Alliance

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

POLICY BRIEF No. 53

Globetrotting crops:

A contribution by ICA and the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) to agricultural research

Summary

Scientific research and technological development is the creative work resulting from the collaboration of multiple institutions, and this has existed for decades in a great synergy between the Colombian Agricultural Institute (ICA) and the Alliance of Bioversity and the International Center for Tropical Agriculture (CIAT). This collaboration has contributed significantly to the distribution and promotion of rice, forage, beans, and cassava genetic materials around the world with improved agronomic characteristics. It has also contributed simultaneously to the maintenance and conservation of the diversity of these crops. The Alliance's breeding programs and genebank records show that both institutions have collaboratively distributed close to 400,000 genetic materials containing base germplasm, advanced lines, or improved varieties to countries around the world, following international standards and phytosanitary certification issued by ICA. The results show that the materials distributed have been requested by a wide range of institutions in different countries and for multiple purposes in research and agronomic engineering. Finally, in this document, we highlight the major achievements of ICA and the Alliance, which have contributed significantly to scientific research and food security worldwide.

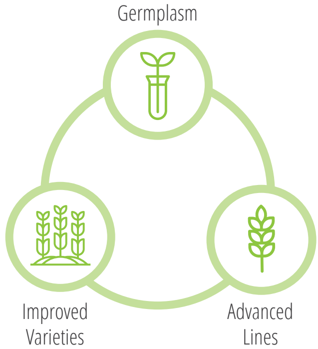
KEY MESSAGES

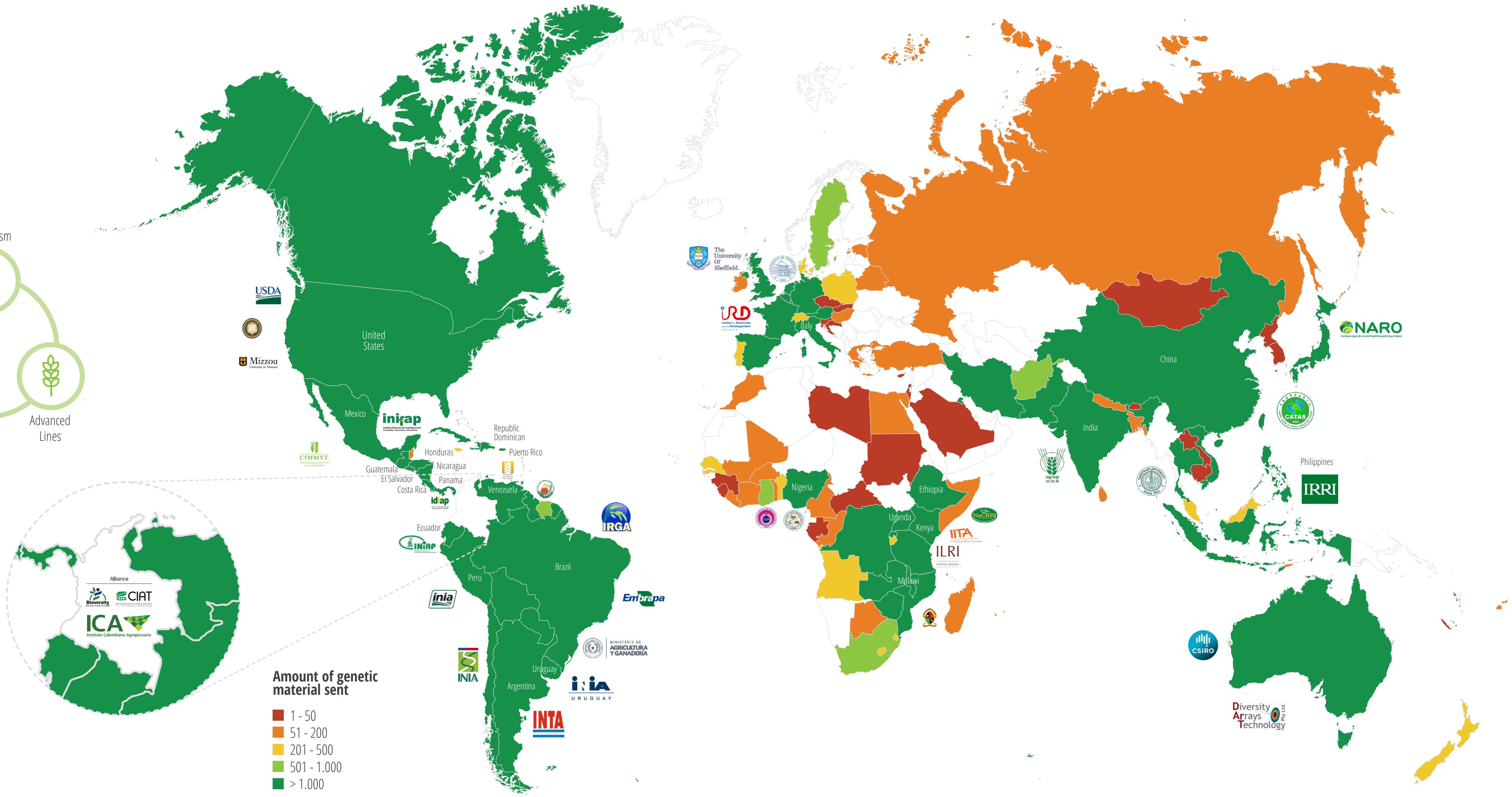
- This collaboration encompasses each of the 395,336 genetic materials (i.e., germplasm, advanced lines, improved varieties) that have been distributed around the world to contribute to agricultural research.
- These institutions have collaborated for more than half a century, contributing to the conservation and recovery of genetic diversity. For example, in Rwanda, through the Seeds for Hope initiative, several bean varieties that were lost during 1994 were recovered.
- The materials have been sent to 133 countries on all continents of the planet with more than a thousand institutions contributing significantly to agricultural research.
- Germplasm distributed around the world has helped to conserve copies of genetic material in different parts of the world to help in case of loss.

KEY WORDS

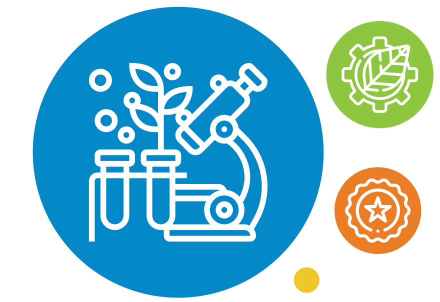
Genetic material, farmers, genebank, breeding program, improved varieties, adoption, impact.

The genebank and breeding programs of the International Center for Tropical Agriculture (CIAT) have shared some 400,000 genetic materials, with the support of ICA for their sanitary certification





Purposes of the material sent



57% Basic and applied research

21% Agronomy

17% Breeding

5% Others

Genetic resources sent

ICA Instituto Colombiano Agropecuario

The movement of genetic resources has contributed to the generation of more than one **thousand improved varieties** that have passed through **ICA** controls.

BEANS 184,342

RICE 140,785

FORAGES 35,908

CASSAVA 34,062

There are backup copies of the genebank safeguarded in the **Svalbard Global Seed Vault and at CIMMYT.**

FUTURE SEEDS Protecting food for the world

The Alliance will continue to send genetic material around the world and is currently building **Seeds of the Future** to meet new challenges.

Introduction

To talk about food security globally implies considering that 1 in 10 people (820 million) regularly go to bed hungry, or do not have access to food diversity in their households (UN, 2019). Research and development in agriculture, nutrition or related fields seek to change this reality by improving the quality and characteristics of foods or the conditions under which they are produced and marketed. Research and development have a direct impact on the quality of life of various stakeholders, including vulnerable groups such as farmers. Based on this premise, progress must continue to be made in research and the development of innovations in these areas, bearing in mind that the problems of malnutrition are global. For these reasons, collaboration is key to achieving the Sustainable Development Goals related to agriculture (e.g., malnutrition, zero hunger, poverty, climate action, gender equality, among others).

One of the alternatives proposed for decades to improve food security conditions has been the development of varieties resistant to pests and diseases, with greater nutritional value, high yields, and resilience to climate change. These varieties have been generated thanks to the collaborative efforts of various institutions (national and international) in different parts of the world. The most iconic example has been the improved wheat varieties developed by Norman Borlaug in Mexico in the 1960s, which helped save millions of people from starvation in India and subsequently throughout the world (Borlaug, 1972). Thus, the internationalization of research and knowledge transfer between regions has been essential, which has been supported by hundreds of examples like those developed by Borlaug.

Sharing this genetic material is crucial to boost the use, dissemination and adoption of improved varieties and thus benefit a significant number of producers, intermediaries, industrialists, and consumers. However, the transfer of genetic material (germplasm, advanced lines, and improved varieties) requires efficient, transparent, and controlled methods to ensure quality, safety and speed. The International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International) and the Colombian Agricultural Institute (ICA) have been a reference for the synergy that exists between an international institute that develops and disseminates genetic material and its local partner that facilitates, certifies, and guarantees the health and quality of this material so that it can circulate worldwide.

Some examples of the successful collaboration that has existed between ICA and CIAT during this time have allowed the successful shipment of thousands of seeds around the world, giving rise to several improved varieties. These genetic materials have been adopted in multiple countries, generating a substantial impact on farmers.

Borlaug and his "Wheat Apostles" (Source: https://borlaug.cfans.umn.edu/)

ICA-CIAT IN CONTEXT

ICA is responsible for regulating agricultural health and food safety in Colombian agriculture. Among its tasks, is to verify that the export and import of genetic materials are carried out under certain sanitary criteria that comply with international standards. ICA was created in 1962 with the purpose of "coordinating and intensifying research, teaching and extension work in agricultural sciences, for the better and more harmonious development of all activities in the sector and especially to facilitate agrarian social reform" (ICA, 2021a). In 1993, ICA focused its functions on the control of the country's agricultural health, carrying out activities such as advising the Ministry of Agriculture and Rural Development (MADR), coordinating activities with the agricultural sector, civil and military authorities, and the general public, with the objective of preventing, controlling, eradicating and managing pests and diseases of quarantine importance in the country, and technical research (ICA, 2021b). However, scientific research tasks have been undertaken by Agrosavia (formerly Corpoica) since 1992. During 2020, ICA allocated COP$125 billion for staffing costs (equivalent to about USD34 million).[1] In terms of the investment required to carry out its work, ICA has received COP$119 billion of government funding and $70 billion of its own resources, which is a total investment of $189 billion (USD51 million).

CIAT was created on October 17, 1967, in the municipality of Palmira (Valle del Cauca). The Ministry of Agriculture (now MADR) delegated to ICA the task of monitoring and propagating material from the time CIAT was established. Since then, a relationship of more than half a century that has developed between these entities, mutually contributing to their growth and strength.

FIGURES

Information is available on shipments of genetic material from CIAT to the international community requested for multiple purposes and by various research, educational, private, or even farmers' organizations. Some of the most common objectives are breeding, or conservation. The database contains information on breeding programs and the genebank for nearly 40 years. More than one thousand international shipments (1,081) have been made from the breeding programs since 2007,[2] and more than four thousand five hundred (4,573) shipments have been made from the genebank since 1973. In total, there are 5,654 records of shipments, of which 2,454 are shipments of bean material, 1,867 of forages, 795 of cassava and 529 of rice.

Shipments around the world

The total amount of genetic materials shipped has included bean crops (184,342 genetic materials in 2,400 shipments), followed by rice (140,785 in 529 shipments), forages (35,908 in 1,900 shipments) and (34,062 in 795 shipments) for cassava (Figure 1).

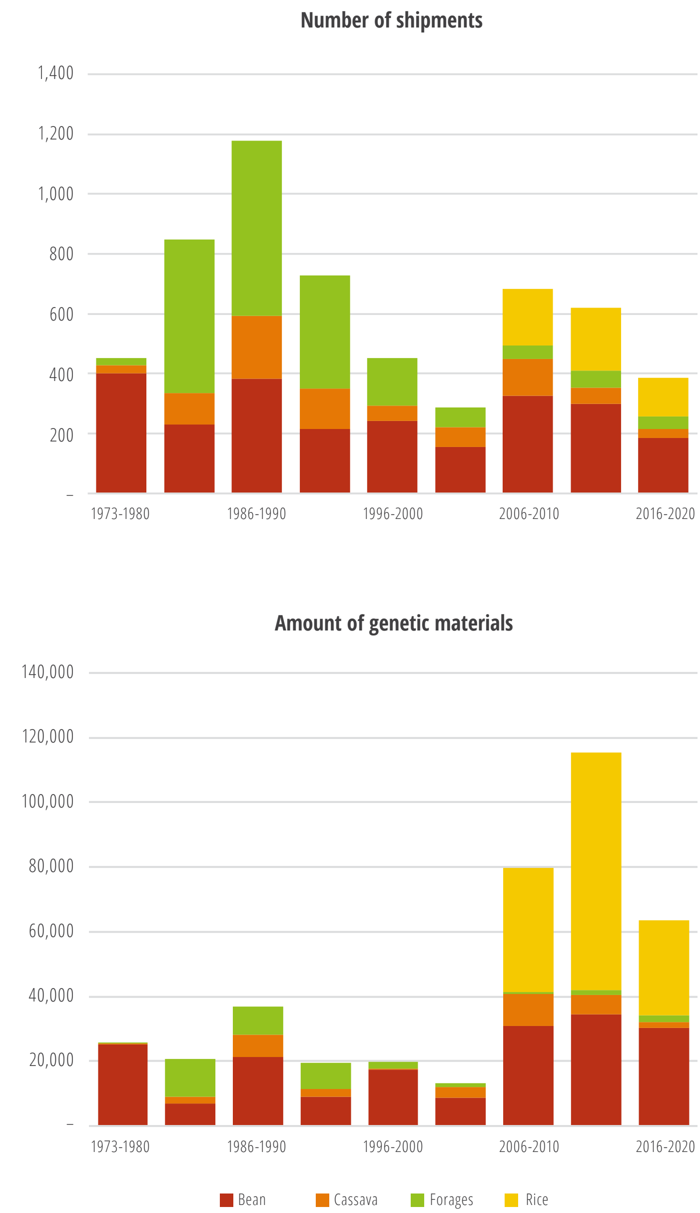


Figure 1: Number of shipments and genetic material, by crop.

Source: Data taken from the breeding programs and the Alliance's genebank.

1 Average dollar reference rate for 2020, set at COP$3,693.36 to one U.S. dollar. (http://www.superfinanciera.gov.co).
2 This database has records since 2007 due to the establishment of the Standard Material Transfer Agreement (SMTA).

There are several facts to highlight. Although CIAT does not maintain genetic material in its genebank for rice cultivation, it has sent numerous advanced lines to Latin America through its breeding program in cooperation with FLAR (Latin American Fund for Irrigated Rice). In the case of cassava and forage crops, it began to send materials to other countries in the 1980s, and finally, bean materials have been sent in large quantities constantly over the 47 years for which data are available. It is also important to highlight the fact that there is a shipment of 24,850 lines of rice to the International Rice Research Institute (IRRI)[3] in the Philippines for the purpose of applied research (Figure 1).

Regarding the destinations of genetic materials, they have been sent mainly to the Americas, Asia, and sub-Saharan Africa. Individually, the United States, Brazil and Mexico stand out in the first continent, the Philippines, India, and China in the second, and Uganda, Ethiopia, and Malawi in the African sub-region.

In terms of number of shipments and crops, the United States is the country that has received the most material, mainly beans. This is due to the fact that the University of California has requested and acquired more than 5,600 genetic materials. Brazil receives mainly fodder and bean material, where the main partner is Embrapa. In the case of the Philippines, given the relationship with IRRI, a significant number of rice lines have been shipped. Cassava has been shipped mainly to sub-Saharan Africa and developed countries.[4]

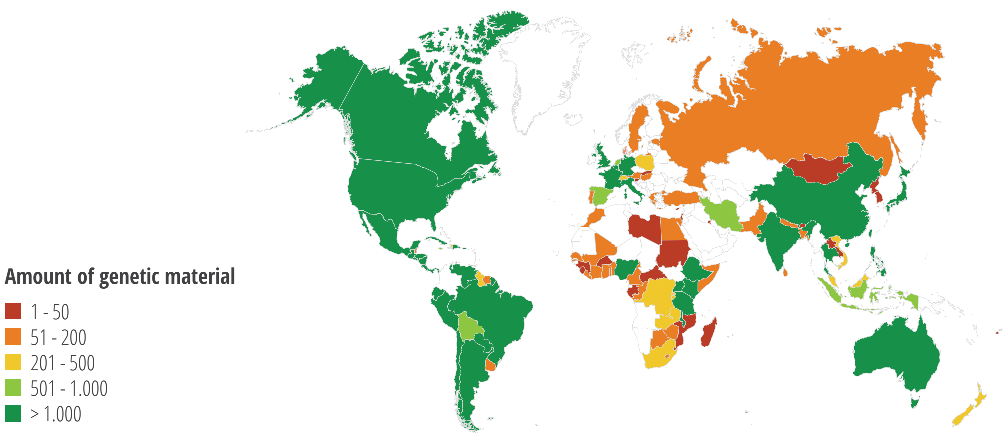


Figure 2a: Map of genetic material worldwide from 1973 to 2006.[5]

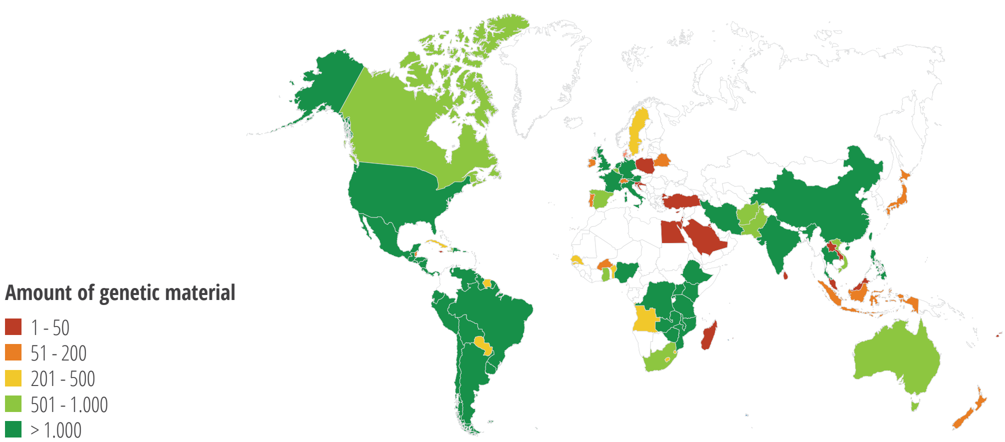


Figure 2b: Map of genetic material worldwide from 2007 to 2020.[5]

Source: Data from the breeding programs and the Alliance's genebank.

3 IRRI is a research center dedicated to reducing poverty and hunger in regions that depend on rice food systems and is a sister center of the Alliance as it is also part of the CGIAR.

4 As developed countries, the 15 countries with the highest gross domestic product in 2019 were considered. Conversion to purchasing power parity was taken for international comparisons (most recent data from the World Bank: https://bit.ly/3s43m7H). These countries are: Brazil, Canada, China, France, Germany, India, Italy, Japan, Mexico, Russia, South Korea, Spain, Turkey, United Kingdom, and United States.

5 The numbers on the map correspond to the total shipments made by the respective country.

It is important to clarify that the distribution by number of shipments is different from the number of genetic material (Figure 1), because there is no limit to the material that can be requested in each shipment, which can lead to inconsistencies between these two distributions. Two activities with a large average volume of seeds per shipment stand out: *Applied Research*[6] (131 materials per shipment) and *Breeding*[7] (123 materials per shipment), in contrast to research related to the agronomic characteristics of seeds and training activities, from which an average of 38 and 19 genetic materials are sent per shipment, respectively. The *Agronomy* category refers to activities that explore how these genetic materials react to different agronomic management (Figure 3).

The main reason for requesting genetic material is for applied research. About 130,000 materials were sent for this purpose, mostly for rice and beans. However, requests are also received for agronomic purposes; more than 80,000 materials were sent, mainly for beans and forage crops. Regarding crops, rice was requested for applied research, breeding, basic research, and agronomy, while bean, cassava and tropical forage materials were requested for conservation and training (Figure 3).

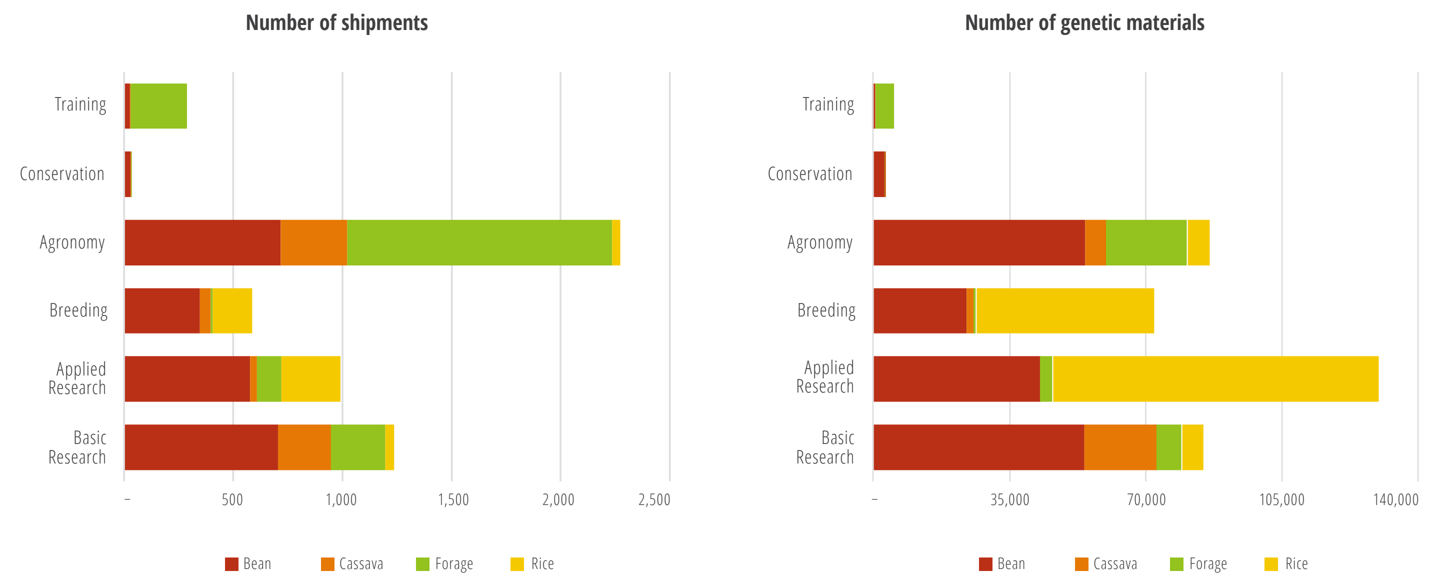


Figure 3: Purpose by number of shipments and quantity of genetic material, by crop.

Source: Data from the breeding programs and the Alliance's genebank.

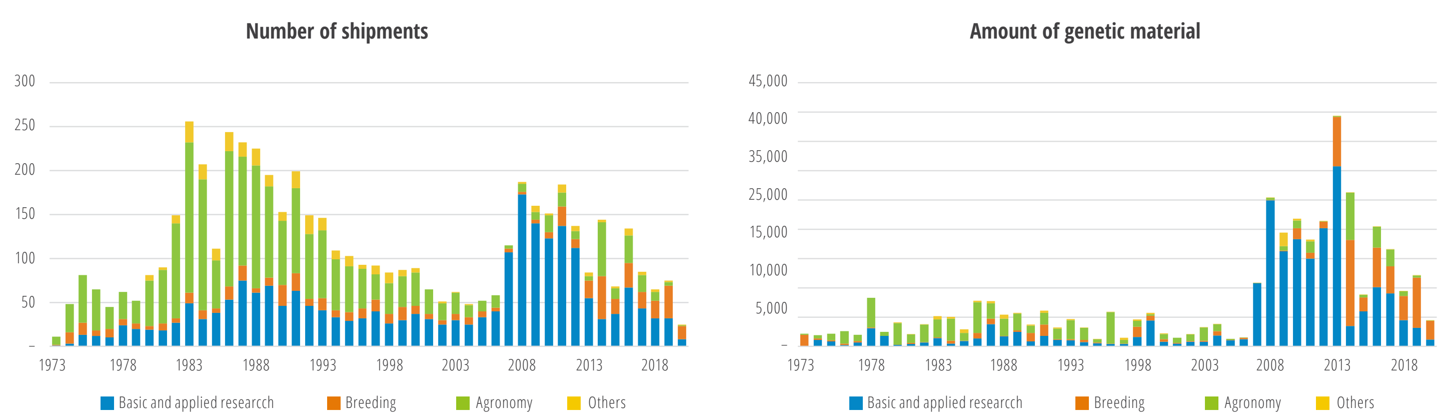


Figure 4: Time trends according to purpose from 197to 2020.

Source: Data from the breeding programs and the Alliance's genebank.

6 This category groups shipments for breeding or basic research activities.

7 This category groups together those shipments whose objective is the development of improved varieties that will be disseminated in the receiving country.

Since 1973, the main purpose of requesting genetic material is to understand its performance under different agronomic management,[8] followed by applied research. During 2008, the trend showed a change and applied research became more common than Agronomy. This is due to the influence of the availability of data from Breeding programs, which have only been available since 2007. For this same year, there is also a considerable increase in shipments for basic research and breeding. During the 47 years analyzed, materials for Applied research were mainly requested by countries in Latin America and the Caribbean, Sub-Saharan Africa and developed countries. Latin American countries also requested a large amount of material for Breeding and agronomy, while developed countries and African countries showed great interest in material for Applied research and Basic research.

The institutions that requested the most material during the 47 years observed were the National Agricultural Research Systems (NARS) and universities (Figure 6). This is expected because most of the submissions are for *Agronomy, Applied research* and *Basic research purposes.* International institutions also requested a considerable amount of genetic material, largely due to the case of rice, as mentioned above. It is important to highlight that shipments to international and private institutions had a considerable increase in the first decades of the 21st century, which is reflected in the materials sent between 2011 and 2020 (Figure 6).

In terms of the amount of genetic material, Applied Research was requested more than Agronomy, and although CIAT made just over 200 shipments, in terms of breeding, almost 35,000 materials were used. The universities required these materials for Basic research and Agronomy in most cases.

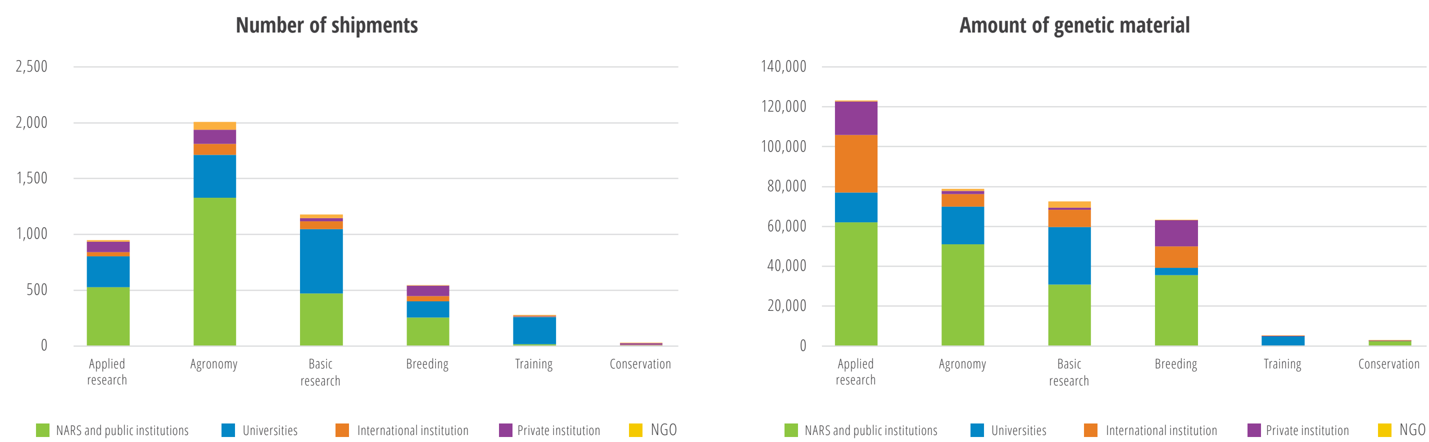


Figure 5: Number of shipments and amount of genetic material dispatched by CIAT, by decade.

Source: Data from the breeding programs and the Alliance's genebank.

Figure 6: Number of shipments and amount of genetic material dispatched by CIAT, by purpose of application.

Source: Own calculations, with data from the breeding programs and the Alliance's genebank.

8 We understand that, when materials are requested for this purpose, they are intended to be used for research on agronomic practices.

Contributions from ICA and the Alliance

There are many examples that demonstrate the benefits of the alliance between ICA and CIAT. One of the oldest examples is presented by Vallejo and Estrada (2002), who mention that the old rice varieties yielded approximately 1.2 tons per hectare, while in the year of publication, the yield of the varieties were between 9 and 12 t/ha, thanks to the joint efforts of ICA and CIAT (p. 24). Similarly, the studies carried out by ICA between 1974 and 1975 led to the establishment of the First International Mustia Nursery, consisting of some 100 lines that CIAT distributed for evaluation at regional level (Profrijol, 1993).

Another example that highlights the importance of mobilizing genetic resources is the case given by Mendez et al. (2015). They highlight CIAT's work in crop improvement in Guatemala (thanks to the shipment of bean materials, the quality of which was verified and certified by ICA), thus contributing to agricultural development and adaptation to climate change.

Authors such as Debouck et al. (2008) highlight the importance of genetic diversity for breeding programs in Latin America. They show that about 6,000 cassava clones were evaluated to identify two elite clones that had the desired characteristics to obtain more whitefly resistant and higher yielding varieties. The materials used came from CIAT and were quality controlled by ICA so that they could be used internationally and contribute to mitigating the economic effects that this pest can cause.

Rice cultivation in Colombia (photo: N. Palmer/CIAT)

In vitro preservation of cassava seedlings (photo: N. Palmer/CIAT)

In addition, cassava germplasm submitted to breeding programs in Thailand and Vietnam has contributed significantly to the development of new improved varieties targeted for the starch industry in Asia. A major example of this is the adoption and area occupied by KU50 (KM94), which has generated about USD$400 million between 1992 and 2010, with a potential to benefit more than 8 million farmers producing cassava across Asia (CGIAR, 2021; Malik et al., 2020; Ocampo et al., 2021).

For CIAT's 50th anniversary, Labarta et al. (2017) made a compilation of the impacts of the collaborative research carried out in that half century, highlighting the results of the efforts made in each of the crops. In the case of bean, 357 varieties were released in sub-Saharan Africa and 322 in Latin America and the Caribbean and 35 cassava varieties were released in Latin America and 25 in Southeast Asia. Tropical forages, mostly Brachiaria, introduced and promoted by CIAT, were found on 3.76 million hectares in Colombia, Costa Rica, Honduras, Nicaragua, and Peru. With respect to rice, the document mentions the collaboration between CIAT and FLAR, under which 299 varieties were released through 23 programs in 2003. The distribution of all these materials was possible thanks to the collaboration between ICA and CIAT.

Similarly, the genebank has played an important role in the conservation of crop varieties, as Juan Lucas Restrepo, Director General of the Alliance, points out, *"we were able to achieve the goal of having two 90% backup copies of almost 38,000 varieties in two geographically distant locations, delivering 904 accessions to the Svalbard Global Seed Vault".* The other location where these backups are located is the International Maize and Wheat Breeding Center (CIMMYT) in Mexico (Alliance, 2020), germplasm that received the corresponding certifications from the ICA.

The Alliance is currently implementing a major project called *Future Seeds*, which seeks to address one of the greatest challenges facing humanity in the future: the loss of crop diversity at an alarming rate. Thanks to *Future Seeds,* vulnerable farmers can count on seeds that are part of their repository, and scientists can research materials that are not found on farms or in nature, thanks to the genebank and the agreement with the ICA that allows great flexibility for the flow of germplasm (CIAT, 2021).

Juan Lucas Restrepo, General Director of the Alliance, accompanying the delivery of backups in Svalbard. (photo: NordGen)

Finally, Sellitti et al. (2020) highlight the importance of the genebank, because thanks to the diversity of CIAT's bean collection, it was possible to develop seven biofortified bean varieties, using more than 1,000 varieties with high levels of iron (Fe) and zinc (Zn), in order to improve the varieties grown in Rwanda. This document also highlights CIAT's work in the recovery of bean diversity in the African country after the loss evidenced in the Rwandan genocide. The material passed through the controls established by ICA prior to shipment.


Svalbard Global Seed Vault (photo: NordGen)

Lessons for the future

There is ample evidence to show how important it is to ship genetic materials responsibly with the respective sanitary controls. ICA has been vital in this regard, since by guaranteeing the quality of the seeds that are distributed, it protects food systems and provides vital inputs for their development worldwide, thus contributing to the battle against hunger and malnutrition.

ICA and the Alliance, in collaboration with various institutions worldwide, have worked hard to ensure that the genetic material required for those who need it arrives in optimal conditions and can be used efficiently. In this way, it has boosted research around the world, reduced poverty and malnutrition, and at the same time combated the deterioration of crop diversity. The work carried out by ICA and the Alliance is fundamental to guarantee the quality of the material stored by CGIAR which is kept at the disposal of the international community, protecting diversity through the conservation of seeds and materials that are vital for this purpose.

In view of the above, we can conclude that it is essential to continue promoting, to the greatest extent possible, the activities carried out jointly by ICA and the Alliance.

Future Seeds (Render)

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