



**GBioS**

Genetics, Biotechnology  
and Seed Science Unit  
Excellence in Seed Science



UNIVERSITY OF ABOMEY-CALAVI  
(UAC)

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FACULTY OF AGRICULTURAL SCIENCES  
(FSA)

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DEPARTMENT OF PLANT SCIENCE  
(DSTPV)

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LABORATORY OF CROP PRODUCTION,  
PHYSIOLOGY AND PLANT BREEDING  
(PAGEV)

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**Genetics, Biotechnology and Seed Science  
(GBioS)**

2023  
ANNUAL  
REPORT



Genetics, Biotechnology  
and Seed Science Unit

Faculty of Agronomic Sciences  
University of Abomey-Calavi



## About GBioS

The Genetics, Biotechnology and Seed Science Unit (GBioS) of the Laboratory of Crop Production, Physiology and Plant Breeding (PAGEV) is a research and training group of the Department of Plant Science, Faculty of Agricultural Sciences (FSA), University of Abomey-Calavi (UAC). The Unit was created in 2014 as a response to the increasing end-users, professionals and students' needs to improve their knowledge of cultivated and wild species of tropical Africa. GBioS aims at providing evidence-based knowledge on the use and conservation of major crops, opportunities crops (known as orphan crops) and crop wild relatives (CWR) in Africa. Crop categories include specifically cereals, legumes, fruits, vegetables, roots and tubers, oilseed, aromatic, medicinal and ornamental plants.

## Citation

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## Vision

Our vision is to become by 2027 a centre of excellence in the management and valorisation of plant genetic resources for improved nutrition and sustainable food security for local communities in West Africa with an international reputation for quality, relevance, sustainability, and impact of research results on the target population.

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## Mission

Our mission is to provide evidence-based results and innovative solutions in the area of food and nutrition security to decision makers and end-users. To achieve this, GBioS actions portfolio is organized around the following axes:

**Axis 1:** safeguarding plant genetic resources for diversification of agricultural systems in West Africa;

**Axis 2:** improving crop productivity for food and nutrition security of local communities; and

**Axis 3:** promoting the quality of agricultural products for better life among vulnerable population.



Genetics, Biotechnology & Seed Sciences – GbioS/FSA



[www.gbios-uac.org](http://www.gbios-uac.org)



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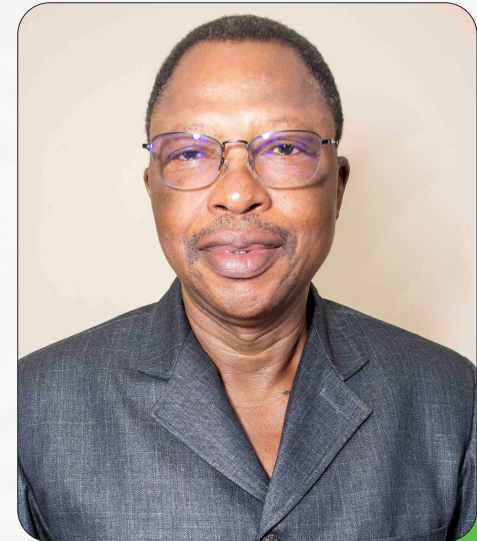
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# Preface

I am glad to introduce the annual report 2023 of the Genetics, Biotechnology and Seed Science Unit of the Laboratory of Crop Production, Physiology and Plant Breeding (PAGEV). Annual reports are sacred, and the effort made by the Unit to produce consistent and regular reports is a noble endeavour that I encourage forcefully. This report is a continuation of efforts made during the last five years to deliver bolder research and development outputs, relevant to end-users who are in a dearth of knowledge and innovations to accelerate the economic growth at community levels.

Our team envisioned to become by 2027 a leading research centre of excellence in the management and valorisation of plant genetic resources for improved nutrition and sustainable food security for local communities in West Africa with an international reputation for quality, relevance, sustainability, and impact of research results on the target population. Overall, the work of GBioS is structured around three major axes: **1)** improving crop productivity for food and nutrition security of local communities; **2)** promoting quality of agricultural products for better life of vulnerable populations; and **3)** safeguarding PGRs for diversification of agricultural systems in West Africa. The core function of the Unit remains the provision of quality seeds and good agricultural practices that can contribute to increase agricultural products, alleviate hunger and poverty, and accelerate economic growth.

With an unwavering belief, GBioS will undoubtedly continue its growth to generate knowledge and innovations relevant to farmer groups and industries in Benin and Africa. It will continue to fulfil its academic mandate as well as to connect learners to the professional world which makes its mission impactful.



## Adam Ahanchede,

Professor of Weed Science  
 Director of the Laboratory of Crop Production,  
 Physiology and Plant Breeding (PAGEV)  
 Department of Plant Science, Faculty of Agricultural  
 Sciences, University of Abomey-Calavi.

”

**GBioS will undoubtedly continue its growth to generate knowledge and innovations relevant to farmer groups and industries in Benin and Africa.**

# We have made it!

If there is anything visible I must highlight in 2023, it is absolutely that our team has achieved more complex milestones than ever before. I am privileged to thank and recognize the unwavering commitment of young and dynamic collaborators who contributed largely to the results accomplished. With the team, scientific production remains constant and the ambition to increase the volume of knowledge will be coiled with the motivation to disseminate information and technologies to end-users effectively. That is why our communication office strives to produce technical notes and briefs that are disseminated through various media. We seek to make our actions more relevant to the real users and meet their needs. We strongly believe that science can alleviate knowledge barriers to accelerate our adaptation to climate hazards for better food and nutrition in vulnerable communities.

In 2023 we finished the construction of the Unit in terms of the main building. We started in 2015 with a few blocks and a strong leadership and commitment of a team of precursors. We thank every single contributor who agreed to “divert” her/his resources in this ambitious plan that started with no financial support. The commitment and tenacity of the team triggered a self-funding scheme which allowed the construction of the building and acquisition of initial research equipment. An innovative approach has been developed to conduct research and develop business skills



## Enoch G. Achigan-Dako

Professor of Genetics and Plant Breeding  
 Director of the Genetics, Biotechnology and Seed Sciences  
 Laboratory of Crop Production, Physiology and Plant Breeding  
 Department of Plant Science, Faculty of Agricultural Sciences,  
 University of Abomey-Calavi

among graduates, support the creation of start-ups which in the medium term will fund the lab activities. The capacity building approach used in the Unit is based on a set of informal learning skills acquisition through self-directed learning, experiential learning, and socialization. In the national context, this initiative is a ground-breaking strategy that other laboratories, faculties, universities in developing countries can get inspiration from. This is not straightforward though!

After the instrumentation program of Seedling Labs that facilitate the donation of initial equipment for the laboratory, we should recognize and thank several organisations such as the African Union through the Sweet Potato project; Enabel, through the TAERA-DeSIRA project; the French government with the Biovalor project; Crop Trust with the BOLD project; and World Vegetable Center that involved the Unit in the TAVI and CGT-BMZ projects. Those projects contributed each for its part to equip the laboratory in a substantive manner. Five working platforms are now fully functional at GBioS to serve the students, professional and reputed scientists across the globe. Our molecular biology platform was enriched this year with a FastPrep lysis machine and a SeqStudio that will increase our capacity to conduct diversity analysis and disease diagnostics. The tissue culture lab is now well equipped and functional for our ambition to dive into potato and plant sanitation research. The cytology platform also received a new BX53 microscope and opened a new perspective for floral biology and cytogenetic investigation. More importantly, the genebank of the University of Abomey-Calavi has come into physical shape with CalaviGen, the new platform for genetic resources conservation hosted by GBioS. This platform, quite unique in the country, holds close to 20,000 accessions of more than 70 species with 17,000 vegetables species. A plan to safeguard

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**GBioS has set out to develop a virology platform that will advance knowledge of infectious diseases associated with orphan crops.**

5,000 accessions at Svalbard Seed Vault is close to achievement and our information management system is now connected to Genesys. With this achievement, GBioS can serve the region of West and Central Africa as a real hub, a specialized center for vegetable crops and wild relatives' conservation. Strategically, GBioS has set out to develop a virology platform that will advance knowledge of infectious diseases associated with orphan crops. That project is underway and will culminate sometime in 2024. We would like to thank all our donors and the institutional support of the Faculty of Agricultural Sciences and the University of Abomey-Calavi, without whom such achievements would not be possible.

# 1. Training activities and institutional capacity strengthening

## 1.1. Training activities

### 1.1.1. Training on seed regeneration protocol

As part of the scientists, genebank staff and students' capacity building portfolio of the Taiwan Africa Vegetable Initiative (TAVI) project, two technicians of the World Vegetable Center, namely Abdul Shango from the Arusha genebank and Chiao Ching-Nung from Taiwan genebank visited the TAVI project local team in Benin for a ten-days training. During this visit, held from 10th to 20th June 2023, several activities including CalaviGen (the University of Abomey-Calavi genebank) visit, indoor communications and training, field visits were conducted. Key topics discussed during the indoor communications included germplasm regeneration procedure, dormancy breaking treatments and database management. For the nearly 20 students and regeneration technicians who attended the training, the various indoor sessions were very insightful as they have been equipped with knowledge to tackle some of the issues they often encounter on their respective crops and regeneration sites. Most importantly, they enjoyed the practical sessions conducted on different regeneration sites where they applied flower bagging for seed production, and seed extraction, among others. MSc students also appreciated their interactions with the two World Vegetable Center technicians on their respective crops. The World Vegetable Center also brought several working tools to support the UAC team in their regeneration and characterization activities. These included tools such as pollination bags, regeneration nets, insect traps, SPYKR colour corrector. Some of the key moments of this training activity were captured in Figs. 1-2.



Figure 1. Visit of the CalaviGen seed storage room by the WorldVeg staff at GBioS, Abomey-Calavi



Figure 2. Group photo at the end of the indoor training on seed regeneration protocol, GBioS, Abomey-Calavi.

## 1.1.2. Third TAVI training course in Arusha

As part of the capacity building efforts for scientists and students involved in the TAVI project, a team from the Genetics, Biotechnology and Seed Science Unit (GBioS) of the University of Abomey-Calavi, attended the 3rd TAVI Training course held in Arusha from October 9th to 13th 2023. The team consisted of Prof Enoch Achigan-Dako, Dr Dèdèou Tchokponhoué, Mr Belchrist Sossou, Ms Emilienne Bonou and Ms Merveille Kamade (Fig. 3). The course's theme was: "Germplasm conservation, quality management and connecting genebanks to society". In his introductory presentation on the first day (Fig. 4), Dr Dèdèou Tchokponhoué, from GBioS, emphasized that the GBioS currently holds nearly 16,000 accessions of vegetable genetic resources that are dominated by the Malvaceae family and that initiatives are ongoing for the safety duplication of the bulk of this material. On that same Day 1 of the training course, Prof Enoch Achigan-Dako gave a talk on seed ecology. He insisted on the importance of the seeds meso-environment for their germination and presented studies of GBioS research team on the seed dormancy phenomenon using examples of *Cucurbits*, *Synsepalum dulcificum*, *Gynandropsis gynandra* and *Vitex doniana*. On Day 4, Prof Achigan-Dako gave another talk on participatory variety selection (PVS). He highlighted four steps in any PVS exercise namely the clear identification of farmers' needs, the search for suitable advanced lines or cultivars to test in farmers' conditions, the implementation of the experiment on farmers' fields, and the dissemination of preferred cultivars. Talks of Day 2 and 3 were also very interesting and were related to Quality management system, genebanking experience from IITA and ICARDA, the key international policies and agreement on Plant genetic resources. From these presentations, the one that captured the CalaviGen

staff was the presentation by Isabella Lopez on the decision tree on plant genetic resources sharing. This provided the team with an informed framework for its future genetic resources sharing. Overall, the Benin delegation took a very active part in the animation of this 3rd TAVI course.



Figure 3. Benin team: Eliel Sossou (Left), Emilienne Bonou, Enoch Achigan-Dako, Merveille Kamade and Dèdèou Tchokponhoué (Right) attending the 3rd TAVI training course in Arusha in October 2023.

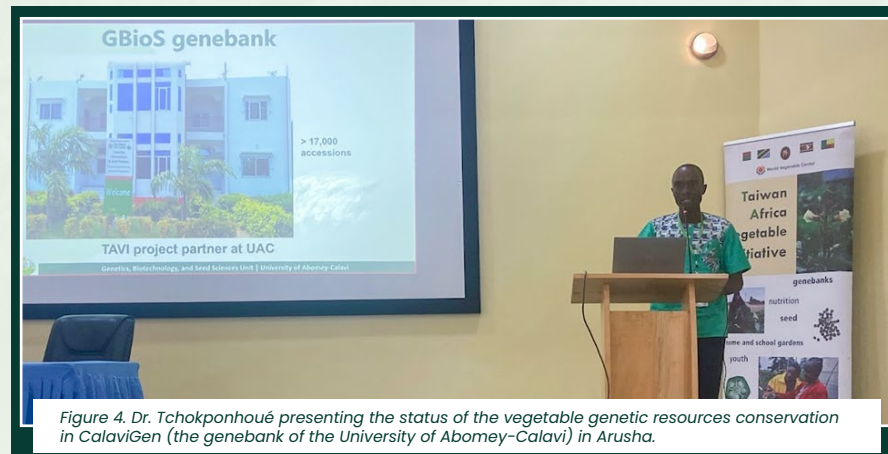


Figure 4. Dr. Tchokponhoué presenting the status of the vegetable genetic resources conservation in CalaviGen (the genebank of the University of Abomey-Calavi) in Arusha.

### 1.1.3. Theses and dissertations defence

In 2023, the GBioS Unit released a total of 19 graduates, comprising 5 with a Bachelor of Science (BSc) degrees, 9 with Master of Science (MSc) degrees, 3 agricultural engineers, and 2 PhD holders. The BSc graduates conducted diagnostic studies on the production systems of the following crops: fonio (*Digitaria exilis* (Kippist) Stapf), pineapple (*Ananas comosus* (L.) Merr.), groundnut (*Arachis hypogaea* L.), and tomato (*Solanum lycopersicum* L.). MSc and agricultural engineers' graduates explored various research topics including, but not limited to:

- floral biology and reproductive phenology in the Sistrè berry plant (by Mario Vigninou, **Fig. 5**);
- agromorphological or/and genetic diversity assessment among Egusi (Judith Djossou), amaranth (by Laurinda Debora Dodo and Judes Sefounon), Ethiopian sorghum (Pinanwe Agbandou), and soybean (Harris Attikpa) germplasm;
- assessment of vegetable seed systems in Benin (by Amos Manassé Hounnoume);
- efficacy of some botanical species against bacterial wilt caused by *Ralstonia solanacearum* and planting density optimisation in association with onion for root-knot nematode management in tomato (by Dorella Elegbede);
- application of citizen science approach to identify high-performance varieties of jute mallow in the agroecological ecological contexts of Benin with farmers (by Arsène Nakou); and
- evaluation of the effect of biochar on the yield and the beta-carotene content of the orange-flesh sweetpotato in Benin (by Come Glory Dossa).

PhD graduates including Dr. Fernand Sohindji (**Fig. 6**) and Dr Luther Nkoulou (**Fig. 7**), conducted their research on the topics “Endogenous knowledge and genetic diversity analysis of sweetpotato (*Ipomoea batatas* (L), Lam) for vitamin A-rich variety breeding and production in Benin Republic” under the SWEET POTATO project and “Assessment of banana accessions performance and genomic selection across environments with drought and BSD contrasted conditions” in GENES project, respectively.



Figure 5. MSc defence of Mr Mario Vigninou, Abomey-Calavi.



Figure 6. PhD defence of Dr Fernand Sohindji (third position from left), Abomey-Calavi.



Figure 7. PhD defence of Dr Luther Nkoulou (2nd position from left), Abomey-Calavi.

## 1.2. Institutional capacity strengthening

In 2023, our team participated in various institutional capacity strengthening and scientific events. Details of these events are provided in this section.

### 1.2.1. Participation in FSA Curriculum review

To address the needs of the labour market, the FSA authorities decided to update the Faculty's curricula in 2023. This curriculum revision aligns with the Competency-Based Approach advocated by the University of Abomey Calavi (UAC) and was supported by the Biovalor project. Specifically, the initiatives were grounded in a survey of required skills and professions among industry professionals, which evaluated the current FSA training content, identifying both provided and lacking skills. Several meetings were held focusing on two key actions: assessing training programs and adopting a skills-based approach.

The analysis of training programmes encompassed several sessions. These sessions included gathering curricula from UAC, UL, and IA Montpellier at both the Bachelor's and Master's levels. Additionally, there was a focus on conducting a comparative analysis of FSA training offerings with a mixed team of partners from the North and South. Furthermore, the process involved revising and consolidating subjects in the units and courses, and sharing feedback among stakeholders. Regarding the competency-based approach, two sessions were held from May 23-25 and July 4-6 at the Anouriate center in Abomey-Calavi (as shown in **Fig. 8**). These sessions brought together FSA lecturers to establish the framework and job descriptions for FSA training programs (i.e., Nutrition and Food Technologies and Plant Science), including the assessment of provided and missing skills, and identifying learning and evaluation scenarios for implementation. Highlights of these sessions can be found in **Figs. 9 a, b**.



Figure 8. Group photo of participants at the first workshop on the skills-based approach development, Anouarite centre (Abomey-Calavi, Republic of Benin).

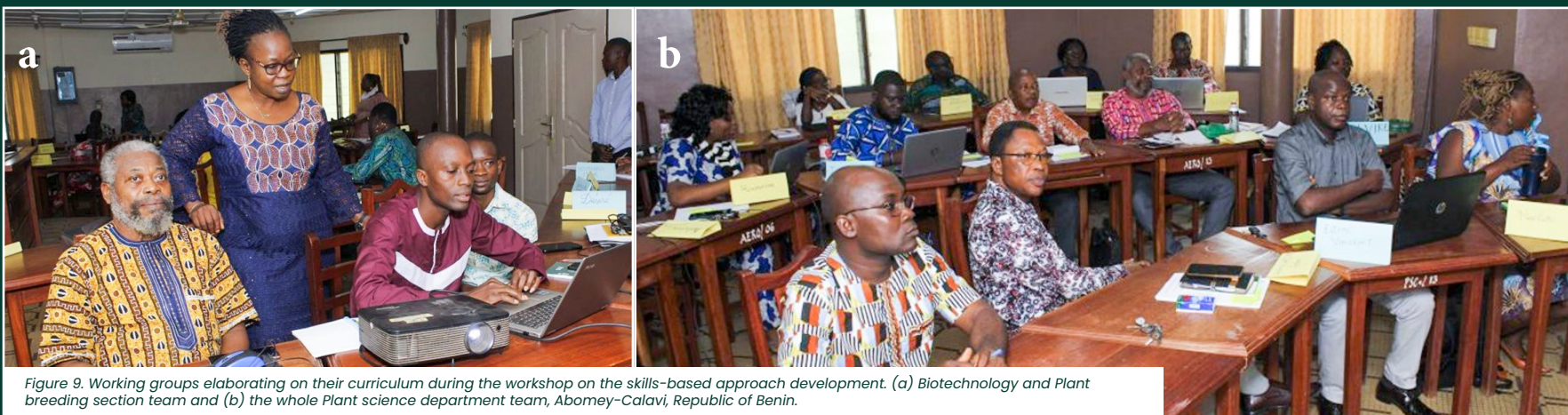


Figure 9. Working groups elaborating on their curriculum during the workshop on the skills-based approach development. (a) Biotechnology and Plant breeding section team and (b) the whole Plant science department team, Abomey-Calavi, Republic of Benin.

## 1.2.2. Biovalor PhD students' day

In the week of January 16 to 20, 2023, the actors of Biovalor (funded by the French Development Agency (AFD) through the new partnership for higher education in Africa (PEA) of the French Research Agency (ANR)) met at the University of Abomey-Calavi for the first edition of the Biovalor days. This meeting brought together a delegation including around 20 lecturers and researchers from the University of Lorraine, the Institut Agro Montpellier, the Faculty of Agricultural Sciences (FSA/UAC) and the International Cooperation in Agricultural Research for Development (CIRAD). The objective was to track the progress made by the project team and to define the strategies for the remaining period of the project and even after. During the week, there were series of sessions, namely: the management committee (COMOP), the presentation of the research proposals of the eight PhD theses, the first edition of the innovation competition aiming at selecting ten best project ideas to incubate at the Biovalor hub, a visit to the laboratories, exchanges between North-South lecturers, an update on mobility, the implementation of the gender strategy, etc.

These days saw the participation of the professionals (stakeholders' representatives) affiliated with the project to validate whether the doctoral students' research proposals are aligned with their constraints. Another activity is the session with the financial and technical donors to discuss areas of intervention in order to better discuss areas of synergies and areas of collaboration. This session brought together around thirty financial and technical partners. It is worth mentioning that project members were trained on the quality approach. The Biovalor PhD students' days were officially closed on the last day by the council under the chairmanship of the rector of UAC.

## 1.2.3. DivSeek/Crop Trust workshop

DivSeek International and the Crop Trust co-organized a brainstorming workshop on "Plant digital commons: conservation to consumption". The meeting took place at Cornell University in Ithaca, New York, from June 26-29, 2023. It gathered participants from the conservation, research, and end-user communities to discuss how integrating data can transform gene banks or static repositories into dynamic research collaborators for crop improvement, particularly in the face of climate change. Participating institutions included the University of Abomey-Calavi (**Fig. 10**), the African Plant Breeders Association, USDA, EMBRAPA, Pennsylvania State University, EMBL-EBI (European Bioinformatics Institute), Boyce-Thompson, Oregon State University, ICARDA, Julius Kuehn Institute, DivSeek Intl, Australian Grains Genebank, Crop Trust, IC Foods, ITPGRFA, Biomass Quality Network, Cornell University, USDA, Università Politecnica delle Marche, Integrated Breeding Program, Colorado State University, Bayer Crop Science.

Topics discussed were related to the context of domain communities (Genebanks, Pre-breeding/R&D, Breeding, Ag & End-user communities, data engineering/Information flow), research value chain (functional/non-functional overlaps, Benefits of operational congruence) identifying barriers for PGR communication/use (data domain overlaps - DivSeek Commons matrix, landscape of information flow - big picture overview, Genesys, GLIS and the challenges of working with diverse data providers, managing and visualizing genotypic data, durable data repositories. Other topics were related to awareness and implementation of Standards (current standards, AgBioData, terminology of crop-specific 'descriptor lists' vs generic evaluation fit for market, engagement with international data repositories, current state-of-the-art and limitation with PGR standards: DOIBioSample, OBO ontologies,

NCBI taxon, Plant ontology, Trait ontology, AGRO, Crop ontology). Participants also discussed how to promote bio-economy engagement and developing robust specifications (engaging relevant bio-economy communities through the research value-chain, overview and vision of big data in research value chain, value of generic platforms – investment / implementation of standards).

The research work at the Genetics, Biotechnology and Seed Science Unit has yielded tangible results in the production and promotion of neglected crops adapted to soils in Africa. With a gene bank containing nearly 20,000 accessions of African crops, the Unit needs more advanced tools to further enhance its capacity and adaptability. Currently, gene banks primarily serve as providers of diversity through physical specimens used in gene discovery (digital descriptor data) and applied plant breeding projects. However, the flow of information remains largely unidirectional, as genomic data is rarely linked to genebank accessions. This lack of systematic coordination between these two research domains is a missed opportunity for both improved conservation efforts and enhanced utility.

Participants suggested that a conference focusing explicitly on linking gene bank conservation efforts with breeding through emerging genomic data is both timely and useful. Participants recognize that each of these scientific communities' measures and uses biodiversity in different ways. They intend to highlight exemplary projects that have successfully integrated these scientific domains and identify common best practices, bottlenecks, and capacity needs.

A major result of the Workshop was the initiation of a white paper on: "Plant Genetic Resource Digital Commons: conservation to consumption. A Tactical Roadmap for investment to increase



Figure 10. High-level discussion at the DivSeek Crop Trust workshop, Cornell University, Ithaca (New York).

knowledge exchange and harness Crop Plant Genetic Resources curated in genebanks for the benefit of humanity". The document will present an analysis of the value proposition of Plant Genetic Resources (PGR) and the current state and the future potential of information flow around PGR collections conserved in genebanks. As a result, there is a pressing need to make popular access to the world's PGR to ensure that humanity can realise the benefits from the tangible connections between food security and health and peace outcomes.

## 1.2.4. Vision for Adapted Crops and Soils (VACS) workshops

Prof. Enoch Achigan-Dako participated in the technical workshop on phase 1 of the Vision for Adaptive Crops and Soils (VACS) on May 18-19, 2023 in Rome, Italy. The Vision for Adapted Crops & Soils (VACS), launched by the U.S. Department of State, in partnership with the African Union and The Food and Agriculture Organization of the United Nations (FAO) in February 2023, seeks to adapt our agricultural systems – starting with Africa – to the anticipated challenges of climate change.

The Food and Agriculture Organization, the African Union (AU) and the United States Department of State (DoS) are working on a Vision for Adaptive Crops and Soils (VACS) which is a three-phase initiative. First, phase 1 aims to identify the most important crops for nutrition in Africa through a multi-stakeholder process. Then, phase 2 will assess the impact of climate change on these crops until 2050. Finally, phase 3 aims to accelerate investments and research to adapt selected crops to climate change. It was with that perspective in mind that the phase 1 workshop took place.

For several years, the Faculty of Agricultural Sciences has developed expertise to build and teach agricultural practices resilient to climate change and sensitive to nutrition. In this context, it needs the support of national and international organizations to support its vision and mission technically and financially. The participation of Professor Enoch Achigan-Dako (Fig. 11) in all phases of the FAO VACS initiative is a promise

of collaboration and research support from the United Nations system for the strengthening of research and teaching at the Faculty of Agricultural Sciences.

The participants, around twenty, represented a diverse range of scientific and geographical backgrounds. Prior to the meeting, they were asked to review a list of crops and come prepared with potential candidates for discussion in Rome. During the workshop, participants engaged in a facilitated discussion to guide the crop selection process. Although there was no predetermined formula for making selections, criteria included nutrition, food group, geography, consumption, and potential for plant breeding. Crops were chosen from each of Africa's five economic subregions across the following categories: cereals, roots and tubers, fruits, vegetables, legumes, and nuts/seeds/oilseeds.

A systematic review is currently underway to assess the extent of existing evidence on the selected VACS crops. The GBioS team, consisting of Dr. Dèdéou A. Tchokponhoué, Dr. Aristide C. Houdegbe, and Ms. Jelila Blalogue, is actively contributing to this review.

VACS is a movement led by the USDoS in collaboration with USAID, and in partnership with the AU and the FAO. These phases were implemented to provide high-level insights for guiding VACS in its initial phases, with grant funding provided by The Rockefeller Foundation.



Figure 11. Participation of GBioS, represented by Prof. E. Achigan-Dako (right) together with APBA delegates (Prof. Eric Y. Danquah and Prof. Julia Sibiya), to the VACS initiative at FAO Rome (Italy).

## 1.2.5. Crop Diversity Summit and Crop Trust workshop

Under the patronage of the German Federal President, Frank-Walter Steinmeier, the Crop Trust, in collaboration with the International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty), hosted the Global Crop Diversity Summit on 14th November 2023. The Summit addressed the urgent need for more productive, sustainable, resilient and healthy agri-food systems in the face of the climate, biodiversity and food crises. As a contribution to preparations for the Climate COP 28 in December 2023 in Dubai, representatives of governments, civil society and indigenous communities, the private sector, and the agricultural research community, as well as seed bank managers, engaged in a lively dialogue on the crucial role of seed banks in transforming our agri-food systems.

The Summit welcomed Svenja Schulze, Federal Minister for Economic Cooperation and Development of Germany, Anne Beathe Tvinnereim, Minister of International Development of Norway, who graced the meeting with their presence as guests of honour; in addition, there were renowned experts, such as: Prof. Lindiwe Sibanda, Chair of the System Board, CGIAR, and Dr. Éliane Ubalijoro, CEO, CIFOR-ICRAF.

The goals of the Summit were to raise political awareness on the importance of crop diversity for opportunities, livelihoods, and development in order (1) to mobilize more financial resources which are urgently needed to conserve this crop diversity and make it available for use and (2) to strengthen cooperation among seed banks around the world; and increase their impact. Prof. Enoch G. Achigan-Dako participated (Fig. 12) from 14-15 November 2023 in Berlin (Germany) in the 'Global Crop Diversity Summit' hosted by the Global Crop Diversity Trust (Crop Trust) as



Figure 12. Dr. Kent Nadazie (left) and Prof. Enoch Achigan-Dako (right) at the Crop Diversity Summit in Berlin, Germany.

well as the satellite event on 'Making successful safety duplications and communicating effectively'. His participation was organized and fully sponsored by the Crop Trust, as one of the 11 lead partners under the BOLD Work Package 4 (WP4) Project.

Based in Germany, the Crop Trust is an international non-profit organization established to support a sustainable global system for the conservation and use of crop diversity. BOLD WP4 aims to regenerate and safely duplicate in the Svalbard Global Seed Vault the crop diversity from countries classified by the Development Assistant Committee (DAC) as eligible to receive Official Development Aid.

The satellite event on '**Making successful safety duplications and communicating effectively**' aims to build the capacity of project partners on the procedures, requirements, and best practices employed by genebanks to guarantee a reliable backup of their genetic resources, thereby supporting their mission to preserve life's green treasures. Additionally, they were equipped with essential skills to share their successes and achievements through traditional and social media and other events.

## 1.2.6. WorldVeg golden jubilee biodiversity panel

From November 2nd to 3rd 2023, the Genetics, Biotechnology and Seed Sciences Unit was represented at the 50th anniversary Jubilee of the World Vegetable Center (WorldVeg) formerly known as Asian Vegetable Research and Development Center (AVRDC). WorldVeg is a non-profit autonomous international agricultural research centre solely dedicated to vegetables research and development. As the country coordinator of the Taiwan Africa Vegetables Initiative in Benin, Prof. Achigan-Dako (Fig. 13) was invited during the jubilee to participate in the panel entitled “Rescuing vegetable biodiversity to boost nutrition and climate resilience”. Other panellist included: Dr. Chutchamas Kanchana-udomkan, Lecturer, Tropical Vegetable Research Center, Department of Horticulture, Kasetsart University, Thailand, Ms. Hsin Yi Tseng, Associate Researcher, Crop Genetic Resources and Biotechnology Division, Taiwan Agricultural Research Institute, Taiwan, Dr. Maarten van Zonneveld, Head of Genetic Resources, World Vegetable Center, Taiwan. The discussion was moderated by Dr. Sognigbé N’Danikou, Scientist Traditional Vegetables Conservation and Utilisation, World Vegetable Center, Tanzania. According to the panel, there are more than 1,100 known vegetable species worldwide, and even more wild relatives of these vegetables, sister species that we don’t eat directly but use for breeding better crops. Within each of these species there is so much diversity. The panel recognized that vegetables are very important for three main reasons. First, vegetable biodiversity provides the building blocks to diversify cropping systems with climate-resilient and nutritious crops; for example, in Eswatini farmers are now intercropping maize with amaranth and nightshade to increase productivity and spread income risks by

connecting to various markets. Second, vegetable biodiversity is celebrated in different food cultures with local varieties and crops that have unique tastes. Finally, vegetable biodiversity provides the necessary genetic variation that breeders use to develop better vegetables now and in the future. However, vegetable biodiversity is rapidly declining in farmers’ fields and natural ecosystems, in line with global trends in the decline of agricultural biodiversity. This is because our global agricultural landscape is undergoing a profound transformation towards a monocropping system while changing consumer preferences leading to reduced emphasis on vegetable crops that used to be important in local diets. The lack of diversity makes these food systems especially vulnerable to climate change.

To enhance the use of vegetable biodiversity, the panel proposed to work through the **3Ps approach**, which stands for **Push, Pull and Policy**.

Push Genebanks should better connect to users, by supplying vegetable germplasm needed by breeders and researchers to develop improved varieties that are desired by farmers and consumers. They should thus support the different vegetable breeding programmes and consortia to promote utilisation of the conserved vegetable germplasm. Breeding programmes should engage more in research on vegetable biodiversity, including the nutritional components and their resilience to different stresses. Genebanks should also innovate to provide access for farmers to germplasm of under-researched vegetable crops to evaluate them through participatory research and select varieties suitable to their farm conditions and demanded by consumers.

**Pull [raise demand]**. Promote the consumption of vegetables in general and traditional vegetables in particular. To do this we need to safeguard vegetable biodiversity and raise awareness about their contribution to food security and nutrition. This calls

for clear actions for prospecting and collecting genetic resources and characterising them for further use.

**Policy: enabling environment.** We need an enabling policy environment that supports the rescue, conservation, and use of vegetable biodiversity, while ensuring access and benefit sharing among stakeholders. For instance, germplasm import and export, seed policies and food policies need substantial improvement

in many countries to facilitate access and use of vegetable germplasm in order to address key global challenges of rampant malnutrition and poverty. National governments, regional and international agencies should also consider and provide special attention to vegetables in agricultural policies.



Figure 13. Discussion panel "Rescuing vegetable biodiversity to boost nutrition and climate resilience" during the WorldVeg golden jubilee, Taiwan. From left to right: Dr. Sognigbe N'Danikou, Dr. Chutchamas Kanchana-udomkan, Prof. Enoch Achigan-Dako, Dr. Maarten Zonneveld and Ms. Hsin Yi Tseng.



## 2. Research and development activities

### 2.1. More than 6,000 new accessions of vegetable and legume genetic resources added to CalaviGen collection

Germplasm collection and acquisition is an important task in genebanking. At CalaviGen, a continuous effort is being made to ensure an optimal geographical coverage in collections representativeness across the country and the safeguarding of a maximum of the country's plant genetic resources. Consequently, the genebank team organized a new collecting mission in February and March 2023 in 38

of the 77 communes in Benin. From this mission, a total of 6,034 new accessions of 29 species (Table 1). The major species collected during this mission were *Solanum macrocarpon*, *Corchorus olitorius*, *Amaranthus cruentus*, and *Abelmoschus esculentus*. Thanks to this collecting mission, CalaviGen with its nearly 16,000 accessions of vegetable species stands as a marked West African Hub of Vegetable genetic resources conservation.

**Table 1.** Overview of species and accessions collected per phytogeographical region in Benin during the 2023 prospection mission.

Species	Guineo-congolian region	Sudanian region	Sudano-Guinean region	Total number of accessions
<i>Abelmoschus callei</i>	26	324	122	472
<i>Abelmoschus esculentus</i>	202	755	369	1326
<i>Amaranthus dubius</i>	3	73	47	123
<i>Amaranthus cruentus</i>	35	192	130	357
<i>Amaranthus spinosus</i>	1	11	4	16
<i>Capsicum annum 1</i>	5	12	60	77
<i>Capsicum chinense</i>	2	0	0	2
<i>Capsicum frutescens</i>	0	26	7	33
<i>Celosia argentea</i>	31	49	48	128
<i>Citrullus mucosospermus</i>	23	176	81	280
<i>Corchorus olitorius</i>	121	310	251	682
<i>Crotalaria sp</i>	0	1	3	4
<i>Cucumeropsis mannii</i>	32	109	137	278

<i>Cucumis metuliferus</i>	0	0	1	1
<i>Cucurbita maxima</i>	0	4	2	6
<i>Curcubita pepo</i>	0	4	0	4
<i>Gynandropsis gynandra</i>	15	2	7	24
<i>Hibiscus sabdariffa</i>	0	135	32	167
<i>Lagenaria siceraria</i>	21	117	27	165
<i>Momordica charantia</i>	47	68	70	185
<i>Ocimum basilicum</i>	23	91	37	150
<i>Ocimum gratissimum</i>	43	117	125	285
<i>Sesamum indicum</i>	0	4	3	7
<i>Sesamum radiatum</i>	7	183	114	304
<i>Sesamum sesamoides</i>	8	113	27	148
<i>Solanum aethiopicum</i>	0	0	4	4
<i>Solanum lycopersicum</i>	0	28	41	69
<i>Solanum macrocarpon</i>	160	353	199	712
<i>Solanum melongena</i>	0	2	5	7
<i>Vernonia amygdalina</i>	1	0	16	17
Total	806	3259	1969	6034

## 2.2. More than 1,200 accessions regenerated in 2023 for safeguarding in Norway

In the framework of the SAFE-PGR (Safeguarding plant genetic resources of Benin for a sustainable future use) project, a two-years conservation initiative funded by Crop Trust through the BOLD (Biodiversity for Opportunities, Livelihoods and Development) initiative and dedicated to support the regeneration and safety duplication of 1,000 accessions of 18 species collected in Benin, the CalaviGen conducted in 2023 the second-year regeneration activities. For this campaign, a total of 1,256 new accessions were regenerated against 421 accessions expected in the project. This figure now brings to 2,388 the total number of accessions regenerated under the project against 1,000 planned for the whole project: almost three times the target. Six species were regenerated for the first time in 2023 and included the Egusi gourd [*Cucumeropsis mannii* or *Melothria sphaerocarpa* (Cogn.) H.Schaefer & S.S.Renner], bitter melon [*Momordica charantia* L.], the bottle gourd *Lagenaria siceraria* (Molina) Standl., jute mallow [*Corchorus olitorius* L.], Gboman eggplant [*Solanum macrocarpon* L.] and African basilic [*Ocimum gratissimum* (Fig. 16)] sharing a total of 765 accessions.

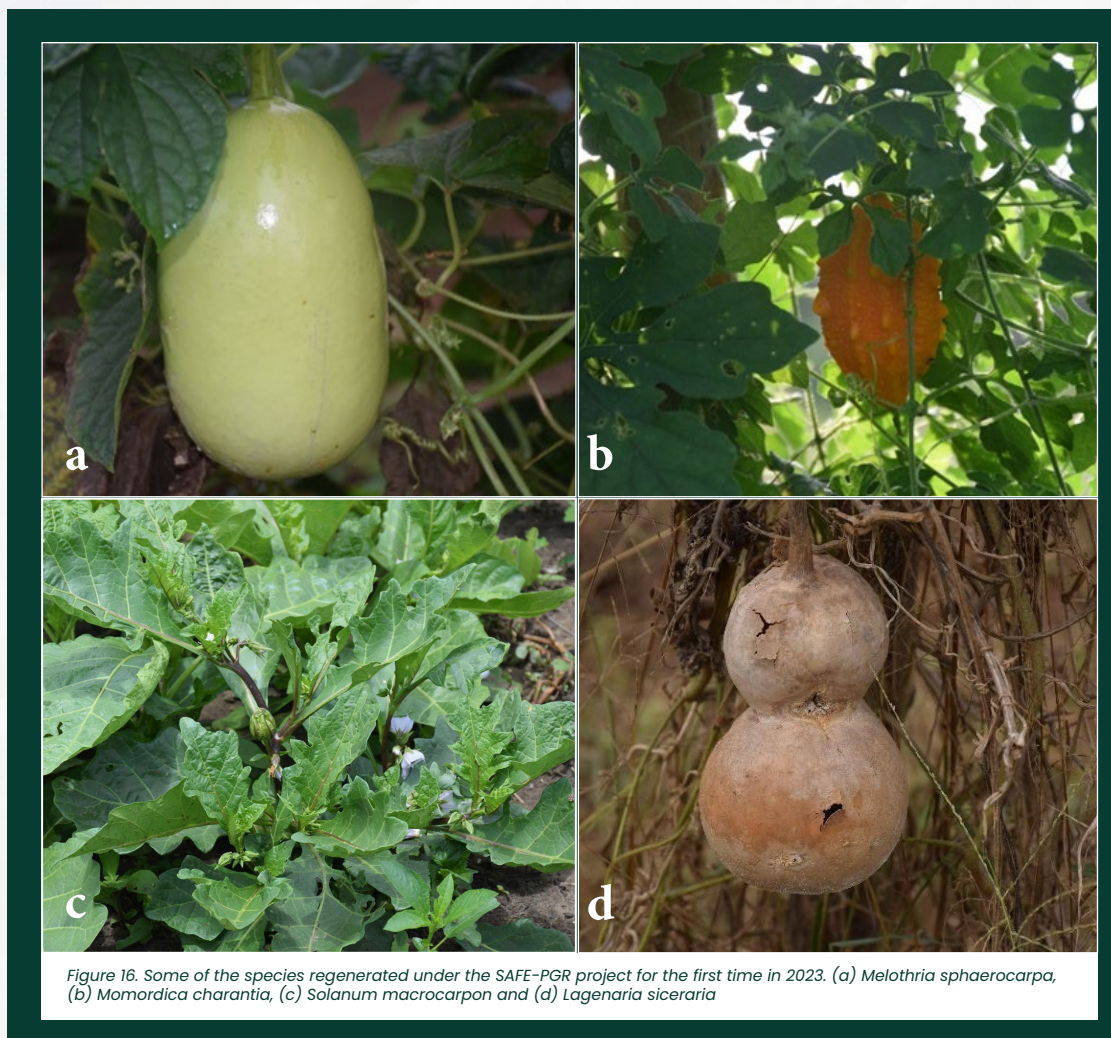


Figure 16. Some of the species regenerated under the SAFE-PGR project for the first time in 2023. (a) *Melothria sphaerocarpa*, (b) *Momordica charantia*, (c) *Solanum macrocarpon* and (d) *Lagenaria siceraria*

## 2.3. Genebanking at GBioS



Figure 17. CalaviGen staff in activity and infrastructures in image. (a) Seed sorting, (b) Seed germinating testing, (c) seed packaging and (d) new CalaviGen's drying room.

The year 2023 has been very fruitful in terms of accomplishments and brought light on the GBioS genebank in its growth towards becoming the West African hub for vegetable resources conservation. From < 12,000 accessions held in 2022, the genebank now counts more than 17,000 accessions, a major evolution that came along with a name change: the GBioS genebank is now known as CalaviGen, the University of Abomey-Calavi genebank. With its new position, CalaviGen seeks a formal recognition by its peers in engaging into the process leading to its presence on Genesys. In terms of activities, the CalaviGen staff continued to conduct routine genebank activities, but have mostly invested in the ongoing safety duplication process of nearly 2,500 accessions at Svalbard. The CalaviGen staff also benefited from various trainings in 2023 that contributed to improving the team hand-on skills and performance in plant genetic resources conservation. The Genebank infrastructures are also being upgraded to align with international standards. **Figs 17 a-c** showcased some routine activities conducted by the CalaviGen staff and **Fig. 17d** the rebuilt drying room of the genebank.

## 2.4. Citizen Science Trials using TRICOT approach with 2000 farmers

In the framework of the “Choose Grow Thrive: using citizen science in expanding west Africa’s food basket with African vegetables to tackle malnutrition (BMZ-CGT)” project, two seasons for citizen science (second and third) trials were established in 2023 with the aim to assess farmers preferred traits for okra, jute mallow and amaranth as well as to identify high-yielding and preferred varieties. To this end, 29 field agents were recruited and trained during a training workshop in October 2023 (Fig. 18a). During the workshop, a brief overview of the project’s activities was presented, and trainees were informed about the fundamentals of the TRICOT citizen science approach, the use of the ODK application for data collection during a practical phase, and their roles and responsibilities for the

success of these trials. The training was facilitated by Dr. A. Carlos Houdegebe – GBioS/FSA/UAC, and Mr. Lys Amavi AGLINGLO – World Vegetable Center Benin. The seed kits distribution (Fig. 18b) for the third season started in November 2023, and 1,921 farmers over 2000 farmers were enrolled and received their seed kits from the field agents. The 1,921 farmers were from 34 municipalities of 4 territorial agencies of agricultural development (ATDAs 1, 2, 5 and 7), expanding the target area of the CGT project from 5 departments to 7 departments with 30% of women. In fact, 988 farmers participated in trials for amaranth, 492 for jute mallow and 444 for okra. Two MSc students were trained and successfully defended their thesis on citizen science.



## 2.5. Omics, biotechnology, and plant breeding

In 2023, GBioS' research activities on omics focused on understanding the evolutionary history and population structure of the Sisrè berry plant (Syn: miracle fruit) plant (*Synsepalum dulcificum* [Schumacher & Thonn.] Daniell) in West Africa ([Tchokponhoue et al. 2023](#)), assessing genetic diversity in sweet fig banana (*Musa acuminata* cv Sotoumon) in Benin ([Capo-Chichi et al. 2023](#)), and unravelling genetic diversity in a banana accessions complex made up of plantain cultivars, cooking banana cultivars, and cultivars with unknown genomic affiliation ([Nkoulou et al., 2023](#)). using single nucleotide polymorphism. The findings on the Sisrè berry plants suggested the existence of at least two genepools in West Africa, namely the Upper Guinea and the Dahomey Gap populations with a suspected incipient allopatric speciation ongoing, and which is yet to be properly studied. The study on the 'sotoumon' banana cultivars overall indicated a low diversity in the studied germplasm coupled with a low differentiation in the collection. Likewise, the neighbour-joining analysis partitioned the germplasm into three clusters out of which a predominant group one contained 98.1% of all accessions. This is supportive of the low diversity and also indicative of the necessity to broaden the genetic base of the crop while maintaining its quality attributes and improving yield performance in this uniquely appreciated cultivar in Benin. The disentanglement of genomic relationships among a complex of bananas accessions made it possible to determine for the first time the affiliations of local accessions. Another ground-breaking research concluded by GBioS in collaboration with its partners is the release of the reference genome of the cosmopolitan leafy vegetable and medicinal plant, *Gynandropsis gynandra* ([Hoang et al., 2023](#)). *Gynandropsis gynandra* locally known as "Akaya" has

also been used as a model to study C4 photosynthesis due to its evolutionary proximity to C3 Arabidopsis. The release of its reference genome opens the room for in-depth research for this crop improvement. A key research on stability analysis released in 2023 by the GBioS team related to the testing of 19 promising accessions in eight environments spread across four agro-ecological zones of Benin ([Azon et al., 2023b](#)). The team successfully established three genotypes (G10, G13, G19) as highly yielding and stable, which are recommended for the crop's improvement programs in Benin. Lastly, another interesting research conducted in the same field is the understanding of the floral biology and mating systems in Houintakpakoun (*Macrotyloma* sp.), through phenology, floral organs ultra-structure, traits correlation, stigma receptiveness, pollen viability and germinability analyses. The team established that the Benin accessions of the so-called Houintakpakoun were non-echinate, while other accessions held in other international genebanks rather exhibited spinuliferous pollen. This discrepancy in floral traits observed among accessions from various origins calls for the necessity to thoroughly collect and conserve the species plant genetic resources in Benin.

## 2.6. Conservation and utilisation of Plant Genetic Resources

Research on plant genetic resources is central to GBioS' work. Our investigation in this field in 2023 related to the Genebank phenomics and genomics of nearly 1,300 accessions currently held at CalaviGen (The University of Abomey-Calavi), with the

results expected to be shared with the scientific communities in coming months. In parallel, various studies were conducted to document traditional knowledge and farmers perception on a few of the Unit's target neglected and underutilized species (NUS) including the Sistrè berry plant, Sesame and Kersting's groundnut, among others. Research by the team indicated the existence of two Sistrè berry morphotypes in Nigeria with interestingly a geographical isolation between them; the ordinary known red morphotype being confined to the Western part on Nigeria while the yellow morphotype is exclusively recorded in the eastern part of the country ([Tchokponhoué et al., 2023b](#)). Likewise, production challenges on the two morphotypes were differentially perceived depending on the respondent's cultural affiliation. Local farmers traditional knowledge of Kersting's Groundnut (*Macrotyloma geocarpum*) diseases and pests were also documented by the GBioS Team ([Touré et al., 2023](#)). The findings of the study offer interesting perspectives in terms of development of control measures. On Sesame, we documented the use values of the species across Benin socio-linguistic groups and highlighted the use of the seeds in sauce and as appetiser as the most salient ones. Interestingly, we reported the existence of five cultivars defined by the seed coat colour ([Azon et al., 2023](#)) that deserved to be adequately conserved for future improvement programs on the species.

## 2.7. Crop production and agroecological intensification

Within the framework of the project entitled "Supporting the Agro-ecological Transition through Agricultural Research (TAERA)", funded by the European Union and implemented in Benin by the

Belgian Development Agency, Enabel, GBioS, in compliance with the subsidy agreement has carried out actions to achieve the objectives of the program. Market gardening and rice production are the two areas of investigations for GBioS.

The project's objective is to support the agroecological transition in Mono and Couffo departments. GBioS' mission in this project is to propose, test, and confirm agroecological and practical solutions for managing diseases (bacterial wilt) and pests (nematodes and phytophagous insects). During 2023, trials were implemented to assess the effect of various enriched compost with botanical plants to control bacterial wilt in farmer's fields (**Fig. 19**). Furthermore, the characterisation and identification of the different collected bacteria samples was conducted at the Laboratoire de Défense des Cultures (LDC) of INRAB.

Research on crop production and agroecological intensification in 2023 focussed on the evaluation of biopesticide potential of four plant species (*Allium fistulosum*, *Senna siamea*, *Hyptis suaveolens* and *Ricinus communis*) through field experiment in the municipality of Abomey Calavi to reduce the incidence of bacterial Wilt caused by *Rastonia solanacerum*. The four plant species were used as a mulch and applied by broadcasting or in a hole close to the crop. It came out that use of *Senna siamea*, *Ricinus communis*, and *Allium fistulosum* applied by broadcasting could be used in the disease management against bacterial wilt. We also explored the effect of the combined application of biochar and potassium fertilizer on the growth, yield, and beta-carotene content in orange fleshed sweet potato. Combining five levels of fertilisation (biochar +K<sub>2</sub>SO<sub>4</sub>) (F1 Control (Ck), (F2) Biochar 5t/ha (B), (F3) 180 kg/ha K<sub>2</sub>O (EM), (F5) 100% B+EM and (F4) 100% B+ 90 kg/ha K<sub>2</sub>O (EM)) with three orange fleshed sweet

potato varieties (V1 = ACAB 220; V2 = Amelia and V3 = BF59XCIP), it came out that the combination of 5 t/ha biochar+ 180 kg/ha fertilizer K<sub>2</sub>O improved the growth, yield and beta carotene content of the Orange fleshed sweet potato.

To support the transition to agroecology in the rice (*Oryza sativa*) sector in Benin, a rotation system based on legumes in combination with reduced mineral fertilization was explored for its agronomic performance on paddy rice in the Mono and Couffo departments. Implemented in the municipalities of Dogbo-Agnvo and Grand Popo-Sazué, *Mucuna pruriens* and mungbean (*Vigna radiata*) were used as preceding crops to rice, combined with three different doses of mineral fertilizer (FM1: No mineral fertilizer application, FM2: Mineral fertilizer application at the recommended dose of N = 64.5

kg/ha, P<sub>2</sub>O<sub>5</sub> = 30 kg/ha, K<sub>2</sub>SO<sub>4</sub> = 30 kg/ha, and FM3: Mineral fertilizer application at half the recommended dose of N = 32.25 kg, P<sub>2</sub>O<sub>5</sub> = 15 kg, K<sub>2</sub>SO<sub>4</sub> = 15 kg). Preliminary results indicated a significant improvement in growth parameters in treatments where legumes were rotated compared with treatments without legume rotation. Similarly, using legumes (*Mucuna pruriens* and *Vigna radiata*) as preceding crops in lowland rice, combined with half the recommended dose of fertilizer in rice cultivation, significantly increased yield by 25 to 35% and reduced mineral fertilizer use by 50%. However, further studies are underway to quantify not only the nutritional contribution of these legumes to rice plants but also their sustainable impact on soil fertility improvement.



Figure 19. Mr Moukaila Bagri conducting his field evaluations on tomato bacterial wilt.

During the various trials established, supervision missions (Fig. 20) were conducted to assess the progress of the trials, to interact with farmers and to identify the constraints encountered by the

students. Furthermore, the students presented their results at the Agroecology week organised by the University and the UAC colloquium.



Figure 20. Field (a) and laboratory (b) visit for student supervision by members of the TAERA project.

## 2.8. Post-harvest biology and value chain

Regarding the post-harvest biology and value chain, we worked with the Applied Horticultural Research to characterise the fruit and vegetable value chains in Benin through in-depth review of the literature on post-harvest and food security issues to set priorities for research and action in the fruit and vegetable sector in Benin and identify entry points for change. It came out that few studies estimated losses in fruits and vegetables at various levels (farm, retailers, wholesaler, transport, etc.) of the value chains ([Fassinou Hotegni et al. 2022](#)). The available data on fruits and vegetable post-harvest loss focused only on specific regions of the country. Besides, there have been limited interventions to

reduce post-harvest losses along the fruit and vegetable value chains. Proposed interventions were among others to (i) generate evidence on post-harvest loss, and safety of fruits and vegetables (ii) design, pilot and scale innovations to reduce post-harvest losses and improve safety (iii) raise awareness of stakeholders and build their capacity.

Overall, few studies estimated losses in fruits and vegetables at various levels (farm, retailers, wholesaler, transport, etc.) of the value chains. The available data on fruits and vegetable post-harvest loss focused only on specific regions of the country. Besides, there have been limited interventions to reduce post-harvest losses along the fruit and vegetable value chains.

Based on existing gaps, the following interventions areas have been identified:

**Generate evidence on post-harvest loss, and safety of fruits and vegetables.**

- Assessment (both quantitative and qualitative) of post-harvest loss along fruit and vegetable value chains. Such assessment should integrate the seasonal variability in post-harvest loss of the selected crops especially tomatoes, leafy vegetables, mango and pineapple. This information will shed light on hotspots of post-harvest losses along the value chains for targeted interventions.
- Assess vegetable and fruit production safety in different production systems (conventional, agroecological, organic).
- The overuse of pesticides is still a major challenge in production of safe vegetables. Diversification of pest control products, and training of farmers in integrated pest and soil fertility management along with market development could improve the production of safe vegetables.

**Design, pilot and scale innovations to reduce post-harvest losses and improve safety.**

- Co-develop (stakeholders' involvement in the process is vital) and disseminate appropriate technologies that can reduce post-harvest losses in fruits and vegetables and enhance shelf life of products. Low-cost cooling systems (e.g., solar powered refrigeration system, forced air cooling systems) at market level or products aggregation hub, can be tested.

**Awareness creation and capacity building**

- The data generated from post-harvest and safety should be translated into accessible info to a wider audience including farmers, traders, consumers and policy-makers.
- Develop visual tools in local languages to raise awareness of vegetable and fruits safety issues.

## 2.9. Scientific publications in 2023

A total of 17 papers was published in 2023 by the GBioS team on topics anchored in three key thematic areas including Omics and plant breeding, Agroecology and Seed system. These papers were published in both indexed journals (6.25% of papers) and highly ranked journals (93.75% of papers) whose impact factors ranged from 1.6 to 12. **Fig. 21** presents the relative importance of papers published by the lab per impact factor class.

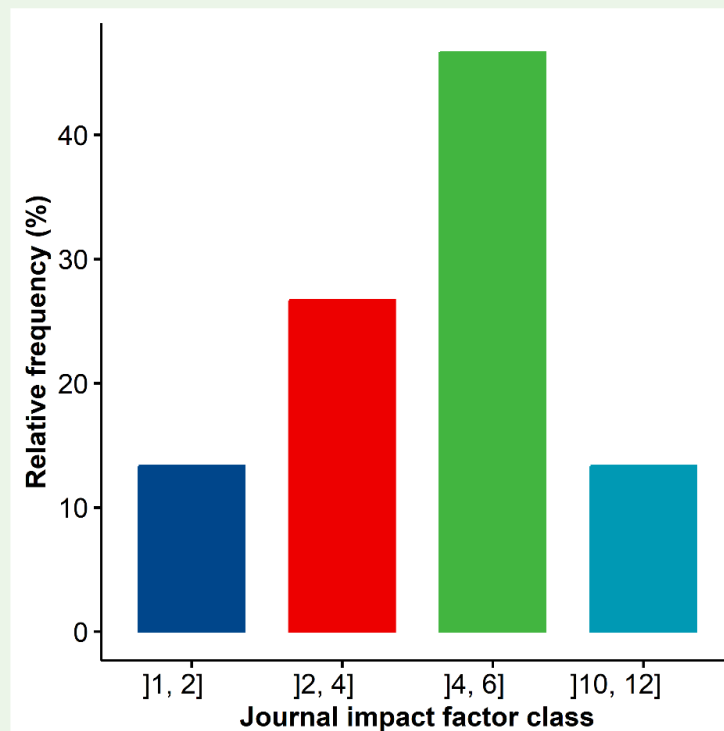


Figure 21. Relative impact of GBioS papers in 2023 assessed by published in journals impact factors.

Most of the 2023 papers were published in journals with IF > 4. The categorization of the various papers per thematic areas is presented below.

## 2.9.1. Omics and plant breeding

**Agossou, A.C.O., N'Danikou, S., Fassinou Hotegni, V.N., Coulibaly, M., Kakpo, T.A., Oselebe, H.O., and Achigan-Dako, E.G.** Determinants of farmers' willingness to pay for improved cultivars of *Macrotyloma geocarpum* (Harms) Maréchal and Baudet in Benin and Togo. *Frontiers in Sustainable Food Systems* 7:1180961.

**Ahoudou, I., Sogbohossou, D.E., Hotegni, N.V.F., Adjé, C.O., Komlan, F.A., Moumouni-Moussa, I., and Achigan-Dako, E.G.** (2023). Farmers' selection criteria for sweet potato varieties in Benin: An application of Best-Worst Scaling. *Experimental Agriculture* 59:e25.

**Azon, C.F., Fassinou Hotegni, V. N., Adjé, C.A., Agossou, C.O., Sogbohossou, O.E., Nouletope, H., Akotchayé, O.-P.K., Kékpè, P., Aïso, C., and Guirguissou, M.A.** (2023a). Socio-demographic factors and ethnobotanical knowledge associated with sesame management practices across agroecological zones in Benin. *Experimental Agriculture* 59:e10.

**Azon, C.F., Fassinou Hotegni, V.N., Sogbohossou, D.E.O., Gnanglè, L.S., Bodjrenou, G., Adjé, C.O., Dossa, K., Agbangla, C., Quenum, F.J., and Achigan-Dako, E.G.** (2023b). Genotypex environment interaction and stability analysis for seed yield and yield components in sesame (*Sesamum indicum* L.) in Benin Republic using AMMI, GGE biplot and MTSI. *Heliyon* 9.

**Capo-Chichi, D.B., Tchokponhoué, D.A., Sogbohossou, D.E., and Achigan-Dako, E.G.** (2023). Narrow genetic diversity in germplasm from the Guinean and Sudano-Guinean zones in Benin indicates the need to broaden the genetic base of sweet fig banana (*Musa acuminata* cv Sotoumon). *Plos One* 18:e0294315.

**Hoang, N.V., Sogbohossou, E.D., Xiong, W., Simpson, C.J., Singh, P., Walden, N., van den Bergh, E., Becker, F.F., Li, Z., and Zhu, X.-G.** (2023). The *Gynandropsis gynandra* genome provides insights into whole-genome duplications and the evolution of C4 photosynthesis in Cleomaceae. *The Plant Cell* 35:1334-1359.

**Kaczmarek, T., Causse, S., Abdul, S.D., Abraham, S., Achigan-Dako, E.G., Adje, C., Adjebeng-Danquah, J., Agyare, R.Y., Akanvou, L., and Bakasso, Y.** (2023). Towards conservation and sustainable use of an indigenous crop: A large partnership network enabled the genetic diversity assessment of 1539 fonio (*Digitaria exilis*) accessions. *Plants, People, Planet*.

**Nkoulou, L.F.M., Ninla, L.A.T., Cros, D., Martin, G., Ndiang, Z., Houegban, J., Ngalle, H.B., Bell, J.M., and Achigan-Dako, E.G.** (2023). Analysis of genetic diversity and agronomic variation in banana sub-populations for genomic selection under drought stress in southern Benin. *Gene* 859:147210.

**Tchokponhoué, D.A., Legba, E.C., N'Danikou, S., Nyadanu, D., Oselebe, H.O., and Achigan-Dako, E.G.** (2023a). Developing improvement strategies for management of the Sistrè berry plant [*Synsepalum dulcificum* (Schumach & Thonn.) Daniell] based on

end-users' preferences in Southern Nigeria. *Frontiers in Sustainable Food Systems* 7:1252036.

**Tchokponhoué, D.A., Achigan-Dako, E.G., Sognigbé, N.D., Nyadanu, D., Hale, I., Odindo, A.O., and Sibiya, J.** (2023b). Genome-wide diversity analysis suggests divergence among Upper Guinea and the Dahomey Gap populations of the Sistrè berry (*Syn: miracle fruit*) plant (*Synsepalum dulcificum* [Schumach. & Thonn.] Daniell) in West Africa. *The Plant Genome* 16:e20299.

**Touré, O.Y., Sanni Worogo, J.S., Tchemadon, G.C., Nebie, B., Afouda, L.A., and Achigan Dako, E.G.** (2023). Farmers' Knowledge and Perception on Kersting's Groundnut (*Macrotyloma geocarpum*) Diseases and Pests in Benin. *Plant Dis.*:PDIS-09-22-2190-RE.

**van Zonneveld, M., Volk, G.M., Dulloo, M.E., Kindt, R., Mayes, S., Quintero, M., Choudhury, D., Achigan-Dako, E.G., and Guarino, L.** (2023b). Safeguarding and using fruit and vegetable biodiversity. In *Science and Innovations for Food Systems Transformation*, (Springer International Publishing Cham: pp. 553-567

**Isiaka, A.I., Agossou, C.O., Agbolade, J.O., Adje, C.A., Fassinou Hotegni, V.N., Tossou, M.G., Oselebe, H., and Achigan-Dako, E.G.** (2023). Phenology, floral organs ultra-structure, traits correlation, stigma receptiveness, pollen viability and germinability in horsegram (*Macrotyloma uniflorum* Lam.) Verdc. *South African Journal of Botany* 161:444-453.

## 2.9.2. Agroecology

**Tapsoba, P.K., Aoudji, A.K., Kestemont, M.-P., Konkobo, M.K., and Achigan-Dako, E.G.** (2023). Clustering smallholders' farmers to highlight and address their agroecological transition potential in Benin and Burkina Faso. *Current Research in Environmental Sustainability* 5:1002220.

**Tapsoba, P.K., Aoudji, A.K., Kestemont, M.-P., Konkobo, M.K., and Achigan-Dako, E.G.** (2023). Current Research in Environmental Sustainability. *Current Research in Environmental Sustainability* 5:100220.

**Tapsoba, P.K., Aoudji, A.K., Ouédraogo, F., Dassekpo, I.S., Kestemont, M.-P., Konkobo, M.K., and Achigan-Dako, E.G.** (2023). Understanding the behavioral drivers of smallholder agro-ecological practice adoption in Benin and Burkina Faso. *Farming System* 1:100023.

## 2.9.3. Food security

**van Zonneveld, M., Kindt, R., McMullin, S., Achigan-Dako, E.G., N'Danikou, S., Hsieh, W.-h., Lin, Y.-r., and Dawson, I.K.** (2023). Forgotten food crops in sub-Saharan Africa for healthy diets in a changing climate. *Proceedings of the National Academy of Sciences* 120:e2205794120.

## 2.10. Progress of our PhD students

Many PhD students are conducting their study within GBioS in a range of interesting subjects. Most of these theses are applied-research oriented and aim at developing innovations to improve livelihoods of -smallholder- farmers. Here we report the progress they made during the last two years.

**Subject 1: Optimising agroecological practices for the integrated management of bacterial wilt of tomato caused by the *Ralstonia solanacearum* species complex in the Mono and Couffo departments. PhD student: Moukaila Bagri**

Reported officially in Benin in 2009, bacterial wilt caused by the *Ralstonia solanacearum* species complex persists and has become the main biotic factor limiting tomato production in the market gardening basin of the valley (Mono, Couffo, and Ouémé). The objective of this thesis is to strengthen the capacities of market gardeners in the agroecological management of this devastating soil-borne bacterium in solanaceous crops, particularly tomatoes. Started in May 2021, two literature reviews (qualitative and quantitative) were conducted to synthesise knowledge on this disease, including identifying agroecological practices studied in its management and identifying best practices. These two reviews were complemented by an analysis of the occurrence of this disease in the departments of Mono and Couffo, the knowledge of market gardeners about this disease, and the control practices implemented through a participatory survey. This understanding of the epidemiology of the disease led to the participatory evaluation of several tomato varieties and accessions in market gardeners'

fields in four districts in the two departments to replace the highly susceptible local variety to this disease. In addition to this, classical composts were enhanced by incorporating sanitizing plants such as *Crotalaria juncea*, *Azadirachta indica*, *Brassica oleracea*, and *Allium cepa*. The biofumigant and repellent capacities of these improved composts were tested under real conditions in Lalo and in a greenhouse at CRA-Agonkanmey in Abomey-Calavi. Scheduled to be completed by December 2024, farmer field schools and training sessions were conducted to raise awareness and equip market gardeners in the agroecological management of this disease in order to increase cultivated areas, yields, and incomes from tomato cultivation.

**Subject 2: Targeted selection of shea trees (*Vitellaria paradoxa* CF Gaertn) rich in specific fatty acids and unsaponifiable matter for the chocolate and cosmetics industry in Benin. PhD student: Guillaume J. Bodjrenou)**

Shea tree (*Vitellaria paradoxa* CF Gaertn) is mainly exploited for its butter from the kernels, which is a multi-billion-dollar export product. According to Transparency Research Market (2019), the shea butter market is estimated at \$3.5 billion, with a projected annual growth rate of 5.2% by 2028. This exponential growth in the shea butter market reflects the growing importance attached to the product by manufacturers. However, shea production is triennial, resulting in irregular annual output and wide variations in yield. What's more, the tree's very slow growth, with reproductive maturity ranging from 10 to 25 years, considerably hinders natural regeneration, thus maintaining a high rate of

ageing. The identification of shea trees rich in specific fatty acids and unsaponifiable matter for industrial use remains a little-addressed research issue. The aim of this research is to select shea trees with high nut and metabolite yields, including specific and unsaponifiable fatty acids, for the cosmetics and chocolate industries respectively, in the species' areas of distribution in Benin. Specific objectives are to: (i) investigate through a literature review the use of the "omics" approach in the identification of genes coding for fatty acids and their biosynthesis pathway in shea; (ii) characterise phenotypic, genotypic and biochemical variations in shea germplasm in Benin parks; (iii) establish the transcriptomic and metabolomic profile (in fatty acids and unsaponifiable matter) of genetic groups of shea trees through a comparative transcriptome and metabolome analysis; (iv) determine the impact of current and future climatic variations on the survival and distribution of Benin's shea tree stands. Activities so far conducted included in situ phenotypic data collection, leaves and kernels sampling and lab activities towards total gas chromatography and liquid chromatography on the kernel's fat. Ultimately, the fatty acid and unsaponifiable compound profile of shea tree from various genetic groups will be established.

**Subject 3: Etiology, Genome-wide association, and evaluation of a West African germplasm of Gboma eggplant (*Solanum macrocarpon* L) to bacterial wilt disease caused by *Ralstonia* spp in Benin. PhD student: Eliel Sossou.**

Gboma eggplant (*Solanum macrocarpon* L.) is a highly consumed and cultivated vegetable in Benin, particularly in the southern

regions. Notable for its nutritional value and profitability during off-seasons, its yield per hectare has seen a concerning decrease over recent years. Despite high production rates, demand remains unmet, particularly due to challenges in managing bio-aggressors such as bacterial wilt (BW) caused by *Ralstonia* spp, which significantly impeded on yield. Current management practices against BW are inadequate. Consequently, losses of up to 75% were recorded in some areas, prompting the need to breed for resistant varieties. This study aims to enhance Gboma production by selecting high-yield and BW-resistant varieties in Benin. Specifically, our objectives are to (1) evaluate farmers' perceptions and management practices regarding BW caused by *Ralstonia* spp (2) characterise strains of *Ralstonia* spp. responsible for BW and identifying affected regions in Benin (3) identify genetic diversity within a West African collection of *Solanum macrocarpon* using morphological descriptors and SNP markers and (4) assess Gboma eggplant accessions for resistance to BW disease. Since October 2022, we conducted a comprehensive review on review on "Breeding for resistance to bacterial wilt in Solanaceae crops: lessons learned and ways forward for Gboma eggplant (*Solanum macrocarpon* L.), a traditional African vegetable", and surveyed 570 farms to collect *Ralstonia* strains and understand farmers' knowledge and perceptions of BW severity. We also characterised a germplasm of 300 accessions of Gboma during two seasons. The outcomes of this research will directly benefit farmers by providing them with disease-resistant cultivars. Additionally, insights into farmers' perceptions can inform intervention policies to enhance adoption rates. The exploration of Gboma eggplant diversity will

also provide seed companies with access to genetic material for breeding programs aimed at developing high-yield, BW-resistant varieties.

**Subject 4: Agronomic Tools for Intensification and Sustainable Production of Aromatic Rice in the Mono and Couffo Departments.**  
**PhD student: Ulrich Djido.**

This thesis work is part of the "Support for Agroecological Transition through Agricultural Research (TAERA)" Project. One of the goals of this project is to support the transition to sustainable agricultural practices in rice production in Benin. The thesis aims at improving the yield and production of aromatic rice using sustainable agroecological practices in the Mono and Couffo Departments. To achieve this, various research activities supported by participatory field experiments were conducted. These included mapping agronomic practices used by small-scale farmers in southern Benin for sustainable agroecological transition in rice production and perspectives for a rice-legume cropping system. Participatory evaluations of the yield of aromatic rice lines in different environments, as well as the mineral contribution (N, P, K, Ca, Mg) of a rotation system based on legumes *Vigna radiata* and *Mucuna puriens* (mung bean and mucuna) to rice plant nutrition have also been conducted. Through this research we will provide farmers with knowledge related to the best rotation systems based on legumes (mung bean and mucuna) and the best aromatic rice lines to sustainably improve their yield by around 25 to 30% and

their income. These research activities began in May 2021 and are expected to conclude by December 2024.

**Subject 5: Response of fonio (*Digitaria exilis*) genotypes to pedoclimatic conditions and agroecological practices.** PhD Student: Tania L. Akponikpe.

Fonio, is an indigenous West African cereal, free of gluten and rich in essential nutrients. It has remarkable ecological characteristics, such as adaptability to a diversity of soils in Africa, low water requirements, and short development cycle. These characteristics offer agricultural opportunities to extend the fonio production area, particularly in regions where water is a limiting factor, to restructure cropping systems and to integrate this crop into diets. To capitalise on these opportunities, research orientations have been identified. These include improving agroecological practices to increase fonio production, such as integrating legumes into crop rotation systems, identifying individuals genetically adapted to production zones, and understanding the interaction between genotype and environment, as well as improving natural soil fertility for fonio production without chemical inputs. The research conducted by this PhD student aims at (1) evaluating the interaction between genotype and environment along a pedoclimatic gradient in northern Benin, (2) measuring the biological fertility of production zones, (3) analysing and identifying microbial diversity associated with environment and genotypes, identify microbial strains of interest for the mineralization and solubilization of nutrients

(nitrogen, phosphorus and sulfur), and (4) assessing their impact on fonio growth, and test the effect of legumes preceding fonio on its growth and nutrient utilisation efficiency. This research project began in November 2022. Multi-environment experiments were established in Boukoubé, Gogounou, Ina, Kandi, Natitingou, and Parakou, using eleven genotypes selected based on previous agro-morphological and molecular characterization studies. Rhizospheric soil samples were taken from experimental units to assess chemical and biological soil fertility indicators, as well as the structure and abundance of the bacterial community in these soils, analysed at the Laboratory Agronomy Environment of the University of Lorraine. This research will provide new horizons for fonio producers in Benin and would help expand the crop production areas.

**Subject 6: Selection of essential oil crops, *Hyptis suaveolens* L. (Lamiaceae) for tomato pests' control in the horticultural system of Benin. PhD Student: Frida Dossa.**

Chemical insecticides have a variety of detrimental impacts, such as environmental pollution and their presence in food as residues. They also pose a major risk to human health and have negative impacts on natural enemies. Integrated pest management now requires the use of essential oils (EOs) obtained from plants as potent bio-agents. *Hyptis suaveolens* (L.) Poit is one of the most widely recognized essential oil plants from the Lamiaceae family and a potential biopesticide. It is found all over the world and is widely used for medicinal purposes and as a mosquito repellent. This study started in March 2019 and aimed at determining the

best genotypes of *H. suaveolens* accessions which provide a high quality and quantity of essential oils to control pests in horticultural systems of Benin. The activities already realised are: a review of the genetic diversity, essential oil's chemical constituents of *H. suaveolens*, and its uses in crop protection; the assessment of agro morphological characterization, the genetic diversity, and population structure of *H. suaveolens* accessions collected in Benin; in vitro tests of *H. suaveolens* essential oil on pests and a survey to evaluate the local knowledge on the use of *H. suaveolens* in Benin's horticultural system. In the current context of climate change, it is important to find a solution for the increasing yield losses due to pests and for improving farmers' livelihoods.

**Subject 7: Development of high seed yielding cultivars in sesame (*Sesamum indicum* L.) adapted to agroecological zones of Benin. PhD Student: Christel F. Azon.**

Sesame is an important oilseed crop belonging to Pedaliaceae, and important for its high nutritive value and high market value. Predominantly cultivated by small-scale farmers, particularly in the northern regions of Benin, sesame production faces traditional seed system challenges. This study aims at enhancing Benin's sesame production by developing high-yielding cultivars adapted to diverse agro-ecological zones. The research activities carried out since 2019 turned around: 1) exploring current status of sesame production in Benin through literature review and providing tips for promotion of the crop , 2) documenting the socio-demographic factors and

ethnobotanical knowledge associated with sesame management practices across agroecological production zones through survey with farmers 3) assessing genetic diversity in Benin and Chinese varieties through agromorphological and molecular markers 4) identifying performant and stable accessions through multi environment trials in eight environments across agroecological zones and 5) developing hybrids varieties using stable and high yielding accessions identified during the multi environment trials. Main results obtained so far provided documentation on the variation of production system across agroecological zones and found out management practices providing high yielding. In addition, accessions with high yielding and early flowering accessions among Benin and Chinese accessions as well as stable and high yielding accessions across agroecological zones in Benin were selected. Hybrids varieties were developed using stable and high yielding identified genotypes. Two papers have been published in high impact journals. This research will help improve the sesame production in Benin by exposing farmers to high yielding cultivars.

**Subject 8: Diversity and performance of endophytic and rhizosphere bacteria for stimulating the growth of *Synsepalum dulcificum* (Schumach & Thonn.) Daniell.** PhD Student: Rabiath Adigoun.

This thesis work focuses on the analysis of the diversity of endophytic and rhizosphere bacteria associated with a panel of accessions of the Sistrè berry plant [*Synsepalum dulcificum* (Schumach & Thonn.) Daniell] in order to isolate beneficial bacteria that can stimulate the species growth. The Sistrè berry plant is a tropical fruit tree

species native to West Africa which has several applications in medicine (cancer and diabetes treatment), pharmaceutical, cosmetics, food and beverage industries. The species could also contribute to the creation of novel markets for income generation due to its economic value in the international market. However, despite its high value, the volume of its production is still low in relation to its increasing demand due to its slow-growing habit. Thus, this research will explore the possibility of harnessing the diversity of the associated plant bacteria with plant growth promoting properties in order to produce a biostimulant that will improve the growth of the Sistrè berry plant. The research activities carried out so far included: (i) prospection and collection of leaf, root and rhizosphere soil samples from 29 accessions of the Sistrè berry plant across 16 municipalities in Benin; (ii) physicochemical analysis of the samples to quantify their mineral and organic contents; (iii) metagenomic DNA extraction, PCR amplification, high-throughput Illumina sequencing of the 16S rRNA gene from the samples and bioinformatics analysis of the sequencing data; and (iv) the writing of a manuscript for publication in a high impact peer-reviewed journal currently under review. This study will provide farmers with a sustainable strategy for intensifying the production of the crop to meet market demands and for the promotion of the sector in Benin.

**Subject 9: Development of pepper varieties resistant to viruses for the West African market.** PhD Student: Herbaud Zohoungbogbo

This thesis work is part of the initiative to increase pepper productivity in West Africa and more specifically in Benin. This

research aims at (1) identifying the various viruses affecting pepper production in West Africa (2) assessing producers' perception and knowledge of viral diseases, associated vectors, and their management strategies in pepper production in Benin, and (3) developing pepper varieties resistant/tolerant to these viruses. Through this thesis, different viruses affecting pepper production in Benin, Nigeria and Ghana were identified and characterised; sources of peppers with resistance genes to the identified viruses were evaluated, and virus-resistant pepper varieties with interesting horticultural traits for the market through interspecific crosses were developed. Preliminary results have allowed us to identify three major viruses affecting pepper production in Benin, Nigeria and Ghana, including Pepper Vein Mottle Virus (PVMV) and Cucumber Mosaic Virus (CMV) being the most important. Several sources of resistance to these known viruses were collected from gene banks and evaluated to identify the most resistant/tolerant ones. Breeding work is currently underway to develop virus-resistant varieties adapted to the West African market. This study will provide pepper farmers with high-quality varieties resistant to the main viruses affecting the crop and will increase pepper production in the region. This thesis is conducted at the University of Abomey-Calavi through the Genetics, Biotechnology and Seed Science Unit (GBioS) in collaboration with the World Vegetable Center. This research work started in February 2021 and is expected to conclude by September 2024.

#### **Subject 10: Farmer's Participatory Approach and Modeling Methods for the Diffusion of OFSP to Alleviate Vitamin A**

#### **Deficiency Diseases in Benin. PhD Student: Idrissou Ahoudou.**

Vitamin A deficiency remains a significant health issue in developing nations like Benin, leading to diseases and impaired growth, especially among vulnerable groups like children and pregnant women. Orange-fleshed sweet potato (OFSP), rich in  $\beta$ -carotene, one of the numerous provitamin A sources, emerges as a promising crop to combat this deficiency. However, OFSP adoption and consumption are limited due to agronomic challenges, socio-economic constraints, and cultural preferences. This research project, "Farmer's Participatory Approach and Modeling Methods for the Diffusion of OFSP to Alleviate Vitamin A Deficiency Diseases in Benin," initiated in 2020, aims at investigating OFSP dissemination to alleviate vitamin A deficiency among vulnerable populations. As progress made, in-depth study of farmers' preferences for sweet potato varieties was carried out through surveys and interviews. It came out that yield performance and marketability were very important for farmers. Building on this, nine OFSP genotypes underwent participatory multi-environment evaluations over two years. In collaboration with local farmers and experts, genotype performance across Benin's agro-ecological zones were assessed. High-yielding OFSP genotypes suited to diverse production and consumption contexts were identified. Moreover, investigation under this PhD research delved into the complex dynamics surrounding vitamin A-rich crop adoption and consumption, with OFSP as a focal point in Sub-Saharan Africa. Quantitative consumption pattern assessments and qualitative analyses of socio-economic and

cultural influences shaped OFSP acceptance and utilisation among target communities, guiding efforts to boost adoption and combat vitamin A deficiency. Employing participatory methodologies and modelling techniques, this research strives to facilitate widespread OFSP adoption as a sustainable measure to enhance dietary diversity and nutritional outcomes, especially for vulnerable demographics, directly addressing vitamin A deficiency diseases in Benin and similar regions.

**Subject 11: Optimising pre- and post-harvest techniques for the production of sugarloaf pineapples in Benin to enhance conservation for maritime export. PhD student: Brunith Ahokossi**

The aim of the research conducted in the framework of this PhD is to extend the shelf life of Sugarloaf pineapple fruits in Benin using pre and post-harvest practices for maritime export. So far, post-harvest damages in sugarloaf pineapples in Benin were assessed. A trial focusing on the evaluation of the effect of urea coating with neem oil on the quality and shelf life of pineapples was set. A paper on the pathogens affecting sugarloaf pineapples (*Ananas comosus* Var *Comosus*) in Benin is in process. Extending the shelf life of pineapples for producers in Benin promises financial stability through improved sales planning and access to more lucrative markets, especially for exports. The reduction of post-harvest losses will enhance the profitability and value chain of pineapples, thereby promoting the economic empowerment of producers. In summary, this initiative will offer more stable incomes, reduce losses, enhance the quality of the final product, strengthen the value chain, and economically empower producers, thus creating

a significant impact on their financial well-being and resilience.

**Subject 12: Knowledge transmission patterns and biomass yield production of black plum (*Vitex doniana* Sweet) for domestication program development. PhD student: Soulemane Nourouline**

Black plum (*Vitex doniana* Sweet) is a Sub-Saharan African wild species of the family Lamiaceae that significantly contributed to improving local communities' livelihoods, especially in women. This species has numerous applications for not only rural dwellers, but also for those in urban areas where it is used for food, healthcare and arts. However, the plant is overexploited by users of this multipurpose species. Among the threatening factors are bushfires and low natural regeneration due to poor seed germination caused by seed dormancy. Ongoing study in the framework of this PhD research aims at determining the sociodemographic drivers for the adoption and production of *Vitex doniana* in Benin to identify the mechanism for domestication and conservation to preserve this genetic resource. The specific objectives around the PhD student has been working on since 2022 were to: 1) assess the sociodemographic determinants for *Vitex doniana* knowledge transmission across generations. 2) evaluate the combining effect of provenance and pretreatment techniques on the *Vitex doniana* seed dormancy breaking. 3) develop the best agronomic practices for *Vitex doniana* leaf yield production. So far a review on the production, domestication, and genetic improvement of *Vitex doniana* to develop the pathways for its conservation has been conducted. A survey in southern

and central Benin on a sample of 252 interviewees to determine the factors underlying the modes of knowledge transmission and the means of adoption and production of *Vitex doniana* has also been conducted. Trials on breaking dormancy and developing agronomic practices are currently underway to provide a better system for producing *Vitex doniana* leaves. This research will provide farmers with new agronomic practices for the production of *Vitex doniana* leaves in Benin.

**Subject 13: Seed quality and vegetable seed systems in Africa: case of tomato, pepper and African eggplant (Gboma) seed in Benin. PhD student: Lys Aglinglo**

In Benin, the production, availability, and accessibility of vegetable crops remain limited. This is partly due to the low availability of production inputs, in particular quality seeds of improved varieties. Since 2017, several initiatives led by public and private organisations have strengthened the capacity of seed producers, seed companies or cooperatives to produce and market quality vegetable seeds. This has resulted in an increase in certified vegetable seed supply from 391.23 kg in 2020 to 1233.576 kg in 2022. However, this supply remains insignificant compared to the share of the informal system. As an essential input for crop production, seeds transmit the genetic potential needed for high productivity and resilience. Seed quality can increase crop productivity by up to 20%, and is therefore an essential element in achieving a sustainable food system. This study aims at contributing to improve physiological and sanitary quality of vegetable seeds made

available to farmers by seed companies and seed producers, through an assessment of seed quality along tomato, pepper and African eggplant seed systems in Benin. More specifically, it will identify farmers' perceptions and methods of assessing vegetable seed quality, establish a typology of local vegetable seed producers in relation to seed systems, and assess physiological and sanitary quality along seed chain, focusing on African tomato, pepper and eggplant. This thesis project started in March 2023, with a first draft of the research proposal currently being finalised. A literature review is underway to better find out what has been done so far and identified the gaps. This thesis will provide seed producers and companies, appropriate seed quality assurance scheme in order to supply farmers with high quality seeds.

**Subject 14. Development of pre- and post-harvest practices to improve the yield, quality and shelf life of tomato fruit for local markets in Benin. PhD student: Yasmine Godonou**

This thesis work aimed at providing efficient practices to optimise tomato fruit yield, quality and mainly the shelf life to the local farmers in the framework of the SafeVeg Project. Based on the fact that tomato fruit production yield, quality and shelf life is a result of combination of pre- and post-harvest practices, we aim at assessing and suggesting a good combination of some pre- and post-harvest methods to increase and optimise tomato fruit yield, quality and shelf life. As pre harvest methods, our hypothesis is that balanced calcium and potassium fertilisation

would increase fresh tomatoes shelf life along with quality and yield. Experiments are being set up on station and results will be available soon. As post-harvest methods to maintain tomato fruit quality and the shelf life after harvest, several methods based on tomato fruits coating are under assessment. The combination of adequate pre- and post-harvest practices are the best way to maintain tomato fruit quality and will be beneficial to farmers. It will help them to reduce tomato production losses and take more advantage of their effort during tomato crop production by improving their income. The research work started in January 2023 and is expected to finish in December 2025. It is conducted under the supervision of researchers from the Genetic, Biotechnology and Seed Science Unit (GBioS) and the Center for International Cooperation in Agricultural Research for Development (Cirad).

**Subject 15: Yield improvement, nutrient variation in kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal and Baudet] and socio-ecological determinants for adoption of improved varieties in West Africa. PhD Chaldia Agossou**

Climate change continues to pose serious threats to agricultural and food systems, especially in Africa, which is known to be highly vulnerable. This research builds on the rationale that legume crops represent a strong asset to diversify production systems

in such a context, and Kersting's groundnut (Doyi) represents a good candidate. The research, entitled "Yield improvement and nutrient variation in Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal and Baudet], and socio-ecological determinants for the adoption of improved varieties in West Africa," employs a mutation approach to broaden the genetic basis of Kersting's groundnut, aiming to develop high-yielding and micronutrient-dense cultivars. This approach is combined with social science methods to gauge end-users' readiness to pay for seeds of such improved cultivars. This research aims to ultimately (1) clarify the conditions under which farmers can purchase improved seeds of Doyi. (2) generate sufficient variability within the crop to constitute a robust breeding population for the species. (3) identify genomic regions associated with the performance of mutant lines. (4) Make high-yielding cultivars available to end-users. To date, one paper on farmers' willingness to pay for the improved Kersting's groundnut variety has been published, and two others on determining lethal doses for various *M. geocarpum* morphotypes, as well as on the influence of fertilization practices on the nutrient content of the same morphotypes, are under preparation. The mutant population developed has already been evaluated, and the collected data will serve for a genome-wide association study on the species.

### 3. Communication, Outreach and valorisation of innovations

During 2023, the GBioS communications team held meetings to define a communications strategy and update the Unit's brand guidelines. This work was diligently validated by the Directorate, guaranteeing its relevance and alignment with the Unit's objectives. Particular attention was also paid to the complete redesign of the GBioS' website, to make it more user-friendly and informative for visitors. Among the major communications achievements during the year 2023 we produced promotional materials such as:

- banners, kakemonos and flyers to promote the activities of the Unit's various projects;
- video clips, spots and reports to highlight the Unit's achievements and progress;
- goodies to highlight the unit's achievements and reinforce its visual identity; and
- Photography and compilation of a rich and diversified image bank.

In all, in 2023, over 50 visuals, 20 banners and 15 roll-ups had been designed and successfully deployed. In addition, more than 20 videos were edited and broadcast, while the GBioS image bank now boasts more than 5,000 photos, taken in the course of various activities.

In terms of social networking, we worked on:

- promoting of the Unit's technical platforms;
- highlighting the Unit's members and their achievements;
- promoting of crops of interest, as well as products from the GBioS farm;
- disseminating of the activities of the Unit's various projects; and
- highlighting GBioS participation in international conferences and summits, as well as delegation visits;

The GBioS communication team also promoted the access to the Unit's scientific publications, master's theses and doctoral dissertations. In terms of publications, 88 items of content were shared in French on Facebook, and 60 items were posted on LinkedIn in English. It is worth mentioning that the recruitment of two communications assistants has played a key role in the Unit's digital growth. On LinkedIn, for example, the number of followers increased from 500 in 2022 to 3,000 in 2023, while the number of monthly impressions rose from an average of 2,000 to 21,000. On Facebook, between 2022 and 2023, GBioS increased its number of followers from 2,300 to 3,600, with an average reach of 3,000 impressions per publication. On YouTube, the Unit grew from 30 subscribers in 2022 to 100 subscribers in 2023. Ultimately, cumulative production on all platforms over the year attracted around 10,000 visitors, generating 20,000 page views, demonstrating the significant impact of GBioS' communication efforts. This communication effort contributed to echoing the

following outreach and innovation valorisations' activities

### 3.1. Book of African vegetable recipes

In the framework of the project "Choose Grow Thrive: using citizen science in expanding west Africa's food basket with African vegetables to tackle malnutrition (BMZ-CGT)", a writing workshop was organized from 09 to 11 March 2023 at the restaurant "Saveurs du Benin", Cotonou, to develop a recipes booklet for okra, jute mallow and amaranth. This is part of food pilot intervention activities, which aimed to enable the environment for increased consumption of vegetables in Benin. Participants included chefs from Saveurs du Benin, key person from the Directorate of Food and Applied Nutrition (Direction de l'Alimentation et de la Nutrition Appliquée – DANA) of the Ministry of Agriculture, Livestock and Fisheries (MAEP), World Vegetable Center, Nutrifood Laboratory and GBioS (Fig. 22a). The workshop started with the opening remarks by the local project Coordinator, Prof. Enoch Achigan-Dako, who recalled the context of the workshop. He pointed out the

strategic aspect of choosing a workplace, which is to get closer to the stakeholders and, if possible, combine theory with practice. Following this, a quick brainstorming session was conducted to list all the vegetables most consumed in Benin. A list of recipes well-known for this species was made. An emphasis was placed on the three target species (okra, jute mallow and amaranth) of the BMZ-CGT project to have an exhaustive list of recipes. In total, 25 recipes were identified and described, including 10 recipes on okra (Fig. 22b), 9 on amaranth (Fig. 22c) and 6 on jute mallow. Each recipe was described for a household of five (05) people (father, mother and 3 children). For each recipe, the ingredients, the preparation mode (including preparatory, cooking, and serving steps) and the nutritional values were detailed. The booklet will be finalized in 2024 with the culinary demonstration session and validation workshop with the multistakeholder platform.



Figure 22. Participants in the writing workshop of a recipes booklet (a), recipe of dried okra soup (b) and of amaranth salad (c).

### 3.2. African Vegetables fair

In Benin, the first-ever African vegetable fair was organized from 31 July to 02 August 2023. This was part of the second pilot food system intervention focusing on communications for consumer behaviour change. The African vegetable fair was officially launched by the General Secretary (Prof. Francoise ASSOGBA KOMLAN) of the Ministry of Agriculture, Livestock and Fisheries (MAEP), who emphasized that the CGT project aligns perfectly with the vision of the Government of HE Patrice Talon, which has always worked for the implementation of several national projects and programs aimed at improving food security and nutritional status of our country. The African Vegetable Fair was about three (03) days of exhibitions and discoveries on African vegetables, mainly amaranth, jute mallow and okra. The fair included : (i) two (02) discussion panels on “the challenges and opportunities of increased African vegetable production” (Fig. 23a), and “the importance of African vegetables for consumer health” (Fig. 23b); (ii) the culinary demonstration (Fig. 24) of over 12 dishes made with African vegetables (e.g. fetri-gboman, amaranth leaf salad, dried okra sauce, ninouwi tindjan, etc.) by two restaurants; (iii) over 70 prizes (t-shirts, bags, vegetable and tasting vouchers, etc.) awarded (Fig. 25) during the games; (iv) 12 local businesses promoting “local food” showcasing their products African vegetables with focus on amaranth, jute mallow and okra (Fig. 26); and (v) over 450

participants (teenagers, young, adults, females and males) who came to explore the world of African vegetables. In addition, 373 participants (34% of females) were interviewed on their knowledge

of African vegetables before and after visiting the fair as part of assessing the impact of the intervention on beneficiaries.



Figure 23. Panel discussion on “the challenges and opportunities of increased African vegetable production” (a) and the importance of African vegetables for consumer health” (b) during the African Vegetable Fair.



Figure 24. Culinary demonstration of African vegetable recipes (okra, jute mallow and amaranth) during the African vegetable fair.



Figure 25. Winners of various games during the African vegetable fair.



Figure 26. Local businesses enterprises promoting their products based on African vegetables (amaranth, jute mallow and okra) during the African Vegetable fair.

### 3.3. Local population training on African vegetable production and seed saving

High-quality seeds play a crucial role in crop productivity and food availability. In Benin, the vegetable seed systems are predominantly informal and rely on low-quality seeds. To enhance the capacity of vegetable farmers in saving high-quality seeds for three selected vegetables—okra, amaranth, and jute mallow—the BMZ-CGT project consortium developed three farmer's guides on African vegetable production and quality seed saving (one guide per species). These guides were utilized to train farmers, extension services agents, and tricot field agents through a series of training workshops held across the country. The first series of training took place from 13 April to 05 May 2023 in 26 municipalities of the Territorial Agency for Agricultural Development (ATDA) 1 and 7, and the second series

from 22 to 29 October 2023 in eight municipalities, including Covè, Klouékanmè, Aplahoué, Dogbo, Lalo, Zangnanando, Djakotomey (ATDA 5) et Kandi (ATDA 2) (Fig. 27). During the first training, 913 people were trained, while 417 people were for the second training, making a total of 1,331 people trained. These included 1,256 vegetable farmers, 53 extension service agents and 22 tricot field agents with about 40% of women. The trainings were jointly organized by the GBioS/FAS/UAC team and the WorldVeg Benin. The facilitators of these trainings were Dr Carlos Houdegbe (GBioS/FSA/UAC), Mr Aglinglo Lys (WorldVeg Benin) and Mrs Judith Honfoga (WorldVeg Benin) (Fig. 28). They were assisted by various team members to ensure high-quality training. Overall, farmers were trained on how to make a vegetable good nursery, the requirements for vegetable production and quality seeds, the agronomic practices, and the post-harvest techniques for high-

quality seed production. It is important to highlight that farmers were also informed that this training does not qualify them to produce and sell seeds as this activity is highly regulated. Farmers were happy and expressed their gratitude to the project team for providing them with such important knowledge. Moreover, copies of the vegetable production and seed-saving guides were

distributed to the President of the vegetable growers' association, the tricot field agents and the extension services agents in each municipality. Farmers expressed the need to buy the guides and/or to have access to the electronic versions in order to consult them on their smartphones.



Figure 27. Training workshop on vegetable production and seed saving at Podo (Kandi).



Figure 28. Training facilitator Mrs Judith Honfoga – World Vegetable Center Benin during a training session on African vegetable production and seed saving.

### 3.4. Consumers' trainings on nutritional values and cooking methods of African Vegetables

As part of food pilot intervention activities of the BMZ-CGT project, which aimed to enable the environment for increased consumption of vegetables in Benin, consumer trainings in social promotion centres, school canteens, restaurants / food vendors on how to cook African vegetables to retain their nutritional content and to optimize the nutritional value of meals (trainings on vegetable processing techniques and culinary demos) is planned. To this end, two training modules were developed. The first module, titled "Nutritional Values of African Vegetables," covered the following

topics: (i) the key health benefits of major nutrients such as iron, calcium, zinc, magnesium, phosphorus, sodium, vitamins, and secondary metabolites; (ii) the nutrient content of okra, jute mallow, and amaranth; and (iii) a comparative analysis of the nutritional values of African and exotic vegetables. The second module, titled "Vegetable Cooking Methods to Preserve Nutritional Values," included information on: (i) hygiene and water sanitation; and (ii) cooking methods that preserve the nutritional values of African vegetables.

For this initial phase, twelve schools were selected in the municipalities of Lokossa, Grand-Popo, Seme-Podji, Porto-Novo, Dangbo, and Allada in collaboration with the NGOs CARITAS, FADEC, and GBEWA. A validation and sensitization mission to the pilot intervention sites was carried out from November 9 to 11, 2023, to validate the chosen schools and identify six pilot schools and six control schools. Therefore, this first series of workshops have primary school pupils (CE2 and CMI classes), canteen workers, parents, headmasters and teachers as beneficiaries. So, the nutritional value of African vegetables (jute mallow, okra and amaranth), the role of nutrients in the body and preparation methods for preserving the nutrients in African vegetables were taught to the beneficiaries in the first step (Fig. 29). In addition to sharing theoretical knowledge, particular emphasis was placed on the practical phase of culinary demonstrations (Fig. 30) followed by a tasting session (Fig. 31), which was greatly appreciated by the participants. Up to December, in all the six pilot schools, 253 people were trained, including 215 school kids, 08 teachers, 02 food vendors, 11 schools' canteens and 17 parents.



Figure 29. Theoretical session on the importance and nutritional values of African vegetables.



Figure 30. Culinary demonstration session with school kids and canteens in Lokossa(a) and Seme-Podji (B).



Figure 31. Tasting session by school kids after culinary demonstration session and evaluation of the training session.

### 3.5. African Vegetable Seeds Kits distribution to vulnerable households in Benin

"Vegetable Seed Kits for Food Security in Madagascar and Benin (VEG SEED KITS 2023)" is a project aimed at improving the nutrition of vulnerable households and schoolchildren in Benin and Madagascar by increasing access to nutritious vegetables. The project provided the most vulnerable populations with the means to produce a balanced supply of protein and micronutrients. In Benin, key activities planned within the framework of this project included: i) Selecting beneficiaries (vulnerable households and primary schools in Benin), ii) Conducting training workshops for trainers on vegetable production, seed saving, and consumption of vegetable crops such as amaranth, okra, and jute mallow, iii) Distributing vegetable seed kits to 1,990 Beninese households and 10 primary school gardens.

As a result, a total of 106 extension agents, field technicians, and school teachers received training in vegetable production, seed saving, consumption, and nutrition. A total of 2,000 vulnerable households and school gardens received kits containing seeds of amaranth, okra, and jute mallow. The beneficiaries were closely monitored and guided in the production and consumption of these vegetable crops.

### 3.6. Training of technician on seed kit distribution

The Seed kits project trained a total of one hundred and six (106) extension agents from nineteen municipalities including 79 males and 27 females on production techniques, seed saving, nutrition and consumption of amaranths, okra, and jute mallow. During the training (**Fig. 32**), the technical itineraries of each crop from nursery to harvest have been addressed. Special points have been made on practices such as sowing in rows during the nursery. The appropriate fertilizers to use, easy recognition of diseases and methods to address them, as well as harvesting techniques, were covered in the training sessions for participants. For seed saving, differences about field conditions for crop production and for seed saving have been explained with the techniques to obtain genetic purity, the type of container and adequate drying place.

Regarding the training on nutrition, several practices were taught, notably the importance of consuming leafy vegetables, water purification techniques, the promotion of hygiene and sanitation, hand washing techniques, as well as good culinary practices for leafy vegetables.



Figure 32. Ms Emilienne Bonou, agronomist training participants from Ndali, Banikoara, Karimama, Ségbana on production techniques, seed saving, nutrition and consumption of amaranth, okra, and jute mallow.

### 3.7. Seed kit distribution to vulnerable households

A total of 1,990 vulnerable households, including 827 female-headed households, were provided with kits containing seeds of amaranth, okra, and jute mallow, as well as containers for seed saving. These beneficiaries were met in nineteen municipalities

of Benin. (Fig. 33). The municipalities included Natitingou, Coby, Boukoumbé, Toucountouna, Karimama, Banikoara, Ndali, Savè, Glazoué, Ouèssè, Bonou, Zagnanado, Djidja, Lokossa, Bopa, Klouékanmey, Toviklin, Tori-Bossito and Zè. These householders have benefited from the assistance of extension members previously trained by the project to produce the crops they have received. An additional ten school gardens were reached.



Figure 33. Women in Karimama received seed kits for horticultural production

### 3.8. Elaboration of the Atlas of cultivated plants in Benin

With its recognized expertise, the GBioS team was invited to participate in the structuring project “Revision of the Flora of Benin” of the National Academy of Sciences, Letters, and Arts (ANSALB). In this project, the GBioS team composed of Prof Dr. Enoch Achigan-Dako, Dr Sognigbe N'Danikou, Dr Dèdéou A. Tchokponhoué and Dr Aristide C. Houdegbe was tasked with drafting the “Atlas of cultivated plants of Benin”. In this endeavour initiated since February 2022, a total of 154 species was finally reported in the deliverable shared with ANSALB in March 2024. Following the successful delivery of the “Atlas of cultivated Plants of Benin”, the team has now been invited to generate a similar production on wild species: “Atlas of wild harvested species of Benin”. The participation of GBioS into a such an initiative positively echoed in the policy making arena.

### 3.9. Amplification of agroecological practices

For the year 2022-2023, the AGRO-ECO project, with the leadership of the GBioS intensified activities to amplify agroecological practices (AEPs) in Benin and Burkina-Faso. The AEPs included:

- the valorization of mung bean (*Vigna radiata*), a legume with high nutritional value and a good capacity to improve soil fertility and a high economic opportunity. To this end, the project recruited three technicians for a technical-economic study of the integration of mung bean in agricultural systems in Natitingou, Tanguieta and Boukoumbe municipalities. These technicians were in the field to train farmers on the agricultural practices of mungbean and to collect technical and economic data on

mungbean production. The beneficiary farmers were supported, through seeds gift (Fig. 34), to establish seed production units in order to guarantee the accessibility and availability of seeds. In each of the municipalities, three (03) villages were selected with four (04) producers per village including two (02) for the model fields and two (02) for seed production units. A total of nine villages, 34 farmers were involved. This includes 18 school fields, each of 400 m<sup>2</sup> and 16 seed production units, each of 0.5 ha. The profitability analysis showed that the profit was 34.25% for 0.5 ha;

- the training on neem oil production. This resulted from the comparative advantages of neem-coated urea and the availability of neem oil as the major difficulty to the large-scale adoption of this technique. There is a need for the development of local expertise in the manufacturing of neem oil, which would promote its availability at a reduced cost for producers. Therefore, training sessions were organized for producers in the intervention villages in the three municipalities of Atacora (Natitingou, Tanguieta and Boukoumbe);
- the manufacturing a coconut shell crusher. The coconut husk (shell) rotor grinder is a machine whose function is to finely grind biological material using high-speed rotation of several blades. In the crusher, the rotor rotates at high speed and the coconut husks are crushed into fine particles by the friction action of the tooth blades and are expelled out of the machine by passing through a sieve. This machine produces two materials: peat and fibre. Each material exits through a specific exit. The machine is operated by a push button connected to a 15-horsepower dynamo; and
- the organisation of the “Agroecology Week”.



Figure 34. Mungbean seeds distribution to selected farmers for production

### 3.10. Agroecology week event

The Agroecology week brought together all the actors (public and private) involved in the agroecology in Benin and Burkina Faso, from 18 to 20 July 2023, at the University of Abomey-Calavi. This event, honoured by the presence of the Belgian embassy in Benin and the ministry of Agriculture, livestock and Fisheries, rectoral and decanal authorities of the UAC, allowed the sharing of experiences, the capitalization of acquired knowledge on agroecology and the perspectives of future collaboration between the institutions present. The launching ceremony (Fig. 35) was marked by the speeches of the representative Dean of the Faculty of Agricultural Sciences (FSA), the coordinator of the AGRO-ECO project, Professor Marie-Paule KESTEMONT, the focal point from the Ministry of Agriculture, Livestock and Fisheries on agroecology, Ir. Charles ACAKPO and the Belgian ambassador to Benin, Mrs. Sandrine PLATTEAU and the opening speech by the rector of UAC, Professor Félicien AVLESSI. Two

opening conferences were delivered by Prof. Silvère TOVIGNAN (Plateforme de l'Agriculture Biologique et Ecologique (PAEB)) and Mr Omar OUEDRAOGO (Permanent Secretary of Confédération Paysanne du Faso (CPF)) and Dr Cédric KAMBIRE (CNRST/Burkina-Faso). Another event was the scientific session with 12 communications organized in three sessions (i) "Agroecology, Sol and Environment" (6 communications); (ii) "Agroecology and Socioeconomic" (3 communications) and "Agroecology, Crop Protection and Health Quality" (3 communications). Other activities included (i) two discussion panels on "Transition to agroecology: opportunities and challenges" (Fig. 36a) and "the amplification of agroecological practices" (Fig. 36b) and (ii) a fair (Fig. 37) with 12 participants including NGOs, enterprises, startup-up in agroecology. On the occasion this event, a steering meeting of the AGROECO was organized.



Figure 35. Group photo picture of the participants to the Agroecology week kick-off ceremony.



Figure 36. Discussion panels on "Transition to agroecology: opportunities and challenges" (a) and on "the amplification of agroecological practices" (b) during the agroecology week.



Figure 37. Fair stands visit by the Vice-chancellor during the agroecology week.

### 3.11. GBioS and Biovalor Entrepreneurship Hub

GBioS is currently affiliated to the Biovalor Entrepreneurship hub established in 2023 within the Faculty of Agricultural Sciences at the University of Abomey Calavi. The objective of the Biovalor hub is to serve as a platform for knowledge and innovation acquisition and development among students and professionals active in the agrifood sector. GBioS has expertise and experience in turning ideas into viable enterprises (e.g., BiLife, Benin Cereals, Seed Services).

### 3.12. Visits and delegations

In 2023, the Unit hosted several delegations on behalf of the Faculty and Agricultural Sciences and the University of Abomey Calavi. Some of those visits are described below for illustrative purposes.

#### 3.12.1. Visit of an EU Representative

From August 14–18, 2023, GBioS welcomed an EU Representative, Professor Baghdad Benstaali, on behalf of the European Union. This working visit was part of a midterm evaluation of EU-funded Projects. These are MoBreed and GENES, two Intra-African mobility scholarship projects implemented at the University of Abomey

Calavi. The GBioS has been respectively responsible for regional coordination for MoBreed and local coordination for GENES.

MoBreed project aimed at enhancing training and research mobility for novel crops breeding in Africa. Its consortium members were the UAC (Benin), the Ebony State University (Nigeria), the University of Jimma (Ethiopia), the University of Namibia (Namibia) and the University of KwaZulu Natal (South Africa). GENES was a mobility for plant genomics scholars to accelerate climate/smart adaptation options and food security in Africa. The consortium of this project was made of: UAC (Benin), the Ebony State University (Nigeria), the University of Yaoundé 1 (Cameroon) and the University of Jimma. During his visit, Prof Bagdad got the opportunity to visit Calavigen (Fig. 38a), the Sedje-Denou production site (Fig. 38b) (Ethiopia) two entities currently managed by Dr Tchokponhoue, an alumni of the MoBreed program. At the end of his visit, Prof Bagdad was very impressed by the MoBreed and GENES achievements, and especially by the capabilities of these two program scholars. A final group photo of his visit is presented in **Fig. 39**.



Figure 38. Visit of the CalaviGen drying room (a) and of the Sèdjè-Dénou regeneration site (b) by the EU Representative (Prof. Bagdad) and a team of GBios.



Figure 39. Group photo after the CalaviGen visit by the EU representative, Prof Bagdad.

### 3.12.2. Visit of the PACOFIDE and COMPETITIVENES delegation

On Wednesday 29 March 2023, the FSA's Genetics, Biotechnology, and Seed Science Unit (GBioS) welcomed a delegation from the "Projet d'Appui à la Compétitivité des Filières Agricoles et de Diversification des Exportations (PACOFIDE)". The aim of the visit, which took place within the framework of the Biovalor project, was to examine the possibilities for collaboration in the production of scientific evidence on the conservation of pineapples for export. The delegation found out that research conducted at GBioS

was well aligned with their expectations and wish they could contact GBioS at an earlier stage. Non-tackled expectations can be integrated into the ongoing research within the unit through the BIOVALOR Project, which enables the leveraging of available expertise and the generation of pertinent information for PACOFIDE and the competitiveness of the pineapple sector in Benin. After the indoor session, the PACOFIDE team visited some of the GBioS' technical platforms (Fig. 40), and the visit concluded with a group photo (Fig. 41). Other opportunities for collaboration have also been identified, particularly in the shea, sesame, and cashew nut sectors.



Figure 40. Visit of the Molecular biology (a) and CalaviGen (b) technical platforms by the PACOFIDE delegation.



Figure 41. Group photo after a visit of GBios by the PACOFIDE delegation.

### 3.12.3. Visit of IFDC, Nigeria office members

The HortiNigeria project team organized meetings in Benin from 17 to 22 December 2023 with institutions, programmes/projects and production organizations involved in market gardening. This project is implemented by the International Fertilizer Development Center (IFDC), Nigeria office.

During their stay in Benin, the team visited the GBioS (Fig. 42) on Monday 18 December 2023. The visit is part of a programme to support Nigerian farmers in adopting new knowledge and/or technologies for horticultural production. The members of GBioS exchanged and shared their experience and expertise with the visitors.



Figure 42. HortiNigeria project team visit at GBioS. Visit of the CalaviGen seed sorting room (a) and group photos of the GBioS team with the visitors from the HortiNigeria project (b).

## 3.13. Participation to conferences

### 3.13.1. Third African Plant Breeders Association Conference

From 21 to 27 October 2023, the GBioS team represented by Prof Enoch Achigan-Dako, Dr. Dedeou Tchokponhoue, Dr. Olga Sogbohossou and the Ph.D. students namely Jelila Blalogue and Eliel Sossou attended the 3rd APBA conference held at Mohammed VI Polytechnic University, Benguerir in Morocco under the following theme “leveraging genetic innovation for a Resilient African food system in the wake of Global shocks”. After the opening ceremony, and the main conference where many presentations were done by several scientists and students from CGIAR centers, we had a session of poster presentation, followed by a business meeting, the election of the APBA executives’ committee, and a closing ceremony.

During this session, innovations and new techniques for improving crop yield were shared. We were most captivated by the sharing of knowledge on breeding in considering selection for high symbiotic relations and maximizing mycorrhizobia (Fungus). This could be interesting in miracle plant (*Synsepalum dulcificum*) and other crops’ yield improvement. In addition, this has become an area of interest for GBioS in recent years, and currently, some of our Ph.D. students are working on crops microbiome. This is a new target that should be factored into breeding programs to increase variety yield. According to the speaker, the interaction

gene (Plant) x gene (mycorrhizobia) could be symbiotic or parasitic. The parasitic is likely when the fungus takes much of the carbon from the plant and releases fewer nutrients. The target should be to find group of lines that perform well in the symbiotic aspect through a good transcription factor. However, research should not only be focused in a controlled environment but transfer in the field context. A burning point was raised during the panel discussion after several presentations on precision phenotyping and concerned with moving the phenotyping platform from a controlled environment to the farmers’ field. Phenotyping platforms did not benefit much towards breeding in Africa and even other continents if it is not just for publications. Henceforth, let’s go to the field. This is also the same thing in terms of QTL identified and published, but how are they used in current breeding programs?

The two research associates namely Dr. Olga Sogbohossou and Dr. Dèdéou Tchokponhoué have also presented our last results in Spider plant (*Gynandropsis gynandra*) and pignut breeding (*Hyptis suaveolens*) (**Fig. 43**) which unravelled their potential respectively in terms of nutrition and essential oil for crop protection using genomics.

After the presentation of different scientists from universities and CGIARs centers, the presentation of different activities carried out by APBA was presented by the secretary, Prof Enoch Achigan-Ako, followed by fundraising and activities conducted by other related committees.

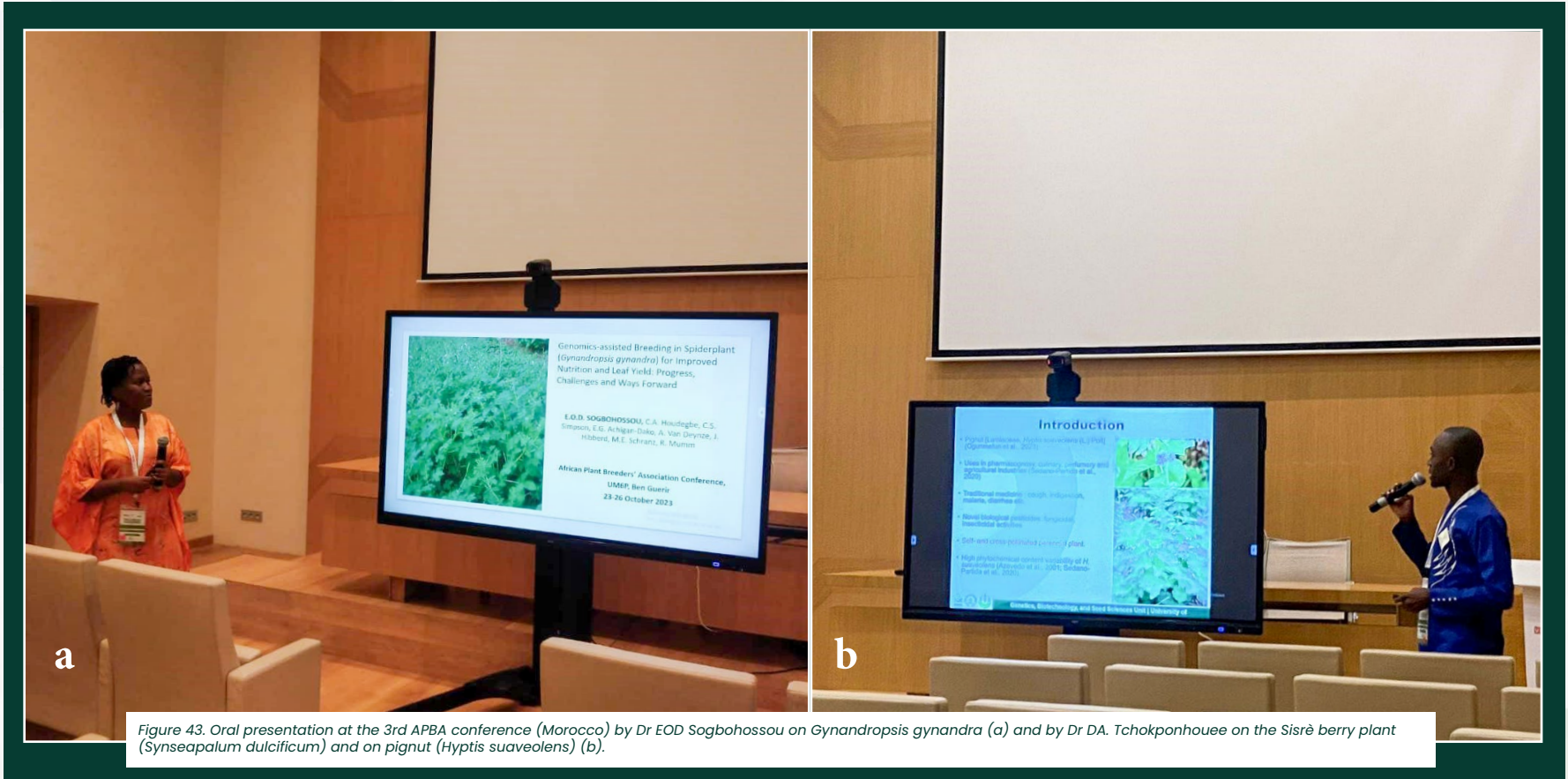


Figure 43. Oral presentation at the 3rd APBA conference (Morocco) by Dr EOD Sogbohossou on *Gynandropsis gynandra* (a) and by Dr DA. Tchokponhouee on the Sistrè berry plant (*Synsepalum dulcificum*) and on pignut (*Hyptis suaveolens*) (b).

The poster presentation sessions were held after the plenary sessions of the second and third days. Our first one (Fig. 44a) is themed Variability in leaf and fruit traits of Gboma Eggplant (*Solanum macrocarpon* L.) is influenced by geographical origin. Many researchers were interested in the topic since it was

oriented on orphan crops. The second poster (Fig. 44b) is entitled Evaluation of Okra (*Abelmoschus Esculentus* L. Moench) seed physical and physiological quality from different seed systems in Benin.



Figure 44. Posters presentation by Mr Eliei Sossou (a) and Mrs Jella Blagoe (b) at the 3rd APBA conference



Colloquium of the University of Abomey-Calavi  
The Genetics, Biotechnology and Seed Science Unit (GBioS) participated in the VIIIth Conference on Sciences, Cultures and Technologies organized by the same University from September 25 to 29, 2023 on the topic “Valorisation of endogenous knowledge as a guarantee of sustainable development”. The Unit presented

ten oral communications (Table 2) during this conference. Professor Enoch ACHIGAN-DAKO and Doctor Nicodeme FASSINOU also contributed to this conference through their pivotal role in the scientific committee appointed on the “Natural and Agronomic Sciences” section to evaluate and select the submitted abstracts for oral and poster presentations.

**Table 2.** Topics and speakers at the 2023 UAC colloquium

Topic	Speaker
Socio demographic factors and ethnobotanical knowledge associated with sesame management practices across agroecological zones in Benin	Chritel Féréol AZON
Crossing possibility for breeding of promising orange-fleshed sweet potato genotypes in Benin	Fernand Sylvere SOHINDJI
Perspective of Production, Domestication and Genetic Improvement of black plum ( <i>Vitex doniana</i> Sweet) Lamiaceae: an overview	Nouroudine SOULEMANE
Local knowledge, uses and production systems of ginger ( <i>Zingiber officinale</i> Rosc.) in the Republic of Benin	Nicodeme FASSINOU HOTEgni
Exploring sweet potato variety selection criteria among Benin Farmers: a Best Worst Scaling approach	Idrissou AHOUDOU
Réponse des génotypes de fonio face aux variations des conditions pédoclimatiques et aux pratiques culturales dans les zones agroécologiques du Bénin	Tania AKPONIKPE
Evaluation de la performance agronomique de cinq lignées de riz aromatique cultivées de manière agroécologique au Bénin	Ulrich DJIDO
Analyzing smallholder's farmer's preferences for ecological fruit flies management practices in western Burkina Faso orchards	Parfait K. TAPSOBA
Etiology, Genome wide association, and evaluation of the West African germplasm of gboma eggplant ( <i>Solanum macrocarpon</i> L) to bacterial wilt disease caused by <i>Ralstonia</i> spp in Benin.	Eliel B. SOSSOU
Phenotypic and molecular characterization of pepper ( <i>Capsicum</i> sp.) resistance to Pepper veinal mottle virus (PVMV) in Benin	Herbaud P. ZOHOUNGBOGBO

### 3.14. Scientists mobility

Under the TAVI (Taiwan–Africa Vegetable initiative) project dedicated to safeguard vegetable genetics resources for a sustained agricultural and food system, a scientists' visit was agreed between the University of Abomey-Calavi and World Vegetable Center to strengthen the capacity of the human resources involved in the project. In this vein, two scientists' visits were organised in 2023. In February 2023, Dr Emmanuel Omondi, specialist of Landscape genomics at the World Vegetable Centre Headquarter in Taiwan visited Benin for 10 days. During his stay he closely cooperated with Dr Dedeou Tchokponhoue, manager of the TAVI project in Benin, gave talks on Landscape genomics, and reviewed the progress made by the UAC team regarding germplasm collection and conservation. He also visited TAVI-recruited MSC students' experimental sites in Sèdjè-

Dénou and Sekou. During this stay, a plan to co-draft scientific papers was also discussed with Dr Dedeou Tchokponhoue. As a follow-up of Dr Omondi's visit, Dr Tchokponhoué had a three-weeks work visit in Taiwan in November–December 2023. During his visits, both scientists under the leadership of the TAVI project coordinator and the project Coordinator in Benin pushed the Landscape Genomics Analysis on *Amaranthus cruentus*. The nice outputs obtained from the analyses were presented through a talk given by Dr Dedeou of Local adaptation quantification in vegetable Crops (Fig. 46) on 13 December 2023 in the WorldVeg conference room in Tainan in Taiwan.



Figure 46. Dr Dédéou Tchokponhoué giving his work visit end presentation in Tainan, Taiwan on Amaranth landscape genomics.

As part of the students' supervision activity in the TAERA "«Accompagnement de la Transition Agro-Écologique par la Recherche Agricole (TAERA)»" project, GBioS hosted Belgian supervisors in the framework of ongoing research activities by the PhD students. This was held from 11 to 15 April 2023 at the GBioS laboratory with the aim was to appreciate the progress so far made by the PhD students through presentation (**Fig. 47a**), to

visit the students' experimental sites (**Fig. 47b**) and address the difficulties encountered by the students.

The Belgian delegation included Pierre Bertin, Charles Bielders and Marnik Vanclooster, professors at the Université Catholique de Louvain (UCLouvain) and co-supervisors of the project's doctoral students.



Figure 47. Supervisors' activity during their stay in Benin. (a) indoor presentation by the PhD students and (b) field visit.

## 4. Resources mobilization

### 4.1. EU-funded projects

Following the launch of the NDICI-2023-MOBAF / Intra-Africa Academic Mobility Scheme call for proposals by the European Education and Culture Executive Agency (EACEA), GBioS has secured fundings for three new intra-Africa academic mobility projects with three consortia, a significant achievement considering the competitive nature of this EU program. These projects include "PATH", "ORPHAN" and "GENES II".

#### 4.1.1. Capacity Building of African Young Scientists in Precision Agriculture Through Cross-Regional Academic Mobility for Enhanced Climate Smart Agri-Food System (PATH)

With a total budget of €1,796,820 (2024-2027), the PATH project is coordinated by the University of Abomey-Calavi (Benin). It aims to enhance the capacity of young African researchers and entrepreneurs in Precision Agriculture to build climate-

resilient agri-food systems. The other project institutions included University of Cape Coast (Ghana), University of Eswatini (Eswatini), University of Rwanda (Rwanda), Institut Agro Montpellier (France) as European technical partner and University Mohammed VI Polytechnic (Morocco) as associate project partner.

#### 4.1.2. Mobility for high skilled scientists and entrepreneurs on orphan crops in higher education for accelerated climate change solutions in Africa (ORPHAN)

ORPHAN is a 4 years (2024-2027) intra-Africa mobility program coordinated by Université Nangui Abrogoua in Côte d'Ivoire, and aims to increase skills and qualifications of current and future professionals and practitioners orphan crops as solutions to climate change through plant breeding, food technology and nutrition. The project has a total budget of €1,796,820 and brought together, apart from the coordination institution, the University of Abomey-Calavi (UAC, Benin), Jomo Kenyatta University of Agriculture and Technology (Kenya), Ebonyi State University (Nigeria), University of Zimbabwe (Zimbabwe) and Université Catholique de Louvain (Belgium) as technical partner.

### 4.1.3. Mobility for Plant Genomics Scholars to Accelerate Climate-Smart Adaptation Options and Food Security in Africa (GENE II)

This is a follow-up project to GENES, a previously run intra-Africa mobility, and aimed to enhance the capacity to accelerate climate-smart adaptation options and food security in Africa through the training of high-profile plant breeders skilled in genomic technologies and research collaboration among the partner African HEIs. GENES II total budget is €1,796,820 (2024-2027) and is coordinated by Ebonyi State University of Nigeria. The partners institutions included the University of Abomey-Calavi (UAC, Benin), Jimma University (Ethiopia), Egerton University (Kenya), North-West University (South Africa), University of Zimbabwe (Zimbabwe), while with Wageningen University (The Netherlands) is a technical partner.

## 4.2. Other projects

Research being a fundamental component of GBioS activities, the team also invested, apart from mobility projects, in securing funds for a sustainable implementation of its research and development activities. In this vein, the Unit engaged in the application process of the multiple-stages call from ARES (Académie de Recherche et d'Enseignement Supérieur) on "Projets de recherche pour le développement" (PRD), and from RVO on the Accelerating Resilient Food Systems in Africa (ARFSA) programme. This resulted

in the submission of the e-Anacarde and Profonio concept notes to ARES and RVO, respectively.

After the shortlisting of the e-Anacarde pre-proposal in October 2023, the organisation of the project formulation mission in January 2024 and the submission of the full project in February 2024, a total budget of € 500,000 has been granted to the project team for a five year-duration. e-Anacarde is an international initiative that brings together the University of Namur (Belgium), the Genetics, Biotechnology and Seed Science Unit, the University of Parakou, the Cashew Professionals Association (IFA), the FENAPAB (Fédération Nationale des producteurs d'anacarde) and the National Agricultural Research Institute of Benin (INRAB) with the aim of selecting and making available to farmers adequate cashew planting material as well as creating a numerical platform for enabling the timely information sharing among all actors involved in various cashew value chains in Benin. GBioS is the South coordinating institution of this five-year initiative.

As for the Profonio initiative, it is a development project that aims to scale up proven Fonio-Bambara and orange-fleshed sweet potato-based production practices to improve resilience of producers in northern Benin to climate change. This project brings together the Faculty of the Agricultural Sciences under the leadership of the Genetics, Biotechnology and Seed Sciences; the African Center for Equitable Development, the Wageningen University and the Maison du Fonio, a non-governmental organisation specialised in fonio promotion. The project team successfully passed the Concept note shortlisting phase in October 2023 and submitted the full project in December 2023. The final selection result is expected by May 2024.

## 5. Outlook for 2024

As we transition from 2023 to 2024, our commitment to enhancing our capabilities in research, innovation, training, and entrepreneurship remains steadfast. We will reinforce our technical platform with new equipment to not only deepen our research but also expand our research areas for the benefit of the local communities. We recognize the importance of co-creation with local communities in driving meaningful impact and sustainability. Regular training will be offered to all GBioS students, mainly the PhDs to increase their scientific capacity. Our strategic plan will serve as a guide for our decisions and interventions to better track our impacts. To achieve our objectives, existing collaboration with fruitful impact will be reinforced while new areas of collaboration will be explored. We will also work to mobilise fundings (local, regional, and international) to support most research activities. A new component for 2024 is also a focus on staff capacity building on selected themes (mainly soft skills) and happiness at work. In addition to our core objectives, 2024 will see a renewed emphasis on staff capacity building, with a focus on nurturing soft skills and fostering a culture of happiness and fulfilment in the workplace. We believe that investing in our team's well-being and professional growth is integral to our collective success.

## 6. Thanks to our financial and technical partners

We would like to express our deep gratitude to all our partners, national and international, who have contributed significantly to the mission and vision of the Genetics, Biotechnology and Seed Science Unit (GBioS) during the year 2023. Your continued support and invaluable collaboration are fundamental to advancing our efforts to promote more resilient agriculture, greater food security and economic prosperity for African communities. Thank you for your commitment and valuable partnership!

## Technical and financial partners





# GBios

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