AFRICA FEEDING AFRICA:
THE AFRICAN ORPHAN CROPS CONSORTIUM (AOCC)
2023 PROGRESS REPORT

From left to right, top to bottom: Launch of the AfPBA breeders' course in December 2013 attended by AOCC members, instructors, and Class I participants; Class II; Class III; Class IV; Class V; and AfPBA CRISPR Class I.

From Idea to Movement: Highlights

- The African Orphan Crops Consortium (AOCC) was hatched in in 2011; it began operations in 2013 with 6 Consortium Members including the African Union Development Agency-New Partnership for Africa's Development (AUDA-NEPAD). To-date it has raised $6.5 million to fund Its African Plant Breeding Academy (AfPBA), including $5.5 million for the AfPBA breeders' course, along with innumerable in-kind contributions from its 40 consortium members.
- Of the 101 African Orphan Crops (AOC) initially targeted by the consortium for improvement, there are 75 for which DNA sequence data are available; genomes of 46 of these have been published.
- With the graduation of AfPBA Cohort 5 in May 2023, AfPBA has graduated 151 plant breeders from 28 African nations (90% PhDs, nearly 40% women).
- AfPBA alumni have landed nearly $168.8 million in highly competitive grants and other external funding for crop improvement, representing a 30:1 return on investment of AfPBA sponsorship funding.
- AfPBA alumni garnered nearly $6.3 million in additional funds from their national programs to supplement their breeding program budgets, mainly to support the release of new varieties.
- AfPBA alumni launched 143 improved crop varieties, 32 of which involved AOCC-designated African orphan crops.
- AfPBA alumni have published over 665 scientific papers in peer-reviewed journals, several which represent the forefront of scientific advancement in the subject area.
- AfPBA alumni have emerged as leaders in the field of plant breeding education, developing 62 graduate-level plant breeding courses - based on knowledge and tools gleaned in AfPBA - that have impacted hundreds of young people, the next generation of crop improvement scientists.
- In 2023 the AfPBA launched its CRISPR Course, a first-of-its-kind effort to train national program scientists in gene editing, with sponsorship by Bayer Crop Sciences, Syngenta, US-based Foundation for Food and Agricultural Research (FFAR), and Morocco-based UM6P Ventures.
- The CRISPR Course graduated 10 scientists from six countries in October 2023
- A large percentage of AfPBA alumni have been promoted to positions of leadership within their organizations.
- AfPBA alumni were instrumental in establishing the African Plant Breeders Association (APBA).
- Partial funding for AfPBA Class VI and future cohorts of the AfPBA CRISPR Course has been secured, and fundraising efforts continue.
- African farmers are using seeds improved by African scientists.
- AOCC in collaboration with FAO will hold a Workshop as part of the 3rd biennial Conference of the APBA in October 2023 to demonstrate proof-of-concept of the AOCC model.

Getting Seeds in the Ground

After a decade of arduous work, the African Orphan Crops Consortium (AOCC) helped African scientists get the seeds of more productive, more resilient, and more nutritious food crops into the fields and gardens to benefit almost 700 million people of rural sub-Saharan Africa.

It has taught scientists to use the latest proven technologies to improve healthy but little-studied ("orphan") African food crops to help feed this hungry continent.

The Highlights above show the astonishing accomplishments along the path toward that goal in terms of education, scientific breakthroughs, and nutritional security through an uncommon and global collaboration across stakeholders.

Africa must produce its own food. The covid epidemic, the war in Ukraine and the normal vicissitudes of food markets and food aid prove this.

Today some 20% of Africa's population, 257 million people, are undernourished, and 10 million children face severe food shortages due to crop failures. One in four African children is stunted, a physical and irreversible manifestation of malnutrition experienced before age five, a syndrome that thwarts the development of both individuals and nations. These stubborn facts persist despite the many complex and expensive programs and initiatives to end hunger, achieve food security, and improve nutrition.

Yet Africa is too often portrayed as a helpless victim. It has high human resilience, social capital, a youthful population, and high levels of mobile connectivity. Its people are capable of complex programs and systems, of which the AOCC is an example.

The AOCC's African Plant Breeders Academy (AfPBA) graduates are not only better scientists due to their academy experience. Together, they are becoming key players in their national agricultural programs and local communities, collaborating with government officials, extension workers and small-scale farmers, and linking researchers of various scientific disciplines, producers, processors, consumers, and policy makers.

For example, AfPBA graduates Deedi Sogbohossou and Enoch Achigan-Dako developed a breeding program for the popular crop cleome or spider plant (Gynandropsis gynandra). They worked with farmers at every step of their program, noting the traits the farmers valued; the women farmers were particularly concerned with aroma. But, to demonstrate the scale of collaboration in one single program, this multilateral, multinational effort involved the AOCC, Wageningen University in the Netherlands, the Kenya Botanical Museum, and the University of Abomey-Calavi in Benin.

The AOCC concept emerged in 2011 from a conversation between Dr. Ibrahim Assane Mayaki, former prime minister of Niger and currently the African Union Commission (AUC) Special Envoy for Food Systems, and international plant scientist Howard Yana Shapiro, Senior Fellow, College of Agricultural & Environmental Sciences, University of California, Davis, and Distinguished Senior Fellow, CIFOR-ICRAF, Nairobi. (The consortium formally began operations in 2013.)

Dr. Mayaki told a meeting of AOCC graduates:

"In my role as Special Envoy for Food Systems for the African Union, I will work to include the key elements of the AOCC development strategy: research, training, and implementation through sound policies and strategies. As the AUC Special Envoy, I think it is important to support your efforts among AUC Member States with high-level advocacy; collaborate with your efforts to leverage the AOCC model and help facilitate your AOCC advocacy efforts with the AU Department of Agriculture and Rural Development and multi-stakeholder technical consultations."

Meanwhile, Dr. Shapiro is using his international reputation and contacts to improve the network of AOCC sponsors and consortium members, having brought on board UN agencies, international NGOs, government departments, and multinational corporations (see list in at end of report). He brought in Nobel Laureate Jennifer Doudna, co-developer of the CRISPR gene editing technology, to endorse and support the development of the newest initiative of the AOCC, the AfPBA CRISPR Course.

Given its proven success and high return on investment in Africa, it is easy to imagine the AOCC model being applied in other parts of the developing world.

Accelerating Food Security: The AOCC Model

The AOCC strategy to accelerate the improvement of nutritional security in Africa has involved a three-pronged approach.

First is the identification of little-studied food crops that play important and traditional roles in African cultures and diets and that, with crop improvement research, could have huge nutritional and economic impacts. A survey was taken of 100+ African scientists (nutritionists, plant breeders, sociologists) to identify approximately 100 crops that fit the profile yet had not benefited from plant breeding efforts directed to greater yield or resiliency. As a result of the survey, 101 food crop species, including a diversity of vegetable, fruit, root, nut, legume, cereal, and oil crops, were identified and dubbed “African Orphan Crops” (AOCs) due to their scientific neglect.

Second, the AOCC committed to sequence the genomes of these 101 AOCs and to make this information public to jump-start crop improvement research. Coordinated by AOCC Scientific Directors Dr. Allen Van Deynze and Dr. Ramni Jamnadass, AOCC members (Appendix A) have leveraged and contributed their expertise to deliver full genome sequences of 16 crops to-date, and others worked to annotate the DNA sequence information. Still others developed and made tools available to enable use of DNA sequences to accelerate plant breeding. To date, DNA-sequence data of 75 AOCs have been generated (Appendix B)

Third, the AOCC through its academy led an initiative to empower African plant breeders to use the DNA-based information to speed the development of varieties that are more productive, more nutritious, better adapted to environmental conditions and more resilient against climate change and pests.

Growing Science and Scientists: The African Plant Breeding Academy

The AfPBA, coordinated by UC Davis, has been implementing a professional development program targeting African scientists in crop improvement, mainly those working in national programs, since 2013. Directed by Dr. Rita Mumm, the AfPBA has organized two continuing education courses to impart the knowledge, skills, and tools to use genomic resources in crop improvement: one benefiting plant breeders and the newest one targeting molecular plant biologists.

The AfPBA course for plant breeders is an intensive six-week program, sharing a seed-industry approach to creating and optimizing a pipeline resulting in continuous improvement of varieties as crop value chain needs evolve and the climate changes. The faculty of the AfPBA are world-class experts complemented by acclaimed guest speakers demonstrating how to apply the concepts and principles taught and addressing all areas vital to effective crop improvement. The course culminates with students formulating and presenting a proposal to improve their breeding program, based on one or more learnings, or using one or more of the free-license tools from the AOCC.

The AfPBA course for plant breeders is hosted by CIFOR-World Agroforestry in Nairobi, Kenya, providing participants with a top-level learning environment and all logistics for traveling to and staying in Nairobi. For Cohorts 1 through 5, the AfPBA course for plant breeders was sponsored by donors (Mars Incorporated, AGRA and Jon and Terase Curtis) covering tuition costs as well as all travel expenses for students to/from their home locations, making the program accessible to all qualified applicants that are accepted to the program.

To-date, the AfPBA has empowered 151 crop improvement scientists from 28 African countries to use genomics-assisted approaches in the development of improved varieties that deliver the portfolio of traits the farmers want, and consumers need. Of these graduates, 90% are PhD-level scientists and nearly 40% are women.

African Scientists designing African Crops for African Communities: the CRISPR Course

As the latest initiative of the AOCC, the AfPBA launched the CRISPR Course in January 2023, which amplifies and extends the success of the AfPBA and its graduates, facilitating multi-disciplinary teams for crop improvement for national programs.

The CRISPR Course trains African scientists to use gene-editing technology to create needed sources of key traits demanded by farmers and consumers, setting the stage for an explosion of innovation and economic growth across the continent and facilitating a quantum leap in nutrition, climate resiliency, and sustainability in African food systems.

The AOCC is partnering with Jennifer Doudna's Innovative Genomics Institute (IGI) over the next five years to empower up to 80 molecular scientists to employ the latest CRISPR technologies to fast-track development of new sources of vital traits in food crops. CRISPR was the basis for the 2020 Nobel Prize in Chemistry to IGI founder Doudna, of University of California (UC) Berkeley, for her discovery of this precision tool, together with French microbiologist Emmanuelle Charpentier. IGI is a partnership between UC Berkeley and UC San Francisco to advance genome research for a better world. CRISPR holds huge promise for making desired genetic changes in a precise way, enabling plant breeders to rise to the challenges of a changing climate and rapidly growing populations at the pace these demand.

Professor David Savage of IGI teaches the latest in gene editing approaches in the AfPBA CRISPR Course. Additionally, CRISPR course participants learn from Dr. Leena Tripathi, the Director of Eastern Africa Hub and Leader of the Biotechnology Program for the International Institute for Tropical Agriculture (IITA) based on the ILRI campus in Nairobi, a maverick in the field of gene editing who is in the process of commercializing gene-edited banana varieties and other innovations in African crops.

An intensive, six-week program, the CRISPR course offers hands-on experience in all facets of gene editing, from design through validation. Course participants use DNA sequence data to identify targets for editing to recreate a gene-edited banana resistant to a devastating pathogen, Fusarium, in a key crop for African nutrition and one of the AOCC's target crops.

However, each participant will implement work in a crop aligned to his/her national and institutional priorities. The course culminates with each participant proposing ways to use CRISPR capacity at their home institution. The course emphasizes the role of gene editing in the overall scheme of cultivar development, and in addressing the needs of smallholder farmers it will support a Community of Practice strongly linked to the disciplines required for product launch, seed distribution, and farmer adoption.

As the AfPBA aims to foster multi-disciplinary teams focused on national and regional crop improvement needs. CRISPR Course participants are linked with AOCC/AfPBA plant breeders for commercial development of improved varieties containing the gene-edited trait. Connecting this cadre to the community of 151 field-based crop improvement scientists will

expedite the development of crop varieties improved with the new CRISPR-generated traits as well as with other agronomic and nutritional traits prized by farmers and consumers. Thus, the CRISPR innovations will have a clear pathway into varieties “of choice,” into crop value chains, into the marketplace, for direct benefit to the African people.

The training in CRISPR technologies is expected to spark innovation in crop improvement across the continent and position Africa as a key contributor on the global stage in this frontier area of agricultural invention in crops important to African nutritional security.

A unique element of this program, facilitated by the IGI, involves mentorship and ongoing support for sustained lab productivity beyond course completion and founding of partnerships for commercialization and value chain development.

A sponsored program with all student costs for tuition and travel covered, the AfPBA CRISPR Course is hosted by CIFOR-World Agroforestry and ILRI in Nairobi. Donors sponsoring the first cohort of AfPBA CRISPR scientists include Bayer, Syngenta, FFAR, and UM6P Ventures. Additionally, AOCC member Morrison and Foerster has provided guidance on legal and IP landscapes.

The AfPBA CRISPR program has the full support of the African Union Development Agency - New Partnerships for Africa’s Development (AUDA-NEPAD) and the AU President’s Council, clearing the way for national approvals of CRISPR-generated trait products.

To be eligible for the course, applicants must hold a PhD in molecular biology (or related area) and be actively employed as a bench scientist in a public institution in Africa. Applicants must have the support of their institutions to develop CRISPR capacity and operations for commercial targets, and the facilities to do so, with reasonable additions. The institutions must qualify for the biosafety authorization level required for CRISPR activities in their country or provide evidence of actively working toward this goal. Extensive recruitment outreach is aimed at representing in the program and providing benefit to as many African countries as possible and equal proportions of women and men scientists.

As of October 2023, 10 scientists from 6 countries have completed the AfPBA CRISPR course and are establishing gene editing programs at their home institutions.

Proving the Concept with the Best Approaches and Technologies

In its efforts to generate genomic resources for its 101 crop species important to African diets, the AOCC has stayed at the forefront of technology since the beginning, using the state-of-the art short-read sequencing and linked-reads in the beginning through our founding consortium member-BGI and on to long-read technologies with Pacific Biosciences RS, Oxford Nanopore and now HI-FI through consortium members. Scaffolding is complemented with Hi-C through Dovetail. Transcriptomes were generated with comprehensive annotations. Dr. Yves Van de Peer with University of Ghent, Belgium, has not only annotated many of these genomes, but also hosts these on his website (https://bioinformatics.psb.ugent.be/orcae/aocc/).

AOCC has published 16 genomes. Other labs have published 30 genomes for AOCs. Forty of these 46 genomes have long read chromosome-scale assemblies, with the last few now achieving telomere-to-telomere assemblies. An additional nine and 20 other AOCs are in progress from AOCC and other labs, respectively, for a total of 75 of 101 AOC species currently being addressed. The vast majority of sequencing efforts are being done together with plant breeders to have direct impact.

Furthermore, the post-AfPBA careers of the graduates have been astounding.

AfPBA alumni have landed highly competitive grants and other external funding for crop improvement totaling more than $168.8 million, representing a more than 30-to-1 Return on

Investment of AfPBA sponsorship funds. For example, Rogério Marcos Chiulele, director of the Centre of Excellence in Agri-food System and Nutrition at Eduardo Mondlane University, helped the center get $30 million in funding from the World Bank.

Many of the grant proposals were developed in the course. Many involved collaborations among AfPBA scientists, winning grants from the EU, IFAD, USAID, Bill and Melinda Gates Foundation, Australian Research Council, NSF-BREAD, BHEARD, UK, GIZ, OCP, and many others.

The AfPBA alumni have launched 143 improved crop varieties, 32 of which are AOC collectively serving all regions of the African continent (Appendix C). AfPBA alumni have garnered nearly $6.3 million in additional internal funds to supplement their breeding program budgets, mainly to support the release of these new varieties. The economic and nutritional impact of these new varieties will be the subject of an analysis by the AOCC in the near future.

AfPBA alumni have become scientific research leaders, publishing over 665 scientific papers in peer-reviewed journals, including Nature Communications, Frontiers in Plant Science, Gigascience, Plant Genome, Crop Science, Theoretical and Applied Genetics, Hortscience, G3-Genes Genomes Genetics, and Plants. (Appendix D)

With some papers being highly cited, it is clear that AfPBA alumni are at the forefront of scientific advancement in their subject areas. For example, a paper co-authored by Dr. Stephen Amoah (KNUST, Ghana) on AOC Bambara groundnut that is published in the high-impact journal Planta has been cited 129 times since its issue in 2019, according to SCOPUS (Mayes et al. 2019). Another example is a paper published by Dr. Kiddo Mtunda (TARI, Tanzania) and collaborators in a Frontiers journal outlines progress in breeding for Vitamin A, iron, and zinc biofortification, drought tolerance, and Sweet Potato Virus Disease resistance in sweet potato, garnering 16 citations since 2021.

Some 26 other publications in high impact journals relevant to AOCs have been produced by scientists serving as AOCC leaders, AfPBA instructors, and researchers in AOCC member institutions have generated over 588 citations to date (Appendix E).

In addition, AfPBA alumni have emerged as leaders in the field of plant breeding education. Alumni have developed 62 graduate-level courses in plant breeding based on knowledge and tools gleaned in AfPBA that have impacted hundreds of young people comprising the next generation of crop improvement scientists. Hundreds of undergraduates at universities across Africa have also benefited from courses spiked with content from AfPBA.

Several alumni have been involved in implementing continuing education programs based on AfPBA knowledge and tools. For example, Dr. Abush Tesfaye and Dr. Gemechu Keneni developed and delivered a short course to train MS-level assistant plant breeders in the Ethiopian Institute of Agricultural Research, playing forward their experience in AfPBA. Dr. Ahmed Abdelmoghny at the Cotton Research Institute, Agricultural Research Center in Egypt coordinated and delivered a course to further build capacity in breeding and processing technologies among ARC cotton researchers. In total, four continuing education programs have been developed and delivered by AfPBA alumni.

Promotion is the norm for the majority of AfPBA alums. A number are now leading R&D efforts in their national programs and providing strategic leadership for new education programs. Examples include Dr. Samson Gwali of the National Agricultural Research Organization in Uganda, who has established field genebanks for a number of tree species in collaboration with Ngetta Zonal Agricultural Research and Development Institute of Uganda and CIFOR-World Agroforestry in Kenya, using accessions to conduct Genome Wide Association Studies and genomic selection to breed for high oil yield in shea butter trees. Dr. Lloyd Mbulwe was promoted to Chief Agriculture Research Officer Crop Improvement and Agronomy for ZARI, Zambia, and leads an international collaboration on

sorghum improvement. Dr. John Saviour Yaw Eleblu is leading a $3 million initiative funded by the African Development Bank to establish an accredited PhD-degree program in biotechnology, as well as an accredited MPhil-degree program in biotechnology at the University of Ghana.

Since their recent completion of the CRISPR Course, the 10 graduates are busy establishing gene editing programs at their home institutions. Their focus is on crops and traits of priority in their national programs in Ethiopia, Ghana, Malawi, Morocco, Kenya, and Nigeria, including disease resistant rice, soybean and tomato, more nutritious barley, drought tolerant and Striga-resistant maize, longer shelf-life tomato, and toxin-free forage sorghum. These alumni are working with plant breeders in their country to facilitate incorporation of the gene-edited traits in improved varieties that bring the whole suite of traits desired by stakeholders in the crop value chain.

Collaboration is remarkably productive among academy graduates. AfPBA Class II graduates conceived of and established - along with the West Africa Centre for Crop Improvement - the APBA (African Plant Breeders Association), which holds biennial conferences for networking and continuing education of its membership. Graduates of the CRISPR course are planning to establish a Working Group within the APBA focused on gene editing.

AOCC: Helping Governments Meet Humanity's Goals

The planet's governments have agreed to meet 17 Sustainable Development Goals (SDGs) by the year 2030. The activities of the AOCC and its academy promotes progress toward most of these goals.

It decreases poverty (goal 1) by increasing farmer income. It obviously decreases hunger (2). Its improved nutrition promotes good health and well-being (3). Goal Four is quality education, and the AfPBA is one of the most effective educational programs in Africa. AOCC promotes gender equality (5) in that most African farmers are women (as are almost 40% of AfPBA graduates).

AOCC activities promote decent work and economic growth (8). They reduce inequality (10) by improving farmers' and women's incomes. They help produce sustainable cities and communities (11) by helping to feed those cities and communities, and they promote responsible consumption and production (12).

More productive crops help manage climate change (13) by decreasing forest clearance for farming, and this improves life on land (15).

Decreasing poverty, hunger and inequality encourages peace, justice, and strong institutions (16).

The final goal (17) calls for improved partnerships for meeting the SDGs. The AOCC is one of the most effective and cost-efficient partnerships among governments, businesses, NGOs, and international organizations ever devised.

AOCC: An Uncommon Collaboration

See https://africanorphancrops.org/Reports/

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For online version of this report and Appendices:
https://africanorphancrops.org/Reports/

APPENDICES

Appendix A: AOCC consortium Members

These are the consortium members of the AOCC and their roles and contributions. Given that the African heads of state at the African Union assembly voted to endorse the AOCC initiative, all African governments are members of the consortium as well.

African Union Development Agency-New Partnership for Africa's Development (AUDA- NEPAD) (Midrand, South Africa) *Founding consortium member*, technical body of the African Union which has provided administrative, logistical and political support for the AOCC.

Alliance for a Green Revolution in Africa (AGRA) (Nairobi, Kenya) Supported by the Bill and Melinda Gates and the Rockefeller Foundations it supports the AOCC in many ways and has contributed USD 1.1 million to the AfPBA.

Agricultural Research Council (ARC) (Pretoria, South Africa) Supports the AOCC by sequencing genes (transcriptomes) for the AOCC.

Bayer Crops Sciences (St Louis, USA). Supports and co-funds the AfPBA CRISPR course and provides genomic resources for AOCC.

Benson Hill Biosystems (St. Louis, Missouri) Plant biology, analytics and cloud computing company focusing on global food systems. It is providing AOCC plant breeders with advanced computational technology to accelerate their breeding programs.

Biosciences eastern and central Africa International Livestock Research Institute (BecA/ILRI) A shared agricultural research and biosciences platform providing laboratory services to African and international scientists conducting research on African agricultural challenges. It provides AOCC with lab and project support, training of breeders, and the curation of germplasm including hosting the AfPBA CRISPR course

BGI (Shenzhen, China) *Founding consortium member*. One of the world's leading sequencing organizations. It is involved in sequencing, annotating, assembling and curating many of the 101 African orphan crop genomes.

CIFOR-ICRAF (World Agroforestry, Nairobi, Kenya) *Founding consortium member,* Hosts and provides logistical support for the AOCC laboratory and the AfPBA. World Agroforestry helps manage the data and website.

Corteva Agriscience A private agricultural company focusing on development of crops. Corteva is helping train plant breeders and development of genomic resources for the AOCC.

CyVerse (Tucson, USA) is a collaborative that has developed a cyber-infrastructure for data- intensive biology driven by high-throughput sequencing, phenotypic and environmental data sets. It has helped the AOCC with analysis and curation of sequence and genotype data.

Dovetail Genomics (Santa Cruz, USA) A genomics company that contributes to assembling AOCC genomes.

Food and Agriculture Organization of the United Nations (FAO) (Rome, Italy) Supports the development of the AOCC through a letter of intent with specific areas of support. Supported and funded workshops.

Foundation for Food and Agriculture Research (Washington, DC). A Foundation that leverages US public and private funds to sponsor Ag innovations. Provided $1.0 M for the AFPBA CRISPR program

Grantham Foundation (Boston, United States) invests in programs to counter effects of climate change. Co-funds the African Plant Breeding Academy

Google (Mountain View, USA) Provides rapid transfer of AOCC data worldwide using cloud space.

Helmholtz University (Munich, Germany) annotates and assembles pan-genome and defines structural variants in complex genomes

International Institute for Tropical Agriculture (Nairobi, Kenya). CGIAR center hosting and providing instruction and labs for the AfPBA CRISPR program

Illumina Inc. (San Diego, USA) Develops technology and kits for use in genetic research and has provided the AOCC with reagents to sequence the gene complement of 50 species and has donated their HiSeq 4000 Sequencer to the AOCC lab. Granted $100,000 in reagents to sequence transcriptomes of African crops.

Livestock Research Institute (ILRI) (Nairobi, Kenya). International CGIAR center hosting and supporting the AfPBA CRISPR program

Innovative Genomics Institute (Berkeley, USA). Founded by Nobel Laureate Jennifer Doudna, provides key instruction, support, and development in the AfPBA CRISPR program

Integrated Breeding Platform Provides data management systems for plant breeders. The IPB provides training to AOCC breeders through the UC Davis Plant Breeding Academy.

Jon and Terase Curtis sponsored a student for the AfPBA.

Keygene Inc, (Rockville, USA) International company supplying genomic tools for plant breeding. It is providing its tools to AOCC breeders and is sequencing AOCC species.

LGC (Hoddesdon, UK) International life sciences measurement and testing company, providing reference materials, genomics solutions and analytical testing products and services. It has also provided genotyping services and training for AOCC plant breeders.

Mars, Incorporated (Maclean, USA) *Founding consortium member*. One of the world's largest privately- owned food companies; it has provided over $4 million for the African Plant Breeding Academy, scholarships for breeding programs and support for AOCC lab personnel.

Morrison & Foerster (San Francisco, CA). Multi-national Law Firm specializing in technologies. Conducted and regulatory and intellectual property audit for Africa and supports the AFPBA CRISPR program.

Oxford Nanopore, (Oxford, UK) Genomics company providing DNA and RNA sequencing technologies. It will provide its platform and reagents to AOCC breeders.

Scotland's Rural College, SRUC (Edinburgh, UK) Promotes AOCC and writes peer reviewed articles in collaboration with AOCC and AfPBA.

Syngenta Inc, (Syngenta, Chicago US) Supports travel for workshops and leads the Demand-Led Breeding initiative. Supports and funded $500,000 towards the AFPBA CRISPR program.

The University of Dundee (Dundee, Scotland) Non-profit research institute specializing in plant breeding. It will provide gene sequencing tools and analyses to AOCC breeders.

Thermo Fisher Scientific (Waltham, USA) Acquired Life Technologies, which donated four Ion proton machines to the AOCC. Thermo-Fisher helps companies and organizations solve their research challenges and donated reagents to AOCC for Proton Sequencers.

UM6P Ventures (Casablanca, Morocco). Investment arm of University Mohammed VI Polytechnic. Supported and funded AfPBA CRISPR Program

UNICEF (New York City, USA) Supports the development of the AOCC.

United States Department of Agriculture. Agricultural Research Service (Stoneville, USA). Provides development of sequence and genomic tools for AOCC.

University of California at Davis (Davis, USA) *Founding consortium member*, one of the world's leading agricultural universities. It manages the AfPBA and co-leads the AOCC laboratory and scientific programs including funding.

University of York (York, England). Leading Agricultural university providing genomic sequencing and plant breeding tools for Amaranths

VIB-U of Ghent Center for Plant Systems Biology (Ghent, the Netherlands) Non-profit research institute in the life-sciences sector with 1,200 scientists conducting basic research on molecular mechanisms. It helps AOCC with bioinformatics and annotation of plant genomes. VIB hosts the completed genomes for AOCC.

Wageningen University (Wageningen, the Netherlands) World-leading agricultural university working closely with AOCC to define the nutritional value of African crops and breeding lines.

World Food Programme The food-assistance branch of the United Nations and the world's largest humanitarian organization addressing hunger and promoting food security. It supports the AOCC in development.

World Wildlife Fund for Nature (Washington, DC) Founding consortium member, Helped with initiation and vision of the AOCC.

Appendix B_AOC Genomes

The AOCC aims to sequence 101 crop species important to African diets. AOCC has stayed at the forefront of technology since the beginning using the state-of-the art short-read sequencing and linked-reads in the beginning thru our founding consortium member-BGI and on to long-read technologies with Pacific Biosciences RS, Oxford Nanopore and now HI-FI thru consortium members. We also complement scaffolding with Hi-C thru Dovetail. Importantly, transcriptomes were generated with comprehensive annotations. Dr. Yves Van de Peer with University of Ghent, Belgium has not only annotated many of these genomes but also hosts them on his website https://bioinformatics.psb.ugent.be/orcae/aocc/.

To-date AOCC has published 16 genomes. In that time, other labs published 30 genomes for African Orphan Crops (AOCs). Importantly, 40 of these 46 genomes have long read chromosome-scale assemblies with the last few now achieving telomere-to-telomere assemblies. An additional 9 and 20 other AOCs are in progress form AOCC and other labs, respectively, for a total of 75 of 101 species being addressed. The vast majority of genomes are being done with plant breeders to have direct impact.

AOC#	Scientific Name	Common Name	Habit	AOCC Genome Sequence in-Progress	Public in-Progress	AOCC Published	Other Published/ Available	High Quality sequence
1	Abelmoschus caillei/esculentus	Okra	annual	x				x
2	Adansonia digitata	Baobab, Mbuyu	tree					
3	Allanblackia floribunda	Allanblackia, Kionzo, Bouandjo, Vegetable tallow tree	tree					
4	Allanblackia stulhmanii	Allanblackia	tree					
5	Allium cepa	Onion, Kitunguu	annual				x	x
6	Amaranthus cruentus	Vegetable Amaranth, Mchicha	annual			x		x
7	Amaranthus tricolor/hypochondriacus	Vegetable amaranth, Mchicha	annual		x		x	x
8	Anacardium occidentale	Cashew, Korosho	tree				x	x
9	Annona reticulata	Custard apple	tree	x				
10	Annona senegalensis	Wild Custard Apple, Mtokwe	tree	x				
11	Artocarpus altilis	Breadfruit, Mshelisheli	tree			x		
12	Artocarpus heterophyllus	Jack Tree, Fenesi	tree			x		
13	Balanites aegyptiaca	Balanites, Mchunju	tree	x				
14	Basella alba	Vine spinach/bologi, Mboga buterezi	perennial					
15	Boscia senegalensis	Aizen, Nabedega	perennial					
16	Brassica carinata	Ethiopia Mustard, Kandhira	annual				x	x
17	Canarium madagascariense	Canarium nut, Mbani	annual					
18	Carica papaya	Papaya, Carica, Mpapai- Pawpaw	tree				x	x
19	Carissa spinarum	Carissa, Mtanda-mboo	perennial					
20	Casimiroa edulis	White sapote	tree					
21	Cassia obtusifolia	Sickle Senna	annual					
22	Celosia argentea	Celosia, Mfungu, Lagos spinach	annual					
23	Chrysophyllum cainito	Star apple, Caimito	tree					
24	Citrullus lanatus	Egusi, Watermelon, Mtikiti	annual		x			x
25	Cleome (Gynandropsis) gynandra	Spider plant, Saga	annual			x		x
26	Cocos nucifera	Coconut, Mnazi	tree				x	x
27	Colocasia esculenta	Taro	perennial				x	
28	Corchorus olitorius	Jute mallow, Mrenda	annual	x				

29	Crassocephalum rubens	Yoruban bologi	annual				x	
30	Crotalaria juncea	Sunn hemp	annual					
31	Cucumis metuliferus	Horned Melon, Maxije	annual				x	x
32	Cucurbita maxima	Pumpkin, Marenge/Matengo	annual				x	x
33	Cyphomandra betacea	Cape tomato, Mgogwe	tree				x	x
34	Dacryodes edulis	African Plum, Safoutier	tree					
35	Detarium microcarpum	Sweet Detar	tree					
36	Detarium senegalense	Sweet detar	tree					
37	Digitaria exilis	White fonio	annual			x		x
38	Dioscorea alata	Water yam, Adzugo	perennial			x		x
39	Dioscorea dume torum	Bitter yam, Kekama	perennial				x	x
40	Dioscorea rotundata	White yam, Guinea yam	perennial				x	
41	Diospyros mespiliformis	African persimmon	tree					
42	Dovyalis caffra	Kei Apple, Kei-appel	tree					
43	Eleusine coracana	Finger millet, Wimbi	annual			x		
44	Ensete ventricosum	Enset	perennial			x		
45	Eragrostis tef	Tef	annual				x	x
46	Faidherbia albida	Acacia (Apple-ring)	tree			x		
47	Garcinia livingstonei	African mangosteen, Mpekechu	tree					
48	Garcinia mangostana	Garcinia, Mangosteen	tree					
49	Gnetum africanum	African Gnetum, Nkoko	tree					
50	Hibiscus sabdariffa	Roselle, Ufuta	tree					
51	Icacina oliviformis	False yam, Basouna	perennial					
52	Ipomoea batatas	Sweet Potato, Matembele	perennial				x	x
53	Irvingia gabonensis	Sweet bush mango, Dika	tree	x				
54	Lablab purpureus	Lab lab Bean, Mfiwi	annual			x		x
55	Lannea microcarpa	Tree grapes, tsambatsi	tree					
56	Lens culinaris	Lentils, Mdengu	annual				x	x
57	Macadamia ternifolia	Macadamia	tree				x	x
58	Macrotyloma geocarpum	Kersting's groundnut, Geocarpa groundnut	annual	x				
59	Mangifera indica	Mango, Maembe	tree				x	x

60	Momordica charantia	Bittergourd, Karela	annual				x	x
61	Moringa oleifera	Moringa, Drumstick tree, Mzunze	tree			x		x
62	Morus alba	Mulberry	tree				x	x
63	Musa acuminata AAA Group	Banana (matoke)	perennial				x	x
64	Musa balbisiana	Plantain	perennial				x	x
65	Opuntia basilaris	Prickly pear, Monducuru	perennial		x			
66	Parinari curatellifolia	Mobola plum, Mbura	tree		x			
67	Parkia biglobosa	Nere, African Locust	tree		x			
68	Passiflora edulis	Passion Fruit, Marakucha	tree				x	x
69	Persea americana	Avocado, Ikloviu	tree				x	x
70	Phaseolus vulgaris	Green Bean, Maharagwe	annual				x	x
71	Plectranthus esculentus	African potato, Ethiopian potato	annual					
72	Plectranthus rotundifolius	African potato, Frafra potato	annual		x			
73	Psidium guajava	Guava, Mpera	tree				x	x
74	Ricinodendron heudelotii	Ground Nut Tree, Muawa	tree	x				
75	Saba comorensis	Gumvines, Mbungu	perennial		x			
76	Saba senegalensis	Nsaban or Zaban, Senegal saba	perennial		x			
77	Sclerocarya birrea	Marula, Mng'ongo	tree			x		
78	Solanum aethiopicum	African Eggplant, Ngogwe	annual			x		x
79	Solanum nigrum	African Nightshade, Mnavu	annual		x			x
80	Solanum scabrum	African Nightshade, Mnavu	annual		x			x
81	Sphenostylis stenocarpa	African yam bean	annual			x		
82	Strychnos cocculoides	Corky bark monkey orange	tree		x			
83	Strychnos spinosa	Kaffir orange, African orange, Kikwakwa	tree		x			
84	Syzygium guineense	Water berry, Mzuari	tree		x			
85	Talinum fruticosum	Lagos bologi, Ceylon spinach	perennial				x	x
86	Tamarindus indica	Tamarind, Mkwaju	tree				x	x
87	Telfairia occidentalis	Fluted gourd, Courge cannelée	annual				x	
88	Tylosema esculentum	Marama bean	perennial				x	x
89	Uapaca kirkiana	Wild apple, Wild loquat, Mkusu	tree		x			
90	Vangueria infausta	African medlars, Muiru	tree	x				

91	Vangueria madagascariensis	African medlars, Muiru	tree		x			
92	Vicia faba	Faba bean	annual					
93	Vigna radiata	Mungbean, Mchooko	annual				x	x
94	Vigna subterranea	Bambara groundnut, Njugu mawe	annual		x	x		x
95	Vitellaria paradoxa	Shea	tree			x		x
96	Vitex doniana	Chocolate berries, Mfudu	tree		x			
97	Xanthosoma sagittifolium	Elephant ears, macabo cocoyam	perennial		x			
98	Xanthosoma spp	Cocoyams, Arrowroots	perennial					
99	Ximenia caffra	Sour plum, Mpingi	tree		x			
100	Ziziphus mauritiana	Jujube, Mkunazi	tree		x			
101	Crotalaria ochroleuca	Rattlebox, Marejea	perennial					
				9	**20**	**16**	**30**	**40**

*High quality sequence refers to chromosome-scale assembly using long-read sequencing technologies.

Appendix C. Released Varieties by AfPBA alumni since they graduated

1. Ahmed Abdelmoghny (ARC, Egypt) Cotton variety, Giza 97, for Egypt. 2020
2. Patrick Adebola (IITA, Nigeria) Water yam (D. alata) UMUDa-27 (AKUABATA), 2019
3. Patrick Adebola (IITA, Nigeria) Water yam (D. alata) UMUDa-28 (VAYAM), 2019
4. Patrick Adebola (IITA, Nigeria) White Yam UMUDr33 (BLESSING), 2023.
5. Patrick Adebola (IITA, Nigeria) White Yam, UMUDr34 (SUNSHINE), 2023.
6. Patrick Adebola (IITA, Nigeria) White Yam, UMUDa35 (DELIGHT), 2023
7. Eric Agoyi (University of Abomey-Calavi, Benin) Kersting's groundnut (Macrotyloma geocarpum (Harms) Maréchal & Baudet) LEA-DOYIWÉ 1, for West Africa/Benin, Application submitted 2023
8. Eric Agoyi (University of Abomey-Calavi, Benin) Soybean (Glycine max) LEA-SOYA-1 for West Africa/ Benin, application submitted 2023
9. Richard Akinwale (Obafemi Awolowo University, Nigeria) Maize hybrid VS2022 for Nigeria, 2022
10. Charles Amadi (National Root Crop Research Institute, Nigeria) Ginger variety Umugin 1, 2021
11. Charles Amadi (National Root Crop Research Institute, Nigeria) Ginger variety Umugin 2, 2021
12. Charles Amadi (National Root Crop Research Institute, Nigeria) Potato variety Kyau, 2023
13. Charles Amadi (National Root Crop Research Institute, Nigeria) Potato variety Babban, 2023
14. Charles Amadi (National Root Crop Research Institute, Nigeria) Potato variety Juriya, 2023
15. Charles Amadi (National Root Crop Research Institute, Nigeria) Potato variety Unica, 2023
16. Charles Amadi (National Root Crop Research Institute, Nigeria) Cassava variety Umucass 56, 2019
17. Maxwell Darko Asante (CSIR-Crops Research Institute, Ghana) Rice variety CRI-Agyapa, 2022
18. Maxwell Darko Asante (CSIR-CRI, Ghana) Rice variety CRI-KoreaMo, 2022
19. Maxwell Darko Asante (CSIR-CRI, Ghana) Rice variety CRI-Baakoye, 2022
20. Maxwell Darko Asante (CSIR-CRI, Ghana) Rice variety CRI-Tuo Mo, 2022
21. Maxwell Darko Asante (CSIR-CRI, Ghana) Rice variety CRI-Kang Mo, 2022
22. Maxwell Darko Asante (CSIR-CRI, Ghana) Rice variety CRI-Onuapa, 2022
23. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 26, 2019
24. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 28, 2019
25. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 29, 2019
26. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 30, 2019

27. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 34, 2019
28. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 35, 2019
29. Clarisse P. Kondombo Barro (INERA, Burkina Faso) Sorghum OPV Sariaso 37, 2019
30. Asnakech Tekalign Beyene (EIAR, Ethiopia) Field pea variety EH07006-5 -Jeldu, Kiki type; 2019
31. Asnakech Tekalign Beyene (EIAR, Ethiopia) Faba bean variety Chalew, 2020
32. Asnakech Tekalign Beyene (EIAR, Ethiopia) Field pea variety Etetu, 2021
33. Asnakech Tekalign Beyene (EIAR, Ethiopia) Faba bean variety EH011089-3 for high potential acreage, 2023
34. Tewodros Mulualem Beyene (EIAR, Ethiopia) Orange-fleshed sweet potato NASPOT-12, with high yield and stable, high beta carotene content, 2023
35. Tewodros Mulualem Beyene (EIAR, Ethiopia) Avocado variety AL-I, with high yield and resistance to root rot, 2023
36. Tewodros Mulualem Beyene (EIAR, Ethiopia) Avocado variety Choquette, with high yield and resistance to root rot, 2023
37. Tewodros Mulualem Beyene (EIAR, Ethiopia) Taro variety Acc058, with high yield and low calcium oxalate content, 2023
38. Agyemang Danquah (WACCI, University of Ghana) Tomato hybrid Tomato Queen, 2021
39. Agyemang Danquah (WACCI, University of Ghana) Tomato Legon Hybrid, 2021
40. Agyemang Danquah (WACCI, University of Ghana) Tomato hybrid Ante Dede, 2021
41. Nicholas Denwar (CSIR-SARI, Ghana) Soybean variety CSIR-Favour, 2018
42. Nicholas Denwar (CSIR-SARI, Ghana) Groundnut variety SARINUT 1, 2018
43. Nicholas Denwar (CSIR-SARI, Ghana) Groundnut variety SARINUT 2, 2018
44. Mathews Dida (Maseno University, Kenya) Maize hybrid Maseno Sukari, 2022
45. Mathews Dida (Maseno University, Kenya) Maize hybrid Maseno T1, 2023
46. Amani Gharib (Horticulture Research Institute, Egypt) Melon variety, 2023
47. Amani Gharib (Horticulture Research Institute, Egypt) Pea (Pisum sativum) variety, 2023
48. Oumarou Goita (National Agricultural Research Organization, Mali) Wheat variety Norman, 2020
49. Oumarou Goita (National Agricultural Research Organization, Mali) Wheat variety Goumria-3, 2020
50. Hortense Noelle Mafouasson Apala (IRAD, Cameroon) Maize hybrid CLH2301, in registration process
51. Hortense Noelle Mafouasson Apala (IRAD, Cameroon) Maize hybrid CLH2302, in registration process
52. Isata Kamanda (Sierra Leone Agricultural Research Institute) Cassava variety Provitamin-A Yellow, 2022
53. Kelvin Kamfwa (University of Zambia) Common bean variety Kundalila, 2023
54. Kesbell Kaonga (Department of Agriculture Research Services (DARS), Ministry of Agriculture, Malawi) Maize hybrid MH58, tolerant to Fall armyworm, 2023

55. Kesbell Kaonga (DARS, Ministry of Agriculture, Malawi) Maize hybrid MH59, tolerant to Fall armyworm, 2023
56. Kesbell Kaonga (DARS, Ministry of Agriculture, Malawi) Maize hybrid MH60, tolerant to Fall armyworm, 2023
57. Kesbell Kaonga (DARS, Ministry of Agriculture, Malawi) wheat variety KAS52, 2023
58. Kesbell Kaonga (DARS, Ministry of Agriculture, Malawi) wheat variety KAS26, 2023
59. Kesbell Kaonga (Department of Agriculture Research Services (DARS), Ministry of Agriculture, Malawi) wheat variety KAS27, 2023
60. Kesbell Kaonga (Department of Agriculture Research Services (DARS), Ministry of Agriculture, Malawi) wheat variety KASS6, 2023
61. Kumba Yannah Karim (Njala University, Sierra Leone) Rice variety NUCOS1, 2022
62. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, TARICASS1, 2020
63. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, TARICASS2, 2020
64. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, TARICASS3, 2020
65. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, TARICASS4, 2020
66. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, TARICASS5, 2020
67. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, Kizimbani, 2020
68. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, Kiroba, 2020
69. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, Mkuranga1, 2020
70. Heneriko Philbert Kulembeka (TARI, Tanzania) Cassava variety, Mkumba, for Tanzania and Rwanda, 2019
71. Lloyd Mbulwe (ZARI, Zambia) Sorghum OPV, FSV-23-1, 2023
72. Lloyd Mbulwe (ZARI, Zambia) Sorghum OPV, ZSV-108, for 2024
73. Friday Nwalo Nweke (Alex Ekwueme Federal University, Nigeria) Sesame hybrid EBS 01 – 05, 2021
74. Friday Nwalo Nweke (Alex Ekwueme Federal University, Nigeria) Sesame hybrid EBS 06 - 10, 2022
75. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Sunshine, 2023
76. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Blessing, 2023
77. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Favourite, 2022
78. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Wonder, 2020
79. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Nagode, 2020
80. Happiness Oselebe (Ebonyi State University, Nigeria) Water yam (Dioscorea alata) variety Delight, 2023
81. Happiness Oselebe (Ebonyi State University, Nigeria) Water yam (Dioscorea alata)

variety Vayam, 2019

82. Happiness Oselebe (Ebonyi State University, Nigeria) Water yam (Dioscorea alata) variety Akuabata, 2019
83. Happiness Oselebe (Ebonyi State University, Nigeria) White yam (Dioscorea rotundata) variety Super, for West Africa – Nigeria, 2020
84. Tesfahun Alemu Setotaw (EIAR, Ethiopia) Barley variety Suba, 2022
85. Tesfahun Alemu Setotaw (EIAR, Ethiopia) Oat variety Y22_15_9, 2023
86. Oumarou Souleymane (INRAN, Niger) Rice variety Seberi 1, 2021
87. Oumarou Souleymane (INRAN, Niger) Rice variety Seberi 2, 2021
88. Oumarou Souleymane (INRAN, Niger) Rice variety Seberi 3, 2021
89. Oumarou Souleymane (INRAN, Niger) Rice variety Seberi 4, 2021
90. Edgar Valentin S. Traore (ANVAR and INERA, Burkina Faso) Rice variety KamBoinseRice8 (or KBR8 or Mouifiida), 2019
91. Edgar Valentin S. Traore (ANVAR and INERA, Burkina Faso) Rice variety KamBoinseRice6 (or KBR6 or Bitonkini), 2019
92. Edgar Valentin S. Traore (ANVAR and INERA, Burkina Faso) Rice variety KamBoinseRice2 (or KBR2 or Massamalo), 2019
93. Edgar Valentin S. Traore (ANVAR and INERA, Burkina Faso) Rice variety KamBoinseRice4 (or KBR4 or Nongsaamè), 2019
94. Robooni Tumuhimbise (NARO, Uganda) Cooking banana variety resistant to disease and pests for East Africa,NAROBan1, 2018
95. Robooni Tumuhimbise (NARO, Uganda) Cooking banana variety resistant to disease and pests for East Africa,NAROBan2, 2018
96. Robooni Tumuhimbise (NARO, Uganda) Cooking banana variety resistant to disease and pests for East Africa,NAROBan3, 2018
97. Robooni Tumuhimbise (NARO, Uganda) Cooking banana variety resistant to disease and pests for East Africa,NAROBan4, 2018
98. Robooni Tumuhimbise (NARO, Uganda) Cooking banana variety resistant to disease and pests for East Africa, NAROBan5, 2019.
99. Pavithravani Venkataramana (The Nelson Mandela African Institution of Science and Technology Tanzania) Lablab bean variety NM-D19, 2022
100. Pavithravani Venkataramana (The Nelson Mandela African Institution of Science and Technology Tanzania) Lablab bean variety NM-D20, 2022
101. Viviane Raharinivo (National Center for Applied research on Rural Development (FOFIFA), Madagascar) Rice variety Fy vary 32, 2021
102. Viviane Raharinivo (FOFIFA, Madagascar) Rice variety Fy vary 85, 2021
103. Konan Jean Louis Konan (CNRA, Côte d'Ivoire) Coconut cultivar PB121 improved (Malayan Yellow Dwarf x West African Tall improved) for Ghana, Nigeria, Sierra Leone
104. Konan Jean Louis Konan (CNRA, Côte d'Ivoire) Coconut cultivar B113 improved (Cameroon Red Dwarf x Rennell Island Tall improved) for Ghana, Nigeria, Sierra Leone
105. Konan Jean Louis Konan (CNRA, Côte d'Ivoire) Coconut cultivar Panama Tall

Monagre for Nicaragua

106. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Early maturing yellow maize variety SAMMAZ 69 with tolerance to multiple stresses, 2023.

107. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Oat variety SAMOAT 1, 2022, mid-altitude adaptation

108. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Oat variety SAMOAT 2 , 2022, mid-altitude adaptation

109. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Drought and Striga tolerant white SAMMAZ 64 and yellow SAMMAZ 65 maize hybrids, 2022.

110. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria). DroughtTEGO® Maize Hybrid WE8206 (SAMMAZ 68) with high yield and good standability, 2022.

111. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Drought and Striga Tolerant Intermediate Maturing White Maize Variety SAMMAZ 66, 2022.

112. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Provitamin A Maize Hybrid SAMMAZ 67, 2022.

113. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Provitamin A Maize Hybrid HAKIMI 1, developed in collaboration with GoldAgric Nig Ltd, 2022.

114. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) White-endosperm Maize Hybrid HAKIMI 2 with high grain yield, developed in collaboration with GoldAgric Nig Ltd, 2022.

115. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Early-maturing White Maize Hybrid HAKIMI 3 with high grain yield, developed in collaboration with GoldAgric Nig Ltd 2022.

116. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Drought Tolerant and Striga Resistant Maize Hybrid Oba Super 15, developed in collaboration with Premier Seed Nig Ltd 2022.

117. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Drought Tolerant and Striga Resistant Maize Hybrids Oba Super 17, developed in collaboration with Premier Seed Nig Ltd 2022.

118. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Early-maturing stress tolerant maize variety ILOMAZ 2, 2022.

119. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Late Maturing White Maize Hybrid SC737, developed in collaboration with AgriSeed Co Nig Ltd, 2022.

120. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Maize Hybrid DK 7500, developed in collaboration with Bayer Nig Ltd, 2022.

121. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Maize Hybrids SAMMAZ 62 with high grain yield, 2020.

122. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Maize Hybrids SAMMAZ 63 with high grain yield, 2020.

123. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Medium Maturing Top-Cross Maize Hybrid SAMMAZ 61, 2020.

124. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Pro-vitamin A Maize Varieties SAMMAZ 59, 2020.

125. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Pro-vitamin A Maize Varieties SAMMAZ 60, 2020.

126. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) early maturing stress tolerant maize variety ILOMAZ-1, 2020.

127. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria). Intermediate-Maturing White Maize Hybrid (SC667), developed in collaboration with AgriSeed Co Nig Ltd, 2020.

128. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Early-Maturing Multiple Stress Tolerant White Maize Hybrid SC419, developed in collaboration with AgriSeed Co Nig Ltd 2020.

129. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Three-way hybrid White Maize SAMMAZ 58, 2019

130. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Provitamin A Maize (Zea mays L.) Hybrid SAMMAZ 57, 2019

131. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) early maturing QPM yellow maize hybrid SAMMAZ 56, 2019

132. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Early maturing maize variety SAMMAZ 55 with tolerance to multiple stresses, 2019

133. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Extra early high yield Maize hybrid ZUMA 450, 2019

134. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Extra early high yield Maize hybrid ZUMA 500, 2019

135. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Maize variety AMANA-1, for mid-altitude, 2018

136. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Maize variety AMANA-2, for mid-altitude, 2018

137. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) White drought-tolerant maize hybrid WE3205, 2018

138. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Yellow drought-tolerant maize hybrid DKB350, 2018

139. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) Yellow maize hybrid P4226 with excellent staygreen and husk cover and good standability, developed in collaboration with DuPont/Pioneer, 2018

140. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) White maize hybrid P4063W with excellent husk cover and resistance to lodging, developed in collaboration with DuPont/Pioneer, 2018

141. Muhyideen Oyekunle (Ahamadu Bello University, Nigeria) White maize hybrid P3966W with high yield and good standability, developed in collaboration with DuPont/Pioneer, 2018

142. Abush Tesfaye (Jimma Agricultural Research Centre, Ethiopia) Soybean variety, Melko-Bonsa, 2020 medium maturity

143. Abush Tesfaye (Jimma Agricultural Research Centre, Ethiopia) Soybean variety, Guda, 2021, early maturity

Appendix D: AOCC Alumni Publications

1. Abate S, Mekbib F, Gebre E: **In vitro somatic embryogenesis and plantlet regeneration in anchote Coccinia abyssinica (Lam.) Cong.** *Plant Physiology Reports* 2019, **24**(3):351-358. 10.1007/s40502-019-00465-9.
2. Abdelmoghny AM: **Prediction of New Genetic Recombination in Two Egyptian Cotton Crosses**. *Egyptian Journal of Agronomy* 2021, **43**(1):83-96. 10.21608/agro.2021.65016.1251.
3. Abdelrahman M, Selim ME, ElSayed MA, Ammar MH, Hussein FA, ElKholy NK, ElShamey EA, Khan N, Attia KA: **Developing Novel Rice Genotypes Harboring Specific QTL Alleles Associated with High Grain Yield under Water Shortage Stress**. *Plants-Basel* 2021, **10**(10). 10.3390/plants10102219.
4. Abebe AT, Adewale S, Chigeza G, Derera J: **Diallel analysis of soybean (Glycine max L.) for biomass yield and root characteristics under low phosphorus soil conditions in Western Ethiopia**. *Plos One* 2023, **18**(2). 10.1371/journal.pone.0281075.
5. Abebe AT, Belachew K, Hailemariam M, Sileshi Y, Ortega-Beltran A: **Interaction of varieties and fungicides across seasons and locations for the control of Asian soybean rust (Phakopsora pachyrhizi) in Southwestern Ethiopia**. *Crop Protection* 2022, **158**. 10.1016/j.cropro.2022.106008.
6. Abebe AT, Kolawole AO, Unachukwu N, Chigeza G, Tefera H, Gedil M: **Assessment of diversity in tropical soybean (Glycine max (L.) Merr.) varieties and elite breeding lines using single nucleotide polymorphism markers**. *Plant Genetic Resources-Characterization and Utilization* 2021, **19**(1):20-28. 10.1017/s1479262121000034.
7. Abihudi SA, Venkataramana PB, de Boer HJ, Treydte AC: **Species-specific responses of "Critically Endangered" and "Least Concern" Aloe seed germination to environmental conditions in Tanzania**. *Global Ecology and Conservation* 2020, **24**. 10.1016/j.gecco.2020.e01241.
8. Abraha T, Tibebu A, Ephrem G: **Rapid Urbanization and the Growing Water Risk Challenges in Ethiopia: The Need for Water Sensitive Thinking**. *Frontiers in Water* 2022, **4**. 10.3389/frwa.2022.890229.
9. Abubakar M, Wasswa P, Masumba E, Kulembeka H, Mkamilo G, Kanju E, Mrema E, Abincha W, Edema R, Tulkamuhabwa P: **Pasting properties of high-quality cassava flour of some selected improved cassava varieties in Tanzania for baking**. *African Journal of Agricultural Research* 2023, **19**(1):1-7.
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Appendix E: AOCC Scientists Publications

AOCC scientists (other than Plant Breeding Graduates) were cited 588 times with 26 publications. Overall, 16,600 articles were written on orphan crops since inception of AOCC in 2011.

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