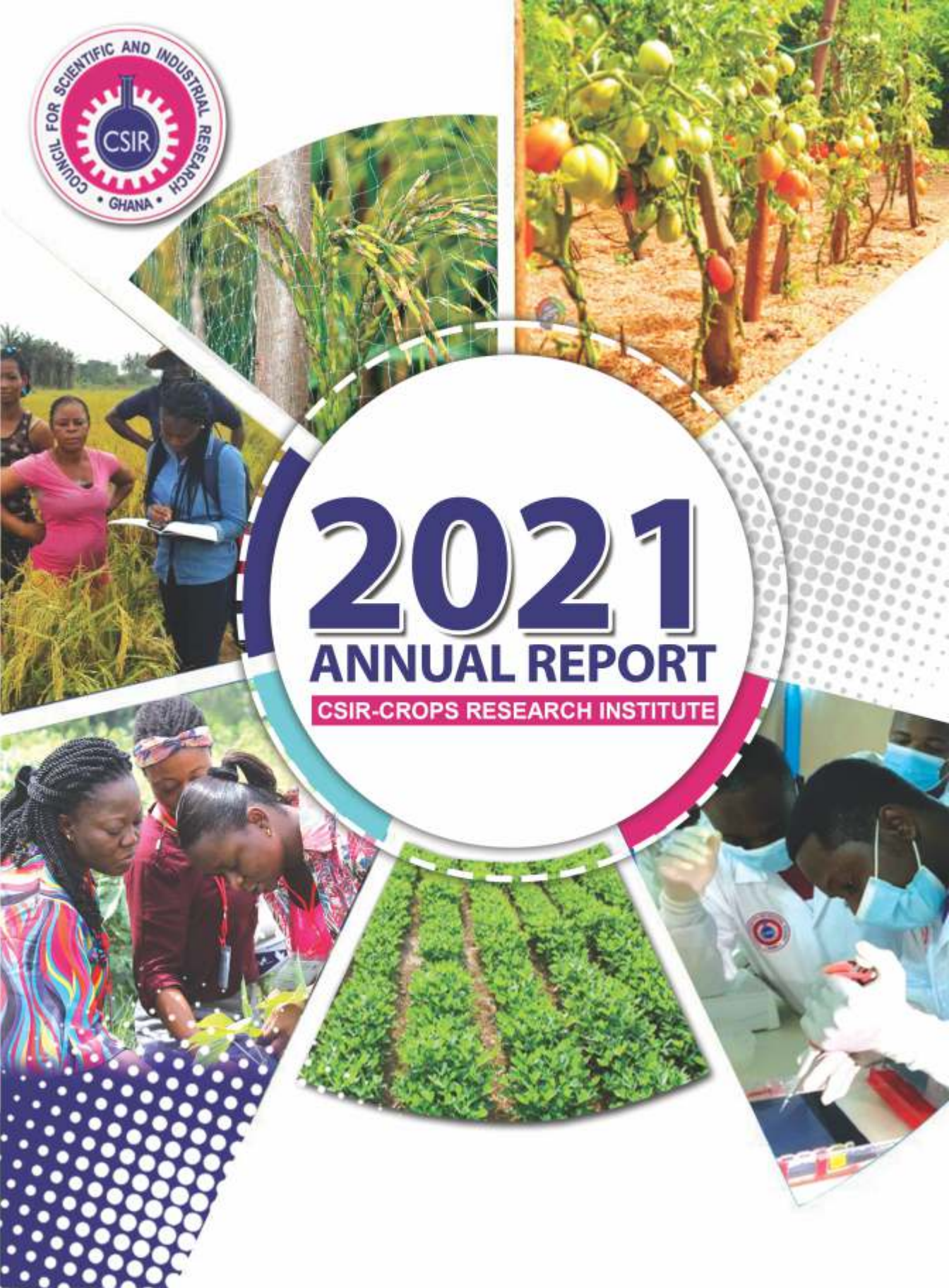

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CSIR-CROPS RESEARCH INSTITUTE

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ACRONYMS

AATF	African Agricultural Technology Foundation
ABBC	Africa Biennial Biosciences Communication
ACMV	African Cassava Mosaic Virus
AEAs	Agricultural Extension Agents
AGG	Accelerating Genetic Gains
AGRA	Alliance for a Green Revolution in Africa
ARS	Agricultural Research Service
AU	The African Union
BCR	Benefit Cost Ratio
BMGF	The Bill & Melinda Gates Foundation
CABI	Centre for Agriculture & Biosciences International
CCST	CSIR College of Science and Technology
CGD	Context Global Development
CGIAR	The Consultative Group on International Agricultural Research
CIAT	The International Centre for Tropical Agriculture
CMD	Cassava Mosaic Disease
CMV	Cassava Mosaic Virus
CORAF	West and Central African Council for Agricultural Research and Development
DNA	Deoxyribonucleic Acid
EACMV	East African Cassava Mosaic Virus
EBCA	Enhancing Breeding Capacity in Africa
EiB	Excellence in Breeding
EU	The European Union
FCR	Food Conversion Ratio
FDA	Food and Drugs Authority
IFAD	International Fund for Agricultural Development
IGF	Internally Generated Funds
IITA	International Institute of Tropical Agriculture
KAFACI	Korea-Africa Food and Agriculture Cooperation Initiative

ACRONYMS

KOPIA	Korea Program for International Cooperation in Agricultural Technology
MAG	Modernizing Agriculture in Ghana
MOFA	Ministry of Food and Agriculture
NBSSI	National Board for Small Scale Industries
NGO's	Non-Governmental Organizations
NVRRC	The National Varietal Release and Registration Committee
OPV's	Open-Pollinated Varieties
PAIRED	Partnership in Agricultural Research Education and Development
PAULESI	Pan African University Institute of Life and Earth Sciences
PCR	Polymerase Chain Reaction
PFJ	Planting for Food & Jobs
PR	Public Relations
RYMV	Rice Yellow Mottle Virus
SGR	Specific Growth Rate
TIBS	Temporary Immersion Bioreactor System
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VAD's	Vitamin 'A' Deficiencies
WACCI	West Africa Centre for Crop Improvement
WAVE	West African Virus Epidemiology
WFP	The World Food Programme
WIAD	Women in Agriculture Development
YIIFSWA	Yam Improvement for Income and Food Security in West Africa

FOREWORD

Greetings

We are pleased to present a brief summary of our research activities for the year 2021. Following from the year 2020, which was very challenging as a result of the covid-19 global pandemic, the year 2021 was also a very difficult one even though covid-19 restrictions and protocols had minimized comparatively. Notwithstanding the difficulties, we continued to engage in several research activities, mostly based on our mandate crops such as cereals, legumes, horticultural crops, tropical fruits and vegetables, roots and tuber crops as well as industrial crops.

We ensured that all research activities undertaken led to an increase in agricultural productivity and improved the lot of our stakeholders and the general public. We worked to ensure that all activities realized the maximum impact and yielded positive results. An indispensable part of research is funding. With no support from the Government of Ghana, we continue to fund all our research activities with donor support. We are eternally grateful to all our sponsors and partners for their continuous financial support. We would literally have nothing to report on but for their support.

We believe the quality of our very qualified and overly dedicated human resource has always been a major contributing factor in our success. Nonetheless, we keep encouraging staff members to build their capacities through further training. Additionally, the Institute continues to make training opportunities available to all staff . We continue to improve on our existing infrastructure as well as increasing commercialization activities in order to generate more internally generated funds (IGF) to complement dwindling donor support.

We are eternally grateful to all those whose contribution, support and criticisms have brought us this far. Our appreciation also goes to our very hardworking and committed staff for enduring the long hours in the offices and on the fields. Together we've made progress towards attaining our vision and we hope to continue working hard as we take advantage of every opportunity presented to us.

Thank you.

ACKNOWLEDGEMENTS

The successes we continue to chalk daily are the result of a combination of several factors. We owe a debt of gratitude to all the groups, institutions and individuals who have contributed in diverse ways to make them possible. To you, we say a huge "Thank You" and we continue to pray that the coming years bring us even more successes together.

We're eternally grateful to our partners, collaborators, and donors for sticking with us through it all despite the difficulties that the covid-19 pandemic brought on global economies. It is our hope that our various partnerships will continue long enough so we achieve our different aspirations. In 2021, we were blessed to receive support from partners such as HarvestPlus, the Accelerating Genetic Gains in Maize (AGG) project, Korea Program for International Cooperation in Agricultural Technology (KOPIA), the Enhancing Breeding Capacity in Africa (EBCA) project, the Excellence In Breeding (EiB) project, the International Fund for Agricultural Development (IFAD), OCP Africa, the Bill and Melinda Gates Foundation (BMGF), the Yam Improvement for Income and Food Security in West Africa (YIIFSWA), Korea Africa Food and Agriculture Cooperation Initiative (KAFACI) and the Modernizing Agriculture in Ghana (MAG) secretariat, Solidaridad, the Centre for Agriculture and Bioscience International (CABI), the Alliance for a Green Revolution Africa (AGRA), the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT), the African Agricultural Technology Foundation (AATF) among many others.

Collaborating with "sister" CSIR institutes as well as other universities, non-governmental organisations (NGOs), civil society, farmer groups, ministries, and other research institutions has played a key role in advancing our cause. Our immense appreciation goes out to all such institutions for their cooperation.

Finally, what can we say to our most dedicated and committed scientists, technical and support staff who continue to work tirelessly to produce all the outputs and achieve all the targets that we're so proud of. We say a big "ayekoo" to you all. Here's to many more fruitful years ahead.

God richly bless us all.

OUR PROFILE

Established in 1964, the CSIR-Crops Research Institute (CSIR-CRI) is the largest of the thirteen (13) institutes of the Council for Scientific and Industrial Research (CSIR) of Ghana and is the foremost national science and technology organization in Ghana. The Institute provides innovative research and research-related services to the general public as well as other institutions.

The CSIR-CRI's mission is to develop and disseminate demand-driven technologies and build capacity for sustainable food and industrial crop productivity, with the vision to become a Centre of Excellence for agricultural research, innovation and capacity building for development.

The Institute's core mandate is to conduct research and develop improved varieties of food and industrial crops and their production technologies in order to enhance food security and eventually leading to poverty reduction. The relevant crops include: legumes (cowpea, soybean, groundnut, canning beans and bambara groundnut), cereals (maize and rice), roots and tubers (yam, cocoyam, cassava, taro and sweet potatoes), vegetables (pepper, garden eggs, tomato, onion, and leafy vegetables), tropical fruits (citrus, mango, avocado, cashew, pineapple, and pawpaw), and industrial crops (rubber and sugarcane).

With values such as Excellence, Fairness, Commitment, Transparency, Accountability and Teamwork at the heart of its operations, the Institute aims to

- develop and disseminate appropriate technologies that are demand driven and acceptable to end users.
- promote and strengthen strategic partnerships with relevant stakeholders to enhance the generation of solutions to challenges in agricultural research, technology development and transfer.
- improve institutional capability to undertake effective research and service delivery to enhance agricultural productivity.
- enhance research and technology delivery through efficient mobilization and management of funds
- improve the management and operating procedures and systems as a means of ensuring efficiency in research delivery.

In addition to its core mandate, the Institute also offers several services to various stakeholders. These include but are not limited to the production of breeder seeds for the National Seed Industry, the supply of healthy planting materials of citrus, avocado, mango, plantain and banana, the development of crop varieties for food and industrial uses, the establishment of farms (tree crop plantations), the integrated management of crop diseases and pests (including weeds), the production of extension materials and advise on the use of appropriate experimental designs for field studies.

EXECUTIVE SUMMARY

The 2021 annual report for CSIR-CRI is a summary of several of the Institute's achievements within the calendar year. It is our sincere hope that we continue to chalk more successes in the coming years.

Coming right on the heels of the covid-19 pandemic, the year 2021 was quite challenging as the world was still getting used to all the restrictions and protocols the pandemic came along with. Selected activities and engagements were held in-person with restrictions, but several other activities and stakeholder engagements were executed virtually.

With funding from HarvestPlus and the Accelerating Genetic Gains in Maize (AGG) project, five high yielding hybrid maize varieties were developed and released onto the market. The varieties are rich in vitamin "A" and tolerant to Striga. Additionally, two new tomato varieties were released with support from the Korea Program for International Cooperation in Agricultural Technology (KOPIA) Ghana Center. The varieties are high yielding and resistant to blight. This is the first open-pollinated tomato varietal release in Ghana.

The Institute is making significant progress in integrating molecular markers into rice breeding. With the support of the EBCA and Excellence In Breeding (EiB) projects, the Institute has fully incorporated the use of DNA markers using high throughput genotyping faculty, Intertek as a source provider. This makes selection of the best lines very accurate and hastens the breeding of superior rice varieties.

With funding from the Bill and Melinda Gates Foundation (BMGF), the Yam Improvement for Income and Food Security in West Africa, Phase II (YIIFSWA II) project which is aimed at transforming the formal seed yam system in Nigeria and Ghana led to the production of several planting materials. In all, a total of 11, 288 plantlets were cultured in-vitro using the TIBS while another 3, 567 yam plantlets were also hardened in the screenhouse. Additionally, 3,108 plantlets were multiplied onto vivipak from seven varieties whereas 2,100 tissue culture derived seedlings in VIVIPAK were supplied to various clients. Additionally, the Modernizing Agriculture in Ghana (MAG) project, led to the production of several acres of planting materials for cassava, rice, taro, yam and groundnuts. Three hundred (300) cassava samples were also indexed for the cassava mosaic virus disease (CMD). Numerous stakeholders have also been trained on appropriate management practices for producing several crops.

The Institute continues to engage stakeholders in both traditional and new media outlets. New media outlets such as Facebook, Instagram, Twitter and the Institute's website continue to serve as avenues for disseminating information to stakeholders. These have all contributed to an increase in the Institute's visibility. The online television platform, CRI-TV, which was set up in 2020 continues to provide excellent content on research and development from the CSIR-CRI and other research institutes.

The Africa Biennial Biosciences Communication Symposium (ABBC 2021), honoured Professor Marian Dorcas Quain, a Chief Research Scientist of the Institute for her commitment to the development of biotechnology in Africa. Prof. Quain is a renowned biotechnologist who has worked on numerous crops with focus on the utilization of tissue culture for production of clean planting materials.

Staff attrition continues to be a major challenge the Institute faces. This has caused a major decline in staff strength.

The Institute continues to engage in various commercialization activities in order to generate funds internally. The production and onward sale of planting materials is the major component of the Institute's commercialization activities.

As members of the scientific and academic community, staff of the Institute continue to make their research findings available to the public by regularly publishing in peer-reviewed journals. In 2021, the Institute recorded over one hundred publications. These comprise refereed journal papers, conference papers, manuals, production guides, books, book chapters, posters, and technical reports.

01 DR. MAXWELL DARKO ASANTE APPOINTED DEPUTY DIRECTOR OF CSIR-CROPS RESEARCH INSTITUTE

Plate 1:*Dr. Maxwell Darko Asante, Deputy Director, CSIR-CRI*

The CSIR-Crops Research Institute appointed Dr. Maxwell Darko Asante, a Principal Research Scientist and a rice breeder at the Institute as its new Deputy Director, with effect from 1st January, 2022. Dr. Asante replaced the then Deputy Director, Prof. Marian Dorcas Quain whose two-year tenure came to an end on 31st December, 2021.

As Deputy Director, Dr. Asante is responsible for all aspects of the technical components of the Institute. He also works closely with the Director in implementing the Integrated Agricultural Research for Development thrust of the Institute's strategic plan. He assists the Director in the preparation of yearly budgets and procurement plans and also chairs the Intellectual Property and Editorial Committees of the Institute. Dr. Maxwell Asante also monitors and evaluates the affairs of all the Institute's outstations.

Profile

Dr. Maxwell Darko Asante obtained a B.Sc. (Agriculture) degree and a Diploma in Education from the University of Cape Coast in 1998. He also obtained an M.Sc. (Plant Breeding) from the Kwame Nkrumah University of Science and Technology, Kumasi in 2004 and a Ph.D. (Plant Breeding) from the West Africa Centre for Crop Improvement (WACCI), University of Ghana, Legon in 2012.

As the lead lowland rice breeder at the Institute, Dr. Asante has contributed to the development and release of fifteen (21) rice varieties; eleven of them as the lead breeder. These varieties are currently being grown on farmers' fields across the country and contributing immensely to Ghana's efforts at becoming sufficient in rice production. His research has mainly been on the genetics of rice characteristics including grain quality, yield component traits, biotic and abiotic stresses.

He is leading the breeding modernization effort at the CSIR-CRI and was recently appointed by the CGIAR Excellence in Breeding (EiB) programme as a consultant to help modernize breeding programmes in Ghana and some African countries. Additionally, he is currently leading efforts at developing the next generation of high-yielding, fragrant rice varieties which are tolerant to rice yellow mottle and blast diseases and have other consumer-preferred grain qualities.

Dr. Asante has attracted over US $1.5 million from various donors for his projects and has served as the Principal Investigator for several rice projects in Ghana. These include projects funded by USAID, BMGF, AGRA and KAFACI. He received the Presidential Award for National Best Agricultural Scientist at the 2018 National Farmers' Day and was also adjudged the overall best scientist at the CSIR-CRI in 2017.

Plate 2: *Dr. Maxwell Asante in a CRI rice field*

Dr. Asante has travelled extensively and has attended several conferences, workshops and training programmes in many countries around the world. He was a visiting scientist at the Department of Plant Breeding & Genetics, Cornell University and the USDA, ARS-Dale Bumpers National Rice Research Center, USA in 2006 and 2011 respectively.

He has authored and co-authored over sixty (60) scientific publications comprising refereed journal papers, book chapters and conference papers including publications in highly-rated international journals. Additionally, He has trained about 100 interns and students and is currently supervising ten graduate students studying at various universities on the African continent.

He is a Senior Lecturer at the CSIR College of Science and Technology (CCST) and a Guest Lecturer at the Pan African University Institute of Life and Earth Sciences (PAULESI) University of Ibadan, Nigeria. Dr. Asante is Ghana's representative on the African Rice Breeders' Task Force. He is a member of the Ghana Science Association and the immediate past President of the CSIR-CRI branch of the Research Staff Association of Ghana. He is a dedicated Christian and married with three kids.

02 HIGH-YIELDING HYBRID MAIZE VARIETIES RELEASED BY CSIR-CROPS RESEARCH INSTITUTE

Sponsors: HarvestPlus/Accelerating Genetic Gains in Maize (AGG) project

In response to Ghana's challenge of lack of enough high-yielding hybrid maize varieties, five (5) high-yielding hybrid maize varieties developed by scientists from the CSIR-Crops Research Institute, have all been approved and recommended for release onto the market by the National Varietal Release and Registration Committee (NVRRC) of Ghana. The varieties, which will have now been gazetted by the National Seed Council are the result of several years of extensive on-station and on-farm trials by the Institute's maize breeding team led by Dr. (Mrs.) Priscilla Francisco Ribeiro, the first female maize breeder at the CSIR-Crops Research Institute with funding from HarvestPlus and the Accelerating Genetic Gains in Maize (AGG) project.

Three of the varieties, are intermediate-maturing, pro-vitamin "A" hybrids with potential yield ranges of between 6.7t/ha-8.1t/ha. One of the varieties is the first early maturing (85-90 days) pro-vitamin "A" maize hybrid released in Ghana and is also tolerant to Striga, the most dangerous weed to maize.

Consumption of pro-vitamin "A" varieties will fight against vitamin "A" deficiencies (VADs) which expose humans to severe health implications such as growth retardation, a weakened immune system, night-blindness and pre-dispose children to several diseases. In Ghana, 72% of children under age 5, are affected by VADs resulting in 17,200 deaths annually. The high prevalence of VADs in Ghana is partly

attributed to low bio-available vitamin "A" in the predominant cereal, root and tuber crop-based foods consumed by adults as well as infants. Given same labour and cultivation costs, hybrids usually yield higher than the more common open-pollinated varieties (OPVs) farmers usually grow.

Research Team: *Priscilla Francisco Ribeiro (PhD), Allen Oppong (PhD), Stephen Yeboah (PhD), Charles Afriyie-Debrah (PhD), Kennedy Agyeman (PhD), Mrs. Zipporah Appiah-Kubi, Mr. Emmanuel Adjei Asamoah, Hillary Mireku Botey (PhD), Felix Frimpong(PhD), Francis Amoako-Andoh(PhD), Harry Okyere (PhD), Mrs. Faustina Okyere, Ruth N. A. Prempeh (PhD), Jonas Osei-Adu (PhD), Patricia P. Acheampong (PhD), Joyce Haleegoah (PhD), Mrs. Lydia Brobbey, Mr. Elvis Obeng-Agyei, Ms. Gloria Adu Boakyewaa, Manfred B. Ewool (PhD), Harriet Dwamena, Eric Owusu Danquah (PhD), Bernard Sakyiamah, Moses B. Mochiah(PhD), Eric Baffoe, Bright Atawura, Richard Yeboah, Emmanuel Acquah, Ebenezer Frimpong Manso, Collins Gyimah, Stephen Kumankumah, Manigben Amadu Kulai*

03 CSIR-CROPS RESEARCH INSTITUTE RELEASES GHANA'S FIRST EVER OPEN-POLLINATED TOMATO VARIETIES

Sponsors: Korea Programme on International Agriculture (KOPIA), Ghana / Hortifresh/Ghana Obaatanpa CARE

Plate 3: *KOPIA Tomato*

Plate 4:*CRI-Kwabena Kwabena*

Tomatoes are one of the most consumed vegetables in Ghanaian households, usually used in the preparation of soups, stews and salads. In addition to local production falling short of national demand, most Ghanaians also prefer imported varieties at the expense of the local ones, creating huge import bills for the country annually. Available data from the Ghana National Tomato Traders and Transporters Association suggest that an average of 70 truck loads of fresh tomatoes are imported from neighbouring Burkina Faso weekly. A major reason for the production shortage is the lack of high yielding tomato varieties.

Plate 5:*Newly released tomato varieties in the field*

It is in response to this that the CSIR-Crops Research Institute with funding from the Korea Program for International Cooperation in Agricultural Technology (KOPIA), Ghana Center and the Government of Ghana through the Obaatanpa Care Programme, developed and released two improved varieties of tomato in 2021. The varieties have been approved by the National Varietal Release and Registration Committee (NVRRC) of Ghana. The committee granted the approval after a visit to the Institute's research station for a final inspection of the tomato fields. The varieties, CRI-Kwabena Kwabena and KOPIA Tomato, are improved open- pollinated varieties with unique attributes such as early maturity, high yield, high brix as well as tolerance to early and late blight.

The varieties mature within 55 days, much earlier than current varieties which take about 80 or 90 days to mature. They also have potential yields of between 15-20 t/ha (higher than current yields of between 7.5t/ha – 10 t/ha) with a shelf life of between 18-26 days after harvesting. The released varieties will do well in both the major and minor planting seasons as well as in the forest and transitional zones of Ghana. With good agronomic practices, they will also do well in other agro-ecological zones. This is the first open-pollinated tomato varietal release in Ghana. The multi-disciplinary research team that worked to develop these varieties comprised virologists, entomologists, agronomists, seed scientists, weed scientists and led by lead tomato breeder, Dr. Michael Kwabena Osei, a Senior Research Scientist of the Institute. Certified seeds of the new varieties will be available in 2023 to enable farmers have access for cultivation.

Research Team: *Michael Kwabena Osei, PhD, Joseph Gyau, Isaac Osei-Bonsu, PhD, Jonas Osei-Adu, PhD, Joseph Adomako, PhD, Faustina Okyere, Moses Brandford Mochiah, PhD*

04 TRAINING WORKSHOP ON TOMATO HELD AT AKUMADAN

Sponsors: Korea Programme on International Agriculture (KOPIA), Ghana / Hortifresh/Ghana Obaatanpa CARE

Plate 6:*KOPIA Ghana Director, Kim Choong-Hoe, at the training.*

A tomato training workshop was held at Akumadan, a major tomato growing area in Ghana to sensitize farmers on the newly released tomato varieties. The event brought together nearly 170 participants comprising tomato farmers, agricultural extension agents (AEAs), scientists from the CSIR, Directors from the Department of Agriculture, Ministry of Food and Agriculture among several others. Other dignitaries at the event included the Korea Ambassador to Ghana and the KOPIA Ghana Director. Poster and PowerPoint presentations were made to reiterate the attributes of the released varieties. Participants expressed their excitement about the new varieties and were hopeful that they would eventually lead to a reduction in the importation of tomatoes from neighbouring Burkina Faso. Tomato products made from the released varieties were also displayed.

Research Team: *Michael Kwabena Osei, PhD, Joseph Gyau, Isaac Osei-Bonsu, PhD, Jonas Osei-Adu, PhD, Joseph Adomako, PhD, Faustina Okyere, Moses Brandford Mochiah, PhD*

05 ACCELERATING THE DEVELOPMENT OF IMPROVED RICE VARIETIES IN GHANA: INTEGRATING MOLECULAR MARKERS INTO BREEDING

Sponsor: Excellence in Breeding (EiB)/IFAD

Markers are snippets of DNA that are associated with genes of interest to breeders. 'Genotyping' of breeding materials provides a profile for which genes are present – or absent – in each plant, helping breeders make decisions about which to use, alongside physical (or 'phenotypic') properties and plant pedigree. With the support of the EBCA and Excellence In Breeding (EiB) projects, the CSIR-CRI has fully incorporated the use of DNA markers using high throughput genotyping faculty, Intertek as a source provider. This makes selection of the best lines very accurate and hastens the breeding of superior rice varieties.

The most important traits for rice breeders in Ghana reflect consumers' wants and farmers' needs. They are aroma, disease resistance – primarily to Rice yellow mottle virus (RYMV), as well as rice blast – and cooking quality, indicated most importantly by medium amylose content. The rice breeding team at CSIR-CRI deploys two breeding strategies. Forward breeding crosses parent plants with valuable traits to produce elite lines that will become new varieties. Even more important for short-term impact is backcross breeding, which implies taking a 'donor' parent with genes for disease resistance and repeatedly crossing it back with existing aromatic, high-yielding varieties, generating new versions of old favourites.

In each case, the team is faced with one of the crucial challenges for any breeder: determining which of their many crosses in each generation are true crosses – i.e. which lines have inherited useful traits, and should be selected as parents for the next cycle. Traditionally – without markers – this has meant growing the plants out for observation and testing. This is even more complicated for recessive key traits such as aroma and rice yellow mottle virus disease. Lines with only one copy of a recessive gene will not show it; instead, they must be self-fertilised and grown again in a time-consuming progeny test. Testing for disease resistance adds yet another challenge, since researchers must laboriously inoculate each plant with the disease to be sure of infection.

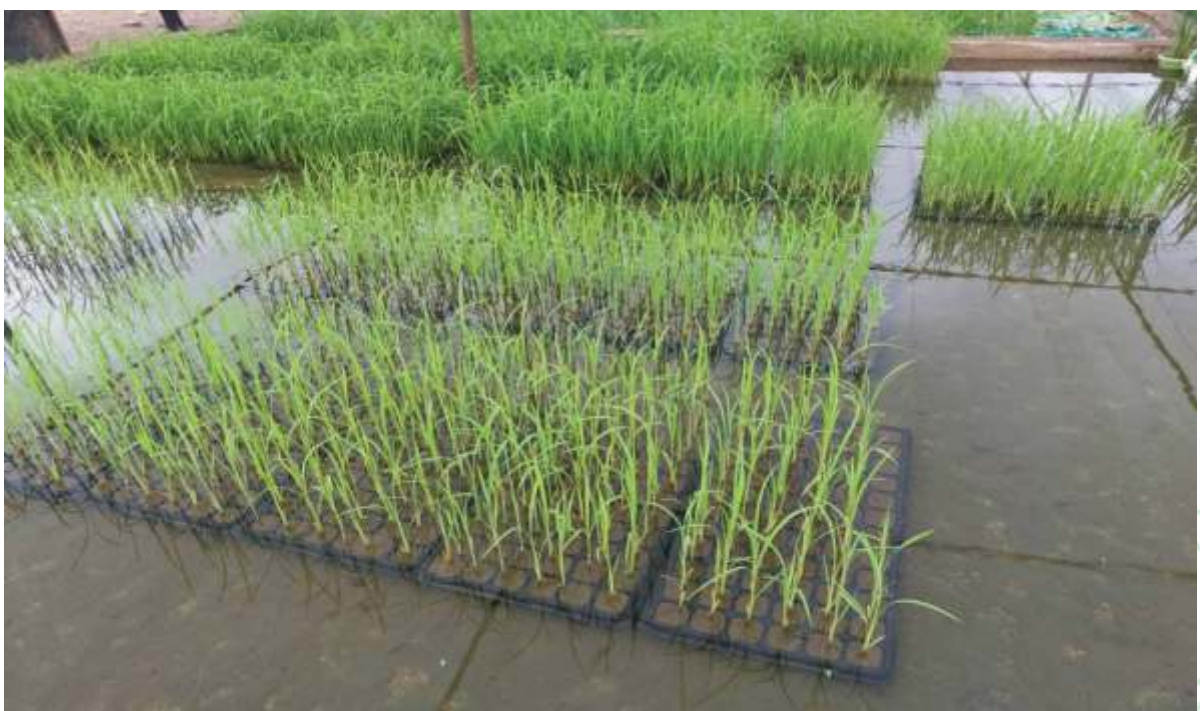


Plate 7:Rice breeding nursery at CSIR-CRI

Currently, the Institute has been able to genotype its core germplasm, testing over 300 lines and narrowing these down to 40 core parents for use in breeding. Even more importantly, the team now tests the results of every breeding cycle, and finds out exactly which progeny have inherited valuable genes.

"For the first time, we are able to use markers in a way that is useful to a breeder," explains Dr Maxwell Darko Asante, rice breeder and Principal Research Scientist at CSIR-CRI, who has led the work. "It is a system that is fit for purpose. It is very high throughput, so we can send 5,000 samples and get our data back within two weeks, and immediately use that data to make decisions. If I'd tried to do so in an academic lab, it would have taken months to extract the DNA alone! "This emphasizes the need for labs with high-throughput marker systems that breeders can utilize as service providers at a reasonable cost".

Impacts

"We found that with our crosses, we were about 70% accurate – so as many as 30% of the lines we were carrying forward in our breeding programme did not have the traits we needed," explains Dr Asante. "Now our accuracy is 100%: we are sure that anything we move forward is a true cross. Additionally, the team has cut their breeding time in half: where a release-ready variety would once have taken six years to develop, it is now available in just three years".
"Molecular markers are working perfectly. The success has gone beyond my expectations," adds Dr Asante, with one unexpected benefit being the discovery of a super donor for disease resistance.

Plate 8: A rice field at CSIR-CRI

Genotyping showed that this single line has two crucial genes: not only resistance to RYMV, the team's top disease priority, but also rice blast, the second-most important disease faced by Ghanaian farmers. We are using this parent to develop varieties with double resistance. "Without molecular markers, we would never have known. Selecting our crosses would also have been much harder, since inoculating the same lines for two diseases is very difficult, whereas markers tell us that the resistance is there at the DNA level."

Being able to work better and faster would be good news for anyone, but it is especially important for the CRI rice team, engaged in a race against time. Ghana has several high-yielding aromatic rice varieties that are highly popular with farmers, but are vulnerable to RYMV. The team is using marker-assisted backcross breeding to convert these otherwise excellent varieties to versions that are resistant to RYMV – and rice blast too, as a valuable bonus.

"Because these susceptible varieties are grown on a wide area, RYMV disease could turn into an epidemic within a very short time," says Dr Asante. "However, we now essentially have resistant products that are ready to go, and just need to go through the standard protocols of testing, registration and release. This is a very important achievement." Without markers this would have taken substantially longer – years that could translate to lost harvests for farmers."

Dr Asante anticipates that within 3-5 years of release – allowing time for large-scale seed multiplication – the new varieties will have almost entirely replaced Ghana's current leaders, achieving at least 70% of national rice coverage. "This is not something we will need to force anybody to use. They are varieties that farmers love already, and we have addressed a weakness that they themselves have identified."

Excitingly, CRI's rice breeders are now in a position to help others follow in their footsteps. They have become regional leaders, and are already helping other programmes in Ghana and West Africa to come up to speed on molecular markers.

Way forward

Breeding is a product pipeline; the hardest part is starting something new, but now that we have incorporated molecular markers, they will continue to yield very strong benefits with every cycle." Molecular markers might be sophisticated science, but their benefits on the ground are concrete: rapid availability of new rice varieties and better, healthier crops for farmers.

Research Team: *Maxwell Darko Asante (PhD), Kirpal Agyeman Ofosu, Phyllis Aculey, Daniel Gamenyah, Elizabeth Norkor Nartey, Peprah, R., Linda Bediako, Sober Ernest Boadu, Yameen Huus Cole, Manilal, W.*

06 IMPROVING SOIL FERTILITY AND NUTRIENT MANAGEMENT FOR IMPROVED CASSAVA PRODUCTION

Sponsors: OCP Africa

Low cassava yields from most Ghanaian farms have been attributed to the low usage of agricultural inputs such as fertilizers. Averagely, the fertilizer consumption in Sub-Saharan Africa is 17 kg of nutrients per hectare. This is far below the global average of 135 kg per hectare. To achieve full potential of our agricultural systems, this huge gap in fertilizer consumption needs to be bridged through awareness creation on the appropriate usage of fertilizers and its potential to increase crop productivity and transform agriculture. In partnership with several other institutions such as the CSIR-Crops Research Institute (CSIR-CRI), OCP Africa is leading efforts at transforming the fertilizer value chain in Africa.

In 2021, the Institute engaged in a project that evaluated the rate and timing of the application of OCP formulated fertilizers on the growth and yield performance of cassava in the forest and forest-savannah transition zones of Ghana. During the cropping season, participatory experimental research on soil nutrient amendments and improved management practices were conducted in 13 communities across four municipalities. The study revealed that a suitable level of fertilizer would be critical in improving the production of cassava in cassava growing areas of Ghana. A root yield advantage of 47.4% was achieved when 800 kg ha-1 (11:22:21) OCP fertilizer rate was applied as compared to using unfertilized cassava treatments. Results such as this provide hope to farmers for sustained production using balanced NPK fertilization and improving the response of high yielding varieties.

As part of the project activities, a farmer field day was also organized for seventy (70) stakeholders within the cassava value chain at Ampemkrom in the Techiman Municipality. The stakeholders comprised farmers, extension agents and district directors of agriculture. Considered a key tool for technology transfer, promotion, and knowledge sharing, the field day led to the promotion of information exchange and technology transfer and also created direct market linkages between producers and farmer groups.

Plate 9: A section of participants at the training

Plate 10: Dr. Kennedy Agyeman of CSIR-CRI interacting with participants at the training

Participants visited on-farm demonstration fields and observed the positive outcomes of fertilizer usage by farmers. Staff of the Institute also disabused the minds of participants on the perceived negative effects of fertilizers on root storage and the poundability of cassava. They suggested that the technology be scaled up in the future so many more farmers could benefit.

Research Team: *Kennedy Agyeman (PhD), Joseph Nketiah Berchie (PhD), Eric Owusu Danquah (PhD), Paul Marno, Joseph Adomako (PhD), Agbesi Kwadzo Keteku (PhD)*

07 PERFORMANCE OF DIFFERENT INSECTICIDE REGIMES ON MANAGEMENT OF COWPEA PESTS

Sponsors: CSIR-Crops Research Institute

Different insect pests attack cowpea depending on the developmental stage of the crop. The critical insects are the thrips which feed on the flowers' pollen thereby leading to a decrease in pod set and subsequently yield. Post flowering insects such as sucking bugs and the bean pod borer, Maruca sp. attack pods and feed on the content.

A project aimed at evaluating the efficacy of different insecticide regimes in managing insect pests of cowpea reported to have developed resistance to commonly used insecticides was undertaken by the Plant Health division of the Institute in 2021. The project applied sole and a combination of botanical Neemazal (Azadirachtin), microbial Bypel (Bt + pierisrapae) and chemical Bon Optimal (Acetamiprid+Lambda); Dean (Emamectin benzoate+Imidacloprid);Cymethoate (Dimethoate + Cypermethrin) to different developmental stages of an improved cowpea variety, *CRI-Zamzam* and two farmer preferred varieties, John *Mahama and Nang*.

Plate 11: Matured CRI-Zamzam cowpea variety

An assessment by farmers during a field day revealed that the application of Neemazal and Bypel at flowering followed by Bon Optimal, Dean and the subsequent use of chemical insecticides, resulted in the suppression of insect pests as well as high yields in all the three cowpea varieties. *CRI-Zamzam* was also rated as the best variety in terms of yield (five times more than *John Mahama and Nang*). It also had uniform (pure) pods and seeds which were attributed to the quality of its planting materials. The farmer varieties however had different seed mixtures. The use of biorationals, Neemazal and Bypel followed by the application of chemical insecticides is therefore highly recommended in managing cowpea pests.

Research Team: *Kofi Frimpong-Anin (PhD), Sylvester N.T.T. Addy (PhD)*

08 PROGRESS OF YAM IMPROVEMENT FOR INCOMES AND FOOD SECURITY IN WEST AFRICA II (YIIFSWA-II) PROJECT

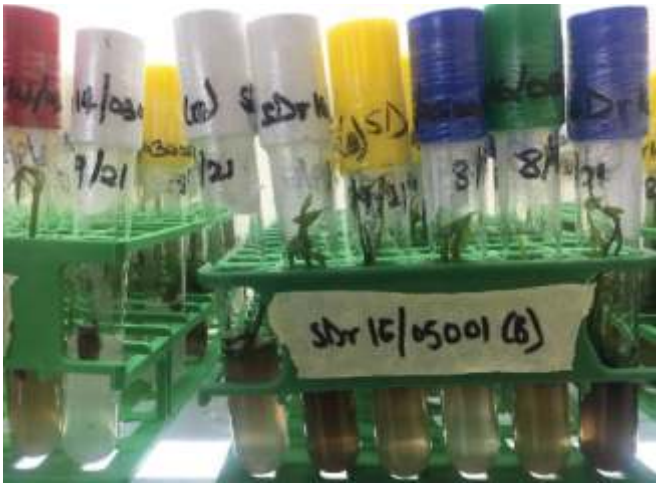
Sponsors: Bill and Melinda Gates foundation (BMGF)

Funded by the Bill and Melinda Gates Foundation (BMGF), the Yam Improvement for Income and Food Security in West Africa, Phase II (YIIFSWA II) project seeks to develop and prove a functional, commercial seed yam seed system in Nigeria and Ghana to benefit smallholder farmers through availability, accessibility and affordability of improved yam varieties through the establishment of high-quality seed system using improved technologies. The project is aimed at transforming the formal yam seed system in Nigeria and Ghana through a private-sector-led seed system that delivers competitively priced, high-quality seed tubers to farmers.

The project is led by the Nigeria-based International Institute of Tropical Agriculture (IITA) in collaboration with Context Global Development (CGD), Sahel Capital (Sahel), national yam research institutions like the CSIR-Crops Research Institute (CSIR-CRI), seed certification agencies, and private seed companies in Nigeria and Ghana.

Plate 12: Seedlings from VIVIPAK planted on Aeroponics System

The unavailability and high cost of quality improved seed yam are foremost production constraints to yam farmers in West Africa. The formal seed yam system has been non-existent due to inefficient seed production, distribution, and quality assurance systems, and inadequate seed production has stalled yam development across West Africa. Yam multiplication ratios are low, and seed tubers are prone to contamination with pests and pathogens in the traditional systems of production. YIIFSWA-II seeks to enable the emergence of a formal seed system that better serves the needs of farmers who depend on the yam value chain for food and income. Primary beneficiaries of the program include seed and ware yam producers, processors, marketers, transporters, and consumers.



At the CSIR-Crops Research Institute, the project is led by the Biotechnology, Seed and Post-harvest division. Along with several achievements and outputs, the project successfully established one fully functional Temporary Immersion Bioreactor System (TIBS). Additionally, fully functional aeroponics and hydroponics systems for high ratio propagation of pre-basic seed yams in Ghana were also established and maintained.

In 2021, a total of 11, 288 plantlets were cultured in-vitro using the TIBS while another 3, 567 yam plantlets were also hardened in the screenhouse. Additionally, 3,108 plantlets were multiplied onto vivipak from seven varieties whereas 2,100 tissue culture derived seedlings in VIVIPAK were supplied to various clients.

Research Team: *Marian D. Quain (PhD), Victor Acheampong Amankwaah (PhD), Mavis Akom, Mary Otiwaa Osei Asante, Michael Arthur, Agnes Achia Aboagye, David Pukinka, Agnes Nimo Bosompem, Michael Odamtten, Patricia Acheampong (PhD), Ruth N.A. Prempeh (PhD), Godfred Osei*

09 TRAINING WORKSHOPS ON TOMATO VALUE ADDITION TO REDUCE POSTHARVEST LOSSES

Sponsors: Korea Africa Food and Agriculture Cooperation Initiative (KAFACI)

Two training workshops on the production of ready-to-eat tomato products were organized as part of activities under the Korea Africa Food and Agriculture Cooperation Initiative (KAFACI) Postharvest Project in 2021. Led by project leader, Dr. (Mrs) Evelyn Adu Kwarteng, a Senior Research Scientist with the Postharvest section of the Institute, the training workshops were meant to address the perennial postharvest losses in tomato production. Ghanaian farmers and traders experience postharvest losses of up to 50 percent in tomatoes from the farm gate to the consumer according to available research. To satisfy consumer demands, the nation imports both fresh and processed tomato products valued at over US$ 100 million annually.

Plate 13:Tomato ketchup being prepared with CRI-released tomato varieties

Participants at the workshops were drawn from the Women in Agricultural Development (WIAD) Directorate of the Ministry of Food and Agriculture (MoFA), the National Board for Small Scale Industries (NBSSI) as well as the Food and Drugs Authority (FDA). Other participants included Agricultural Extension Agents, high school graduates and women's group representatives from churches and institutions. The beneficiaries were trained in the production of tomato ketchup and jam using locally available materials such as onions, ginger, salt, sugar and other local spices.

It is hoped that beneficiaries will put the knowledge acquired to effective use to reduce postharvest losses and also create employment for many people.

Research Team: *Evelyn Adu-Kwarteng (PhD), Isaac Osei-Tutu, Hillary Mireku Botey (PhD), Atta Aidoo Snr, Faustina Okyere, Abigail Amoa-Owusu*

10 EVALUATION OF EXOTIC VEGETABLES AT CSIR-CROPS RESEARCH INSTITUTE

Sponsor: Korea Program for International Cooperation in Agricultural Technology (KOPIA)

A collaboration between the CSIR-Crops Research Institute and Hungary led to the evaluation of twenty-six (26) different exotic vegetables made up of fruits, leafy and root type vegetables. This was done to test their performance in the Ghanaian environment. As part of activities, delegates from Hungary comprising the deputy speaker of the Hungarian Parliament, some members of Parliament and the Hungarian high commissioner to Ghana, visited the Institute's screen house at Kwadaso to observe the performance of the vegetables. Nineteen (19) of the initial 26 exotic vegetables had established very well and were ready for on-farm evaluations after which they would be made available to peri-urban vegetable growers across the country. It is hope that this will increase farmers' incomes and improve their livelihoods.

Research Team: *Michael Kwabena Osei, PhD, Joseph Gyau, Isaac Osei-Bonsu, PhD, Jonas Osei- Adu, PhD, Joseph Adomako, PhD, Faustina Okyere, Moses Brandford Mochiah, PhD*

11 HIGHLIGHTS FROM THE MODERNIZING AGRICULTURE IN GHANA (MAG) PROJECT

Sponsors: Modernizing Agriculture in Ghana (MAG)

The Modernizing Agriculture in Ghana (MAG) is a five-year Canadian Government sponsored programme that focuses attention on demand-driven research and alternative methods of extension delivery with the objective of increasing productivity through intensive farming. The CSIR-Crops Research Institute is responsible for four main activities under the "Support to agricultural research to strengthen agricultural extension services and improve agricultural productivity" component. In 2021, a number of activities were undertaken under the project leading to several outcomes. These comprise the following:

- 2.65 acres of clean cassava planting materials produced (*CRI-Bankyehemaa, CRI-Essam bankye, CRI-Doku-duade, CRI-Bankye, Agra bankye, CRI-Dudzi*)
- 2.5 acres of tissue culture generated cassava planting materials produced and established.
- 1 acre rice field each established in the Ashanti, Bono and Volta regions.
- 1 acre taro field established in the Bono region.
- 0.5-acre yam seed field established in the Bono East region
- 1.5-acre groundnut seed field established in the Bono East region
- Forty (40) laboratory equipment and pipettes calibrated.
- Three hundred (300) cassava samples indexed for the cassava mosaic virus disease
- Capacity building workshops for media and CSIR information and communication officers.
- Farmer field day held for seventy (70) farmers in the Ejisu Municipality
- Farmer field day held for three hundred (300) farmers in the Ashanti Mampong Municipality and 500 farmers in the Gomoa Central district respectively.
- Exhibition held at the 2021 National Farmers' Day.

Research Team: *Ernest Baafi (PhD), Ebenezer Annan-Afful (PhD), Kofi Frimpong-Anin (PhD), Marian Dorcas Quain (PhD), Emmanuel Otoo (PhD), Ruth N.A. Prempeh (PhD), Victor Amankwaah (PhD), oseph Manu-Aduening (PhD), Allen Oppong (PhD), Priscilla F. Riberio (PhD), Kwadwo Adofo (PhD), Michael Kwabena Osei (PhD), Sylvester N.T.T. Addy (PhD), Blankson Wadie Amoabeng (PhD), Joseph Gyau, Osward Ohene Djan, Paul Marno, Kwame Obeng Danquah, Isaac Osei-Tutu, Solomon Gyasi Boakye, Monica Opoku, Peter Appiah Danquah, Lily Allotey, Agnes Nimo Bosompem, Agnes Achiaa Aboagye, Theodora A. Mensah, Sumaila Fuseini, Afua Gyaamah Gyimah, Vashti Owusu-Nkwantabisa, Godfried Ohene Mensah, Jerry A. Asamoah, William Lelabi Kota*

DONOR SUPPORT IN 2021

Funding is a major component of research activities. The Institute continues to receive funding from several local and international agencies for its research activities. In 2021, sponsors such as HarvestPlus, the Accelerating Genetic Gains in Maize (AGG) project, Korea Program for International Cooperation in Agricultural Technology (KOPIA), the Enhancing Breeding Capacity in Africa (EBCA) project, the Excellence In Breeding (EiB) project, the International Fund for Agricultural Development (IFAD), OCP Africa, the Bill and Melinda Gates Foundation (BMGF), the Yam Improvement for Income and Food Security in West Africa (YIIFSWA), Korea Africa Food and Agriculture Cooperation Initiative (KAFACI) and the Modernizing Agriculture in Ghana (MAG) secretariat were our major donors. We also received funding from Solidaridad, the Centre for Agriculture and Bioscience International (CABI), the Alliance for a Green Revolution Africa (AGRA), the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT) as well as the African Agricultural Technology Foundation (AATF).

COMMERCIALIZATION ACTIVITIES

The CSIR-CRI's commercialization division is responsible for driving commercial activities of the Institute to enhance its income generating capacity and fast-track the dissemination and transfer of its technologies to farmers and the general public. The division develops and implements production, marketing, sales and business development strategies for the commercial activities of the Institute. These are categorized into "products", "services" and "facilities". The products include improved varieties of planting materials (seeds & seedlings), farm produce and fruits from the institute's orchards and plantations. In 2021, seedlings of mango, citrus, avocado and coconut were produced for sale. The Institute also provides training, consultancy, and analytical services. Facilities such as conference rooms, a guest house, a seed processing and storage center are also available for use by the general public at a fee.

Team: *Samuel Azuug Ndebilla, Mark Anti, John Kwadwo Fordjour, Richard Peprah, Richmond Owusu Amankwa, Theresa Boakye, Cynthia Badoo, Augustine A Boakye, Isaac Mensah, Eric Donkor, Thomas Acheampong, Agnes Nti*

MEDIA PUBLICATIONS OF RESEARCH OUTPUTS IN 2021

Communication at CSIR-CRI is a major strategic activity because we believe that research is not complete until the results are shared with farmers and other end-users. Good communication systems between actors of agricultural development are vital tools for the transfer of new and improved technologies to farmers. The Institute's public relations (PR) unit is tasked with developing, improving and maintaining an efficient communication system and other support services to fulfill the institute's mission. In 2021, the unit facilitated several media engagements for scientists of the Institute. This was meant to not only increase visibility but also keep stakeholders and the general public informed about the Institute's activities. Media coverages were undertaken for activities such as farmer field days and verifications/demonstrations, training sessions, innovation platform activities and varietal releases. Media reports generated from these research activities are listed below:

Date	Media Organisation	Title of Publication
11/02/21	www.myjoyonline.com	PFJ receives boost as CRI produces tones of groundnut and cowpea seeds
14/03/21	www.myjoyonline.com	Farmers to have vibrant seed system through new PAIRED project
16/04/21	www.myjoyonline.com	CRI develops tomato jam to address post-harvest losses
11/05/21	Ghana News Agency (www.gna.gh.org)	It's time to address disconnect between science and the people – Kwaku Afriyie
17/06/21	www.myjoyonline.com	CRI trains youth in micro-scale tomato ketch-up production
01/08/21	Ghana News Agency (www.gna.gh.org)	MAG assists farmers to increase Taro production for sustainable livelihoods
11/08/21	www.citinewsroom.com	Farmers in Gomoa Central introduced to four new varieties of Taro
21/08/21	www.gna.gh.org www.skypowerfm.com	PAIRED Project assists Ghanaian farmers to maximize maize production
25/08/21	www.graphiconline.com	Agortime tomato farmers introduced to new crop varieties
08/10/21	www.gna.org.gh	CRI-Kumasi trains agric officers to track cassava disease
13/10/21	Ghanaian Times	CSIR-CRI organizes capacity-building workshop for sweet potato farmers in Asesewa

21/10/21	Ghanaian Times	300-acre rice farms destroyed....following collapse of Afram River embankment
13/11/21	www.myjoyonline.com	Farmers at Ejura welcome new varieties of cowpea from CSIR-CRI
21/11/21	www.gna.org.gh	Farmers hail high yielding maize varieties under CORAF-PAIRED
22/11/21	www.gna.org.gh	Resource us to produce more seed varieties for farmers – CSIR-CRI
16/12/21	www.gna.org.gh/1.21294104	CRI to release two new tomato varieties for cultivation
16/12/21	Hello FM News@ 3.30 p.m./ AUD-20211216-WA0...	CRI introduces two new tomato varieties to farmers
17/12/21	UTV Ghana Midday news/ https://fb.watch/a0z8yUlnUx/	CSIR-CRI introduces two new tomato varieties to farmers
20/12/21	Prime-Time-News/UTV/ https://fb.watch/a0ACU8plUj/	Pru West district, Bono Region: Cowpea, groundnut farmers appeal for more support
22/12/21	www.gna.org.gh/1.211301035	Cowpea, groundnut farmers in Pru West appeal for support to boost production
22/12/21	Joynews	CRI gets approval for cultivation of new tomato species
23/12/21	www.myjoyonline.com	CSIR-CRI releases 5 new maize varieties

27/12/21	GBC Radio News	CRI introduces 2 new superior quality tomato to farmers at Akomadan
28/12/21	www.gbcghanaonline.com	Akomadan tomato farmers in Ashanti get new varieties
28/12/21	GTV	Farmers introduced to 2 high yielding tomato varieties. improving on shelf life and marketability

The Institute is also very active on its website and on new media platforms such as Facebook, Twitter, Instagram, and YouTube. Several of the institute's activities have been published on these platforms as well.

Team: *Solomon Gyasi Boakye, Bernard Sakyiamah, Linda Agyeman, Lynda G.S. Nsafoah, William Aidoo, Peter Amankwah, David Know Amo, Augustine Ofosu, Samuel Boateng, Dennis Gyasi Boakye, Enoch Bobie Agyemang, Enoch Osei Tutu, Patricia Konadu Mensah.*

AWARDS

In 2021, the Africa Biennial Biosciences Communication Symposium (ABBC 2021), honoured Professor Marian Dorcas Quain, a Chief Research Scientist of the Institute for her commitment to the development of biotechnology in Africa. The ABBC is a platform for stakeholders in, and with passion for biosciences, to actively exchange experiences and best practices towards improving bioscience communications. The Symposium provides an African-based and African-led platform and plays a fundamental role in addressing pressing communication issues needed to propel biosciences innovations in Africa. The first ABBC symposium was held in Nairobi, Kenya, in 2015, followed by one in Entebbe, Uganda, in 2017 while the third ABBC was held in 2019, in South Africa. Prof Marian Dorcas Quain is a renowned biotechnologist that has worked on numerous crops with focus on the utilization of tissue culture for production of clean planting materials.

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Refereed Journal Papers

1. **Acheampong, P. P., Adu-Appiah, A., Frimpong, B. N., Haleegoah, J., Amengor, E. N., Asante, B. O.** and **Otoo, E.** (2021). Adoption of improved white yam (Dioscorea rotundata) varieties in Ghana: The role of farm and farmer characteristics. *Ghana Journal of Agricultural Science.* 56 (2), 61 – 74. https://dx.doi.org/10.4314/gjas.v56i2.6.

2. **Addo-Danso, A.** and **Amankwaa-Yeboah, P.** (2021) The Potentials of Bamboo-Based Agroforestry Systems in Improving the Productivity of Tropical African Agricultural Systems. *Agricultural and Food Science Journal of Ghana (14)*

3. **Addo-Danso, A.** and **Amankwaa-Yeboah, P.** (2021) The potentials of bamboo-based agroforestry systems in improving the productivity of tropical African agricultural systems. *Agricultural and Food Science Journal of Ghana*, Vol. 14:1467-1481. https:dx.doi.org/10.4314/afsjg.14i1.11

4. **Addo-Danso, A.** and Kwaku, M. (2021) Considerations and significance of tenure security to the development of bamboo plantations in Ghana. *Ghana Journal of Forestry*, Vol. 37: 31 – 46. 2.

5. Adjah, K.L., **Asante, M.D.**, Toure, A., Aziadekey, M., Amoako-Andoh, F.O., Frei, M., Diallo, Y. And Agboka, K. (2022). Improvement of Rice Production under Drought Conditions in West Africa: Application of QTLs in Breeding for Drought Resistance. *Rice Science*, 29(6):512-521.

6. **Adjei A. E., Tetteh E. N.; Darkey S.; Dzomeku B. M.; Mintah P.** and Anti M., 2021. Extrapolating technology from research plots to commercial sale and challenges involved: Case study of plantain macro-propagation technique. *Journal of Agriculture Extension and Rural Development* Vol.13(4): 225-231 DOI: 10.5897/JAERD2021.1258

7. **Adomako, J., Amengor, N.E.**, Larbi-Koranteng, S. and Kankam, F. (2021). Efficacy of spraying intervals of Ridomil Plus 66 WP for control of taro leaf blight disease. *African Crop Science Journal,* 29 (1):133-140.

8. **Adu-Kwarteng, E.**, Baafi, E. Amoa-Owusu, A., Okyere. F. and Carey, E. (2021). Expanding industrial uses of sweetpotato for food security and poverty alleviation. *Open Agriculture* 2021; 6: 1–10

9. Ampofo, D., Agbenorhevi, J.K., Firempong, C.K. and **Adu-Kwarteng, E.** (2021) Glycemic index of different varieties of yam as influenced by boiling, frying and roasting. *Food Science & Nutrition*, 9: 1106-1111. https://doi.org/10.1002/fsn3.2087

10. **Agyeman, K., Asante, B. O**; **Berchie J. N**; Sarkodie-Addo, J., **Marno P.** and Adabah, R (2021). Farmers' perceptions, constraints and preferences for improved Bambara groundnut varieties in Ghana. *Journal of Agriculture and Food Research,* https://doi.org/10.1016/j.jafr.2020.100097.

11. **Aidoo A. K.**, Awuah R. T., **Osei K., Lamptey J. N. L., Quain M. D., Mochiah M. B.**, Afun, J. V. K. and **Oppong A**. (2021). Use of positive selection technique to manage yam viruses in seed yam production by Ghanaian farmers. *African Journal of Agricultural Research*, 17(7): 1049-1057, DOI: 10.5897/AJAR2021.15639

12. **Amoabeng, B. W.**, Stevenson, P. C., Mochiah, M. B., Asare, K. P., & Gurr, G. M. (2021). Economic analysis of habitat manipulation in Brassica pest management: Wild plant species suppress cabbage webworm. *Crop Protection*, 105788.
1057, DOI: 10.5897/AJAR2021.15639

13. **Amponsah**, S. K., **Addo, A.**, Djidohopkin, E. B., Olaye, R and B (2021). Performance assessment of manual rice harvesting methods under farmer's field conditions. *Agricultural Engineering International: CIGR Journal*, 23(2): 162-169

14. **Amponsah, S. K.,** Agodzo, S., Agbeko, E. and Osei, E. A. (2021). Impact of tank geometry on production of African Catfish (Clarias gariepinus). *African Journal of Agricultural Research*, 17(1): 165-172

15. Arkoh, A. K., **Amponsah, S. K.,** Opoku Asante, J. (2021). Comparative analysis of manual and mechanised yam minisett planting. *International Journal of Engineering and Advanced Technology*, 11(1): 114-119

16 **Asante, M.D.**, Ipinyomi, S. O., Abe, A., Kossi, Adjah, Aculey, P., Bam, R.K. and Manneh, B. (2021). Genetic variability for and tolerance to anaerobic germination in rice (*Oryza sativa L.*), *Journal of Crop Improvement.* https://doi.org/10.1080/15427528.2021.188463.

17. Boadi N. O., Badu M., Kortei, N. K., Saah, S. A., Annor B., Mensah, M. B., **Okyere H.** and Fiebor A. Nutritional composition and antioxidant properties of three varieties of carrot *(Daucus carota). Scientific African 12 (2021) e00801*

18. **Boakye-Mensah, I. N.**, Osei, K., and Prempeh, R. N. A. (2021). Screening Tomato Genotypes for Bacterial wilt Disease (Ralstonia solanacearum) Resistance in Ghana. *European Journal of Agriculture and Food sciences*, 3(5) 1-8.

19. Bosomtwe, A., Jinu, E., Myung-Hyun, K., Min-Kyeong, K., Soon-Kun, C., So-Jin, Y., Jeong-Hwan, B., **Owusu Danquah, E.** (2021). Effects of temperature and water management in rice fields on larval growth of *Pantala flavescens* (*Odonata: Libellulidae*). *Korean Journal Environmental Biology* Vol.39 No.4 pp.536-541. https://doi.org/10.11626/KJEB.2021.39.4.536

20. **Botey, H. M.,** Ochuodho J. O., Ngode L., **Owusu Danquah E.** and Agyare Richard R. (2021). Physiological quality of African eggplant seeds as influenced by natural fermentation and drying methods. *Journal of Horticulture and Forestry* Vol. 13(2), pp. 51-57. DOI: 10.5897/JHF2021.0669

21. **Botey H. M.,** Ochuodho J. O. and Ngode L. (2021). Fruit and seed physiological quality changes during seed development and maturation in African eggplant (*Solanum aethiopicum* L.). *African Journal of Agricultural Research.* Vol. 17(8), pp. 1131-1143. DOI: 10.5897/AJAR2021.15690

22. **Botey, H. M.**, Ochuodho, J.O., Ngode, L., **Owusu Danquah, E.**, Agyare, R. (2021). Physiological quality of African eggplant seeds as influenced by natural fermentation and drying methods. *Journal of Horticulture and Forestry*, *13*(2), pp.51-57. https://doi.org/10.5897/JHF2021.0669

23. **Botey, H. M.**, Ochuodho, J. O., Ngode, L. (2021). Qualitative and Quantitative Assessment of African Eggplant Seed Germination in Relation to Seed Maturation. *Agricultural and Food Science Journal of Ghana.* Vol. 14 (1): 1443 -1455. https://dx.doi.org/10.4314/afsjg.v14i1.9

24. Choi, S.K., Jaepil, C., Jeong, J., Kim, M.K., So-Jin, Y., Sera, Jo., **Owusu Danquah, E.**, Bang, J.H. (2021). Assessing Future Water Demand for Irrigating Paddy Rice under Shared Socioeconomic Pathways (SSPs) Scenario Using the APEX-Paddy Model. *Journal of the Korean Society of Agricultural Engineers*, 63(6), pp. 1-16. https://doi.org/10.5389/KSAE.2021.63.6.001

25. **Danso, Y.** and Abugri B. (2021). Plant Parasitic Nematodes Associated with Okra in the Forest Savanna Transition and Semi-Deciduous Forest Agro-Ecologies of Ghana. *Agricultural and Food Science Journal of Ghana 14:* 1483–1492. doi.org/10.4314/afsjg.v14i1.12

26. **Danso, Y., Issa U. S., Adomako J., Adama I., Osei, K., Agyei Obeng E., Opoku M., Amoabeng, W.B.** and Abugri B. (2021). Application of entomopathogenic nematodes in management of fall armyworm infesting maize in Ghana: A greenhouse study. *Egyptian Journal of Agronematology* 20 (2): 159-166. doi:10.21608/ejaj.2021.192214.

27. Darko, C., **Yeboah, S.**, Amoah, A., Opoku, A., **Baafi, E., Nketiah Berchie, J.** (2021). Yield, biochemical properties and cooking quality traits of sweet potatoes (Ipomoea batatas) as affected by Nitrogen and Potassium Fertilizer rates. *Ghana Journal of Agriculture Science.* 56 (1), 16 – 25

28. Debrah, P. Y., **Afriyie-Debrah, C.**, Nuhu, F., **Ribeiro, P. F.** and Obeng, E. A. (2021) "Response of Cabbage (*Brassica oleracea* var capitata L.) to Organic and Inorganic Fertilizer", *Journal of Experimental Agriculture International,* 43(2), pp. 105-114. doi: 10.9734/jeai/2021/v43i230651.

29. Forkuor, G., Amponsah W., **Oteng-Darko, P.** and Osei G. (2021). Safeguarding food security through large-scale adoption of agricultural production technologies: The case of greenhouse farming in Ghana.*C leaner Engineering and Technology* 6 (2022) 100384. https://doi.org/10.1016/j.clet.2021.100384

30. **Frimpong-Anin, K., Mochiah, M. B., Osei, M. K., Bonsu K.O.** and Opoku P. (2021). Integration of biorationals into management of pepper and tomato pests. *Journal of Entomology and Zoology studies.* 2021; 9(2): 14-19

31. Iddrisu, S., Essilfie, M. E. and **Bolfrey–Arku, G.** (2021). Response of Cabbage (*Brassica oleracea var capitata*) to Organic and Inorganic Fertilizers on Growth and Yield Parameters and Incidence of Insect Pest. *International Journal of Environment, Agriculture and Biotechnology* Vol-6, Issue-6; Nov-Dec. https://ijeab.com/ Journal DOI: 10.22161/ijeab

32. Kankam, F., Larbi-Koranteng, S. and **Adomako, J.** (2021). Rhizoctonia disease of potato: epidemiology, toxin types and management. *Egyptian Journal of Phytopathology,* 49(1):197-209

33. **Keteku, A. K.,** Intanon, P., Terapongtanakorn, S. (2021). Impact of soil amendments and fertilizers on maize (*Zea mays* L.) growth and yield and on physical, chemical, and biological soil properties. *Songklanakarin J. Sci. Technol.* 43 (4), 1078-1085. https://doi.org/10.14456/sjst-psu.2021.142

34. **Keteku, A. K.**, Intanon, P., Terapongtanakorn, S. and Intanon, R. (2021). Assessment of fertilizers for improved productivity of maize (*Zea mays* L.). *Songklanakarin J. Sci. Technol.* 43 (4), 1086-1093. https://doi.org/10.14456/sjst-psu.2021.143

35. Kortei, N. K., Annan T., Kyei-Bafour V., Essuman E. K., **Okyere H.** and Tettey C. O. Exposure and risk characterizations of ochratoxins A and aflatoxins through maize (Zea mays) consumed in different agro-ecological zones of Ghana.

36. Liu, L., **Owusu Danquah, E.**, Weebadde, C., Bessah, E., Basso, B. (2021). Modeling soil organic carbon and yam yield under different agronomic management across spatial scales in Ghana. *Field Crops Research* 263 (2021) 108018. https://doi.org/10.1016/j.fcr.2020.108018

37. **Marfo E. A., Lamptey J. N. L., Ennin S.A., Osei K., Oppong A., Quain M. D.,** Bosompem A.N., **Danquah E.O., Frimpong F.,** Kwoseh C. (2021). Positive Selection' A Simple Approach to Reduce High Virus Incidence and Seed Yam Degeneration in Ghana. *Journal of Food processing and Technology*, 12(1):863.

38. Mehdizadeh, M., Mushtaq, W., Anusha S. S., Ayadi, S., Kaur, P., **Yeboah, S.**, Mazraedoost, S., D AL-Taey, K.A., and Tampubolon, K. (2021). Herbicide Residues in Agroecosystems: Fate, Detection, and Effect on Non-Target Plants. *Reviews in Agricultural Science*, 9: 157–167. https://dx.doi.org/10.7831/ras.9.0_157.

39. Mehdizadeh, M., Mushtaq, W., Anusha S.S., Ayadi, S., Kaur, P., **Yeboah, S.,** Mazraedoost, S., D AL-Taey, K.A., and Tampubolon, K. (2021). Herbicide Residues in Agroecosystems: Fate, Detection, and Effect on Non-Target Plants. *Reviews in Agricultural Science*, 9: 157–167. https://dx.doi.org/10.7831/ras.9.0_157.

40. Oloka, B. M., da Silva Pereira, G., **Amankwaah, V. A.,** Mollinari, M., Pecota, K. v., Yada, B., Olukolu, B. A., Zeng, Z. B., and Craig Yencho, G. (2021). Discovery of a major QTL for root-knot nematode (Meloidogyne incognita) resistance in cultivated sweetpotato (Ipomoea batatas). *Theoretical and Applied Genetics*, *134*(7), 1945–1955. https://doi.org/10.1007/s00122-021-03797-z

41. Opata, J., **Dzomeku, B. M., Darkey, S. K., Opoku, E., Bam, R. K.** and Wünsche, J, J-N., 2021. Field Performance of False Horn Plantain (Musa AAB) Corms Treated and with Hormone Solutions. *Journal of Horticulture and Plant Research*. Vol. 13:1-9. doi.org/10.18052/wwww.scipress.com/JHPR.13.1

42. **Oppong A.**, Dadzie M.A., Ifie B., **Asante M. D., Prempeh R. N. A., Abrokwah L. A., Kubi Z. A., Marfo E. A., Ananng E. A.** and Warburton M. L. (2021). Genetic Analysis of New Maize Hybrids for Yield and Resistance to Aflatoxin Accumulation. *Journal of Agricultural Science, 13(10):9752-9760*

43. **Oppong A.**, Dadzie A.M., Ifie B., **Asante M. D., Prempeh R. N. A., Abrokwah L. A., Appiah K. Z., Marfo E. A., Ananng E. A.** and Warburton M. L. (2021). Genetic Analysis of New Maize Hybrids for Yield and Resistance to Aflatoxin Accumulation. *Journal of Agricultural Science, 13(10):1916-9760*

44. **Oppong A., Prempeh R. N. A., Abrokwah L. A., Annang E.A., Marfo E.A., Appiah Kubi Z.**, Danquah N. A. O., Agyekum A., **Nsiah Frimpong B.**, Appiah S.A., **Lamptey J.N.L., Mochiah M.B.**, Pita J.S. (2021). Cassava Mosaic Virus Disease in Ghana: Distribution And Spread, *Journal* of *Plant Physiology and Pathology, 9:8. 258.*

45. Oppong, G.K. and **Asante, M.D.** (2021). Genetic Diversity of Wild Rice (*Oryza longistaminata*) in Ghana. *Agricultural and Food Science Journal of Ghana*.14:1326-1336.

46. Osei-Adu J., Aidoo R., Cudjoe S. F., Ennin S. A., Osei K. and Asante B. O (2021) The role of improved technology to enhance Total Factor Productivity (TFP): The case of quality seed yam production in Ghana and Nigeria, *African Journal of Science, Technology, Innovation and Development*, 13:2, 147-156, DOI: 10.1080/20421338.2020.1831132

47. Tawiah I., **Asante M. D., Oppong A.**, Asare K., Amadu B., Gyameyah D. (2021). Genetic control of resistance to rice yellow mottle virus disease in two rice crosses. *Journal of Crop Improvement.* https://doi.org/10.1080/15427528.2021.1905757. 6.

48. Tawiah, I. **Asante, M.D.**, Oppong, A., Asare, K., Amadu, B., Gyameyah, Daniel., Lamptey, M., Kang, K-H. (2021). Genetic control of resistance to rice yellow mottle virus disease in two rice crosses. *Journal of Crop Improvement* https://doi.org/10.1080/15427528.2021.1905757.

49. **Tetteh, N. E., Owusu Danquah, E.**, Abunyewa, A. A., Ocansey, M. C., Boakye, E. A., Oppong Tuffour, H., Logah, V., Twum-Ampofo, K., **Mensah Dzomeku, B., Yeboah, S.**, Rex Barnes, V. (2021). Plantain-Tree Rubber Intercropping Systems Improved Productivity in the Tropical Humid Zone of Ghana, West Africa. *International Journal of Agronomy*. doi.org/10.1155/2021/3240686

50. **Tetteh, E. N., Owusu Danquah, E.**, Abunyewa, A. A., Melenya Ocansey, C., Boakye, A.E., Tuffour, O.H., Logah, V., Twum-Ampofo, K., **Dzomeku, B. M., Yeboah, S.**, Barnes, V.M., (2021). Plantain-Tree rubber intercropping systems improved productivity in the tropical humid zone of Ghana, West Africa. *International Journal of Agronomy* Vol. 2021, 3240686. https://doi.org/10.1155/2021/3240686

51. **Tetteh, E. N.,** Danquah, E. R.; Abunyewa, A. A.; Ocansey, C. M.; Boakye, E. A.; Tuffour, H. O.; Logah, V.; Twum-Ampofo, K.; **Dzomeku, B. M.**; **Stephen Yeboah, S.** and Victor Rex Barnes, V. R., 2021. Plantain-Tree Rubber Intercropping Systems Improved Productivity in the Tropical Humid Zone of Ghana, West Africa. *International Journal of Agronomy* Volume, 16 pages

52. **Yeboah, S., A. Ennin, S., Ibrahim, A., Oteng-Darko, P.,** Mutyambai, D., Khan, Z., **Mochiah, M. B.**, Ekesi, M and Niassy, S. (2021). Effect of spatial arrangement of push-pull companion plants on fall armyworm control and agronomic performance of two maize varieties in Ghana. *Crop Protection*. 145: 105612. Doi.org/10.1016/j.cropro.2021.105612

53. **Yeboah, S.**, Jun, W., Liqun, C., **Oteng-Darko, P., Narteh Tetteh, E.** and Renzhi, Z. (2021). Nitrous oxide, methane emissions and grain yield in rainfed wheat grown under nitrogen enriched biochar and straw in a semiarid environment. *PeerJ*. 16-37. Doi: 10.7717/peerj.11937

54. **Yeboah, S., Owusu Danquah, E., Oteng-Darko, P., Agyeman, K., Tetteh, E.N.** (2021). Carbon smart strategies for enhanced food system resilience under a changing climate. *Frontiers in Sustainable Food Systems*, p.304. https://doi.org/10.3389/fsufs.2021.715814

Book chapters

55. **Acheampong, P. P., Owusu-Danquah, E., Agyeman, K., Dankwa, O. K.** and Addison, M. (2021). Research and Development for Improved Cassava Varieties in Ghana: Farmers' Adoption and Effects on Livelihoods. *In A. Frediansyah, (Ed.), Cassava - Biology, Production, and Use.* (pp 75-90), IntechOpen, http://dx.doi.org/10.5772/intechopen.87488

56. **Acheampong, P. P., Owusu Danquah, E., Agyemang, K., Dankwa, K. O.** (2021). Research and development for improved cassava varieties in Ghana: Farmers' adoption and effects on livelihoods. *In: Frediansyah, A., Ed. Cassava – Biology, Production, and Use. IntechOpen*, ISBN: 978-1-83968-909-3. https://doi.org/10.5772/intechopen.97588

57. **Addo-Danso, A.** and **Amankwaa-Yeboah, P.** (2021) The potentials of bamboo-based agroforestry systems in improving the productivity of tropical African agricultural systems. *Agricultural and Food Science Journal of Ghana*, Vol. 14:1468-1482. DOI: 10.4314/afsjg. v14i1.11

58. **Addo-Danso, A.** and Kwaku, M. (2021) Considerations and significance of tenure security to the development of bamboo plantations in Ghana. *Ghana Journal of Forestry*, Vol. 37: 31 – 46.

59. **Adjei A. E., Tetteh E. N., Darkey S., Dzomeku B. M., Mintah P.** and Anti M. (2021). Extrapolating technology from research plots to commercial scale and challenges involved: *Case study of plantain macro-propagation technique* Vol.13(4), pp. 225-231 October-December 2021 DOI: 10.5897/JAERD2021.1258 Articles Number: 0DE989867846 ISSN: 2141-2170.

60. **Adomako, J., Kankam**, F., Larbi-Koranteng, S., **Danso, Y.**, Asamoah, J. Y., **Oteng-Darko, P., Agyeman, K., Yeboah, S., Tetteh, E. N., Owusu Danquah, E.** (2021). Phytophthora diseases in Ghana: threats, management options and prospects. *In: Abdulkhair, H. M. W., Ed. Agro-economic risks of Phytophthora and an effective biocontrol approach. Ed. IntechOpen*, ISBN: 978-1-83969-654-1. https://doi.org/10.5772/intechopen.99135

61. **Adomako, J.**, Kankam, F., Larbi-Koranteng, S., **Danso, Y.**, Asamoah, J. Y., **Oteng-Darko, P., Agyeman, K., Yeboah, S., Tetteh, E. N.** and **Owusu Danquah, E.** (2021). Phytophthora diseases in Ghana: threats, management options and prospects. *In: Abdulkhair, H. M. W., Ed. Agro-economic risks of Phytophthora and an effective biocontrol approach. Ed. IntechOpen*, ISBN: 978-1-83969-654-1.

62. **Adomako, J.**, Kankam, F., Larbi-Koranteng, S., **Danso, Y.**, Asamoah, J. F., **Oteng-Darko, P., Agyeman, K., Yeboah, S., Tetteh, E.N., Owusu, E.D.** (2021). Phytophthora diseases in Ghana: Threats, Management options and prospects. In. *Agro-Economic Risks of Phytophthora and an Effective Biocontrol Approach, http://dx.doi.org/10.5772/intechopen.99135*.

63. **Amponsah, S. K.** and Guilherme, L. (2021). Promoting domestic production of fish using recirculating aquaculture system (RAS). *In: Technology in Agriculture*, Chapter 16: 135-153, *INTECH Publishers*

64. **Asiedu, E. A., Adjei, E. A.** and **Asibuo, J. Y.** (2021). Effect of Storage Temperature and Moisture Content on Seed Quality, Plant Establishment and Grain Yield of Cowpea, *Agricultural and Food Science Journal of Ghana*. Vol. 14. December 2021 pp. 1413-1425. https://dx.doi.org/10.4314/afsjg.v14i1.7.

65. Boateng, E., **Adjei E. A, Osei, M. K., Offei, K. O** and Olympio, N. S. (2021). Response of plant spacing on the morphology and yield of five hot pepper lines Vol. 17(10), pp. 1281-1287, October, 2021 DOI: 10.5897/AJAR2017. 12596 Article Number: 9590A2C67854 Author(s) retain the copyright of this article http://www.academicjournals.org/AJAR.

66. Dadzie, M. A., **Oppong, A.**, Obeng-Bio, E. and Warburton M. L. (2021). Genetic Variation and Aflatoxin Accumulation Resistance among 36 Maize Genotypes Evaluated in Ghana (In). *Cereal Grains* - Volume 2. December 2021. DOI:10.5772/intechopen.96461

67. **Frimpong F.**, Anokye M., Windt CW, Naz AA, Frei M., van Dusschoten D., Fiorani F. (2021). Proline-mediated drought tolerance in the barley (*Hordeum vulgare* L.) isogenic line is associated with lateral root growth at the early seedling stage. *Plants*. 2021; 10(10):2177. https://doi.org/10.3390/plants10102177

68. **Frimpong, F.**, Windt, C., van Dusschoten, D., Naz, A., Frei, M., and Fiorani, F. (2021). A wild allele of *Pyrroline-5-carboxylate synthase1* leads to proline accumulation in spikes and leaves of barley contributing to improved performance under reduced water availability. *Frontiers in Plant Science*, 12, 180. https://doi.org/10.3389/fpls.2021.633448

69. **Frimpong-Anin, K., Mochiah, M. B., Osei, M. K., Bonsu, K. O.** and Opoku, P. (2021). Integration of biorationals into management of pepper and tomato pests. *Journal of Entomology and Zoological Studies* 9 (2): 14-19.

70. **Issa, U.S., Frimpong-Anin, K. Adama, I. Mochiah, M. B., Braimah, H.** and Obeng, P. (2021). Indigenous natural enemies attacking fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Ghana. *Journal of Entomology* 18: 1-7.

71. **Nsiah Frimpong B.,** Obeng Ampadu. S., **Oppong A.**, Nunoo, I. and **Brobbey L.**, (2021). "Phytophthora Diseases Prevalence, its Effects and Controls in Ghana in: *Agro-Economic Risks of Phytophthora and an Effective Biocontrol Approach*" edited by Dr. Waleed Mohamed Hussain Abdulkhair. Published 22nd Oct. 2021. Publisher: IntechOpen ISBN: 978-1-83969-854-1.

72. **Ofosu, K.A., Asante, M.D.**, Asare-Bediako, E. and Asare, P. A. (2021). Marker-assisted breeding for resistance to blast and Rice yellow mottle diseases in Ghana. Oral presentation, African Plant Breeders Association Conference, October 25-29, 2021, Kigali, Rwanda.

73. **Osei-Bonsu, I.**, McClain, A. M., Walker, B. J., Sharkey, T. D., Kramer, D. M. (2021) The Roles of Photorespiration and Alternative Electron Acceptors in the Responses of Photosynthesis to Elevated Temperatures in Cowpea. *Plant Cell Environ.* 2021,44;2290–2307. https://doi.org/10.1111/pce.14026

74. **Osei, M. K.,** Adjebeng-Danquah, Egbadzor, K., Ousman, A.S., **Adjei, E.A.,** Abebrese, S.O., Melomey, L.D. and Agyare, R.Y. (2021). Vegetable Seed Production: Prospects and Challenges: The Case of Ghana. Springer Nature Singapore Pie Ltd. 2020 A.K. Tiwari (ed). *Advances in Seed Production and Management*. https://doi.org/10.1007/978-981-15-4198-8 5

75. **Osei, M. K., Akom, M.**, Adjebeng-Danquah, J., K, Egbadzor, F., Abebrese S., Asare B. K. and Richard Yaw Agyare (2021). Cover crops in Vegetable production and Urban Farming in Sub-Saharan Countries. DOI: 10.1201/9781003187301-4 In book: *Cover Crops and Sustainable Agriculture Edition*: First Chapter: 4 Publisher: Taylor and Francis Group. CRC Press

76. **Osei, M.K., Frimpong-Anin, K.**, Adjebeng-Danquah, J., **Nsiah Frimpong, B.** and **Adomako, J.** (2021). Invasive Allien Species (IAS) of Ghana: *Observations and Issues from Around the World*, Volume 1: Issues and Invasions in Africa, First Edition. Edited by T. Pullaiah and Michael R. Ielmini. John Wiley and Sons Ltd. pp. 5: 145-172

77. **Osei, M.K., Frimpong-Anin, K.,** Adjebeng-Danquah, **Frimpong, B.N.** and **Adomako, J.** Invasive Alien Species (IAS) of Ghana (2021). *In: Invasive species: observations and issues around the world*. Vol. 1, Issues and invasions in Africa, E.d. Pullaiah T. and Lelmini M.R. Wiley-Blackwell, NJ. pp 145-169.

78. Pérez-Alfocea, F., **Yeboah, S** and Dodd, I. C. (2021). Rootstocks to improve root function and resource-use efficiency. Burleigh Dodds Science Publishing Limited. (ISBN: 978 1 78676 360 0).1-29. Doi.org/10.19103/AS.2020.0075.25. **Editor:** Emeritus Professor Peter Gregory, University of Reading, UK

Conference Proceedings

79. **Acheampong, P. P., Osei-Tutu, I., Opoku, M., Brobbey, L.** and **Asibuo, Y. J.** (2021). Gender, farm resource access, ownership and Role Play in Crops Production: The case of Cowpea Production at Ejura Sekyeredumase and Atebubu Amantin Municipalities. *Poster Prepared for the 4th annual conference of the Ghana Association of Agricultural Economists, 4th to 7th August, 2021 University for Development studies, Tamale.*

80. **Adjei E. A., Banful B. K., Asiedu E. A.,** Amoah R., **Adomako J., Yeboah S., Kwodane M., Appiah-Kubi Z., Osei Tutu I., Fenteng J. A.** and **Asibuo J. Y.** (2021). Influence of moisture content, packaging material and storage condition on the seed health quality of common bean variety Nsroma, 32nd RSA Annual General Meeting and 3rd Scientific Conference (RSA-AGM 2021) Theme: Advances in Science, Technology, and Innovation for Resilient Food, Health, and Ecological Systems CSIR-Science and Technology Policy Research Institute 19th-21st October 2021 Accra, p. 75.

81. **Adjei, E. A., Banful B. K., Asiedu E. A.,** Amoah R., **Adomako J., Yeboah S., Appiah-Kubi Z., Fenteng J. A.** and **Asibuo J. Y.** (2021). Managing the Physiological Seed Quality of *Nsroma* Common Bean Variety in the Humid Region of Ghana. 32nd Biennial Conference of the Ghana Science Association, Mitigating the COVID-19 Pandemic: The Quest for Scientific and Technological Innovations 6th-8th October, 2021 Kumasi p.62.

82. **Adjei, E. A, Banful B. K., Asiedu E. A.**, Amoah R., **Adomako J., Yeboah S., Appiah-Kubi Z., Fenteng J. A.** and **Asibuo J. Y.** (2021). Influence of Moisture Content, Packaging Material and Storage Condition on Biochemical Seed Quality of *Nsroma* Common Bean Variety in the Humid Region of Ghana. 32nd Biennial Conference of the Ghana Science Association, Mitigating the COVID-19 Pandemic: The Quest for Scientific and Technological Innovations 6th-8th October, 2021 Kumasi p.70.

83. **Adomako, J., Yeboah, S., Asibuo, J., Oteng-Darko, P., Acheampong, P.P., Asamoah Adjei, E.**, Maxwell, L. and Butare, L. (2021). Survey for diseases on common bean and identification of associated pathogens. *Poster prepared for Virtual presentation at BIC Conference, 1st – 4th November, 2021.*

84. Appiah Jr. K., **Oppong A.** and **Adu-Dapaah H.** (2021). Assessing the performance of promising maize genotypes resistant to aflatoxin accumulation in Ghana. Conference paper presented 2nd APBA conference in Kigali, Rwanda (October 2021)

85. **Arthur, S., Bolfrey-Arku, G., Mochiah, M.B.**, and **Asibuo, J.Y.**, Akroma, Sarkodie-Addo, R., J., Mahamah G. and Nboyine, J., Jordan, D.L. and Brandenburg, R. L., Hoisington, D. and Rhoads, J., (2021). Benefits of Peanut – Cereal Rotation and Inputs Systems on Maize Growth and Yield in Northern Part of Ghana. *53rd American Peanut Research and Education Society Conference.* Online (Abstract and Poster) 12th – 16th July, 2021, https://www.youtube.com/watch?v=dCalM_bvyNE; https://apresinc.com/wp-content/uploads/2021/06/ArthurS-Absract-2021.pdf; https://apresinc.com/wp-content/uploads/2021/07/Arthur-Poster-2021-PDF-2.pdf.

86. **Danso, Y** (2021). Detection of root-knot nematodes infecting okra using ITS rDNA Molecular markers. Poster presented at the 32nd CSIR, Research Staff Association AGM and 3rd Scientific Conference, Ghana Academy of Arts and Sciences, Accra Ghana. 19 – 21 October 2021.

87. **Oppong A.**, Dadzie M. A., Ifie B., **Asante M. D., Prempeh R.N.A, Abrokwah L.A. Appiah Kubi Z.**, Warburton M.L. (2021). Genetic analysis of new maize hybrids for yield and resistance to aflatoxin accumulation. Poster Presented at 2021 Maize Genetics conference held Virtually, (March 2021).

88. **Oppong A.**, **Prempeh R.N.A**, Adu. G. B., **Abrokwah L. A.**, **Asante M. D.**, **Marfo E. A.**, Annang E. A. and Adu-Amoah R. (2021). Comparative studies on yield stability of new Brazilian hybrid maize and selected varieties popular with Ghanaian farmers. Presented at APBA conference held in Kigali, Rwanda (October 2021)

89. **Prempeh R. N. A.**, **Oppong A.**, Amankwaah V., **Akomeah B.**, **Abrokwah L.**, Allotey L., Annang, E., Bosompem, A. N., Amoako F. and Mbanjo E. G. N. (2021). Using a low-density single nucleotide polymorphism panel to characterize Ghanaian cassava accessions. Presented at APBA conference held in Kigali, Rwanda (October 2021)

90. **Prempeh, R.**, **Oppong A.**, **Amankwaah V.**, **Akomeah B.**, **Abrokwah L.**, Allotey L., Annang E., Bosompem, A. N., **Amoako F.** and Mbanjo, G. E. (2021). Characterization of Cassava Germplasm Using a Low-cost SNP Panel presented at the African Plant Breeding Association Conference held in Kigali, 25-29 October 2021, pp 43 - 44.

91. **Ribeiro, F. P.**, **Afriyie Debrah, C.**, **Yeboah S.** and Baffoe, E. (2021) Stress Tolerant varieties for sustainable maize production in Ghana- A poster presented at the 2nd African Plant Breeders Conference in Rwanda.

92. **Yeboah, S.**, **Adomako, J.**, **Asibuo, J.**, **Oteng-Darko, P.**, **Acheampong, P.P.**, **Asamoah Adjei, E.**, **Lamptey, M.** and Butare, L. (2021). Improving Bean Productivity through Application of Zinc and Magnesium Foliar Fertilizer in Ghana. *Poster prepared for Virtual presentation at BIC Conference, 1st – 4th November, 2021*

93. Yodying, A., Mahavik, N., Tantanee, S., **Keteku, A. K.**, Kongmuang, C., Chidburee, P., Seejata, K., and Chatsudarat S. (2021). Flood hazard mapping for a repeated flooding area in Northern Thailand. Proceeding of The 42nd Asian Conference on Remote Sensing (ACRS2021) 22-24th November, 2021 in Can Tho University, Can Tho city, Vietnam. ISBN: 9781713843818, 2:1509.

Technical reports

94. **Acheampong, P. P., Yeboah**, S., Adabah, R. and **Asibuo, J.** (2021). Gendered Perceptions and Adaptations to Climate change: The case of Ejura-Sekyedumase and Atebubu-Amantin Municipalities in Ghana. Report submitted to PABRA project, Kenya. Pp25.

95. **Agyeman, K., Berchie, J. N., Marno, P., Adomako, J., Owusu Dankwah, E., Keteku, K. A.,** Brempong, B. M (2021). Improving productivity of Cassava production systems in the Ghana through the evaluation and dissemination of customized fertilizer for enhancing soil fertility. ***Submitted to OCP Ghana Limited.***

96. **Agyeman, K., Berchie, J. N., Owusu Dankwa, E., Marno, P., Adomako, J.,** Agbesi, K., **Badu-Brempong, M.** and **Sakyiamah, B.** (2021). Effect of Yara Fertilizer Combinations / Blends on Productivity of Maize. ***Submitted to YARA Ghana Limited.***

97. Darko, C., **Yeboah S.**, Amoah, A., Opoku A., **Baafi E. and Berchie J. N.** Yield, biochemical properties and cooking quality traits of sweet potatoes (Ipomoea batatas) as affected by Nitrogen and Potassium Fertilizer rates.

SELECTED ABSTRACTS FROM PEER REVIEWED ARTICLES

1. Genetic variability for and tolerance to anaerobic germination in rice (Oryza sativa L.)

Authors: Asante, M.D., Ipinyomi, S. O., Abe, A., Kossi, Adjah, Aculey, P., Bam, R.K. and Manneh, B

Poor germination and seedling establishment under flooded conditions is a major bottleneck in the direct-seeding system of rice. The objectives of this study were to determine the genetic variability for traits associated with anaerobic germination and identify tolerant genotypes. One hundred rice genotypes were screened. Data were collected on survival percentage, shoot length, root length, length of plant above water, and seedling vigor index. Six clusters, which were generally related to the ability of the genotypes to tolerate anaerobic germination, were detected. The first two principal components accounted for 91.1% of the total variation, with survival percentage, seedling vigor index and shoot length being the main discriminatory traits. Genotypic coefficient of variation ranged from 18.21% for shoot length to 50.89% for seedling vigor index. Shoot length and seedling vigor index recorded high broad-sense heritability estimates (>60%), with accompanying high genetic advance as percent of mean (>20%); the latter ranged from 23.12% for root length to 82.21% for seedling vigor index. The high heritability, along with high genetic advance, particularly for shoot length and seedling vigor index, indicated that selection for these traits should be effective in improving tolerance to anaerobic germination. Five tolerant genotypes (OBOLO, ART68-12-1-1-B-B, ART64-31-1-1-B-B, CRI-1-21-5-12, and CRI-Enapa) with high survival percentage (≥70%) under anaerobic conditions were identified. These genotypes could be used to improve commercial rice varieties for tolerance to anaerobic germination.

2. Expanding industrial uses of sweetpotato for food security and poverty alleviation

Authors: Adu-Kwarteng, E., Baafi, E. Amoa-Owusu, A., Okyere. F. and Carey, E.

Sweetpotato breeding over the years solely depended on sensory evaluation for domestic uses, thereby downplaying the need for adjustment of breeding objectives and selection procedures to cater for industrial potential. This study was conducted to evaluate ten elite genotypes of sweetpotato for diversified utilization and commercialization. These genotypes had been selected over the years for high dry matter and starch content according to the preference of Ghanaian consumers. Analyses were carried out on key nutrient components, pasting properties, and starch granule morphology using near infrared reflectance spectroscopy, rapid viscosity analysis, and light microscopy, respectively. Sensory evaluation was carried out using a focus group approach. Based on functional diversity and unique combinations of quality traits identified, the genotypes were found to have several potential applications in the food industry. These include fufu flour, bread, pastries, French fries, gluten-free noodles, yogurt filler, baby food, juices, and raw material for brewery and other industries. These elite genotypes, when released as new varieties, can immensely contribute to a more diversified use of sweetpotato in Ghana and ultimately contribute to the enhancement of food and job security.

3. Impact of tank geometry on production of African Catfish (Clarias gariepinus)

Authors: Amponsah, S. K., Agodzo, S., Agbeko, E. & Osei, E. A.

Geometry of fish tanks tends to affect the growth and yield of fish. The impact of tank geometry on the production of Clarias gariepinus was evaluated. Circular, rectangular and ellipsoid tanks were used to test the variation of water temperature, pH, dissolved oxygen and total suspended solids on African catfish growth performance. Results on water temperature, pH, DO, were within the acceptable ranges of 24.9-25.9°C, 6.39-7.52 and 5.81-8.32 mg/l, for circular tank; 25.1-26.1˚C, 6.49-7.53 and 3.96-8.53 mg/l, for rectangular tank; and 24.5-26.2°C, 6.49-7.50 and 5.08-8.43 mg/l, for ellipsoid tank; respectively. Weight gain ranged from 14 to 576 g, 13 to 330 g and 14 to 557 g; feed conversion ratio (FCR) ranged from 1.11-1.33, 1.23-1.54 and 1.22-1.34; specific growth rate (SGR) ranged from 0.40 g/day to 3.64 g/day, 0.11 to 2.27 g/day and 0.79 to 3.12 g/day; survival rate were >88, >84 and >92% for circular, rectangular and ellipsoid tanks, respectively. Except for weight gain and FCR, all other parameters (length increment, SGR and survival rate) showed no significant difference (P = .05) among the 3 tank geometries. Benefit cost ratio (BCR) for the circular, ellipsoid and rectangular tank was 1.12, 1.13 and 0.79, respectively.

4. Adoption of improved white yam (Dioscorea rotundata) varieties in Ghana: The role of farm and farmer characteristics

Authors: Acheampong, P. P., Adu-Appiah, A., Frimpong, B. N., Haleegoah, J., Amengor, E. N., Asante, B. O. and Otoo, E

Yams (Dioscorea spp) in Ghana are important food staples and the most important non-traditional export crop contributing to foreign exchange and incomes of smallholder producers. Research and development of the crop over the years produced and release three improved Dioscorea rotundata varieties in 2005. However, adoptions of these varieties have been very low. Using cross-sectional data from 544 randomly selected yam farmers and employing the logit model, the farm and farmer characteristics that influence the adoption of yam varieties were assessed. Results revealed the awareness level of improved yam varieties at 50% and low adoption rate of improved yam varieties at about 6%. Factors found to significantly influence adoption were awareness, education, distance to farm and extension access. The study suggests the need to create more awareness and education on the improved yam varieties in order to sensitize farmers and encourage adoption. There is also the need to improve research extension linkage system to enable technology knowledge transfer to extension staff for easy diffusion to farmers.

5. Physiological quality of African eggplant seeds as influenced by natural fermentation and drying methods

Authors: Botey, H. M., Ochuodho J. O., Ngode L., Owusu Danquah E. and Agyare Richard R.

Seed extraction and drying methods are important procedures employed after harvesting fruits of African eggplant as these methods affect the seed quality. This study sought to evaluate the seed physiological quality of two cultivars of African eggplant subjected to various durations of natural fermentation and different drying methods. In the first study, fruits were fermented for 0, 6, 12, 24 and 48 h before seed extraction. In the second experiment, seeds were extracted and subjected to sun/24 h; shade/24 h; shade/48 h; desiccant (silica gel)/24 h; shade/24 h + 30 °C oven (24 h); 30°C/24 h; 35 °C/24 h; 45 °C/24 h; 50°C/24 h and 60°C/24 h for drying. The seed quality evaluation were seed moisture content, seed dry weight, first count, seed germination and accelerated aging. The results suggest that African eggplant seeds do not require natural fermentation during extraction for enhanced seed germination. All drying methods were able to reduce seed moisture content to an ideal level for storage and maintained seed physiological quality. The latent effect of these methods on seed physiological quality needs to be studied.

6. Cassava Mosaic Virus Disease in Ghana: Distribution and Spread

Authors: Oppong A., Prempeh R. N. A., Abrokwah L. A., Annang E.A., Marfo E.A., Appiah Kubi Z., Danquah N. A. O., Agyekum A., Nsiah Frimpong B., Appiah S.A., Lamptey J.N.L., Mochiah M.B., Pita J.S

Cassava is an important staple crop in most of the tropics including Ghana. The productivity of the crop is beset with pest and disease attacks. With the emergence of virulent strains of the cassava mosaic virus (CMV), regular surveys are necessary to ascertain the prevalence of CMV and their whitefly vectors in farmers' fields to help manage CMV disease affecting the crop. Methods: Field surveys were conducted in September and October of 2015 and December 2016 to January 2017 using a harmonized sampling protocol developed by the West African Virus Epidemiology (WAVE) for root and tuber project. Three hundred and ninety-three fields were visited throughout Ghana and 11,760 cassava leaf samples examined. Whiteflies were counted on 5 plants/field. Diseased samples with varying symptoms collected were assayed using PCR and genomic sequencing. Cassava mosaic disease (CMD) symptoms were recorded in about ninety-six percent (96.4%) of fields surveyed with varying severity. These symptoms included leaf mosaic, leaf distortion/twisting, malformation, filiform leaves, stunting and chlorosis. Cultivars with red petiole colour were the most prevalent while those with green petiole colour were the least. No whitefly was found on cultivars with purple and Green petioles while cultivars with reddish-green petioles had highest count of whiteflies/plant. The Upper West and Upper East

regions had the least number of whiteflies/plant. Six CMV strains were detected: ACMV-Ivory Coast, ACMV-Kenya, EACMV-Cameroun, ACMV-Ghana, EACM-Cameroun virus-Ghana and EACMV-Kenya. ACMV-Kenya and EACMV-Kenya are being reported for the first time. This indicates that more CMV strains are being detected in the country.

7. Nitrous oxide, methane emissions and grain yield in rainfed wheat grown under nitrogen enriched biochar and straw in a semiarid environment

Authors: Yeboah, S., Jun, W., Liqun, C., Oteng-Darko, P., Narteh Tetteh, E. and Renzhi, Z.

Soil application of biochar and straw alone or their combinations with nitrogen (N) fertilizer are becoming increasingly common, but little is known about their agronomic and environmental performance in semiarid environments. This study was conducted to investigate the effect(s) of these amendments on soil properties, nitrous oxide (N2O) and methane (CH4) emissions and grain and biomass yield of spring wheat (Triticum aestivum L.), and to produce background dataset that may be used to inform nutrient management guidelines for semiarid environments.The experiment involved the application of biochar, straw or urea (46% nitrogen [N]) alone or their combinations. The treatments were: CN0-control (zero-amendment), CN50 - 50 kg ha-1 N, CN100-100 kg ha-1 N, BN0 -15 t ha-1 biochar, BN50-15 t ha-1 biochar + 50 kg ha-1 N, BN100-15 t ha-1 biochar + 100 kg ha-1 N, SN0 -4.5 t ha-1 straw, SN50 -4.5 t ha-1 straw + 50 kg ha-1 N and SN100-4.5 t ha-1 straw + 100 kg ha-1 N. Fluxes of N2O, CH4 and grain yield were monitored over three consecutive cropping seasons between 2014 and 2016 using the static chamber-gas chromatography method. On average, BN100reported the highest grain yield (2054 kg ha-1), which was between 25.04% and 38.34% higher than all other treatments. In addition, biomass yield was much higher under biochar treated plots relative to the other treatments. These findings are supported by the increased in soil organic C by 17.14% and 21.65% in biochar amended soils (at 0-10 cm) compared to straw treated soils and soils without carbon respectively. The BN100treatment also improved bulk density and hydraulic properties ($P < 0.05$), which supported the above results. The greatest N2O emissions and CH4 sink were recorded under the highest rate of N fertilization (100 kg N ha-1). Cumulative N2O emissions were 39.02% and 48.23% lower in BN100 compared with CN0 and CN100, respectively. There was also a ≈ 37.53% reduction in CH4 uptake under BN100compared with CN0-control and CN50.

The mean cumulative N2O emission from biochar treated soils had a significant decrease of 10.93% and 38.61% compared to straw treated soils and soils without carbon treatment, respectively. However, differences between mean cumulative N2O emission between straw treated soils and soils without carbon were not significant. These results indicate the dependency of crop yield, N2O and CH4 emissions on soil quality and imply that crop productivity could be increased without compromising on environmental quality when biochar is applied in combination with N-fertilizer. The practice of applying biochar with N fertilizer at 100 kg ha-1 N resulted in increases in crop productivity and reduced N2O and CH4soil emissions under dryland cropping systems.

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