ACROSS THE DIVIDE

AGRICULTURAL BIODIVERSITY AND GLOBAL FOOD SECURITY

by: MAURICIO ANTONIO LOPES, PH.D.

The Russian botanist, geneticist, and geographer, Nikolai Vavilov (1887–1943), is unfortunately little known. In 1919, he began expeditions to dozens of countries on five continents to systematically collect the varieties of all the plant species that he could. Vavilov was obsessed with biodiversity and dreamed of solving the problem of hunger. After years of conflict with the Stalinist regime, he died in a labor prison camp in Siberia. Sadly, a man who spent his life promoting nutrition and food ultimately died from the lack of it. Redeemed by history, Vavilov is acclaimed as a Noah of plants, the pioneer of the creation of gene banks for the preservation and improvement of cultivated crop species.

Today, there are thousands of Vavilovs around the world, collecting seeds and trying to study, catalog, and protect them to ensure ample access to plant diversity for crop variety development. Many scientists from institutions in different countries are the keepers of this genetic heritage, recognized as the main foundation of agriculture. A standing symbol of the attention and the care of humanity with these vital resources lies in the Arctic Circle, 1,200 km away from the North Pole, in a remote archipelago of Svalbard, which belongs to Norway. There, inside a permanently frozen mountain, the Global Seed Vault was built on a rock, a giant safe that holds a treasure for humanity.

Three underground concrete chambers, kept at 20 degrees below zero Celsius, were built at the end of a tunnel 150 m long and 180 m below the top of the mountain. This safe, dug into solid rock, guards airtight boxes with about 820,000 samples, originating from almost every country in the world. The collection has unique varieties of major African and Asian food staples such as rice, wheat, cowpea, and sorghum, as well as European and American varieties of maize, eggplant, lettuce, barley, and potato. The entire complex was built to last hundreds and even thousands of years and resist what is possible to imagine: earthquakes, nuclear accidents, and global warming. The capacity is 4.5 million seed samples, which can ensure the recovery of food species hundreds of years in the future, in case of any catastrophic loss.

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The Vault is managed by the Global Crop Diversity Trust, an independent international organization working to guarantee the conservation of crop diversity, in connection with the International Treaty on Plant Genetic Resources for Food and Agriculture, of the United Nations Organization for Food and Agriculture (FAO). The remote storage facility in Svalbard has the mission to safeguard as much of the world's unique crop genetic material as possible, while also avoiding unnecessary duplication. It already holds the most diverse collection of food crop seeds in the world. And more than 100 institutes worldwide are currently regenerating unique accessions and safety duplicates to be deposited in the frozen mountain in the future.

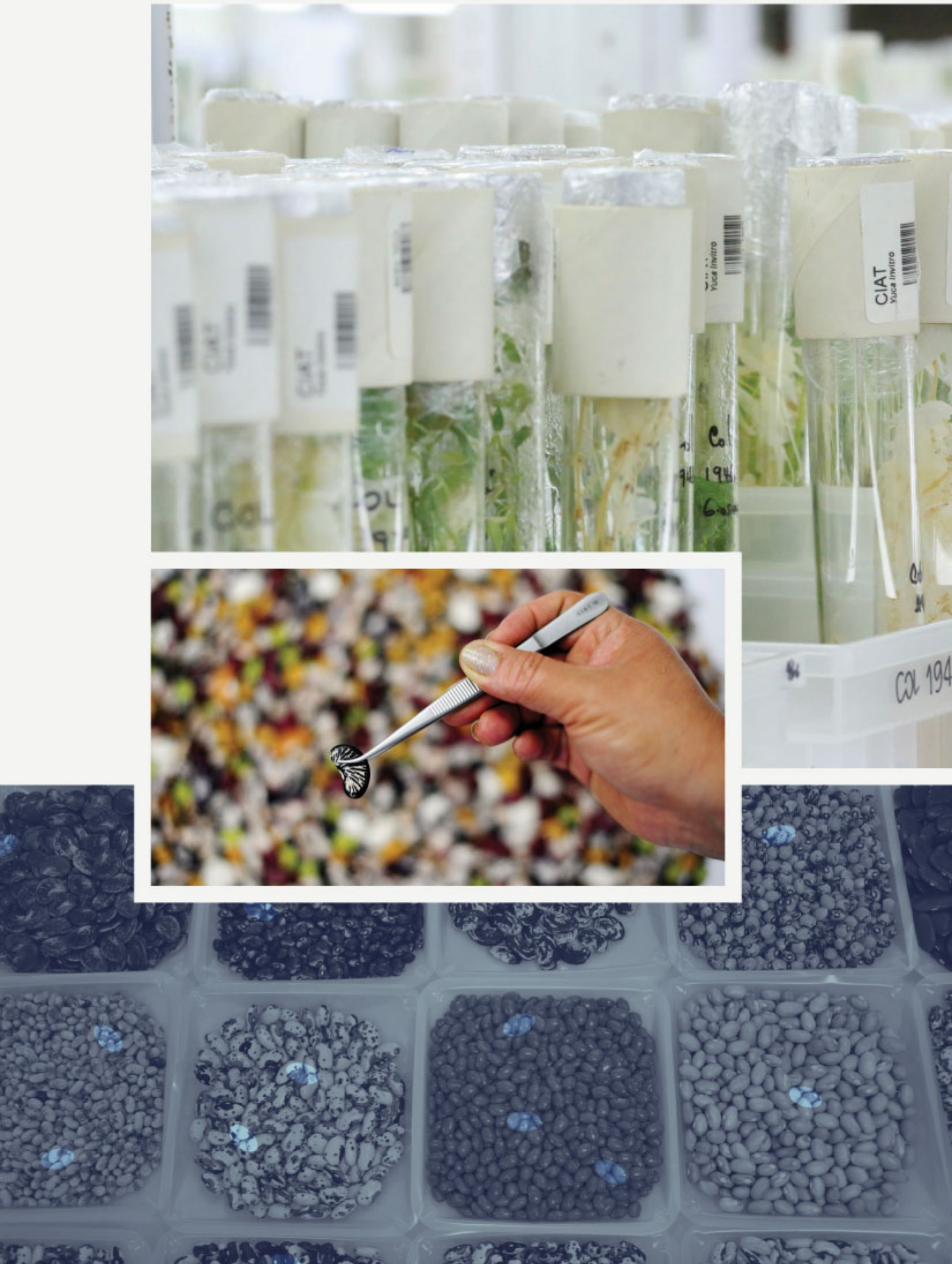
To send a backup to Svalbard symbolizes our care and attention to food security in the future. In fact, the Svalbard Global Seed Bank is a legacy of our generation. It is an insurance policy against the constant threat of loss of genetic variability, one of the greatest dangers to haunt humanity. The seeds stored in germ plasm banks contain reserves of genetic variability that can help us face multiple threats to food and nutrition security in the future. They may, for example, enable responses to the impacts of global warming and stress intensification, expected in the coming decades, as well as yet unknown demands of a society increasingly concerned with sustainability.

PREPARING FOR A CHALLENGING FUTURE

The Svalbard Global Seed Bank helps draw attention and raise awareness to the need to preserve resources essential to the future of humanity. The innovative strategy of calling attention to agricultural biodiversity by storing these essential resources in a safe place is a symbol of the human ability to unite vision and efforts, beyond political, religious, or cultural differences, around a project of survival and sustainability. It is a relief to know that our generation has an insurance policy for future harvests. But, as we hope never to resort to our life insurance policy, we also hope never to face challenges that force us to use the seeds sent to Svalbard.

The Global Seed Bank in Svalbard is a necessary extreme measure to ensure the safety of agricultural biodiversity for food security in the future. However, it should not exempt us from devising other creative strategies to mobilize genetic diversity to help humanity face increasingly challenging times in the years to come. Population will grow from the current 7.2 billion to an estimated 9.0 billion before stabilization around 2050. It means that agriculture will be increasingly pressed to produce more output with less input, and to do so considering all dimensions of sustainability – economic, social, environmental, and political.

Demands for an increase in food production must, therefore, be balanced in relation to pressures on the conservation of natural resources and reduction of deforestation, to minimize the effects of greenhouse gases. Thus, common sense indicates that increases in agricultural production should be pursued primarily by increasing efficiency. Agriculture will require research and innovative systems capable of producing advances in food productivity, safety, and quality, with speed and efficiency higher than those achieved in the past. Many dimensions of agricultural research will have to receive more attention and support, if we are to face the challenges ahead. More attention to research in genetic resources and crop breeding is paramount to expand the variability base, and to mobilize new biological functions capable of helping agriculture fulfill its part in the pursuit of a sustainable future.


CIAT
Yuca invitro

(From top left, clockwise)

Potato crops in test tubes.

The first Austrailian deposit to the Svalbard Global Seed Vault.

Yam in vitro.

Bean diversity at the Svalbard Global Seed Vault.

Beans at the CIAT gene bank in Colombia were shipped for conservation at the Svalbard Global Seed Vault.

Here are some challenges the agricultural research community will have to face to ensure that agricultural biodiversity will be efficiently mobilized to help the world achieve and maintain food security in the future.

STRENGTHENING CROP-BREEDING CAPACITY

The production of new, more adapted and productive crop varieties, a result of genetic improvement, is one of the main contributions of agricultural research to humanity. Plant breeders have been able to adapt plants to a wide range of agricultural areas around the world, to cropland with marked differences in soil and climate, intense biotic and abiotic stresses, and diversified technology usage patterns. Thus, the capacity to develop genetic innovations in the form of improved crop cultivars will continue to be fundamental to all countries, especially in the face of increasing challenges posed by climate change and stress intensification. Strengthening crop-breeding capacity through efficient research in plant genetics and biotechnology will ensure that agriculture maintains the ability to respond to problems that may jeopardize food and nutritional security in the future.

SUSTAINABLE USE OF WATER

Despite being the sector that already consumes the most water, irrigated agriculture will continue to increase in the future, due to climate change, which leads to more extreme weather events – especially droughts. Also, the need to increase agricultural productivity to meet the demands of a growing population will increase concerns and conflicts related to competitive uses of water. Therefore, a major challenge for the future will be the optimization of water use by agriculture in order to reduce the pressure on this finite resource and to release water for other purposes. Innovations to rationalize the use of water and to avoid or reduce its waste will be critical to meet the growing demand for food, with minimal environmental impacts. Access to genetic variability and to biotechnological tools and processes to empower crop breeding will be essential to make crops increasingly efficient in the use of water.

MORE EFFECTIVE PROTECTION OF AGRICULTURE

One of the critical challenges for food production is the movement of exotic organisms or invasive species from one region to another, depending on trade, transport, and tourism. Globalization of pests leads to the displacement of organisms from one region to another, intentionally or not, with significant potential for economic, environmental, and social impacts. This reality has led to the intensification of control practices and, in many cases, the justification for unfair market protection. Strong emphasis on technological innovation is critical to meet the diverse demands of importing countries and response to rigid compliance standards that are consolidated internationally. Countries will have to develop production systems sustained in sanitary practices consistent with internationally accepted patterns of quality and safety assurance for their agricultural products. Availability of genetic resources and breeding research on plant resistance to pests will play an increasingly prominent role in the defense of agriculture around the world.

INCREASING SAFETY AND EFFICIENCY OF AGRICULTURAL INPUTS

There is no doubt that agriculture will be pressed to seek alternatives or substitutes for inputs of high environmental impact and/or derived from nonrenewable sources. Many conventional inputs, like pesticides and fertilizers, contribute to the rising costs in food production, may have deleterious impacts on the environment, and directly or indirectly affect global warming processes. Therefore, it is necessary to develop alternative and safer sources of nutrients, such as nitrogen fixation by bacteria or biorelease of phosphorus and potassium from nonconventional mineral sources. Also, the research in genetic resources can contribute to identify the variability in the efficiency of nutrient use by plants, particularly those nutrients that are scarce or may have a large potential impact on the environment. Crop breeding and biotechnology have the capacity to mobilize this variability to change plant resistance to pests and nutrient use efficiency, with a high potential of impact in the sustainability of agriculture.

LINKING FOOD, NUTRITION, AND HEALTH

The concerted integration of food, nutrition, and health strategies appears to be inevitable because of demographic changes (increase in the average age of the population) and the exhaustion of health and social security systems, even in developed countries. The gradual change to a disease prevention paradigm will require food more suited to the needs of consumers (biofortified with vitamins, minerals, and high-quality protein), adapted to demographic changes (increasingly elderly population), and capable of boosting performance in various capacities (physical, intellectual, etc.). Genetic improvement will have to focus on the development of food with high nutritional and functional density and high quality, producing minimal waste and enabling production at low cost with high productivity.

SUSTAINABLE INTENSIFICATION OF LAND USE

Technologies capable of allowing increased and more sustainable use of the natural resource base will receive more attention in the future. In many parts to the world, agricultural land has been degraded and abandoned. If recovered, these are the ideal areas for the expansion of agriculture, livestock, and planted forest, without the need for further deforestation. It makes more sense to recover degraded areas than to open forested areas to farming. Integrated production systems, such as crop-livestock and crop-livestock-forest, are already proven possibilities for land recovery in many countries, especially in the tropical belt of the world. Such technological innovations may allow configurations of low-carbon agriculture and the dissemination of sustainable and more resilient farming practices. The research on genetic resources and breeding will contribute to the development of plants and animal breeds better adapted to low-carbon agricultural systems based on crop-livestock and crop-livestock-forest integration.

MOVING AGRICULTURE INTO THE BIOECONOMY

The theme "Green Economy" frequently appears in discussions related to the future of sustainable development. Biomass and biorefineries tend to play a key role in response to global climate change, to meet the demands for sustainable energy, chemicals, and new bio-based materials. There is no denying the emergence of a value chain around biomass, which will create significant opportunities for new business and a new technological and industrial paradigm based on low carbon. The growth of the bio-based economy can generate multiple opportunities for economic growth and creation of new jobs, including in rural areas. And one can foresee the number of technical, strategic, and commercial challenges that must be addressed before such green industries flourish. Many countries in the world are able to leverage the economic potential and sustainability of new bioindustries, both to enhance clean energy production and to develop a new and thriving renewable chemicals industry. Agricultural biodiversity and research on genetic resources, breeding, and biotechnology will be essential to support this new development paradigm, which has great potential to contribute to a more sustainable future.

The challenges highlighted previously indicate that changing agriculture and food production in ways that ensure improved sustainability and a healthier and more nutritious food supply involve the increased use of biodiversity for food and agriculture. Despite the scale of the challenges, one must also recognize that the technological progress on several fronts is impressive, increasing chances of successful response. Scientific revolutions are happening in various fields of knowledge, in biology with genomics, in physics and chemistry with nanotechnology, in information and communication technology, with innovations that increase our ability to respond to risks and challenges. In recent years, biology has produced tremendous advances that allow us to broaden our understanding of the complex mechanisms in plants, animals, and microorganisms. From such advances will arise innovations to agricultural diversification, specialization, and value aggregation, besides increased productivity, safety, and quality of food essential to ensure a more sustainable future for humanity. ■

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Maurício Lopes, a plant geneticist by training, received his B.Sc. degree in Agronomy (1983) from the Federal University of Viçosa, Brazil, his M.S. degree in Plant Genetics (1989) from Purdue University, West Lafayette, Indiana, USA and his Ph.D. in Molecular Biology (1993) from the University of Arizona, Tucson, Arizona, USA. Dr. Lopes served in a number of national and international committees, missions, panels, and working groups related to agricultural R&D, including, the Food and Agriculture Organization of the United Nations. Since 2013 he has been a member of the Global Panel on Agriculture and Food Systems for Nutrition, in London, and member of the Executive Board of the Global Crop Diversity Trust in Bonn, Germany. Currently, he is the President of Embrapa, the Brazillian Agricultural Research Corporation.