



THE AFRICAN ORPHAN CROPS CONSORTIUM

2018 PROGRESS REPORT



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OVERVIEW

2018 was a significant year for the African Orphan Crops Consortium (AOCC). This year, the AOCC and the United Nations Food and Agriculture Organization (FAO) mobilized to improve nutritional security in all FAO member states, as detailed in their letter of intent agreed in 2017. This represents a crucial milestone, as the agreement and initiatives recognize and promote the AOCC's 'orphan crops' approach to addressing food security by improving the nutritional content of key crop species in Africa.

'Orphan crops' refers to a diverse range of plant species that are economically and socio-culturally important but which are neglected by science and research because they are not widely traded commodities. The orphan crops approach aims to raise the importance of these essential species and accelerate research activities for plant growth and development. This is crucial for combatting malnutrition and chronic hunger, strengthening food security globally. By 2030, the use of nutritious, climate resilient African crops stimulated by AOCC activities are expected to be a part of dietary improvements in 20% of rural populations and 10% of urban populations.

In 2018, the AOCC approach for improving food security was presented and officially recognized at the October meeting of the FAO's Committee on Agriculture (COAG). During the AOCC's side event at COAG, eight graduates from the AOCC's African Plant Breeding Academy shared their efforts to help fight malnutrition in their own nations through transferring the AOCC's research and training. FAO Director of Nutrition and Food Systems, Dr. Anna Larrey, told the meeting that the AOCC approach has the potential to spur a global revolution for orphan crops in Africa. Moreover, Dr. Larrey highlighted how the AOCC program can contribute to the nutrition agendas of the United Nations 2030 Sustainable Development Agenda, with a focus on the Decade of Action for Nutrition – a UN commitment to eliminate malnutrition in all its forms in the ten years from 2016 to 2025.

BACKGROUND

The AOCC's progress to date

The African Orphan Crop Consortium (AOCC) is an African-led, international consortium founded in 2011 with the goal of sequencing, assembling and annotating 101 African orphan crops.

These crops represent the annual and biennial shrubs, bushes and trees that act as the principal food sources for the 600 million people living in rural Africa. The consortium has been sequencing the genomes of these 101 species to allow scientists to efficiently improve the crops' productivity, climate resilience, disease and pest resistance and nutritional quality, while also training African scientists to best use the genetic information. All completed genetic 'maps' are published online open access, with the intellectual property held by the African Union (AU).

Since its beginning, the AOCC has been improving Africa's genomics resources through reference genome sequencing, transcriptome sequencing and re-sequencing varieties. The list of the 101 crops¹ was drawn from an Africa-centric survey conducted by the World Wildlife Fund, the AU's New Partnership for Africa's Development (NEPAD) and Mars, Incorporated, with support from African women's groups, agricultural scientists, sociologists, anthropologists, nutritionists, policy makers, farmers, government representatives, universities and numerous other stakeholders.

Three primary selection criteria were used for crop prioritization: rich in vitamins, minerals, micro- and macro-nutrients; relevant to pan-African agriculture, and; the disparity in breeding resource and research. The list comprises 50 woody trees/shrubs and 51 non-woody crops, made up of 28 orders and 45 families. By the

end of December 2018, one or more forms of sequence data had been produced for 59 crops. Reference genome sequences for six species were made available for publication, with a further six near completion and 19 in progress.

The AOCC was approved by African heads of state at the African Union Assembly and is led by NEPAD. The AOCC and its African Plant Breeding Academy (AfPBA), which is run by the University of California, Davis, comprise the most comprehensive and integrated crop improvement venture on the continent. AfPBA is funded by Mars, Incorporated and the Alliance for the Green Revolution for Africa (AGRA), among many donors, and is hosted by the World Agroforestry Centre (ICRAF) in Nairobi, Kenya. The academy trains African plant scientists and breeders to develop better crop varieties faster from genetic "maps" of orphan crops. AfPBA has trained 85 of its target 150 African scientists to use the DNA-sequence information to breed more nutritious, productive and resilient varieties that can withstand threats from environmental change. These efforts are supported by an uncommon partnership of 25 government organizations, scientific and agricultural bodies, universities, private and public companies, regional organizations and NGOs, along with a network of more than 20 agricultural and horticultural organizations. The full list of partnerships can be found on pages 13-14.



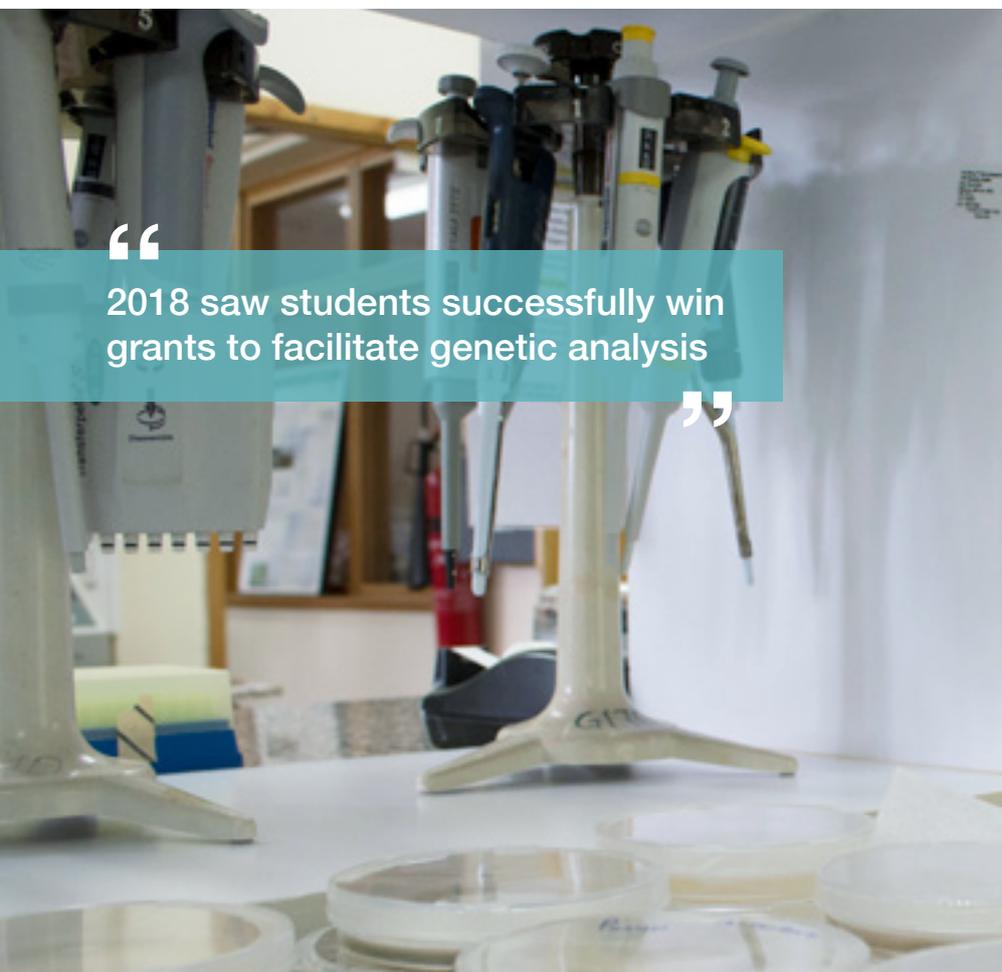
The most comprehensive and integrated crop improvement venture on the continent ”

1. To view the full list, please visit: <http://africanorphancrops.org/meet-the-crops>

OUR STUDENTS

Nurturing the next generation of plant scientists

Thanks to world-class training and the advanced equipment provided, AfPBA empowers plant scientists to meet farmer and consumer demands in their home countries, creating better varieties on accelerated timescales.



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2018 saw students successfully win grants to facilitate genetic analysis
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In December 2018, AfPBA welcomed its fourth class consisting of 36 students from a range of backgrounds. Past and present students represent 29 African countries working to improve other crop species across 149 breeding

programs, in addition to the 101 chosen by the AOCC. Not only is AfPBA truly pan-African, it seeks to make the most of African human resources; among its students, 81% are PhD scientists and one third are women.

Already, AfPBA graduates are achieving major impacts. Working together, cohorts have landed sizeable breeding, research and teaching grants, totaling more than nine million euros in 2018. These awards are subsequently used to facilitate graduate education for more than 100 students outside of direct AOCC training, as well as research undertaken at AfPBA. 2018 saw students successfully win grants to facilitate genetics analysis of their breeding materials, which has opened doors for the development of improved crop varieties. As a result, students have secured scientific articles in high-profile journals, including a landmark paper providing a “roadmap” for genetic improvement of African orphan crops and similar species. These activities help put African orphan crops at the center of mainstream research and breeding efforts.

Outside the academy, graduates have gone on to assume larger roles within their home country organizations, broadening the influence and effect of AfPBA training. For example, two AfPBA alumni have established a continuing education program to upgrade the skills of plant breeders in Ethiopia, modeled after AfPBA. To date, more than 40 masters-level scientists have benefitted from this



“ They are inspired and determined in their fight for safe food and nutritional security ”



program, led by Dr. Gemechu Keneni and Dr. Abush Tesfaye of AfPBA Class II and funded through the Ethiopian Institute of Agricultural Research and USAID.

Additionally, AfPBA has trained several faculty members that lead pan-African training programs through the African Center for Crop Improvement and the West African Centre for Crop Improvement. These individuals in turn have trained over 60 PhD and Masters students to increase capacity for the next generation of plant breeders

in Africa. These programs are also supported by AOCC’s partner, AGRA.

Tools offered through the AfPBA and AOCC partners have been shared broadly within many home institutions to empower and enable even more scientists to develop better crop varieties at an accelerated pace. For example, Dr. Dorcas Ibitoye, Head of the Genetic Resources Unit at the National Horticultural Research Institute of Nigeria (NIHORT) and graduate of AfPBA Class III, was recently recognized as “Most Influential Scientist” by her institute. This award was specially created by NIHORT to recognize Dr. Ibitoye’s work in sharing the new-found skills and tools gained from AfPBA.

Additionally, graduates of Classes I, II and III are establishing an African community of plant scientists named the African Association of Plant Breeders (AAPB). This platform aims to further the professional development of plant scientists, share research findings and continue to educate about best practice genomics. Biennial meetings are planned, with the inaugural meeting to be held in Accra, Ghana, in October 2019 with support from the West

Africa Centre for Crop Improvement at the University of Ghana.

This new community of empowered plant breeders is pushing the boundaries for crop development in Africa. They are inspired and determined in their fight for safe food and nutritional security. USAID and AOCC partners recognized the important influence and potential of this group. As such, USAID and AOCC partners are investing in AAPB as a platform to offer further professional development, not only on the research side, but also as a means to reach the next generation of African plant breeders. Efforts to support the AfPBA graduates in their roles as university instructors include mentorship of new African faculty to develop high quality post-graduate curricula using best practices in teaching.

Through training, education and sharing knowledge via its graduates, AfPBA is confident in its ability to create a pan-African movement to eradicate stunting caused by malnutrition, chronic hunger and undernutrition.

THE ACADEMY

Providing expert training

The academy's intensive six-week course is delivered in three two-week sessions over 13 months. In this advanced professional course, the students learn concepts of genetics, experimental design and statistics, and plant breeding from world-class experts.

During the course, guest speakers, including icons like 2016 World Food Prize Laureate Dr. Robert Mwangi, teach using real-life examples that exemplify complex breeding targets. The course also includes teaching from instructors, guest speakers, and other individuals from partner organizations such as the CGIAR Excellence in Breeding Platform and the Integrated Breeding Platform, Agricultural Research Centre (ARC), Biosciences for East and Central Africa (Beca/ILRI), Benson Hill Biosystems, BGI, Corteva Agriscience, Cyverse, Google Genomics, ICRAF, Illumina

Inc., James Hutton Institute, Keygene BV, LGC, Oxford Nanopore, Thermo Fischer University of Ghent and Wageningen University. These partners also contribute tools for various tasks and critical analyses in the breeding pipeline. AGRA, through its Program for Africa's Seed System, has developed 115 new seed companies in Africa, formed to deliver high-quality seed varieties developed for farmers by African plant breeders.

Session one of the professional program provides a foundation for decision-making in cultivar



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Technologies enhance genetic gain and speed development ”

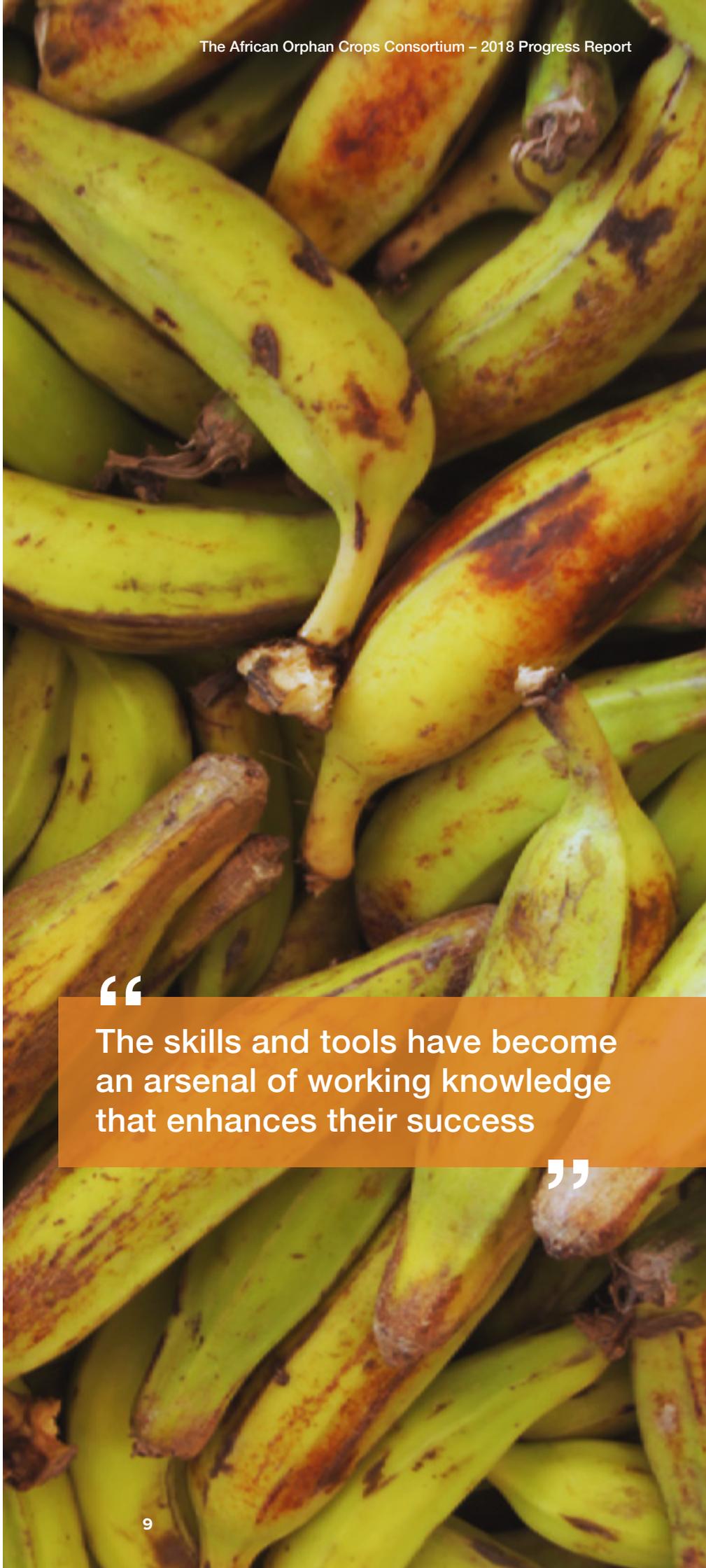
development and introduces students to the tools for data analysis. Session two aims to foster understanding of technologies that enhance genetic gain and speed development of new cultivars. Tools for deploying these technologies are subsequently demonstrated and distributed. Session three focuses on best practices for producing volumes of quality seed for cultivar distribution.

The course culminates with participants presenting proposals that feature one or more of the methods and tools learned in the course, strategically applied to their own crop, their own breeding targets and their own market. In these presentations, participants must demonstrate how their newly acquired information, skills and tools have become an arsenal of working knowledge, showing their success in developing improved cultivars that contribute to their national food security and economic vibrancy. Students also receive constructive feedback and tips from their class peers and the team of instructors. This final exercise builds confidence in applying the know-how and tools in their own unique situation and market, for students to then apply elsewhere.

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The skills and tools have become an arsenal of working knowledge that enhances their success

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FAO-AOCC AGREEMENT

Collaborating to combat malnutrition

On August 8, 2017, the FAO and AOCC signed a letter of intent to:

1

Assist FAO member countries to develop and implement appropriate policies, regulations and laws that facilitate the genetic improvement of orphan crops

2

Strengthen institutional and human capacities of FAO member countries for research and development of genomic tools, plant breeding and seed delivery systems

3

Convene neutral platforms for stakeholder engagements to advocate for greater investments in breeding nutritious and climate-resilient crops



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The AOCC and the African Plant Breeding Academy have created synergy across the continent ”

On October 2, 2018, FAO governments gathered at the FAO's Committee on Agriculture (COAG) at the FAO headquarters in Rome. At COAG, leaders and researchers learned about the AOCC's roadmap to help end hunger and stunting in Africa from eight AfPBA graduates at an AOCC side event. Speakers included Anna Lartey, FAO Director of Nutrition and Food Systems, Daniel Gustafson, FAO Deputy Director-General (Programs), Hans Hoogeveen, Ambassador/Permanent Representative to the UN Organizations from the Kingdom

of the Netherlands and Chikelu Mba, FAO Team Leader Seeds and Plant Genetic Resources. The event concluded by highlighting FAO initiatives that contribute to and support the AOCC's goal to stimulate an orphan crops revolution in Africa.

AfPBA graduate, Ermias Abate Desta, said, “The AOCC and the African Plant Breeding Academy have created synergy across the continent to promote African orphan crops and assist improvement of these crops through knowledge,

skill, and technology transfer to African scientists. This initiative is creating a network of “new breed” African plant breeders with a shared vision of a continent with no hunger, malnutrition and poverty. I am part of this great movement.” During his work at the Academy, Desta developed a plan to increase yields of the Ethiopian staple crop tef, especially in poor soils.

Another AfPBA graduate who spoke at the FAO event was Busiso Olga Mavankeni. During their course, Mavankeni focused on the Bambara groundnut in Zimbabwe. Mavankeni reflected: “Faced with the daunting task of improving such a crop, I was given the opportunity to be trained by the African Plant Breeding Academy. There, I was equipped in modern breeding technologies, which gave me the capacity needed to begin breeding work on Bambara groundnut – helping me develop both personally and professionally as a

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This program has the capacity to change the livelihoods of smallholder farmers across Africa”

scientist. I believe this program has the capacity to change the livelihoods of smallholder farmers across Africa through increased crop yields and income earned from Bambara groundnut production. The AOCC and the African Plant Breeding Academy have brought advanced technology to the doorstep of Africa, transforming crop breeding as we know it. Through this transformation, we hope that hunger and malnutrition will be a thing of the past.”

“Plant breeding offers the best way to turn impoverished countries into productive ones,” said Dorcas Ibitoye of Nigeria, former AfPBA student. “It provides the sure means to fight poverty, hunger and malnutrition. Plant breeders

need all the technologies and tools available to speed the development of high-yielding, nutritious, climate-resilient crops of all kinds and get them into the hands of African farmers. That is why continuing education and the collaborative opportunities offered through the African Plant Breeding Academy for plant breeders are so important. I am delighted that I am in a profession that touches lives in such a profound way.”

Howard-Yana Shapiro, Chief Agricultural Officer of Mars, Incorporated and a founder of the AOCC, stated: “Together we have created a movement to end hunger and malnutrition in Africa. Stunting will be eliminated in your lifetimes, if not earlier.”



FUNDING

Over the years, the AOCC has received generous support, both in funds and in-kind. Those who have donated \$1 million or more include Mars, Incorporated, the Alliance for a Green Revolution in Africa, the World Agroforestry Centre, Thermo Fischer Inc., Illumina (the Illumina HiSeq 4000 sequencer and the Greater Good Initiative) and BGI, which has sequenced 29 genomes as well as donated funding.

Donations have totaled almost \$11.6 million. However, to complete its work, the AOCC needs another \$8.1 million, more than half of which will go toward the resequencing work.

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AOCC has received generous support, both in funds and in-kind
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 **80**
SCIENTISTS
GRADUATED

29 GENOMES
SEQUENCED


 **11.6**
MILLION DONATED



AOCC PARTNERSHIPS

Below are the partners 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 partners in the Consortium.

1. **Alliance for a Green Revolution in Africa (AGRA)** (Nairobi, Kenya) is an organization supported by the Bill and Melinda Gates and the Rockefeller foundations, which supports the AOCC in many ways and has contributed \$1.1 million to AfPBA.
2. **Agricultural Research Council (ARC)** (Pretoria, South Africa) supports the AOCC by sequencing genes (transcriptomes).
3. **Benson Hill Biosystems** is a plant biology, analytics and cloud computing company focusing on global food systems. It is providing all AOCC plant breeders with advanced computational technology to accelerate their breeding programs.
4. **Biosciences Eastern and Central Africa – International Livestock Research Institute (Beca-ILRI) Hub** (Nairobi, Kenya) is a shared agricultural research and biosciences platform providing laboratory services to African and international scientists conducting research on African agricultural challenges. It provides the AOCC with lab and project support, training of breeders, and the curation of germplasm used by the AOCC.
5. **BGI** (Shenzhen, China) is the world's leading genomic sequencing organization. It is involved in sequencing, annotating, assembling and curating many of the 101 African orphan crop genomes as well as supporting development of the AOCC.
6. **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.
7. **Corteva Agriscience** is a private agricultural company focusing on development of crops. Corteva is helping train plant breeders and development of genomic resources for the AOCC.
8. **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.
9. **Google Genomics** (Mountain View, USA) provides rapid transfer of AOCC data worldwide using cloud space.
10. **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 to sequence 10,000 accessions of African crops.
11. **Integrated Breeding Platform** provides data management systems for plant breeders. The IPB provides training to AOCC breeders through the UC Davis Plant Breeding Academy.

12. The James Hutton Institute (Dundee, Scotland) is a non-profit research institute specializing in plant breeding. It will provide gene sequencing tools and analyses to AOCC breeders.

13. Keygene Inc., (Rockville, USA) is an international company supplying genomic tools for plant breeding. It will provide tools to AOCC breeders.

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

15. Mars, Incorporated (McLean, USA) is one of the world's largest privately-owned food companies; it has provided over \$2 million for the AfPBA, scholarships for breeding programs and support for AOCC lab personnel.

16. New Partnership for Africa's Development (NEPAD) (Midrand, South Africa) is a technical body of the African Union which has provided administrative, logistical and political support for the AOCC.

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

18. Thermo Fisher Scientific (Waltham, USA) helps companies and organizations solve their research challenges; it has donated four Proton sequencers and four Chef Stations and reagents. It recently acquired Life Technologies, which had donated four Ion proton machines to the AOCC.

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

20. University of California, Davis (Davis, USA) is one of the world's leading agricultural universities. It manages the AfPBA and co-leads the AOCC laboratory and scientific program.

21. VIB-UGhent Center for Plant Systems Biology (Ghent, the Netherlands) is a non-profit research institute in the life-sciences sector that has 1,200 scientists conducting basic research on molecular mechanisms. It has helped AOCC with bioinformatics and annotation of plant genomes.

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

23. World Agroforestry Centre (ICRAF) (Nairobi, Kenya) hosts the AOCC laboratory and the AfPBA lab and helps manage its data.

24. World Food Programme is 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 a variety of ways.

25. World Wildlife Fund for Nature (Washington, DC) has worked with the AOCC since its inception, helping with initiation and vision.





AOCC NETWORK:

The AOCC also works through a network of additional organizations involved in agriculture and horticulture in Africa:

• African Bean Consortium • BioInnovate • Bioversity • CIAT • Cleome Consortium • Crop Breeding Institute • Crops for the Future Research Centre • Discorea Consortium • Ethiopian Orphan Crops Center • Fababean Consortium • Hohenheim University • ICARDA • IITA • Lentil Sequencing Consortium • MoBreed • Canadian National Research Council • NWO Food & Business Applied Research Fund • Pan-African Bean Alliance • Shea Consortium • Sweet Potato Consortium • The James Hutton Institute • University of Georgia • USDA-ARS Subtropical Horticultural Research Station • USDA-ARS, Wisconsin • World Vegetable Center (AVRDC)

For more information about the African Orphan Crops Consortium visit: africanorphancrops.org, or contact

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