GBioS
Genetics, Biotechnology and Seed Science Unit
Excellence in Seed Science

10 YEARS

ANNUAL REPORT 2024

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 center of the Department of Plant Science, Faculty of Agricultural Sciences (FSA), University of Abomey-Calavi (UAC). It 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 Unit 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.

Vision

Our vision is 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.

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 populations.

Correct citation:

Fassinou Hotegni N.V., Tchokponhoué D.A., Mikpasso M., Houdegbe A.C., Adje C.A.O., Azon C.F., Soulemane N., Salaou M., Sohindji F., Vigninou M., Bagri, M., Kossouho W., Achigan-Dako EG. 2025. Annual report 2024. Genetics, Biotechnology and Seed Science Unit, Laboratory of Crop Production, Physiology and Plant Breeding, Faculty of Agricultural Sciences, University of Abomey-Calavi. Abomey-Calavi, Republic of Benin, Pp 92.

Genetics, Biotechnology & Seed Science – GbioS/FSA

www.gbios-uac.org

10 years of commitment

to innovation in plant breeding and seed sciences

20,000+
accessions preserved in our genebank

70+
plant species studied

10,000+
smallholder farmers supported

6,000+
seed kits distributed across 40 municipalities

100+
Master's students

20+
PhD candidates trained

15+
research and development projects implemented

10+
orphan crops studied

10+
start-ups created

200+
Scientific publications in high-impact journals

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Preface

In ten years of existence, the Genetics, Biotechnology and Seed Science Unit (GBioS) of the Laboratory of Crop Production, Physiology and Plant Breeding (PAGEV) of the University of Abomey-Calavi has produced resounding results that we are proud to acknowledge. In achieving the objectives of our academic ecosystem, it is increasingly necessary to ensure quality higher education, to produce convincing and relevant scientific outputs for end-users. Also, providing services to the community becomes an unstoppable requirement to which all research teams devote themselves. And it is here that we recognize the merit of our laboratory which strives daily to co-create with stakeholders along agricultural products value chains (inputs providers, farmers, etc.) and industries convincing results useful for the improvement of the living conditions of the community. Several examples highlight our commitment and include the distribution of improved seed kits, tested on the producers' farms under the supervision of accredited public services to better meet the needs of market gardeners. The adoption of the citizen science approach in participatory selection trials of improved varieties is a commitment with producers to accelerate the adoption of varieties, but also to ensure that the right variety fits very well with the appropriate environment. This is why we are excited about the results achieved so far and would like to deeply thank our donors and partners who actively participate in our ambitions in valorising plant genetic resources and the training of talented young scientists. Our wish and ambition are crystallized around excellence in the supply of quality seeds, in the safeguarding of plant genetic resources and the valorisation of these resources to solve the problem of low productivity of major and minor crops for the economic growth of our nations. To all those who participate in this dream we say thank you very much.

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.

Words from the Director

Dear readers,

You may remember that last year we celebrated the completion of the construction of our laboratory, a modern workspace, which aims to be friendly and welcoming for ourselves and for all our students from various nationalities (South Africa, Benin, Burkina Faso, Cameroon, Congo, Ivory Coast, Eswatini, Ethiopia, Ghana, Mali, Niger, Nigeria, Uganda, etc.) who come on research mobility as part of their thesis or master's work! We thank the European Union, the Agence Nationale pour la Recherche (ANR), Académie de Recherche et d'Enseignement supérieur (ARES), Vision for Adapted Crops and Soils (VACS) and all the partners for the projects such as BIOVALOR, TAERA, PATH, GENES II, ORPHAN, E-ANACARDE and BOLDER. We are also happy to continue the initiatives started with our partners to build cutting-edge training in genomics and precision agriculture, to ensure the transfer of knowledge, technologies and skills for the well-being of producers.

This year we celebrated the shipment of our first seed collection to Svalbard. More than 2,700 accessions (27 species) were sent for the first time by the University of Abomey-Calavi to the Global seed vault! We now have more than 6,930 accessions registered in Genesys! At the same time, we distributed, through our partners, more than 2,000 seed kits to more than 1,990 farmers and 10 school canteens as part of citizen trials on jute mallow, okra, and amaranth. In addition to this connection with producers and consumers, we maintained our pace of scientific production with an increase by 23% of published manuscripts.

As we approach the celebration of our Tin Jubilee, our priorities would be to: 1) continue to position the laboratory in the African ecosystem as a center of expertise in genomics, conservation of plant genetic resources and precision agriculture, 2) strengthen the next generation of high-quality scholars at the African level and develop human resources for national and international research and development centers, 3) produce convincing outputs and innovations for producers, industries and businesses. The recognition and promotion of our scientific work must better feed the needs of end users. This is why, by embarking on a new decade of scientific research for development, GBioS must capitalize on its achievements and remain attentive to resolving the major bottlenecks of improving crop productivity and their effective valorization through co-creation with stakeholders in the rural world. It is with this commitment that our entire team will have to align itself in connection with our strategic plan, of which a mid-term review is necessary.

Enoch G. Achigan-Dako

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1. Research and development activities

1.1. Genebanking at CalaviGen

CalaviGen, the genebank of the University of Abomey-Calvi, has become a noticeable Plant Genetic resources Conservation platform with a higher visibility on a platform such as Genesys. CalaviGen counts nearly 7,000 accessions published on genesys.pgr including nearly 3,000 accessions loaded in 2024 only. This achievement is backed-up by the unconditional commitment of a dedicated team running daily activities including seed sorting, seed regeneration and seed sorting, among others. A particular emphasis was also on safety-duplication activities in 2024 that culminated with the shipment to Global Seed Vault at Svalbard of 2,701 accessions (**Fig. 1**) of 27 plant species and the preparation of 2,618 accessions of the same for primary duplication at the International Institute of Tropical Agriculture (IITA) in Nigeria.

***Fig. 1**. CalaviGen seeds samples of 27 plant species prepared for safety duplication at Svalbard Global seed vault.*

Fig. 2. *Dr Dèdéou A. Tchokponhoué (Manager of CalaviGen) explaining long term conservation practices at CalaviGen to Crop Trust experts during their visit at GBioS in 2024.*

The 27 species included vegetables [e.g., okra: *Abelmoschus esculentus* (L.) Moench; amaranth: *Amaranthus cruentus* L.)], legumes [e.g., Doyi: *Macrotyloma geocarpum* (Harms) Marechal and Baudet; Bambara groundnut: *Vigna subterranea* L.], cereals [e.g., Fonio: *Digitaria exilis* L.; maize: *Zea mays* L.]. This safety duplication was completed in the framework of the Safeguarding Plant Genetic Resources of Benin for a Sustainable Future Use (SAFE-PGR) project, funded by the work package 4 of the Building Opportunities for Livelihood and Development (BOLD) initiative. The genebank was also briefly reviewed by a team of crop trust experts made up of Dr Nora Castaneda and Janny van Beem (**Fig. 2**) who during a week visit went through the key operations implemented by the genebank team and gave insightful advice. The genebank also launched in 2024 a services provision component to improve seed phenotyping practices for research activity.

1.2. Citizen science trials on jute mallow

Implemented from August to December 2024, the project "BOLD citizen science: Scaling tricot citizen science for farmer participatory variety evaluation to promote the use of opportunities crops", aimed at contributing to the overall goal of the Biodiversity for Opportunities, Livelihoods and Development (BOLD) project, to improve nutrition security in West and East Africa through the increased use and value of nutritious but currently underused, climate resilient and environmentally-friendly crops. More specifically, the project aimed to pilot and scale up mechanisms to increase farmers' access to quality seeds of underexploited crops through the use of citizen science trials (based on the triadic comparison of technologies (TRICOT) approach) for participatory variety evaluation in the Republic of Benin and Tanzania. Funded by The Norwegian Agency for Development Cooperation (NORAD), through the Global Crop Diversity Trust (Crop Trust), this project is coordinated by World Vegetable Center and is implemented in Benin by the University of Abomey-Calavi (UAC) through the Genetics, Biotechnology and Seed Science Unit (GBioS) of the Faculty of Agricultural Sciences (FSA).

In the Republic of Benin, the TRICOT trials involved 180 jute mallow growers in agricultural development hubs 5, 6, and 7 in collaboration with ATDA5, ATDA6, ATDA7, and FeNOMa-Benin. The municipalities covered included Adjohoun, Bonou, Bopa, Dogbo, Ifangni, and Sakété. Trials were implemented from September to December 2024 during the short rainy season. To this end, seven field agents were selected and trained on September 19, 2024, on the implementation of the TRICOT approach, field monitoring, and data collection. The training was provided by Drs Aristide Carlos Houdegbe and Silvère Fernand Sohindji - Researchers at GBioS/FSA/UAC and Mr Lys Amavi AGLINGLO - Research Assistant at World Vegetable Center Benin. In addition, during two workshops series, the selected farmers were trained on the implementation of the citizen science TRICOT approach and received their seeds kits. These workshops were launched by the project coordinator, Dr Sognigbe N'Danikou, from the World Vegetable Center – Tanzania (**Fig. 3**). ***For Dr. N'Danikou, these trials aim to speed up on farm participatory evaluation and farmers' access to improved varieties of opportunity crops for increased production and consumption for better nutrition and climate resilience.*** Farmers successfully implemented the trials from nursery to harvest under the guidance of the field agents. Several field visits and supervision

Fig. 3. *Workshop on the implementation of the citizen science triadic comparison of technologies (TRICOT).*

were organized at different growth stages of the crop (including nursery, transplanting and harvesting), and also during cooking. Data collection at various growth stages were ensured by the field agents and submitted to climmob. During the trial from November 24 to 30, 2024, M. Neil Palmer, Crop Diversity Digest Contributor from CROP TRUST, in Benin for field visits, had the opportunity to discuss with both GBioS/FSA/UAC and World Vegetable Center teams as well as farmers, seed enterprises and restaurants embarqued on jute mallow valorization. In December 2024, feedback workshops and meetings with farmers and extension services agents were organized in each municipality.

1.3. Omics, biotechnology, and plant breeding

Omics, biotechnology and plant breeding research is steadily growing at GBioS. Following the understanding of the evolutionary history and population structure and diversity studies in Synsepalum dulcificum in 2023, another stride was made in 2024 with the investigation on the drivers of the Sisrè plant rhizosphere bacterial communities to anticipate on the production of microbionte-based fertilization inoculum for plant growth (Adigoun et al. 2024). This study revealed a bacterial diversity of rhizosphere soils (assessed by Illumina sequencing of the 16S rRNA gene after DNA extraction) represented mostly by the Actinobacteriota, Proteobacteria Firmicutes and Chloroflexi. Plant phenotype, habitat, climate and soil physicochemical properties affected the bacterial communities, but our study pointed out that soil physicochemical parameters were the main driver of rhizobacterial communities' structure and diversity. Among them, the assimilable phosphorus, lead, potassium, arsenic and manganese contents, texture and cation exchange capacity of rhizosphere soils were the major determinants of the composition and diversity of rhizosphere bacterial communities. Further studies are ongoing to produce in fine an efficient growth inoculum.

On sesame, our team has continued its endeavours. In 2024, we investigated the molecular diversity and agronomic performance of sesame cultivars in Benin focusing on local cultivars and lines Introduced from China (Azon et al 2024). Our study revealed a first group of accessions from China characterized by early flowering and low seed yields (on average 380.13 kg ha-1). A second group included late flowering accessions and intermediate seed yield (on average 548.68 kg ha-1). A third group included higher yielding accessions (on average 715.7 kg ha-1). The SSR markers revealed polymorphic information content values between 0.17 and 0.92. A total of 62 alleles were detected, with each locus exhibiting 2 to 15 alleles. The gene diversity ranged from 0.18 to 0.92, with an average value of 0.55. Most of the Chinese lines were clustered together. Based on these results, hybrids' cultivars are being developed for further evaluation.

Although our research on maize is still at its infancy, new results came out in 2024 with our study on yield assessment of new streak-resistant topcross maize hybrids (Emeraghi et al. 2024). In this study eleven open pollinated varieties were crossed to two inbred lines in a line × tester mating design to generate 22 topcross hybrids. The topcross hybrids were evaluated across four environments in the Republic of Benin. The environment had a significant effect on grain yield and agronomic traits. General and specific combining ability effects were significant for grain yield and other traits indicating the presence of additive and non-additive gene effects. Four topcross hybrids exhibited positive mid- and better-parent heterosis for grain yield

and DMR ESR W × TZIL07A01322, which is the highest yielding topcross hybrids, at 5.1 tons per hectare, had 29.1 and 13.3% yield increase over its mid-parent and better-parent mean yields, respectively, with the potential for commercialization by local seed enterprises. Four open pollinated varieties contributed favourably to observed heterosis and could serve as potential genotypes for inbred line extraction.

We have also improved our knowledge of kersting groundnut through the analysis of Genotype by environment interaction and stability analysis of three agronomic traits in Kersting's groundnut (*Macrotyloma geocarpum*) using factor analytic modelling and environmental covariates (Coulibaly et al. 2024). A total of 375 accessions were evaluated across three years (2017, 2018, and 2019) and two locations (Sékou and Savè) in Benin, generating five environments. The traits measured included days to 50% flowering, grain yield, and 100-seed weight. The study generated multi-environment values for grain yield and its components in Kersting's groundnut. Through this study the accessions AF202, AF221, AF223, AF225, and AF256 were identified as accessions combining best performance for grain yield, early flowering, and 100-seed weight, showing adaptability across environments and stability to some environments.

1.4. Conservation and utilization of Plant Genetic Resources

GBioS organized several germplasm collections and the accession were preserved in CalaviGen. Germplasms were assembled from several locations in Benin but also outside the country. To improve conservation of germplasms and facilitate their use, the GBioS strives to analyze and evaluate the potential of these resources to provide growers with accessions with desired characteristics. The utilization of those germplasms requires a deeper knowledge of the traits of interest. This is done through the charaterization of the morphological and agronomical traits and reveal the polymorphism that can serve for crop improvedment. In 2024, the GBioS research team participated in assessing the genetic diversity of 283 Corchorus accessions (Affokpe et al. 2024). This study revealed significant morphological diversity within the accessions, grouped into four groups. The main discriminating morphological traits of the accessions were leaf shape, leaf margin, growth habit, and the number of primary branches. The results of this study will help guide and accelerate breeding programs targeting important traits such as leaf shape, branching, flowering time, and leaf and seed yield. Other genetic diversity research has focused on sesame (*Sesamum indicum*) and shea (*Vitallaria paradoxa*) to identify superior genotypes.

1.5. Crop production and agroecological intensification

As part of agroecological management efforts to address tomato bacterial wilt in the Republic of Benin, analysing yield and economic losses are essential to raise awareness among policymakers, farmers, and researchers about the severity of the issue. To this end, within our ongoing initiative on "Agroecological Management of Tomato Wilt Caused by RSSC in Southern Benin", we conducted a survey alongside field trials. The survey involved 184 vegetable growers across 12 municipalities located in agroecological zones 6, 7, and 8 in southern Benin. Field trials were carried out in three municipalities within the agroecological zones. The findings revealed significant yield losses in tomato cultivation, posing a serious threat to food security. Yield losses across districts ranged from 53.3% ± 41.88 (13.87 t/ha ± 11.87) to 80% ± 9.78 (18.37 t/ha ± 7.30), while losses across agroecological zones ranged from 70.89% ± 18.21 (7.55 t/ha ± 4.11) to 73.59% ± 25.01 (9.69 t/ha ± 12.47). Similar high yield losses were observed during both the trials and surveys. Revenue losses during experiments ranged from $3,592.51 USD/ha ± $2,656.40 to $6,760.50 USD/ha ± $4,117.78, while survey-based estimates ranged from $409.57 /ha ± $367.10 to $1,473.76 /ha ± $991.11. These findings underscore the urgent need to implement appropriate policies and management strategies to control and reduce the spread of this disease.

Another ongoing initiative aims to increase aromatic rice yield through sustainable agroecological practices in the Mono and Couffo departments of the Republic of Benin. A total of 216 rice producers were surveyed. Results indicated a very low adoption of agroecological practices in the local rice production systems. Only a small proportion (9.25%) of rice producers reported using the System of Rice Intensification (SRI). However, most respondents expressed interest in integrating Mucuna and soybean into their rice farming systems.

In addition to the survey, five experiments were conducted using five aromatic rice varieties to identify those best suited to local conditions. Three varieties: ARA 05, ARA 18, and ARA 23, were selected across the production zones. These selected varieties were subsequently tested in a crop rotation system with mungbean (a legume) to enhance soil fertility and improve yields. Data collection is still ongoing, and the final results will be shared in the next report.

1.6. Postharvest biology and value chain

Activities related to post-harvest and value chains focused on experimentation with fresh tomatoes. In early 2024, studies were conducted to assess post-harvest losses along the fresh tomato value chain in Benin. Various stakeholders involved in the tomato value chain were interviewed and engaged in the study. Findings revealed that post-harvest losses are particularly high in southern Benin, especially at the Dantokpa and Cococodji markets where the tomato fruits are often laid out in baskets of different sizes (**Fig. 4**) with different and covered by different structures (**Fig. 5**). Losses were estimated to over 20% at the semi-wholesale level and around 16% at the retail level. The full report of the activity is available here https://cgspace.cgiar.org/items/477f2457-775d-40c0-98e1-b9f295af419e.

Fig 4. *Types of baskets available in the market, bigger type (left) and smaller type (right)*

Fig 5*. Layout of tomato baskets in vans (from left to right: large baskets covered with clothes; medium baskets covered with cement paper), baskets are arranged on wooden boards in the van.*

Different interventions were explored, such as the integration of plastic crates (**Fig. 6**) in fresh tomato value chains. Although some effects were observed in terms of post-harvest loss reduction, results were not consistent across value chains. The full report is available here https://cgspace.cgiar.org/items/477f2457-775d-40c0-98e1-b9f295af419e

Fig. 6*. Plastic crates and traditional tomatoes packaging and transportation to the markets.*

1.7. Scientific publications in 2024

A total of 21 papers were published by the lab members in 2024, representing a 23.5% increase in publication volume compared to 2023. These included two papers in indexed journals and 19 in impact factor journals. The targeted journal IFs ranged from 1.1 to 8.2. Nearly 37% of the papers were placed in a journal with an impact factor higher than 4 (**Fig. 7**). These publications spanned various domains including plant breeding, agroecology, seed science and technology, indigenous knowledge management, and food security and nutrition.

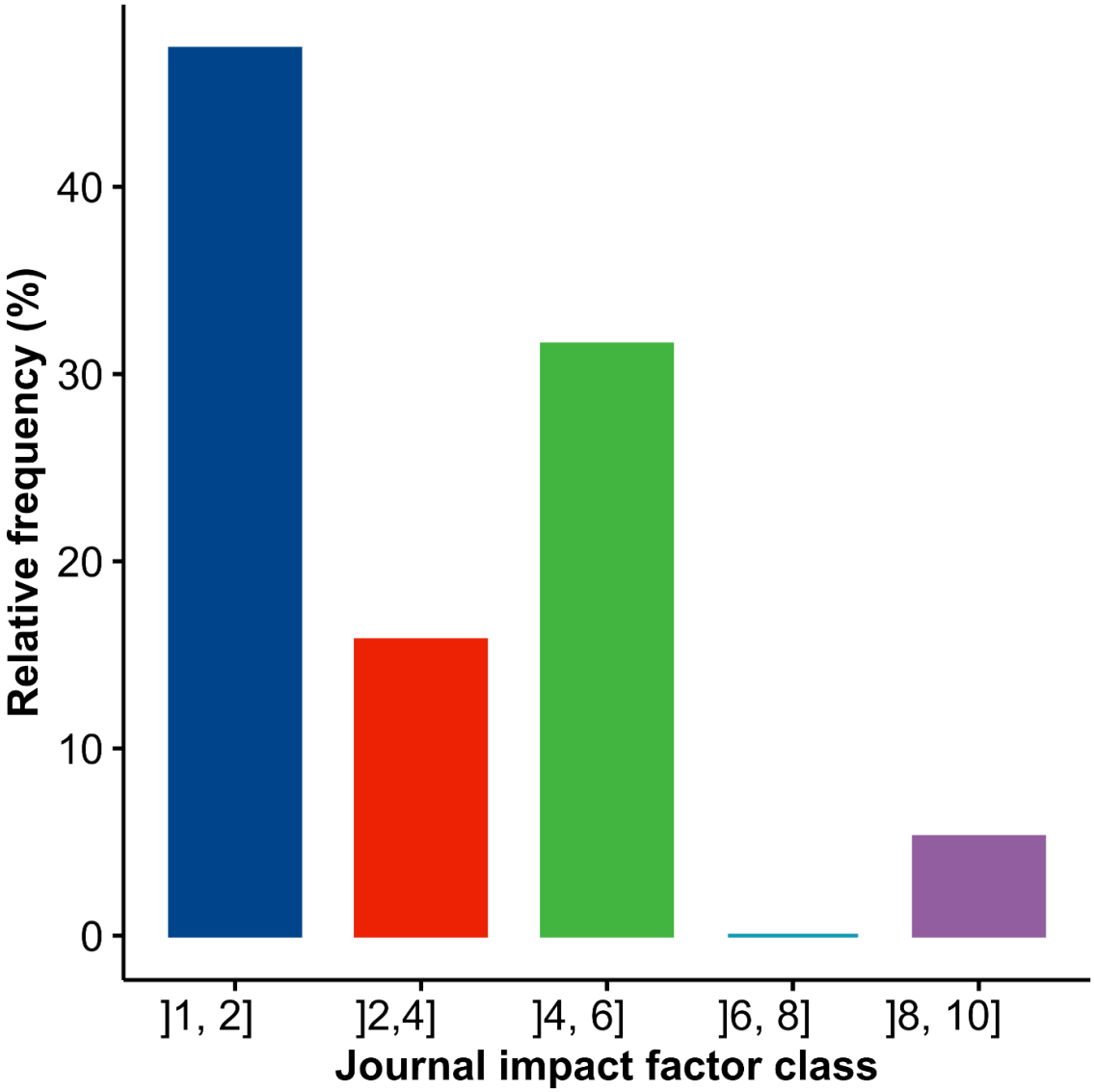


Fig. 7. *Relative quality of GBioS 2024 papers measured through the impact factor of publishing journals.*

1.7.1. Omics, characterization, evaluation, and plant breeding

1. Afokpe, P. M., Ologou, S., Kouiho, S. R., de Hoop, S. J., N'Danikou, S., Achigan-Dako, E. G., and Schranz, M. E. (2024). Unveiling genetic diversity in jute mallow (*Corchorus* spp.): morphological clustering reveals distinctive traits among accessions from Africa and Asia. Genetic Resources and Crop Evolution 72, 5753-5775.

2. Azon, C. F., Fassinou Hotegni, N. V., Adjé, C. O., Gnanglè, L. S., Benjamin, E., Mhuruyengwe, R. L., Salaou, A. M., Houdegbe, A. C., Sogbohossou, D. O., and Sedah, P. (2024). Molecular Diversity and Agronomic Performance of Sesame (*Sesamum indicum*) Cultivars in Benin: Local Cultivars and Lines Introduced From China. Plant-Environment Interactions 5, e70024.

3. Attikora, A. J. P., Yao, S. D. M., Dago, D. N., Silué, S., De Clerck, C., Kwibuka, Y., Diarrassouba, N., Alabi, T., Achigan-Dako, E. G., and Lassois, L. (2024). Genetic diversity and population structure of superior shea trees (*Vitellaria paradoxa subsp. paradoxa*) using SNP markers for the establishment of a core collection in Côte d'Ivoire. BMC Plant Biology 24, 913.

4. Coulibaly, M., Bodjrenou, G., Fassinou Hotègni, N. V., Akohoue, F., Agossou, C. A., Azon, C. F., Matro, X., Bello, S., Adjé, C. O., and Sanou, J. (2024). Genotype by environment interaction and stability analysis of three agronomic traits in Kersting's groundnut (*Macrotyloma geocarpum*) using factor analytic modeling and environmental covariates. Crop Science 64, 2095-2115.

5. Sossou, B. E., Ayenan, M. A., Schafleitner, R., Rachidatou, S., and Achigan-Dako, E. G. (2024). Breeding for resistance to bacterial wilt in Solanaceae crops: lessons learned and ways forward for Gboma eggplant (*Solanum macrocarpon* L.), a traditional African vegetable. Euphytica 220, 153.

6. Soulémane, N., N'Danikou, S., Tchokponhoué, D. A., Ekué, M. R., and Achigan-Dako, E. G. (2024). Production, domestication and genetic improvement of Vitex doniana Sweet: an overview. Genetic Resources and Crop Evolution, 72, 1271-1287.

7. Zohoungbogbo, H. P., Vihou, F., Achigan-Dako, E. G., and Barchenger, D. W. (2024b). Current knowledge and breeding strategies for management of aphid-transmitted viruses of pepper (*Capsicum* spp.) in Africa. Frontiers in Plant Science 15, 1449889.

8. Emeraghi, M., Iseghohi, I., Idohou, J., Mkpuma, K. C., Agbandou, P. C., Afouda, L., Akponikpe, P. I., Hotegni, N. V. F., Missihoun, A. A., and Oselebe, H. (2024b). Yield assessment of new streak-resistant topcross maize hybrids in Benin. Open Agriculture 9, 20220370.

9. Mbo Nkoulou, L. F., Nkouandou, Y. F., Ngalle, H. B., Cros, D., Martin, G., Molo, T., Eya'a, C., Essome, C., Zandjanakou-Tachin, M., and Degbey, H. (2024). Screening of triploid banana population under natural and controlled black sigatoka disease for genomic selection. Plant Disease 108, 2006-2016.

10. Dossa, A. F., Fassinou Hotegni, N. V., N'Danikou, S., Yayi-Ladekan, E., Adjé, C. A., Lagnika, L., Bokonon-Ganta, A. H., and Achigan-Dako, E. G. (2024). Genetic diversity, essential oil's chemical constituents of aromatic plant *Mesosphaerum suaveolens* (L.) Kuntze Syn. Hyptis suaveolens (L.) Poit. and its uses in crop protection: a review. Frontiers in Plant Science 15, 1454146.

11. Voss, R., de Sousa, K., N'Danikou, S., Shango, A. J., Aglinglo, L. A., Laporte, M.-A., Legba, E. C., Houdegbe, A. C., Diarra, D. d. Y., and Dolo, A. (2024). Citizen science informs demand-driven breeding of opportunity crops. bioRxiv, 2024.07. 31.605211.

1.7.2. Agroecology

12. Adigoun, R. F., Durand, A., Tchokponhoué, D. A., Achigan-Dako, E. G., Aholoukpè, H. N., Bokonon-Ganta, A. H., and Benizri, E. (2024). Drivers of the Sisrè berry plant [*Synsepalum dulcificum* (Schumach & Thonn.) Daniell] rhizosphere bacterial communities in Benin. Science of the Total Environment 938, 173550.

13. Bouraïma, M. B., Bielders, C. L., Sikirou, R., Ezin, V. A., Ahohuendo, B. C., and Achigan-Dako, E. G. Do agroecological practices control Ralstonia solanacearum wilt on solanaceous crops? A meta-analysis. Plant Pathology 74, 3-17.

1.7.3. Indigenous knowledge management

14. Francisco, R. A., Fassinou Hotegni, N. V., Sogbohossou, D. E., Houdegbe, C. A., Achigan-Dako, E. G., and Bokonon-Ganta, A. H. (2024). Knowledge and management of insect pests affecting *Gynandropsis gynandra* [(L.) Briq (Cleomaceae)] among vegetable growers in Benin. International Journal of Tropical Insect Science 44, 2527-2538.

15. Hotegni, N. V. F., Agbo, N. F., Salaou, M. A., Odjo, S., Bokonon-Ganta, A. H., and Achigan-Dako, E. G. (2024a). Granaries used in maize storage and conservation across agroecological zones in the Republic of Benin: Distribution, characteristics and associated postharvest losses. Journal of Stored Products Research 107, 102348.

16. Ibrahim Bio Yerima, A. R., Oselebe, H., Nnamani, C. V., Ifekwe, C., Adje, C. O., Kwon-Ndung, E. H., Afiukwa, C. A., Uyoh, E. A., Dangana Abdul, S., and Opaluwa, H. (2024). Stakeholders' perceptions of and preferences for utilizing fonio (*Digitaria exilis*) to enrich local diets for food and nutritional security in Nigeria. Genetic Resources and Crop Evolution 71, 999-1011.

17. Houegban, J., Aglinglo, L. A., N'Danikou, S., Tchokponhoué, D. A., Amissah, J. N., Ankamah-Yeboah, T., and Achigan-Dako, E. (2024). Traditional African vegetables' seed access and management practices: case of *Vernonia amygdalina* (Delile) in southern Benin. Frontiers in Sustainable Food Systems 8, 1276736.

18. Zohoungbogbo, H. P., Ganta, J. S., Oliva, R., Chan, Y.-L., Adandonon, A., Bokonon-Ganta, A. H., Ba, M. N., Achigan-Dako, E. G., and Barchenger, D. W. (2024). Farmers' Perception of Viral Diseases and Their Management in Pepper (*Capsicum* spp.) Production in Benin. HortScience 59, 110-120.

1.7.4. Food and nutrition security

19. Hotegni, N. V. F., Sohindji, F. S., Salaou, M. A., Agbandou, P. C., Azonhoumon, L. W., Tchokponhoué, D., Houdegbe, C., Adjé, C. A., and Achigan-Dako, E. G. (2024). Agronomic biofortification of cereals and legumes with iron, zinc, calcium and magnesium for food and nutrition security: Available options for farmers in Sub-Saharan Africa. Journal of Agriculture and Food Research 18, 101391.

20. Oselebe, H., Nnamani, C., Degbey, H., and Achigan-Dako, G. *Dioscoreophyllum cumminsii* (stapf)diels., an African underutilised indigenous fruit. Nigerian Journal of Botany Journal., 36 (1).

1.7.5. Seed Science and Technology

21. N'Danikou, S., Soulémane, N., Akpo, E., Adjileye, A., Logbo, J., Mensah, A. G., and Fandohan, A. B. (2024). Seed soaking treatments differently effect seed germination and seedling phenology for different populations of Vitex doniana Sweet. Seed Science and Technology. Volume 52, Number 3, December 2024, pp. 211-226(16) https://doi.org/10.15258/sst.2024.52.3.0

1.8. Progress report of our PhD students

This section reviewed progress made by our various PhD students. Basically, the students are operating under different projects including the PATH project, the GENES II project, the ORPHAN project, the BIOVALOR project, the e-anacarde, and others.

1.8.1. PATH PhD students

PhD students working under the PATH project are six in total. They are investigating various aspects of crops combining digital technologies, precision agriculture and omics.

Ms **Natacha Quenum** is working on "High-throughput phenotyping of okra (*Abelmoschus esculentus*) germplasm under drought stress using unmanned aerial vehicle (UAV)". Drought stress is a major constraint to okra (*Abelmoschus esculentus*) production in sub-Saharan Africa, where climate change has led to increasingly irregular rainfall patterns. This research aims to identify drought-tolerant okra accessions using a high-throughput phenotyping approach combined with transcriptomics analysis. A total of 250 okra accessions will be evaluated under well-watered and drought-stressed conditions using an alpha lattice design. Field trials will be conducted during the dry season at two drought-prone sites in Eswatini: the Big Bend and Luve research stations. Agronomic and physiological traits will be assessed using both conventional field methods and unmanned aerial vehicle (UAV)-based spectral imaging. Data on yield and related traits will be used to calculate drought susceptibility indices to identify the best-performing accessions. Furthermore, transcriptome sequencing will be performed to identify drought-responsive genes, and machine learning models will be developed to predict yield performance under drought stress. The outcomes of this study will support the development of drought-tolerant okra cultivars to improve food security in rain-fed agricultural systems across sub-Saharan Africa.

Mr **Zubuko Njabulo Sondelani** is using Multispectral imaging approach to assess drought tolerance in groundnut (*Arachis hypogaea* L.) genotypes and to predict yield in water stress conditions in Benin. The main objective of his study is to assess the physiological and biochemical responses of groundnut genotypes at different growth stages using multispectral imaging and predict yield under water stressed conditions. The specific objectives are to: (a) use multispectral imaging to assess water stress responses of groundnut genotypes at different phenophases, (b) identify the critical growth stages of groundnuts at which water stress has the most significant impact on yield, (c) identify and quantify key phenotypic traits associated with drought tolerance in groundnut genotypes using multispectral imaging, and (d) use multispectral imaging data to develop predictive models for groundnut yield under water stressed conditions.

Mr **Hermann Tiare William Some**'s PhD research focuses on improving the accuracy of groundnut leaf disease phenotyping using high-throughput phenotyping (HTP) and computer vision tools. The objectives of his research are to develop computer vision models for detecting and distinguishing leaf diseases, and integrating these models with a forecasting system for early disease management. This thesis is co-supervised by a team of GBioS and of the Department of Computer Science (IFRI) of the Abomey-Calavi University. A draft literature review on groundnut production challenges in Benin and the WCA region has been presented to the GBioS team. A groundnut cluster has been established at GBioS to address farmer challenges in Benin, and seed transfer from Senegal to Benin is ongoing. The validated review topic, "Computer Vision-Based Plant Leaf Disease Diagnosis: A Comprehensive Review on Dryland Crops," supports this research. An urgent assessment of leaf spot disease incidence in Benin is planned to align the study with groundnut production challenges in Benin and the WCA region.

The thesis of Mr **Barnabas Khayil** focuses on developing an integrated solar-powered smart irrigation and early fall armyworm (FAW) detection system to improve maize yields in Benin. Maize production in the region faces challenges such as inefficient irrigation, soil nutrient deficiencies, and FAW infestations, which cause significant crop loss. Traditional methods are often costly and not adapted to farmer's needs. The main objectives are to design a solar-powered drip irrigation system that monitors soil nutrients and moisture for optimal growth, develop an IoT-based early detection system using machine learning to identify FAW pests, and integrate both systems into a unified smart farming solution. The project also aims to evaluate the system's effectiveness through field trials, focusing on yield improvement, water conservation, and pest control. The methodology includes developing a low-cost, solar-powered system with soil sensors and pest detection modules, and using machine learning for early FAW detection. Field trials will assess the system's impact on maize yield and resource use. The expected outcomes include a functional prototype that improves maize yields through optimized irrigation and pest management, as well as guidelines to help farmers adopt the technology. This research aims to address key agricultural challenges, providing smallholder farmers in Benin with affordable, sustainable solutions to enhance productivity and resilience.

Ms **Orthia L. F. Linkpon** is PATH PhD student registered at the University of Cape Coast in Ghana. She is currently working on drafting her research proposal entitled "«Optimization of Pineapple (*Ananas comosus* (L.) Merr.) Crop Nutrition in Ghana". Her study aims to provide pineapple farmers with new, modern technologies adapted to their plantations and accessible to them, allowing for improved yields through the implementation of precision agriculture techniques for better adaptation to variable climatic conditions, increased income, and, reduced soil overexploitation and atmospheric pollution.

Mr **Judicael Ganta** is investigating on the topic "Integrating precision agriculture tools for effective pest and disease management of irish potatoes (*Solanum tuberosum* L.) in Rwanda". His thesis is exploring the integration of precision agriculture tools for effective pest and disease management of Irish potatoes (Solanum tuberosum L.) in Rwanda. His research aimed to review the current state of precision agriculture technology in managing crop pests and diseases in sub-Saharan Africa, highlighting its potential benefits and challenges. It will assess Rwandan farmers' knowledge of agro-ecological management practices for potato pests and diseases and their perceptions of factors influencing the adoption of precision farming tools. Moreover, the thesis will evaluate the effectiveness of aerial hyperspectral imagery (UAV-based remote sensing) in the early detection of bacterial wilt in potatoes. The study will also test agro-ecological management strategies for potato insects and diseases, focusing on crop associations, biopesticides, improved biofertilizers, and bio-stimulants. Lastly, the research will develop a decision support tool using convolutional neural networks to identify the severity of potato late blight, bacterial wilt, viral diseases, and insect pests and recommend appropriate treatments. This comprehensive approach will seek to enhance sustainable pest and disease management practices in Rwandan potato farming, ultimately improving crop yield and farmer livelihoods.

1.8.2 GENES II PhD students

Four PhD students are working under Genes II project on crops such as fonio, Sesame and mungbean.

Ms **Ntombifuthi Msewu** is dedicated to work on Fonio (*Digitaria* spp.) which is an ancient traditional cereal species in West African countries. Fonio belongs to the grass family Poaceae under the Digitaria genus. The genus comprises 230 - 325 species of annual and perennial herbaceous plants with a wide geographic distribution in tropical and subtropical regions. Fonio millet is an essential indigenous crop that significantly contributes to households' nutritional stability in drought-prone, semi-arid, and sub-humid areas of West Africa. *Digitaria exilis* (Kippist) Stapf and *Digitaria iburua* Stapf are the two cultivars commonly grown in the West African, commonly referred to as white and black fonio, however local farmers referred to the species as wild fonio. Ms Mabuza is currently reading scientific papers to refine her research proposal whose tentative title is Genome-Wide Association Studies (GWAS) for Improved Yield and shattering resistance.

Mr **Trymore Mateyo** is working on SNP-Based Analysis on Yield and Oil Content of Sesame Cultivars from Diverse Geographical Regions. His research focuses on using Single Nucleotide Polymorphism (SNP) markers to assess genetic variations influencing seed yield and oil content in sesame (*Sesamum indicum* L.) with the aims to identify candidate genes associated with these key traits. Mr. Trymore has presented his sesame literature review to the GBioS team at the Faculty of Agricultural Sciences, University of Abomey-Calavi. Following discussions about his research plan, he is refining his research topic to align with his supervisors' recommendations. He is currently reviewing scientific papers and preparing for further discussions to finalize the topic. A review paper titled «Genetic Insights into Sesame (*Sesamum indicum* L.) Yield and Oil Content: Advances in SNP-Based Analysis and Breeding Prospects» is in process.

Mr **Abdoul Mouizz Salaou** research is entitled "Combining genome wide association study and genomic selection to develop high yielding and drought-tolerant mungbean [*Vigna radiata* (L.) *Wilczek*] cultivars in Kenya". Mungbean [*Vigna radiata* (L.) Wilczek] is one of the most nutritious legumes, widely consumed in Asia and East Africa and source of income for communities around the world. Despite its nutritional density and global economic significance, mungbean faces many challenges, including low productivity attributed to lack of improved varieties, biotic and abiotic factors. Among abiotic factors, drought stress is one of the most important, prevalent in arid and semi-arid regions like Kenya, with the devastating effects of global climate change. It affects several aspects of the plant development, including photosynthesis and mostly at reproductive stage. Developing drought-tolerant mungbean varieties is critical for enhancing yield and ensuring production stability under increasing climate variability. This requires unravelling the genetic architecture of photosynthesis and yield-related traits under drought conditions at reproductive stage. His study therefore aims at: (1) evaluating the performance and stability of mungbean genotypes for agronomic, yield-related and photosynthesis traits across environments under drought stress; (2) identifying genome-wide nucleotide variations associated with agronomic, yield and photosynthesis traits in mungbean germplasm under drought stress; (3) building prediction models for drought tolerance, yield and photosynthesis traits through genomic selection. His results will advance mungbean genetic improvement by identifying stable high-performing drought-tolerant genotypes, candidate SNPs and genes for marker- and genomic-assisted selection in mungbean. This research work started in December 2024 and is expected to conclude by November 2027.

Ms **Pinawè Cheryle Agbandou** has just begun her PhD journey, focusing on genomic selection for improved disease resistance and higher yield in Bambara groundnut [*Vigna subterranea* (L. verde)] in Zimbabwe. Her main objective is to contribute to food security and promote sustainable agriculture by enhancing the productivity and disease resistance of this vital crop. With her proposal near finalization, Pinawè is preparing to engage in the various activities outlined in her research plan. She will begin by writing a literature review on legumes, with a particular emphasis on Bambara groundnut. Simultaneously, she will be planning her activities to assess farmers' perceptions and knowledge of Bambara groundnut diseases in Zimbabwe. Pinawè's research is significant as it aims to enhance the utilization of Bambara groundnut in Zimbabwe, Benin, and beyond, focusing on improving seed quality and understanding disease impacts. By developing high-yield, disease-resistant varieties, her work seeks to reinforce food security and agricultural resilience, ensuring local communities have access to affordable, nutritious food. In the coming months, Pinawè will develop her survey instruments and begin her field work. She is excited about the potential insights her research may provide and looks forward to making a meaningful contribution to global food security and sustainable agriculture.

1.8.3 ORPHAN PhD students

Our two ORPHAN PhD students included Ms Scholastica Nneka Chukwu and Mr Jean Paul Ebrin.

Ms **Scholastica Nneka Chukwu** is working on Morphological characterization and oil quality of *Citrullus mucosospermus*. *Citrullus mucosospermus* popularly known as 'Egusi' is native to sub-Saharan western Africa and is one of the most widespread oilseed crops. Its valorization could make a significant contribution to the development of local communities with regards to environmental change and be a source of income for farmers and processors. However, the cultivars of this previously enumerated species are unproductive and the increasing of production requires the development of large areas. Scholastica study aims at (1) documenting the production constraints of Egusi in Nigeria, (2) assessing the morphological characteristics of a West African collection of Egusi, and (3) establishing the nutritional and oil content profile of the collection.

Mr **Ebrin Jean-Paul Noé** is investigating on Voandzou (*Vigna subterranea* [L.] Verdc.), a crop considered one of the main legumes of tropical regions due to its versatile advantages. It is the third most important legume after groundnut and cowpea, and is an under-utilized grain legume belonging to the Fabaceae family and Faboidea subfamily. Mr Ebrin plan to contribute to increasing production of this plant in Benin by screening local accessions and proposing elite genotypes to farmers, thereby increasing their income. To achieve this objective, morphological and genetic studies will be undertaken. This methodology will make it possible to identify cultivars of the species and areas of high production in Benin; characterize the potential of local cultivars using morphological and molecular markers.

1.8.3 BIOVALOR PhD students

Ariane AHOKPOSSI, L. Tania I. AKPONIKPE, Ms. Rabiath ADIGOUN, Ariane AHOKPOSSI and Mr Guillaume BODJRENOU are our four PhD students under the BIOVALOR project.

Ms **L. Tania I. Akponikpe**, is a PhD student jointly registered at the University of Abomey-Calavi (Benin) and University of Lorraine (UL, France), conducting her research on the « Response of fonio (*Digitaria exilis* Stapf.) genotypes to variations in soil and climate conditions and agroecological practices in Benin ». Her doctoral project focuses on the selection of adapted genotypes, the study of biofertilising bacteria associated with fonio and their impact on the crop, and the improvement of sustainable agricultural practices. As part of her research, she has conducted trials in six communes in northern Benin (Parakou, Ina, Kandi, Gogounou, Natitingou, and Boukoumbé) to identify high-performing genotypes for fonio production zones and as well as a suitable environment to expand the crop. She is also assessing bacterial diversity in the fonio rhizosphere, identifying biofertilizer strains isolated from the fonio rhizosphere, and analysing their effect on nutrient use efficiency. Finally, she is testing cultivation practices aimed at improving grain yields from fonio. In the long term, her research will promote large-scale fonio cultivation, thereby contributing to food and nutritional security in Africa while promoting local economic development by improving fonio production.

Ms **Rabiath Adigoun**'s PhD research whose title is "Diversity and performance of endophytic and rhizosphere bacteria for stimulating the growth of *Synsepalum dulcificum* (Schumach & Thonn.) Daniell" focuses on depicting the diversity of endophytic and rhizosphere bacteria associated with a panel of accessions of the Sisrè berry plant [*Synsepalum dulcificum* (Schumach & Thonn) Daniell]. Her research will also explore the possibility of harnessing this diversity to select beneficial bacteria to promote the species' growth. Thus, the research activities carried out so far include: (i) prospection and collection of leaf, root and rhizosphere soil samples from 29 accessions of the Sisrè 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; (iv) isolation and molecular characterization of rhizosphere and endophytic bacterial strains; (v) cooccurrence analysis for selection of synergistic bacteria and screening of their growth-promotion activities; (vi) bacterial inoculum preparation and inoculation tests on the Sisrè berry plant seedlings in the nursery (currently ongoing). This study will provide farmers with a sustainable strategy for intensifying the Sisrè berry plant production to meet market demands and promote the sector in Benin.

The shea tree is a widely exploited plant genetic resource for the butter obtained from its kernels, making it a multi-billion-dollar export product for West African countries such as Benin. Its production remains in the wild, and few breeding programs have focused on improving it. This situation creates a shortfall for all players in the value chain, particularly in the supply of quality shea nuts with good fat and secondary metabolite composition in butter. The aim of the PhD research of Mr **Guillaume Bodjrènou** is to select elite shea trees on the basis of fruit/nut yield, fat content and unsaponifiable matter composition, all of which are profitable for the chocolate and cosmetics industries. Initial results obtained on a set of 165 shea trees sampled in northern Benin revealed two significantly distinct genetic groups of shea trees for yield and yield components. In addition, GC and HPLC chromatographic studies of the kernels from 20 trees revealed significant differences in stearic, oleic, linoleic and palmitic acid content. The data obtained by HPLC orbitrap are currently being analysed to identify trees specifically for cosmetics.

Ms **Ariane Ahokpossi** is working on the optimization of pre- and post-harvest techniques for the production of Sugarloaf pineapple in Benin to improve conservation for export by sea. Sugarloaf pineapple (*Ananas comosus)* is the third most cultivated crop in Benin and is globally appreciated for its white flesh and exceptional sweetness. Despite its commercial potential, the fruit remains highly perishable due to physiological sensitivity, and physicochemical characteristics. Inadequate compliance with good agricultural practices, poor harvesting methods, and suboptimal postharvest handling contribute to rapid quality deterioration, resulting from physical injuries, physiological disorders and microbial damage. The aim of the study is to identify effective strategies to extend the shelf life of Sugarloaf pineapple in Benin. Four complementary approaches were explored. The first results revealed the prevalence of postharvest disorders such as translucency, black rot, insect damage, brown heart, crown rot and sunburned. A higher K2O: N fertilization ratio significantly increased fruit weight and sugar content. The use of neem oil-coated urea improved nitrogen use efficiency, reduced nutrient loss, and contributed to better performance and economic returns. Significant differences were observed in physicochemical properties and shelf life of fruits harvested at various maturity stages. Harvesting at 2200 degree-days and 2300 degree-days extended the shelf life while maintaining export-grade quality.

1.8.4 e-Anacarde PhD students

A total of three PhD students are involved in the e-Anacarde project,

Mr **Mario Ronel Vigninou** is working on the genetic improvement of cashew in Benin. His research is entitled "*Genetic improvement and development of high yielding cultivar and reduction of seedling mortality rate for increased cashew* (*Anacardium occidentale* L.) *productivity in Benin*". As part of his research, he aims to support the growth of cashew processing industries in Benin and enhance export revenues by developing high-yielding and resilient cashew cultivars. His study focuses on the use of marker-assisted selection (MAS) to identify elite individuals with high nut yield and kernel output ratio (KOR). Additionally, Aside the genetic improvement aspect, his research will also explore optimal water regimes and acclimation period-based treatments to enhance seedling survival in field and the overall plant development.

Mr **Ben Salès** research focuses on designing a digital platform to facilitate the integration of local actors in Benin's cashew sector into the global value chain. The platform aims to meet key requirements such as trust, transparency, security, accessibility, adaptability, and support for decision-making. So far, the work has primarily involved a comprehensive literature review on the cashew supply chain, covering production zones, export dynamics, value chain mechanisms, local transformation challenges, cooperative structures, and demographic factors, including gender distribution among industry stakeholders. Additionally, existing digital solutions, artificial intelligence (AI) techniques, and decision support systems (DSS) used to optimize supply chain operations have been explored. To strengthen the research framework, courses on blockchain and smart contract development are being undertaken. These technologies are expected to enhance transparency and trust within the platform by enabling secure, tamper-proof transactions and data sharing among stakeholders. Currently, his focus is on finalizing the platform's requirements document, which will help define technical and functional specifications. The next phase will involve planning field visits to key actors, such as farmers and cooperatives, to validate and refine the system architecture. These interactions will ensure the platform effectively meets the needs of local stakeholders while aligning with global market standards.

Mr **Abdul-Fadel Mohamed** is working on research questions including: what is the economic relationship between global value chains and the cashew sector in Benin? what is the impact of the adoption of agricultural technology (genetic improvement of cashew plants and digital platform) on the income of producers in the Republic of Benin ? And what are the factors that encourage cashew producers to adopt these agricultural technologies in Benin? To answer these research questions, we formulate hypotheses such as: the integration of Beninese producers into global cashew value chains has a positive impact on their income by improving access to international markets and more competitive prices; the adoption of genetically improved plants leads to an increase in the income of cashew producers in Benin and the adoption of a digital platform leads to an increase in the income of cashew producers in Benin. Firstly, the general equilibrium model is applied using Bayesian methods including Structured Vector AutoRegressive (SVAR) to analyze the impact of international shocks on the cashew sector in Benin.

1.8.5. TAERA PhD students

Two PhD students are working on the agroecological practices development in Mono-Couffo with the support of the TAERA project. These include Moukaila Bagri and Ulrich Djido

Mr **Moukaila Bagri** is working on the impact of bacterial wilt on tomato production and the development of ecological solutions for farmers in Benin. Recognized as the second most important plant disease worldwide due to its diversity, severity, distribution, and scientific significance, bacterial wilt caused by the Ralstonia solanacearum species complex has been identified as the primary limiting factor for tomato cultivation in the major production areas of southern Benin. Among various environmentally friendly management strategies in Africa, a global meta-analysis has identified grafting, varietal resistance, biological control, and integrated approaches as the most effective methods to reduce disease incidence and improve yields. A study conducted in southern Benin estimated potential yield and economic losses ranging from 53.3% ± 41.88 (13.87 t/ha ± 11.87) to 80% ± 9.78 (18.37 t/ha ± 7.30) and $3,592.51 USD/ha ± $2,656.40 to $6,760.50 USD/ha ± $4,117.78, respectively. An investigation in the affected areas revealed that vegetable farmers have a moderate understanding of the pathogen, which limits their ability to effectively manage the disease. A varietal screening conducted in the region identified tomato genotypes tolerant to bacterial wilt that were well appreciated by farmers. Concurrently, enriched composts aimed at reducing pathogen inoculum in the soil and disease incidence showed mixed results in both greenhouse and field conditions.

Mr **Ulrich Djido**'s research project, entitled "Agronomic Tools for Sustainable Intensification and Production of Aromatic Rice in Mono and Couffo, Benin", was initiated to support the agroecological transition of rice farming in Benin through the TAERA project (Transition Agro Ecologique par la Recherche Agricole). The study focuses on two key aspects: sustainable soil fertility management and the selection of high-performing aromatic rice varieties adapted to local conditions. Several experiments were conducted, initially to investigate and map the agricultural practices used by smallholder farmers in southern Benin for the agroecological transition in rice production. Thus, a survey of 216 rice farmers assessed existing agronomic practices and their adoption of agroecological approaches. Results indicated a low adoption rate (mean = 1.28) but strong interest (90%) in legume-based crop rotations. In the second phase, we tested legume-based crop rotations (mungbean and mucuna) combined with reduced mineral fertilizer applications. Over two growing seasons, nine treatment combinations were evaluated using a split-plot design. Preliminary results indicate that legume rotations significantly improved phenological growth parameters, with a 25–35% increase in rice yield (4–6.5 t/ha) compared to non-rotational systems (2–3 t/ha), while reducing mineral fertilizer use by 50%. Finally, to support sustainable rice production with high-performing varieties, five aromatic rice lines (ARA 01, ARA 02, ARA 05, ARA 18, ARA 23) were evaluated across three agroecological zones (Dogbo, Grand-Popo, Lalo), alongside two reference varieties (IR 841, Orylux 6). Performance assessments, including yield components and farmer participatory selection, identified ARA 05, ARA 18, and ARA 23 as the most promising varieties. These lines exhibited superior tillering capacity, grain yield, and adaptation to local environmental conditions. These studies, conducted since 2021, are nearing completion and have led to the development of three techno-economic reference guides on best practices, made available to rice producers and stakeholders in Benin, as well as two scientific publications currently under review.

1.8.5. Safeveg PhD students

Our collaboration with the Safeveg project support two Phd students.

Mr **Belchrist Eliel Sossou** PhD research entitled "Etiology and genetic resistance of gboma eggplant (*Solanum macrocarpon* L.) to bacterial wilt disease caused by *Ralstonia* spp. in Benin" focuses on gboma eggplant (*Solanum macrocarpon*), a well-known West African vegetable, and identifying sources of resistance against bacterial wilt disease. His work helped uncover vital insights to help farmers and researchers fight this disease. First, he reviewed how bacterial wilt spreads and the strains diversity in Africa, its impact on some vegetable crops in Africa, and strategies to breed disease-resistant varieties accompanied by a proposed roadmap for developing resilient gboma varieties, ensuring farmers can continue growing this nutritious vegetable. Next, a survey of 572 farmers across Benin was conducted and revealed the alarming spread of the disease. Many farmers lacked knowledge on effective control, with some relying on synthetic pesticides while others had no strategy at all. However, those using longer crop rotations, biopesticides like neem and cassava peels, and improved crop varieties reported lower disease incidence. Besides, another study revealed the importance of the disease among the traits of preference in terms of development of varieties that they want. Finally, bacterial strains from infected gboma were collected across Benin. Our findings identified Phylotype I sequevar 31 as the most aggressive strain, particularly damaging to the popular Kombara and Sika variety. Future research will screen 30 Gboma accessions for resistance, followed by qPCR analysis to pinpoint resistance genes.

Ms **Jelila Blalogoe** is conducting a PhD thesis on the topic: "Current Status and Prospects for Improvement of the Okra (Abelmoschus esculentus L. Moench) Seed System and Seed Quality in Benin." This research aims to promote increased use of high-quality seeds of traditional African vegetable crops, particularly okra, that are well adapted to the agroecological conditions of West Africa. The thesis is being conducted as part of the regional SAFEVEG project, funded by the World Vegetable Center (WVC), for West and Central Africa – coastal and humid regions. In 2024, the focus was on completing data collection and analyzing data related to okra seed systems in Benin. The results revealed a highly informal sector, characterized by the predominance of uncertified seeds, weak regulation, and poorly controlled practices of seed conservation and dissemination. A first scientific article has been submitted for publication, while the writing of other articles is underway. These articles cover the physical and physiological quality of commercial seeds and a morphological characterization of the varieties available on the market.

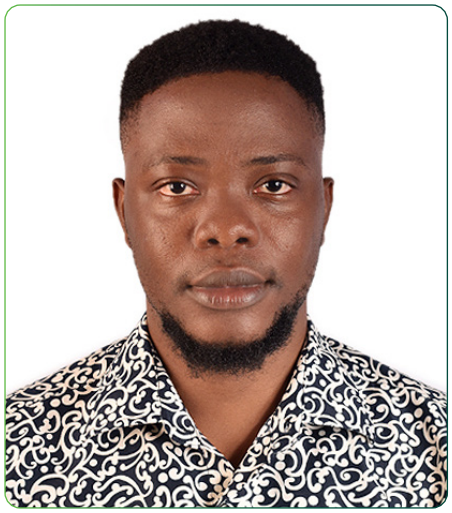
The research work being conducted by Ms **Yasmine Godonou** aimed at providing to the local farmers efficient practices to optimize tomato fruit yield, quality and mainly the shelf life. That objective has been set as part of the SafeVeg Project following the main issue of farmers facing a huge post-harvest losses of tomato production making them selling their products at low price. Based on the fact that tomato fruit production yield, quality and shelf life is a result of combination of adequate pre- and post-harvest practices, we aimed at assessing and suggest a good combination of some pre- and post-harvest methods to increase and optimize tomato fruit yield, quality and shelf life. (1) As preharvest methods, balanced calcium and potassium fertilization has been experimented and found to improve tomato fruit physical properties and reduce fruit loss during storage. (2) As post-harvest methods to maintain tomato fruit quality and the shelf life, our experiments so far investigated the impact of melatonin and chitosan in maintaining tomato fruit for longest period. Following the experiments, melatonin treatment on tomato was effective in reduction tomato fruit loss as well as maintaining fruit for longest time. Our research is still ongoing to release much more regarding efficient practices needed in maintaining our local tomato production in better quality and good shelf life.

1.8.5. PhD students on other projects

Several PhDs students are working on various crops and subjects.

Mr **Idrissou Ahoudou** is a final year PhD candidate in Biotechnology and Plant Breeding at the University of Abomey-Calavi, Benin. His research focuses on improving the adoption of orange-fleshed sweet potato (OFSP) in sub-Saharan Africa by integrating farmer preferences and agroecological adaptability into breeding strategies. Using a multi-disciplinary approach, he first identified farmer preference heterogeneity through Best-Worst Scaling experiments and Latent Class Analysis, revealing distinct varietal selection criteria across communities. He then conducted multi-environment trials (METs) combined with participatory variety selection (PVS) to evaluate OFSP genotypes for yield stability and adaptability in Benin's diverse agroecosystems. Spatial modelling techniques were further employed to map adoption potential and prioritize intervention zones. His work bridges the gap between breeding programs and end-user needs, offering actionable insights for climate-resilient varieties, targeted policy frameworks, and context-specific dissemination strategies. This research contributes directly to enhancing food security and combating vitamin A deficiency in the region. Idrissou has completed his data analysis and manuscript preparations, with his public defense scheduled in early 2025.

Ms **Fustelle M. Francisco Merinosy** research is entitled "Drivers of microbial diversity and beneficial interactions between cotton (*Gossypium* spp.) and its functional microbiome for sustainable cotton production in Benin" and is being conducted in the framework of the project PReFoSyC (Professionalization and Reinforcement of Training for Sustainable Cotton-based Production Systems), jointly run by the Faculty of Agronomy at the University of Parakou (UP), ISTOM (Ecole Supérieure d'Agro-développement International) and CIRAD (Centre de Coopération International en Recherche Agronomique pour le Développement). In this thesis research, the interactions between microbial communities will be studied to adjust crop rotation practices to maintain a balanced microbiota, a guarantee of sustainable cotton productivity. This includes an analysis of the synergies and antagonisms that can influence plant health and productivity. The results will lead to practical recommendations for improving agroecological practices and take better advantage of biotic relationships to reduce the use of synthetic inputs



Mr **Latif Adegolou** PhD research is entitled "Evaluation of improved lines, pathogen identification and germplasm screening for new resistance sources in *Amaranthus spp* in West Africa". In a changing world affected by climate change, plants face diverse challenges that reduce their production and threaten food security. Amaranthus production encounters severe challenges, including low awareness of its utilization, the absence of a seed system, limited market access, pests, diseases, and many others. Climate change, causing extreme conditions, has also intensified disease pressure on crops due to factors such as pathogen outbreaks, an increase in disease vectors, and weakened plant defenses. Despite its resilience, Amaranth is highly susceptible to a wide range of diseases that significantly threaten its production and marketability. Mr Latif Adégolou's work aims to identify the major biotic and abiotic stresses faced by Amaranth growers in the West Coastal and dry regions of West Africa, characterize the pathogens associated with the diseases in these regions, and identify resistant accessions to the major pathogens. Additionally, his research will explore the genomic regions associated with disease resistance traits and leaf yield. He is currently at the validation stage of my proposal and research questions with my supervisors.

Mr **Amavi Lys Aglinglo** is a PhD candidate in Genetics and Plant breeding at the University of Abomey-Calavi. His research focuses on assessing the physiological and sanitary quality of locally produced vegetable seeds from different seed systems in Benin, with tomato, peppers and gboma as target crops. Through this work, farmers' perceptions of seed quality and its incidence on vegetable production will be assessed; local seed producers/companies will be characterized according to seed systems and quality of vegetable seeds collected from these actors will be evaluated. In-fine, evidences on current locally produced vegetable seed quality and improvement area will be provided to local seed companies and breeders in order to supply farmers with high quality seeds. To date, he has developed and implemented a rapid method for classifying local seed producers according to criteria that characterize different seed systems. At the same time, a survey is underway to identify farmers' perceptions of seed quality, the endogenous methods used to assess them, and the repercussions on productivity. Also, tomato, peppers and gboman seed samples are being collected for physiological, physical and sanitary analysis.

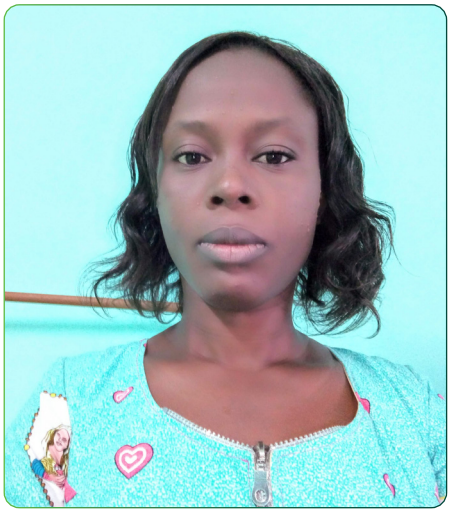
Ms **Mary Emeraghi** is a final year PhD student working on "Current status of impact of maize streak virus disease on the maize production system in Benin Republic and the way forward for resistant hybrid development". Maize streak virus disease (MSVD) caused by maize streak virus (MSV) is the most serious viral disease of maize known to devastate yields and whose erratic epidemics pose dire consequences in unprepared production systems, affecting the livelihood of mostly resource-poor growers without sufficient knowledge of its control. This doctoral research screened maize germplasm adapted to and widely grown in the Republic of Benin over the course of two years to ascertain their resistance to MSVD. Results showed a variation in resistance among the materials screened indicative of a need for improvement in order to boost resilience of smallholding growers and ultimately ensure food security. To further confirm the above findings, a country-wide survey and analysis of maize samples collected across 114 fields was carried out. Results revealed the occurrence of MSV, sugarcane mosaic virus (SCMV), and maize yellow mosaic virus (MaYMV). MSV was found in all major maize-growing regions of Benin, with higher incidences and severity observed in the northern parts of the country constituting of Zones II, III, IV, and V. The detection of MaYMV infecting maize in this study is the first report in the country. This knowledge led to the development of 22 topcross maize hybrids (THs) in 2019 by crossing two maize inbred lines, TZIL07A01005 and TZIL07A01322 with tolerance to drought and resistance to MSVD

and other foliar diseases, to eleven open-pollinated varieties (OPVs) popularly grown in the country. Yield assessment of the THs across multi-environments spread across three agroecological zones of Benin and estimation of combining abilities of parental lines used in the study led to the selection of four THs that exhibited positive mid- and better-parent heterosis for grain yield. DMR ESR W × TZIL07A01322, which was the highest yielding TH, at 5.1 tons per hectare, had 29.1 and 13.3% yield advantages over its mid-parent and better-parent mean yields respectively with the potential for commercialization by indigenous seed enterprises. Four OPVs were shown to contribute favourably to observed heterosis and could serve as potential genotypes for inbred lines extraction. An assessment of the effect of genotype-by-environment interaction on grain yield was also conducted and stable-performing THs for broad and specific adaption across Benin were identified.

Mr **Soulemane Nouroudine** is final year PhD student working on the knowledge transmission patterns and biomass yield production of black plum (*Vitex doniana* Sweet) for domestication program development. Black plum (*Vitex doniana* Sweet) is a wild species native to Sub-Saharan Africa, belonging to the family Lamiaceae. It plays a significant role in enhancing the livelihoods of local communities, particularly those of women. The species has numerous applications, benefiting not only rural dwellers but also urban populations, where it is used for food, healthcare, and artisanal purposes. However, *Vitex doniana* is currently overexploited due to its multiple uses. Major threats include bushfires and low natural regeneration, primarily caused by poor seed germination resulting from seed dormancy. The ongoing PhD research aims to identify the sociodemographic factors influencing the adoption and production of *Vitex doniana* in Benin. The ultimate goal is to support the domestication and conservation of this valuable genetic resource. Since 2022, my PhD thesis has focused on the following specific objectives: 1. Assess the sociodemographic determinants of *Vitex doniana* knowledge transmission across generations. 2. Evaluate the combined effects of provenance and pretreatment techniques on breaking seed dormancy in *Vitex doniana* 3. Develop optimal agronomic practices for increasing leaf biomass yield. To date, a literature review on the production, domestication, and genetic improvement of Vitex doniana has been conducted and published. Additionally, a field survey involving 252 respondents from southern and central Benin was carried out to investigate the factors influencing knowledge transmission, adoption, and production of Vitex doniana. Agronomic trials are also underway to develop improved practices for leaf production. The research is currently in the thesis writing phase, with the defense scheduled for 2025. This study is expected to provide Benin farmers with practical, science-based agronomic techniques to enhance the production of *Vitex doniana* leaves, contributing to both conservation and local development.

Mr **Christel Ferréol Azon** is a final year PhD student working on sesame, a valuable but underutilized crop in many regions of the world and priority crops under the VACS (Vision for Adapted Crops and Soils) program. His PhD research work focuses on Developing pathways for high seed yielding cultivars of sesame (*Sesamum indicum* L.) adapted to agroecological zones of Benin, with the overall aim to increase Benin's potential in sesame production through the development of high seed yielding cultivars adapted to different agro-ecological zones. To achieve this goal, his study integrated agronomic management practices, ethnobotanical studies, and both conventional and molecular breeding approaches. Christel's work has generated reliable data to support better organization of the sesame value chain, developed a breeding plan for sesame improvement in Benin, identified five key management practices across production zones, and highlighted those with the highest yield potential. He finally identified high yielding cultivars that meet the needs of farmers across different environments of Benin through Multi Location Trials. He is finalizing his dissertation in preparation for his PhD defense.

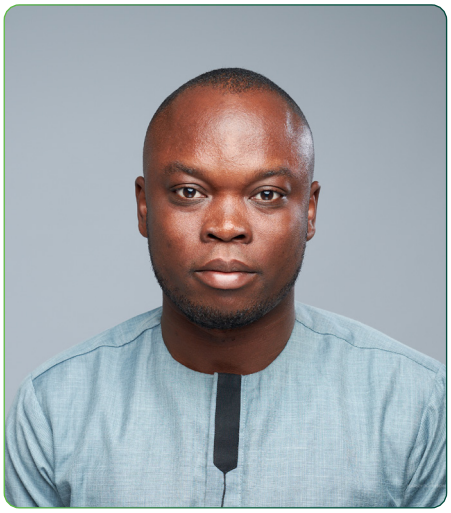
Ms **Frida Dossa** is a final year PhD student interested in the selection of essential oil crops, *Mesosphaerum suaveolens* (L.) Kuntz (Lamiaceae) for tomato pest control in the horticultural system of Benin. Chemical insecticides have a variety of detrimental impacts, such as environmental pollution 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. *Mesosphaerum suaveolens* is one of the most widely recognised essential oil plants from Lamiaceae family and a potential biopesticide. It is found all over the world and is widely used for medicinal purposes, and as mosquitoes' repellent. This study started in march, 2019 aimed to determine the best genotypes of M. suaveolens accessions that provide a high quality and quantity of essential oils to control pests in horticultural systems of Benin. The activities already realized are: a review on the genetic diversity, essential oil's chemical constituents of *M. suaveolens* and its uses in crop protection; the assessment of agromorphological characterization, the genetic diversity and population structure of *M. suaveolens* accessions collected in Benin; in vitro tests of *M. suaveolens* essential oil on *Maruca vitrata* and a survey to evaluate the local knowledge on the use of *M. suaveolens* in Benin's horticultural system. The different realized activities allow the achievement of the three objectives of the doctoral project. In the current context of climate change, it is important to find a natural solution for the increasing yield losses due to pests to improve farmers' livelihood.



Ms **Elodie Capo-chichi** is a final year PhD student with focus on the « Genetic and agro-ecological determinants of yield of sweet fig banana landrace (Musa acuminata cv Sotoumon)». This thesis aims to investigate the agroecological and genetic factors influencing yield in sweet fig banana through ethnobotanical surveys and genomic approaches, providing resources to inform and enhance breeding programs for this cultivar. The broad question guiding this thesis is: What shapes the yields of sweet fig bananas? To address this question, we first reviewed the factors affecting yield in edible bananas, focusing on promising avenues for quantitative breeding of sweet fig bananas. Next, we conducted an ethnobotanical survey in Benin to identify the drivers of traditional knowledge, management, and foresight for enhancing productivity, along with the attributes that users desire in new sweet fig banana varieties. The paper is currently under review. We then assessed the phenotypic and genetic diversity and population structure of 273 sweet fig banana genotypes using genotyping-by-sequencing. The results show narrow genetic diversity in the "Sotoumon" germplasm, providing insights into sustainable conservation practices. This study was published in the PLoS One journal. Finally, we investigated the causative loci underlying the growth and yield performance of "Sotoumon," laying the groundwork for implementing marker-assisted breeding in this species. We collected fifteen yield traits over a cycle in two experimental fields (Sékou and Dan) from August 2019 to March 2023 under rainfed conditions. The Genome-wide association studies (GWAS) identified 59 loci across the eleven chromosomes linked to these traits. The paper is currently under review.

Ms **Chaldia Agossou** PhD thesis research is entitled "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. Climate change continues to pose serious threats to agricultural and food systems, especially in Africa known as highly vulnerable. This current research is built on the rationale that legumes crops represent a strong asset for food diversification and that improving, kersting's groundnut (Doyi), the most economically valuable leguminous crop in Benin, holds the potential to help ensure food and nutrition security. Ms. Agossou research combined mutation breeding approach in developing high yielding and micronutrients-dense cultivars for Doyi with social science approach to gauge end-users' readiness to pay for improved cultivars seed. Her research is expected to ultimately help: i) clarify conditions under which farmers can buy improved seed of Doyi, ii) generate sufficient variability with the crop to constitute a strong breeding population in the species; iii) reveal genomic regions associated

to mutant lines' performance; iii) make available outyielding cultivars for the end-users. To date, the factors likely to affect farmers willingness to pay for improved Doyi seeds have been elicited; the lethal Ethyl methane sulfonate doses suitable to induce mutation in various Doyi cultivars have been identified, and the mutant population developed already evaluated phenotypically and equally at the molecular level. The phenotypic evaluation of the mutants pointed to highly performing mutant genotypes yielding up to threefold more than the current landraces. To date, Ms. Agossou has one published paper and, and three others in preparation.



Mr **Herbaud Zohoungbogbo** research focused on the development of pepper varieties resistant to viruses for the West African market. Viral diseases are one of the major constraints to pepper production, causing significant yield and income losses in Africa. Sustainable management of these viral diseases is crucial to reduce their incidence and improve yields for farmers. This thesis aims to identify the various viruses affecting pepper production in West Africa, to assess producers' perception and knowledge of viral diseases, associated vectors, and their management strategies in pepper production in Benin, and to develop pepper varieties resistant/tolerant to these viruses. Through this thesis, we have identified and characterized the different viruses affecting pepper production in Benin, Nigeria and Ghana; evaluated sources of peppers with resistance genes to the identified viruses, and finally developed virus-resistant pepper varieties with interesting horticultural traits for the market through interspecific crosses. 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 have been 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 March 2025.

2. Training activities and institutional capacity strengthening

2.1. Training activities

2.1.1. Professional training on precision agriculture

From February 26 to March 8, 2024, the Genetics, Biotechnology, and Seed Science Unit (GBioS), in partnership with the Agence Universitaire de la Francophonie (AUF) and the Agritech company AgroSfer, launched the first edition of the certified training in digital agriculture through the AgroDigiLab project. This first cohort took place at the Francophone Digital Campus of the University of Abomey-Calavi.

Funded by the French company ENGIE Access Energy Bénin, the main sponsor of this edition, the AgroDigiLab project equipped young graduates in agronomy and related fields with digital skills applied to agriculture. The goal was to improve their employability and promote digital agricultural entrepreneurship. More broadly, the project seeks to help young African graduates better integrate digital technologies into the agricultural sector (**Fig. 8**).

Fig. 8. *Group photo of first cohort of participants and trainers at the launch of the first edition of the certified training in digital agriculture*

For this first edition, 61 applications were received, including 12 from women. After evaluation, 30 candidates were selected, including nine women (70% men and 30% women). However, only 8 participants, including 1 woman (87.5% men and 12.5% women), actually completed the training. The training was structured around three key modules: precision agriculture and drone operation, digital management of producer organizations' performance, and an introduction to agricultural entrepreneurship. It was delivered by 11 trainers from agronomic

research, digital transformation, and agricultural entrepreneurship. During the training, participants were introduced to the concept of precision agriculture and how remote sensing can improve soil fertility, correct water deficits, and prevent biotic and abiotic stresses affecting crops. They also learned how to operate drones and use them to capture aerial images of agricultural fields.

As part of the practical activities, a field visit was organized at Ferme Comlanvi in Abomey-Calavi (**Fig. 9**). Participants had the opportunity to explore and use modern agricultural technologies, such as moisture sensors and automatic irrigation monitoring and control systems, allowing them to apply their theoretical knowledge in a real-world setting (**Figure 9**).

Fig. 9. *Practical drone piloting session with participants and trainers at Comlanvi Farm in Abomey-Calavi.*

In addition, participants were trained in managing and coordinating production within farmer organizations and using the AgroSfer platform to ensure agricultural production traceability. They also received training in agricultural entrepreneurship, with insightful sessions led by AgriTech Benin promoters, who shared their experiences and introduced their innovative solution, e-pinA. Through this project, several concrete actions were implemented, including:

- designing and delivering training curricula for participants on digital agriculture and entrepreneurship;
- organizing practical sessions on drone piloting and spatial data processing; and
- assessing participants' acquired knowledge and facilitating networking between them, professionals, and key stakeholders in the agricultural sector.

2.1.2. First regional training of Genomics and Plant Breeding

The training was officially launched on November 18th at the Genetics, Biotechnology & Seed Science Unit, University of Abomey-Calavi. This first edition brought together 17 participants (**Fig. 10**) from universities and research institutes across Benin, Côte d'Ivoire, and South Africa, marking the beginning of a transformative journey in genomics and plant breeding.

Fig. 10. *First cohort of participants and trainers at the first regional training of Genomics and Plant Breeding.*

Throughout the training, participants delved into three main modules: advanced genomics for plant breeders; genome, bioinformatics, and applications; and classical Breeding; covering genome sequencing, landscape genomics, bioinformatics, and comparative genomics. Genome sequencing, a game-changer in biology, agriculture, and medicine, involves decoding an organism's entire DNA sequence to uncover the genetic blueprint of life. Market intelligence and demand led-breeding. The bioinformatics module introduced participants to the core principles and applications of this interdisciplinary field, which blends biology, mathematics, and computer science. Participants learned to harness digital tools for analyzing complex datasets, such as genomic sequences and gene expression profiles, with a focus on developing efficient workflows and mastering data analysis techniques (Fig. 11). The comparative genomics session shed light on the ever-changing nature of plant genomes, highlighting frequent chromosomal rearrangements, the abundance of transposable elements, and shifts in ploidy. These insights contribute to a deeper understanding of plant evolution and diversity. This training, which was more practical than theoretical, aimed to provide professionals, postdoctoral researchers, and PhD students with advanced techniques in plant breeding and genomics, as well as analytical tools for crop improvement research. The goal was to tackle pressing issues such as food security and the challenges posed by climate change.

Fig. 11. *Participants in the indoor section on Genomic selection application.*

2.1.3. Measure of the sustainability of vegetable production systems

A workshop was held on 12 and 13 September, 2024 to share the findings of the study "Assessing sustainability in smallholder vegetable farms in Benin Republic: A matrix approach" with extension agents and provide them with better information and skills on approaches to measuring farm sustainability. The workshop was attended by 16 agents from Development Poles 1 and 7 (major vegetable production regions in the country), and was held on the GBioS premises at the University of Abomey-Calavi (**Fig. 12**). After exploring the theoretical aspects of the IDEA (Indicateurs de Durabilité des Exploitations Agricoles) approach, and the results of its application to vegetable production systems in Benin, participants were given the opportunity to apply the IDEA approach to a real life-setting at the GBioS demonstration site (**Fig. 12**). This was an opportunity for the participants to gain a practical understanding of how to collect, analyse and interpret data, in order to better support farmers in improving their farming practices. A guided tour of the various technical platforms of GBioS as well as the World Vegetable Center research station (led by Dr Mathieu Ayenan), gave participants a close-up view on research on vegetable variety development and good agronomic practices. The workshop covered various aspects of the sustainability of production systems, including ecological sustainability, social sustainability and economic sustainability. The participants confirmed that the results of the study reflect the reality on the ground and understood that sustainability takes into account three dimensions: environmental, social and economic. For the participants, this workshop provides the tools to understand and apply the various practices in the field, so as to better support producers in the transition to more environmentally-friendly practices, while guaranteeing their economic and social viability.

Fig. 12. *Group photo of participants attending the training on the use of the IDEA approach to measure farm's sustainability (left) and practical activities by participants (right).*

2.1.4. Training on Semi-Autotrophic Hydroponic technique

Semi-Autotrophic Hydroponic (SAH) technology is a plant propagation method that combines hydroponic cultivation with elements of autotrophic cultivation. This method allows plants to grow with minimal nutrient inputs and under strict environmental control, promoting faster growth and greater resistance to diseases and environmental stresses. Initially developed for potato propagation, semi-autotrophic hydroponic systems have also been adapted for cassava. The GBioS unit finds this technology as an opportunity to boost its ambition to produce potato seeds for farmers. It is in this context that two of the GBioS team (Dr Charlotte Adje and Ms Michelle Quenum) went to IITA (Ibadan) to get trained on the technology. The objective of this training was to increase the skills of GBioS on proven SAH technology to improve agricultural productivity through the production and availability of good quality of potato seeds. For this training, the learning method included a basic theoretical information followed by hands on experience in different units involved in the process of the SAH from 8th to 19th July, 2024. It started from learning the Standard operating procedures at SAH laboratory, in SAH Screenhouse, at SAH fields, procedure of Green-stem and shoot tip SAH technique, and the procedure of cassava plantlets production. Hands-on activities (**Fig. 13**) were hold on nutrient preparation, plant monitoring, substrate filling in a yam screenhouse, procedures for one nodes planting, virus indexing (**Fig. 14**), and field operations.

***Fig. 13**. Hands on cassava nodes preparation and transplanting.*

Fig. 14. *The GBioS visiting scientists: Dr Charlotte Adjé and Ms. Michelle Quenum with the IITA virus indexing team.*

2.1.5. Theses and dissertations defence

During 2024, GBioS successfully graduated 18 students among which 3 BSc holders, 10 MSc holders, 4 Agricultural engineers and one PhD holder.

The PhD holder, Dr Omar Yacouba Touré **(Fig. 15**) sponsored by the GENES I intra-Africa mobility project successfully defended his thesis entitled: "Identification of diseases and pests associated with Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal et Baudet] in Benin". As part of this research Dr Yacouba reported for the first time several diseases and their associated causal agents and is currently proceeding with their molecular identification.

***Fig. 15**. PhD defence of Dr Omar Yacouba Toure, University of Abomey-Calavi, Republic of Benin*

The MSc graduates and Agricultural engineers investigated on topics that fall under two research umbrellas: the development of eco-friendly production practices and the phenotypic characterization. A total of five engineers graduated on the first research umbrella and tackled several topics including the "Effect of neem oil coated urea application on maize varieties (by Gildas Houessou), on tomato production and shelf-life (by Sergio Hounyo). The topics of the other three students included: "Ecological alternatives for flowering induction treatment with calcium carbide in conventional sugarloaf pineapple production in Benin" by Orthia Linkpon, "The effect of three liquid organic fertilizers on the production of African eggplant on ferralitic soil in southern Benin" by Melchior Agbokou, and "The effectiveness of compost enriched with biofumigant plants in the agroecological management of *Ralstonia solanacearum* bacterial wilt in Benin" by Sedami Gbaguidi.

Students on the second research umbrella investigated on the phenotypic diversity assessment and stability analysis of various vegetable, fruit and tree species. Their research topics were as follows: "Agro-morphological diversity of the African leafy vegetable jute mallow (*Corchorus spp.*)" by Serge Ologou; "Agro-morphological evaluation of a collection of Egusi (*Citrullus mucosospermus*) from the three phytogeographical region of Benin" by Mohammed N'tcha; "Phenotypic characterization of a collection of *Ocimum gratissimum* L. from the three Phytogeographical regions of Benin" by Majorelle Sonon, "Phenotypic characterisation of a collection of *Corchorus olitorius* collection from the three phytogeographical regions of Benin" by Spero Coffi) and Phenotypic characterization of a collection of *Solanum macrocarpon* L. from three phytogeographical regions of Benin" by Noe Kounde; "Phenotypic diversity and indirect selection for yield and its components in shea tree (*Vitellaria paradoxa* C.F. Gaertn) in northern of Benin" by Matice Gbetoho; "The molecular characterization of pineapple morphotypes and responses of their stem cutting to natural phytohormones and organic substrates" by Flora Atoun and the "Stability

analysis of farmers preferred traits in a breeding population of *Gynandropsis gynandra* in Athieme, Benin" by Balbine Alindekon. Another MSc holder, Willbroad Doudou, explored the propagation modes affecting growth and development in the Sisrè berry plant under the topic: "Propagation modes affected the growth, development and fruit quality attributes in the Sisrè berry plant (*Synsepalum dulcificum*)".

The three recent BSc graduates conducted diagnostic studies on agricultural production systems. They respectively focused on cucumber production in Benin; strawberry cultivation at Décor jardin and grass growth in a photovoltaic system at the Bouzule farm, both in France.

2.2. Institutional capacity strengthening

2.2.1. Competency-based approach implementation for curriculum review

Through a competence-based approach, the curricula of the Faculty of Agricultural Sciences (FSA) training programs (specifically in Nutrition and Food Technologies and Plant Science) were improved to emphasize practical, hands-on learning experiences for students. This reform aims to better equip graduates with the skills and competencies required by the agricultural sector and related industries. The improved curricula are currently being implemented within the FSA, marking a major step forward in aligning academic training with real-world demands. Encouraged by this progress, the remaining departments are actively engaged in revising their own curricula to ensure coherence, relevance, and consistency across all programs offered by the Faculty.

2.2.2. First meeting of the VACS Amaranth Breeding team

As part of the Vision of Adapted Crops and Soils (VACS) initiative for Africa, the VACS Amaranth Breeding team held its inception meeting at the World Vegetable Center Eastern and Southern Africa at Arusha from 20th to 21st August 2024 (**Fig. 16**). The Genetics, Biotechnology and Seed Science (GBioS) of the University of Abomey-Calavi attended with the active participation of Dr Aristide Carlos Houdegbe. Dr Houdegbe gave a holistic view of the GBioS' Amaranth breeding program (**Fig. 17**). In addition, progress in Amaranth breeding at KALRO was presented by Dr Emerita Njiru and at the World Vegetable Center in Tanzania by Dr Fekadu F Dinssa. Dr Sognigbe N'Danikou gave an overview of the conservation of Amaranth genetic resources at the Genebank of the World Vegetable Center. During the two days, the ongoing breeding activities on amaranth in Tanzania, Benin and Kenya were discussed, and the work plan for the successful implementation of the VACS Amaranth breeding activities was developed. The VACS Amaranth Breeding Team is led by Dr Roland Schafleitner from the World Vegetable Center and Professor Enoch Achigan-Dako from GBioS of the University of Abomey-Calavi. The VACS Amaranth Breeding Team includes the World Vegetable Center, The Genetics, Biotechnology and Seed Science (GBioS) of the University of Abomey-Calavi (Republic of Benin), the Kenya Agricultural and Livestock Research Organization (KALRO – Kenya), the Tanzania Agricultural Research Institute (TARI - Tanzania).

Fig 16. *VACS breeding team partners in Arusha at the program inception meeting.*

Fig. 17*. Dr Houdegbe presenting GBioS research on Amaranthus at the VACS breeding meeting.*

2.2.3. Launching of the VACS Capacity building Project

From October 1st – 4th, 2024, two VACS scholars at GBioS, Mr Adegolou F.A. Latif and Pascal Agoligan, participated in the kick off meeting of the Vision for Adapted Crops and Soils Capacity Project at Gem Forest Hotel, Nairobi, Kenya (**Fig. 18**). They were among the 30 African scholars selected through a highly competitive process. The meeting began with a presentation by the Project Lead Prof. Julia Sibiya on an overview of the VACS Capacity Budling activities. This was followed by several sessions aimed at preparing the scholars on the next steps of their journey as student fellows. Participants were equipped with guidelines for preparing a sound plant breeding proposal, introduced to the advantages of the project and the key institutions—IITA, WACCI, and BecA-ILRI, serving as hubs to train and support the scholars throughout the program. Other sessions focused on "ongoing activities of VACS breeding teams", "gender responsiveness in the breeding of opportunity crops" and "integrating participatory plant breeding and seed systems". The planned research by the scholar were presented as posters with feedbacks and suggestions from representatives of the different hubs. The meeting was successful with a visit to the Biosciences eastern and central Africa–International Livestock Research Institute (BecA-ILRI) Hub, highlighting opportunities in gene editing, biotechnology approaches for crop improvement and the different units. GBioS is proud to announce that five of his members were selected as recipients of the VACS scholars and professional fellowships and five VACS scholars. The fellows are: Mrs Flora Atoun, Mr Christel Azon, Mr Soulemane Nouroudine, Dr Dèdéou Tchokponhoue and Dr Carlos Houdegbe. The VACS scholars included five PhD students: Mrs Pinawè C. Agbandou, Mrs Natacha J. Q. Zountounnou, Mr Kenneth C. Mkpuma, Mr Abdoul-Razak O. Mahamane, Mr Latif F. A. Adegolou and one Msc student Mr Pascal Agoligan. Mr Latif F. A. Adegolou and Mr Pascal Agoligan received full scholarships while others VACS scholars received partial scholarships. We wish success to all our scholars and fellows.

Fig. 18. *VACS scholars at Participation in the launching of the VACS Capacity Project in October 2024 in Nairobi, Kenya.*

2.2.4. “Crops that nourish” meeting at the Hopkins Blooming Center

Dr Aristide Carlos Houdegbe from the Genetics, Biotechnology and Seed Science Unit of the Department of Plant Science of the University of Abomey-Calavi is privileged to be one of the Vision for Adapted Crops and Soils (VACS) Fellows. As such, he participated in the meeting "Crops that nourish" at the Hopkins Blooming Center in Washington DC, United States of America from 10 to 11 October 2024 (**Fig. 19**). The meeting was co-hosted by CIMMYT, the US Department of State Office of the Special Envoy for Global Good Security, and Johns Hopkins University's School of Advanced International Studies and Institute for Planetary Health. The two days discussions were intense and rich around how to scaling diverse, nutritious and climate adapted opportunities crops on farms and plates for better nutrition and health.

Fig. 19. *VACS scholars at the “Crops that nourish” meeting at the Hopkins Blooming Center in Washington DC (10-11 October 2024)*

Keys outcomes included pathways to support effective and sustainable opportunities crops breeding and seed systems, value chains and market development, raising awareness, improving soil health but also to support environmental sustainability and nutrition, enabling policies and community engagement.

Dr Houdegbe had during the discussion shared stories from the Republic of Benin and met experts from all over the world. As VACS fellow, he envisions to understand consumer behaviour change, market development, breed and scale new multipurpose varieties of opportunities crops, and generate evidence-based knowledge to support policy makers decision. As networking is crucial in achieving VACS goals, the VACS fellows will have the support of all the participants from CIMMYT, Johns Hopkins University's School of Advanced International Studies and Institute for Planetary Health, Alliance Bioversity and CIAT and many more.

2.2.5. BOLDER genebanks workshop

Following the successful co-organization with Crop Trust and IITA, on 5th and 6th August 2024, of the BOLDER stakeholders' workshop in Benin by the Genetics, Biotechnology and Seed Science Unit (GBioS), a team of the same Unit also attended a follow-up workshop organized by the Crop Trust from 19th to 23th August 2024 in Nairobi, Kenya. GBioS was represented at this meeting by the CalaviGen (the University of Abomey-Calavi genebank) team composed of Ms Pinawè Agbandou, Ms Merveille Kamade and Dr Dèdéou Tchokponhoué. This workshop brought together the four genebanks involved in the implementation of the conservation activities, namely CalaviGen, the national Genebank of Ghana (Council for Scientific and Industrial Research - Plant Genetic Resources Research Institute, CSIR-PGRRI); the National Plant Genetic Resources Centre of Tanzania (NPGRC) and the Uganda National Genebank (UNGB). At this meeting, the BOLDER project's objectives, components, partner institutions, activities, and reporting and communication approaches were presented (**Fig. 20**) by the Crop Trust team. That was the opportunity for the participants to ask questions and get feedback.

Fig. 20. *BOLDER project presentation by Nora Castaneda-Alvarez. BOLDER national genebank inception workshop, Nairobi, August 2024.*

Then, each participating genebank presented its baseline conservation efforts with focus on the institutions highlights, the genebank team and major collections as well as the current collecting, regeneration, and safety duplication approaches. On this exercise, Dr Tchokponhoué gave an insightful presentation on the CalaviGen activities (**Fig. 21**). The content of its presentation triggered several questions that were answered through a second presentation (**Fig. 22**) on the successful implementation of a plant genetic resources collecting mission. Lastly, the participants visited the World Agroforestry Center (ICRAF) to discover the conservation activities being implemented by the institution genebank. Basically, their expertise is on tree conservation with their partners institutions in more than 30 countries around the globe.

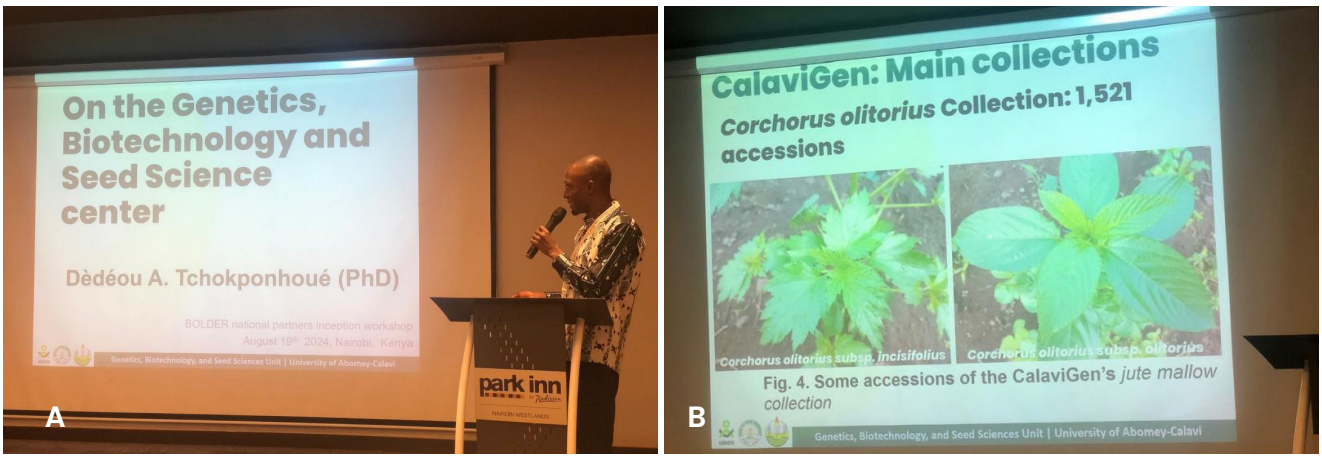


Fig 21. *GBioS introduction (**A**) and CalaviGen major collections (**B**) presentation by Dr Tchokponhoué. BOLDER national genebank inception workshop, Nairobi, August 2024.*

Fig. 22. *Dr Tchokponhoue's presentation on tips to succeed plant genetic resources collecting, BOLDER national genebank inception workshop, Nairobi, August 2024.*

2.2.6. African vegetables for improved household nutrition in West Africa

Enhancing the value of African vegetables and quality seeds is key to improving human nutrition and transforming the lives of communities in West Africa. The preservation and promotion of long-established vegetables, which are on the verge of extinction, are at the heart of the concerns of researchers and those involved in agricultural development. These healthy, locally-produced vegetables offer a viable solution for ensuring food security and improving living conditions for consumers in the region.

Researchers met from 4 to 6 June 2024 at the World Vegetable Center (WorldVeg) office in Bamako (**Fig. 23**) to take stock of the progress made in research on African vegetables, targeted by the BMZ-CGT (Choose, Grow, Thrive) project. The workshop was a platform for exchange and reflection on strategies to be adopted for better promotion and valorization of these valuable plant resources. Indeed, the overall objective of the BMZ-CGT project is to revitalize the cultivation of traditional African vegetables, often neglected but rich in essential nutrients in order to expand the food basket and combatting malnutrition in West Africa.

***Fig. 23**. Participants in the BMZ annual workshop in Mali, Bamako.*

During the workshop, the project team, in collaboration with all stakeholders involved, presented the progress made since the launch of the project in March 2021. They shared the research outputs and discuss the planning of the next steps. This workshop represented an important step to assess the impacts of the project and adjust strategies to maximize the benefits for local communities.

The University of Abomey-Calavi, through the Genetics, Biotechnology and Seed Science Unit (GBioS) of the Faculty of Agricultural Sciences, participated in this important activity as the implementing partner of the BMZ-CGT project in Benin. The results of the three years of implementation were presented, ranging from studies on the food and seed systems of African vegetables to

pilot interventions to improve vegetable consumption and citizen trials to introduce new varieties of okra, amaranth and jute mallow. In summary, the project in Benin (i) trained 05 MSc students, (ii) distributed 10,917 seed packs to 3,639 farmers over three years in four agricultural development hubs (ATDA1, 2, 5 and 7), (iii) trained 1,256 farmers, field agents and agricultural extension agents on healthy okra, amaranth and jute mallow production and high quality seed saving, (iv) developed one recipes booklet, 25 recipes videos and 03 vegetable and seed saving guide for okra, jute mallow and amaranth, and (v) trained 369 school kids and parents and canteen chefs in six primary schools and more than 150 female students from secondary school.

2.2.7. Benin National Academy Seminars

The Academy's Friday is a periodic scientific exchange session organized by the Benin National Academy of Letters, Art and Sciences to discuss research and development topics with potential societal impacts. Its session of 17 May 2024 entitled "Valorization of Egusi products and by-products in Benin" was animated by three speakers including Prof Enoch G. Achigan-Dako and Prof Fernande Honfo from the Faculty of Agricultural Sciences (**Fig. 24**)

Fig. 24. *Prof Fernand Honfo at the National Academy Seminars.*

During this session, which brought together a wide range of players including researchers, agri-food processing specialists, processor associations and many others, Prof Enoch Achigan-Dako spoke about the origin, diversity and systems of production and conservation of genetic resources, followed by the creation of egusi varieties in Benin. His presentation focused on the species that make up the goussi group, notably *Citrullus mucosospermus* Fursa, *Lagenaria siceraria* (Molina) Standl, *Telfairia occidentalis* Hook f. and *Cucumeropsis manii* Naudin. Local production systems for these species and efforts to conserve their genetic resources were discussed, and participants were given the opportunity to ask questions and receive answers. The meeting also provided an opportunity to clarify once again the difference between egusi and sesame, and to discover the nutritional importance of egusi, as well as a number of innovations. The session was very rich in exchanges and new knowledge, and participants felt they were better equipped thanks to the various presentations. Virginie Donadjè, a PhD student at Benin's National University of Agriculture and one of the participants, commented: "This session was very enriching, and the research results presented by the presenters have opened up new avenues of research for me".

2.2.8. African Orphan Crop Consortium (AOCC) phase II planning meeting

On October 12th 2024, Prof. Enoch Achigan-Dako took part in the AOCC Phase II Planning meeting at the World Agroforestry Center in Narobi (Kenya) **(Fig. 25)**. The meeting was moderated by Allen Van Deynze (Director of AOCC) and Tony Simons (Former Director ICRAF) and discussed the need for fundraising for nutrition and food security in Africa. Food insecurity can be equated with public health crisis and resources need to be mobilized to address it. According to Ibrahim Mayaki, AOCC is about full transformation of foods systems. He pledged to raised his voice to support AOCC in the ongoing post Malabo process. He remembered the audience that with applied science we can cope with our needs with regards to food systems. Dr Mayaki recognized that more plant breeders need to be trained for outstanding results. That is why he is extremely willing to be part of the resources' mobilisation movement. As coherence with all the approaches and ongoing actions is important, he call for more synergies among the initiatives. Coordination, coherence are two fundamental aspects. Dr Mayaki promised that AOCC as an instrument can be flagged in the post Malabo agenda. Participants explored innovative ways and messages to promote AOCC. While global perspectives should not be overlooked, participate encourage AOCC to continue mobilizing resources for professionals training as well as generating data and knowledge for African Orphan Crops. Trained people should be enabled to help coordinate movement and develop regional target for nutrition, climate resilience, food storage, post storage issue.

Fig. 25. *Dr Allen Van Deynze facilitating the AOCC phase II planning meeting in Nairobi (Kenya).*

2.2.9. African orphan crops consortium (AOCC) proof of concept

After a decade of implementation and training, 172 scientists representing nearly 40% women and 28 African countries have been empowered through the AOCC's African Plant Breeding Academy (AfPBA) in the use of genomics-assisted approaches to crop improvement. This important achievement was brought up by the AOCC-FAO workshop as a proof of concept, to demonstrate a model to leverage the outcomes of the AOCC consortium; to recognize the importance of AOCC being embedded in national agriculture strategies as an essential component of the transformation of food systems, and the magnificent, increasing, and unlimited stimulants that AOCC provides to the economic, social, environmental, and human development of the people of local communities, farmers, women, consumers, new businesses and to identify next steps and plans to take the essential elements of the AOCC model to the next level in African countries and elsewhere. The workshop was moderated by Ambassador Ya Olaniran, Permanent Representative of the Federal, Republic of Nigeria to FAO. Several speeches and keynotes were delivered by diverse speakers including Dr. Alice Muchugi (Team Leader, Biodiversity and Tree Genetic Resources, CIFOR-ICRAF), Professor David Savage (Professor of Biochemistry, Biophysics and Structural Biology, University of California Berkeley / Innovative Genomics Institute (IGI). Other speakers included Professor Hamadi Boga, (VP, Program Delivery, AGRA a) with his keynote address on "The Future of Science and Technology for Africa" and Dr. Howard-Yana Shapiro (AOCC founder) on his keynote presentation entitled "From the origins of the AOCC to the AOCC model and the unfolding movement in the fight for Nutritional Security across Africa".

In the "AOCC Proof-of-Concept in Action", Prof Enoch Achigan-Dako delivered two talks.

The first one was about a brief presentation by AfPBA Alumni on various collaborations developed with AfPBA colleagues and internationally, garnering millions of USD in external funding for R&D in shea, okra, tomato, sorghum, etc. as well as graduate-level training with numerous competitive grants for collaborative research and training involving a wide range of partners (>$10M). The second talk was related to AfPBA Alumni featuring shining examples of leadership in the scientific community, developing the private sector seed business in Zimbabwe, multi-disciplinary teamwork for finger millet improvement in Kenya, and graduate-level teaching excellence in Nigeria and Ghana (**Fig. 26**). Other important segments of the workshop included: i) Constraints Limiting Impact" led by Dr. Allen Van Deynze, Scientific Director AOCC, including AfPBA Alumni; ii) open talk by Heidi Kühn, Founder of Roots of Peace, and 2023 World Food Prize Laureate, on "Uniting efforts to restore and enhance food system productivity" iii) a panel discussion led by Dr. Tony Simons, former Director General of ICRAF, with audience participation to brainstorm regarding actions to support, extend, and amplify AOCC results and impact for farmers, women, consumers, new businesses going forward.

***Fig. 26**. Panel of AfPBA alumi speakers at the FAO-AOCC workshop in Nairobi.*

2.2.10. CRISPR Class II graduation ceremony

The CRISPR Class II graduation ceremony was a success. A total of 11 graduates were celebrated October 11, 2024 at CIFOR-ICRAF, Nairobi, Kenya. They came from Burkina Faso, Nigeria, Malawi, South Africa, Kenya, Ghana, Mozambique and Ethiopia. The ceremony was directed by Allen Van Deynze, Director, Seed Biotechnology Center, UC Davis. More than six speeches were delivered to recognize the relevance of the CRISPR courses, and to stress on the need to amplify that train for me inclusion across the continent. Prof Achigan-Dako, from the GBioS also gave a speech (**Fig. 27**) that revolved around setting the scene about the African context of lack of quality seeds for major and orphan crops, the urgency of looking for solutions to end hunger and malnutrition through more productive agriculture, the need to promote locally adapted crops and varieties that are climate-resilient. He took the opportunity to recognize on behalf of APBA the tremendous accomplishments of Rita, Allen, and Howard, for their faith in Africa, for their vision, and pragmatism in transforming capacity-building efforts. A few advices were offered to graduates before Prof Achigan-Dako thanked the Seed Biotechnology Center at the University of California, Davis, the Innovative Genomics Institute (IGI) at the University of California, Berkeley, CIFOR-ICRAF, and the International Institute for Tropical Agriculture (IITA). The following donors were recognized: Stephen M. Badger, Bayer, the US-based Foundation for Food & Agriculture Research (FFAR), the Grantham Foundation, Syngenta, and UM6P Ventures. Furthermore, we acknowledged the African Union Development Agency and the African Union for their ongoing support and alignment with these efforts.

***Fig. 27**. Prof Enoch Achigan-Dako addressing the participants during the Crispr training graduation ceremony.*

2.2.11. NAPB Borlaug Scholarship program to African students

On October 13th, 2024, renowned scientists from Africa and America met to profile a plan for the extension of the NAPB Borlaug Scholarship program to African students. The meeting held at the World Agroforestry Centre (ICRAF-CIFOR) was attended by Enoch G. Achigan-Dako (from the University of Abomey-Calavi, Benin) on behalf of the African Plant Breeders Association, Donn Cummings, Allen Van Deynze, Catherine Lang'at and Stella Salvo (Bayer Crop Science, Chesterfield, Missouri, USA) (**Fig. 28**). An introductory remark by Donn to set the scene and present the proposal. The objective of this scholarship is to expand the Borlaug scholarship program of NAPB to African scholars through the support and mentorship of APBA. This program is intended to give visibility to 4-6 African students, to mentor them and expose them to highly qualified breeding programs in Africa and elsewhere when possible. Target groups include students from sub-Saharan Africa, studying in Africa and holding a scholarship from intra-Africa mobility projects (e.g. EACEA, DAAD), VACS-Capacity building or any other scholarships that cover research work, monthly allowance, insurance in Africa. The program will initially focus on PhD students only. The NAPB Borlaug's scholarship will cover the participation of the beneficiaries to 2025 APBA Conference in Zimbabwe conference (locally supported by the student's training program or APBA), the participation in the 2026 NAPB Conference in Texas A&M in 2026. This is this a two-year long international scholarship, travel grant, professional development, and mentoring program based on experiential learning and relationship building. For the participation in the two conferences, the registration fees are free for the beneficiaries. Scholars are exposed to the world plant breeding community. The selection should be meritorious based. Enoch will lead the process on behalf of APBA. APBA as primary organization leads the process of soliciting and selection of qualified candidates from the target groups indicated above. This program starts as soon as possible immediately after the recruitment of the students. The students are expected prior to their participation in the 2025 Zimbabwe Conference to be offered a short-term experiential learning stay in seed companies in Zimbabwe. The President, Frank Magama, Tobacco Research Board and Edmore Gasura, Associate Professor, University of Zimbabwe (NAPB contact for ZPBA) of the Zimbabwe Plant Breeding Association (ZPBA) will be solicited to implement this process.

Fig. 28. *Pool of experts attending the meeting on the NAPB Borlaug expansion plan.*

2.2.12. Conversation about the Global Vegetable Biodiversity Rescue Plan

This conversation involved panellists such as: Cary Fowler, US Special Envoy for Global Food Security, Washington DC, (USA), a pioneer in biodiversity conservation with the Svalbard Global Seed Vault, and former Executive Director of the Global Crop Diversity Trust, he is the architect of the Vision for Adapted Crops and Soils (VACS), and World Food Prize Laureate 2024; Sarada Krishnan, Director of Programs, The Global Crop Diversity Trust, Bonn, Germany (Europe), supervises a team of scientists and project managers and plays a key role in implementing strategies to safeguard agricultural biodiversity; Enoch Achigan-Dako, University of Abomey -Calavi, (Benin, Africa), founder and head of the Genetics, Biotechnology and Seed Science Center (GBioS) at the University of Abomey-Calavi, and the Head of the Department of Plant Science at the Faculty of Agricultural Sciences; He is a former Director of the Plant Resources of Tropical Africa (PROTA) an alumni of the African Plant Breeding Academy of the University of California, Davis and a co-founder (and now Vice-President) of the African Association of Plant Breeders (APBA); Peter Wenzl manager of the Colombia genebank of the Alliance of Bioversity & CIAT where he coordinates efforts to harness crop diversity using genomics; Chutchamas Kanchana-udomkan, Kasetsart University, Bangkok, Thailand, a molecular breeder and passionate advocate for climate-resilient food security, she is an Assistant Professor in the Department of Horticulture of Kasetsart University in Kamphaeng Saen and Director of the Tropical Vegetable Research Center (TVRC), working closely with WorldVeg in Thailand (**Fig. 29**). The conversation was facilitated by Delphine Larrousse, Director Global Engagement, World Vegetable Center, Bangkok, Thailand) with a keynote address from Dr. Maarten Van Zonneveld, Head of the international vegetable genebank, which is hosted by the World Vegetable Center, in Taiwan. Maarten was Scientist in Plant Genetic Resources at Bioversity International and has working experience in the Americas, Africa and Asia. The panellists recognized Vegetable biodiversity as essential for enhancing climate resilience, ensuring balanced diets and reducing malnutrition worldwide. They emphasised on the importance of vegetables as a crucial source of income and livelihood opportunities, particularly for women and youth. However, without long-term conservation efforts, vegetable landraces and their wild relatives are at risk of being lost forever. Unfortunately, over 700 million of people are undernourished and hungry while Climate change is not improving agricultural productivity and we Need to feed 10 billion by 2050 in a context where some staple crops showing decline of 30%. Panellists reminded the Borlaug dialogue audience the advancements done on the Rescue Efforts in different parts of the world. These included the regional collaboration for collecting and safeguarding traditional vegetables (e.g. TAVI in Africa and TasVI in Asia) and the elaboration of the African Vegetable Biodiversity Rescue Plan, the seed dissemination interventions through citizen Science in pilot countries to promote African vegetables, the documentation of recipes of traditional African vegetables and the design of school feeding programmes in pilot countries to include production and consumption of traditional vegetables. The question that arose was how can these initiatives be scaled regionally, globally and to all kinds of vegetables? To meet that objective keys actions will include: 1) the long term conservation of genetic resources to facilitate the breeding of

suitable cultivars links to traits identified by consumers and farmers by utilisation of genetic resources from genebanks; 2) the development of seed systems with crop diversification as a core component, while identifying key bottlenecks of the industry for traits discovery; 3) the market development with the promotion of public awareness on vegetable diversity and importance of conservation. R&D on consumer preferences to define traits linked to consumer preferences. These actions will ultimately translate into more income generation for households for improved child education, reduced public health issues (heart diseases, diabetes, blood pressure, etc.), reduced malnutrition and stunting in children and women in reproductive age, recognition and valorisation of food culture, promotion of food diversity, cultural diets, preferences.

Fig. 29. *Participants (With Prof Enoch Achigan-Dako at right) in the Conversation about the Global Vegetable Biodiversity Rescue Plan*

The conversation happened in the framework of the annual presentation of the World Food Prize during the Norman E. Borlaug International Dialogue, a globally renowned high-level event focusing on cutting-edge issues in food security and agriculture. The Borlaug Dialogue gathers world leaders and top experts in development, agriculture, economic policy, resource management and nutrition – all inspired by the historic legacy of Norman Borlaug and the achievements of the World Food Prize Laureates in fighting global hunger.

2.2.13. Scientific writing workshop

Scientific publication is key for the visibility of GBioS. As new incomers and more and more students at various levels are joining the team, shaping their scientific writing skill has become of great importance to maintain the publication standards of the lab. To this, a near-live writing platform has been initiated to accompany the team members in their publishing journey: scientific writing workshop. In 2024, a total of six series were organized and witnessed the participation of more than 25 MSc, PhD candidates as well as researchers from the lab. The initiative has culminated with 21 scientific papers published, representing the highest number of manuscripts so far achieved in a single year by the team.

3. Communication, outreach, and valorization of innovations

3.1. Elaboration of the Atlas of edible wild plant relatives in Benin

Following the successful completion by the GBioS team of the "Atlas of cultivated plants of Benin", a book designed to contribute to the "Flora of Benin" structuring project (led by the Academician Prof Brice Sinsin), an invitation to develop a compendium on wild harvested vegetables was received. From March to December 2024, the GBioS team gathered information and pictures on 45 wild vegetables including *Ipomoeae aquatica*, *Vitex doniana*, *Passiflora foetida* (**Fig. 30**), among others. The team expect to report on nearly 100 species for the first volume of the complete document.

Fig. 30. *Some species being reported in the forthcoming Atlas of Wild harvested vegetables of Benin (Left: Vitex doniana; Right: Ipomoea aquatica).*

3.2. Development and amplification of agroecological practices

Agroecological practices are important in the global quest to implement sustainable, economically viable, environmentally friendly and nutritious agriculture. GBioS is also part of this global movement through the implementation of TAERA and AGRO ECO projects.

For the TAERA project, whose contract ended in June 2024, we organized two workshops to review and validate the six technico-economical leaflets (**Fig. 31**) two feedback workshops (**Fig. 32**) with producers from Mono and Couffo departments, two supervision missions to monitor students' research activities and a mission to capitalize on the project's achievements at the University of Abomey-Calavi.

Fig. 31. *Feedback workshop on technico-economical leaflets development, engagement with stakeholders for content validation*

The six technico-economical leaflets developed on rice and tomatoes were:

1) bacterial wilt in tomato: what do you need to know for successful participatory control?

2) varietal control in the agroecological management of bacterial wilt (**Kouyɔ** or **Dɔplɔyɔ**) in Mono and Couffo;

3) tomato-onion intercropping system in the ecological management of root-knot nematodes in tomato cultivation;

4) technico-economical reference on the sustainable production of rice IR 841 in a rotation system with mung bean (Vigna radiata);

5) technical-economic reference on the sustainable production of rice IR 841 in a rotation system with Mucuna (Mucuna pruriens); and
6) technical information document on the potential of new rice varieties for agroecological production in the Republic of Benin.

Fig. 32. *Feedback workshop on the experimental testing in farmer fields.*

With regard to the AGRO ECO project, field activities consisted mainly of scaling up the integration of mungbean into agricultural production systems in the Atacora department, the project intervention area, with the voluntary participation of 173 producers, who cultivated mungbean on 33.6225 ha. These fields of amplification of this agroecological practice (PAE) were monitored by field technicians through the collection of technical and economic data on mung bean production in the intervention environment. Data analysis is underway to highlight the economic profitability of implementing this PAE.

3.3. Visits and delegations

3.3.1. Visit of a Crop Trust delegation to the University of Abomey-Calavi

From July 10 to 12, 2024, the Genetics, Biotechnology and Seed Science Unit (GBioS) hosted a delegation of the Crop Trust for scientific and technical exchanges (**Fig. 33**). A visit that fosters collaboration and benefits both institutions through high-level exchanges on the safeguarding and utilization of genetic resources conserved at CalaviGen. The teams also discussed classical and certifying training programs, varietal selection pipelines, and seed dissemination to end-users.

On the first day of the visit, Nora P. Castaneda-Alvarez, coordinator of scientific projects at the Crop Trust, Janny van Beem, and Ms Juana Thimnu, expressed their appreciation for the skills and working facilities available at GBioS.

On the morning of Thursday July 11th, 2024, Dr Nora P. Castaneda-Alvarez, Scientific Project Coordinator at Crop Trust, accompanied by Dr Janny van Beem, Crop Trust Global Genebank Partnership Coordinator, Ms Juana Thimnu, Crop Trust Project Specialist and Professor Enoch G. Achigan-Dako, Director of the Genetics, Biotechnology and Seed Science Unit (GBioS) paid a curtesy visit to the Vice-chancellor of the University of Abomey-Calavi, Professor Felicien Avlessi. The visit aimed to introduce the Vice-chancellor to the Crop Trust team, who had come to assess and observe the work in progress at CalaviGen (the University of Abomey-Calavi genebank).

Professor Félicien Avlessi, Vice-chancellor of UAC, welcomed the team, underlining the importance of their visit to CalaviGen. Dr. Nora and her team Dr Janny Van Beem and Juana Thimnu also shared information on possible future collaboration with the University of Abomey-Calavi. Basically, this visit was a preparatory one for the launching of the upcoming BOLDER (Building Opportunity for Lesser-Known Diversity in Edible Resources).

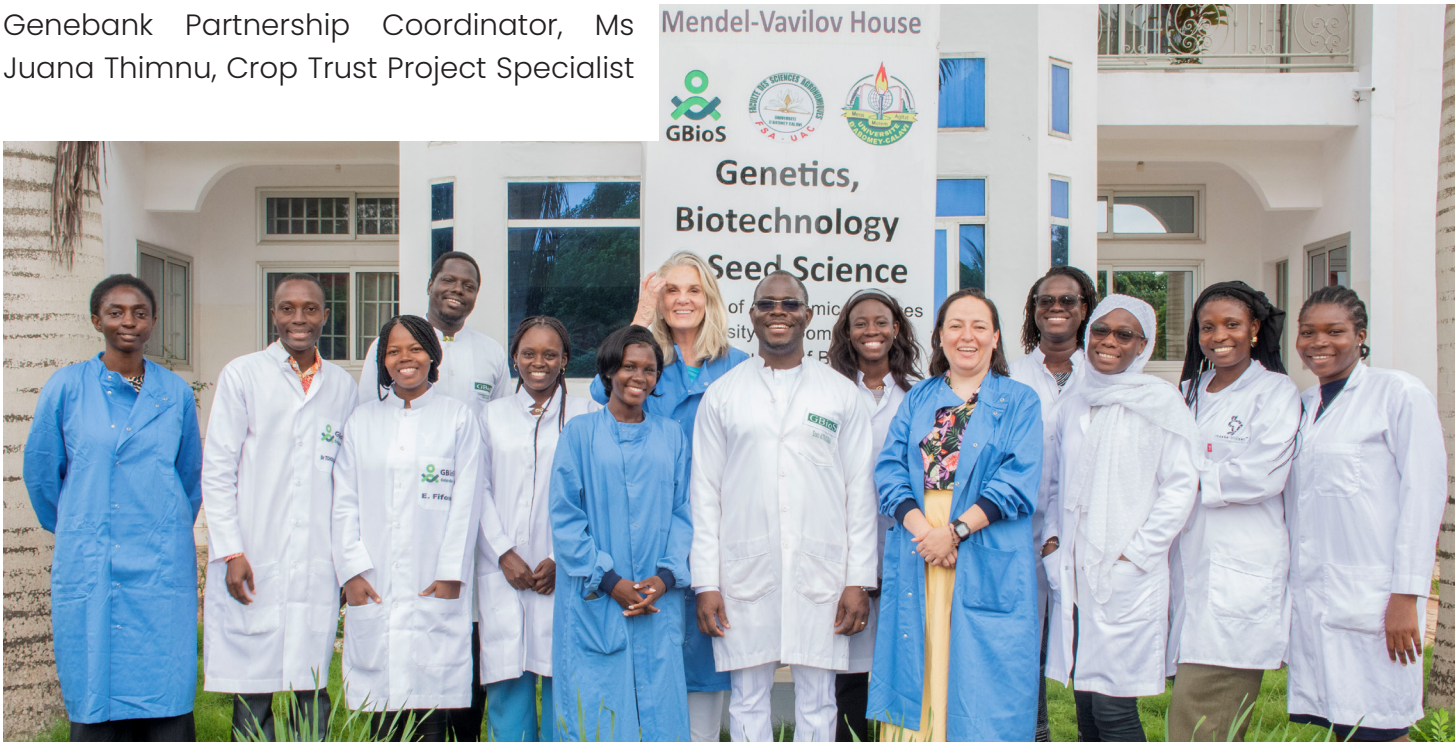


***Fig. 33**. Group photo during the Crop Trust team visit in Benin in 2024.*

3.3.2. Visit of the World Vegetable Center Board of trustes

In the framework of the 66th World Vegetable Center Board meeting in Benin at the West and Central Africa Regional Center (Abomey-Calavi) from 18 to 22 November 2024, the Board paid a visit to the GBioS Unit on Thursday, 21 November 2024 (**Fig. 34**). At the beginning of the visit, the General Director of WorldVeg, Dr Marco Wopereis, said GBioS is a strategic partner for WorldVeg's activities implementation in Benin. Led by the Founder and Director of GBioS, Prof Enoch Achigan-Dako, the Board members had the opportunity to visit the CalaviGen Platform, the Molecular Biology Lab, and other platforms. All the components of the CalaviGen, including the seed testing room, seed drying room, seed packaging room, seed sorting room and cold room were visited. After the lab tour, a short discussion was held between the Board members and the GBioS Director. An emphasis was made during the tour on the contribution of TAVI projects and other projects with WorldVeg in strengthening the Capacity of the CalaviGen in equipment acquisition and capacity building through the supervision of various students from diverse projects of World Vegetable Center. Other aspects included the implementation of various projects for new varieties dissemination.

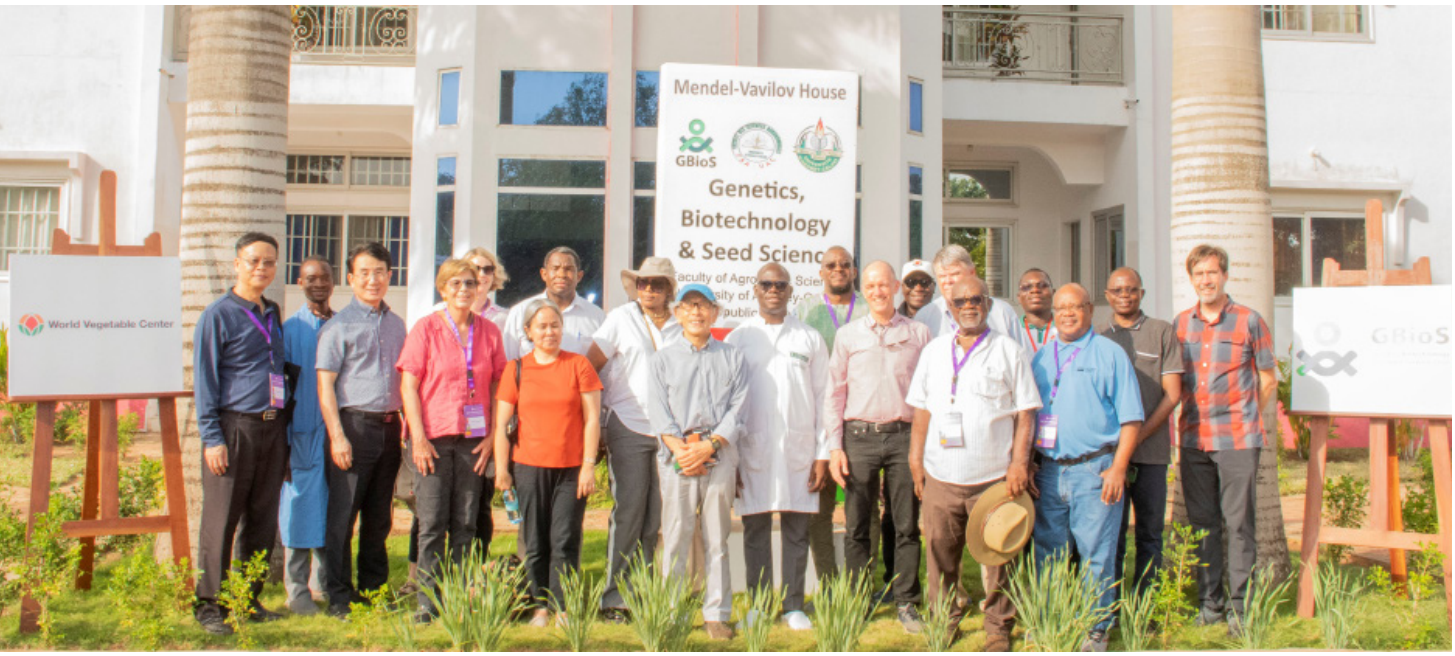


Fig. 34. *Visit of the World Vegetable Center Board to the GBioS Unit*

3.3.3. The World Vegetable Center's visit to CalaviGen

As a follow-up of the visit of the World Vegetable Center Board to GBioS on Thursday 21st November 2024, the genebank staff of the same institution also took a tour of CalaviGen, the University of Abomey-Calavi genebank. The objective of this tour was to have an updated overview of the progress made by the genebank and profile possible areas of future collaborations between the two genebank. This World Vegetable Center delegation was led by Dr Maarteen Von Zonneveld, manager of the World vegetable Center genebank in Taiwan (**Fig. 35**).

Fig. 35. A delegation of the World Vegetable Center visiting CalaviGen, the genebank of the University of Abomey-Calavi.

3.3.4. The Women's association of UAC at GBioS

The Genetics, Biotechnology and Seed Science Unit (GBioS) was pleased to welcome a delegation from the women's association of the Université d'Abomey-Calavi and COUS-AC (**Fig. 36**). The visit was part of the celebration of International Women's Rights Day.

The tour began with a welcome from the Dean of the Faculty of Agricultural Sciences, Professor Bonaventure Ahohuendo. A team from the unit then guided the delegation through the production farm as well as the technical platforms, in particular the gene bank and the molecular biology unit. The women had the opportunity to learn about plant genetic resource conservation activities and the DNA extraction and sequencing work carried out within the unit. At the end of the visit, they expressed their admiration. "It's remarkable work that's being done here. It's captivating, and the women of GBioS are an example of resilience," said Ms Yvette Ahoton Ganse, Administrative Secretary of CEBELAE.

Fig 36. A delegation of the Women's association of the University of Abomey-Calavi visiting the GBioS center

3.3.5 The West and Central African Council for Agricultural Research and Development at GBioS

The Genetics, Biotechnology and Seed Science Unit (GBioS) welcomed Dr Alioune Fall and CORAF's delegates (**Fig. 37**) in the framework of the 14th ordinary session of the General Assembly of the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) held in Cotonou from April 15 to 17, 2024.

This was a timely opportunity for GBioS to introduce to visitors its various facilities, including CalaviGen (the genebank of the University of Abomey-Calavi), the microscopy platform used for cytogenetics research and discoveries, and molecular biology and sequencing platform dedicated to genetics, genomics and plant breeding research.

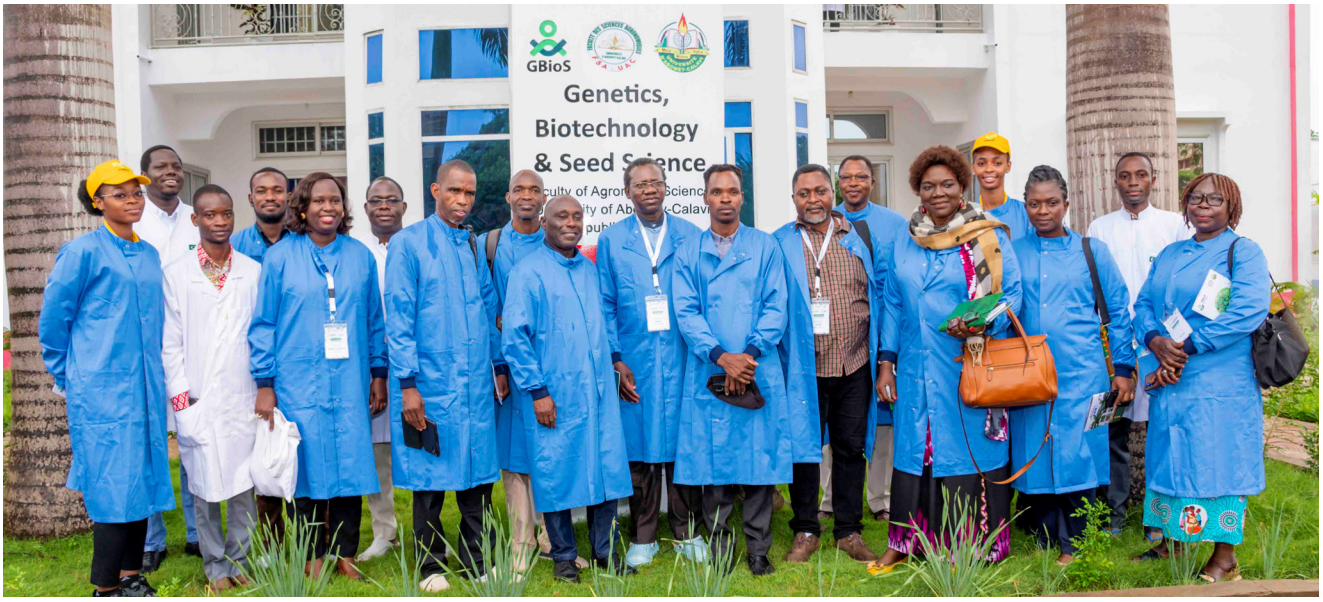


Fig 37. Visit of a Delegation of CORAF at the GBioS center.

3.3.6 The European Education and Culture Executive Agency at GBioS

The University of Abomey-Calavi welcomed a delegation from the intra-Africa academic mobility scheme team of the European Education and Culture Executive Agency (EACEA) for a courtesy visit to the Vice-Chancellor and his team (**Fig. 38**) and also to meet with Intra-Africa project management teams.

On Friday, October 25, 2024, the Vice-chancellor of the University of Abomey-Calavi, Prof. Félicien Avlessi, and the Vice-Rector in charge of international cooperation, Prof. Nelly Kelome, and Prof Victorien Dougnon, head of the cooperation-department, received the Intra-Africa team of the European Union (EU): Ms Elif Memis Marsman, Ms Alves Inès, Ms Wiebke Groth, and Ms Kateryna Shalayeva, as well as various coordinators of the Intra-Africa projects such as Prof Enoch G. Achigan-Dako, Prof Michel Dossou, Prof Pélagie Agbobatinkpo, Prof Nicodeme V. Fassinou Hotegni, and Prof Luc Hippolyte Dossa.

The meeting aimed to review the implementation of new and existing intra-Africa mobility projects, providing recommendations and clarifications on the rules and procedures for managing European Union funded projects. It was also an opportunity to discuss the results achieved and the impact of finalized projects: MoBreed and GENES, as well as ongoing projects: PATH, ORPHAN, GENES II, CareFoAfrica, Homegrown Clean Energy, and TAFSA. EACEA's Intra-Africa team had the opportunity to talk to the alumni of the various projects. Project progress, constraints, challenges, and prospects for offering more opportunities to students benefiting from the projects were discussed.

This discussion continued on GBioS premises with the Dean of the FSA, Prof Bonaventure

Fig 38. *Visit of a delegation of the European Union at the UAC vice-Chancellor office in the framework of the progress review on the EU-funded projects at UAC.*

Ahohuendo, and several professors from the Faculties of Agronomic Sciences (FSA), such as the Director of Doctoral School of Agricultural and Water Sciences Prof Marcel Houinato, Prof Pélagie Agbobatinkpo, Prof Nicodeme V. Fassinou Hotegni: Prof Florent Quenum, Prof Luc Hippolyte Dossa and Prof Enoch G. Achigan-Dako were present. Discussions were around the challenges encountered in managing the projects. These challenges included: budget management, language barrier faced by students, visa obtention by students etc.

During their tour of the GBioS Center, the EACEA Intra-Africa team visited GBioS technical platforms such as Molecular Biology, CalaviGen, Post-harvest, and the Microscopy lab.

3.4. Conferences and workshops organization

3.4.1 BOLDER stakeholders meeting in Benin

In the framework of the preparatory works to the inception of the Building Opportunity for Lesser-known Diversity in Edible Resources "BOLDER" project, the Genetics, Biotechnology and Seed Sciences Unit (GBioS) co-organized with the Global Crop Diversity Trust (Crop Trust) and the International Institute of Tropical Agriculture from August 5th to August 6th 2024, at Nobila Airport hotel, the Benin stakeholders consultation workshop (**Fig. 39**)

***Fig 39**. Group photo of the participants in the BOLDER stakeholders' consultation workshop in Benin (Cotonou, August 2024).*

The workshop brought together 68 participants from various stakeholders' groups including policy makers, consumers, genebank staff, researchers from university, national and international agricultural research centers, NGOs, farmers, processors, and chefs was dedicated to map the landscape of key actors interested in opportunity crops and to prioritize a total of four these opportunity crops that the BOLDER project could focus. Key activities of the workshop included three very enriching presentations, species and traits prioritization. In the presentations (**Fig. 40**) the need to change the paradigm on Neglected and Underutilized Species, which we must now perceive as opportunity crops because of their unique potential, has been highlighted. The realization of the opportunity crops' potential will leverage on several pillars including the conservation pillar, among others and deserve attention by the central government. Following the presentations, the mapping of stakeholders' groups involved in opportunity crops was conducted. At the end of the sessions, the four species prioritized by the stakeholders included fonio (*Digitaria exilis*), Sisre berry (*Synsepalum dulcificum*), Bambara groundut (*Vigna subterranea*) and Jute mallow (*Corchorus olitorius*). Various traits on interest were elicited by the participants and included for instance sliminess and leaf yield (in C. *olitorius*), Improved yield, resistance to lodging (in D. *exilis*), reduced cooking time, improved yield, low anti-nutritional factors (in V. *subterranea*) and pulp yield, fruit yield and increased miraculin content (in S. *dulcificum*). These traits will be further investigated by the research and capacity building teams of the project.

***Fig 40**. Speakers at the BOLDER stakeholders' consultation workshop. A) Prof E. Achigan-Dako, B) Dr. Dèdéou Tchokponhoué and C) Prof Nadia Fanou.*

3.4.2. Third African Conference on Precision Agriculture

From 3rd to 5th December 2024, the GBioS team represented by Dr Fassinou Hotegni Nicodeme participated in the third African conference on Precision Agriculture (AfCPA) held in Marrakech, Morocco (**Fig. 41**). The conference was organised and hosted by the African Plant Nutrition Institute (APNI) in cooperation with the University Mohammed VI Polytechnic (UM6P), the International Society of Precision Agriculture (ISPA) and the African Association for Precision Agriculture (AAPA).

The conference took place in a hybrid format with more than 100 participants in Marrakech, Morocco and nine in-person satellite sites scattered across North, West, East and Southern Africa. During the conference in Marrakech, Dr Fassinou Hotegni gave a presentation on the Intra Africa PATH project being implemented in Benin, Ghana, Rwanda and Eswatini with Morocco as associate partner and France technical partner as well as neem oil coated urea technology. He shared updates about the project with the participants and pointed out the urgent need of capacity building of youth on precision agriculture. This was emphasised by the high number of applications received after the call of PhDs and MSc applications in the framework of PATH. Questions related to the sustainability of the project along with the needs to have national agricultural research participating in the projects were asked. At the end of the conference, Dr Fassinou Hotegni was elected as President of the AAPA for a mandate of two years.

Fig 41. *GBioS Participating in the third African Conference on Precision Agriculture.*

The African Conference on Precision Agriculture (AfCPA) aims to bridge the gap between science and practice to advance precision agriculture across the African continent. The 2024 AfCPA was a multi-site event with the main site in Marrakech, Morocco, and satellite sites hosted in various locations, including the site satellite of the University of Abomey-Calavi, Abomey-Calavi, Republic of Benin. The event was hosted by the Genetics, Biotechnology and Seed Science Unit (GBioS) (**Fig. 42**).

Fig 42. *Group photo of participants and organizing staff at the AFCPA launch*

The event provided a platform for local and international stakeholders, scientists, policymakers, agronomists, and service providers to explore advancements in precision agriculture, share knowledge, and discuss strategies for enhancing the resilience and productivity of African cropping systems. The conference was both live at the site and virtually with some pre-recorded presentations. This hybrid setup enables participants both in-person and at satellite sites to engage in real-time discussion and for some of the speakers to share their contributions from remote places (**Fig. 43**).

Fig 43. *Live projection of remote sessions at the local satellite site*

Out of 60 registrants, 42 were selected based on three criteria: their ability to attend the conference physically in Benin, timely submission of the form, and the capacity of the conference room. The participants were predominantly men (67%) while women (33%) were the less represented gender. Majorly represented by Beninese (88%), participants came from diverse backgrounds including Benin (88%), Eswatini (5%), Burkina-Faso (2%), Ethiopia (2%) and Congo Democratic Republic (2%). All participants held university degrees and were majorly composed of MSc students, PhD students and research assistants. Only 18% of participants were part also part of the organizing committee.

3.4.3. Seed at the Heart of the Agroecological transition in West Africa

GBioS hosted from May 22 to 24, 2024, a workshop involving twenty-one actors (**Fig. 44**) of the West African agricultural sector to develop a consortium theory of change in the context of agroecology and agrobiodiversity in West Africa, with the financial support of Agropolis Fondation, CIRAD, AFSA (Alliance pour la souveraineté alimentaire en Afrique), COASP (Comité Ouest Africain pour les Semences Paysannes) and the Service de coopération et d'action culturelle du Bénin. The participants were composed of farmers' organizations, non-governmental organizations and research institutions. The objective was to develop the Seed at the Heart of the Agroecological transition in West Africa (SHAWA) dynamic by:

- collectively building a theory of change on strengthening farmer seed networks in West Africa, based on: (i) a shared vision of a desirable future, (ii) an analysis of the history of the farmer seed issue and its stakeholders, and (iii) a mapping of desirable medium-term changes (including obstacles, levers, strategies) in public policies, technical quality of seeds produced and made available, and capacity building and structuring of networks working on farmer seeds; and
- strengthening a collective involving a diversity of stakeholders (farmers' organizations, NGOs, research players) around farmers' seeds in West Africa, building a shared vision and moving towards joint action strategies, including collective responses to calls for projects.

The ImpresS ex ante approach used throughout the workshop was participative, iterative and adaptive. Following group works and plenary sessions facilitated by CIRAD's ImpresS team, participants agreed on a shared vision of farmers' seed systems to 2040 and identified three key areas for change, including: public policy and advocacy, quality and guarantee of farmers' seeds, and network structuring and capacity building. The theory of change developed during this workshop will serve as the basis for future call for proposals. The workshop ended with a presentation of the next steps in project writing, followed by an evaluation.

Fig 44. *SHAWA workshop participants, Abomey-Calavi, Republic of Benin.*

3.5 Participation in conferences and workshops

3.5.1. 16th International Conference on Precision Agriculture

From July 21-24, 2024 the GBioS team represented by Dr Nicodeme Fassinou Hotegni participated in the 16th International Conference on Precision Agriculture (ICPA) held in Manhattan, Kansas, USA. The conference gathered 430 attendees, with 293 oral presentations, 123 posters, and representatives from 40 countries. The event provided a platform to explore the latest advancements in precision agriculture and offered numerous networking opportunities. During that conference, Dr Nicodeme Fassinou Hotegni shared a panel on: Building a Collaborative Future: Enhancing ISPA's Global Presence and Regional Impact during which he shared his expectations for joining the International Society of Precision Agriculture (ISPA), his vision for the future of precision agriculture mainly in Africa and opportunities to value ISPA framework (**Fig. 45**).

Fig 45. *Overview of the ICPA conference (left) and panel discussion on Building a collaborative future with the participation of Dr Nicodeme Fassinou Hotegni (right)*

A presentation of the new intra Africa project PATH focusing on the capacity building of Young scientists in Precision Agriculture through intra Africa mobility was made with about 50 attendees. The conference was also an opportunity for Dr Nicodeme Fassinou Hotegni to attend capacity building activities in Agricultural Robotics and R Shiny. At the end of the conference, Dr Nicodeme Fassinou Hotegni was elected as African Representative of the ISPA board for a two-year term.

3.5.2. The seventh edition of Africa days

From June 26-29, 2024, under the auspice of the Crop Trust Prof. Enoch G. Achigan-Dako participated in the seventh edition of Africa Days organized by SOS Sahel and the Institut Français du Senegal, Dakar (Senegal). The event was graced by the representative of the ambassador of France who delivered a speech on her behalf. In essence the speaker recognized that agriculture is the basis of culture, food, our lifestyle; agriculture is also our job and the plants of the past are our history, they are our experiences. We should value them. On the mobilization day four high level panels were organized. Those panels included: Panel 1. Why Bring Neglected Crops to Current Food Systems? Panel 2. Is there a future for lost crops? Panel 3. What are the current initiatives on lost crops? This was followed by a round table to launch the African Crops Alliance with the participation of Fabienne Diouf, Managing Director and founder, FD & Partners; Aaron Adu, Managing Director, Global Shea Alliance; Abdourahmane Diop, Entrepreneur, Venture Builder, Impact Investor, Co-Founder and CEO of Haskè Venture Michel Ghanem, Founder of The Forgotten Crops Society, Senior Scientist CIRAD; Rémi Hémeryck, Executive Director, SOS SAHEL; Laura Layousse, General Director of CAA; Simballa Sylla, Entrepreneur, President of Sustainable African Foods; Pierre Thiam, Chef & Activist, Vice-Chair of SOS SAHEL USA.

Professor Achigan-Dako participated in the third panel of discussion of the mobilization day about the current initiatives on lost crops where he presented ongoing initiatives such as BOLDER of the Crop Trust (**Fig. 46**). The co-panelists included: Leena Koni Hoffmann, Associate Fellow, Africa Programme Chatham House, Board member of SOS SAHEL USA; Aboubaker Beye, Scientist, Professor at UCAD; Pierre Thiam, Chef & Activist, Vice-Chair of SOS SAHEL USA; Sibiri Traore, Country Lead, ICRISAT Senegal, Salimata Wade, Professor, Department of Animal Biology, Faculty of Science and Technology UCAD, Dakar. He also presented a talk on : Fonio (Digitaria exilis) production and utilization in Africa, state-ot-the-art during the working group session. The audience recommended the following actions:

- advocacy to develop clear valorization policies for fonio with emphasis on production; in the production areas, agricultural practices must be improved; policy reforms are requested to boost research and production of fonio;
- expansion of the production of fonio to other regions of countries where it is produced and integrate this into rotation cycles;
- development of a network of seed companies for the dissemination of fonio;
- breeding for traits of interest such as shattering, photoperiodism, flowering time, lodging, etc.

- sharing of knowledge on processing technologies. Processing is still a challenge in many countries. Improving the dehulling technology is critical.
- Development of fertilization scheme for fonio together with the density, the cultivation practices, the selection of cultivars, etc.
- the conservation of fonio genetic resources through regeneration, duplication of existing germplasms.

***Fig 46**. Enoch Achigan-Dako presenting a case about fonio at the 7th edition of Africa Days*

3.5.3. BOLD Media Event: celebrating crop diversity

From 24 to 25 September 2024, scientists and journalists met in Nairobi (Kenya) to celebrate crop genetic resources diversity conservation, availability and utilization. This event witnessed the participation of 14 journalists and 1 influencer (**Fig. 47**), including professionals working for international news agencies (Associated Press, Agence-France-Presse and Agencia EFE); international media related to science and development (Devex and SciDev.Net); Pan-African media (AllAfrica and AfricaReport) and Kenyan media outlets (e.g. The Daily Nation, and The Standard) and the Chief Communications Officer of the Crop Trust. Together with the journalist were scientists from institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Genetic Resources Research Institute Kenya Agricultural and Livestock Research Organization, the International Center for Agricultural Research in the Dry Areas (ICARDA), the Genetics, Biotechnology and Seed Science Unit (GBioS) of the University of

Abomey-Calavi (Benin), the Alliance Bioversity CIAT, the Seed Savers Network, Kenya. The main goal of the event was to inspire intermediate folks that can help raise awareness on the importance, challenges and opportunities related to crop diversity conservation, availability and use. We are aware that crop diversity is disappearing from our fields and natural habitats. It is also disappearing from genebanks, the institutions tasked with the job of keeping crop diversity safe over the long term. But the guardians of this global common good are fighting the good fight, determined to conserve and share this diversity. And farmers and scientists are using this diversity – including the so-called "orphan" crops that can be key to providing affordable, nutritious diets for all – to make sure the world's ever-growing global population can feed itself, today and tomorrow. Those initiatives should be disseminated to a larger audience. That is why this event was made possible thanks to the Biodiversity for Opportunities, Livelihoods and Development (BOLD) Project, a 10-year global effort that aims to strengthen food and nutrition security worldwide by supporting the conservation and use of crop diversity. Funded by Norad, BOLD is led by the Crop Trust in partnership with the NMBU - Norwegian University of Life Sciences and the International Plant Treaty.

Fig 47. *Visit of Kenya Agricultural and Livestock Research Organization (KALRO)*

4. Resources mobilization

4.1. BOLDER Conservation

Thanks to the conservation effort demonstrated by the GBioS team under the SAFE-PGR project funded by BOLD WP4, Crop Trust has extended its support to the genebank through its involvement in the Building Opportunity for Lesser-known Diversity in Edible Resources (BOLDER) work package conservation activity. In this three years new project, the genebank has an amount of USD 135,00 to improve the conservation profile of four priority opportunity crops in Benin. These crops included the Sisrè berry plant (*Synsepalum dulcificum*), jute mallow (*Corchorus olitorius*), Fonio (*Digitaria exilis*) and Bambara groundnut (*Vigna subterranea*). Key activities targeted by this conservation component of the BOLDER project included germplasm collecting, regeneration, characterization and duplication. Capacity building activities are also underseen to support the above-mentioned conservation activities.

4.2. BOLDER Capacity building

With its renowned expertise in scholars training on opportunity crops, the Genetics, Biotechnology and Seed Science Unit (GBioS) of the University of Abomey-Calavi has been spotted to host the BOLDER capacity building component in training four PhD students for West Africa in the domains of Plant breeding and Food systems. This initiative jointly led by the University of Abomey-Calavi and the Norwegian Life Sciences University (NMBU) will offer Benin and Ghanaian scholars the opportunity to contribute to improving the potential of two to four crops towards ensuring food and nutrition security.

4.3. BOLDER pilot TRICOT project

Giving the experiences of GBioS and World Vegetable Center on the implementation of citizen science trials through the triadic comparison of technologies (TRICOT) approach for on-farm participatory evaluation of improved genotypes for African vegetables under the BMZ CGT project, the World Vegetable Center was granted to pursue the scaling of the TRICOT in Benin, Ghana, Tanzania and Uganda through the project "Scaling tricot citizen science for farmer participatory variety evaluation to promote use of NUS germplasm". This is under the funding of The Norwegian Agency for Development Cooperation (NORAD), through the Global Crop Diversity Trust (Crop Trust). An initial 9 months pilot phase was implemented in Benin and Tanzania. GBioS was the implementing partner on jute mallow in Benin from August to December for a budget of USD 24,647. The next steps will be the implementation of TRICOT trials on select crops for Benin under the BOLDER project from 2025 to 2027.

4.4. VACS Amaranth breeding

As part of the Vision for Adapted Crops and Soils Breeding Consortium, the World Vegetable Center and the University of Abomey-Calavi through GBioS are leading the Breeding activities on amaranth, one of the seven target crops of VACS. For this, GBioS was granted USD 139,850 for the implementation of planned activities in Benin on Amaranth from October 2024 to June 2026.

5. Technical platforms

5.1. CalaviGen equipment and services

More than just a simple genebank, CalaviGen is positioned as a service provider as it comes to seed testing and phenotyping. The Genebank is now equipped with a Marvin Seed Analyzer, a high throughput phenotyping machine and Digital seed moisture analyzer, a magic device for a live seed moisture quantification. More than 10 seed quality traits including, seed length, seed width, seed sphericity factors among others can be assessed in a few minutes on an infinite number of seeds. We are improving the quality of our materials phenotyping for more accurate information to our end-users. For more information on our offers, please consult the genebank webpage at https://gbios-uac.org/calavigen/.

5.2. MoBLab equipment and services

The GBioS molecular biology platform (MoBLab) has a triple vocation: training, research and services. This platform hosted the practicals of Bachelor's and Master's students in Molecular Biology. It also received two interns from partner laboratories to strengthen their capacities on the use of equipment, analysis techniques in molecular biology. In terms of research, it supported the research work for the writing of end-of-year dissertations of Master's and Doctoral students who worked on understanding the molecular bases of plant growth and development for their improvement. This platform also supports all GBioS research programs in their various activities. It provides various DNA extraction, disease identification and molecular genotyping services to researchers from universities and research institutions. The unit, already equipped with high-performance equipment to carry out detailed molecular biology analyses, nucleic acid assays and quality controls for studies of host and/or pathogen gene expression, has strengthened its platform with the acquisition of Seqstudio in order to increase the range of services offered and the precision of the results delivered.

5.3. MMULab equipment and services

The Microscopy and Microanalysis platform (MMULab) of the Genetics, Biotechnology, and Seed Science Unit is one of the platforms dedicated to research, capacity building, and service provision to partners. These activities are made possible thanks to qualified personnel and the use of sophisticated equipment. The microscopy platform is equipped with several instruments, including magnifying glasses, standard microscopes, and advanced microscopes. Among the advanced microscopes, we have indicated the Olympus BX53, a high-performance upright biological microscope featuring UIS2 infinity-corrected optics, ensuring superior resolution and contrast. It supports multiple observation methods, including brightfield, darkfield, phase contrast, differential interference contrast (DIC), polarization, and fluorescence microscopy. Equipped with LED illumination, it provides consistent, high-quality lighting with adjustable intensity. The modular and ergonomic design of the BX53 allows for customization with motorized options, digital imaging systems, and Olympus software (cellSens) for advanced analysis. Its precise focusing system and

X-Y mechanical stage ensure smooth and accurate sample observation, making it ideal for research and industrial applications. The Zeiss Axio Imager M1 is a high-precision upright research microscope, designed for advanced fluorescence, brightfield, darkfield, phase contrast, DIC, and polarization microscopy. It features high-performance infinity-corrected optics (ICS) and apochromatic objectives, ensuring exceptional resolution and contrast. Equipped with LED or halogen illumination, it provides stable and adjustable lighting for various applications. The motorized focus and optional automated components enhance ease of use, while its ergonomic and modular design allows integration with digital cameras and Zeiss imaging software (AxioVision) for advanced analysis. Ideal for life sciences, material sciences, and research, the Axio Imager M1 ensures high stability, precision, and imaging flexibility. These advanced microscopes enable us to provide high-quality services to researchers and other professionals.

5.4. Postharvest platform and services

The postharvest platform is a platform meant to apply cutting-edge technologies to improve the mastering of postharvest-related issues faced by our crops. This platform led by Dr Fassinou Hotegni Nicodeme and operated by Dr Dèdéou Tchokponhoué has become fully operational in 2024 with its first activities being the freeze drying of the Sisrè berry fruit as well as of some yam samples for some students of the department of nutrition and food sciences. The platform aims to dive into postharvest biology science to deliver tailored solutions to various end-users interested in mankind the best uses of their agricultural products.

6. Ongoing projects

6.1. Projects technical note

6.1.1. AgroEco

The activities implemented in the framework of the AGRO ECO project in 2024 included:

1) the scaling up of mung bean (*Vigna radiata*) production on 33 ha to improve soil fertility, nutrition and income with the project support to 173 volunteer farmers (including 38% of women) from eight (08) villages from three municipalities (Bokoumbé: Koutchatawongou, Kountchougou, Koumaagou; Tanguiéta: Biacou, Kogniga, Wankou; and Natitingou: Tigninti, Kota) in the Atacora Department. This has been possible thanks to the engagemebt of eight field technicians in charge of monitoring the on-site impementation;

2) an inventory of agroecological practices and experiences in pest management in West Africa through a literature review on agroecological practices and experiences in the management of insect pests in West Africa, accompanied by a draft policy brief for decision-making on the agroecological transition in pest management;

3) the development of a tool for monitoring and evaluation of the agroecological transition at the territorial level, which will be tested in 2025 for validation;

4) the production of compost from local residual materials on the BAMA platform (Rural

Commune of Bobo-Dioulasso, Burkina Faso), a space for experiences sharing among local farmers as well as with young people looking for jobs, wishing to embark on composting as an income-generating activity, through a technico-economical evaluation. A total of 54 piles, each with a unit volume of 3.6 m³, or approximately 200 m³ of compost were made with two hundred and ninety-nine (299) bags for a weight of 14 tonnes 950 kilograms of conditioned compost on an expected production of 25.63 t; and

5) the inventory of proven agroecological practices implemented in Burkina Faso, which are categorized into two groups: (i) water and nutrient management, and the production of biofertilizers, including Biim de fiente (a liquid biofertilizer based on poultry droppings and water), the enriched substrate adapted for above-ground, the Zaïner (motorized Zaï), and fertineem (an organic compost made from neem pressing residues); and (ii) the control of crop enemies including Solnat Neem (a bio-repellent made from neem oil obtained after pressing the almonds, both an antifungal and an antibacterial, used in ecological or organic agriculture as a phytosanitary treatment for crops), FANKOODO (a bio-pesticide based on calcedrate, local basil, soap and water), the bio-growth activator based on moringa leaves, the liquid bio-pesticide based on chili pepper, garlic, papaya leaves and tobacco, cereal-legume crop associations, the improved traditional granary (GTA), designed with locally available materials and allowing seeds to be preserved; and the use of Roudou: traditional practice (DIOBASS).

6.1.2. BIOVALOR

In February 2024, during the BIOVALOR meetings, the project stakeholders received the ANR evaluators for a mid-term evaluation of the project (**Fig. 48**). The evaluators gave positive feedback on the implementation of the project and proposed actions for a better impact. On this occasion, the Biovalor Cluster was officially inaugurated on February 8th 2024 in the presence of three ministries of the Benin government, namely the Minister of Higher Education and Scientific Research, the Minister of Agriculture, Livestock and Fisheries, the Minister of Small and Medium Enterprises and Employment Promotion, and other authorities such as the Ambassador of the French Republic in Benin, the President of the University of Lorraine and the Director General of the Agro Montpellier Institute. In March, Biovalor participated in the Entrepreneurship Week in Benin which took place from March 27th to 30th, 2024 at the Palais des Congrès in Cotonou. On April 9th 2024, the project members welcomed Mr. Kossi Atchonouglo, IMPACT Project Coordinator, and Ms. Catherine SIGAL, Project Coordination Officer, from Togo, in Benin. On September 10th 2024, Biovalor also welcomed the visit of French senators who came to visit the winners of the Africa-France Academic Partnerships program (**Fig. 49**). From December 10th to 12th, 2024 at the French Institute of Benin, all the leaders of the projects supported by the PeA, as well as actors from the academic and research ecosystem, met for the first time for a rich program of round tables and workshops. It was a privileged moment of dialogue and reflection on current and future partnerships to respond to the new challenges facing African education, namely the professionalization of training, the development of high-level research, as well as the employability of young people in the service of a priority sector of the economy.

Fig 48. *Visit of ANR evaluators accompanied by Biovalor coordinators to the rector of the University of Abomey-Calavi.*

Fig 49. *Ms Stecyna Kiki presenting the Biovalor project to the French senators during their visit at the Faculty of Agricultural Sciences.*

6.1.3. PATH

The Capacity Building of African Young Scientists in Precision Agriculture Through Cross-Regional Academic Mobility for Enhanced Climate-Smart Agri-Food System "PATH" project aimed at (i) training 32 MSc and 12 PhD African scholars in PAAC to upgrade the continent's capability; (ii) building the capacity of 10 young African trainees and 10 staff in precision agriculture and entrepreneurship; (iii) improving PAAC and ICT4Ag curricula and research at the participating African Higher Education Institutions (HEIs) to address more efficiently the current challenges of agriculture and climate change; and (iv) developing a network of HEIs in Africa involved in Precision Agriculture Adapted to Crops (PAAC) research and training. PATH is implemented by a consortium of four African universities, namely University of Abomey-Calavi (Coordinating institution), the University of Rwanda (Rwanda), University of Cape Coast (Ghana) and the University of Eswatini (Eswatini), one European technical partner, Institut Agro Montpellier (France) and University of UM6P in Morocco as associate partner.

With a budget of 1,796,820 Euros, the project will last four years (2024 to 2027) and will ultimately increase the capacity of African HEIs to produce highly skilled young scientists to develop PAAC technologies for sustainable agri-food systems resilient to climate change in Africa. As outgoing students, the University of Abomey-Calavi will fill a quota of 2 PhD, 4 MSc, 2 Staff, 3 Trainees. Concerning the incoming students, the University of Abomey-Calavi through GBioS will host 3 PhDs, 8 MSc, 2 Trainees and 3 Staffs. Currently GBioS hosts 3 PhD, 4 MSc in the framework of this project. The project was launched on 17 June 2024 at Houdegbe room with the presence of the University of Abomey-Calavi authorities and the representative of the Ministry of Higher Education (**Fig. 50**).

***Fig 50**. PATH project launching at the Houdegbe Amphitheater of the University of Abomey-Calavi.*

6.1.4. GENES II

The GENES II (Mobility for Plant Genomics Scholars to Accelerate Climate-Smart Adaptation Options and Food Security in Africa II) project is an INTRA AFRICA mobility scholarship project funded by the European Union, which brings together six universities across three African regions, namely, Western, Eastern and Southern Africa and one technical partner from the European region. The universities involved in the consortium included the Ebonyi State University of Nigeria as coordination, the University of Abomey-Calavi (Benin), the Jimma University (Ethiopia), Egerton University (Kenya), University of Zimbabwe (Zimbabwe), North-West University (South Africa). The technical partner is the Wageningen University of Science (Netherland). This project was initiated to tackle the lack of a critical mass of trained graduates with knowledge in relevant areas such as genomics and digital technologies to mitigate the effects of climate change through the mobility scheme of plant genomics scholars to accelerate climate smart adaptation options and food security. The project's specific objectives are to i) train and build capacities of students, staff and trainees and ii) enhance the skills and competencies of students to ensure employability. The expected results from the project are i) capacity building of 64 African scientists comprising 12 PhDs, 32 masters, 10 trainees and 10 staff in genomic and digital technologies, specifically artificial intelligence and machine learning to accelerate crop improvement for climate change adaptation and mitigation; (ii) enhancement of the entrepreneurial skills of beneficiaries in agribusiness and enterprise management to enhance graduate employability; (iii) harmonization of academic programmes and research agenda to enhance research collaboration among African HEIs.

With a total budget of 1,796,820 Euros, the project will last four years from January 2024 to December 2027. The University of Abomey-Calavi through GBioS will host 2 PhD and 6 MSc students, 1 Staff and 2 trainees as incoming students in the framework of this project. Also, 2 PhD, 4 MSc, 1 Staff and 2 trainees will be provided by the University of Abomey-Calavi as outgoing students. Currently the two PhD and 1 MSc students are hosted by GBioS in the framework of the first call for application. The project was officially launched in July 2024 At Ebonyi State University (EBSU) of Nigeria (**Fig. 51**).

Fig 51. *GENES II project launching ceremony: Prof Happiness Oselebe handing a welcome gift to Mr. Christel Azon.*

6.1.5. ORPHAN

The Intra Africa ORPHAN project titled "Mobility for high skilled scientists and entrepreneurs on orphan crops in higher education for accelerated climate change solutions in Africa" funded by European Union intends to: 1) Train 12 high-profile PhD graduates, 32 MSc graduates, 10 academic staff and 10 trainees with skills in plant breeding, food technology and nutrition to address current and future challenges related to climate change and agrifood systems with a focus on promising orphan plant species of Africa; 2) Harmonize training programs and research agenda on the improvement of the value chain of orphan crops for food and nutrition security in Africa; 3) Enhance national –regional – international collaboration and programmatic agenda that promotes orphan crops research and training for agricultural innovations in Africa through cross regional mobility.

ORPHAN will be implemented from 2024 to 2027 by a team of five African universities including University Nangui Abrogoua and University of Zimbabwe (new to Intra-Africa mobility scheme) with Université Catholique de Louvain as technical partner. The other African consortium members include the University of Abomey-Calavi (Benin), Ebony State University (Nigeria) and Jomo Kenyatta University of Science and Technology (Kenya) (**Fig. 52**).

The University of Abomey-Calavi has to fill a quota of 2 PhD, 4 MSc, 2 Staff, 2 Trainees as outgoing students (Target group 1) and will receive 3 PhDs, 6 MSc, 2 Staff, 2 Trainees. Currently the GBioS on behalf of the University of Abomey-Calavi hosts 2 PhDs, 2 MSc. The project has been launched officially in Cote d'Ivoire on 27 August 2024.

***Fig 52**. Launching of ORPHAN project at the University of Nagui Abrogoua Côte d'Ivoire*

6.2. Project financial management

The 2024 year was marked by the active implementation of multiple research, development, and capacity-building projects at the GBioS laboratory (**Table 1**). These initiatives, funded by various national and international partners, have contributed significantly to the visibility and scientific impact of our institution.

The financial report herein provides a comprehensive overview of the use of resources allocated to each project during the year. It reflects the laboratory's commitment to sound financial governance, compliance with donor requirements, and the efficient use of funds in achieving the set objectives. The report also highlights key financial indicators, budget execution rates, and the overall coherence between planned activities and actual expenditures.

This document serves as an accountability tool and a reference for ongoing and future collaborations.

Table 1. Financial management record of all the projects ran by GBioS in 2024.

Project	Total Budget	Expenses until 31/12/2024	Planning over 2025	Project duration	Donor
AGRO ECO	€ 499 984,25	€ 472 650,31	€ 27 333,94	2019 - 2025	ARES (Belgium)
BIOVALOR	€ 3 180 000,00	€ 1 903 665,00	€ 2 749 226,68	2022 - 2026	AFD (France)
BMZ CGT	€ 123 508,00	€ 99 838,59	€ 23 669,41	2021 - 2024	World Vegetable Center
PATH	€ 1 796 820,00	€ 540 835,00	€ 357 575,00	2024 - 2027	European Union
GENES II	€ 293 376,00	€ 26 485,00	€ 61 620,00	2024 - 2027	European Union
ORPHAN	€ 379 647,50	€ 36 010,00	€ 101 340,00	2024- 2027	European Union
TAVI	8 182 207 TWD$	€ 8 240 030,00	-	2021 - 2024	World Vegetable Center
SAFE PGR	84795,23$	3221,17$	-	2022 -2024	CROP TRUST
E-ANACARDE	€ 500 000,00	€ 4 064,70	€ 73 453,22	2024 - 2029	ARES (Belgium)
BOLDER TRICOT	$24 647	$24 663	-	2024	World Vegetable Center

7. Outlook for 2025: GBioS Pewter Jubilee

Ten years ! In 2025 GBioS is celebrating ten years of existence, ten years of growth, challenges and development, but also ten years of development of human resources. Our ambition to become a center of excellence in the management and valorisation of plant genetic resources for improved nutrition and sustainable food security for local communities in West Africa resonates stronger and stronger. From 2025, GBioS will reinforce its objective to generate scientifically sound and economically acceptable and transferable technologies and innovations in the agricultural sector for sustainable livelihood in Africa. Clear emphasis will be put on the following actions: 1) safeguarding plant genetic resources for crop improvement and quality seeds dissemination to end-users; 2) generating pre- and post-harvest technologies to reduce losses for improved food security and nutrition; 3) improving the productivity of strategic and major crop species through the development of eco-friendly agronomic practices and higher yielding cultivars with improved quality traits; 4) improving the productivity of neglected crop species with high economic and nutritional value for local communities through development of improved varieties, formal seed supply systems, design of improved and resilient agronomic practices and development of value chains; 5) enhancing research and training activities and the valorisation of relevant knowledge and technologies through the creation of viable and innovative companies managed by young entrepreneurs for higher impacts in Africa; 6) increase the capacity of the Unit to mobilise funds through better collaboration and equitable partnerships; and 7) train a highly profiled young generation of scientists and professionals for addressing food and nutritional security issues in African countries. With three ongoing intra-Africa mobility projects funded by the European Union, our hope is to witness a stronger growth in human resources development. Our outputs indicators will be the number of master students graduated, the numbers of papers produced, the number of webinars, conferences, scientific discussion and training organized for specific target groups with focus on crops such as sesame, fonio, maize, bambara groundnut, peanut and egusi crops. The partnership with CIMMYT, the World Vegetable Center around the Vision for Adapted Crops and Soils (VACS) is expected to generate new knowledge and technologies for sesame and amaranthus, two key crops of that partnership. With Crop Trust and the University of NMBU our ambition to advance the knowledge on crops such as jute mallow, amaranthus, fonio is strong. The partnership with the Crop Trust carries another important milestones: advancing the quality management system information and documentation of GBioS. This will be one of the major progresses expected for 2025!

8. Acknowledgements

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 2024. 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!