Science & Technology Briefs

Perennial Grains: The Next Food Frontier?

The bulk of the world's farmlands is devoted to growing grains—corn, wheat, barley, rice, millet—providing over 70% of global caloric consumption. But once harvested, they must be replanted every year, so they are called "annuals." Yet there are some plants, including many flowers, fruits and nut crops, some herbs and vegetables, and some grains that grow back year after year on their own ("perennials"). The development of perennial grains, legumes, and oilseed varieties would constitute a tremendous advance in our ability to feed a hungry world.

Because they do not have to be reseeded or replanted every year, perennials significantly reduce the need for plowing and herbicide applications. Perennials are better at protecting soil from erosion, have greater nutrient retention, and require less water than annuals.

One method of breeding a new perennial species is to cross an existing annual grain with a wild perennial cousin which has one or more desirable attributes, such as high and consistent seed yield, synchronous flowering and seed maturation, or seed retention (also called non-shattering). When successful, these "wide hybrid crosses" produce plants that maintain seed yield and quality similar to the annual parent, while inheriting the perennial lifestyle from the other parent. Individual plants are then cross-pollinated, and the resulting seeds are planted to produce the next improved breeding population, a process called domestication.

Another method is to produce new varieties. For example, Kernza, a distant cousin of annual wheat, is a domesticated perennial grain. Originating from a forage grass called intermediate wheatgrass, it is now available to consumers. A perennial rice, developed at China's Yunnan University, was released to farmers for commercial production in 2018. Perennial sorghum is now undergoing field trials. Perennial wheat is being developed by the Land Institute in Salina, Kansas by crossing durum wheat with wheatgrass. Silphium integrifolium, a perennial in the sunflower family native to America's Great Plains, is being domesticated as an oilseed crop that could replace annual oilseed crops such as sunflower and soy.

The Land Institute, an American nonprofit research, education, and policy organization, is collaborating with the Missouri Botanical Garden (one of the world's largest research botanical gardens), and Saint Louis University to identify other perennial candidates for domestication and use in perennial polycultures.

China Authorizes Thorium Reactor, then Thorium-Powered Container Ship

On June 16, 2023 the Shanghai Institute of Applied Physics obtained a 10-year operating license to build and operate a 2 megawatt thorium-powered molten salt reactor near the Gobi Desert. The molten salt serves as both the solvent for the fuel and the primary coolant, eliminating the need to fabricate solid fuel elements. The fuel is a mixture of fluorides of fissile uranium and non-fissile thorium, but only the thorium is consumed. Thorium is over 400 times more plentiful than fissile uranium-235.

Six months later, on Dec. 13, a China shipyard showcased, at the Marintec China 2023 show in Shanghai, a design for a large nuclear-powered container ship, capable of carrying 24,000 20-foot containers (TEUs). Dubbed the KUN-24AP, the ship was designed by the Jiangnan Shipbuilding Group Co., Ltd., a subsidiary of China State Shipbuilding Corp.

The ship is to employ a fourth-generation thorium-based molten salt reactor. Like the reactor near the Gobi desert, this is a breeder reactor that conserves neutrons from the fission of uranium, using them to convert enough thorium to fissile uranium-233 to maintain the fissile content, thus consuming only thorium. The reactor's primary loop uses fluorinated salt as a medium, which, after cooling through a secondary loop of fluorinated salt, transfers heat to a tertiary loop using pure water or carbon dioxide as a medium. The heat is then directed to a turbine to generate electricity, which powers twin electric motors that drive dual shafts to two propellers, delivering high power, high speed, and maneuverability.

This system is projected to drive the ship to a speed in excess of 26 knots, compared to the current norm of diesel single-propeller systems with a top speed of 16 knots. The thorium reactor completely eliminates the need for refueling during the ship's projected 25-year lifespan.

China-Arms of Dec. 12, 2023 emphasized the advantages of a thorium-based molten salt reactor over traditional pressurized water reactors, primarily using enriched uranium: no core meltdown risk, and relatively safe reactor byproducts.

The primary drawback is in the use of fluorinated salt as the loop medium.

This medium is highly corrosive to pressure vessels and loop pipelines, resulting in a relatively short maintenance interval (every 10-15 years) for the reactor. As a shipborne reactor, the challenges include solving fluorine corrosion issues within the reactor and loop pipelines, and addressing salt spray corrosion during maritime operations.

The ship design has already obtained an Approval in Principle Certification from Det Norske Veritas (DNV), a Norwegian company that provides services related to quality management, risk assessment, and sustainability.

Chinese Semiconductor Company Indicates Breakthrough

ChangXin Memory Technologies (CXMT), a China-based semiconductor company, announced Dec. 13 at IEEE's International Electron Devices Meeting that it may be nearing parity with the top Western chip manufacturers.

In a technical paper presented at the conference, representatives of CXMT indicated that it has solved the technical problem to begin producing 3-nanometer grade chips.

While the news is not of an actual product, nor has the company demonstrated its capacity physically yet, it is being viewed as a technological breakthrough. If CXMT is able to produce 3 nm chips in the near future, it will have nearly caught up with the most advanced semiconductor producers in the world.

Survival of Lichens and Ancient, Single-Cell Organisms in Space

A new study shows that most specimens of a hardy lichen (a symbiotic partnership of fungi and algae), exposed to space conditions on the International Space Station (ISS) for 1.5 years, remained viable after being returned to Earth. The lichen *Xanthoria elegans* was part of the Lichen and Fungi Experiment (LIFE).

As reported in *Futurism*, lichen from Antarctica's McMurdo Dry Valleys survived 18 months on a platform attached to the exterior of the ISS. Though they emerged in worse shape than lichens grown in temperate climes, many still survived. This is strong evidence that the lichen is tougher than anything else alive, by many orders of magnitude. For all other carbon-based life forms—the only form of life that we currently know to exist—outer space is unsurvivable, due to its extreme temperatures, high radiation levels, and plethora of fast-moving objects.

Meanwhile, as reported on *Space.com*, Chinese researchers sent anaerobic archaea microbes to the *Tiangong* Space Station on Jan. 17. These archaea are among the oldest life forms on Earth and a major contributor to methane in our atmosphere. They consume hydrogen and carbon dioxide, and give off methane. Taking them into space and exposing them to cosmic radiation and the microgravity environment will reveal whether they can survive in that environment.

According to Liu Zhu, professor in the Department of Earth System Science, Tsinghua University:

"If [methanogens] can survive in this environment, and can, for example, produce methane and grow well, then it can be demonstrated that the original life on Earth can actually exist in an extraterrestrial environment…. If the methane found on Mars has life as its source, then this life may be homologous to life on Earth."

Huge Celestial Structures Challenge Our Theories About the Cosmos

It is one of the fundamental principles of cosmology: At a large enough scale, things "even out"—the universe appears to be uniform, no matter where you look. In other words, the universe is isotropic.

Two years ago, however, researchers discovered a colossal arc of galaxies spanning 3.3 billion light years, situated 9.2 billion light years away. Now the same team has discovered another structure, a ring of galaxies 1.3 billion light years in diameter, also 9.2 billion light years distant. Named the "Giant Arc" and the "Big Ring," the two structures are 12 degrees apart on the sky.

The discoverer of both, Alexia Lopez, a graduate researcher at the University of Central Lancashire's Jeremiah Horrocks Institute, presented her findings at the 243rd meeting of the American Astronomical Society.

As reported by IFL Science, Lopez explained that these discoveries are challenging everything that we've presumed about how the universe operates:

"We could expect maybe one exceedingly large structure in all our observable universe. Yet, the Big Ring and the Giant Arc are *two* huge structures and are even cosmological neighbors, which is extraordinarily fascinating…. Neither of these two ultra-large structures is easy to explain in our current understanding of the universe. Their ultra-large sizes, distinctive shapes, and cosmological proximity must surely be telling us something important—but what exactly?

"Cosmologists calculate the current theoretical size limit of structures to be 1.2 billion light-years, yet both of these structures are much larger—the Giant Arc is almost 3 times bigger and the Big Ring's circumference is comparable to the Giant Arc's length…. From current cosmological theories, we didn't think structures on this scale were possible."

Lopez, with her adviser Dr. Roger Clowes and collaborator Gerard Williger from the University of Louisville, discovered the new structures by looking at absorption lines in the spectra of quasars from the Sloan Digital Sky Survey (SDSS).