www.cipotato.org

CGIAR

Science for a food-secure future

The International Potato Center (known by its Spanish acronym CIP) is a research-for-development organization with a focus on potato, sweetpotato, and Andean roots and tubers. CIP is dedicated to delivering sustainable science-based solutions to the pressing world issues of hunger, poverty, gender equity, climate change and the preservation of our Earth's fragile biodiversity and natural resources.
www.cipotato.org

CIP is a CGIAR Research Center.
CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of partners across the globe.
www.cgiar.org

facebook.com/cipotato *@cipotato* *cip_cipotato*

International Potato Center
Av. La Molina 1895, La Molina. Apartado 1558, Lima 12, Perú
5-11-3496017 *cip-comms@cgiar.org* *www.cipotato.org*

CIP
INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

Annual Report 2017

HARNESSING POTATO AND SWEETPOTATO'S POWER
FOR FOOD SECURITY, NUTRITION AND CLIMATE RESILIENCE

Annual Report 2017

HARNESSING POTATO AND SWEETPOTATO'S POWER FOR FOOD SECURITY, NUTRITION AND CLIMATE RESILIENCE

CIP
INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

Harnessing Potato and Sweetpotato's Power
For Food Security, Nutrition and Climate Resilience

International Potato Center | Annual Report 2017
© 2018, International Potato Center

ISSN 0256-6311
DOI: 10.4160/02566311/2017
Hecho el Depósito Legal en la Biblioteca Nacional del Perú N° 2005-9640

Readers are encouraged to quote or reproduce material from this report. As copyright holder CIP requests acknowledgement and a copy of the publication where the citation or material appears. Please send this to the Communications and Knowledge Resources Center at the address below.

International Potato Center
Av. La Molina 1895, La Molina, Perú
Apartado 1558, Lima 12, Perú
cip@cgiar.org
www.cipotato.org

Press run: 500
September 2018

Editor/Writer
David Dudenhoefer (consultant)

Production coordinator
Cecilia Lafosse

Design and layout
José Enrique Torres

This work by the International Potato Center is licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0)
To view a copy of this license, visit https://creativecommons.org/licenses/by/4.0/. Permissions beyond the scope of this license may be available at: http://www.cipotato.org/contact/

Printed by Tarea Asociación Gráfica Educativa. Pasaje María Auxiliadora 156-164 Breña, Lima-Perú

© S. Quinn/CIP

CONTENT

FOREWORDS 06
Dr. Rodney Cooke, Board Chair 06
Dr. Barbara H. Wells, Director General 07
OUR CROPS 09
Potato 10
Sweetpotato 11

13

14 Innovations Help Andean Farmers Improve their Food Security and Incomes

16 Use of Orange-fleshed Sweetpotato Purée in Bread Boosts Demand for the Crop

18 Participatory Varietal Selection Brings Biofortified Potatoes Closer to National Release

20 Improving Farmer Livelihoods and Resilience with Sweetpotato in India

22 Quality Seed Potato Enables Farmers to Move Beyond Poverty in Africa

26 Resilient Sweetpotato Varieties Benefit Families Across Mozambique

28 International Award Recognizes CIP's Farmer-Centric Approach to Disease Control

29 Pest Risk Atlas Informs Efforts to Help Farmers Prepare for Climate Change

30 Genetic Sequencing Sheds New Light on Potato and Sweetpotato Diversity

32 Understanding Gender Differences to Improve Development Work

34 Ensuring a Sustainable Supply of Quality Sweetpotato Planting Material

36 Late Blight-Resistant Potato Holds Promise for Farmers in East Africa

37 New Insight on Potato Variety Adoption and Impacts in Peru

40 RTB: Root and Tuber Innovations for Better Harvests and Livelihoods

40

42

BOARD OF TRUSTEES 42
LEADERSHIP 43
FUNDERS 44
FINANCIALS 45
GLOBAL PRESENCE 46

Our mission is to work with partners to achieve food security, well-being, and gender equity for poor people in root and tuber farming and food systems in the developing world. We do this through research and innovation in science, technology, and capacity strengthening.

© S. Fajardo/CIP

© J. Torres/CIP

Board Chair Foreword

The International Potato Center's Board of Trustees is committed to providing programmatic governance and financial oversight and leadership to ensure the Center's effective and efficient management. I'm pleased to report that CIP made good progress toward its strategic objectives in 2017, through both upstream research and the deployment, with partners, of technologies to improve lives in farming and food systems in developing countries that involve roots and tubers.

CIP moved closer to its goal of reaching 15 million households in Africa, Asia and Haiti with orange-fleshed sweetpotato by 2023, while facilitating seed system and market innovations to accelerate the scaling process in the coming years. By December of 2017, CIP and partners reached the milestone of more than 4.5 million households benefitting from this nutritious crop. CIP has also made significant gains in expanding the use of quality seed potatoes in Africa, where the Center is more than two-thirds of the way to its goal of improving the potato production of 600,000 smallholder farmers.

Achievements in Asia include the release of CIP-bred, climate-smart potato varieties in India, Central and Southeast Asia, and the formalization of the CIP-China Center for Asia Pacific (CCCAP) in Yanqing. CIP also helped smallholders in South America to improve their potato production and access new markets, and played a major role in the organization of the 10th World Potato Congress, held in Cusco, Peru in 2018.

Financial Performance

Total Revenue reported in 2017 was $63.6 million, which was an increase of $5.2 million when compared with 2016, demonstrating CIP's continuous success in securing Window 3 and Bilateral funds, while stabilizing Windows 1 and 2 revenue sources. The long-term financial stability indicator, which measures the number of days of unrestricted net assets that can be used to cover CIP's forward-planned operations, is 86 days (within the CGIAR recommended norms). CIP's overall financial position continues to be sound and the Center did not need to use any credit facility during the year.

These financial results are derived from CIP's audited December 31, 2017 consolidated financial statements, which contain an unqualified audit opinion. They reflect CIP's continued financial health, though no institution is immune to financial or operational risk. To mitigate risk, the Board's Audit Committee ensures oversight of the Center's risk management policies and plans. In a much broader sense, the Board also oversees CIP operations in the interest of Funders and stakeholders.

Appreciation

I would like to express my gratitude to Dr. Alberto Maurer, who served on the Board until February of 2017, and congratulate him on his new role as the Chief Science Officer at CCCAP. I want to welcome Dr. Miguel Barandiaran, the Head of Peru's National Institute of Agricultural Innovation, who replaced Dr. Maurer as the representative of Peru's Ministry of Agriculture on the Board, and HE Rhoda Peace Tumusiime, from the Republic of Uganda, the former Commissioner of Rural Development for the African Union, who also joined the Board in 2017. On behalf of the Board, I would like to thank CIP's funders, investors and all CGIAR partners for their support. I also extend my appreciation to CIP's management and staff for their continued dedication to the organization and to its important mission.

Dr. Rodney Cooke
Chair, Board of Trustees

© J. Torres/CIP

Director General Foreword

It is a pleasure to share with you these examples of the research for development that CIP scientists are undertaking on behalf of poor people around the world. 2017 included important achievements in our work to conserve and study root and tuber biodiversity and to tap the power of those genetic resources to improve food security, incomes and farm resilience for the benefit of men, women and youth in Africa, Asia and Latin America.

CIP scientists are involved in groundbreaking research to deepen our understanding of potato and sweetpotato and develop innovations to improve the capacity of farmers to produce more nutritious food while adapting to climate change. Diagnostic tools to detect sweetpotato viruses and a biotech potato variety that is highly resistant to late blight have become a reality. Further downstream, CIP and partners are deploying technologies and practices that we have developed and validated: from climate resilient potato and sweetpotato varieties to seed system innovations to value chain approaches that create income generating opportunities.

The CIP Biodiversity Program, which focuses on our genebank activities, safeguards some of the world's most important collections of potato, sweetpotato and Andean roots and tubers – as *in vitro* germplasm, seeds and herbarium specimens. That genetic diversity, held in trust for humanity, is the foundation of much of our work. CIP is well respected as the leading center of excellence in cryopreservation, and we are grateful to Germany's Federal Ministry for Economic Cooperation and Development/GIZ and The Global Crop Diversity Trust for funding the expansion of our Genebank's cryopreservation lab and herbarium.

CIP's promotion of orange-fleshed sweetpotato (OFSP) to improve food security and reduce vitamin A deficiency – which causes child blindness and other afflictions across the developing world – continues at an impressive pace. By December of 2017, we had reached 4.5 million households across Africa with this nutritious biofortified crop, and also increased its cultivation in Asia. This has been possible thanks to a broad coalition of partners and the generous support of various funders. Enhancing the breeding of improved sweetpotato varieties, expanding the supply of quality planting material, and creating new value chains is accelerating the scaling of vitamin A-rich OFSP.

We are likewise harnessing the power of the potato to improve food security and livelihoods. This includes the ongoing evaluation of biofortified potato varieties with elevated levels of iron and zinc, an initiative to expand the production and utilization of quality seed potatoes in Africa, and the promotion of early-maturing, climate-smart varieties to strengthen food security and improve incomes in Asia and Latin America.

2017 was a very significant year for CIP in China as we opened and began operating our state-of-the-art research facility in Yanqing. We are extremely grateful to the Chinese government for all they have done to make this possible.

CIP is the lead center coordinating the CGIAR Research Program on Roots, Tubers and Bananas (RTB), which facilitates cross-crop learning and innovation in areas that include seed systems, gender responsive crop breeding, and taking technologies to scale. This collaboration, which benefits CIP and partners alike, has been complemented by multi-crop initiatives such as Building Nutritious Food Baskets, in Africa, and FoodSTART+ in Asia. These and other collaborations are helping us achieve our mission of food security, well-being and gender equity for poor people in root and tuber food systems across the developing world.

Dr. Barbara H. Wells
Director General

Potato and sweetpotato have great potential for reducing hunger and malnutrition, and helping farmers adapt to climate change, thanks to their resilience and ability to produce nutritious food in less time than many other crops.

Our Crops

09

POTATO

A potato contains about half the daily adult requirement of vitamin C and significant amounts of vitamin B, iron, potassium, and zinc.

China is the world's largest producer, harvesting more than 73 million tons of potato a year.

More than a billion people worldwide eat potato as a staple food.

Potato can grow in almost any climate, from sea level to about 4,000 meters above sea level.

There are 5,000 different varieties of potato in CIP's genebank, half of them can be found only in Peru.

Potato is the third most important food crop after rice and wheat and produces more calories per hectare than either of those grains.

Potato produces more food per unit of water than any other major crop.

SWEETPOTATO

Just 125 g of fresh orange-fleshed sweetpotato root contains enough beta carotene to provide the daily vitamin A needs of a preschool-aged child. The crop is also a valuable source of vitamins B, C, and E.

Sweetpotato is also a healthy, cheap animal feed. Studies suggest that livestock fed on sweetpotato vines produce less methane, meaning its use could potentially mitigate global warming.

More than 105 million tons are produced globally each year, with 95% in developing countries.

Worldwide, sweetpotato is the sixth most important food crop after rice, wheat, potatoes, maize, and cassava, but it ranks fifth in developing countries.

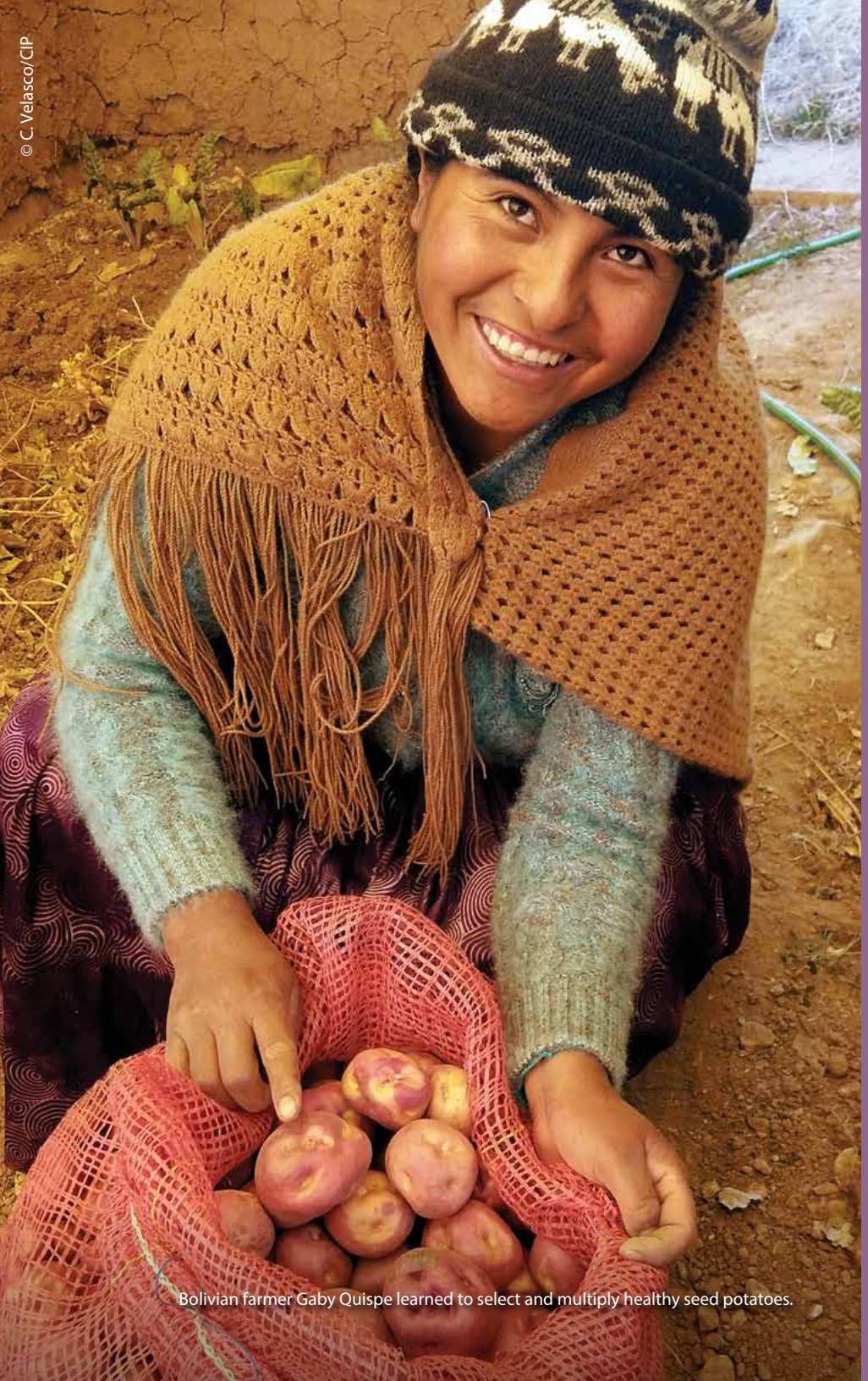
Sweetpotato is a storage root, not a tuber like the potato.

Sweetpotato can grow at altitudes from sea level to 2,500 meters above sea level, and comes in varieties ranging in color from white to yellow to orange to purple.

CIP is a global leader in the conservation of root and tuber biodiversity and research for development to harness potato and sweetpotato's power to improve food security, nutrition and incomes.

Stories

13



© C. Velasco/CIP

Bolivian farmer Gaby Quispe learned to select and multiply healthy seed potatoes.

Innovations Help Andean Farmers Improve their Food Security and Incomes

Funder: International Fund for Agricultural Development (IFAD)
Countries: Bolivia, Ecuador, Peru

Farmer Madelaine Rodríguez has learned an array of ways to improve the production of her potato farm in Huarochirí, high in the Andes east of Lima, Peru. She knows how to select and store healthy seed potatoes for the coming season and how to bury a plastic barrier around her field to keep weevils from damaging the tubers, among other good practices. This is because Madelaine is one of more than 30 farmers in Huarochirí, and hundreds across the region, who have participated in farmer field schools run by CIP and local partners.

> "We've learned things we didn't know before. We used to farm our way, but now we're farming better," she said.

Madelaine is one of approximately 1,200 smallholders participating in a two-year project called "Strengthening innovation to improve the incomes, food security and resilience of potato farmers in Bolivia, Ecuador and Peru," supported by IFAD. According to André Devaux, CIP Regional Director for Latin America and the Caribbean, that initiative is helping farmers adopt technologies and approaches that CIP researchers have developed and validated over the past two decades. The project facilitated the development of collaborative mechanisms to help local governments, national programs such as the Peruvian Ministry of Agriculture and Irrigation's *Proyecto Sierra y Selva Alta*, and non-governmental organizations such as ADERS-Peru to use those innovations and knowledge in ways that add value to IFAD's projects in the region.

In addition to providing farmers with tools and knowledge to improve their potato production, CIP has encouraged the cultivation of native

CIP and partners taught more than 1,200 Andean farmers how to improve their potato production and farm resilience.

potato varieties, while assessing the nutritional and commercial value of local landraces, and using a participatory market approach to help farmers access urban markets for those colorful tubers. CIP helped farmers from Huarochirí attend the annual gastronomic fair Mistura, in Lima, where they sold dried native potatoes – which are combined with pork, chicken and other ingredients to make the tasty Peruvian dish *carapulcra* – and made contacts with restaurant representatives.

As one of those farmers, Ceferino Pomalia, explained: "The sale of potatoes helps our community improve our homes and the education of our children."

The farmers' association in Huarochirí is one of 15 such groups in Peru and approximately 40 across the three participating countries. In Bolivia, where CIP partners with the government programs ACCESOS and *Plan Vida*, farmers have learned to produce quality seed potatoes to improve their production of 23 native and commercial potato varieties. CIP is building on previous initiatives to promote the consumption of native potatoes as a way to help farmers conserve potato biodiversity while tapping its potential to improve incomes and nutrition in highland communities.

The initiative has also worked with farmers and partners to evaluate improved varieties with resistance to late blight disease and climate-smart qualities, among them the CIP-bred varieties Kawsay in Peru, Libertad in Ecuador, and four varieties in Bolivia, in collaboration with Fundación PROINPA. Agronomists have also provided training in integrated pest and disease management, such as the use of a CIP-developed decision support tool for controlling late blight that enables farmers to tailor fungicide use to specific varieties and weather conditions, reducing the number of fungicide applications, which results in significant savings and a smaller environmental footprint.

Ecuador project coordinator Claudio Velasco cited the example of the farmers' association in Tiupitian, in Ecuador's Bolivar province, whose members improved their yields by using healthier seed potatoes and reduced the amount of fungicides they used to control late blight. This resulted in better harvests and lower production costs, which allowed the association to pay off an outstanding debt.

Claudio explained that CIP collaborates with the Ecuadorean Ministry of Agriculture's *Buen Vivir Rural* program, as well as municipal and provincial governments and other partners. Both he and Paola Flores, the project coordinator in Bolivia, report that local governments have begun incorporating the technologies and approaches that CIP has introduced into their own farmer extension programs, which will ensure that those innovations continue to be disseminated after the project's 2018 conclusion.

> "I think that we are setting a foundation for local actors to continue the work we've started," Claudio said.

Madelaine Rodríguez learned ways to improve her potato production in Huarochirí, Peru.

In all three countries, CIP is working with the agriculture and education ministries to get certificates awarded to project participants who have mastered important agronomic skills and could serve as extensionists in their areas. One of those farmers is Gaby Quispe, from the community of Huañajahuira, in Bolivia's Patacamaya municipality. She hopes to be certified as a rural seed production expert and work with the National Potato Program.

> "I'm very happy to have learned these things, and I want to go to other communities and share them with my brother and sister farmers," she said.

© C. Bukania/CIP-SSA

Baked goods made with nutritious OFSP purée are gaining popularity in East Africa.

Use of Orange-fleshed Sweetpotato Purée in Bread Boosts Demand for the Crop

Funders: Bill & Melinda Gates Foundation, UK aid/DFID, U.S. Agency for International Development (USAID)

Region: East Africa

CIP's efforts to increase consumption of orange-fleshed sweetpotato (OFSP) – and thereby reduce the incidence of vitamin A deficiency (VAD) – include the promotion of baked or fried products made with OFSP purée. These nutritious products not only contain significant levels of beta-carotene, which the body converts into vitamin A, they are generating greater demand for sweetpotato roots, thereby improving the incomes and diets of thousands of smallholder farmers.

Dr. Tawanda Muzhingi, a CIP regional food scientist and nutritional biochemist based in Nairobi, Kenya, explained that the principal goal of promoting the use of OFSP purée by bakeries is to catalyze new value chains for the crop, in order to get more farmers growing and more rural families eating those nutritious roots. Research has shown that consuming OFSP reduces VAD, which causes blindness, stunting and other ailments in young children and mothers across sub-Saharan Africa (SSA). CIP promotes OFSP to pregnant and lactating mothers in Kenya through prenatal health programs, and provides farmers with planting material and nutrition education, yet not all are willing to plant OFSP, because some prefer more traditional crops.

> "If a crop can be consumed at home and sold for income, the likelihood of adoption is higher," observed Tawanda.

The relatively short shelf life of sweetpotato roots means that farmers need to sell them quickly, which creates harvest season gluts that depress their market value. Tawanda and colleagues have thus tested options for extending roots' shelf life, and the most promising option is the transformation of OFSP roots into a purée that – if mixed with preservatives – can be stored in vacuum-packed bags without refrigeration for up to three months. Bakeries can substitute the purée for 45 percent of the flour used to make dough, reducing their production costs by decreasing the need for sugar and imported wheat.

CIP provided technical assistance to the company Organi Ltd, which set up an OFSP processing plant in Homa Bay County, in Western Kenya, that purchases 20 tons of OFSP roots per month from about 3,000 smallholder farmers to produce purée. While Organi uses some of that purée to produce OFSP bread for the local market, most of it is sold to Tuskys, Kenya's biggest supermarket chain, which bakes about 3,000 loaves of OFSP bread and a comparable amount of OFSP buns each day for sale in 23 stores.

OFSP bread is gaining popularity in Nairobi, which is good news for Organi's staff and suppliers, many of who are women. Organi pays farmers twice the market rate for roots, to ensure a supply of quality OFSP. CIP and partners used a value chain approach and provided agronomic training for those farmers and the decentralized vine multipliers who sell them planting material, to facilitate increased production.

One of those farmers, Olga Otieno, explained that she began growing OFSP three years ago for food security, income and a source of vitamin A. The money she earns selling roots to Organi Ltd now covers her children's school fees, among other household expenses. As demand for OFSP baked products grows, more farmers like Otieno will benefit from the market it creates.

New markets for OFSP roots motivate more farmers to grow them, which means more children eat the nutritious crop.

Organi Ltd buys OFSP roots from 3,000 farmers in Western Kenya and sells OFSP purée to supermarkets in Nairobi.

Tawanda explained that CIP provided technical assistance to Tuskys for the development OFSP baked products in 2015, and did in-store research on consumer acceptance and willingness to pay. The consumer response was positive, but Tuskys' management decided to roll out OFSP baked goods gradually, out of concern that demand might exceed their ability to produce them. This decision proved sound when a drought hit East Africa the following year, significantly reducing sweetpotato harvests. As the rains returned in 2017, OFSP production rebounded and Tuskys was able to increase the number of stores that sell the bread, though less than half of 56 Tuskys supermarkets currently offer those products.

In June of 2017, CIP began training bakers at Naivas, Kenya's second biggest supermarket chain, in preparation for the sale of OFSP bread products in five stores. A second company has begun producing OFSP purée in Kenya, creating new employment opportunities for women and youth, and companies in Tanzania and Malawi are also developing OFSP products. Tawanda observed that rapid urbanization in Africa is creating potential markets for OFSP bread that entrepreneurs can capitalize on. He added that CIP's OFSP purée technology will facilitate this process.

> "There is now organic growth that is driven by small and medium enterprises that want to make money from agriculture, without a lot of support from donor-funded projects, which makes me very excited," Tawanda said.

Participatory Varietal Selection Brings Biofortified Potatoes Closer to National Release

Funders: European Union, CGIAR Trust Fund contributors through the CGIAR Research Programs on Roots, Tubers and Bananas (RTB), Agriculture for Nutrition and Health (A4NH) and Harvest Plus

Countries: Peru, Ethiopia, Rwanda, Bhutan, Nepal

In May of 2017, indigenous farmers in five rural communities of Yauli district, in Peru's Huancavelica Region, harvested fields planted with 17 potato clones with increased levels of iron and zinc, developed by CIP as part of its mission to reduce malnutrition. While their families ended up eating most of those colorful potatoes, farmers saved tubers from what they had collectively determined to be the best seven clones for planting when the rains resumed in November, as part of a participatory varietal selection process to choose the best candidates for release as new varieties in Peru, based on farmer and consumer opinions.

Those potatoes are the result of almost 15 years of work by CIP and local partners. The process began with lab analyses of approximately 200 native Andean landraces, which resulted in the identification of 16 with relatively high levels of iron, zinc and vitamin C. CIP breeders then spent a decade crossing those nutritious potatoes and selecting offspring with even higher levels of iron and zinc – a process known as biofortification. The resulting clones have between 40 and 80 percent more iron and zinc than commonly grown varieties, which means they have the potential to make a significant contribution to reducing micronutrient malnutrition.

An estimated 1.6 billion people globally suffer iron and zinc deficiencies, primarily young children and women of childbearing age, and severe cases can result in childhood stunting, hindered mental development, susceptibility to infections and maternal mortality. According to a Peruvian government study, one-third of children five years or younger in the Huancavelica region suffer chronic micronutrient malnutrition, and 40

Participatory varietal selection allows rural men and women to select candidate potato varieties for national release.

The biofortified potatoes being grown in Huancavelica, Peru are the result of crosses between native varieties with elevated levels of iron and zinc.

percent are anemic. Malnutrition is also common among women of reproductive age in the region.

With support from the European Union and CGIAR Trust Fund contributors, through A4NH and RTB, CIP has been able to get biofortified potatoes to farmers in highland areas of Peru and other countries where micronutrient malnutrition is common. According to CIP biologist and nutritionist Gabriela Burgos, "These potatoes have great potential for reducing anemia because they also contain high levels of vitamin C, which facilitates the absorption of iron, and low levels of phytates, which inhibit the absorption of iron."

CIP partnered with the Peruvian nonprofit Grupo Yanapai to coordinate the participatory varietal selection of the biofortified potatoes by farmers in Huancavelica, and to provide nutrition education to get local families to diversify their diets – a strategy that CIP and partners use frequently. Grupo Yanapai's Executive Director, Maria Scurrah, explained that local women have started growing vegetable gardens and now feed their children more animal protein. She noted that those families eat a lot of potatoes, and they like the biofortified clones because they look and taste like the native varieties they've traditionally grown.

> Alicia Azorsa, who grows the seven selected varieties on her small farm in the village of Castillapata, in Huancavelica, said that she and her daughter, Luz, eat them every day. "We like these potatoes very much because they protect our children and us against diseases. They are also delicious," she smiled.

According to CIP scientist Thomas zum Felde, CIP and local partners have also organized the participatory varietal selection of biofortified potato clones with farmers in Ethiopia and Rwanda, and CIP is working with partners in Bhutan and Nepal to do the same. He noted that even though those small, colorful clones are quite different from the potatoes grown in Africa and Asia, the African farmers who have tasted them liked them. In parallel, CIP is building the capacity of regional partners in Africa and Asia to perform lab analyses of iron and zinc levels, in preparation for the incorporation of biofortified potatoes in breeding programs and scaling efforts in those regions.

While the biofortified potatoes currently being grown by farmers are quite nutritious, they have lower yields and are less resilient than other improved varieties. CIP Breeders have thus spent the past six years crossing them with parents in CIP's advanced breeding populations, resulting in a new population of biofortified clones with much higher yields, as well as resistance to late blight and virus diseases. Multilocational field trails and participatory varietal selection of that second set of biofortified clones began in Peru in late 2017, in partnership with the National Institute for Agricultural Innovation, and should take two or three years to result in a nationally released variety. *In-vitro* plants of those clones have also been shipped to Ethiopia, Rwanda, Bhutan and Nepal for local testing.

CIP biologist and nutritionist Gabriela Burgos with children in one of the Peruvian communities that are growing, eating, and evaluating biofortified potatoes.

> "We are pioneers in the biofortification of potato," observed CIP potato breeder Walter Amorós. "We've accomplished a lot, but we need to continue increasing the micronutrient levels and other desirable characteristics of these potatoes."

CIP helped approximately 6,000 farmers in Odisha improve their sweetpotato production under GAINS.

Improving Farmer Livelihoods and Resilience with Sweetpotato in India

Funders: Government of India, Odisha Directorate of Horticulture
Country: India

Dr. Sreekanth Attaluri, who has worked for CIP in India since 2002, has witnessed an important change in the perceptions and cultivation of sweetpotato in the eastern state of Odisha. Whereas few people considered sweetpotato important and only white-fleshed varieties were grown in Odisha a decade ago, production has increased and farmers and consumers are more interested in nutritious orange-fleshed sweetpotato (OFSP) varieties.

> "Sweetpotato was once considered a poor man's crop here, but now it is considered a rich man's crop," Sreekanth said.

Much of that change took place during the past four years, thanks to a CIP-led project called Generating Advances in Incomes and Nutrition through Sweetpotato (GAINS). Funded by India's Ministry of Agriculture and managed by the Odisha state government, GAINS has improved the sweetpotato production and incomes of approximately 6,000 of the state's smallholder farmers. And when the project ended in November of 2017, Odisha was poised for even greater expansion of the crop.

Odisha is India's largest sweetpotato producer, and the crop has religious and cultural significance there, yet Sreekanth lamented that too few people know about its nutritional value and value chain opportunities. This only began to change after government officials become aware of one of sweetpotato's many attributes – it's resiliency in extreme climate events. In 2013, Cyclone Phailin battered India's eastern coast, destroying much of Odisha's crops and raising the specter of hunger. However, most sweetpotato fields survived, so farmers dug up those roots in the days following the storm, saving tens of thousands from hunger and confirming sweetpotato's value as a disaster recovery crop.

Indian officials consequently decided to promote sweetpotato cultivation in Odisha. In 2013, CIP signed an agreement with the Government of India for the four-year GAINS project, for which CIP partnered with the Odisha

By the end of 2017, farm productivity among participating farmers had increased by 17%.

CIP facilitated the production and distribution of planting material for high-yielding sweetpotato varieties.

Directorate of Horticulture, with participation by the Indian Council of Agricultural Research. Together, they crafted a gender-responsive approach to help farmers increase their yields and incomes while promoting consumption of sweetpotato in four Odisha districts: Ganjam, Dhenkanal, Koraput and Sundargarh.

Improved sweetpotato varieties like Kanjangad and orange-fleshed Bidhan Jyoti, which are more nutritious and higher yielding than local varieties, were introduced into those districts. CIP facilitated the production and distribution of planting material for them, set up demonstration blocks, and arranged training in good agricultural practices for more than 2,000 farmers and extension agents. That training was tailored to the needs of farmers in different areas, since commercial production dominates the lowlands of Ganjam and uplands of Dhenkanal districts, whereas the hilly Koraput and Sundargarh districts are predominantly home to tribes that mainly grow sweetpotato for family consumption.

Smallholder Srinivas Sahoo and various other farmers from the village of Shankarpur, in Dhenkanal district, had traditionally grown rice, but suffered poor harvests during low-rain years. They got planting material for the improved sweetpotato varieties from a nearby horticulture station, and were happy to find that sweetpotato tolerates drought and produces more food per hectare than other crops. "There are now around 500 farmers in our village growing sweetpotato," he said.

By the end of 2017, the area dedicated to sweetpotato in the four districts had grown by 25%, productivity had increased by 17%, and farmer incomes had increased by as much as 40%. CIP complemented its efforts to increase production with campaigns to promote sweetpotato consumption – a campaign that benefitted from lessons learned in Africa, where Sreekanth visited several CIP projects. CIP scientists and World Food Prize Laureates Maria Andrade and Jan Low – who have led highly successful campaigns promoting OFSP in Africa – travelled to Odisha to advise Sreekanth. The resulting campaign included educational posters, murals and street shows about sweetpotato's nutritional value, its introduction into school lunch programs, sweetpotato kiosks near Hindu temples and a mobile kitchen where cooking demonstrations with sweetpotato are offered to the public. Odisha chef Ahmad Khan noted that sweetpotato can be used in an array of Indian dishes including *samosas*, the flatbread *paratha* and the deserts *gulab janum* and *khir*.

As a testament to GAINS' success, the Government of India approved a second phase of the project starting in July of 2018. That phase will replicate achievements of phase I in four additional districts, while placing greater emphasis on nutrition education and varieties with high beta-carotene content. Though GAINS has only worked in four of Odisha's 30 districts, it has established a scalable approach that can be used to accelerate adoption of improved varieties in the rest of the state.

> "We've built the confidence of the farmers, the state government and the other research institutions," Sreekanth said. "In the second phase, we want to focus on getting more people to grow and eat sweetpotato."

© R. Jumah/FIPS-Africa

Seed multiplier Harun Kirimi with seed potatoes of the variety Asante.

Quality Seed Potato Enables Farmers to Move Beyond Poverty in Africa

Funders: German Federal Ministry for Economic Cooperation and Development/GIZ, Syngenta Foundation for Sustainable Agriculture, U.S. Agency for International Development (USAID)

Region: Sub-Saharan Africa

Potato holds great promise for reducing hunger and poverty in Africa, but with average yields of 6 to 12 tons per hectare (compared to 35-45 tons/ha in Europe and North America), the continent's smallholder farmers are far from achieving the crop's potential. One reason for this is that most farmers plant seed potatoes they save from their last harvest, or purchase them at a local market, and those tubers are usually infected with viruses or other pathogens that reduce yields.

CIP is thus using an integrated approach to improve potato harvests by increasing farmer access to quality seed potatoes of high-yielding, disease-resistant varieties. To accomplish this, CIP works with partners in various African countries that include government institutions, NGOs, cooperatives and businesses. The strategy is based on facilitating the production of disease-free, early generation seed, promoting national efforts to regulate the use of quality seed potatoes, and building supply chains to expand seed potato availability and affordability.

Current efforts build upon years of research and interventions to accelerate and expand seed potato production in sub-Saharan Africa (SSA). CIP developed a "3G" approach that has reduced the time it takes to produce certified seed potatoes from five-to-seven field generations to just three, and promoted the use of sand hydroponics and aeroponics. CIP scientists have recently enhanced this approach through the use of apical cuttings: plantlets grown from cuttings from disease-free mother plants that are hardened in a screen house and planted in soil once they sprout roots. This method produces more disease-free seed tubers in less time and for less money than other seed multiplication technologies.

Experience has shown that smallholders who used high quality seed potatoes produce better harvests – and thereby enjoy greater food security

CIP has spent years working to accelerate and expand seed potato production in SSA.

and incomes – than farmers who don't. One study in Kenya found that farmers who used quality seed doubled their incomes from the sale of ware potatoes in just two years. Nevertheless, the cost and difficulty of obtaining quality seed potatoes, and a lack of awareness of their potential, have prevented the vast majority of African farmers from using them.

CIP and partners have thus trained hundreds of independent farmers and members of cooperatives and youth groups to become decentralized seed multipliers (DSM), and connected them to government agencies or businesses that can sell them disease-free tubers or rooted apical cuttings as starting material. By multiplying that material and selling seed potatoes to smallholders, those DSMs have introduced tens of thousands of farmers to the power of quality planting material.

To help farmers get the best possible yields from their seed potatoes, CIP and partners have also trained approximately 100,000 potato farmers in SSA in good farming practices. Additionally, members of cooperatives and youth groups have received training in business skills, to help them build successful seed enterprises. Seed multipliers that have participated in the project are now earning an average of US $3,000 per hectare, compared to farmers surveyed in Kenya who earned an average of US $1,325 per hectare for ware potatoes in a season when market prices were high.

Mary Kinya, a DSM in Kenya's Meru County, suffered meager yields before receiving training and certified seed potatoes from CIP partner Farm Input Promotions Africa. She was amazed when her first potato harvest from certified seed produced the equivalent of 26.75 tons per ha – more than double the average local yield. She saved a third of those potatoes for planting, sold a third as seed, gave one-kg bags to 100 farmers to plant, and sold or saved the rest for food. Local farmers have pre-ordered much of her next seed potato harvest.

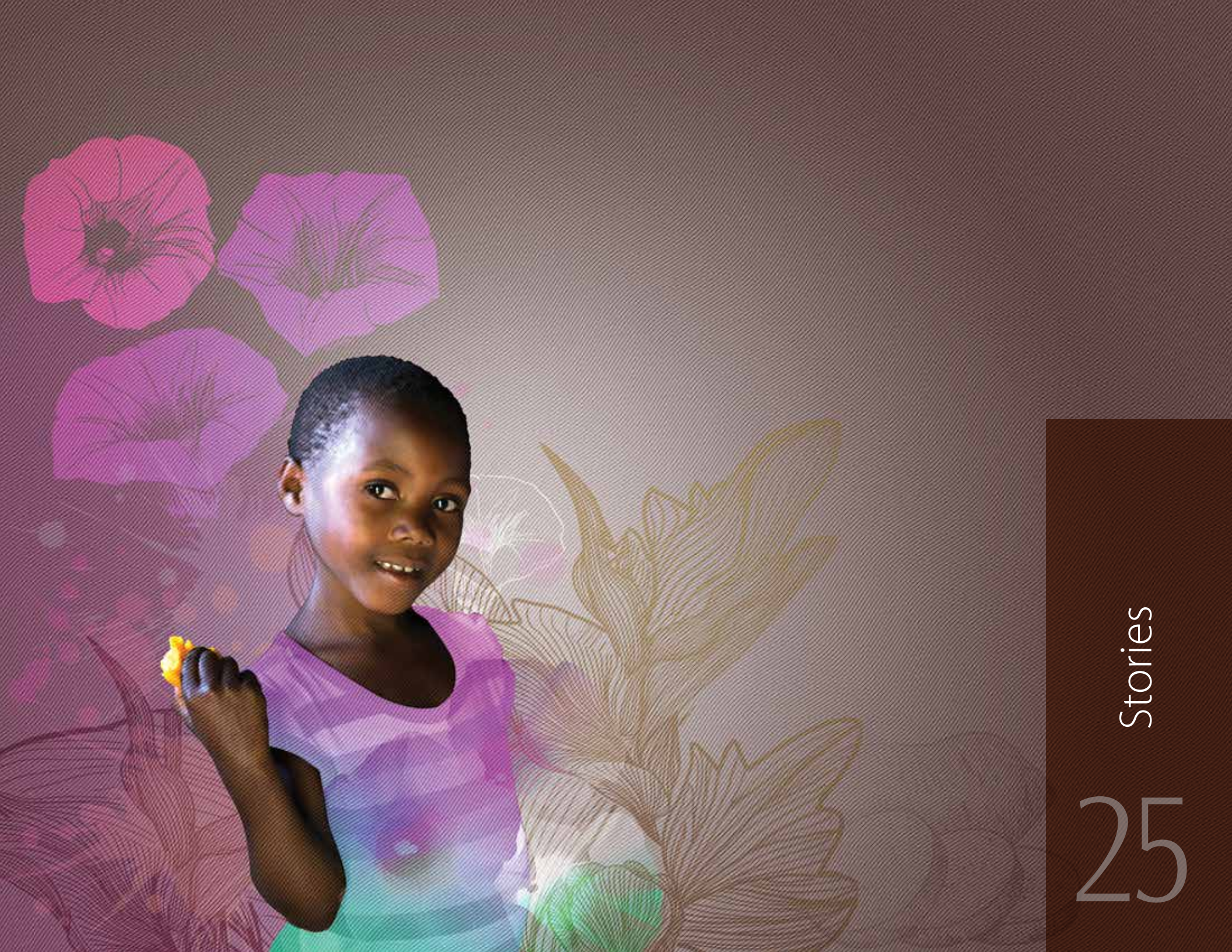
> "I never knew the local seed I was planting was one of the reasons my potato production was poor," Mary said. "Life was a real challenge before I became a seed multiplier, but today, I have enough money to buy good food for my family,"

In Ethiopia, CIP has supported government agencies in the promotion of quality declared planting material as an alternative to certified seed, with comparable results. CIP and partners provided training in quality seed production to approximately 150 potato cooperatives, which purchase early generation seed from the Ethiopian Institute of Agriculture Research for multiplication and sale. This has resulted in more than 200,000 Ethiopian farmers using quality declared seed potato. CIP and national partners conducted a study of 116 of those farms and found that their yields were 63 percent greater than those of farmers who didn't use quality seed.

Seed multiplier Mary Kinya gives one kilogram of seed potatoes to a farmer to try.

Thus far, this initiative has gotten quality seed potatoes to more than 380,000 farmers in Kenya, Ethiopia and Malawi, plus about 100,000 in Burundi, Cameroon, Rwanda, Tanzania and Uganda, which means CIP is rapidly approaching its target of 600,000 farmers between 2014 and 2023. At the same time, CIP and partners have validated technologies such as sand hydroponics, apical cuttings and improved varieties that can be taken to scale to improve the food security and livelihoods of a growing number of potato farming families.

CIP and partners are engaged in groundbreaking research in potato and sweetpotato, and the development of innovations to improve farmers' capacities to produce more nutritious food in a climate-changing world.



Stories

25

Resilient Sweetpotato Varieties Benefit Families Across Mozambique

Funders: Bill & Melinda Gates Foundation, U.S. Agency for International Development (USAID)

Country: Mozambique

In December of 2017, a total of 2,778 farmers in Inhambane province, in southern Mozambique, planted the CIP-bred sweetpotato variety Alisha, which had been released the year before. It was a significant increase from the 500 farmers who planted that variety in 2016, indicating that nutritious and resilient Alisha has good potential for contributing to efforts to reduce hunger and malnutrition with orange-fleshed sweetpotato (OFSP).

According to CIP sweetpotato breeder and 2016 World Food Prize Laureate Maria Andrade, Alisha is comparable to Irene, Mozambique's most popular OFSP, which was one of 15 CIP-bred varieties released nationally in 2011. Maria has been promoting the cultivation and consumption of sweetpotato in Mozambique for more than two decades, and the OFSP varieties that she and her colleagues have developed now constitute one third of the sweetpotato grown there.

Irene is especially popular because its narrow leaves can be eaten as a vegetable 60 days after planting, and its delicious orange-fleshed roots are ready to harvest after 100 days. Like all the varieties that Maria has developed, Irene is drought tolerant, a vital trait in a country where extreme weather events frequently destroy crops. Maria and three other scientists were awarded the World Food Prize for their promotion of OFSP to combat vitamin A deficiency, which causes a host of health problems in sub-Saharan Africa, but she notes that the varieties she develops also contribute to food security and disaster recovery.

> "I have visited farms during droughts when the maize crop had collapsed but Irene was growing well," Maria said.

© B. Rakotoarisao/CIP

2,778 farmers in Inhambane, Mozambique, planted the OFSP variety Alisha in 2017.

© B. Rakotoarisao/CIP

Farmers in Inhambane harvest Irene, Mozambique's most popular OFSP variety.

Irene and Alisha are just two of the 22 sweetpotato varieties that Maria has developed over the past decade – 19 of which are OFSP, with high pro-vitamin A content, and three of which are purple-fleshed varieties with high levels of antioxidants. As part of the Sweetpotato Action for Security and Health in Africa (SASHA) project, Maria and her team are currently evaluating a new group of sweetpotato clones – purple-fleshed and OFSP – five or six of which should be released as new varieties in 2019.

The regular release of improved sweetpotato varieties in Mozambique is the result of an accelerated breeding scheme that cut the time it takes to develop and release a new variety from eight years to four. It involves simultaneous field assessments in three or four different environments, which allows scientists to identify viable candidates more quickly.

> "Being able to refresh the system every four years with more productive and nutritious varieties is wonderful for farmers," Maria said.

And Mozambican farmers aren't the only beneficiaries, since Irene is also being grown in Burkina Faso, Ivory Coast and Kenya. Maria's breeding work is thus improving lives across the continent.

CIP researchers designed a farmer-centric IPM approach to improve late blight management.

International Award Recognizes CIP's Farmer-Centric Approach to Disease Control

Funder: International Fund for Agricultural Development (IFAD)
Regions: Latin America, Africa and Asia

Late in 2017, CIP was informed that it had been chosen for an International Team Award of Excellence for its research and interventions promoting the integrated management of potato late blight through the farmer field school (FFS) approach, which has helped smallholder farmers manage this devastating disease. The award was bestowed by the organizers of the tri-annual International Integrated Pest Management (IPM) Symposium in recognition of about two decades of research and work with farmers on three continents.

A multidisciplinary team of CIP researchers and partner organizations designed and evaluated an IPM approach to address the human and technical dimensions of managing potato late blight disease in smallholder communities across Latin America, Africa and Asia. Potato late blight can cause catastrophic crop loss for smallholder farmers, who often can't afford the fungicides needed to control that disease, or may not know how to use them properly, in which case they can suffer significant yield loss despite spending money on agrochemicals.

In the late 1990s, those researchers recognized that scientific innovation alone wasn't enough to avoid the devastating losses in potato yields that late blight can cause on smallholder farms, so they designed a farmer-centric approach based on the FFS approach. The FFS approach, developed by the Food and Agriculture Organization of the United Nations (FAO), uses group-based learning to facilitate farmer access to information, knowledge and technologies. Between 1999 and 2007, in partnership with research and development organizations (government and NGO) in Bangladesh, China, Ethiopia, Uganda, Bolivia, Ecuador and Peru – primarily with support from IFAD – CIP and partners developed and tested discovery-based learning methods to help small-scale – and frequently illiterate – farmers to understand principles and practices involved in late blight management.

CIP adopted a two-pronged approach: making the principles of late blight management more visible and understandable for farmers while testing new potato clones with resistance to the disease. A subsequent assessment of the approach's effectiveness documented a 32% average increase in potato productivity and incomes on farms in Peru. Farmers in other countries who benefitted from the approach experienced comparable improvements.

> "Successful farmer adoption of agricultural technology, crop varieties, and practices, requires taking time to truly understand farmers and their current needs, preferences, and goals, and how they can learn about crop problems and technologies" explained Dr. Oscar Ortiz, CIP's Deputy Director General for Research and Development. "By working together with government organizations, NGOs, other research organizations and the farmers themselves, with each of them bringing their experience and perspectives, we can develop viable solutions that improve the livelihoods of smallholders worldwide. The FFS approach has continued evolving and now we talk about farmer business schools"

The potato tuber moth (*Phthorimaea operculella*) is already a serious pest in many of Africa's potato farming areas.

Pest Risk Atlas Informs Efforts to Help Farmers Prepare for Climate Change

Funders: German Federal Ministry for Economic Cooperation and Development (BMZ), CGIAR Trust Fund contributors through the CGIAR Research Program on Roots, Tubers and Bananas (RTB)

Region: Sub-Saharan Africa

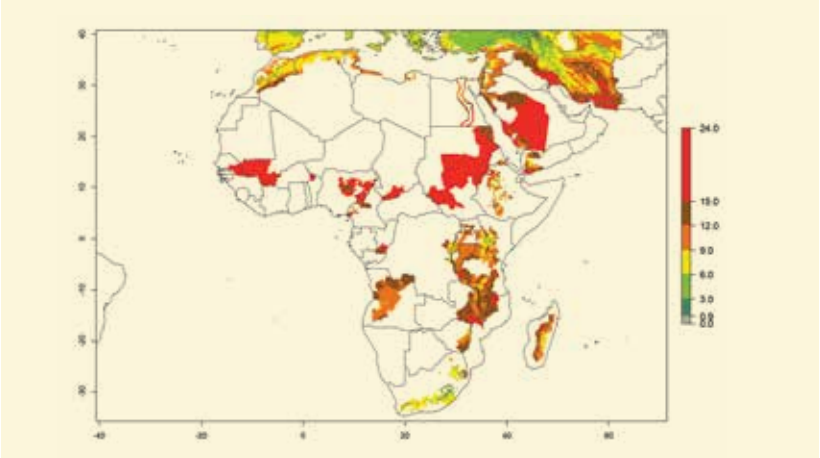
It is estimated that between 30 and 50 percent of the yield loss on African farms is caused by crop pests, a problem that is expected to grow worse as climate change advances. In early 2017, CIP launched an online Pest Distribution and Risk Atlas for Africa to help governments and other actors improve crop pest management across the continent.

That open-access, mobile-accessible resource combines up-to-date information on major insect threats to potato, sweetpotato, vegetable and maize production with current risk maps for each pest and predictions for future climate scenarios. Researchers, agricultural ministry officials and extensionists can use that information to plan efforts to help farmers better manage crop pests now and prepare for future threats.

> "Any increase in temperature caused by climate change will have drastic effects on pest invasions and outbreaks that will affect pest management, crop production and food security," warned Dr. Jürgen Kroschel, CIP Agroecology and Integrated Pest Management science leader, who initiated the Pest Risk Atlas project.

He explained that rising temperatures can result in both range expansion and more intense outbreaks of insect pests. To predict those risks on global, regional and local levels, CIP scientists used advanced pest phenology modeling and geographic information system risk mapping, among other tools. Risk assessments from a collaborative project with the International Institute of Tropical Agriculture and the International Centre of Insect Physiology and Ecology were also included. In addition to the risk maps and assessments, the Atlas includes information on pest identification, ecology and impacts, as well as phytosanitary measures and farm-level adaptions for controlling them.

Jürgen explained that while its principal focus is raising awareness and disseminating scientific information, the Atlas also promotes the use of pest risk adaptation plans on a country level, as well as on-farm sustainable pest control methods that are not overly dependent on pesticides, such as biocontrol strategies for invasive pests. The ultimate goal is to improve pest management on the ground, increase crop yields, and contribute to the food security and incomes of Africa's smallholder farmers.



Map of predicted abundance of potato tuber moth (*Phthorimaea operculella*) in Africa by 2050

Genetic Sequencing Sheds New Light on Potato and Sweetpotato Diversity

Funders: German Federal Ministry for Economic Cooperation and Development/GIZ

Country: Peru

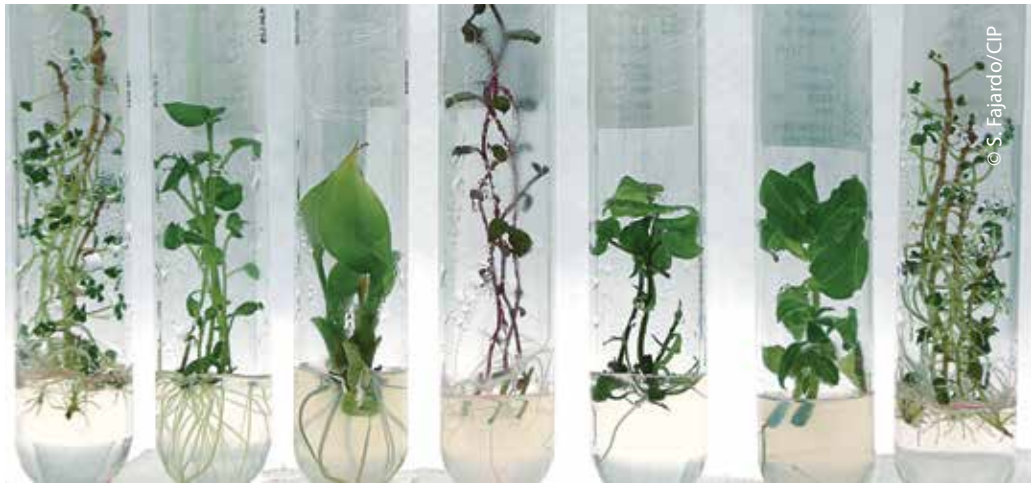
The collections of potato and sweetpotato biodiversity that the CIP genebank safeguards for humanity are among the world's most important for those crops. As part of an effort to improve the management of those genetic resources, the genebank undertook DNA fingerprinting for the entire collections of cultivated potato and sweetpotato, and the results have the potential to improve scientists' understanding of those crops.

Genebank Head David Ellis explained that for the more than 4,500 accessions of cultivated potatoes in the genebank, DNA fingerprints were established using thousands of genetic markers called single nucleotide polymorphisms (SNP) that can be used to identify individuals and understand their relatedness. The identification of species, subspecies and varieties has traditionally been based on morphological traits such as tubers, flowers and leaves, but genetic fingerprints can yield new insight into crop diversity, and the decreasing cost of sequencing is making that tool more accessible.

"Our main goal was to better understand our collection and build information that will make it more useful for current and future users," David said. He explained that the SNP data revealed that approximately 20 percent of CIP's potato accessions were misidentified, which he believes is a common, yet unstated, problem in genebanks. CIP genebank personnel corrected the misidentified accessions to ensure all users receive the material they need, and they will continue to use the fingerprints in a quality management system where randomly selected samples are genotyped to ensure fidelity of the collection.

While these corrections have improved the genebank's collection management, David and his colleagues quickly realized that the SNP data had many other applications. For example, the ability to identify genetically unique accessions will help the genebank make its field collection process

DNA fingerprints have helped genetic resources manager Ana Panta improve the fidelity of the genebank's cultivated potato and sweetpotato collections.



The genetic data could help scientists better understand the origins and relatedness of potato and sweetpotato taxa.

more efficient and cost-effective. The genotyping data have also provided a new understanding of cultivated potato taxonomic relationships, which suggests that further examination of the taxonomy of cultivated potato is warranted.

While the genetic fingerprinting of potato was based on between 4,000 and 6,000 SNP markers, a comparable analysis of cultivated sweetpotato used as many as 55,000 markers, which allowed researchers to map distinct populations of cultivated sweetpotato in the collection to different regions of the world. Researchers then collaborated with Diversity Arrays Technology to narrow those markers down to approximately 5,000 that can be used for comparably accurate identification at a cost of less than $10 per accession. This opens the door for more widespread uses of genetic fingerprinting, such as tracking parental lines in the breeding process, or determining which varieties farmers are growing.

"We will be mining these data for years to come," David predicted.

Researchers have found that understanding the needs and preferences of men and women is essential for achieving impact.

Understanding Gender Differences to Improve Development Work

Funders: CGIAR Trust Fund contributors through the CGIAR Research Programs on Roots, Tubers and Bananas (RTB) and Policies, Institutions, and Markets (PIM)

Region: South America

As part of an effort to improve income in Bolivian potato farming communities several years ago, CIP and partners developed, tested and delivered machinery for sorting potatoes, to reduce the time and labor needed to select marketable tubers by size. However, a follow-up assessment revealed that the technology wasn't being used. The machines had been designed for and validated by men, but selecting potatoes is traditionally the job of women, who found it too difficult to lift and pour bags of potatoes into, and operate the machine.

> "The moral of the story is that it is important to engage women to understand their roles, perceptions and responsibilities before designing a technology, in order to ensure that what you design responds to their needs," said Vivian Polar, a Gender, Monitoring and Evaluation Specialist with RTB.

Vivian is the lead author of a study titled *Technology is not Gender Neutral,* which was completed by a team of CIP researchers in Bolivia, Ecuador and Peru in 2017. They conducted focus group discussions in potato farming communities in the three countries and interviewed agricultural development professionals who work in those areas to identify factors that influence the adoption of agricultural technology by men and women farmers, and provide recommendations for the gender-responsive design and development of agricultural technologies.

Vivian noted that such research applies to a wide range of innovations: from improved crop varieties to seed systems to postharvest technologies. The study adds to a growing body of gender research by CIP and partners,

Women and men often have different roles, perceptions and constraints that affect their adoption of agricultural technologies.

which includes several studies of sweetpotato interventions in Africa by CIP Gender Research Coordinator Netsayi Mudege. Given that women provide somewhere between 40% and 60% of the labor for small-scale agriculture, and are in charge of household diets, research for development professionals have come to realize that understanding the roles, needs and constraints faced by women in developing countries is essential for widespread impact.

> "I think that gender awareness and responsiveness is gradually being internalized by researchers," Vivian said.

Ensuring a Sustainable Supply of Quality Sweetpotato Planting Material

Funder: Bill & Melinda Gates Foundation

Region: Sub-Saharan Africa

As CIP and partners breed resilient and nutritious sweetpotato varieties and work to get millions of African families growing and eating them, making sure that there is enough quality planting material available for farmers is both a priority and a challenge.

CIP has facilitated the creation of supply chains that extend from the tissue culture laboratories that propagate disease-free plantlets of improved varieties to decentralized vine multipliers who multiply planting material for sale to smallholders. National Agricultural Research Institutes (NARIs) constitute a vital link in these supply chains, because they are responsible for varietal release, micro-propagation of pathogen-tested tissue culture plantlets, and production of sweetpotato cuttings under screen house conditions. Those cuttings – known as 'early generation seed' (EGS) – are sold to decentralized vine multipliers, who grow them and sell quality planting material to farmers. Under the Sweetpotato Action for Security and Health in Africa (SASHA) initiative, CIP is helping NARIs meet the growing demand for sweetpotato planting material in an efficient and cost effective manner.

> "We need to ensure that farmers have timely access to quality seed and improved varieties. Ensuring a consistent supply of EGS by our national partners is an important component of this," said CIP agricultural economist Srinivasulu (Srini) Rajendran.

Srini explained that public institutions in many sub-Saharan African (SSA) countries, have a mandate to produce quality planting material, but are hampered by unreliable funding and a lack of validated production and

© H. Rutherford/CIP

African farmers need quality planting material to tap sweetpotato's full potential as a vitamin A-rich, food security crop.

CIP and partners are creating supply chains to ensure that SSA farmers have healthy sweetpotato vine cuttings to plant.

business models. In response to this, CIP provided technical support to government and private sector actors in 11 SSA countries as they developed and launched business plans to improve and sustain EGS production and sales. CIP supported a team of scientists and experts in finance and administration to work with senior management at partner organizations on the development and implementation of the business plans, which included technical, financial, institutional and policy components. The technical component included capacity building in production processes to increase multiplication rates, establish internal quality assurance systems for EGS, and schedule production to match farmer planting schedules. Financial innovation focused on the establishment of a revolving fund mechanism whereby income from seed sales is reinvested in future production. This has also required changes in institutional policy and organizational culture.

> "The business plan guides the institution to ensure that recurrent production costs can be met from the revolving fund by linking the technical, financial, institutional and policy components to improve overall seed systems," Srini said.

CIP social scientist Margaret McEwan explained that researchers used real-time monitoring to determine the cost of early generation seed production at each NARI. "We now have evidence of the real cost of sweetpotato EGS production by public institutions. This lays the basis for appropriate pricing strategies to ensure the sustainability of the business in the medium term," she said.

Srini noted that while some of the NARI's face challenges, most of them are on track to being able to cover their production, administrative and marketing costs with the sale of planting material by 2019, when SASHA ends. "When we started this work in 2014, there were zero sales. Now all the NARIs we work with are generating revenues from the sale of pre-basic and/or basic sweetpotato seed, and nearly all of them are covering their costs of production," he said.

The Kenya Plant Health Inspectorate Service (KEPHIS) is a good example, having earned a profit from sales of OFSP planting material in 2017. Dr. Esther Kimani, KEPHIS Managing Director, explained that the institution reduced its production costs while increasing demand for high-quality orange-fleshed sweetpotato (OFSP) seed through web advertising, awareness raising activities and a variable pricing scheme based on the type of customer and the time of year planting material is delivered. Between 2016 and 2017, KEPHIS' sales of quality OFSP seed increased by 79 percent. Moreover, whereas KEPHIS primarily sold OFSP cuttings to NGOs before 2016, farmers now constitute the majority of it customers.

> "This has strengthened the sweetpotato seed system and availability of quality planting material for the sweetpotato farming community, improving the livelihoods of farmers and the food security of the nation as a whole," Dr. Kimani said.

Florence Munguti, the Officer in Charge of KEPHIS' Plant Quarantine and Biosafety Station, where sweetpotato EGS is produced, explained that since KEPHIS' senior managers have seen the benefits of undertaking the costing exercise as the basis of developing a business plan for sweetpotato EGS production, they want to apply the approach to seed production for other crops.

CIP and partners plan to conduct financial feasibility analyses for enterprises engaged in seed production for multiple root and tuber crops. "This will help to optimize use of production facilities and capacities," Margaret said.

Dr. Esther Kimani (L), Jackson Mandago, Governor of Uasin Gishu County and Ms. Florence Munguti (R) in KEPHIS sweetpotato EGS screenhouse.

CIP and NARO's assessment of the late blight-resistant biotech potato includes confined field trials at three sites in Uganda.

Late Blight-Resistant Potato Holds Promise for Farmers in East Africa

Funders: United States Agency for International Development (USAID), 2Blades Foundation.

Country: Uganda

Late blight disease is a major constraint for potato farmers, costing an estimated US $3-$10 billion per year globally. In Uganda, where about 300,000 smallholder farmers grow potatoes, the disease can destroy as much as 60-100% of a potato crop. Farmers use fungicides to control late blight, but because the cost of those agrochemicals commonly represents from 10 to 25 percent the value of a farmer's potato harvest, their use significantly reduces family incomes, whereas their application poses risks to human health and the environment.

Over the years, breeders have crossed potatoes with wild relatives to produce highly late-blight-resistant varieties, but those varieties often lacked other traits that people wanted, so adoption was limited. Breeders have had better luck crossing cultivated clones with resistance to the disease, which has produced varieties that combine late blight resistance with high yields and flavor and cooking traits that consumers demand. However, the pathogen's rapid evolution can leave those varieties less resistant over the years, and many farmers are happy to grow varieties with little or no resistance to the disease if there is a strong market for them, even if it means they need to spend a significant portion of their earnings on fungicides to ensure a good harvest. CIP scientists have thus taken a new approach - using transgenesis to transfer resistance genes from potato wild relatives into potato varieties that are already popular with farmers and consumers.

CIP partnered with Uganda's National Agricultural Research Organisation (NARO) to test a biotech version of the popular variety Victoria that contains a stack of three resistance (R) genes. Confined field trials conducted at NARO's Kachwekano Zonal Agriculture Research Institute showed that the 3R-stack Victoria is highly resistant to late blight, surviving exposure to the pathogen while it destroyed conventional potatoes plants nearby. In 2017, CIP and NARO began collaborating on a compulsory assessment of possible risks to human health or the environment that is required by Uganda's National Biosafety Committee. Confined fields were established and initial trials completed near Fort Portal (Rwebitaba), Mbale (Buginyanya) and Kabale (Kachwekano).

Marc Ghislain, CIP Program Leader for Game-Changing Solutions, explained that once several seasons of field trials have been completed in three locations, NARO will present the results to Uganda's National Biosafety Committee as part of a request that the biotech version of Victoria be released to Ugandan farmers. If released, Ghislain predicts that it will greatly benefit smallholder families through better harvests and lower production costs, without the health and environmental risks that fungicides pose.

A biotech version of the popular variety Victoria under evaluation in Uganda is highly resistant to late blight.

Field researchers interviewed 1,098 potato farmers in 11 regions of Peru.

New Insight on Potato Variety Adoption and Impacts in Peru

Funders: CGIAR Trust Fund contributors through the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and Peruvian Ministry of Agriculture and Irrigation's Secretariat for Technical Collaboration with the CGIAR (STC).

Country: Peru

Potato breeders strive to develop varieties with the agronomic and consumer traits that farmers and the market demand, but once a new variety is released in a developing country, it is difficult to know how many farmers adopt it. A study of the adoption and impact of improved potato varieties in Peru published in 2017 holds valuable information for potato breeders and policy makers, and confirms that CIP's potato breeding program has made an important contribution to smallholder production and incomes.

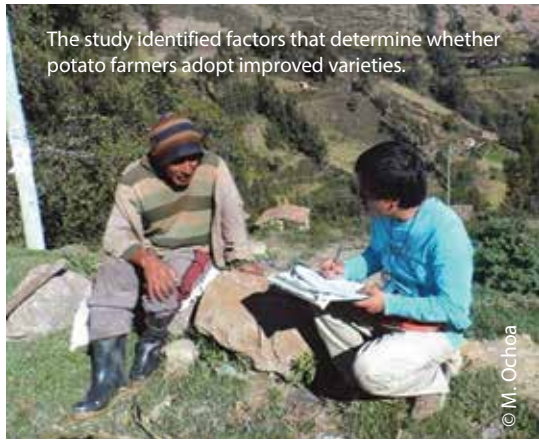
CIP Agricultural Economist Willy Pradel, the study's lead author, explained that there was previously a lack of reliable data on which varieties Peru's farmers were growing. Government agricultural censuses group the country's 2,500 potato varieties into just three categories – white, yellow or native potatoes – whereas expert consultations that produce adoption estimates for specific varieties are less than optimal.

> "We need rigorous information about what is happening in the countryside. We can't effectively breed new varieties, or design strategies for seed systems, if we don't know which varieties farmers are growing and why," Willy said.

CIP thus partnered with Peru's National Institute for Agricultural Innovation (INIA), which has evaluated and released 34 CIP-bred potato varieties over the past four decades, for a comprehensive assessment of potato varietal adoption. Together they interviewed 1,098 farmers in 120 potato-farming areas of 11 regions in 2013. The researchers used a methodology that ensured the sample was statistically representative of 86 percent of the country's potato production.

They found that approximately 38 percent of Peru's farmland dedicated to potato was planted with native varieties and 62 percent with improved varieties. More than 33 percent (91,000 hectares) of the potato area was planted with CIP-bred varieties, three of which – Canchán, Amarilis and UNICA – accounted for 27 percent. Researchers found that farmers who grew improved varieties sold more potatoes and earned more money than their neighbors who didn't, and that CIP-bred varieties produced one ton more potatoes per hectare – almost 10 percent more yield – than the other improved varieties.

In addition to documenting the economic benefits of CIP-bred varieties, the authors found that some are mainly grown in specific regions. Amarilis, for example, occupies 40-44 percent of the potato area in northern Peru, where the variety was tested through the farmer field schools in the late 1990s. They suggest that variety dissemination efforts target specific agro-ecologies, and tap the power of the market to increase adoption. They also identified factors that determine whether farmers adopt improved varieties, such as agronomic training and an understanding of the benefits of improved varieties, which increase the likelihood of adoption.



The study identified factors that determine whether potato farmers adopt improved varieties.

This information can help CIP and INIA develop and disseminate the next generation of improved potato varieties.

The CGIAR Research Program on Roots, Tubers and Bananas (RTB) works globally to harness the untapped potential of those crops to improve the food security, nutrition, income and climate change resilience of smallholders, especially women and youth.

© H. Rutherford/CIP

Sweetpotato vine distribution in Rwanda. Improving farmer access to quality planting material is one of RTB's areas of cross-crop research.

RTB: Root and Tuber Innovations for Better Harvests and Livelihoods

CIP is the lead center of the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and most of CIP's work is planned and reported through RTB, which brings together diverse partners to jointly conduct research, develop solutions, and share knowledge across crops and centers. The spirit of cross-crop learning and collaboration that lies at the heart of the program has enhanced the research for development of CIP and an array of partners.

For its second phase, which began in 2017, RTB has placed more emphasis on scaling the technologies and approaches that research centers develop. This is spearheaded by the program's Flagship Project 5 on 'Improved Livelihoods at Scale,' which is facilitating the design and implementation of strategies for scaling innovations to achieve the greatest possible impact.

One of the mechanisms created for this is the RTB Scaling Fund, which in 2017 awarded its first grants to three teams of scientists as part of a broader effort to help take promising innovations to scale. Grantees included a team led by CIP researcher Margaret McEwan that is working on a method for conserving sweetpotato roots to produce planting material.

Known as Triple S, which stands for 'Storage in Sand and Sprouting', the method involves storing sweetpotato roots in sand during the dry season and planting them in seedbeds six to eight weeks before the rains are expected, which allows farmers to produce enough vine cuttings to plant when the rains resume. Triple S has been successfully tested in varied agroecologies and used by farmers across nine sub-Saharan African countries. CIP and partners are using the RTB Scaling Fund grant to train trainers and run gender-responsive mass media campaigns with the aim of getting 45,000 farmers in Ethiopia and Ghana to take up the technology.

Seed system toolkit

The difficulty of producing sweetpotato vines for planting in areas with long dry seasons is indicative of obstacles that root and tuber farmers face in obtaining or maintaining quality planting material. Root and tuber crops and bananas are clonally propagated, meaning farmers plant tubers,

Cassava stalk distribution in Nigeria. Clonally propagated crops present common seed challenges for smallholder farmers.

suckers, stalks or vine cuttings, which are commonly referred to as 'seed'. This presents several challenges for farmers, including low seed multiplication rates, bulky and perishable planting material and rapid seed degeneration, which leads to low crop yields.

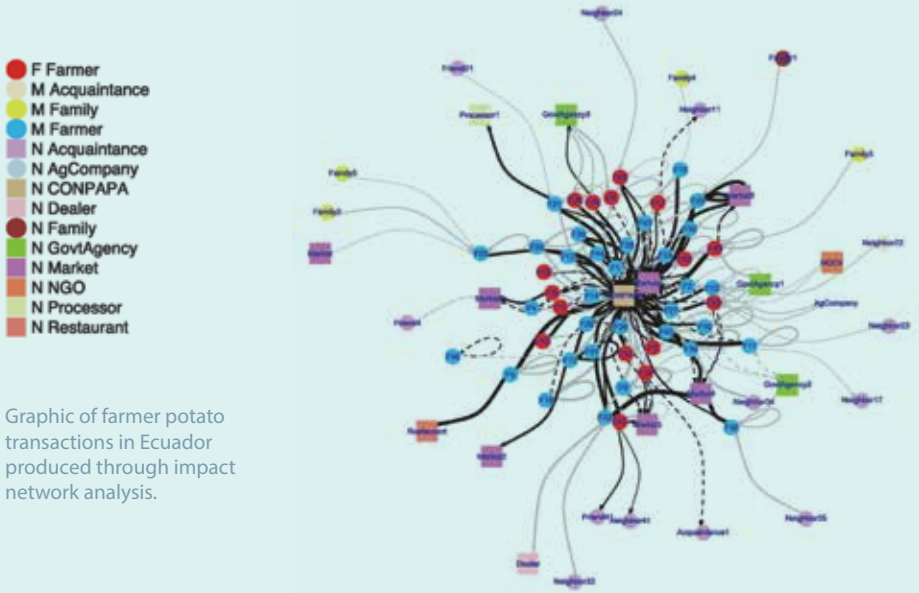
"Because these crops share similar challenges and opportunities, a method or technology developed for one can often be used for another crop," said CIP researcher Jorge Andrade-Piedra. He explained that RTB consequently brought together scientists from different research centers and disciplines to work on seed issues. "RTB facilitated the creation of an informal community of practice where we came up with common research questions that led to the development of cross-crop approaches."

Jorge and Margaret led collaboration by researchers from all the RTB centers to develop a seed system toolkit. Those tools enable practitioners to understand and systemically diagnose problems in clonally propagated seed systems and determine how to effectively intervene in them. In 2017, technologies from that toolkit began to be validated in 14 projects with RTB crops, in Asia, Africa and South America.

One of them, a gender-responsive, cross-crop seed system framework, has been used to assess the effectiveness of rapid-multiplication technologies for seed potato production in Africa and to identify bottlenecks in potato seed systems in India. The framework is also being used to analyze sweetpotato seed systems in Ethiopia, farmer sourcing of cassava planting material in Nigeria, and banana planting material in Uganda, among other research.

Another tool, 'impact network analysis,' has deepened researchers' understanding of farmer seed exchange networks and how they facilitate the spread of pathogens. A survey to estimate the structure of the networks of farmer seed and ware potato transactions in Ecuador allowed researchers to identify priority nodes for disease monitoring and training in disease management.

> "It is great to see CIP scientists so engaged with RTB, contributing across our full range of crops. Many RTB seed system interventions have been suboptimal, but since there was no systematic framework for comparison or intervention design, few lessons where drawn on what works. I thus expect that the seed system toolkit will be widely used in RTB and beyond. It's going to save time, as researchers can draw on existing tools rather than develop their own, and by building evidence of what works, it should broaden the impact from seed system interventions," said Graham Thiele, RTB Director.



Graphic of farmer potato transactions in Ecuador produced through impact network analysis.

BOARD OF TRUSTEES

Patrick Murphy | Dr. Rodney D. Cooke (Chair) | James C. Ekles | Andrés V. Casas,

Dr. Qu Dongyu | Dr. Linley Chiwona-Karltun | Dr. Barbara H. Wells | Dr. Vo tong Xuan | H.E. Rhoda Peace Tumusiime | Dr. Miguel Barandarian

LEADERSHIP

Management Committee

Dr. Barbara H. Wells (Chair)

Dr. Andre Devaux
Michael Gerba
Selim Guvener
Carla Lazarte
Xiaoping Lu
Dr. Adiel Mbabu
Luis Felipe Mendes
Dr. Samarendu Mohanty
Dr. Oscar Ortiz
Amalia Perochena
Pietro Turilli

Scientific Leaders

Dr. Oscar Ortiz (Chair)

Dr. Hugo Campos
Dr. Andre Devaux
Dr. David Ellis
Dr. Marc Ghislain
Dr Guy Hareau
Dr. Simon Heck
Dr. Jurgen Kroschel
Dr. Alberto Maurer
Dr. Roberto Quiroz
Dr. Elmar Schulte-Geldermann

Principal Scientist
Dr. Jan Low

Operations Team

Michael Gerba (Chair)

Sandra Coyle
Carla Lazarte
Luis Felipe Mendes
Michelle Rodrigo
Carlos Varela

Regional Leaders

Dr. Andre Devaux
Xiaoping Lu
Dr. Adiel Mbabu
Dr. Rusudan Mdivani
Dr. Samarendu Mohanty

FUNDERS

Thank you to all of our generous donors

- 2BLADES Foundation
- African Agriculture Technology Foundation
- Australian Centre for International Agricultural Research
- Austrian Development Agency
- Asociación Pataz
- Biotechnology and Biological Sciences Research Council
- Benefit-sharing Fund from the Secretariat of the International Treaty on Plant Genetic Resources for Food and Agriculture (various donors)
- Bioversity International
- Bill & Melinda Gates Foundation
- Centro Internacional de Agricultura Tropical
- CGIAR Trust Fund Donors
- CGIAR Research Program on Roots, Tubers and Bananas
- CGIAR Research Program on Climate Change, Agriculture and Food Security
- CGIAR Research Program on Policies, Institutions and Markets
- CGIAR Platform for Big Data in Agriculture
- CGIAR Genebank Platform
- Government of the United Kingdom of Great Britain and Northern Ireland – Department for International Development
- Government of Odisha, Directorate of Horticulture
- European Commission
- Gansu Agricultural University
- Global Crop Diversity Trust
- Government of the Federal Republic of Germany – Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Government of India
- Hebei North College

  Harvest Plus Challenge Program (various donors)
- Ireland's Bilateral Aid Programme – Minister for Foreign Affairs and Trade of Ireland
- International Fund for Agricultural Development
- McKnight Foundation
- National Science Foundation (U.S.)
- República del Perú – Programa Nacional de Innovación Agraria
- Rural Development Administration of the Republic of Korea
- Syngenta Foundation for Sustainable Agriculture
- United States Agency for International Development
- World Potato Congress INC.

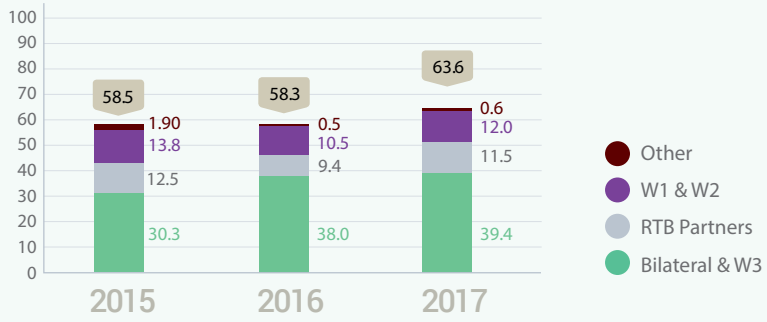
FINANCIALS

Financials

Total revenue and expenses reported in 2017 were $63.6 million. Total revenue increased by $5.2 million compared to 2016, demonstrating CIP's continued success in securing Window 3 and bilateral funding while stabilizing revenue for Windows 1 and 2.

The financial results depicted here are derived from CIP's audited December 31, 2017 consolidated financial statements, which contain an unqualified audit opinion. CIP's complete, audited financial statements can be obtained online at https://cipotato.org/about/finances/

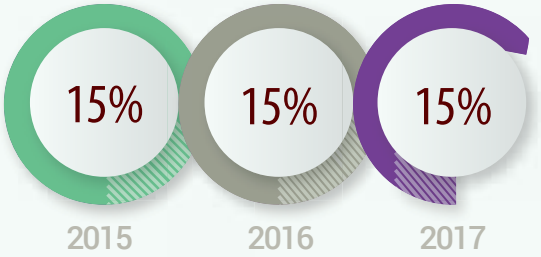
Luís Felipe Mendes / Chief Financial Officer



$63.6mn.
Revenue

Overhead Rate

The ratio of indirect cost to direct cost as an indicator of our operational efficiency remained stable at 15%. The ratio has been calculated following the CGIAR Financial Guidelines N°. 5.



15%
Overhead

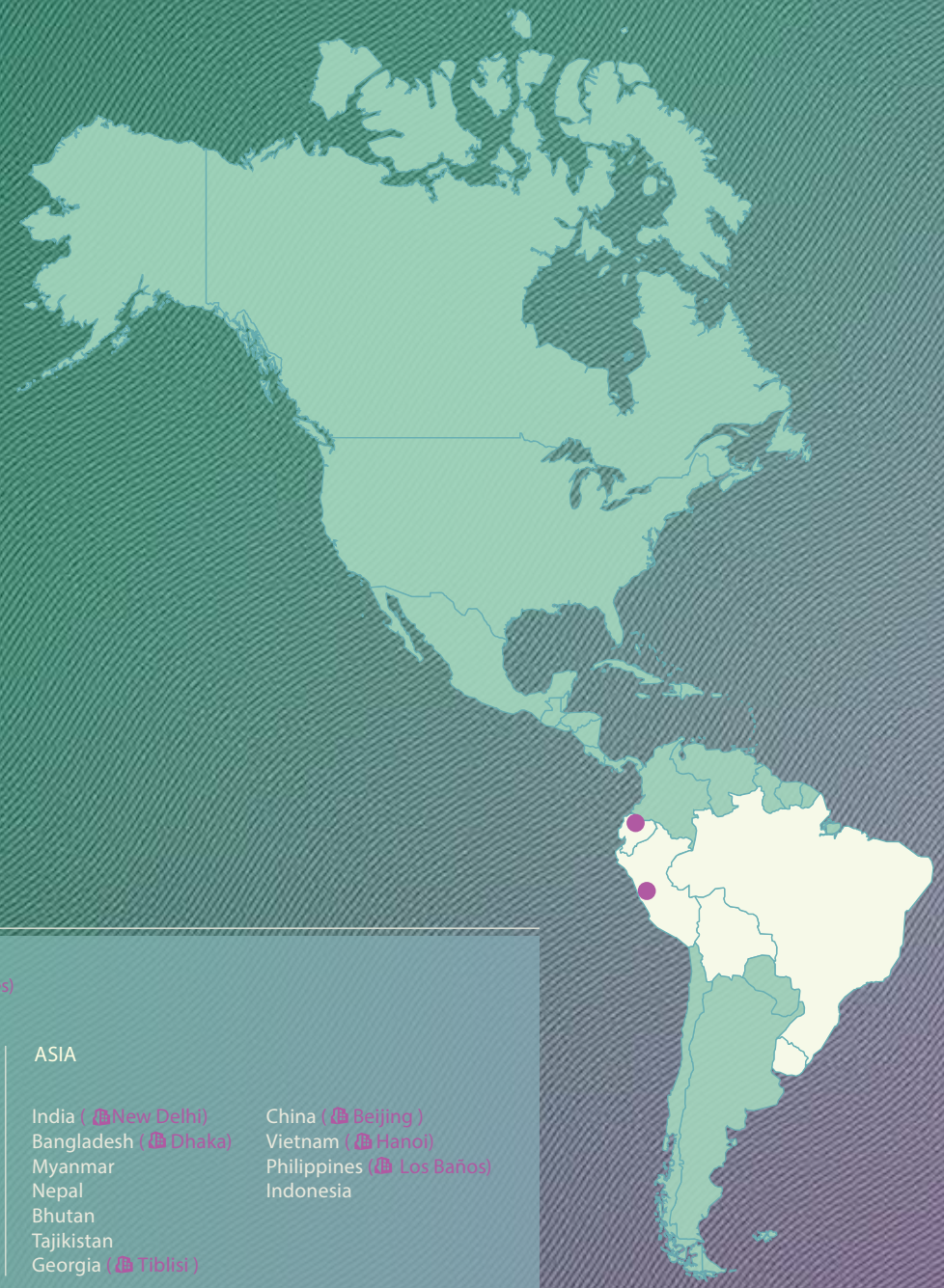
Liquidity and Financial Stability

The long-term financial stability indicator, which measures the number of days of unrestricted net assets that can be used to cover CIP's forward planned operations, is 86 days (within the CGIAR recommended norms). CIP's overall financial position continues to be sound and the Center did not need to use any credit facility during the year.

86
days
Reserves

Global presence

27 countries worldwide



Global research (27 countries) **Country offices** (17 countries)

LATIN AMERICA & THE CARIBBEAN

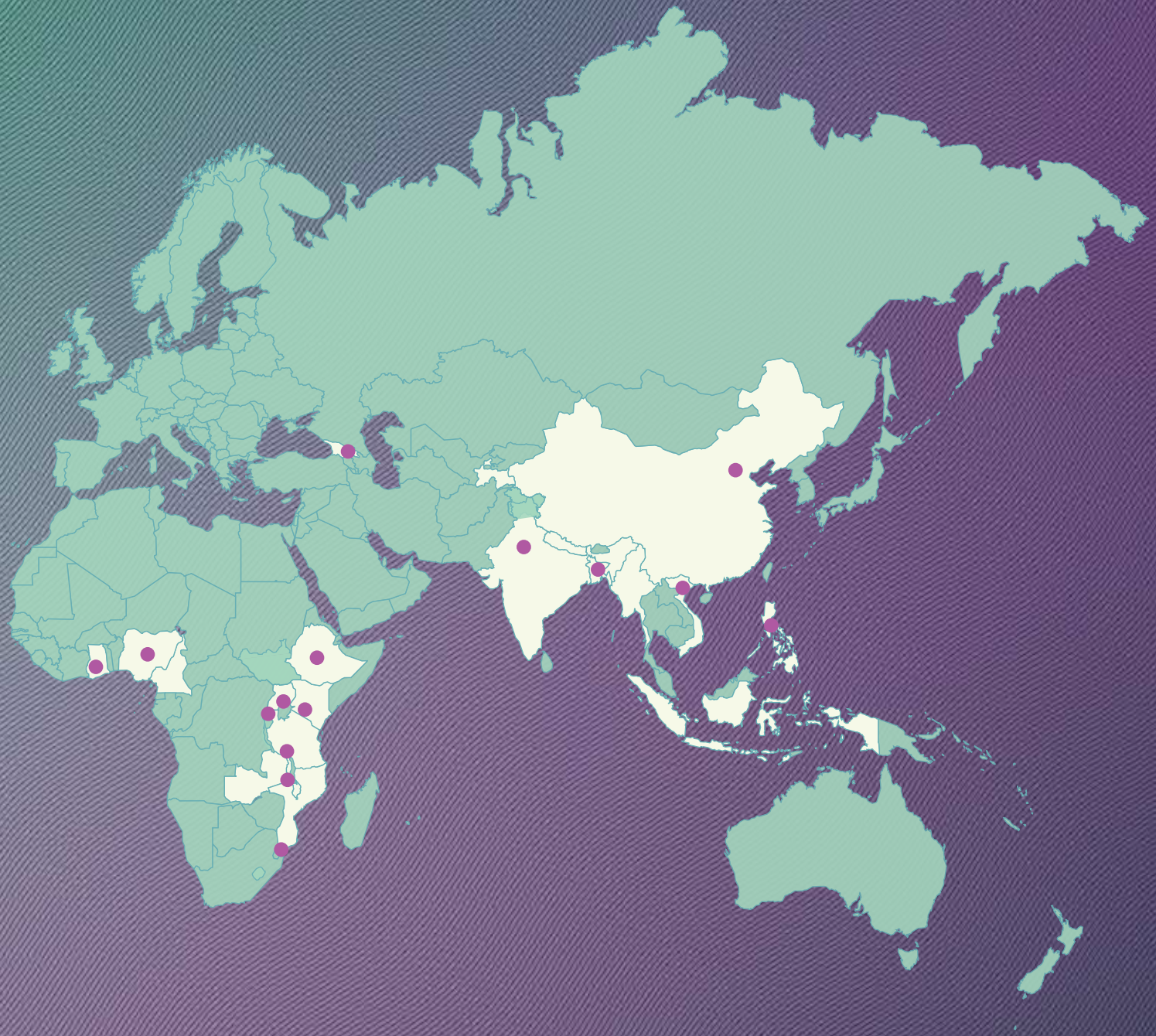
Peru (Lima)
Ecuador (Quito)
Bolivia
Brazil
Uruguay

AFRICA

Ghana (Kumasi)
Cameroon
Nigeria (Abuja)
Ethiopia (Addis Ababa)
Uganda (Kampala)
Kenya (Nairobi)
Rwanda (Kigali)
Tanzania (Mbeya)
Malawi (Lilongwe)
Zambia
Mozambique (Maputo)

ASIA

India (New Delhi)
Bangladesh (Dhaka)
Myanmar
Nepal
Bhutan
Tajikistan
Georgia (Tiblisi)
China (Beijing)
Vietnam (Hanoi)
Philippines (Los Baños)
Indonesia



© H. Rutherford/CIP