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ACRONYMS

AATF	The African Agricultural Technology Foundation
AGG	Accelerating Genetic Gains
AGRA	Alliance for Green Revolution in Africa
AICCRA	Accelerating Impacts of CGIAR Climate Research for Africa
ARS	Agricultural Research Service
AWD	Alternate Wetting and Drying
BCR	Benefit Cost Ratio
BMGF	Bill and Melinda Gates Foundation
BNARI	Biotechnology and Nuclear Agriculture Research Institute
CHPRRU	Corn Host Plant Resistance Research Unit
CIAT	The International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CMD	Cassava Mosaic Disease
CORAF	West and Central African Council for Agricultural Research and Development
CTAB	Cetyltrimethylammonium Bromide
DNA	Deoxyribonucleic Acid
EiB	Excellence in Breeding
EU	European Union
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FAW	Fall Army Worm
FCDO	Foreign Commonwealth and Development Office
FCS	Food Consumption Score
GBC	Ghana Broadcasting Corporation
GCRF	The Global Challenges Research Fund
GI	Galling Index
ICRAF	International Centre for Research in Agroforestry

ACRONYMS

KOPIA	Korea Program for International Cooperation in Agricultural Technology
MOFA	Ministry of Food and Agriculture
NAS	National Academies of Sciences
NVRRC	National Varietal Release and Registration Committee
OFAB	Open Forum on Agricultural Biotechnology
PCR	Polymerase Chain Reaction
PEER	Patnerships for Enhanced Engagement in Research
PGRRI	Plant Genetic Resources Institute
PPRSD	Plant Protection and Regulatory Services Department
PS	Positive Selection
PVC	Polyvinyl Chloride
RDA	Rural Development Administration
ROI	Return On Investment
RYMV	Rice Yellow Mottle Virus
UENR	University of Energy and Natural Resources
UKAID	United Kingdom Agency for International Development
UKFCDO	United Kingdom's Foreign Commonwealth & Development Office
UKRI	United Kingdom Research and Innovation
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UV	Ultra-violet
WAVE	West African Virus Epidemiology
IITA	International Institute of Tropical Agriculture
INERA	Institute of Environment and Agricultural Research
KAFACI	Korea-Africa Food and Agriculture Cooperation Initiative

FOREWORD

It is with great pleasure that we present a summary of our activities in 2022.
Research activities returned to normalcy in 2022 due to the removal of national restrictions on movements and meetings as a result of the covid-19 pandemic. The research activities in 2022 centred mainly on cereals, legumes, horticultural crops, tropical fruits and vegetables, roots and tuber crops as well as industrial crops, which are our mandate crops . We are happy to report that all our activities positively impacted our stakeholders and the general public leading to numerouns succes stories and increased agricultural productivity.

Funding for research activities has been a major setback for the Institute for a long time. With very little support from the Government of Ghana towards research, sponsorships from donor agencies have become the major source of funding for all our activities. Our gratitude goes to all our partenrs who have continually supported us in diverse ways to achieve our targets. Staff of the Institute continue to build their capacities through various technical trianing programmes as well as graduate and postgraduate studies.

This is to ensure that the quality of our human resource is always at a very high level. We continue to improve on our existing infrastructure and also increase commercialization activities in order to generate more internally generated funds (IGF) to complement dwindling government and donor support.

Our gratitude and appreciation go to our very hardworking and committed staff for enduring the long hours in the office and the fields to ensure that demand-driven technologies are developed and released for the improvement in the rural and national economies. 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

Our continuous success in agricultural research is as a result of several contributing factors. We are grateful to all our stakeholders who have relentlessly supported us all these years. We say a very big “Thank you” to you all and it is our prayer that we continue to work together in the coming years to achieve greater successes.

We are very grateful to our partners and collaborators who sponsored most of our project activities in 2022. These comprised the Korea Program for International Cooperation in Agricultural Technology (KOPIA), the Korea Africa Food and Agriculture Cooperation Initiative (KAFACI), Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA), the Excellence In Breeding (EiB) Project, CORNELL GREAT, International Centre for Research in Agroforestry (ICRAF), United Kingdom Research and Innovation (UKRI), Crop Trust, CORAF, the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT) as well as the African Agricultural Technology Foundation (AATF) among several others. We are also grateful to the Canadian Government for supporting the Modernizing Agriculture in Ghana (MAG) programme.

We continued to work closely with other institutes of the Council for Scientific and Industrial Research (CSIR), public and private universities, farmer groups, civil society, ministries, departments, non-governmental organizations (NGOs) and other research institutions. Our immense appreciation goes out to all such institutions for their cooperation.

Our final but definitely not the least appreciation goes to all our hardworking and committed scientists, technical and support staff. Your long hours of work, sleepless nights and tireless efforts have produced all the successes we are reporting this year. We say a big “ayekoo” to you all.

God richly bless us all.

OUR PROFILE

The Council for Scientific and Industrial Research (CSIR) is the foremost national science and technology organization in Ghana. Established in 1964, the CSIR-Crops Research Institute (CSIR-CRI) is the largest of the thirteen (13) institutes of the CSIR. 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 food and industrial crop varieties and their production technologies to enhance food security and poverty reduction. The mandate 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, okra and leafy vegetables), tropical fruits (citrus, mango, avocado, cashew, pineapple, and pawpaw), and industrial crops (rubber and sugarcane).

With Excellence, Fairness, Commitment, Transparency, Accountability and Teamwork as our core values, 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 our core mandate, the Institute also offers several services to various stakeholders.These include but are not limited to the production of foundation seeds for the National SeedIndustry, the supply of healthy planting materials of citrus, avocado, mango, plantain and banana, cassava, cocoyam, sweetpotato, taro and yam, the establishment of farms (tree crop plantations), the production of extension materials and advise on the use of appropriate experimental designs for field studies.

EXECUTIVE SUMMARY

The 2022 annual report has summarized our key achievements within the year, and it is our firm belief that we will continue to rise to every challenge in order to achieve even more success in the coming years.

By the beginning of the year, the effects of the covid-19 pandemic had reduced, and normalcy had resumed. With no covid-19 restrictions, all research activities and stakeholder engagements were held in-person.

Having identified major constraints in the country's quest to achieving self sufficiency in rice production, the Institute has been developing and releasing improved varieties of rice to reduce the huge production deficit. With support from RDA-KAFACI/KOPIA, AfricaRice, AGRA and INERA, the Institute released nine (9) improved varieties of rice in 2022. These comprised six lowland and three upland varieties. Additionally, with support from the Accelerating Genetic Gains in maize and wheat (AGG) project, the Institute has developed and released six (6) new hybrid maize varieties. These varieties combined verified resistance to aflatoxin contamination and high yields, and will contribute greatly towards food security for both farmers and consumers.

The Central and West African Virus Epidemiology (WAVE) for root and tuber crops project, funded by the Bill and Melinda Gates Foundation embarked on a sensitization campaign on cassava viral diseases. The campaign created awareness on the major diseases that adversely affect productivity of the crop and sensitized farmers on how to identify and mitigate against such diseases to promote food security. Over five hundred (500) cassava farmers and agricultural extension officers (AEAs) directly benefitted from the campaign while millions benefitted indirectly through several media outlets.

The Institute also introduced a water- saving irrigation technology called alternate wetting and drying (AWD) to rice farmers in Ghana.

The AWD technology is a water saving irrigation technology that can reduce irrigation water use by up to 40% in irrigated rice production and was developed in collaboration with Lancaster University, UK under the GCRF funded project called RECIRCULATE. AWD enhances water and nutrient use efficiency in irrigated rice production. It also reduces greenhouse gas emissions.

The Institute maintained active involvement with stakeholders through a combination of conventional and contemporary media channels. Platforms like Facebook, Instagram, Twitter, and the Institute's official website played crucial roles in sharing information with stakeholders, contributing significantly to increased visibility. Additionally, CRI-TV, an online television platform established in 2020, consistently delivered a high-quality content on research and development from CSIR-CRI and other research institutes.

Professor Marian Dorcas Quain, a Chief Research Scientist at the Institute, received recognition at the 2022 Open Forum on Agricultural Biotechnology (OFAB) Awards. The African Agricultural Technology Foundation (AATF) organizes OFAB, and she was acknowledged for her valuable contributions to advancing agricultural prosperity in Africa.Staff attrition continues to be a major challenge the Institute faces. This has caused a major decline in staff strength. The Institute persists in participating in diverse commercialization endeavors to generate funds internally. The primary focus of these activities is in the production and subsequent sale of planting materials.

As active contributors to the scientific and academic realm, the Institute's staff consistently disseminate their research findings to the Community of Practice (CoP) and the public through regular publications in peer-reviewed journals and production guides, manuals etc. In the year 2022, the Institute achieved a milestone with over one hundred publications, encompassing refereed journal papers, conference papers, manuals, production guides, books, book chapters, posters, and technical reports.

01 ACHIEVING RICE SELF-SUFFICIENCY IN GHANA: CSIR-CRI RELEASES NINE IMPROVED RICE VARIETIES

Sponsors: RDA-KAFACI/KOPIA, AfricaRice, AGRA and INERA

Plate 1: Lowland rice variety, CRI-Tuo Mo, at the reproductive stage

The gap between the demand for rice and the volumes produced in Ghana has resulted in an annual import bill of about US $ 200 million. The need to increase rice production in the country to achieve self-sufficiency and save the millions of dollars spent on rice importation yearly, has been championed by the CSIR-Crops Research Institute for years. The Institute has identified the major constraints to achieving rice self-sufficiency as low production levels, poor grain quality and ineffective marketing of domestically produced rice. To eliminate these constraints and consequently reduce the huge deficit, the Institute continues to develop and release improved varieties of rice for cultivation by farmers.

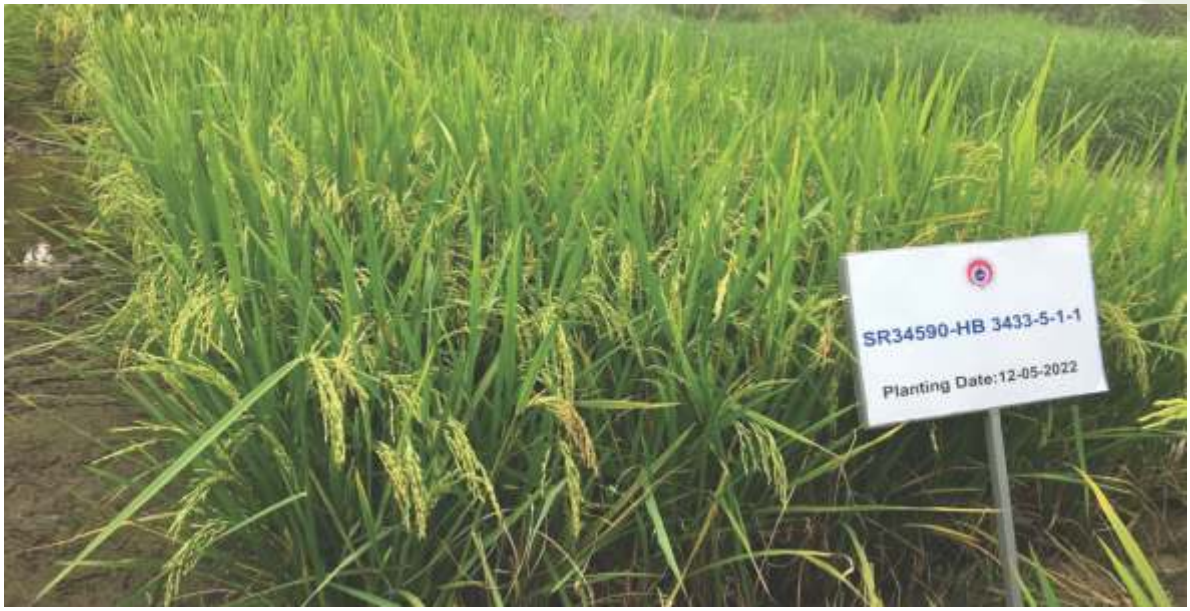

Plate 2:Lowland rice variety, CRI-Kang Mo, at the reproductive stage.

In October 2022, the Institute out-doored nine (9) newly-improved rice varieties to the general public. The varieties, which comprised six lowland rice (rice that grows in paddy or flooded fields) and three upland rice (rice that grows in drier soils) are the result of several years of extensive research conducted by scientists of the Institute. All nine varieties were approved by the National Varietal Release and Registration Committee (NVRRC) of Ghana in August, 2022.

Plate 3:Lowland rice varieties, CRI-Korea Mo and CRI-Baakoye at their reproductive stages

The lowland varieties namely ***CRI-Tuo Mo, CRI-Kang Mo, CRI-Korea Mo, CRI-Baakoye, CRI-Agyapa***, and ***CRI-Onuapa***, mature between 115 - 128 days and are high yielding with average yields of between 6 tons/ha to 7 tons/ha. Some of the lowland varieties have potential yields of up to 9 tons/ha. All the varieties possess quality consumer attributes and are also tolerant to the Rice Yellow Mottle Virus (RYMV) disease. Additionally, one of the varieties, ***CRI-Baakoye***, due to its high paste viscosity, is suitable for industrial use in the preparation of baby foods and breakfast cereals.

Plate 4: Lowland rice varieties, CRI-Agyapa and CRI-Onuapa at their reproductive stages

The three (3) upland varieties, namely, CRI KAFACI upland, CRI-Cho upland and CRI-Fosu upland are long and aromatic with low to intermediate amylose content. They mature between 97 and 105 days and have a yield potential of 6 tons/ha.

Plate 5: Panicles of the three new upland rice varieties

Economic analyses of all nine varieties revealed high benefit-cost ratios indicating that farmers will gain about fifty percent (50%) profit upon adoption of these varieties. The lead breeders for both the lowland and upland research teams, Dr. Maxwell Darko Asante (for the lowland varieties) and Dr. Paul Kofi Dartey (for the Upland varieties) are very optimistic of the potential these new varieties possess and stated that the new varieties are game changers towards Ghana's quest to attain rice self-sufficiency. They called on the Government of Ghana to increase its support for local rice production in order to drastically reduce the rice import bill and also increase the genetic gain to meet domestic needs. The CSIR-CRI acknowledges the support of its collaborators (RDA-KAFACI/KOPIA- Republic of Korea, AfricaRice, AGRA and INERA-Burkina Faso) in the release of these varieties.

Team: *Dr. Maxwell Darko Asante, Dr. Paul Kofi Ayirebi Dartey, Dr. Felix Frimpong, Dr. Charles Afriyie-Debrah, Daniel Dzorkpe Gamenyah, Kirpal Agyemang Ofosu, Phyllis Aculey, Elizabeth Norkor Nartey, Dr. Ralph Bam, Dr. Ebenezer Annan-Afful, and Bernard Sakyiamah.*

02 RELEASE OF NEW HYBRID MAIZE VARIETIES

Sponsors: Accelerating Genetic Gains in Maize and Wheat (AGG) Project USAID NAS PEER

Maize production in Ghana has seen a considerable increase over the last few years but the country is still not self-sufficient as shortfalls keep resulting in high market prices. Additionally, maize production is constrained by both biotic and abiotic stresses. Biotic stresses such as diseases and pests as well as aflatoxin contamination caused by Aspergillus flavus, affect productivity, quality of grains and farmers' incomes. The presence of aflatoxins in food and feed makes them unsafe for consumption. Abiotic factors such as poor soil conditions, and climatic factors also expose the crop to yield losses which can result in food insecurity. The development of maize varieties that combine verified resistance to aflatoxin contamination and high yields in the country will contribute greatly towards food security for both farmers and consumers. Consequently, in the third quarter of 2022, the CSIR-Crops Research Institute got formal approval from the National Varietal Release and Registration Committee (NVRRC) for the release of six hybrid maize varieties. Four of the varieties, CRI-Anyemi, CRI-Nyamekye, CRI-Adinkra and CRI-Sompa are single cross hybrid varieties with good levels of aflatoxin accumulation resistance. They are early-to-intermediate yielding with a potential yield of up to 7.5 tons/ha and mature within 100- 105 days after planting.

Plate 6:CRI-Nyamekye and CRI-Adinkra

Plate 7:CRI-Anyemi and CRI-Sompa

One variety, CRI AGG22, a three-way hybrid has a potential yield of 7.3 tons/ha, while CRI Tenganbie, a top cross hybrid has a potential yield of 7.0 tons/ha. Both varieties are intermediate maturing (110-115 days) and tolerant to drought and Striga. Sensory evaluations and economic analysis performed on all six released varieties revealed consumers' acceptance as well as very high benefit cost ratios (BCRs).

Plate 8:Two of the newly released varieties, CRI Tenganbie and CRI- AGG22

Team: *Allen Oppong, Priscilla Ribeiro, Manfred B. Ewool, Gloria Boakyewaa, Patricia Pinamang Acheampong, Evelyn Adu-Kwarteng, Stephen Yeboah, Kennedy Agyeman, Eric Owusu Dankwah, Zipporah AppiahKubi, Benedicta Nsiah Frimpong, Ruth Prempeh, Linda Abrokwah, Esther Agyemang Marfo, Esther Afoley Annang, Maxwell Darko Asante, Bernard Sakyiamah, Francis Amoako-Andoh, Michael Akuamoah Boateng, Sylvia Kafui Archer, Esther Nseasom, Abigail Amoa-Owusu, Elvis Obeng Agyei, Faustina Okyere, Victor Amankwaah, Jerry Asamoah Fenteng, Blankson Amoabeng, Richard Adu Amoah, Richard Yeboah, Kwasi Paul, Stephen Kumankuma, Eric Baffoe, Rose Osei Kofi, John Vanuagbe, Isaac Amengbor, Rogger Kanton, Saka Buah, Felix Frimpong, Charles Afriyie-Debrah, , Emmanuel Adjei Asamoah, Hillary Mireku Bortey, Harry Okyere, Philip Ghanney, Jonas Osei-Adu, , Natson Eyram Amengo, Iddrisu Yahaya, Harriet Dwamena, Patricia Amankwa-Yeboah, M. B. Mochiah, , Bright Atawura, Richard Yeboah, Emmanuel Acquah, Ebenezer Frimpong Manso, Collins Gyimah, and Manigben Amadu Kulai*

03 FOUR HIGH YIELDING YELLOW-FLESHED CASSAVA VARIETIES RELEASED BY THE CSIR-CROPS RESEARCH INSTITUTE

Sponsors: Bill and Melinda Gates Foundation (BMGF), HarvestPlus and NextGen

In response to the growing global need for high beta-carotene (a precursor for vitamin A) crop varieties, the CSIR-Crops Research Institute developed and released four yellow-fleshed cassava varieties for cultivation and consumption. The varieties were all approved and recommended for release by the National Varietal Release and Registration Committee (NVRRC) of Ghana in 2022. The lack of enough yellow-fleshed cassava varieties in Ghana has been a challenge for stakeholders within the cassava value chain and the release of these varieties couldn't have come at a better period. The four improved yellow-fleshed cassava varieties mature between 12 and 15 after planting, and are high yielding with potential yields of up to 40 tons/ha. They also possess high storage root drymatter (30-35%), are tolerant to the Cassava Mosaic Disease (CMD), are vigorous and produce dense canopies early in their growing cycles and therefore, are good for weed management. All the varieties are yellow fleshed with total carotenoid content ranging between 4 µg/g and 12 µg/g. These attributes will boost food security and improve health status of consumers.

Plate 9: CRI-Kent, one of the released, yellow-fleshed cassava varieties.

Plate 10: Gari and confections made from the released cassava varieties.

All four released varieties can be processed into wet cake as an intermediary product for further processing into gari, cassava dough and high-quality flour. Additionally, they fit into the existing cropping systems of the different ecological zones of Ghana. One variety, CRI-Kent , with a potential yield of 40 tons/ha, is also "poundable" and can be used in the preparation of "fufu".

Team: *Joe Manu-Aduening, Ruth Prempeh, Kwame Obeng Dankwa, Allen Oppong, Victor A. Amankwaah, Marian D. Quain, Francis Amoako-Andoh, Adelaide Agyeman, Harriet Dwamena, Evelyn Adu-Kwarteng, Benedicta Nsiah Frimpong, Zipporah Appiah-Kubi, Grace Bolfrey-Arku, Stephen Arthur, Kofi FrimpongAnin, Yaw Danso, Eric Owusu Danquah, Kennedy Agyemang, Habibah Aggrey, Faustina Okyere, Linda Abrokwah, Abigail Amoa-Owusu, Nasiru Issah, Sarah Odame, Stella A. Ennin, and Moses B. Mochiah.*

04 CASSAVA FARMERS AND EXTENSION OFFICERS BENEFIT FROM "TOGETHER LET'S SAVE OUR CASSAVA" CAMPAIGN BY CSIR-CROPS RESEARCH INSTITUTE

Sponsors: Bill and Melinda Gates Foundation (BMGF), UKFCDO, EU, CORAF

The CSIR-Crops Research Institute, Ghana's foremost agricultural research institute intensified its campaign against cassava diseases particularly those caused by viruses in the country. Dubbed "Together, let's save our cassava", the campaign created awareness on the major diseases that adversely affect productivity of the crop and sensitized farmers on how to identify and mitigate against such diseases to promote food security.

Over five hundred (500) cassava farmers and extension officers selected from four popular cassava growing districts across the country; Asesewa (Eastern region), Wenchi (Bono region), Atebubu-Amantin (Bono East region) and Akatsi (Volta region) directly benefitted from the campaign while millions benefitted indirectly through several media outlets. At each district, the participants were informed about the need for the campaign which is to raise awareness on the increasing threats cassava viral diseases pose to the crop in Ghana and on the African continent. They were advised to apply themselves to the knowledge gained from the campaign in order to not only increase their yields but also achieve sustainable production of the crop.

Plate 11: A section of participants during the "Save Our Cassava Campaign" at Asesewa

The "**SAVE OUR CASSAVA**" campaign was one of several activities under the Central and West African Virus Epidemiology (WAVE) for root and tuber crops project, which seeks to equip and prepare scientists, policy makers and other stakeholders on the need to take pre-emptive steps aimed at protecting citizens from famine caused by viral diseases on cassava and other root and tuber crops. In additon, WAVE aims to understand and predict the emergence and evolution of root crop viruses in West and Central Africa by using modern environmental and disease monitoring systems. This will help to reduce the impact of these viruses on smallholder farmers and improve food security across the continent.

The project is being implemented in ten (10) African countries with funding from the Bill and Melinda Gates Foundation (BMGF) and the United Kingdom through the Foreign, Commonwealth and Development Office (FCDO) and supported by the European Union (EU) through CORAF based in Dakar, Senegal.

Plate 12:Participants being educated on cassava viral diseases at Asesewa and Wenchi

In Ghana, the project is led by Dr. Allen Oppong, a virologist and Principal Research Scientist of the CSIR-Crops Research Institute.

Plate 13: Dr. Allen Oppong interacting with farmers on the WAVE demonstration field in Wenchi.

The sensitization programme started on the 5th of May, 2022 at Asesewa and proceeded through to the three other locations. At each location, participants were taken through pre- and post-sensitization surveys where farmers' knowledge of various cassava diseases was tested. They were later educated on the symptoms of the various cassava viral diseases and diseases caused by other agents. They were also sensitized on the need to monitor their fields regularly, use disease-free planting materials of improved varieties for cultivation and adhere to good agronomic practices to improve their productivity. Participants also visited WAVE demonstration cassava fields where the knowledge acquired during the presentations was put into practice for better understanding and appreciation.

Plate 14:Participants indicating their knowledge of cassava viral diseases in Akatsi

Participants were grateful for the opportunity to learn and requested for more of such training programmes in the future. They were able to share their various experiences on cassava diseases they had encountered on their farms during the sensitization workshop. They also informed the team about the measures they have adopted to combat the diseases which mostly affect the leaves, stems, and roots of the crop. Field monitoring and regular reporting of any strange and unfamilier diseases to agricultural extension officers (AEAs) was stressed to help forestall any threats that can affect productivity and food security in the country.

Feedback from Participants

Plate 15: A farmer from Wenchi taking part in the discussions.

Participants were extremenly grateful to the WAVE Project after the campaign and indcated their readiness to implement the new ideas and knowledge gained. Madam Kate Obuor Amankwaah, a farmer from Asesewa said, *"I have learnt a lot, I now know how to deal with diseases affecting the yield of my cassava farm and I am ready to put in place measures to combat these diseases".* Madam Juliet Tali, a participant from Akatsi, stated that the pre- and post- sensitization surveys had been very revealing and would be very beneficial to the farmers.

Team: *Allen Oppong, Ruth Prempeh, Benedicta Nsiah Frimpong, Esther Agyemang Marfo, Esther Afoley-Annan, Solomon Gyasi Boakye, Bernard Sakyiamah, Peter Amoah, Rose Osei Kofi*

05 TRAINING WORKSHOP ON THE DETECTION OF CASSAVA VIRUSES HELD AT CSIR-CROPS RESEARCH INSTITUTE

Sponsors: Bill and Melinda Gates Foundation (BMGF), UKFCDO, EU, CORAF

A training workshop on the detection of cassava viruses using Polymerase Chain Reaction (PCR) and symptoms was held at the premises of the CSIR-Crops Research Institute from 5th to 7th April, 2022. The training drew participants from the Plant Protection and Regulatory Services Department (PPRSD) of the Ministry of Food and Agriculture (MoFA), the Biotechnology and Nuclear Agriculture Research Institute (BNARI), Accra, the University of Energy and Natural Resources (UNER) Sunyani, the CSIR-Plant Genetic Resources Research Institute (CSIR-PGRRI) as well as the CSIR-Crops Research Institute.

The hands-on practical training workshop was aimed at introducing participants to the use of symptoms and molecular tools, particularly, PCR, for the detection of the cassava mosaic viruses (CMV) that are known to cause the cassava mosaic virus disease.

Plate 16: Some participants observing a diseased cassava plant on the field.

The workshop was one of several activities under the Central and West African Virus Epidemiology (WAVE) for root and tuber crops project, which seeks to equip and prepare scientists, policy makers and other stakeholders on the need to take pre-emptive steps aimed at protecting citizens from famine caused by viral diseases. The project is being implemented in ten (10) different African countries with funding from the Bill and Melinda Gates Foundation (BMGF) as well as the Foreign, Commonwealth and Development Office (formerly UKAid) and CORAF.

Plate 17: Participants eagerly observing field and laboratory procedures during the training.

Led by the WAVE project team member and senior research scientist, Dr. (Mrs.) Ruth N.A. Prempeh, participants were trained on symptom identification, DNA extraction, PCR, and agarose gel electrophoresis. These comprised activities such as the sampling of leaves for genomic nucleic acid extraction, genomic DNA extraction from cassava using the CTAB method and nucleic acid quantification as well as setting up PCR tests to amplify viral strains that cause the CMV disease. Other activities covered at the training included loading an agarose gel with PCR product, running an agarose gel and viewing it using a UV transilluminator and scoring, using a micropipette, symptom observation and description.

Plate 18: Dr. Ruth Prempeh leading one of the sessions in the laboratory.

Plate 19:Participants observing diseased cassava plants at the screenhouse.

Participants expressed their utmost satisfaction at the end of the training workshop and were very grateful to the WAVE project for the opportunity. “We have been equipped with so much knowledge and hands-on experience and we can't wait to demonstrate what we've learnt in our respective Institutes and in the field”, Mr Nasiru Issah, a participant, indicated. “We pray that the WAVE project continues to receive sponsorships to organize many more of such workshops in the coming years, he added.

Dr. Allen Oppong, the Ghana coordinator of the WAVE project was grateful to the participants for meticulously going through all the laboratory procedures and indicated that his outfit was ready to extend the training to more institutions with the required sponsorship.

Plate 20: A participant being presented with a certificate at the end of the training

Team: *Allen Oppong, Ruth Prempeh, Benedicta Nsiah Frimpong, Esther Agyemang Marfo, Esther Afoley-Annan, Solomon Gyasi Boakye, Bernard Sakyiamah, Peter Amoah, Rose Osei Kofi*

06 CSIR-CRI ORGANISES FARMER FIELD DAY FOR PEPPER FARMERS

Sponsors: United Kingdom Agency for International Development (UKAID)

The CSIR-Crops Research Institute is researching into new and improved varieties of chili pepper to increase the options available to both farmers and consumers within and outside Ghana. In line with the Institute's policy of stakeholder involvement in demand-driven research, key stakeholders including farmers, were brought to its Kwadaso station during a farmers' field day in September, 2022 to select desirable lines with high yields and economic value.

Plate 21:Participants observing the pepper varieties during the field day.

The farmers' field day which was an activity under the UKAID sponsored project brought stakeholders in the pepper industry together to score different traits of pepper preferred by different value chain actors . The two-year project is being implemented by the Institute in partnership with the World Vegetables Centre based in Taiwan. Participants at the filed day included pepper farmers, market players, seed companies and staff of Worldveg from Taiwan, Benin and Ghana. Other participants included research staff of the CSIR-Crops Research Institute (CSIR-CRI), agro-chemical companies and the media.

Plate 22: Participants making their choices of the varieties during the field day.

Participants visited the trial fields and individually observed and evaluated the lines to select their preferred ones in terms of quality. They were also made to taste and smell the ground mature pepper fruits and make their choices based on taste and smell. The exercise was very fruitful and yielded impressive and informative results.

Nana Kwame Boateng, the Gyaasehenne of Akomadan and a pepper farmer indicated after the field day, *"The varieties we are cultivating now peak after just 6 months of planting but what we have seen here are able to bear fruits every two weeks for more than the lifespan of the existing ones. If we follow the advice of the breeders, pepper will end our poverty"*, he said.

On her part, 47-year-old pepper farmer, Madam Naomi Ofori, who has been a pepper farmer for about 20 years, said *"I have realized very high prospects in these new varieties. They don't only bear more fruits but are fleshy too."*

The Principal Investigator of the project, Dr. Michael Kwabena Osei, a Senior Research Scientist of the CSIR-CRI, stated that the exercise formed part of the demand-driven approach to crops breeding at the Institute. *"We have assembled market players, farmers, seed companies and all the stakeholders to evaluate together. These varieties come in different shapes. We are here to make the selections together with the farmers after which we will perform multilocational trials as well as on-farm evaluations"*, He also stated that selected lines will be further evaluated and eventually released as varieties.

Team: *Michael Kwabena Osei, Isaac Osei-Bonsu, Akwasi Antwi Adjei, Raphael Acquah*

07 CSIR-CRI SCIENTISTS BREED INSECTS TO FIGHT FALL ARMYWORM

Sponsors: Korea-Africa Food & Agriculture Cooperation Initiative (KAFACI)

Plate 23:Telenomus remus

The fall army worm (FAW), (Spodoptera frugiperda) was accidently introduced in Ghana in 2016 and has posed a threat to sustainable maize production and food security since. In 2017, Ghana had FAW-induced yield losses in maize of about 27% translating into an economic loss of US $177 million. While some level of control has been achieved in Ghana using synthetic insecticides, research has revealed that, these chemicals are associated with human and animal poisoning as well as several ecological problems such as the destruction of beneficial insects (pollinators), pest resistance, and contamination of water bodies. To sustainably manage FAW, biological control with natural enemies (parasitoids) holds promise. This is a more ecologically sustainable means of managing FAW. To this end, scientists from the CSIR-Crops Research Institute with support from the Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI) have been exploring other management tactics other than the use of synthetic insecticides since 2020.

Plate 24:Members of the CSIR-CRI research team.

In 2022, the project successfully found Telenomus remus, a natural enemy of FAW. Telenomus remus is known for its role in controlling populations of certain pest insects, particularly the eggs of various lepidopteran pests. The female Telenomus remus wasp lays her eggs on the eggs of these pests. When the wasp larvae hatch, they feed on the contents of the pest eggs, effectively killing them.

The insects which have about 90 percent efficacy have been mass-reared in the Institute's laboratories and are ready to be released in maize farms to control fall armyworm. It is hoped that this breakthrough will lead to a drastic reduction in the fall army worm population. The first release of Telenomus remus to fight FAW was done in August, 2022.

By using natural predators like Telenomus remus for pest control, farmers can reduce their reliance on chemical pesticides, which can have negative impacts on the environment and non-target organisms. This approach is often considered a more sustainable and environmentally friendly method of pest management.

Team: *Blankson W. Amoabeng, Kofi Frempong-Anin, Ernestina N. Awarikaby, Yaw Danso, Jerry A. Fenteng, Moses B. Mochiah*

08 CSIR-CRI INTRODUCES NEW TECHNOLOGIES TO BOOST PRODUCTION OF YAM AND CASSAVA

Yam-Pigeon Pea Intercrop Technology

Yam (Dioscorea spp.) production in Ghana and along the West African belt is characterized by dwindling productivity, land degradation, and deforestation resulting from shifting cultivation in search of fertile soil and stakes for yam vines to climb. This has resulted in declining productivity, threatening rural livelihoods and food security. The pigeonpea-yam cropping system was developed to address these challenges. This technology intercrops pigeonpea between two (2) ridges/rows for the yam vines to climb as live stakes. A spacing of 0.8 – 1 m between pigeonpea and ridges enables the vines to climb easily. The vines also serve as nitrogen-fixing agents and also shade the ridges to conserve moisture in the soil. Experiments conducted revealed that the pigeonpea-yam intercrop, increased yam productivity (yield) by 30 – 68 %. Additionally, nitrogen level and moisture conservation resulting from the presence of the pigeonpea reduced the recommended fertilizer rate for yam production on continuously cropped fields by half.

Yam-Pigeon Pea Intercrop Technology

One of the key challenges to cassava production in Ghana is the inadequate quality-declared planting materials of improved varieties. Additionally, farmers are also constrained with the relatively long maturity period (mostly 12 months) of the crop. Farmers usually require a lot of stem cuttings for production hindering their ability to cultivate large land areas for more returns and profit.

The rapid multiplication technique seeks to address these challenges. The technique involves the removal of a single bud to generate new cassava seeds. Each bud can raise a plant. Hence about four plants can be obtained from one stem cutting. Plants cultivated by this technique mature within 6-8 months, increasing the availability of planting materials for increased productivity. Experiments conducted showed that the rapid cassava multiplication technique increased the availability of cassava planting materials by more than 200%.

Team: *Owusu Danquah, E., Frimpong, F., Danquah, O. F., Otoo, E., Weebadde, C., Ennin, S. A, Keteku, A, K., Aggrey, H., Dankwa, O, K., Manu-Aduening, J.*

09 CSIR- CRI INTRODUCES ALTERNATE WETTING AND DRYING WATER- SAVING IRRIGATION TECHNOLOGY TO RICE FARMERS

Sponsors: GCRF-Recirculate Project

The CSIR-Crops Research Institute (CRI) has introduced a water-saving irrigation technology called alternate wetting and drying (AWD) to rice farmers in Ghana. The AWD technology is a water saving irrigation technology that can reduce irrigation water use by up to 40% in irrigated rice production and was developed in collaboration with Lancaster University, UK under the GCRF funded project called RECIRCULATE. AWD enhances water and nutrient use efficiency in irrigated rice production. It also reduces greenhouse gas emissions, expecially methane (CH_4) and nitrous oxide (N_2O) in lowland rice production.

The technology uses simple PVC pipes (known as water table cylinders) to monitor real time soil water for irrigation scheduling. PVC pipes with a nominal diameter of 101.6 mm (4 inches) are cut to a length of 30 cm. One half of approximately 15 cm length is then punched with holes. The holes are spaced longitudinally at 3 cm and horizontally at 5 cm. The half with the punched hole is inserted into the soil to a depth of about 15 cm. Soil is removed from the inserted half. Water accumulates in the pipe through the punched holes. The depth of the water in the water table cylinder is monitored until it drops to the edge of the buried depth after which irrigation water is applied to the field. The cycle continues until physiological maturity where the fields are left to dry for harvest. Reducing irrigation water use does not compromise on yields of the rice crop. The AWD technology is being publicized and promoted widely by the CSIR-Crops Research Institute across the country.

Team: *Stephen Yeboah, Patricia Amankwaa Yeboah, Maxwell Darko Asante, Ebenezer Annan-Aful, Moses Brandford Mochiah, Joseph Adomako, Stella Ama Ennin.*

DONOR SUPPORT

Funding for agricultural research is essential for driving innovation, ensuring food security, and promoting sustainable and resilient agricultural systems that can meet the needs of a growing global population. A major percentage of the Institute's research funding is sourced from donor agencies. In 2022, several local and international funding agencies sponsored most of the Institute's research activities. These comprised the Korea Program for International Cooperation in Agricultural Technology (KOPIA), Korea Africa Food and Agriculture Cooperation Initiative (KAFACI), Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA), Excellence In Breeding (EiB) project, CORNELL GREAT, the International Centre for Research in Agroforestry (ICRAF), United Kingdom Research and Innovation (UKRI), Crop Trust, CORAF, the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT) as well as the African Agricultural Technology Foundation (AATF) among several others.

MEDIA PUBLICATIONS OF RESERARCH OUTPUTS

Communicating the results of research activities to the public is a very key component in achieving desired results. Good communication systems between actors of agricultural development are vital tools for the transfer of new and improved technologies to farmers. The Institute continues to engage the media in all of its activities. These include media coverage of farmer field days, field demonstrations, training sessions, varietal releases and innovation platform activities. In 2022, several media engagements (print/electronic) were undertaken to disseminate information and technology to stakeholders. Some of these have been listed below. 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.

DATE	MEDIA ORGANIZATION	TITLE OF PUBLICATION
9th May, 2022	Ghana News Agency	CRI assists Asesewa farmers in combating infections
16th May, 2022	Daily Graphic	120 Wenchi cassava farmers receive training on crop diseases
28th April, 2022	myjoyonline.com	Job Creation: Some government workers and farmers undergo fish farming training
2nd February, 2022	JoyNews Business	Curbing rice imports-CSIR-CRI educates farmers on techniques to increase yields.
2nd February, 2022	myjoyonline.com	Crops research and farmers join forces to make Ghana self-sufficient in rice production
4th February, 2022	TV3 Midday News	CRI Introduces new intervention on rice
4th February, 2022	Onua TV Dwadie Kasiebo	Improving rice yields
6th September, 202	Myjoyonline.com	CRI strengthens engagement with stakeholders
6th September, 2022	Adomonline.com	CSIR-CRI scales up engagement with stakeholders on pepper variety
7th September, 2022	Onua TV Midday News	Food Security: CSIR research into new pepper variety
24th October, 2022	Ghana News Agency	CSIR-CRI releases nine new rice varieties
24th October, 2022	Myjoyonline.com	9 new rice varieties introduces by CRI, KOPIA-Ghana
25th October, 2022	Luv FM	9 new rice varieties introduced by CRI,KOPIAGhana
26th October, 2022	Adom TV/News	Improved varieties-Nine new rice varieties introduced by CRI,KOPIAGhana
26th October, 2022	Radio Ghana (GBC)	Fumesua: Crops Research Institute releases nine rice varieties

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

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 Income generating activities of CSIR-CRI are categorized into products, services and administrative overheads charged on research and development and commercial projects. The products include improved varieties of planting materials (seeds & seedlings), farm produce and fruits from the Institute's orchards and plantations. In 2022, various quantities of mango, citrus and avocado seedlings were produced for sale. The Institute also provides trainings, consultancies and hiring services. There are also facilities such as a biotechnology laboratory, conference halls, guest houses, seed processing and storage centers available at the Institute for use by the general public at a fee.

Team: *Samuel Azuug Ndebilla, Mark Anti, Briamah Abdul-Manaf, Richard Peprah, Ivy Osei-Adu, Bismark Ababio, Nana Kamkam Boadu, Joel Adu, Mark Kwabiah, Theresa Boakye, Augustine A Boakye, Isaac Mensah, Eric Donkor, Thomas Acheampong, Agnes Nti*

STAFF PROMOTIONS AND AWARDS

The Institute continues to reward deserving and hardworking staff with promotions every year. In 2022, eleven (11) senior members were promoted. Several staff in the senior and junior staff categories were also either promoted or upgraded. In all, a total of fifty (51) members of staff gained various forms of promotions to higher grades.

Additionally, Professor Marian Dorcas Quain, a Chief Research Scientist at the Institute and nine other nominees were honoured at the 2022 Open Forum on Agricultural Biotechnology (OFAB) Awards. OFAB, a project of the African Agricultural Technology Foundation (AATF), awarded the nominees during a ceremony to mark the 2nd OFAB Day, an annual event held in Accra, for their contributions to the prosperity of farming in Africa. The Open Forum on Agricultural Biotechnology in Africa (OFAB) is a platform that brings together stakeholders in biotechnology and enables interactions between scientists, journalists, the civil society, industrialists, lawmakers and policy makers. It is a monthly lunch meeting that provides an opportunity for key stakeholders to know one another, share knowledge and experiences, make new contacts and explore new avenues of bringing the benefits of biotechnology to the African agricultural sector. Prof. Quain is a plant biotechnologist with expertise in plant physiology, tissue culture, molecular biology, genetic engineering and biosafety and was awarded for her contributions towards the usage of biotechnology tools for crop improvement.

OUR PEOPLE

Prof. Moses B. Mochiah, Director

Dr. Maxwell Darko Asante,
Deputy Director

Mr. Francis O. Amofah,
Head, Administration

Dr. (Mrs.) Priscilla F. Ribeiro,
Head, Cereals

Mr. Paul Berko,
Head, Finance

Dr. Joyce Haleegoah,
Head, Socioeconomics/Biometrics

Dr. Sylvester N.T.T Addy,
Head, Legumes/Oil Seeds

OUR PEOPLE

Dr. Yaw Danso,
Head, Plant Health

Dr. Shadrack K. Amponsah,
Head, Agric Engineering/Transport

Dr. Beloved Mensah Dzomeku,
Head, Horticulture

Mr. Samuel Ndebilla Azuug,
Head, Commercialization

Dr. Francis Amoako Andoh,
Head, Boiotech, Seed and Postharvest

Prof. Emmanuel Otoo,
Head, Roots and Tubers

Mr. Solomon Gyasi Boakye,
Head, Scientific Support Services

OUR PEOPLE (SENIOR MEMBERS)

ROOTS AND TUBER

Abigail Addo -Danso
Cynthia Darko
Emmanuel Otoo
Eric Owusu Danquah
Ernest Baafi
Habbibah Aggrey
Kwadwo Adofo
Kwaku Onwona-Hwesofour Asante
Kwame Obeng Dankwa
Mary Otiwaa Osei Asante
Mavis Akom
Peter Appiah-Danquah
Richard Dormatey

BIOTECH, SEED & POSTHARVEST

Abigail Amoa Owusu
Agnes Achiaa Aboagye
Agnes Nimo Bosompem
Belinda Akomeah
David Appiah-Kubi
Emmanuel Adjei-Asamoah
Faustina Okyere
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Gertrude Osei-Diko
Harry Okyere
Hillary Mireku Botey
Isaac Osei Tutu
John Vinoagbe
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Linda Abrokwah Appianimaa
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Phyllis Aculey
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Stephen Yeboah
William Lelabi Kota

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Agbesi Kwadzo Keteku
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Jonas Osei-Adu
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Lydia Brobbey
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Richard Adabah

AGRIC ENGINEERING/TRANSPORT

Michael Tetteh Odamtten
Patricia Amankwaa - Yeboah
Shadrack Kwadwo Amponsah

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SELECTED ABSTRACTS FROM PEER REVIEWED ARTICLES

Does food security exist among farm households? Evidence from Ghana.

Authors: Acheampong. P. P., Obeng, E. A., Opoku, M., Brobbey, L. and Sakyiamah, B.

Food security exists when households have physical, social and economic access to sufficient, safe and nutritious food at all times that meets their dietary needs and food preferences for an active and healthy life. Food security remains a serious challenge for many households in Ghana and the situation is even more prevalent among smallholder farmers. Therefore, this study had its objectives to assess food security status and also estimate their determinants for policy recommendations. Using data collected from 2,603 farm households across Ghana and employing an ordered probit model the determinants of food security among farm households were assessed. The food security indicator, Food Consumption Score (FCS) which combines diet diversity, frequency of consumption and relative nutritional importance of different food groups was used to determine food security status of farm households. Results showed that farm households (76%) across Ghana were within the acceptable household food consumption groups. Nonetheless, 19% and 6% of farm households, respectively, were within the borderline and poor food consumption groups, respectively. Determinants of food security included experience, gender, improved variety adoption, access to credit and location. Food security risk is prevalent among farm households in Ghana. Based on the results on determinants of food security, the suggestions are that government and private institutions should create an enabling environment to enhancing credit access and encouraging adoptions of improved crops varieties for increased production.

Plant Parasitic Nematodes and Disease Severity of Common Bean Lines Evaluated for Reaction to Root Knot Nematodes Infestation.

Authors: Adomako, J., Yeboah S., Asamoah J. F., Amankwaa-Yeboah, P., Adjei, E. A., Obeng E. A., Sakyiamah B., Lamptey, M., Butare L. and Asibuo, J. Y.

Plant parasitic nematodes are important pests in crop production in sub-Saharan Africa. The objective of this study was to identify the occurrence of nematodes associated with common bean (*Phaseolus vulgaris* L.) and evaluate breeding lines for their reaction to *Meloidogyne* spp. in Ghana. Common bean rhizosphere soil was sampled and processed using Modified Baermann Tray method. Five nematode genera, namely *Meloidogyne*, *Pratylenchus*, *Rotylenchulus*, *Helicotylenchus* and *Trichodorus* were extracted. The first four genera listed above were prevalent across locations, with *Trichodorus* present in 30% of the fields sampled. The highest nematode population density of 319 juveniles per 200 cubic centimeter of soil was recorded for *Meloidogyne* spp. compared to 45 juveniles per 200 cubic centimeter, for *Trichodorus*. Twelve breeding lines were evaluated by inoculating roots of two-weeks-old plants with 2000 infective-stage juveniles of *Meloidogyne* sp. Reactions of test lines to *Meloidogyne* sp. infection were assessed by determining the number of egg masses and galling index (GI) on roots. Reproduction index (RI) was used to classify test lines as resistant or susceptible. Significant differences ($P < 0.05$) were observed in the number of eggs, GI and RI among lines tested. No resistant line was identified; however, lines SEF 47, BFS 35 and BFS 60 were moderately resistant, with RI of 13.1, 17.4 and 23.7%, respectively. Line SEF 60, although classified as slightly resistant, recorded a 100 seed weight of 26.0 g, which was 60% higher than line SEF 53 with seed weight of 16.2 g. Moderately resistant common bean lines identified could be used in common bean improvement programmes to develop elite cultivars tolerant to root knot nematodes.

Enhancing the Productivity and Sustainability of Bambara Groundnut (*Vigna subterranea* (L.)Verdc.) Production Using Inorganic Phosphorus Fertilizer.

Authors: Agyeman, K., Berchie, J. N., Owusu Danquah, E., Addy, S., Keteku, A. K., Marno, P.,Obeng, E. A., Adomako, J., Atta Poku Snr, P., Addo-Sarkodie, J., Sakyiamah, B. and Quaye, M. O.

Phosphorus (P) is a vital element required for nodulation, stomatal regulation and photosynthesis in legume crops. P-deficiency in tropical soils limits the growth and productivity of Bambara groundnuts. The current study focused on determining the potential suitability of underutilized crops for food security using phosphorus fertilizer as soil amendment practice. A field trial was carried out at the Council for Scientific and Industrial Research—Crops Research Institute (CSIR-CRI), over two growing seasons to determine the optimum P rate for Bambara production. This trial was laid out in a split plot in a randomized block design with three replications. Bambara genotypes represented the main plots while four P fertilizer rates (0, 30, 45 and 60 kg P2O5 ha^{-1}) were the sub-plots. The appropriate application rate of 60 kg P2O5 ha−1 showed excellent performance based on growth and yield analysis, and the results indicate a positive significant interaction between landraces and phosphorus fertilizer rates. The biological suitability of 60 kg P2O5 ha^{-1} increased the number of nodules per plant for Tiga Necuru, Kenya Capstone and Nav Red by 42.8%, 51.3% and 42.1% respectively, over control plots. The same for pod yield is 12%, 28% and 52% significantly higher than when P was applied at 45, 30 and 0 kg P2O5 ha^{-1} respectively. The results further revealed that on days to flowering and maturity, the plant height, the number of branches and dry matter increased significantly at each level of P fertilizer rate applied. Bambara production at 0 kg P fertilizer rate might not be sufficient to enhance Bambara productivity significantly. The outcome of this study reveals the suitability of phosphorus fertilizer application in enhancing the sustainability of Bambara groundnut productivity and the potential of Bambara in diversifying crop production to ensure food security.

Stability analysis of yield and aflatoxin accumulation resistance in maize using GGE biplot.

Authors: Oppong, A., Dadzie, A. M., Ifie, B., Asante, M. D., Prempeh, R. N., Abrokwah, L. A., & Marfo, E. A.

Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa. However, its production is constrained by many factors including low yields and aflatoxin contamination. Host resistance to aflatoxin accumulation and productive hybrid varieties are seen as key approaches in addressing these challenges. Sixteen aflatoxin-resistant inbreds obtained from Corn Host Plant Resistance Research Unit (CHPRRU), USDA ARS in Mississippi, USA, CIMMYT, IITA, etc., were crossed as males to six locally adapted inbreds in a North Carolina II design to generate 160 new hybrids and planted together with 9 checks using 13 lattice with three replications. The new hybrids were evaluated across six environments. Thirty-one of the most promising hybrids were subjected to the GGE biplot analysis to determine their stability for yield and aflatoxin accumulation resistance. Genotype, G10 (ENTRY-5 . Tzi8, G20 (TZEE-15 . CML343, G28 (TZEEI-6 . CML247 and G26 (TZEEI-6 . CML11 were highly stable hybrids for yield while G08 (ENTRY-5 . Ki3, G11 (ENTRY-85 . CML247 and G19 (TZEEI-15 . MP715 were relatively stable for aflatoxin accumulation resistance. This means that it is possible to produce high-yielding aflatoxin-resistant hybrids for consumers in the trial agro-ecologies.

Pigeonpea *(Cajanus cajan)* and white yam (*Dioscorea rotundata*) cropping system: Improvedresource use and productivity in Ghana.

Authors: Owusu Danquah, E., Frimpong F., Yeboah, S., Tetteh, E. N., Weebadde, C., Ennin, S. A.,Agyeman, K., Amankwaa-Yeboah, P., Akley, E. K., Hayford, P., Snapp, S.

Yam production along the West African yam belt is challenged with deteriorating soil fertility and unavailability of stakes, resulting in decreased yam productivity, and farmers' livelihood. This study evaluated resource use and yam productivity in pigeonpea-yam cropping systems in Ghana's forest and forest-savannah transition zones from 2017 through 2019 cropping seasons. Pigeonpea was established either in an alley or as a border during the 2017 cropping season, while yam was cultivated in 2018 and 2019. A split-plot design of cropping system (yam planted in alleys of pigeonpea—PA; yam planted with pigeonpea as a border—PB and sole yam) as main-plot treatments and chemical fertilizer (0–0–0; 23–23–30; 45–45–60 N-P_2O_5-K_2O kg ha^{-1}) as subplot treatments were used for the study. Productivity data on pigeonpea and yam were collected. The results revealed significantly higher leafy biomass and correspondent higher N content and N due to fixation in PA fields than PB fields in both locations and seasons. The presence of the pigeonpea and its biomass resulted in a significant suppression of ridge erosion and weeds, while soil moisture and nutrients improved, resulting in increased yam tuber productivity than in sole yam production. Further, planting yam with pigeonpea and half (23–23–30 N-P_2O_5-K_2O kg ha^{-1}) the recommended fertilizer rate significantly improved tuber yield and productivity than planting sole yam with full recommended fertilizer level in both locations and seasons. Promoting and adopting the pigeonpea-yam cropping system could sustain soil fertility, provide readily available stakes to address the constraint of deforestation and land degradation associated with yam production.

Sustainable Intensification and Climate-Smart Yam Production for Improved Food Security in WestAfrica: A Review

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Intensification of staple food crops such as Yam (Dioscorea spp.) while sustaining the environment is imperative in providing food for the expected 9.6 billion global population by 2050. In West Africa, amid the threat posed by climate change on food security, yam production is associated with deforestation and land degradation. Integrated soil fertility management and improved staking options for intensification and sustainable yam production on continuously cropped fields hold the key to addressing this challenge. This review evaluates the last decade's yam production trends in West Africa and in three leading yam-producing countries, Nigeria, Ghana, and Côte d'Ivoire, using the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) data. A production increase of 1.72, 1.43, and 1.35 times resulted in an area harvest increase of 2.25, 1.23, and 1.59 times in Nigeria, Ghana, and Côte d'Ivoire, respectively. Nigeria and Côte d'Ivoire had the worst yam productivity across the decade by producing at an average yield 17.3 and 12.5%, respectively, of the estimated potential yam yield (50 t ha−1). Even in Ghana, where the productivity increased across the decade, the average productivity was 33% of the estimated potential yield. Thus, it can be observed that the primary reason for the increase in yam production across the globe and in West Africa is mainly because of the increase in area under cultivation in the major yam-producing countries. The projected future erratic rainfall and elevated daily mean temperature as a result of climate change would cause declining tuber yields. Meanwhile, the importation of food such as rice as a strategy to improve food availability cannot be accessed by poor rural households due to the strong correlation between international food price hikes and prices of these foods. However, there is less relationship between international yam price hikes and yam prices in West Africa. Therefore, yam production and sustenance could be vital for food security for the increasing population of West Africa. This study reviews current research on soil fertility and staking options for sustaining yam production on continuously cropped fields. Promotion and adoption of these improved technologies would enhance food security and contribute to achieving Sustainable Development Goals 1 (No poverty), 2 (Zero hunger), 13 (Climate action), and 15 (Life on land).

Profitability of positive selection technique for seed yam production in Ghana and Nigeria

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Over the years, the traditional seed system has failed to deliver quality seed yam for propagation. This is due to the high incidence and severity of the yam mosaic virus leading to yield losses of 52.6%–65.4%. The Positive Selection (PS) technique has shown promise as a possible mitigation measure. This study was therefore aimed at evaluating the profitability of seed-yam production through the use of PS technique as a viral mitigation measure. Three hundred and sixty-eight (368) seed yam farmers across Ghana and Nigeria were sampled. Profitability was determined using Return on Investment (ROI) and Benefit Cost Ratio (BCR) analysis. Regression analysis was applied for the determinants. Result from this study indicates that seed yam production is more profitable when the effect of the yam mosaic virus is mitigated using PS technique with a net return of US$ 3,417.98/ha compared to US$ 1,795.58/ha for non-use. This implies the use of PS technique can increase seed yam profitability by 26.69%. Sex, farmer experience in yam production, education, migration status, extension contact, off-farm income and use of PS technique were significant determinants of profitability. It is therefore recommended that the PS technique be widely disseminated as a mitigation strategy for the control of the yam mosaic virus disease.


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