THE CGIAR cassava PROGRAM

Cassava is the third most important food crop in the tropics, after rice and maize. The root crop is grown by millions of smallholders who rely mostly on low-technology farming systems and often in marginal areas with poor soils and low water availability. Cassava farmers are among the world's poorest and most disadvantaged, but despite the challenges cassava remains one of the few crops offering both food and economic security to smallholder communities living in those environments. For many it also signifies a path out of poverty.

ALLIANCE

Bioversity International

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

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CGIAR CONSORTIUM OF INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

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Sustaining the tropics

Since the turn of the millennium, world annual cassava production, currently at about 270 million metric tons, has been increasing at an annual growth rate of about three per cent, although this growth has been mainly driven by increases in planting area. Cassava is predominantly grown for its starchy roots, but leaves are also consumed as protein-rich food and feed for livestock. In Africa and Latin America, most cassava is grown as a food crop, while in Southeast Asia it is primarily processed into starch for the food and beverage industries and various other industrial applications.

Due to its industrial utility, cassava is also an important and highly competitive, climate-change-ready cash crop, thus contributing to the basic sustenance of smallholders and landless farmers. Dry cassava roots contain more than 80 per cent starch, which is processed at different scales, from artisanal to highly technical processing plants, which creates employment for numerous traders and processors worldwide.

Even though cassava starch represents only eight per cent of global starch production, it is the most traded starch in the world. In Southeast Asia, cassava has evolved to become a major industrial crop, feeding a US$4 billion trade in chips, pellets and raw starch, with markets in China and other growing Asian economies as the main buyers.

Cassava production in Southeast Asia has gone through a steep growth phase and is now moving into a period of market consolidation. With ongoing challenges like climate change, pest incursions via informal seed systems, and declining yields this is a critical period during which One CGIAR needs to focus on providing support to this young cassava industry and particularly to the eight million farmers who depend on this crop, many of them belonging to poor ethnic minorities.

REGIONALITY

Agronomic performance of varieties is typically region-specific and requires tailored solutions. Factors limiting productivity are diverse and go beyond common agronomic challenges; they include availability and access to essential resources such as good soils, water and fertilizer, experience with sustainable practices, and farming system integration.

Latin America and the Caribbean

Cassava originated in the southern Amazon basin before spreading across the tropical regions of the Americas during the process of domestication, thousands of years ago. Hundreds of regionally different landraces, along with a wide range of processing methods and consumption patterns, bear witness to a long tradition of cassava growing in the tropical Americas.

Brazil and Paraguay are the main producers of cassava in Latin America, with production shared by small and large farmers. Some regions in Brazil and Paraguay have experienced a gradual increase in industrial uses for cassava starch, with processing plants being established and supply chains developed.

For many years, the CGIAR Cassava Program has been working on increasing industrial cassava production in Colombia. Their work includes technological improvements, reducing energy and water consumption, and the creation of market value chains for cassava derived products. Success for these efforts depends on market accessibility and capital assistance, which is where the strengths of the program lie, thanks to its established national and international research, development and extension networks.

Despite its long history of cultivation in Andean countries, cassava yields in this region are in decline. As cassava remains a key crop for sustenance due to its resilience and adaptability, farmer needs in the region are being addressed by targeted varietal diversification as well as improved processing technology. Novel, attractive industrial applications and increased urban consumption are needed to make cassava a profitable crop with the potential to improve the livelihoods of many smallholders.

Efforts towards achieving this goal are exemplified by work being carried out by the Cassava Program to improve the productivity of small industrial starch-processing plants in Colombia and to transition cassava starch into mainstream starch markets, with due consideration to changing eating habits of a more urbanized population.

Sour starch is an important local product in parts of Colombia, used to prepare a traditional bread called pan de bono. The Cassava Program has helped improve the starch extraction process and the use of defined microbial starter cultures to raise the overall efficiency of the process. Sour starch production is an example of a small, artisanal rural industry with potential for improvement and integration into the urban value chain.

ARTISANAL CASSAVA STARCH PROCESSING, WITH WORKERS COLLECTING SEDIMENTED CASSAVA STARCH FOR SUN-DRYING.

Africa

Since the introduction of this New World crop hundreds of years ago, cassava has become a traditional and widely grown food energy source for more than half a billion people in sub-Saharan Africa, with Nigeria and Ghana responsible for about half of the continent's production, which totals more than 60 per cent of world's cassava production. Production has steadily increased over the years through expanded planting area rather than productivity improvements, especially in the more arid regions. About 90 per cent of production is in the hands of smallholder farmers and mostly as part of mixed-cropping farming systems in which cassava constitutes an essential sustenance element due to its higher resilience to infertile soils and water-stressed environments.

Cassava is generally consumed fresh or processed domestically by sun-drying, grating, soaking in water or fermentation to remove the cyanide liberated from glucosinolates present in all parts of the plant and make the derived products storable and acceptable for human consumption. Most cassava in Africa is consumed locally, with delivery into domestic markets ranging anywhere between 20 and 70 per cent, depending on market integration of farms.

Nigeria, the major cassava producer in the world, has shown initiative by partially substituting wheat flour with cassava flour in bakery products, thereby saving the country foreign exchange and increasing the income of cassava processors and farmers. Because of the perishability of cassava roots, such initiatives depend on improved access for producers to the transport and energy grid before production can be diversified into industrial uses such as starch, animal feed, ethanol and flour. Flour processors are also affected by competition with garri processors, as the latter can afford to pay higher prices for cassava starch due to their larger profit margins.

Over time, the Cassava Program has distributed thousands of cassava accessions and varieties in Africa (see also germplasm section) and contributed to major biological control campaigns to manage pests like the cassava hornworm using baculoviruses or parasitic worms to combat cassava mealybug, with the latter alone having saved the continent about US$20bn in potential losses. These days, the program is part of an international program to combat whitefly, contributing to the molecular characterization resistance sources for breeding purposes.

Southeast Asia

Countries in the region account for about a quarter of global cassava production, contributing to the livelihood of more than eight million smallholder farmers.

Cassava's adaptability makes it a potential gateway crop to long-term environmentally and economically sustainable farming systems by allowing farmers to bring exhausted and degraded land back into production, ideally as a bridge to more valuable crops.

While mainly consumed as a staple in Africa, Latin America, Indonesia and the Pacific, industrial applications predominate in mainland Southeast Asia, contributing to rural livelihoods and national economies.

Thanks to its wide adaptability and resilience to various stresses, cassava is a climate-ready crop and expected to perform better than many other tropical crops. The role of cassava in food security and income stabilization for the world's poorest is expected to become increasingly critical in a changing world climate.

Cassava starch quality and pricing makes it competitive against other starches, but productivity must keep improving to retain this market position.

In Southeast Asia, farmers obtain about eight metric tons of dry matter per hectare from roots, of which more than 80 per cent is starch. Over time, the Cassava Program's contribution has led to doubling of yields and a 20 per cent increase in dry matter, further contributing towards Sustainable Development Goals related to poverty alleviation.

Informal seed systems operating across international borders create a major challenge to sustainable production in Southeast Asia by exacerbating the spread of diseases that have entered the region in recent years and which are already causing some significant losses. The Cassava Program is working with major players in the region to harness the power of existing informal seed systems while addressing phytosanitary and quality issues.

A VIETNAMESE SMALLHOLDER FARMER WORKING IN HER CASSAVA FIELD.

Why cassava?

Cassava has been a traditional crop of Latin America for almost 10,000 years, with its center of origin located on the south-western border of the Amazon basin. From here it spread to become one of the most important calorie source staples in the least-developed and low-income, food-deficit countries in the tropics. This is due to cassava's resilience, which allows it to grow on low-fertility soils and under harsher drought and heat-stress conditions than other staples, while remaining an economically viable cash crop.

Cassava varieties are propagated via stem cuttings, which means farmers can produce and trade their own planting material. Cassava roots make up for their post-harvest perishability by being able to remain in the ground and harvested over several months as needed, providing additional management flexibility and compatibility with diverse farming systems. Also, cassava is widely transformed into a range of traditionally processed, storable product. These attributes explain why cassava has become such a success story in the tropics. At the same time, these same attributes and their association with marginal lands have contributed to cassava becoming a misunderstood crop by some people working in human development organizations.

> Although commonly considered a calorie source, cassava is also becoming a source of the vital micronutrient beta-carotene, or provitamin A. The Cassava Program has identified germplasm rich in this essential micronutrient and made lines carrying this nutritional attribute an essential component of its breeding program, thereby contributing to the United Nations' Sustainable Development Goal 3, Good Health and Well-being, by improving the health status of cassava consumers, especially children.

Cassava consumption is quite diversified, with the root being eaten fresh or processed in many traditional ways for storability. They are also pelletized for animal feed or processed into ethanol, and dry starch can be used as industrial feedstock, while the leaves can be used for human consumption and animal forage.

End-uses of cassava are being further diversified in ways that may require more specialized varieties to meet specific requirements. Due to its desirable physicochemical properties, cassava starch finds its way into many daily-life products such as food flavorings or thickeners in the paper and textile industries.

CASSAVA GERMPLASM FOR THE WORLD

Being the center of origin of cassava makes Latin America the main source of genetic diversity for breeding programs. The Alliance of Bioversity International and CIAT holds the largest cassava germplasm collection in the world, with more than 6500 in-vitro accessions.

This living collection is a labor-intensive, but necessary, activity to preserve the genetic identity of the clones maintained at the Alliance's headquarters in Cali, Colombia. Using this available genetic diversity, the Cassava Program has been generating novel breeding materials.

A big share of the work since the inception of the program has gone into generating breeding lines to address specific productivity bottlenecks in Asia and Africa, the latter delivered via CGIAR's sister center, the International Institute of Tropical Agriculture (IITA), in Nigeria.

Over the years, the Cassava Program has played a crucial role as the supplier of strategic breeding lines to IITA, infusing essential traits into new varieties, such as resistance to virus-induced cassava mosaic disease, pest resistance genes, low cyanide content for human consumption, improved drought tolerance, early maturity and yield components.

The packaged traits are now being delivered more efficiently thanks to advanced molecular techniques being applied by the Cassava Program, which are contributing to faster and more efficient breeding cycles, further assisted by novel approaches to parental selection to capture genetic diversity more efficiently, and early induction of synchronized flowering.

These activities complement the program's capacity to trial breeding lines in all target environments to ensure the deployment of desirable traits in adapted backgrounds.

IN A CASSAVA NURSERY (PICTURED), CASSAVA MUST BE MULTIPLIED CLONALLY FROM STAKES. IN A GERMPLASM COLLECTION, CLONES MUST BE MULTIPLIED REGULARLY AND EVERY ACCESSION IN THE COLLECTION MUST BE CLEARLY LABELLED TO MAINTAIN ITS IDENTITY.

THE *MANIHOT ESCULENTA* (CULTIVATED CASSAVA) FEMALE FLOWER (LEFT) AND THE *MANIHOT FLABELLIFOLIA* (BELOW), A WILD RELATIVE THAT HAS BEEN IDENTIFIED AS A SOURCE OF RESISTANCE AGAINST WHITEFLY.

CASSAVA AND DEVELOPMENT

Cassava is contributing toward several Sustainable Development Goals by reducing malnutrition and poverty while addressing sustainability, climate adaptation and gender-related issues, such as improving women's and youth farm labor conditions. Cassava allows smallholders to connect with export industries, independent of scale. An example is the collaboration between the Cassava Program and Ingredion, a company that connects thousands of smallholders growing cassava as a cash crop with global starch markets.

In the past 20 years, cassava has transitioned from a crop for household consumption to a commercial crop, mainly due to increased production in Thailand and Vietnam to satisfy growing demand in China. In countries like Cambodia, cassava has been contributing to the economic recovery of the country since the early 2000s; there it is the fastest growing crop in terms of production; 13.4 per cent growth in average yield and 15 per cent in total area grown, between 2012 and 2018. It has become the second largest agricultural crop in Cambodia and is estimated to contribute between two and three per cent of the country's GDP. Cassava is now grown on more than 500,000 hectares and by more than 90,000 rural households across the country, creating many seasonal jobs for local laborers. A recent United Nations Development Programme report found the potential returns to public investment in cassava were substantial, with a benefit–cost ratio of 3:1 over a 10-year period. When accounting for wider socioeconomic impacts (in employment and poverty reduction), the report found cassava also outperformed alternative investments in rice production, livestock and food, and tourism sectors.

PHOTO: ANNIE SPRATT/UNSPLASH

IN AN EXAMPLE OF ARTISANAL STARCH PROCESSING, A WORKER CARRIES A PLATE OF PROCESSED CASSAVA TO BE PLACED ON A RACK FOR SUN-DRYING.

The Cassava Program

The strengths of the Cassava Program include an integrated team with experienced in-country experts and leveraging of local partners, creating a capacity legacy while establishing partnerships between actors and countries that would otherwise not come into being.

MISSION STATEMENT

The stated mission of the Cassava Program is to improve livelihoods of cassava-growing smallholders and their communities by delivering technical packages of sustainable, region and farm system-specific solutions that maximize yield and quality of the crop throughout the value chain.

OBJECTIVE

Increased productivity, resilience and opportunities for disadvantaged smallholders facing climate change challenges and growing cassava as part of their farming system.

LONGER-TERM OUTCOMES

- Efficient delivery of varieties with product profiles for specific regions and uses
- Increased capacity to recover degraded soils
- High yield potential and reduced yield gap across farming systems
- More sustainable resource use and reduced environmental footprint

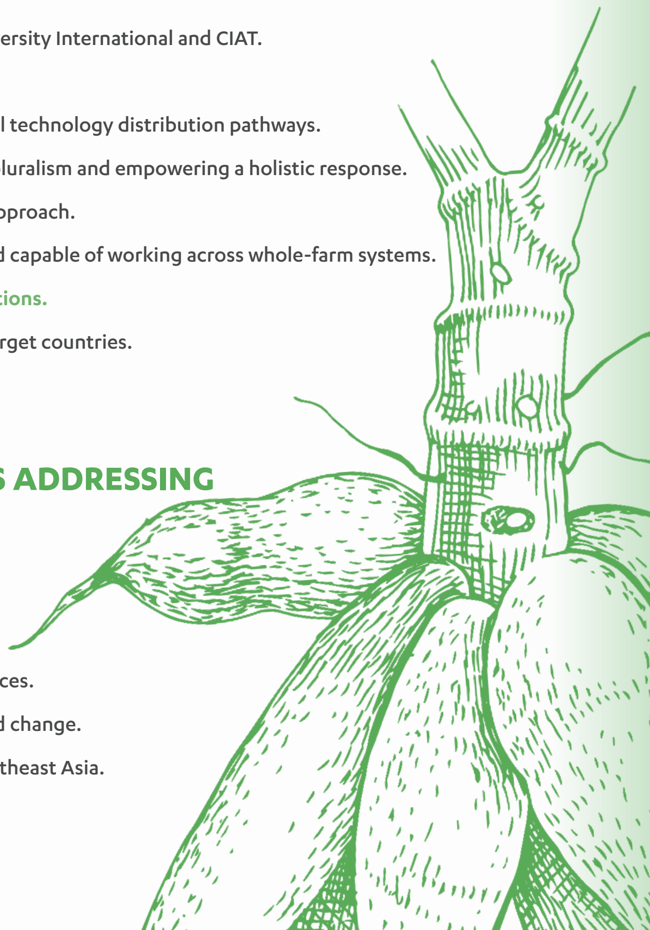
- Smarter and more affordable solutions in breeding and across the value chain
- More efficient management of pests and diseases
- Research and interventions targeted to beneficiaries and technology adoption pathways

PROGRAM STRENGTHS

- **Direct access** to the global cassava germplasm collection held by the Alliance of Bioversity International and CIAT.
- **Highly qualified scientists in-country, embedded into cultures and landscapes.**
- **Diverse and robust partnerships in target countries** with access to regional and local technology distribution pathways.
- **Established relationships** with a range of donor agencies, creating funding priority pluralism and empowering a holistic response.
- Program structure delivering **an integrated technical, cultural and socioeconomic** approach.
- **Cross-disciplinary teams feeding the varietal breeding-to-deployment pipeline** and capable of working across whole-farm systems.
- A **team of passionate researchers** seeking **innovative and context-appropriate solutions.**
- **Established institutional and government relationships**, with capacity building in target countries.
- **Long history** of crop-specific R&D and quantifiable, global impacts.

ONGOING CHALLENGES THE CASSAVA PROGRAM IS ADDRESSING

- **Ongoing threat of pests and diseases** placing pressure on varietal resistance.
- **Informal seed systems** acting as disease vectors across country boundaries.
- **Growing yield gap** menacing many smallholder livelihoods.
- **Technology adoption pathways** depend on local intermediaries often lacking resources.
- **Dependence on national policies** and crop-specific support to implement on-ground change.
- **Negative perceptions of cassava** as contributing to deforestation and erosion in Southeast Asia.



DOING WHAT WE DO BEST

Since its inception, the Cassava Program has excelled in germplasm deployment and development based on the identification of regional needs, be it climatic adaptation, consumer needs and management of biotic stresses. More than 43,000 accessions, including about 6500 varieties, have been handed to 84 countries worldwide. The program has also released 35 improved varieties in LAC and 25 in SEA. Worldwide, 48 varieties related to CGIAR material cover 40 per cent of the cassava growing area. A multibillion-dollar investment by CGIAR and partners over time has resulted in a benefit-to-cost ratio of 2.28 globally or 5.27 for SEA alone.

The Cassava Program focuses on delivering novel cassava varieties based on product profiles defined by regional needs (see graph). Pest incursions pose one of the worst challenges to progress made to date. They are moving targets that require continual attention if gains to date are to be maintained and further improved.

Whiteflies, for example, are carriers of several viral plant diseases, among them cassava mosaic disease (CMD), which causes annual losses of about US$1 billion in eastern and central Africa alone. It also affects countries in SEA. Another whitefly-transmitted virus causes cassava brown streak disease (CBSD), resulting in losses of more than US$700 million annually in Africa. The mycoplasma caused witches' broom disease affects several countries in Southeast Asia while frogskin disease causes important losses in Latin America and the Caribbean.

Disease incursions previously unknown to growers have reinvigorated the role of the CGIAR and their partners in developing and delivering disease-resistant, locally adapted varieties. The Cassava Program is also one of 16 international partners in the Bill and Melinda Gates Foundation-funded Cassava Whitefly Project and is working on the molecular characterization of genetic sources of resistance.

STRATEGIC PRODUCT PROFILES BEING DELIVERED TO NATIONAL PROGRAMS TRAITS

TRAITS

- **Nutrition and sustenance:** High provitamin A; delayed postharvest physiological deterioration; low glycemic index
- **Industrial uses:** High and stable dry matter; waxy starch; small-granule starch
- **Agronomy:** Herbicide resistance; tolerance to high-density planting
- **Quality and functionality:** Cooking quality and texture
- **Disease resistance:** CMD, CBSD, whitefly, witches' broom, and frogskin disease
- **Physiology:** Drought and heat tolerance; early maturity; vigorous growth
- **Breeding:** Hybrid breeding to boost yield.

RSA-6 RSA-1

OUTCOMES

- Diversifying cassava genetics targeted to specific agroecologies and uses.
- Reduced yield gaps in diverse farming systems.
- Smarter, cost-effective solutions across the breeding and value chains.
- Variety-specific agronomic packages, including more efficient pest and disease management.
- More sustainable resource utilization.
- Targeted research and interventions for efficacious technology adoption. Improved soil health on degraded lands

RSA-2 RSA-3 RSA-5 RSA-4

SUSTAINABLE DEVELOPMENT GOALS

NO POVERTY

ZERO HUNGER

GOOD HEALTH AND WELL BEING

LIFE ON LAND

CLIMATE ACTION

GENDER EQUALITY

To address the great diversity of challenges faced by cassava growers, the Cassava Program is organised into six Research and Service Areas (RSAs) that span the whole value chain to develop integrated solutions with regional partners. This array of multidisciplinary teams is highly skilled in the biophysical and socioeconomic sciences and contributes to developing in-country capacity and strengthening national research systems to pursue the achievement of the United Nations' Sustainable Development Goals.

RSA-1
Enhancement of Genetic Resources: develops potential genetic solutions, aiming to increase productivity, sustainability and utilisation of cassava.

RSA-2
Agronomy and Soil Management: seeks to improve the sustainable production of cassava in diverse farming systems.

RSA-3
Crop Protection: contributes to the development of integrated pest and disease management approaches that are economically viable and environmentally sound.

RSA-4
Seed Systems and Harvesting: devises strategies to develop commercially sustainable or improved informal cassava seed value chains to increase adoption of improved varieties and healthy seed material.

RSA-5
Post-harvest and Enhanced Nutrition: works to identify cassava-derived products with desired end-user traits, acting as an interface between breeding and users, and improves cassava processing.

RSA-6
Value Chain, Markets and Policy: provides support to the whole program by helping to set research priorities by assessing different stakeholder and end-user demands and needs; identifying market opportunities and trends; developing inclusive business models; and generating evidence of program impacts.

Please visit www.globalcassavaprogram.org for more details about our people, projects and progress in addressing some of the major issues affecting cassava growers around the world.

Synergistic partnerships

The Cassava Program has developed long-term relationships with multiple national partners. The program has an established reputation and the power to launch and coordinate regional initiatives, extending achievable impacts in all target regions. Together with its national partners, the Cassava Program monitors developments around the crop, including market forces and opportunities, but also looming threats such as climate change and evolving pests and diseases, giving the program the necessary lead time to search and breed for the traits required to deal with such threats and opportunities at early stages. These are some of the international partners the Cassava Program has been collaborating with.

Australia
- **ACIAR** – Australian Centre for International Agricultural Research
- **UWA** – The University of Western Australia
- **UQ** – University of Queensland

Brazil
- **Embrapa** – Empresa Brasileira de Pesquisa Agropecuária

Cambodia
- **CAVAC** – Cambodia–Australia Agricultural Value Chain Program
- **CARDI** – Cambodian Agricultural Research and Development Institute
- **GDA** – General Directorate of Agriculture

China
- **CATAS** – Chinese Academy of Tropical Agricultural Sciences
- **CAS** – Chinese Academy of Sciences

Colombia
- **Genetic Resources Unit, the Alliance of Bioversity International and CIAT**
- **AGROSAVIA** – Corporación Colombiana de Investigación Agropecuaria
- **ASOMUSACEAS** – Asociación Musáceas del Valle
- **UNAL** – Universidad Nacional de Colombia Sede Palmira
- **MINCIENCIAS** – Ministerio de Ciencia, Tecnología e Innovación

Costa Rica
- **IICA** – Instituto Interamericano de Cooperación para la Agricultura

France
- **RTBfoods** – Breeding Roots, Tubers and Banana products for end–user preferences
- **CIRAD** – Agricultural Research for Development

Germany
- **DSMZ** – German Collection of Microorganisms and Cell Cultures, Leibniz Institute
- **GIZ** – Deutsche Gesellschaft für Internationale Zusammenarbeit

Ghana
- **CSIR** – The Council for Scientific and Industrial Research

India
- **ICAR** – Indian Council of Agricultural Research
- **CTCRI** – Central Tuber Crops Research Institute

Honduras
- **DICTA** – Dirección de Ciencia y Tecnología Agropecuaria

Indonesia
- **UB** – University of Brawijaya
- **ILETRI** – Indonesian Legumes and Tuber Crops Research Institute

Japan
- **RIKEN Center for Sustainable Resource Science**
- **Kyushu University**
- **YCU** – Yokohama City University

Laos
- **NAFRI** – National Agriculture and Forestry Research Institute
- **DOA–LAO** – Ministry of Agriculture and Forestry
- **PPC** – The Plant Protection Center

Malawi
- **MARI** – Mikocheni Agricultural Research Institute

Myanmar
- **DOA-MYANMAR** – Ministry of Agriculture, Livestock and Irrigation
- **DAR** – Department of Agricultural Research

Netherlands
- **WRU** – Wageningen University & Research

Nicaragua
- **INTA** – Instituto Nicaragüense de Tecnología Agropecuaria

Nigeria
- **IITA –** International Institute of Tropical Agriculture
- **NRCRI** – National Root Crops Research Institute

Peru
- **RTB** – Roots, Tubers and Bananas, CIP (International Potato Centre)
- **UNDAC** – Universidad Nacional Daniel Alcides Carrión
- **INIA** – Instituto Nacional de Innovación Agraria
- **FECONAYA** – Federación de Comunidades Nativas Yaneshas
- **IBC** – Instituto del Bien Común

Switzerland
- **SADC** – Swiss Agency for Development and Cooperation
- **ETH Zurich** – Swiss Federal Institute of Technology Zurich
- **SFSA** – Syngenta Foundation for Sustainable Agriculture

Tanzania
- **TARI** – Tanzania Agricultural Research Institute

Thailand
- **KU** – Kasetsart University
- **TTDI** – Thai Tapioca Development Institute
- **DOA** – Department of Agriculture Thailand

Uganda
- NaCRRI – National Crops Resources Research Institute
- NARO – National Agricultural Research Organization

United Kingdom
- **NRI** – Natural Resources Institute
- **RHUL** – Royal Holloway University of London

United States
- **Cornell University**
- **BMGF** – Bill and Melinda Gates Foundation
- **UCR** – University of California, Riverside
- **MSU** – Michigan State University
- **UF** – University of Florida
- **Ingredion Incorporated**

Vietnam
- **AGI** – Agricultural Genetics Institute
- **RDRDC** – Root Crop Research and Development Center
- **HLARC** – Hung Loc Agricultural Research Center
- **NOMAFSI** – Northern Mountainous Agriculture and Forestry Science Institute
- **TNU** – Tay Nguyen University
- **IAS** – Institute of Agricultural Sciences for Southern Vietnam
- **FCRI** – Field Crops Research Institute
- **PPRI** – Plant Protection Research Institute

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DESIGN AND PRODUCTION: www.coretext.com.au