH Aachen Campus provides a unique research environment for academic and industrial collaborations. RWTH Aachen Campus is highly visible and highlights the research power of the University. The entrepreneurial mindset and collaboration with industry benefit students, employees, and the society. For many years, RWTH Aachen has been continuously awarded excellence status by the German federal and state governments. Aachen is Germany's westernmost city at the borders to Belgium and the Netherlands. The three countries, their various languages and cultures place Aachen in the center of a dynamic, international cross-border region. More than 9,500 international RWTH students from over 135 countries provide a highly international flair.

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