CSIR-CROPS RESEARCH INSTITUTE

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RESEARCH FOR DEVELOPMENT

CSIR-CRI, 2017

CSIR-CROPS RESEARCH INSTITUTE

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CSIR-CRI MANAGEMENT BOARD

The newly reconstituted management board of CSIR-CRI with the Director-General of CSIR, Professor Victor Agyeman

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(Ag. Director, Extension Directorate MoFA, Accra)	Member
Director, CSIR-Soil Research Institute Cognate	Member
Mr. Emmanuel Brako (Director of Finance, CSIR Head Office)	Member

List Of Acronyms

AFS	Aquaponics-Based Food System
AGRA	Alliance for a Green Revolution in Africa
APTC	Agricultural Productivity Technology Centre
BCR	Benefit Cost Ratio
BMGF	Bill and Melinda Gates Foundation
CAY-seed	Community Action in Improving Farmer-Saved Seed Yam
CBSD	Cassava Brown Streak Disease
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CMD	Cassava Mosaic Disease
COTVET	Council for Technical and Vocational Education and Training
CRI	Crops Research Institute
CSIR	Council for Scientific and Industrial Research
DWT	Dry Weigh
GAP	Good Agricultural Practices
GASGD	Ghana Agenda for Shared Growth and Development
GAWU	Ghana Agricultural Workers' Union
GDP	Gross Domestic Product
GETFUND	Ghana Education Trust Fund
GPRTU	Ghana Private Road and Transport Union
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
INEA	International Network for Edible Aroids
IR	Institutional Repository
KAFACI	Korea-Africa Food and Agriculture Cooperation Initiative
MAP	Months After Planting
MDG	Millennium Development Goals

MESTI	Ministry of Environment, Science, Technology and Innovation
MiDA	Millennium Development Authority
MMDCE	Metropolitan, Municipal and District Chief Executive
MOFA	Ministry of Food and Agriculture
NCoS	National Centre of Specialization
NGO	Non-Governmental Organisation
NVRRC	National Variety Release and Registration Committee
NYEP	National Youth Employment Programme
QPM	Quality Protein Maize
RCoE	Regional Centre of Excellence
ROI	Return on Investment
SANAS	South African National Accreditation Systems
STMA	Stress Tolerant Maize for Africa
TLBD	Taro Leaf Blight Disease
TUC	Trades Union Congress
WAAPP	West Africa Agricultural Productivity Programme
WAVE	West Africa Virus Epidemiology
YEA	Youth Employment Agency

FOREWORD

Dear friends

It is with much pleasure that we present to you an overview of our activities for 2017. As happens with any research institute, we at CSIR-Crops Research Institute (CSIR-CRI) engaged in a number of research activities within the year in our quest to become a Centre of Excellence in agricultural research, innovation and capacity building for development. We are happy to report on a few "success stories".

As the largest of all the institutes under the CSIR, we identify with three of the seven thematic areas of research developed by the council. These are Food Security/Poverty Reduction, Biomedical/Public Health and Science/People.

As a result, several of our research activities were guided towards these thematic areas as well as the Institute's 5-year strategic plan which fits directly into these thematic areas.The Instituite continues to research into all of its mandate crops which include cereals, legumes, roots and tubers, horticultural crops, tropical fruits and vegetables as well as industrial crops. We also keep building human capacity and infrastructure as well as increasing commercialization activities.

In all we do, we realize that we would not have come this far without the support of all our donors, development partners, sponsors and collaborators. We will like to appreciate them and all those who have in diverse ways contributed to our success.

We would like to thank our entire staff for their hard work and dedication. Together, we made giant strides in 2017 and took another step towards realising our vision. We hope to continue to work even harder and seize every opportunity presented to us and secure our success.

Thank You

Dr. Stella A. Ennin
(Director, CSIR-CRI)

Dr. Abu Sakara Forster
(CSIR-CRI Board Chairman)

ACKNOWLEDGEMENTS

We express gratitude to all our stakeholders for their various contributions and support without which there will be no success stories to tell. We cannot underestimate the support we received from sister institutions under the CSIR, other research institutions, universities, non-governmental organisations (NGOs), civil society organisations, farmers and ministries.
The tremendous financial support we received from our donors and funding agencies such as

The International Institute of Tropical Agriculture (IITA), the Bill and Melinda Gates Foundation (BMGF), the Alliance for a Green Revolution in Africa (AGRA), the Council for Technical and Vocational Education and Training/Skills Development Fund (COTVET/SDF), the Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI), YARA-Ghana, CALLI-Ghana, SEEDCO International, USAID, the World Bank, among others cannot be over emphasized.

We also acknowledge CSIR-CRI's newly reconstituted Management Board, for providing guidance and oversight to the institute.
Finally, we thank all our scientists, technical staff and support staff for working tirelessly to achieve all the successes reported here.

About CSIR-Crops Research Institute

CSIR-Crops Research Institute (CSIR-CRI) is one of the 13 institutes of the Council for Scientific and Industrial Research (CSIR) of Ghana. It was established in 1964.

Vision

To be a Centre of Excellence for innovative and quality agricultural research for development.

Mission

To develop and disseminate appropriate technologies for high and sustainable food and industrial crop production.

Core Values

Our core values are Excellence; Fairness; Commitment; Transparency and Accountability and Teamwork

Goals

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

Mandate Crops

- Cereals (maize and rice)
- Legumes and Oil Seeds (cowpea, soybean, groundnut, bambara groundnut and canning beans)
- Roots and tubers (cassava, cocoyam, sweet potato, yam and taro)
- Horticultural crops

- Plantain and banana
- Tropical fruits (citrus, mango, avocado, pineapple, pawpaw)
- Vegetables (pepper, garden eggs, tomato, onion and leafy vegetables)

- Industrial crops (rubber and sugar cane).

Service to Clients

CSIR-CRI offers the following services:

- Production of breeder seeds for the National Seed Industry
- Supply of healthy planting materials of citrus, avocado, mango, plantain and banana.
- Development of crop varieties for food and industrial uses
- Establishment of farms (tree crop plantations)
- Integrated management of crop diseases and pests (including weeds)
- Production of extension materials
- Advise on the use of appropriate experimental designs for field studies
- Molecular Biology, Aeroponics and Tissue Culture Laboratory works

EXECUTIVE SUMMARY

This Annual Report captures the Institute's achievements under three main thematic areas: Food Security/Poverty Reduction, Biomedical/Public Health, and People/Science. These are 3 of the 7 thematic areas of research developed by the Council for Scientific and Industrial Research (CSIR).

Under Food Security/Poverty Reduction, new varieties of taro, groundnut, sweet potato, yam, cassava and rice varieties were all released unto the market.

With support from the West Africa Agricultural Productivity Programme (WAAPP), the Institute released four (4) new taro varieties tolerant to the taro leaf blight disease (TLBD). The released varieties *CRI-Huogbelor***,** *CRI-Asempa, CRI-Agyenkwa* and *CRI-Yen anya woa* have potential yields of between 12-25 t/ha. This is the first time taro varieties have been released in Ghana. The Institute intends to generate five thousand (5,000) taro plantlets to distribute to farmers by 2018.

The Institute also released three (3) new groundnut varieties namely *Crops Pion*, *Crops Agbeyeye* and *Crops Nkatie.* These varieties are early maturing, aflatoxin-tolerant, have high oil content, and rosette-tolerant.

Two sweet potato varieties, *CRI-Mbofara* and *CRI-Gavana* with potential yields of 38 t/ha and 28 t/ha respectively and a maturity period of less than five months were also released by the Institute. These new varieties possess a high dry matter and a high starch content and are also tolerant to the sweet potato weevil and virus disease.

In response to the high demand for water yam in neighbouring countries, the Institute released four new water yam varieties (*CRI-Afaase Adepa, CRI-Afaase Hoodenfo, CRI-Afaase Biri* and *CRI-Afaase Soanyinto*). These varieties possess a very high starch content and can be used for various forms of food. The varieties have also been declared safe for diabetic patients and can be used as a substitute for white yam.

The Alliance for Green Revolution in Africa (AGRA) sponsored a project that led to the release of six new rice varieties (*CRI-Dartey, CRI-Kantinka, CRI-Emopa, CRI-Mpuntuo, CRI-Oboafo* and *CRI-Aunty Jane*). Four of the six rice varieties released were developed from local crosses of the Institute. This is unprecedented and a major milestone for national research in Ghana

Yam mosaic virus and plant parasitic nematodes have been identified as the major causes of yam yield decline. The Community Action in Improving Farmer-Saved Seed Yam (CAY-seed) project, sponsored by the Bill and Melinda Gates Foundation (BMGF) and managed by the CSIR-Crops Research Institute, introduced a "positive selection" strategy to remedy the situation.

A West Africa Virus Epidemiology (WAVE) project which seeks to equip and prepare scientists and other stakeholders with knowledge about the cassava mosaic disease and the cassava brown streak disease was also undertaken under the Biomedical/Public Health thematic area. Four (4) farmer field days were organized in four regions of Ghana to educate farmers on the need to plant virus-free planting materials for improved productivity. The field days attracted over 300 farmers and agricultural extension officers in all.

An "Open Day" was organized by the Institute in July, 2017 to showcase various technologies and interact with major stakeholders. The event was a huge success and attracted over 500 participants including the Minister of Environment, Science, Technology and Innovation (MESTI), Professor Kwabena Frimpong Boateng.

Commercialization is a key component of the Institute's strategic plan. As a result, we engaged in a number of revenue generating activities in 2017. Key among these activities was the production of breeder and foundation seeds of maize, rice, cassava, soybean and pepper towards the Government of Ghana's "Planting for Food and Jobs" programme.
The Institute's efforts towards agricultural research were recognized and duly awarded by various bodies in 2017. A number of the Institute's scientists including Dr. Maxwell Asante, Dr. Kofi Dartey, Dr. (Mrs.) Priscilla Francisco Ribeiro and Dr. Ernest Baafi, were awarded for their various contributions towards research.

Staff attrition has been a major concern for the Institute since the Government of Ghana's freeze on public sector employment. The Institute was however able to recruit six (6) new staff to replace the many who retired within the year.

The Institute continues to make its research findings available to the scientific society through various scientific publications. In 2017, we recorded seventy-six (76) publications. These included refereed journal papers, conference papers, manuals and production guides.

Research Themes and Support Functions

The institute's five strategic thrust areas fall under three of the seven thematic research areas of the CSIR. These are the key areas selected to drive the institute's focus in achieving its vision of becoming a Centre of Excellence for agricultural research, innovation and capacity building for development. The thematic areas inter-relate to achieve the desired results which will satisfy its mission of developing and disseminating demand-driven technologies and build capacity for sustainable food and industrial crops productivity to enhance livelihoods for development in Ghana. The support functions which involved the non-core research activities provide the needed anchor for effective delivery of the research activities

RT 1: Food Security And Poverty Reduction

Food security is defined in its most basic form as access by all people at all times to the food needed for a healthy life. The first Millennium Development Goal (MDG) is dedicated to eradicating extreme poverty and hunger globally. Key issues to be addressed by CSIR under this research theme include:

- Cereals and Legumes
- Roots, Tubers, Horticultural (Vegetables and Fruits) and Industrial Crops
- Forest, Trees and Plant Resources (Natural Products)
- Livestock and Poultry
- Fisheries and Aqua-culture
  Soils, Mechanization, Agro-food processing
  Biotechnology (Genetics, Germplasm Conservation, Bio-prospecting and Bio-processing)

Crop varietal releases

Output 1: ***Ghana's First Ever Taro Varieties Released***

Taro (*Colocasia esculenta*) is a very important food security and income generating crop in Ghana whose production has been bedeviled by the taro leaf blight disease (TLBD), almost leading to the crop's extinction. The TLBD has affected food security and income levels of farmers and stakeholders in the taro industry. Management measures such as chemical and cultural controls have been largely ineffective and hence breeding for disease-resistant varieties has been identified as the most sustainable approach to manage TLBD. The future of taro in Ghana thus, depends on the availability of improved cultivars.

A farming household in Bomaa (Brong Ahafo region) excited with the new taro varieties released

In response to farmers' and consumers' demand, the CSIR-Crops Research Institute with sponsorship from the International Network for Edible Aroids (INEA) and the West Africa Agricultural Productivity Programme (WAAPP), has released four new taro varieties tolerant to the taro leaf blight disease (TLBD). The varieties released are ***CRI-Huogbelor*** (*Food Security taro*), ***CRI-Asempa*** (*Good News*), ***CRI-Agyenkwa*** (*Saviour*) and ***CRI-Yen anya woa*** (*Good to have you*) with potential yields of between 12-25 t/ha and corm dry matter content of 33-42%. The released varieties have varied uses. They can be prepared into 'ampesi', fufu, chunk-fried, crispy chips, flour, starch, and varied bakery products. It is estimated that 5,000 plantlets will be generated by the end of 2018 for supply to farmers. This is the first time taro varieties have been released in Ghana.

A research scientist, Dr Ernest Baafi, the leader of the taro improvement programme during field inspections by the NVRRC

Economic analysis of the released taro varieties resulted in a benefit-cost ratio (BCR) of 3.0 - 11.0 as against 1.4 for the local variety indicating higher profitability for farmers. A BCR of 3.0 implies that every GHS 1 invested in the production of these varieties will result in a profit of GHS 2.

CRI-Huogbelor

CRI-Agyenkwa

CRI-Asempa

CRI-Yen anya woa

Table 1: Attributes of The Released Taro Varieties

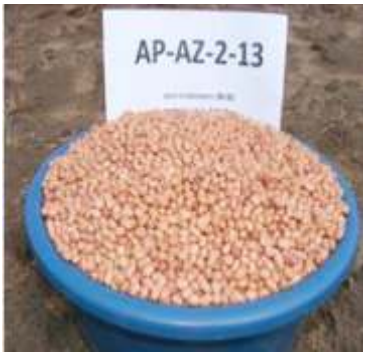
Variety	Maturity	Potential Yield (t/ha)	CDM	BCR	Varied Uses
CRI-Huogbelor	6-7 MAP	13.14	33%	2.95-5.91	"Ampesi", Chunk Fried
CRI-Agyenkwa	8-12 MAP	12.20	42%	2.74-5.49	"Ampesi",Fufu, Chunk Fried, Crispy Chips, Flour, Starch, Varied Bakery Products
CRI-Asempa	8-12 MAP	25.32	37%	5.69-11.39	"Ampesi",Fufu, Chunk Fried, Crispy Chips, Flour, Starch, Varied Bakery Products
CRI-Yen anya woa	8-12 MAP	15.76	41%	3.54-7.09	"Ampesi",Fufu, Chunk Fried, Crispy Chips, Flour, Starch, Varied Bakery Products

CDM=Corm Dry Matter; BCR=Benefit-Cost Ratio; MAP=Months After Planting

Output 2: ***CSIR-CRI Releases Three New Groundnut Varieties***

All groundnut varieties released in Ghana have been introductions from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). These varieties, though high-yielding and tolerant to rosette and other foliar diseases, are late maturing (120 days) compared to the local landraces grown by farmers which mature within 90 days. Most farmers are therefore reluctant to adopt these new varieties despite all their good attributes. In response to farmers' demand, a hybridization programme was initiated at the CSIR-Crops Research Institute using released varieties (originally from ICRISAT) that are well adapted to the major agro-ecologies in Ghana and local landraces that are popular in various agro-ecologies. The objective of the breeding programme was to improve the pod yield and tolerance to diseases of farmer-preferred early maturing groundnut varieties by introgression of rosette resistant gene into local landraces and to disseminate the improved varieties to farmers and end-users. After evaluation by the National Variety Release and Registration Committee (NVRRC), the Institute released three (3) new varieties namely ***Crops Pion***, ***Crops Agbeyeye*** and ***Crops Nkatie***.

These varieties are aflatoxin-tolerant, have high oil content, rosette-tolerant and early maturing. This is the first time groundnut varieties have been developed and released in Ghana.



Crops Pion

Crops Agbeyeye

Crops Nkatie

Table 2: Attributes of The Released Groundnut Varieties

Variety	Attributes
Crops-Pion	Potential Yield (2.8 t/ha), Early Maturing, Rosette Tolerance, Suitable for Forest Agro-ecology
Crops-Agbeyeye	Potential Yield (1.9 - 2.3 t/ha), Early Maturing (90 - 95 days), Suitable for Transition zone and Northern Ghana, High Biomass
Crops-Nkatie	Potential Yield (2.2 - 2.4t/ha), Early Maturing (90 - 95 days), High Oil (48%), Rosette-Tolerant, Bold Red Seed

Output 3: ***Sweetpotato for Health and Income***

Sweetpotato (*Ipomoea batatas* [L.]) is the seventh most important food crop in the world and the third in sub-Saharan Africa after cassava and yam. In Ghana, sweetpotato is becoming a major player in improving food security and nutrition as well as in providing employment and income for most rural households. The crop is able to grow in marginal soils under low input application by resource poor farmers. Despite its potential, changing environmental conditions in Ghana pose a threat to farmers engaged in its production. The need to have high-yielding, climate-smart, pest and disease tolerant varieties for farmers to ensure sustained production and productivity is of great concern.

The Sweetpotato Improvement Programme at CSIR-Crops Research Institute, has recently released two varieties ***CRI-Mbofara*** and ***CRI-Gavana*** with potential yields of **38 t/ha** and **28 t/ha** respectively. Other attributes these varieties possess include a high dry matter content (35-38 %), a high starch content (70-72 % DWT) as well as tolerance to sweetpotato weevil and virus disease.

Freshly Harvested Roots

Cut fresh roots

The maturity period of these varieties is less than 5 months. *CRI-Gavana* is the first open-pollinated variety developed and released in 2017 from the program's hybridization block and possesses an appreciable level of beta-carotenes (9.17 mg/100 g DWT).

With benefit-cost ratios (BCR) of 4.3 and 2.1 respectively, both *CRI-Mbofra* and *CRI-Gavana* offer farmers an opportunity to produce, consume as well generate income for better nutrition, health and livelihood under the different constraints the crop currently experiences in Ghana. These varieties also have potential for industrial use as a raw material for starch and high quality flour production and other processed products.

The National Varietal Release and Registration Committee (NVRRC) inspected the sweetpotato fields before approval was granted for release.

Excited farmers happily displaying their sweetpotato harvest from their fields

Output 4: ***Four New Water Yam "Afaase" Varieties Released***

After a 10-year period of trials and evaluations, the CSIR-Crops Research Institute finally released four (4) new water yam varieties in 2017. The released varieties are ***CRI-Afaase Adepa (Good thing), CRI-Afaase Hoodenfo (Mighty one) , CRI-Afaase Biri (Purple Fresh Tuber Colour) and CRI-Afaase Soanyinto (Good yield and taste)***.These varieties are not only nutritious, high yielding and pest-resistant but are also improved versions of the water yam varieties currently on the market.

Some harvested water yam varieties in the Institute's yam barn

They possess very high starch content and can be used for various forms of food such as iced cream and noodles. The varieties have also been declared safe for diabetic patients and can be used as a substitute for white yam. The high demand for water yam in neighbouring countries such as Burkina Faso, Cote d'Ivoire, Mali and Niger present a huge potential for Ghana to produce water yam seedlings for export.

The leader of the Yam Improvement Programme at the Institute, Prof. Emmanuel Otoo leading the National Varietal Release and Registration Committee to inspect the yam fields before approval was given for release.

Output 5: ***New Rice and Cassava Varieties Released***

Dr Maxwell Asante, the leader of the rice team explaining a point to the NVRRC during their field inspection

For the first time, six new rice varieties — four of which were wholly developed locally — have been released as commercial varieties in Ghana, by a team of AGRA-funded researchers from the CSIR-Crops Research Institute. The effort aims to help boost rice production and quality, as well as reduce dependence on imports. Currently, Ghana's rice import bill is about US $600 million, despite the fact that the country has the potential to produce to meet local and international demand. Besides maize, rice is the second most important cereal and major staple in Ghana. Figures from the Ministry of Food and Agriculture show current annual per capita consumption of about 40 kg per person and is expected to hit 63 kg by 2019.

The six new varieties released by the Institute, ***CRI-Dartey, CRI-Kantinka, CRI-Emopa, CRI-Mpuntuo, CRI-Oboafo*** and ***CRI-Aunty Jane*** are expected to respond to industry challenges of low production, low average yield, and poor grain quality. They will also satisfy the strong demand for high-yielding jasmine and conventional US long grain rice types in Ghana.

CRI Dartey

CRI Aunty Jane

CRI-Emopa

CRI Mpuntuo

CRI-Kantinka

CRI-Oboafo

All 6 varieties, which are suitable for lowland and irrigated rice ecologies, are high-yielding, tolerant to Rice Yellow Mottle Virus Disease and Iron toxicity, as well as have high cooking and aromatic qualities, making them farmer- and consumer-preferred varieties.

The National Varietal Release Committee had no problem at all accepting all six varieties for release onto the local market. The development of four (4) varieties from local crosses of the Crops Research Institute (CRI), is unprecedented and a major milestone for national research in Ghana.

Table 3: Attributes of the Released Rice Varieties

Variety Name	Days to Maturity	Yield Potential (MT/ha)	Quality
CRI-Dartey	120-125	9	Excellent cooking quality, Aromatic
CRI-Emopa	125-130	8	Excellent cooking quality, Slightly aromatic
CRI-Mpuntuo	115-120	8	Good cooking quality, Aromatic, Good Processing quality
CRI-Aunty Jane	125-130	9.5	Excellent cooking quality, Slightly aromatic
CRI-Kantinka	120-125	8.5	Excellent Cooking quality
CRI-Oboafo	130-135	8.5	Good cooking quality, Good processing quality

In a related development, two new cassava varieties ***Crops-Bankye*** and ***CRI-Bediako*** have also been released by the Institute. The two varieties are CMD-resistant, early maturing (12 months) and possess a high dry matter content (30-33%). The varieties can be used to prepare fufu (*CRI-Bediako*), flour and starch; producing yields of between 37 t/ha and 40 t/ha.

Output 6: Enhancing The Productivity of Farmer Saved Seed Yam: The Positive Selection (PS) Effect

Yam (*Dioscorea* spp.) plays a significant role in the socio-cultural lives of people in Ghana. In most West African countries, yams are steeped in cultural history and revered as a cultural symbol of fertility. Also, yam has tremendous pharmaceutical significance. For instance, *dioscorin* is extracted from the tuber of Chinese yam, *Dioscorea batatas* with sufficient antioxidant potential. The production of yam also provides cash income for a wide range of Small holder farmers, including many women who work as processors and traders.

Unfortunately, current yield of this life-saving crop is in rapid decline. The average yield of 10 t/ha realized by farmers in West African countries is actually half its potential yield. Yam mosaic virus and plant parasitic nematodes have been identified as the major causes of the yield decline. Traditionally, Ghanaian farmers use recycled seeds which may have accumulated pathogens and pests to produce tubers. The "positive selection" (the identification, tagging, monitoring and harvesting of tubers from symptomless "mother" plants for seed production) strategy was employed by the Institute to remedy the situation.

Farmers tagging symptomless plants with red ribbon (Positive Selection)

The Community Action in Improving Farmer-Saved Seed Yam (CAY-seed) project sponsored by the Bill and Melinda Gates Foundation and managed by the CSIR-Crops Research Institute, introduced a special package (positive selection, planting on ridges, minisetts and neem leaf powder application) to improve the quality of farmer saved-seed yam. Demonstration plots were established in various communities. Each demonstration plot measured 40 m x 40 m and minisetts of 30 g each planted on ridges 100 cm apart and 30 cm within rows.

Treatment of cut minisetts with fungicide and insecticide prior to planting

Minisetts were treated with a fungicide (100 g of Mancozeb ai. Ethylene bisdithiocarbamate) and an insecticide (70 ml Sunpyrifos ai. Chlorpyrifos) in 10 litres of water. Treated minisetts were air-dried before planting. Results indicated that virus disease incidence was significantly reduced by 44%, (as compared to farmers' practice (FP), while severity reduced by 22%. In addition, seed yams under PS out-yielded those under FP by 25%. Tuber cracks (incidence and severity) reduced in PS fields by 32% and 8% respectively compared with FP. Tuber galling caused by root-knot nematodes followed a similar trend where incidence and severity reduced by 53% and 18 % respectively in PS fields.

Farmers planting their demonstration plots at Watro in the Atebubu Amanten district of Ghana

Positive selection (PS) is an environmentally friendly strategy that has the potential to increase the productivity of seed and ware yams and re-vitalize the yam industry in Ghana.

A PS treatment demonstration plot managed at Bisiw. Plants have been staked the Trellis way.

Harvest from Kramokrom demonstration plot

Output 7: **International Workshop On Root and Tuber Entrepreneurship Development**

The CSIR-Crops Research Institute has over the years organized several international research and training programs to enhance the capacity of various actors in the crop production chain. The Agricultural Productivity Technology Centre (APTC) of the institute in collaboration with the West Africa Agricultural Productivity Program (WAAPP), organized one of such international workshops with the aim of enhancing entrepreneurship development in root and tuber crops production in the West Africa sub – region.

A total of 28 participants from 14 different West African countries including Mali, Senegal, Gambia, Cote d'Ivoire, Burkina Faso, Togo, Niger, Liberia, Nigeria and Ghana were taken through series of technological training and other business-oriented programs in entrepreneurship. The workshop discussed issues from the planting stage of root and tuber crops to the final delivery point.

Dr. Allen Oppong (left) and Prof. Joe-Manu Aduening (right), members of the WAVE team speaking to the media during the training

Participants were introduced to new technologies in root and tuber development

Participants at the workshop practicing a technology they were introduced to during the workshop

Participants also visited the screen houses at the institute

Output 8: ***CSIR-CRI Offers Technical Assistance to Adopters of the Aquaponics-Based Food Systems (AFS) Raised Fish Pond Technology***

After successfully setting up its own aquaponics-based food system cottage and producing over one thousand (1000) catfishes for sale, the CSIR-Crops Research Institute, has successfully introduced the technology to farmers and other interested parties.

In 2017, ten (10) adopters of the technology were provided with technical assistance to set up their own systems. The adopters were assisted to construct the fish ponds and also provided with the initial stock of fingerlings.

Adopters were able to construct their own fish ponds after technical assistance from the Institute

An adopter's pond stocked with fingerlings

Harvested catfish from an adopter's pond

RT 2: Biomedical and Public Health

Biomedical and Public Health research at CSIR focuses on human and animal epidemiology (including research into infectious diseases, clinical epidemiology and in the field of risk evaluation), Biostatistics, Health Communication, Health Policy and Nutrition. Other research programmes under this theme will include:

- Plant and Animal Health (Pathology, Virology, Entomology, Micro-Biology, Molecular Biology, Cell Biology)
- Genetics, Germplasm Conservation, Bio-prospecting and Bio-processing
- Bio-Informatics, Bio-Physics and Bio-Chemistry
- Biomedical, Biosafety and Public Health Ethics

Output 1: ***Management of Cassava Viral Diseases in Ghana***

Cassava production is greatly limited by a number of diseases such as cassava mosaic disease (CMD) and cassava brown streak disease (CBSD); each of which can cause yield losses of up to 100%. The West Africa Virus Epidemiology (WAVE) project, being undertaken by CSRI-CRI is important because it seeks to equip and prepare scientists, policy makers and other stakeholders on the need to take pre-emptive measures aimed at protecting citizens from famine caused by viral diseases. The main objectives of the WAVE project are:

- To ensure a clear understanding of virus threats to root and tuber crops in West Africa.
- To equip breeders with accurate information needed for identification and deployment of resistant/tolerant root and tuber crops.
- To strengthen national and regional capacities to respond to viral disease threats.
- To facilitate increased demand and availability of clean planting materials as a component of integrated management of root and tuber crop viruses.

To achieve these objectives, four (4) farmer field days were organized in the Central, Western, Northern and Eastern regions of Ghana to educate farmers on the importance of viral cassava disease and the need to plant virus-free planting materials for improved productivity.

Virus infected cassava in Ghana

The four farmer field days attracted over 300 farmers and agricultural extension officers from all four regions. Farmers were educated on how to spot diseases. They were advised to report symptoms of any strange disease to the appropriate quarters for effective diagnosis and management. In total, one hundred and eighty (180) cassava fields were visited by the WAVE team.

A section of participants after the training

RT 3: Science and People

This thematic area is in line with the research agenda of the CSIR which has been aligned with the development priorities of government and development partners by putting research in the context of socio- economic development and sustainable resource utilization. It recognizes national priorities as outlined in the Ghana Agenda for Shared Growth and Development (GASGD) which focuses on research on social protection, and has the potential to reduce the vulnerability of poor people to the extent that they can manage moderate risks without external support. The priority areas under this thematic area include:

- Policy and Governance
- Statistical, Social and Economic Research
- Culture, Indigenous Knowledge and Community Improvement
- Technology for Livelihood and Wealth Creation

Output 1: ***The Benefits of Seed Yam Production in Aeroponics***

Yam production in Ghana is hampered by many constraints including diseases and pest infestations as well as availability of quality planting materials. Yam is traditionally propagated vegetatively by means of the edible tuber. This practice is however, associated with low multiplication rates (less than 1:10), a long dormant phase of the tuber prior to sprouting and planting materials that are infested with pathogens. The aeroponics method of producing seed yams in Ghana is seen as the way forward to solving this planting material acquisition menace. The 'aeroponics system' is a means of growing plants with nutrient water in a soil-less environment. The multiplication rate of the seed yams in an aeroponics system is as high as 1:100. Concerns have however been raised about the economic viability of setting up such a system. Farmers have wondered whether the benefits to be derived from the system will outweigh the expected cost of setting it up. The socio-economics division of the CSIR-CRI therefore decided to carry out a project to evaluate the system. Evaluations carried out on the aeroponics system at the Institute, revealed that seed yam production in the system is profitable.

An aeroponics structure with plants ready to be harvested

The level of seed yam production was very high (1:55) indicating the potential of the system to increase yam production and improve food security in the country. The economic analysis of the production is as seen in Tables 4, 5 and 6.

Table 4: Fixed Cost of an Aeroponics Structure

Parameter	Fixed cost (GH¢)
Land purchase/acre	5,000
Total cost of structure	89,196.15
Total fixed cost	94,196.15
Depreciation[1].	8,669.615

Table 5: Cost of Inputs for Production (Aeroponics Structure)

Parameters	Cost (GH¢)
Labour cost (Salaries)/year	57,637.5
Electricity charges/year	5,000
Seed from the tissue culture(plantlet)[2]	98,000
Nutrient solution	240
Consumables(gloves, labels, tape measure, etc.)	2,585
Total Input cost	16,3462.5

Table 6: Revenue from Seed Yam Production from the Aeroponics System

Parameter	
Total production of vine cuttings/year	215,600
Selling price/cutting (GH¢)	1.7
Gross revenue (GH¢)	366,520
Net revenue (GH¢)	150,731.9
BCR (Benefit cost ratio)	1.4
Payback period (months)[3]	19

1 Depreciation computed using straight line method= (Initial Cost – Salvage value) / Life span (salvage value estimated at GH¢ 2500 and life span estimated at 10 years)
2 1960 plantlets from the tissue culture@GH¢ 50/plantlet for the structure
3 Payback =Investment cost/ Net annual income

A minimum multiplication ratio of 1:55 is attainable with seed yam production in the aeroponics system while the traditional seed yam production has a multiplication ratio of 1:10. A return on investment (ROI) of 140% also indicates that an investor would recoup the 100% of his or her total cost of production plus an additional 40% as profit over 1 year

*Output 2**: CSIR-CRI Open Day 2017***

Dr. Stella A. Ennin, the Director of CSIR-CRI delivering her welcome address during the Open Day

Under the leadership of the Public Relations Unit of the Institute, the CSIR-CRI organized an "OPEN DAY" in July, 2017 under the theme **"Harnessing Agricultural Research for Food Security and Job Creation"**. The objective of this event was to showcase CSIR-CRI technologies and interact with major stakeholders to highlight the importance of agricultural research to national development. The "Open Day" saw more than five hundred (500) participants from both the private and public sector visit the Institute. Traditional authorities, farmers and other stakeholders were also present.

The Special Guests of Honour were the Chief of Atwima, Nana Fobi Kropa III, the Minister of Environment, Science, Technology and Innovation, Professor Frimpong Boateng, the Director-General of the CSIR, Prof. Victor Kwame Agyeman and the Board Chairman of CSIR-CRI, Dr. Abu Sakara Forster. Participants visited the crop fields, screen houses, laboratories and exhibition stands to witness the technologies and innovations the Institute had to offer.

The Director of CRI, Dr Stella A. Ennin explaining a point to the sector Minister, Prof. Frimpong Boateng

Chief of Atwima, Nana Fobi Kropa III, listening keenly to Dr. Joseph Berchie, a Principal Research Scientist of the Institute

The D-G of CSIR, Prof. Victor Agyeman and the sector Minister, Prof. Frimpong Boateng (red tie) during the field visits

The Board Chairman of the Institute, Dr Abu Sakara Forster, speaking to the media during the Open Day.

Dr. M.B. Mochiah and Dr. Shadrack Amponsah explaining a technology to participants

Dr. M.B, Mochiah, a Principal Research Scientist leading a group during the field visit

Prof. Frimpong Boateng delivering his keynote address at the function

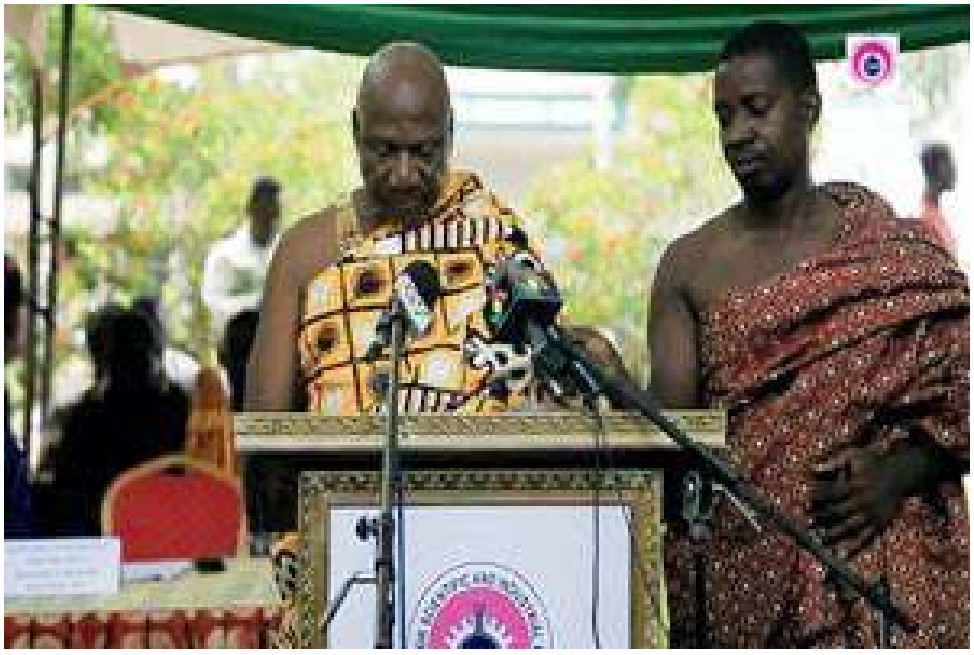
Mr. B.M. Dzomeku, the head of the Horticulture division explaining the plantain multiplication technology to the Sector Minister, Prof. Frimpong Boateng (red tie)

Dr. James Asibuo of the Legumes division explaining activities of the division to some participants at the Open Day

Nana Kropa III and the sector Minister fascinated by the cassava fertilization technology being explained by Dr. J.N. Berchie, a Principal Research Scientist

Overall, the Open Day was a huge success. Participants were excited about the technologies the Institute displayed. In his speech, the Sector Minister, Prof. Frimpong Boateng pledged Government's continual support for agricultural research.

Output 3: ***"Hidden" Crops Research Treasure***



Nana Fobi Kropa III, Omanhene of Apemanim Traditional Area and Otumfuo's representative at 2017 Open Day of CSIR-CRI.

It is so much like us, as nation and people. All the answers to our development questions are with us. Yet we close our eyes, ignore everything and beg others to ask questions on our behalf and provide answers on their behalf. When I was asked to write a comment in the visitors' book, I simply wrote 'Revealing.' To me, the wonders I saw at the Crop Research Institute of the CSIR Open Day on Friday, July 20, 2017, is solution to WHATEVER our unemployment problem is and yet we have unreasonable unemployment everywhere. People must have been wondering what the chief in golden sandals standing in the Crops Research field was fretting about. I was telling my Unit Committee chairman to ensure he would bus all the unemployed (especially the young girls/women and boys/men) to the place without delay.

I saw seeking positive relief from our community's unemployment problem all there. Some onlookers appeared more worried about this maverick chief being derelict in tradition and custom wandering all over the place. His sun protecting umbrella was tucked under the armpit of his *"ahenkwaa*" instead of shielding him from the burning sun. Those onlookers had no idea about how enthused the chief was about the tour and how he wished so much would come out of it.

After touring only part of the CRI facility and seeing and realizing the massive potential of the conversion of already established research results, the potential in the efforts of the scientists to break the unemployment stranglehold on the motherland was evident. My humble solution to the unemployment problem is for every person in the motherland to seek some inspiration and direction from what is happening at the place. Let every unemployed person visit the place.

The underemployed should visit too. Street sellers, "*kayayee"* (female/ male), the graduate unemployed, all must visit CSIR CRI, Fumesua. All entrepreneurship course (compulsory in university) students must mandatorily write their term papers on what they would do with what they see at the Crops Research Institute. Every SHS student (especially in the Agriculture and Home Economics programmes) compulsorily visit the place.

Kwame Nkrumah built the Atomic Energy facility as a self-contained city. Provide the scientists with all they would need; food, shelter and clothing, school for their children. Don't make them need anything. And in their small comfort zone, they would use their brains to solve all our problems. That is what we should do with the CSIR Crops Research Institute and all the 12 other institutes I haven't seen.

All MMDCES and heads of institutions which directly disburse motherland cash should be there to learn more about how we can develop value for money and investment with whatever little we have. I hear the Finance Minister has been there. Let him be followed by the administrators of the common fund, MASLOC, LEAP and GETFUND. Those dealing with people such as the NYEP/GYEEDA/YEA and National Service scheme must also visit the place.

All MPs, MMDCEs, Sub-Metro directors should visit the place. The President of the National House of Chiefs must visit with his team of Presidents of the Regional Houses of Chiefs.

The Chief Justice must visit, the Speaker of Parliament must visit, and the President of the Republic must visit and ensure each and every one of his Ministers visits. I saw the deputy minister of Agriculture there. The Minister of Labour should be there. I saw the GAWU General Secretary; the TUC Secretary-General and all his General Secretaries should be there. Food vendors, the tourist authority and organizations must show up for some valuable insights.

CSIR-CRI must be lucky to have Minister Kwabena Frimpong-Boateng. Not just can do but will do was written all over his face. Despite the burning sun, he seemed in a hurry to make research have an immediate impact. He quizzed about why a 12-month research yield cannot be reduced to three or six months. And he kept insisting on why things ought to be done differently to speed up results. He lamented over the woeful lack of financial support to research and reiterated the old man President's radical promise of 1.0% of GDP to rise to 3.0% to be allocated to research.

My compatriots, please let's sing: "*Ade papa bia m'ahu wo CSIR Crop Research Institute oye, oye... Oyeee, oyee, oye"* because it has practical answers to our unemployment problems.' To visit, though, especially from officialdom dressed formally, CRI must have a plan. Those visitors must make some time to change apparel. Wearing designer heavy Obama resplendent chief attire with golden "ahenemma" to match, or suit and tie, is not the most suitable attire for a CRI field visit. Something like a smock, as the Deputy MOFA Minister wore with wellington boots, would be the ideal.

(As published in the Monday, 24th July 2017 edition of the Daily Guide Newspaper)

Output 4: ***2017 National Farmers' Day Celebration, Exhibitions, Fairs***

The CSIR-Crops Research Institute participated in the 33rd National Farmers' Day celebration which came off on 1st December, 2017. The event which was held at the Heroes Park behind the Baba Yara Sports Stadium in Kumasi was under the theme *"Farming for Food and Jobs"* to reflect the Government's emphasis on agriculture as a tool to deliver food security, create employment and enhance the socio-economic wellbeing of farmers. The week long programme was officially launched by the Vice President of the Republic of Ghana H.E Dr. Alhaji Mahamadu Bawumia. Other dignitaries at the opening ceremony included the Minister for Fisheries and Aquaculture Development Hon. Elizabeth Afoley Quaye.

Preceding the main event was an 8-day exhibition by stakeholders in agriculture. Various institutes and organizations exhibited a number of technologies they had developed. The institute was well represented and exhibited a number of technologies.

Mr. Stephen Ayeh explaining the plantain multiplication technology to some students who visited the CRI stand

Several people visited the CRI stand during the exhibition

A number of crop varieties were on display

The PRO, Mr. Solomon Gyasi-Boakye speaking to the media

Technologies Exhibited

- Cereals: Maize and Rice varieties
- Legumes: Groundnuts, Cowpea and Beans varieties
- Root and tuber crops (Rapid multiplication techniques / tissue culture):
  - Aeroponics-based planting materials
  - Tissue manipulation techniques for plantain
  - Two node cutting technique for cassava multiplication
- Commercialization: Seedlings of Citrus, mango, lime, avocado and coconut were available for sale.
- The institute also exhibited various crop production and marketing guides and made them available for purchase to farmers who needed them.

The event was hugely successful judging from the several number of people who visited the CSIR-CRI stand and expressed interest in the various technologies on display. Several seedlings of citrus, avocado, coconut and mango were sold to farmers and other interested persons. A number of production and marketing guides were also purchased from the CRI stand. The Institute also participated in the 7th Annual Pre-Harvest Agribusiness event in Tamale on 19th October, 2017.

Output 5: ***Institutional Visits***

Activities at the Institute attracted a number of high profile visits in 2017. Prominent among these were working visits from the Sector Minister, Prof. Kwabena Frimpong Boateng and his Deputy, Mrs. Patricia Appiagyei, the Minister of Finance, Mr. Ken Ofori-Atta and the Minister of Employment and Labour Relations, Mr. Ignatius Baffuor-Awuah. The Institute was very pleased to also host students from Elon University in North Carolina, USA as well as a delegation of Chinese businessmen.

The Finance Minister, Mr. Ken Ofori-Atta observes yam "growing in air" at the aeroponics section of the Institute

The sector Minister, Prof. Frimpong Boateng interacts with staff during one of his visits

CSIR-CRI Director, Dr. Stella A. Ennin (green cap) and her Deputy,Prof. Joe-Manu Aduening (far right) leading the Deputy Sector Minister, Mrs. Patricia Appiagyei, (white cap) on a field visit

A staff at the Biotechnology division of the Institute explaining the aeroponics technology to Mr. Ignatius Baffuor-Awuah (Min. of Employment/Labour Relations)

Students from Elon University, USA visit the screen house at the Biotechnology division of the Institute

CSIR-CRI Deputy Director, Prof. Joe Manu Aduening leading students from Elon University on field visits

Dr. Stella A. Ennin (CRI Director) interacts with the Chinese delegation during their business visit

Some senior members of the Institute take students of Elon University on a field trip

Output 6: ***Media Engagements***

It is the Institute's firm belief that continuous media engagements will go a long way to keep stakeholders and the general public informed of its activities and technologies. The use of print, electronic and social media has contributed greatly towards achieving this. The Institute continues to contribute articles in various national newspapers such as the Daily Graphic and Ghanaian Times in addition to various TV and radio programmes.

Numerous articles were also uploaded unto the Institute's website and social media platforms to further inform the general public of the Institute's activities and to make us more visible. The use of social media especially has enabled us reach a younger crop of audience who hitherto had no idea what the Institute was about. It is our hope to keep engaging the public even more in order to increase the Institute's visibility.

Table 7: A Summary of the Institute's Media Engagements in 2017

DATE	MEDIA ORGANIZATION	TITLE OF PUBLICATION
6th April, 2017	Daily Graphic	Maize Improvement In Ghana – The contribution of CSIR-CRI
9th April, 2017	www.scidev.net	Sweetpotato Project Improves Nutrition and Income
18th May, 2017	www.myjoyonline.com	Narrowing Food Base Threatens Ghana's Food Security – CRI warns
7th June, 2017	www.myjoyonline.com	Ghana Partners India to boost tomato production
24th July, 2017	www.ghanaweb.com	'Hidden' Crops Research Treasure
1st September, 2017	Ghanaian Times	Use Integrated Approach to Tackle Armyworm Invasion-Expert
6th September, 2017	Daily Graphic	Food and Agric. show slated for Tamale
6th September, 2017	Ghanaian Times	Fall armyworm destroys 16.5 hectares of farm in Nadowli/Kaleo district
18th September, 2017	Ghanaian Times	Stakeholders discuss challenges confronting Agric. sector
25th September, 2017	www.myjoyonline.com	New disease resistant groundnuts introduced to boost production, export
26th September, 2017	Daily Graphic	CSIR to commercialize goods, services
9th October, 2017	Ghana News Agency	Let's have open, candid debate on GMOs – Prof Adu-Dapaah
16th October, 2017	www.myjoyonline.com	Fresh innovations needed to tackle Fall Armyworm - Scientists
23rd October, 2017	Daily Graphic	CSIR works to improve yam seeds
24th October, 2017	Ghanaian Times	CRI partners 6 in Aeroponics seed system
24th October, 2017	Ghana News Agency	National Biosafety Authority works to ensure safety of GMOs
3rd November, 2017	Daily Graphic	Achieving rice self-sufficiency-The role of CSIR-CRI
8th December,2017	www.graphiconline.com	CRI, Chinese Centre sign agreement on rice research

Output 6.1 ***Achieving Rice Self-Sufficiency in Ghana: The Contribution of CSIR - Crops Research Institute***

In Ghana, rice is the second most important staple cereal after maize. The consumption of rice is increasing faster than any other crop due to rapid urbanization and changing dietary habits. However, there is a big gap between the demand for rice and the volumes produced resulting in a huge import bill.

Currently, the annual consumption of rice in Ghana is about one million metric tonnes (milled rice). Sixty percent (60%) of this amount is imported (MoFA, 2016). The need to increase rice production in the country in order to achieve self-sufficiency and save the millions of dollars spent on rice importation yearly, cannot be overemphasized. The major constraints to achieving rice self-sufficiency are low production levels, poor grain quality and ineffective marketing of domestically produced rice.

In order to eliminate these constraints and reduce this huge deficit, the CSIR-Crops Research Institute (CRI) has released nine improved rice varieties for cultivation by farmers. Two of these Jasmine-styled (aromatic, cooks soft) varieties, *CRI-Amankwatia* and *CRI-AgraRice* have been widely adopted by famers. Currently, many large and small scale entrepreneurs sell these varieties under their own brand labels in various markets across the country. The CSIR-CRI produces basic seed of these varieties every year for seed growers to multiply for farmers.

Seed production of CRI-Amankwatia at CSIR-CRI, Fumesua

In order to continually meet the needs of farmers, many new rice varieties that are high yielding and resistant to the major rice diseases and pest in the country have been developed.

At least five of these rice varieties will be presented to the National Variety Release and Registration Committee (NVRRC) in July, 2017 for possible release for cultivation by farmers. These varieties can yield over 8 metric tonnes per hectare as compared to our traditional local rice which yield about 1 metric tonne. These are either Jasmine-styled or conventional USA long grain quality rice preferred by most consumers.

Grain quality type is an innate property of rice, which is also affected by the way the grain is handled in the field and after harvest. The CSIR-CRI has developed protocols to help prevent the disruption of the good innate qualities of these varieties which occur through poor agronomic and post-harvest practices. The innate grain quality of rice is mainly determined by grain length and translucence which control the physical appearance of the grain, amylose content which controls the texture of cooked rice and aroma which determines how the rice smells.

These grain quality characteristics have been clearly defined by rice breeders at CSIR-CRI even to the DNA level using popular imported rice varieties as benchmarks (Asante et al., 2015). We are therefore able to select for specific grain qualities that match the quality of imported rice once post-harvest practices and milling are handled appropriately.

Rice needs well developed paddy fields and optimum water and fertilizer management to achieve its maximum yield. In collaboration with AfricaRice, we have developed good agricultural practices (GAP) and successfully piloted RiceAdvice, a fertilizer recommendation software that aids farmers with the type, amount and timely applications of fertilizer for optimum yields. Upscaling this technology which can be operated on any smartphone will help bridge the yield gaps between rice yields on research and farmers' fields. We have also developed a low cost small scale irrigation system with farmers called "SAWAH" meaning a well bunded and leveled paddy with inlet for irrigation and outlet for drainage.

SAWAH field developed at Sokwae, Ashanti Region

The rice varieties developed by CSIR-CRI and the associated technologies such as GAP RiceAdvice and "SAWAH" will go a long way to facilitate the government's policy of increasing rice production by 40% under the planting for "food and jobs" programme.

While we subscribe to the government's strategy for increasing rice production under the planting for food and jobs programme, we encourage a stronger value chain approach that addresses production, post-harvest, processing and marketing constraints, which adversely affect the domestic rice industry. The value of relevant research findings and continuous technology improvement along the value chain cannot be overemphasized.

The CSIR-CRI wishes to encourage the government to invest more resources in scientific research in general, and rice research in particular because of the negative effects of rice importation on our balance of payment and the stability of the cedi. Our technologies will not make the desired impact if government does not support the private sector to take up production, processing and marketing of locally produced rice.

In conclusion, the CSIR-CRI and other research institutions in Ghana have developed improved rice varieties with grain qualities comparable to high grade imported rice and the associated techniques to create the right environment for these varieties to yield to their full potential.

However, there is the need for increased investment in production, processing and marketing of rice from the private sector and government to make Ghana truly self-sufficient in rice production.

(As published in the 3rd November, 2017 edition of the Daily Graphic)

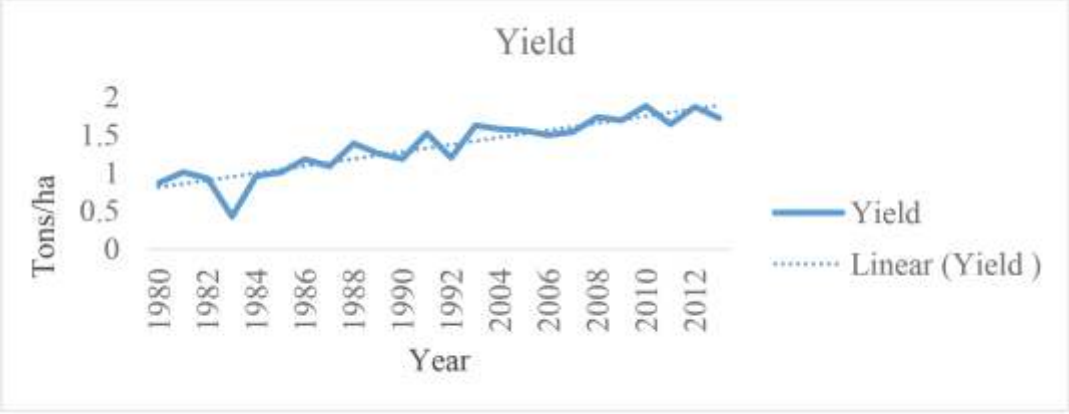
Output 6.2 ***Maize Improvement in Ghana: The Contribution of CSIR-Crops Research Institute***

Maize is the most important cereal in terms of production and use in Ghana. The crop is produced in all the five agro-ecologies which is characterized by significant climatic variations with frequent periods of drought and other stresses, resulting in crop losses.

In Ghana, the CSIR-Crops Research Institute (CSIR-CRI) based in Kumasi has contributed immensely to maize improvement. The contributions of CSIR-CRI Maize breeding programme to Ghana's development can be found in every household where maize product of local origin is consumed.

The focus of maize breeding at the institute has been to develop stable and high yielding maize varieties with the capacity to perform well in all the agro-ecologies in Ghana.

It is estimated that over 80% of improved maize varieties grown in Ghana were developed and released by CSIR-CRI with support from its partners. Prior to official release of maize varieties, maize cultivation in Ghana was dominated by unimproved landraces whose yield potentials were less than one t/ha but now hovers around 1.9 t/ha on farmers' fields (See graph). Other Maize breeding objectives are focused on enhancing nutritional benefits of the crop to consumers.



Maize yield per hectare in farmer fields from 1980-2013 (Courtesy, FAO)

The development of hybrid varieties has been embraced by Maize Breeders at CSIR-CRI. Hybrid breeding is a tedious process that involves the identification of suitable parents which when crossed will produce off-springs that are far more productive than their parents. Farmers will always have to buy fresh seeds every year/season for planting if they want sustained yields, a situation most Ghanaian farmers have not woken up to.

A technician performing artificial pollination for breeding of hybrid maize at CSIR-CRI

Drought constitutes a major threat to maize productivity worldwide. With climate change and irregular rainfall, the need for maize varieties with resistance/tolerance to drought is needed. In collaboration with international partners CSIR-CRI has developed and released commercial varieties that are drought resistant. CSIR-CRI was the first research institute/organization in the whole of sub-Saharan Africa to breed for quality protein maize (QPM) varieties rich in lysine and tryptophan. The famous *CRI-Obatanpa* maize variety released in 1992 by CSIR-CRI is currently grown under various names in about 20 African countries and continues to stand tall both in terms of yield and nutritional quality. One estimate showed that over 80 million US dollars have been saved to the country upon the development of QPM varieties. Other nutritionally superior varieties rich in beta carotene and high yielding have been released by CSIR-CRI. Beta carotene rich maize are good for children, pregnant women and poultry. Important agronomic packages for improved productivity have been developed by the Institute. These range from good land preparation, timely planting, proper planting, fertilizer application, weed management, timely harvesting to proper storage of all the released varieties which are available.

The major challenge to maize improvement efforts have been inadequate funding. According to a report prepared by Ghana's Millennium Development Authority (MiDA), Ghana has a shortfall in maize production of about 9% to 15% of national requirements and this is projected to increase. Adequate funding for the development of new varieties is needed to close this gap.

Low adoption of hybrid varieties is another challenge. Rapid adoption of hybrid maize varieties has the potential to triple farmer yields from the current 1.9 t/ha to over 4.5 t/ha or even higher in farmers' fields. The challenges of poor seed supply systems in the country cannot be over-emphasized. Perhaps, with the promulgation of the Plant Breeders' Bill, Maize breeders can liaise with emerging private seed companies to help disseminate newly released hybrid varieties for rapid adoption.

Other important areas that need research attention are breeding for improved popcorn and sweet corn varieties for the Ghanaian market. Farmers can earn decent incomes from the cultivation of these varieties. However, serious efforts are underway to attract funding from potential donors to support the breeding of these types of maize in the country.

The challenge posed by pests and diseases is not completely won as new and potent pathogens and pests keep emerging. The recent outbreak of armyworms in some parts of the country is a case in point which had a toll on maize productivity in 2016. Overcoming these challenges require constant monitoring and breeding interventions to curtail any catastrophic consequences.

We conclude by requesting for support of the Ghana government, donor agencies and organizations interested in food security to support maize improvement research particularly, at CSIR-CRI to develop new higher yielding and preferred varieties for the diversified users.

(As published in the 6th April, 2017 edition of the Daily Graphic)

Output 7: ***Ghana Sweetpotato Net Tunnel Training in Ashanti, Brong Ahafo, Volta and Central Regions***

Scientists and staff of the Institute involved with the SASHA project reached out to farmers in the Ashanti, Brong Ahafo, Volta and Central Regions of Ghana for the formation of sweetpotato innovation platforms. The team also trained farmers on the construction of net tunnels for clean planting materials production.

In all, one hundred and twelve (112) farmers from all four regions, participated in the training exercise. Participants were taught the procedures for land clearing and preparation, manure application, assembling of materials, constructing the net tunnels, planting the sweet potato vines with appropriate spacing in the tunnels and maintenance practices. They were then organized into groups and assigned a section of land, materials for construction and 300 cuttings of an improved CRI sweet potato variety.

Staff of CSIR-CRI interacting with participants before the practical demonstration

Participants demonstrating proper spacing for in the net tunnels

A farmer clearing her piece of land for planting

A farmer clearing her piece of land for planting

A partially complete net tunnel constructed participants after the training

A wholly complete net tunnel after construction

Output 8: **CSIR-CRI Staff and Others Trained in Marker Assisted Selection Techniques**

Scientists involved in a project aimed at developing aflatoxin-resistant maize hybrids for improved nutrition and health for Ghanaian maize consumers. Dubbed and currently being hosted by the CSIR-Crops Research Institute with funding from the USAID, have undergone training in marker assisted selection techniques.

The training was meant to upgrade the capacity of staff so that they can apply these skills in even larger breeding programmes. The course instructor, Dr. Marilyn Warburton, from the USA, led participants through the 3-day training workshop. All forty-seven (47) participants were taken through theoretical lectures to explain "marker assisted selection" and the detection and quantification of aflatoxins in maize.

Participants were taken through hands-on training on plant genomic DNA extraction, agarose gel analyses with SSRs and application of microplate reader for SNP analyses using KASP assay for the detection of genotypes with aflatoxin resistant genes was also done.

The course instructor, Dr. Marilyn Warburton supervising an experimental set-up at the laboratory

Certificates were presented to participants at the end of the workshop

Participants at the end of the workshop

Participants at the workshop visited the Biotechnology laboratory at the CSIR-CRI

As part of the implementation of this project, USAID provided the Institute with an aflatoxin detection and quantification set up. This equipment (below) is currently being used for the detection and quantification of aflatoxins in maize.

The aflatoxin-detection and quantification set up provided by USAID

Output 9: ***Validation Workshop On Standardization, Grading and Pricing of Maize in Ghana.***

Despite its potential as an income generating and food security crop, the domestic maize market faces a number of challenges; key among these challenges is the issue of low standardization and product differentiation. This has affected the nation's competitiveness and integration into international markets. As a result, the CSIR- Crops Research Institute with support from the USAID- Feed the Future project, conducted a field survey with stakeholders in the maize value chain and organized the workshop to share findings, validate results and collectively discuss the way forward towards addressing the grain standardization issue.

Participants were drawn from the Ministry of Food and Agriculture, Municipal Assemblies, grain processors, the poultry industry, traders' associations, farmer associations, GPRTU, research institutions and the media. Prevailing marketing standards were presented from the study for participants' interactions.

A section of the participants at the workshop

A break out session during the workshop

Highlights

- Members saw the need for a more formalized standard such as using 100 kg for a bag of maize.
- In terms of improving the quality of the grains, the groups suggested training for maize stakeholders on sorting and the use of moisture meters
- Participants agreed on awareness creation on the developed standards by the Ghana Standards Authority (GSA). This was to be done by the department of agriculture, the municipal assemblies and organized farmer and trader associations through face to face meetings as well media engagements.
- Information on standards to be packaged in simplified forms like flyers that could be used by the less educated.
- Farmers to be trained on good agricultural practices.
- The need to enact bye-laws to regulate and enforce grain and cereal trade.
- Market task forces to be charged by the assemblies to ensure standards are adhered to on market days.

A farmer making a contribution during the workshop

A participant expressing an opinion during the workshop

Participants at the end of the workshop

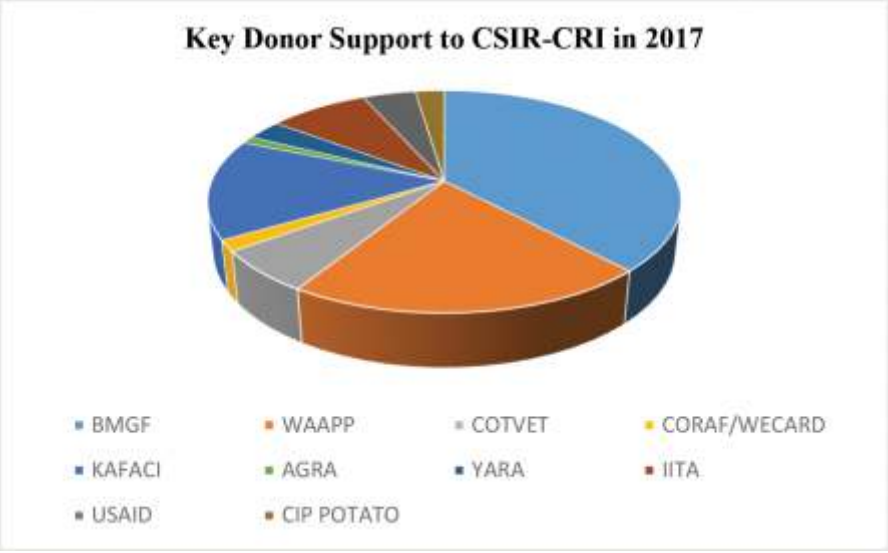
A brainstorming session during the workshop

Research Support Activities

Output 1: Donor Support in 2017

The Institute receives donor support from a number of local and international funding agencies. Donor support to the Institute decreased slightly in 2017 as compared to the figure for 2016. The total amount received was approximately GH₵ 6,628,103.52

Most of our donor support for 2017 came from the Bill and Melinda Gates Foundation (PEARL I), the World Bank (WAAPP), the COTVET Secretariat (APTC) and CORAF/WECARD. Others included KAFACI INTERNATIONAL, AGRA, YARA, IITA, USAID, CIP POTATO etc.



Key Donor Support to CSIR-CRI in 2017

Output 2: ISO 17025:2005 Accreditation for The Detection of ACMV in Cassava

One of the criteria for migrating from a National Centre of Specialization (NCoS) to a Regional Centre of Excellence (RCoE) is the ISO 17025:2005 accreditation for testing and calibrating laboratories. The molecular laboratory of the Institute was therefore tasked to obtain the accreditation for at least one of its test methods. This involves the development of documentation for ISO 17025:2005 for the quality management system and implementation and continuous improvement of the quality management system. Several records were generated and the quality management system was implemented and improved. Over 100 documents consisting of manuals, standard operating procedures and work instructions were developed. The team resubmitted the application and other relevant documents to the South African National Accreditation Systems (SANAS) for assessment. Various equipment have been calibrated and certificates filed. Corrective actions have been conducted and sent to the South African National Accreditation Systems (SANAS).

Output 3: Installation of Solar Panels

Boxes containing solar panels before installation

Solar panels being installed at the CRI main building

In our quest to be energy efficient, the Institute has started the process of installing solar panels on its main building. This is to provide a reliable and efficient energy source for our activities.

Output 4: Establishing A Digital Institutional Repository (IR): Prospects for Online Visibility

Interface of the Institute's Institutional Repository (IR)

The advent computers and the internet has caused several changes regarding information availability, accessibility and storage. New concepts such as online-journal publishing, e-resources among others are mandating scholarly communication to be restructured. Indeed, academic and research institutions are taking steps to reorganize and disseminate research output

using modern and appropriate technologies. One of the most recent tools for online scholarly research dissemination, is the Institutional Repository (IR).
An IR is a system that uses software to collect, manage, disseminate and preserve an institution's intellectual output in digital form. With online presence, IRs highlight the collective effort of an Institution's intellectual output.

The CSIR-Crops Research Institute has set up its own IR and trained its library staff to manage it. Over 158 published journal article have been uploaded so far. These and other content uploaded will be available to the general public.

Commercialization Activities

Production and onward sale of planting materials is the major commercialization activity the Institute partakes in. Planting materials for mango, maize, rubber, cassava, pepper and citrus are produced on large scale and sold to various stakeholders such as the EXIM Bank of Ghana. In 2017, the Institute also produced breeder and foundation seeds of maize, rice, cassava, soybean and pepper towards the Government of Ghana's "Planting for Food and Jobs" programme. In 2018, the Institute is tasked to produce quantities of breeder seeds of maize **(2000 kg)**, rice **(2000 kg)**, soybean **(555 kg)**, pepper (**21 kg)** and cassava **(80,000 cuttings)** for the programme. Production of various planting materials for sale will also continue

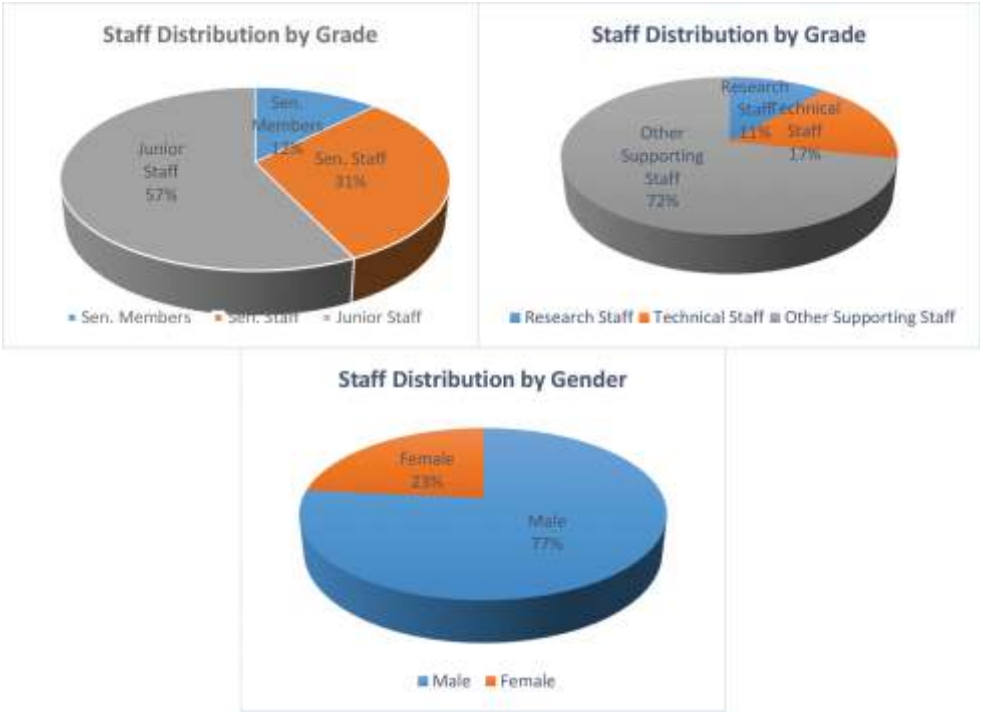
An orange juice production unit has also been set up by the Institute. The unit purchases the orange from the stock produced by the commercialization division and uses them as raw materials. The juice is then sold to customers in and and around Fumesua. The unit also supplies any quantity upon demand.

Grafted mango seedlings produced for sale

Ungrafted mango seedlings produced for sale

Human Resource And Staff Recruitment

The need to build capacity is essential to the Institute's vision of becoming a Centre of Excellence. As a result, staff are always encouraged to add value to themselves by seeking higher education and earning promotions. As many as thirty-three (33) members of staff were promoted in 2017. This comprised 6 in the research grade, 14 in the senior staff grade and 13 in the junior and monthly-rated grades. The Institute's staff strength has suffered a 4% decrease since 2016 and now stands at 605. This is made up of 75 senior members, 185 senior staff and 345 junior staff. Ninety-one (91) members of staff have post-graduate degrees (Ph.D., M.Sc., M.Phil., M.A.) while 45 have bachelor's degrees (B.Sc., B.A., B.B.A). The remaining 469 members are hold Diplomas, College Certificates or other qualifications. Throughout the course of the year, students from 17 agricultural institutions visited the Institute to acquaint themselves with practical field and laboratory activities. In addition to fifty-one (51) national service personnel, the Institute also offered internship opportunities to seventy-eight (78) students from various tertiary institutions.



CSIR-CRI 2017 Staff Distribution

Despite the over 30 percent staff attrition rate that the Institute experiences yearly, the freeze on public sector employment by the Government of Ghana has prevented new appointments from being made. However, in 2017, the Institute was cleared to employ six (6) staff. This number, though nowhere near the number of retiring staff that year, has filled some vacancies which hitherto existed. The Institute recruited one research scientist and five (5) principal technologists.

New Staff Recruited by The Institute in 2017

Mrs. Jacinta Adoma Opoku
(Plant Breeder, MPhil. Agronomy)

Mr. Bernard Sakyiamah
(Scientific Secretary, MPhil. Agricultural Economics)

Miss Monica Opoku, M&E Officer,
(M.Sc. Management Economics and Consumer Studies)

Mr. Benjamin Annor, Principal Technologist
(Plant Breeder, M.Sc. Crop Science)

Mr. Godfried Ohene-Mensah, Plant Pathologist
(M.Sc. Biotechnology)

Dr. Kofi Frimpong Anin, Entomologist
(PhD, Entomology)

AWARDS

As has been the tradition in previous years, a number of scientists from the Institute were honoured with various awards for their exemplary performances in 2017. **Dr. Maxwell Asante** and **Dr. Kofi Dartey**, two rice breeders from the Institute won the National Best Researcher Awards for 2017.

Dr. Maxwell Asante, Rice Breeder-CSIR-CRI

Dr. Kofi Dartey, Rice Breeder-CSIR-CRI

A group of scientists from CSIR-CRI and other institutes also received the **Best Maize Breeding Team** award under the Stress Tolerant Maize for Africa (STMA) project. The team representing Ghana was coordinated by **Dr. (Mrs.) Priscilla Francisco Ribeiro**, a research scientist from CSIR-CRI who received the award on behalf of Ghana. They were presented with a cash prize of three thousand dollars (US$ 3000) and a plaque. The STMA project aims to mitigate constraints in maize production across many regions in sub-Saharan Africa. The best breeding, dissemination and promotion teams are awarded yearly for their hard work. The award is funded by the Bill and Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID) through the International Institute for Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Centre (CIMMYT).

Dr. (Mrs.) Priscilla Ribeiro (left) and her team presenting the award to the Director of the Institute, Dr. Stella A. Ennin

Dr Ernest Baafi, a sweetpotato breeder of the Institute, also won the **Scientific Excellence and Innovation Award f**or 2017**.** The award committee selected his paper, **"***Exploitation of Genetic Potential of Sweetpotato for End-User Traits Improvement"* as the best scientific sweetpotato paper for 2017. He was reserved a slot to present his paper at the meeting and received a certificate and an amount of US$ 500. Dr. Ernest Baafi is the first recipient of this award.

Dr. Ernest Baafi receiving the award

Members of the award committee with Dr. Ernest Baafi

Previous awards received by the Institute

- Gold Award for Excellence in Research (2007)
- National Best Agriculture Researcher Award on eleven (11) occasions from the President of Ghana.
- Best Maize Breeding Team Award for West Africa (2008, 2009 and 2010).
- Premier Presidential Gold Award for Best Scientist in Ghana (2011)
- Woman of Excellence AWARD (2012)
- Best Maize Technology Development and Dissemination Team Award (2015)
- Scientific Excellence and Innovation Award (2016)

MANUAL SEEDER PATENT

(P. Osei-Bonsu, CSRI-Crops Research Institute; R. Owusu Bio, Kumasi Technical institute)

Small scale farmers in developing countries generally plant crops with hoes, cutlasses and even sticks. This planting method is difficult, time-consuming and expensive. Additionally, treated seeds are handled with bare hands; a situation which poses health risks to farmers. This traditional method also results in over seeding and also requires additional labour for thinning.

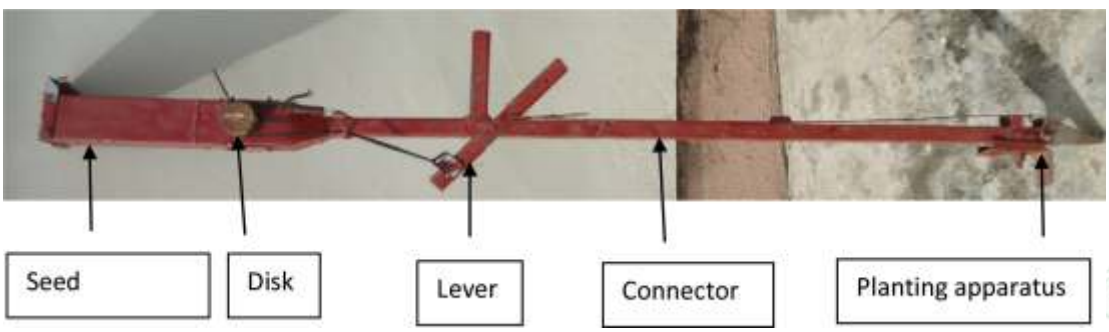
Crops can be planted with tractor-mounted seeders. However, these seeders are expensive and not suitable for the stumpy and uneven fields of most peasant farmers. Many planting devices have been developed for small scale farmers. Typical examples are devices that have wheels and are operated manually by pushing. These devices are often heavy and can therefore, not be carried to fields that are not accessible to vehicles. They are also not suitable for stumpy and uneven fields.

Jab planters are designed for use by small scale farmers. The most popular jab planter is the Brazilian type. Its main drawback is its complexity of use. On the other hand, the Chinese jab planter, while simple to use, is complex in construction, expensive, not durable and prone to malfunction.

The objective of this invention was to provide a planting device that is simple in construction, durable and affordable for small-scale farmers.

The jab planter comprises a seed container and a planting apparatus that are connected together by a pipe or connector as shown below. A seed disk is inside the base of the container.

The disk and planting apparatus are simultaneously operated by pressing and releasing a lever which is fixed below the container. The disk has depressions that collect seeds and drop them through the connector to the apparatus. Disks with different sizes of depressions are provided for planting different seed sizes. The entire planter is metallic, except the disk and a connecting rope.



Prototype of the jab planter

A draft patent application has been submitted to the Industrial Property office of the Registrar-General's Department of Ghana. The necessary amendments will be made upon receipt of a response.

RESEARCH PUBLICATIONS FOR 2017

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