COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
SAVANNA AGRICULTURAL RESEARCH INSTITUTE

ANNUAL REPORT 2014

Effective farming systems research approach for accessing and developing technologies for farmers

A Profile of CSIR-Savanna Agricultural Research Institute

The Savanna Agricultural Research Institute (SARI) is one of the 13 research institutes that make up the Council for Scientific and Industrial Research (CSIR) – a quasi-government organization that operates under the ambit of the Ministry of Environment, Science, Technology and Innovation. The Institute was originally known as the Nyankpala Agricultural Experiment Station (NAES). In June 1994, it was upgraded to a full-fledged Institute and re-named Savanna Agricultural Research Institute.

The Mandate of the institute is to **"provide farmers in the Northern, Upper East and Upper West Regions with appropriate technologies to increase their food and fiber crop production based on a sustainable production system which maintains and/or increases soil fertility"**. The crops covered in its research mandate include sorghum, millet, rice, maize, fonio, cowpea, groundnuts, soybean, bambara groundnuts, pigeon pea, yam, cassava, sweet and frafra potatoes, cotton and vegetables.

The Vision is to **"become a lead research and development (R&D) Institution by making agricultural research responsive to farmer needs and national development"**.

The Mission is to **"conduct agricultural research in Northern Ghana with the aim of developing and introducing improved technologies that will enhance overall farm level productivity for improved livelihoods"**.

The Savanna Agricultural Research Institute is located 16 km West of Tamale in the Northern Guinea Savanna Zone of Ghana. With one rainy season from April to October, it receives over 1000 mm of rainfall annually. The altitude is 200 m above sea level.

Core Values – What keeps us strong!
The Institute strives to uphold nine enduring core values: Discipline, Dedication, Reliability, Transparency, Teamwork, Hard work, Mutual respect, Professionalism and Selflessness. These values guide the decisions, actions and relationships as SARI works towards fulfilling its mission.

Our Strategy
The Institute's niche is an innovative response to the challenges presented by low productivity in the agriculture sector in Northern Ghana. Three strategic goals below guide the institute. These are:

- **Access to appropriate technologies**
- **Develop and adapt technologies and**
- **Deploy and commercialize technologies for impact**

These goals are anchored on a strong and effective institutional programming and a conducive environment.

ANNUAL REPORT 2014

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

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TABLE OF CONTENT

Contents

LIST OF TABLES

LIST OF FIGURES

FOREWORD

The year 2014 was one of immense activity to consolidate the transformational gains of CSIR-SARI for optimum productivity which marked productive 20 years of operation as a full-fledge institute with an effective farming systems research approach for accessing and developing technologies for farmers. It was a busy year that raised our resource mobilization endeavour to $2,381,324.64 from new and existing donor project support to access and develop technologies that are widely adaptable by farmers to ensure the scalability of the technologies for faster and wider implementation.

The dynamic nature of scientific research implies the need for the scientists to be abreast with new techniques/tools and modern trends in research and apply them in addressing the needs of farmers and other stakeholders thereby contributing to higher productivity and improvement in livelihoods. It is therefore pertinent that efforts are geared towards procuring the necessary tools, equipment and know-how and deploy the new technologies appropriately. This requires financial and material resources to establish the appropriate laboratories and equipment as well as trained human resources to operate. It also implies a new way of thinking and doing research for the benefit of society at large. I am glad to report that CSIR-SARI continued expanding its partnerships and collaborations so as to comprehensively and holistically address farmer constraints in northern Ghana.

In furtherance of the mandate to conduct agricultural research as it relates to food and fibre crop farming in the three regions of northern Ghana, CSIR-SARI made good progress during 2014 that we are happy to share with you. These achievements are captured under the major achievement in research programmes. Among the findings are the following:

The crop improvement programme has made strides in developing crop varieties that fit into the agroecologies of the mandate zone. Four promising drought and striga tolerant maize hybrids were identified and proposed to the National Variety Release and Registration Committee (NVRRC) for release and cultivation by farmers. They were formally release in April 2015 under the names Kunjor-wari, Suhudoo, Wari-kamana and Kpari-faako. These hybrids have the potential to increase significantly the level of maize production and income of maize producers. Additionally, five pearl millet genotypes were also identified and proposed to the NVRRC for release and cultivation by farmers in the Upper East region.

The integrated soil fertility management (ISFM) programme continues to develop innovative strategies to improve the organic matter content of the soils in the northern savannah zones to enhance land use on a permanent basis. Adoption of best-bet practices by farmers resulted in maize yield of **3 t/ha** on average. Research efforts on inoculation of soybean and cowpea with rhizobium also resulted in yield increase from **0.8 to 1.5 t/ha** and **0.45 to 1.2 t/ha** at farmer level, respectively. Farmers' participation in ISFM demonstration had significant influence on soybean, rice or maize yields. Farmers who participated in demonstrations had higher yields than those who did not participate in the Agricultural Value Chain Mentorship Project (AVCMP) demonstrations. Average yield increases as a result of farmer participation in AVCMP demonstrations were 50, 75 and 100% for maize, rice and soybean, respectively.

In pursuit of moving away from hazardous and expensive insecticides, plant-based products continue to be an integral part of our work on integrated pest management for key biotic constraints in the region.

We cannot conclude this message without mention of the Quality rice development project with the objective to boost domestic rice production. This project was aimed at improving farmers' access to quality rice seed and expanding knowledge on best-bet rice technologies. With funding from the AGRA, the project reached out to 6,488 farmers in 18 project action sites in the Upper East and Northern regions and increased paddy production. These farmers gained access to best-bet rice technologies through on-the-job training and through videos on rice technologies. Rural radio and TV broadcasts on these technologies were also used to reach other farmers not directly involved in the project.

I wish to commend the staff, management and board of CSIR-SARI for the good work that they continue to do. Bringing technologies on a royalty-free basis for use by farmers in northern Ghana and doing that through partnerships and collaborations with others is no mean feat. I believe that agricultural technology can and should make a difference to our farmers' lives. To achieve this, business as usual will not get these technologies into the hands of the farmers – there is a lot more that needs to be done, some differently.

Looking back, 2014 was a good year for CSIR-SARI and on behalf of the management board, I would like to express our gratitude to all partners, donors, staff and board members for their support and commitment to the fulfillment of the CSIR-SARI vision and mission. Our special appreciation goes to the Ministry of Food and Agriculture and numerous press houses that helped us disseminate our technologies to the farmers.

We hope that you will enjoy reading this report with as much pleasure as it gives us to present the CSIR-SARI Annual Report 2014 to you. Never hesitate to consult us for any of the technologies we have developed.

Dr. Stephen K. Nutsugah
Director

ADMINISTRATION

Management

The Institute is managed by a seven-member Management Board chaired by Mr. Alhassan Andani, MD of Stanbic Bank, and a fifteen-member Internal Management Committee (IMC), chaired by the Director. Membership of the Management Board and IMC are presented below:

Table 1 *Membership of CSIR – SARI Management Board*

No.	**Name**	**Designation**
1	Mr. Alhassan Andani	MD, Stanbic Bank, Chairman
2	Dr. (Mrs.) Rose Emma Mamaa Entsua-Mensah	Deputy Director-General, R&D
3	Dr. E. K. Adu	Cognate Director, CSIR-ARI
4	Dr. S. K. Nutsugah	Director, CSIR-SARI
5	Mrs. Gina Odartefio	Private Sector
6	Mr. William Boakye-Acheampong	MoFA
7	Mr. Mohammed Adam Nashiru	Peasant Farmers Association of Ghana

Table 2 *Membership of CSIR – SARI Internal Management Committee*

No.	**Name**	**Designation**
1	Dr. Stephen K. Nutsugah	Director (Chairman)
2	Dr. Mumuni Abudulai	Deputy Director
3	Dr. Wilson Dogbe	Head, NR Farming Systems Research Group
4	Dr. Roger A. L. Kanton	Head, UER Farming Systems Research Group
5	Dr. S.S.J. Buah	Head, UWR Farming Systems Research Group
6	Dr. Benjamin D. K. Ahiabor	Head, Scientific Support Group
7	Dr. N. N. Denwar	Representative, Research Staff Association
8	Mr. E. O. Krofa	Representative, Senior Staff Association
9	Mr. Mahama Tibow	Representative, Local Union
10	Mr. Thomas K. Coker-Awortwi	Head, Accounts Division
11	Mr. Eric Appiah	Head, CID
12	Mr. Robert K. Owusu	Snr. Scientific Secretary, Recorder
13	Mr. Augustine K. Owusu	Workshop Manager
14	Mr. Zakaria S. Seini	Farm Manager
15	Rev. G. Y. Nachim	Head, Administration Division, Recorder

*

Staff Strength

Staff strength as at the beginning of April 2014 stood at 454. However, by the end of the year the number had decreased to 429 comprising of 52 senior members, 115 senior staff and 262 junior staff members. Staff distribution and the list of senior members and staff are presented below. Staff strength was affected in the course of the year by promotions, appointments, retirements, resignations and deaths. See Table 3 for full details.

The out stations located in Manga and Wa had staff total of 49 and 44, respectively. Manga had 5 senior members, 10 senior staff and 34 junior staff while Wa had 6 senior members, 11 senior staff and 27 junior staff.

***Table 3**: Promotions, appointments and deaths*

	Chief Research	**Principal Research**	**Senior Research**	**Senior Members**	**Senior Staff**	**Junior Staff**	**Total**
Promotion				-	5	18	23
Appointment			-	4	1	-	5
Retirement		-	-	3	4	10	17
Death			-	-	1	3	4

***Table 4** Human Resource Development*

The Human Resource Development Committee has received approval for staff on local and foreign training for 2014/2015 academic year.

No.	**Name**	**Course**	**Completion**	***Institution**
1	Edwin Kwabla Akley	MSc/PhD	2018	Kansas State Univ. USA
2	Emmanuel Ayipio	MSc	2015	Univ. of Hanover, Germany
3	Michael Asante	MSc	2015	Univ. of Bonn, Germany
4	Adogoba Desmond Sunday	MSc	2015	Univ. for Dev. Studies, Navrongo Campus
5	Ali A. Ibrahim	Dip	2016	Univ. of Ghana, Legon
6	Helina Oboamah Asiedu	HND	2016	Tamale Polytechnic, Tamale
7	Mahama George Yakubu	PhD	2015	Kansas State Univ., USA
8	Tahiru Fulera	PhD	2016	Univ. of Bonn, Germany
9	Abdul-Salam M. Baba	MSc	2016	KNUST, Kumasi
10	Issah Sugri	PhD	2017	Univ. of Ghana, Legon
11	Mohammed Alima	MBA	2016	KNUST, Kumasi
12	Abdulai Baba Al-hassan	MSc	2017	Univ. for Dev. Studies, Wa Campus
13	Aliu Siise	PhD	2017	Univ. of Nottingham, Malaysia
14	Haruna Mohammed	PhD	2017	Tshwane Univ. of Tech., South Africa
15	Jerry Asalma Nboyine	PhD	2017	Lincoln Univ., New Zealand

16	Haruna Bashiru	MSc	2015	Ohio State Univ, USA
17	Afia Serwaa Kariakri	PhD	2016	Univ of Georgia, USA
18	Ibrahim Alhassan Zakaria	MSc	2015	Forte Valley State Univ, USA
19	Abubakari Muntari	PhD	2017	Univ. for Dev. Studies, Tamale
20	Iddrisu Yahaya	PhD	2015	Kansas State Univ., USA
21	A.N. Wiredu	PhD	2015	Univ. of Hohenheim, Germany
22	Tahiru Fulera	PhD	2018	Wageningen Univ., The Netherlands

Table 5: *Staff back from training*

No.	Name	Grade	Programme
1	Askia M. Mohammed	Research Scientist	PhD
2	Abukari Alidu Issah	Research Scientist	PhD
3	Richard Y. Agyare	Prin. Tech. Officer	MSc
4	Abdul Aziz A. Latif	Prin. Tech. Officer	MSc
5	Peter A. Asungre	Prin. Tech. Officer	MSc
6	Salim Lamini	Prin. Tech. Officer	M.Phil.
7	Emmanuel Vorleto	Prin. Tech. Officer	BSc
8	Sumaila Ayishetu	Snr. Tech. Assistant	Diploma
9	Kwabena Yaw James	Snr. Tech. Assistant	Diploma

Membership of Committees

Staff continued to serve on various committees listed below:

- Publication/Editorial
- Human Resource Development
- Expenditure Control
- Guest House
- Housing Allocation
- Land use and Water Conservation
- Internal Management
- Ground and Compound
- Promotion Screening
- Commercialization Oversight
- Welfare
- Health Fund
- Club House
- Seminar/Field Visit
- SARI Estate Management

National Service
Thirty four graduates from tertiary institutions in the country undertook their national service at the Institute. The details are presented in Table 6 below.

***Table 6**: National Service Personnel*

Institution	**No.**
KNUST	8
Ohawu Agric. College	1
University of Cape Coast	1
University for Development Studies	18
Tamale Polytechnic	4
Sunyani Polytechnic	1
Methodist University	1
Total	**34**

***Table 7**: Staff Distribution among Divisions*

Division	**Senior Members**	**Senior Staff**	**Junior Staff**	**Total**
Northern Region Farming Systems Research Group	10	18	24	52
Upper East Region Farming Systems Research Group	5	10	34	49
Upper West Region Farming Systems Research Group	6	11	27	44
Scientific Support Group	25	36	56	117
Commercialization and Information Division	2	3	1	12
• Documentation	1	2	1	
• Library		1	1	
Accounts	1	12	4	17
Administration Division • Personnel • Transport/Workshop • Farm Management • Estate • Security	2	22	114	138
Total	**52**	**115**	**262**	**429**

List of Senior Members and Senior Staff at various Divisions and Sections

***Table 8**: Administration, Accounts, Farm Management and Workshop*

Name	Qualification	Area of Specialization	Designation
Administration			
S. K. Nutsugah	BSc MSc PhD	Agriculture Plant Pathology Plant Pathology	Director
G. Y. Nachim	BA MPhil Post - Graduate Dip	Sociology and Study of Religions Sociology PGDTLHE	Administrative Officer
Bawah M. Saffiatu	BA	IDS	Principal Administrative Assistant
F. Amea	DBS	Secretariat Option	Senior Admin. Assistant
Ibrahim K. Osman	HND BSc Admin.	Sec & Mgt Human Res. Mgt.	Principal Administrative Assistant
Alidu Feruza	HND	Sec & Mgt.	Senior Administrative Assistant
Francisca Abaah	DBS BEd Admin.	Secretariat Option Secretarial Mgt.	Principal Administrative Assistant
Accounts			
T.K. Coker – Awortwi	BEd EMBA	Accounting Strategic Mgt.	Accountant
Paul Berko	BEd CA MBA	Accounting Accounting Accounting	Chief Accounting Assistant
Mohammed Alima	HND BA	Accounting IDS	Principal Accounting Assistant
Wumbei Mohammed	HND	Accounting	Accounting Assistant
Abdulai Baba Alhassan	BA	IDS	Principal Accounting Assistant
Bawah Ford	HND	Accounting	Chief Accounting Assistant
Issah Issifu	Diploma in Commerce	Accounting	Chief Accounting Assistant
Sebastian Tigbee	RSA III Dip. Com.	Accounting	Chief Accounting Assistant
Mahama A. Rufai	HND B Com	Accounting	Chief Accounting Assistant

Zulai Abihiba	DBS BSc	Accounting Accounting	Prin. Stores Superintendent
Kofi Konadu Asare	HND	Accounting	Principal Accounting Assistant
Alhassan Abukari	HND	Accounting	Principal Stores Superintendent
Yakubu Mohammed	HND	Accounting	Accounting Assistant
Francis Alemawor	Diploma	Commerce	Accounting Assistant
Farm Management			
Zakaria S. Seini	HND	Agric. Engineering	Chief Technical Officer
Emmanuel Odoom	BSc	Animal Science	Senior Tech. Officer
Workshop			
Augustine K. Owusu	MVT	Part I &II	Works Superintendent
B.D. Boamah	Basic Refrigeration &Air Conditioning	NVTI Gd. I	Senior Works Superintendent
J.Y. Wasaal	Junior Tech. Sup. Mgt.	Workshop	Works Superintendent
G. Akotia	Trade Test Gd I	Welding	Works Superintendent
G. Abdulai Zulkania	BSc	Agric. Engineering	Senior Works Superintendent
Estate			
Beatrice Osei A.	BA	IDS, Planning	Principal Estate Asst.
Emmanuel Tetteh	NVTI Gd I	Plumbing	Works Superintendent
P.A. Anaaba	NVTI National Craft Man	Carpentry & Joinery	Works Superintendent
M. Jabiru	HND	Building Technology	Works Superintendent

Table 9*: Upper East Region Farming Systems Research Group*

Name	**Qualification**	**Area of Specialization**	**Rank**
R.A.L. Kanton	MSc PhD	Agronomy	Principal Research Scientist
E.Y. Ansoba	BSc	Agriculture	Prin. Tech. Officer
Francis Kusi	MSc	Entomology	Research Scientist
Julius Yirzagla	MSc	Agronomy	Research Scientist
Issah Sugri	MPhil	Post harvest	Research Scientist
J.K. Bidzakin	BSc MSc	Agric Economics Agric Economics	Research Scientist
N.K. Abass	HND	Accounting	Chief Accounting Assistant

Peter A. Asungre	BSc MSc	Agric Agronomy	Prin. Tech. Officer
Zakaria Mukhtaru	BSc. Agric	Agriculture	Prin. Tech. Officer
Abdulai Abubakari	HND	Sec & Mgt.	Prin. Admin. Assist.
Salim Lamini	BSc MPhil	Agric Technology Plant Pathology	Prin. Tech. Officer
Albert Alem	Dip.	Agriculture	Senior Technical Officer
J. N. Azure	Certificate	Agric. College	Assistant Farm Manager
Musah Alhassan	Certificate	Agric. College	Assistant Farm Manager

***Table 10**: Northern Region Farming Systems Research Group*

Name	Qualification	Area of specialization	Designation
Wilson Dogbe	MSc PhD	Agronomy Soil Microbiology	Senior Research Scientist
J.M. Kombiok	BSc MSc PhD	Agriculture Agronomy Agronomy	Principal Research Scientist
Mumuni Abudulai	BSc MSc PhD	Agricultural Agriculture Entomology Agriculture Entomology	Principal Research Scientist
Baba Inusah	MSc	Irrigation Agronomy	Research Scientist
A. Nimo Wiredu	BSc MSc	Agriculture Agricultural Economics	Research Scientist
Afia S. Karikari	MSc	Entomology	Research Scientist
Michael Mawunya	BSc MPhil	Agriculture Weed Science	Research Scientist
D.Y. Opare-Atakora	BSc MSc	Agriculture Crop Science	Assistant Research Scientist
Aliyu Siise	BSc MSc	Agric. Biotechnology	Principal Technical Officer
Jerry Asalma Nboyine	MSc	Entomology	Research Scientist
S. Oppong Abebresseh	MSc	Crop Breeding	Research Scientist
Sulemana D. Alhassan	BSc	Agriculture Technology	Chief Technical Officer
Rakiatu Abdulai	HND	Statistics	Chief Technical Officer

Haruna Abdulai	BSc	Agriculture	Principal Technical Officer
Haruna I. Misbaw	Certificate	Agriculture	Senior Technical Officer
E. Ofosu Krofa	BSc	Agriculture Tech.	Chief Technical Officer
Mahama Alidu	Dip	Horticulture	Chief Technical Officer
Iddrisu Sumani	Dip	General Agriculture	Chief Technical Officer
Sayibu Zanyeya	Cert. in Agric.	General Agriculture	Assist. Farm Mgr.
Haruna Bashiru	BSc	Agric. Economics	Principal Technical Officer
Price M. Etwire	BSc Mphil	Agric. Technology Agric. Economics	Principal Technical Officer
Edward Martey	MPhil	Agric. Economics	Research Scientist
Elsie Sarkodee-Addo	BSc MSc	Agriculture Agronomy	Principal Technical Officer
Alhassan Sayibu	BSc	Agriculture	Principal Technical Officer
Jalilatu Ayuba	BSc MSc	Agric. Technology Agronomy	Principal Technical Officer
Abdul-Rahaman A. B. Iddrisu	BSc	Agric. Technology	Principal Technical Officer
Abdul-Salam M. Baba	BSc	Agric. Technology	Principal Technical Officer
Freda Ansah A.	BSc	Agric. Technology	Principal Technical Officer
Daniel E. Halolo	BSc	Agric. Technology	Principal Technical Officer
Douglas B. Alhassan	Dip	General Agric	Chief Technical Officer
Desmond A. Sunday	BSc	Bio - Mathematics	Principal Technical Officer
Alhassan Nuhu Jimbaani	BSc	Agric. Tech	Principal Technical Officer

Table 11: *Upper West Region Farming System Research Group*

Name	Qualification	Area of Specialization	Rank
J.B. Naab	BSc PhD	Soil Science Soil Physics	Senior Research Scientist
S. S. J. Buah	BSc MSc PhD	Agriculture Agronomy Soil Fertility & Plant Nutrition	Senior Research Scientist
S.S. Seini	BSc MPhil	Agricultural Agricultural Entomology	Research Scientist
George Mahama Yakubu	BSc MSc	Agriculture Agronomy	Assist. Research Scientist
Asieku Yahaya	BEd MSc	Agricultural Science	Assist. Research Scientist
Yahaya Iddrisu	MPhil	Agric Economics	Research Scientist
Nyour Anslem Bawayele-Azaa	BSc	Agricultural Tech.	Principal Technical Officer
Asiata A. Ali	B. Management Stud.	Management	Prin. Admin. Assist.
Haruna K. Ali	Dip	General Agric	Prin. Technical Officer
Godwin Opoku	BSc	Laboratory Technology	Chief Technical Officer
Ibrahim Hashim	HND BSc	Statistics Statistics	Principal Technical Officer
Ibrahim A. Ali	Diploma	General Agric	Senior Technical Officer
Vincent K. Dordah	HND	Agric Engineering	Chief Technical Officer
A.K. Alhassan	BSc Accounting & Finance	Accounting	Chief Accounting Assistant

Table 12: Scientific Support Group

Name	Qualification	Area of specialization	Designation
Stephen K. Asante	BSc MSc PhD	Agriculture Plant Protection Agricultural Entomology	Principal Research Scientist
I.D.K. Atokple	BSc Dip. In Ed. MSc PhD	Agriculture Education Plant Breeding Plant Breeding	Senior Research Scientist
Mashark S. Abdulai	BSc MSc PhD	Agriculture Plant Breeding Plant Breeding	Senior Research Scientist
Mathias Fosu	BSc Dip. In Ed. MSc PhD	Agriculture Education Soil Chemistry Soil Chemistry	Principal Research Scientist
Nicholas N. Denwar	BSc MPhil PhD	Agriculture Plant Breeding	Research Scientist
Benjamin D.K. Ahiabor	BSc MSc PhD	Agriculture Plant Physiologist Microbiology	Senior Research Scientist
Joseph Adjebeng-Danquah	BSc MSc	Agriculture Plant Breeding	Research Scientist
Fulera Tahiru (Miss)	BSc MSc	Agriculture Agric	Asst. Research Scientist
N.A. Issahaku	HND	Agricultural Engineering	Chief Technical Officer
Haruna Mohammed	BSc MSc	Agriculture Agronomy	Research Scientist
Alhassan L. Abdulai	BSc MSc	Agriculture Agro meteorology	Research Scientist
A.S. Alhassan	Dip.	General Agriculture	Principal Technical Officer
Abdulai A. Mohammed	Certificate	General Agriculture	Senior Technical Officer
Askia M. Mohammed	BSc MPhil PhD	Chemistry Soil Science Soil Science	Research Scientist
Kwabena Acheremu	BSc MSc	Agriculture Crop Breeding	Research Scientist

Richard Oteng-Frimpong	MPhil	Crop Science	Research Scientist
Abukari A. Issah	BSc. MSc PhD	Agriculture Agronomy Agronomy	Research Scientist
Abukari Saibu	BSc	Agriculture Tech.	Chief Technical Officer
Abubakari Mutari	BSc MSc	Agriculture Food Safety and Quality Mgt.	Research Scientist
Williams K. Atakora	BSc MSc	Agriculture Soil Science	Research Scientist
Issah A. Rashid	BSc	Agric Tech	Principal Technical Officer
Haruna Alidu	MSc	Plant Breeding	Research Scientist
Emmanuel Vorleto	HND BSc	Lab. Technology	Principal Technical Officer
Edwin K. Akley	BSc	Agric. Technology	Principal Technical Officer
Prosper Amenuvor	HND	Lab. Technology	Technical Officer
Michael Asante	BSc	Agric. Technology	Principal Technical Officer
Ibrahim Sumaila	Certificate	Agric. College	Technical Officer
Fuseini S. Issifu	Agric College	Agric	Asst. Farm Manager
Gloria Boakyewaa Adu	BSc MSc	Agriculture Plant Breeding	Research Scientist
Richard Agyare	BSc MSc	Agriculture Plant Breeding	Principal Technical Officer
Emmanuel Y. Owusu	BSc	Agric. Technology	Principal Technical Officer
Godfred D. F. Atawura	BSc	Agric. Technology	Principal Technical Officer
Wohor O. Zakaria	BSc	Agric. Technology	Principal Technical Officer
Kangben F. Yambout	BSc	Agric. Technology	Principal Technical Officer
Emmanuel Ayipio	BSc	Agric. Technology	Principal Technical Officer
Alhassan I. Zakaria	BSc Tech	Agric. Technology	Principal Technical Officer
David Barton	BA	IDS	Principal Technical Officer
Abdul-Aziz Abdul-Latif	BSc	Agric. Technology	Principal Technical

	MSc	Soil Science	Officer
Alhassan Sayibu	BSc	Agriculture	Principal Technical Officer
Issah I. Ramat	Certificate	General Agric	Chief Technical Officer
Isaac K. Nantari	GCE 'O' LEVEL	Agric Science	Principal Technical Officer
Flora Amagloh	MSc	Food Science & Tech.	Research Scientist
Francisca Addae-Frimpomaah	MPhil	Nuclear Agriculture	Research Scientist
Gloria A Adezebra	MPhil	Nuclear Agriculture	Research Scientist
Ramson Adombilla	MSc	Soil & Water Mgt	Research Scientist
Kenneth Opare-Obuobi	MPhil	Crop Science	Research Scientist
Emmanuel Adjei	MPhil	Crop Science	Research Scientist
Emmanuel B. Chamba	PhD	Plant Breeding	Research Scientist

Table 13: *Business Development and Information Unit*

Name	Qualification	Area of Specialization	Rank
E. Appiah	BA MSc	Political Science Marketing	Marketing Officer
M. Abdul-Razak	BA MBA MPhil	Political Science Strategic Mgt. Agri-Business	Marketing Officer
R. K. Owusu	BSc MSc	Agricultural Post-Harvest and Food Preservation Engineering	Senior Scientific Secretary
Mumuni Abubakari	HND	Marketing	Senior Marketing Assistant
Ms. Warihanatu Baako	HND BSc	Marketing Marketing	Principal Marketing Assistant
Wilhelm N Kutah	BSc	Agric Technology	Principal Technical Officer
Yamyolya B. Alhassan	HND BSc	Marketing Marketing	Principal Marketing Assistant
Issah Issifu	Dip	Library	Senior Library Assistant
Musah Iddi	Full Tech. Certificate BSc	Radio, Television and Electronics ICT	Chief Works Superintendent

COMMERCIALISATION

Introduction

With the CSIR Act (CSIR Act 521, 1996) as a road map, CSIR-SARI during the year under review generated income from various activities. Being an agricultural-based research institution, most of the revenues emanated from agricultural related activities.

The main sources of revenue of the Institute are as follows:

- Guest House
- Soil & Plant Analysis laboratory
- Tractor & Combine services
- Breeder & Foundation Seed
- Conference Hall
- Hire of Vehicle
- Gbewaa Rice

Table 14: *Commercialization Income and Expenditure - 2014*

Item	**Gross Income (Gh¢)**	**Expenses (Gh¢)**	**Net Income (Gh¢)**
Guest House	13,591.50	5,595.00	7,996.50
Soil & Plant Analysis	22,581.00	22,999.09	-418.09
Tractor Services	15,652.00	6,223.00	9,429.00
Rice Processing Centre	38,975.50	31,824.80	7,150.70
Combine Harvester	27,658.75	14,944.50	12,714.25
Seed	24,224.00	15,684.86	8,539.14
Conference Hall	47,201.00	3,500.00	43,701.00
Hire of Vehicle	14,319.00	0	14,319.00
Gbewaa Rice	7,105.00	0	7,105.00
Rent	103,474.88	0	103,474.88
Project Support	178,231.04	0	178,231.04
Total	**493,013.67**	**100,771.25**	**392,242.42**

The highest income generating centre was Project support which generated a total net income of GH₵ 178,231.04. The lowest income earner was the Soil and Plant analysis laboratory which earned a total net income of GH₵ -418.09. This low performance by the Soil and Plant laboratory can be attributed to a GH₵ 22,999.09 expenditure on consumables and other investments under taken at the laboratory.

Technologies Identified For Commercialisation weak

- Improved Crop Varieties
- Crop and Soil Management Practices
- Soil Fertility Management
- Insect Pest Control
- Soil and Plant Analysis
- Agro-meteorological data

DOCUMETATION AND LIBRARY

Robert Kwasi Owusu, Wilhelm Nomu Kutah, Issah Issifu and Ibrahim Sumaya

Introduction

The function of the Documentation Centre is to collate and edit all reports prior to submission to Head Office, deal with correspondences in relation to research reports, coordinate exhibitions, seminars and field visits within and outside the institute.

Preparation and submission of Reports

The institute received the printed copies of the 2011 Annual Report that was sent for print production. A number of copies were distributed to Scientists while the Library sent some to outsiders on our mailing list. Within the reporting period both the 2012 and 2013 Annual Reports were completed and sent for print production. The first and third quarterly reports were also collated and submitted to Head Office.

Coordination of Exhibitions and trainings

The Documentation Centre also coordinated the following exhibitions:

- Launch of National Climate Change Policy and National Environment Policy, Accra International Conference Centre, 22nd July.
- Third Northern Ghana Investment Conference 2014, Tamale Sport Stadium Conference Centre, 13th to 16th August.
- Agribusiness Entrepreneurship Fair organised by WAAPP at the Kofi Annan Centre of Excellence and ICT, Accra, 19th to 21st August.
- 30th Regional Farmers Day at Tamale Jubilee Park, 5th December.
- TEEAL/AGORA training of trainers workshop at CSIR-SARI Seminar Room, 18 – 20 November.

Experimental Field Visit

The weekly experimental field visit came on between 9th September and 14th October. Attendance was very encouraging as Scientists and Technical Officers attended in their numbers.

LIBRARY AND INFORMATION

The Institute's library was established in 1980. Its main objective is to develop a strong information service to support the institute's research programmes and to meet the needs of the scientific community. The Library's collections are mainly on Agriculture with special collections on Farming Systems Research. The book collections currently exceed 5900 volumes. The Library gets donations from over 40 journals and subscribes to two daily and one weekly newspapers. The library also stocks theses, seminar and conference papers, as well as journals of Scientists, which are stocked in their various box files (except theses which are shelved).

Electronic Resources
With the acquisition of TEEAL (The Essential Electronic Agricultural Library) pack from ITOCA, the Training of Trainers workshop that followed and successful installation through Local Area Wireless Network system, Scientists can now access full-text Journals at their offices. The ICT Officers have helped a number of Scientists to connect directly.
Besides the TEEAL, the library also offers literature search from the following sources:

- AGORA (Access to **Online** Research in Agriculture): username and password are available at the library
- OARE (Online Access to Research in Environment)
- HINARI (Health InterNetwork Access to Research Initiative): username and password available
- ScienceDirect. Username and password available
- CD-ROMS (FAO, INASP, AGROMISA & CTA, CAB Int. Compedium, etc.)
- TEEAL

Within the reporting period the Library received and catalogued a number of books from sister CSIR institutes and other organisations that have our name on their mailing lists. The Library also received seven Theses from staff who have completed various courses. The Library also embarked on the registration of researchers' technical report, conference papers, etc. for promotion purpose.

Book Donation
During the year under review the Library received over 100 volumes of books and journals, 59 magazines and Newsletters and 13 Reports all through donations.

PUBLICATION

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MAJOR ACHIEVEMENT IN RESEARCH

SCIENTIFIC SUPPORT GROUP

The Scientific Support Group (SSG) is made up of Agronomists, Soil Scientists, Agrometeorologist, Entomologists, Plant Breeders and Plant Pathologist whose objectives include conducting on-station investigations to find solutions to problems encountered on farmers' fields. Such problems, under normal circumstances, do not lend themselves easily amenable at the farmers' level. Members of the group when necessary work in collaboration with the Farming Systems Research Groups on-farm to monitor and evaluate new technologies being assessed on the farmers' fields. Presented below are reports on activities carried out in 2014.

AGROMETOEROLOGY

Monitoring of weather elements at CSIR-SARI stations

Principal Investigator: Alhassan Lansah Abdulai
Collaborating Scientists: R.A.L. Kanton, S.S. Buah, W. Dogbe
Estimated Duration: Long Term
Sponsors: Government of Ghana
Location: Nyankpala, Manga and Wa

Background Information and Justification
The production and productivity of agriculture in the Savannah zone of Ghana is highly dependent on the patterns of weather elements prevalent for any given year. This is because crop growth and development is affected by weather elements. Rainfed agriculture is the mainstay of the Savannah zone where CSIR-Savanna Agricultural Research Institute (CSIR-SARI) has the mandate for producing agricultural technologies for enhanced productivity. Climate variability influences the production systems of this area. Successful development and deployment of agricultural technologies (crop varieties and appropriate agronomic practices) is prerequisite for optimizing agricultural production. This requires accurate information on weather elements. The Agro-meteorology unit monitors the patterns of weather elements within the mandate area and maintains the data base. The unit also reports the outlook on weather elements as well as communicates the implications of such observed patterns in weather elements for agricultural production.

Accurate and timely information on the key weather elements is not only a crucial output for the Agro-meteorology unit but also required for effective delivery on the mandate.

Objectives

1. To produce reference point climatic information for the research stations of CSIR-SARI
2. To analyze and present data and agro-meteorological information in appropriate format, and ensure accessibility of such for use by researchers and other stakeholders for making agricultural decisions
3. To provide weather information for developing technologies that can enhance the resilience of rural households to climate change and variability

Expected Beneficiaries

Research Institutes, MOFA, NGOs and farmers and other clientele of research output.

Materials and Methods

Manual and automated weather stations were used for data collection. Parameters monitored were rainfall, pan evaporation, temperature, solar radiation, relative humidity, wind speed, wind direction, wind gust and sunshine hours.

Results/Major Findings

The humid period of 2014 started in June and lasted till the end of October and August was the most humid month (Figure 1a).

Rainfall was below normal and lower than that of 2013. Unlike 2013, there was no terminal drought in 2014 because of the quantum of rain in October (Figure 1b). Monthly anomalies for minimum temperature ranged from -1.3 to 3.8ºC with 9 months having higher than normal and 3 months having lower than normal minimum temperature. August was the only month with lower than normal minimum temperature during the growing season of 2014 (Figure 1c). Monthly anomalies for maximum temperature ranged from -1.1 to 2.7ºC. Below normal maximum temperatures were observed in April and October, therefore monthly mean maximum temperatures were above normal throughout the crop growth period (Figure 1d). Above normal rainfall was received in three months only, but there was no terminal drought because rainfall in October was 74.2 mm above normal (Figure 1e) and 33.4 mm higher than that for 2013 (Figure 1f). The critical role of October rains for success of crop production in Nyankpala and its catchment was demonstrated by the rainfall pattern in 2014.

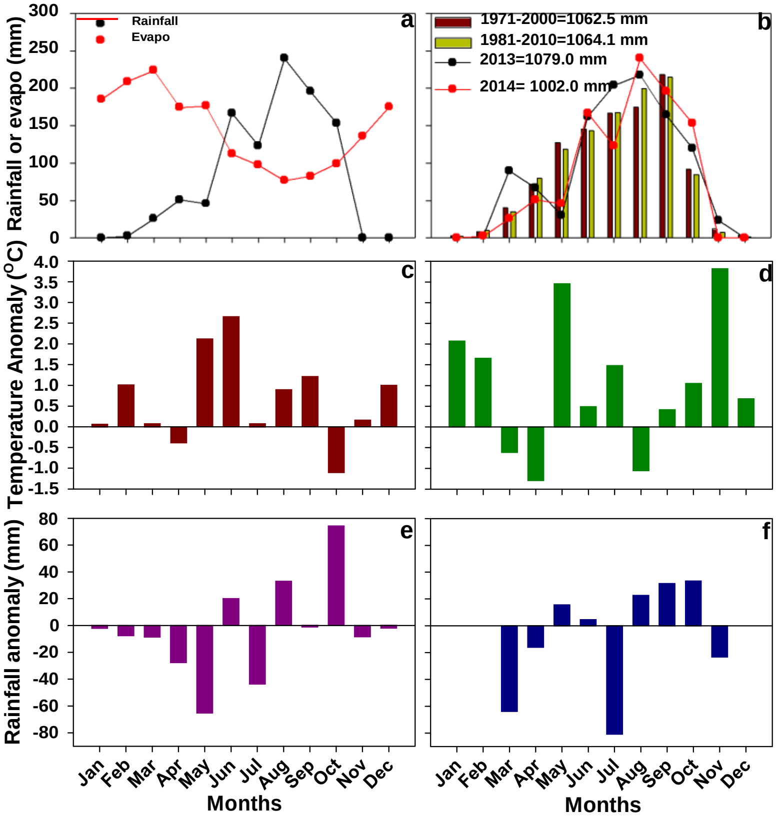

Figure 1: Monthly patterns of rainfall and evaporation (a) longterm and current rainfall, (b) anomalies for maximum temperature, (c) minimum temperature, (d) anomalies of rainfall against long term mean, (e) against previous year and (f) Nyankpala in 2014.

Dekadal anomalies for minimum temperature ranged from -1.3 to 3.6°C; was above normal for 32 of the 36 annual dekads; was normal for 1 dekad only; and was lower than normal for the 7th, 24th and 36th dekads (Figure 2a). Dekadal anomalies for maximum temperature ranged from -1.0 to 3.2ºC; was below normal in 8 dekads; and was above normal in 28 dekads (Figure 2b). Dekadal rainfall anomalies for 2014 were between -44 and 100 mm; 7 dekads were above normal; 3 dekads were normal; and 26 dekads were below normal (Figure 2c). The positive anomalies observed for the 28^{th} and 30^{th} dekads reduced the risk of terminal drought in 2014. Compared to the previous year, 10 of the dekads were same as the previous year, 16 dekads were below the previous year, while 10 dekads were above that of the previous year (Figure 2d).

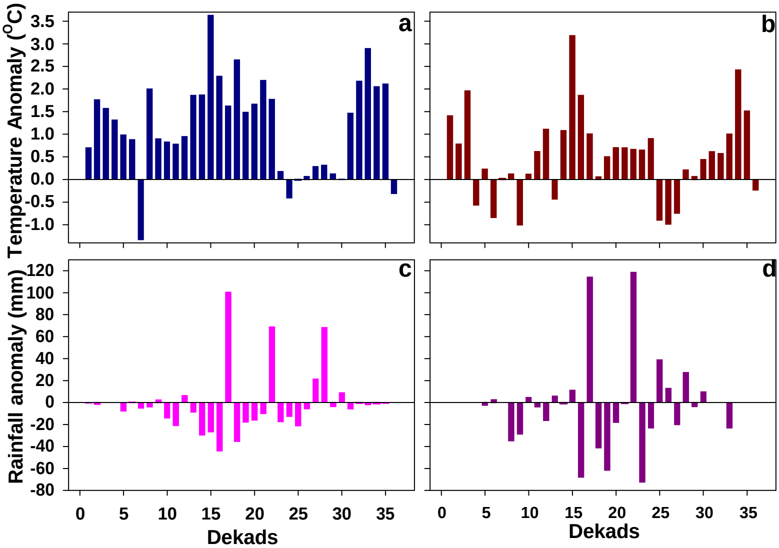

Figure 2: Decadal patterns of anomalies for minimum temperature (a) and maximum temperature (b), anomalies of rainfall against long term mean (c) and against previous year (d) for Nyankpala in 2014.

Conclusions/Recommendations

The rains were well distributed for the year under consideration while the thermal environment could best be described as favorable. The combination of these elements created a year with great potential for crop production as well as enormous challenges in the form of diseases and insect pests pressure. It is recommended that varieties or cultivars be selected in such a way as to avoid the critical phases in terms of moisture requirements coinciding with the second and third dekads of October.

Enhancing the Resilience and Adaptive Capacity to Climate Change through integrated land, water and nutrient management in semi-arid West Africa (ENRACCA-WA)

Principal Investigator: Alhassan Lansah Abdulai
Collaborating Scientists: S.S.J. Buah and J.K. Bidzakin
Estimated Duration: 2 years
Sponsors: CORAF/WECARD
Location: Demonaayili, Kpalsogu and Silbelle

Background Information and Justification
Climate change is confronting smallholders with multiple challenges and uncertainties since most rural households rely on rain-fed production for their livelihood and have weak buffering mechanisms to protect them from negative impacts of climate shocks. Even though farmers already use a broad variety of mechanisms to cope with variable weather conditions and adapt to climate change, strategies that will enhance resilience and ability to cope with risks are still needed.

The project aims to contribute to improving food security by increasing agricultural productivity through the use of appropriate SLWNM practices to enhance capacity of smallholder farmers to manage climate risks and reduce their vulnerability to climate change and its impacts.

Objectives
To strengthen the resilience and adaptive capacity of participating communities and institutions to cope and adapt to climate change and variability through up-scaling of integrated land, water and nutrient management strategies and creation of enabling environment.

Expected Beneficiaries
The primary beneficiaries of the project were rural community groups exposed to the socio-economic and environmental impacts of land degradation. Secondary beneficiaries include the frontline staff of MOFA and field staff of NGOs who trained as trainers on climate change and its response options. An estimated 2000 households potentially benefited from improved management of land and water resources, resulting in enhanced land productivity and income generation. Among these, special efforts were devoted to ensuring that the project benefits at least 25-30% of households headed by women. All community members likely benefited from the successful implementation of the project, as they used the results to better improve any agricultural-related decisions in order to reduce their vulnerability to climate change and consequently to improve agricultural outputs.

Materials and Methods
Routine monthly innovation platform meetings were held at the sites to discuss pertinent issues related to the project. Demonstration of SLWNM options on maize at Kpalsawgu, Gbullahigu and Dimabi in the Tolon district and Silbelle in the Sissala West district as well as on yam at Demonaayili in the Nanumba North district. Field days (one each at vegetative and maturation

phases) were organized on the demonstration plots to show case the performance of the selected SLWNM options at each of the sites. Harvesting and yield assessment at each of the sites as well as shelf life studies for the yam treated to the selected SLWNM options at Demonaayili.

Results/Major Findings

Community members were well versed with good agricultural practices for maize and yam due to the discussions during the innovation platform meetings. Maize plots treated to organic matter suffered less drought stress than plots without organic matter, but plots with recommended rate of inorganic fertilizers performed best under optimum moisture conditions. The use of organic matter (5 t/ha) was shown to widen the planting window for yam and gave better yields than the other treatments. Shelf life of yam did not differ with the different treatments, allaying the fears of farmers about the deleterious effects of fertilizer material on the shelf life of yam.

Conclusions/Recommendations

The discussions on good agronomic practices improved the capacity of the participating community members to carry out agronomic practices at the most appropriate times. Farmers at the Sisaala West and Tolon districts appreciated the effects of organic matter on moisture holding capacity of soils and the ability of crops plots treated with organic matter to cope with drought stress. Farmers at Nanumba North district were convinced of the benefits associated with the use of fertilizer materials on Yam and pledged to replicate that on their farms.

MAIZE IMPROVEMENT

Multi-Location Testing of Drought Tolerant Varieties and Hybrids in Regional Trial

Principal Investigator: Alidu Haruna
Collaborating Scientists: M.S. Abdulai, S.S.J. Buah, R.A.L. Kanton and Gloria Boakyewaa Adu
Estimated Duration: Four Years
Sponsors: International Institute of Tropical Agriculture (IITA)
Location: Damongo, Manga, Nyankpala, Yendi and Wa

Background Information and Justification

In Ghana, maize is the largest staple crop and the most widely cultivated due to its high potential grain yield, wide adaptability and relative ease of cultivation. It has the greatest potential of combating food security challenges posed by population increase in the country.

The Guinea and Sudan savannas of Ghana have the highest potential for increased maize production and productivity due to its high solar radiation, low night temperatures and low incidence of diseases. Regrettably production is seriously constrained by natural low soil fertility (low levels of nitrogen), low investment in nitrogenous fertilizers, recurrent drought and *Striga hermonthica* parasitism. These stresses have an overwhelming constraint to maize production, affecting the livelihood of millions of people, food security and economic development.

Drought is a major constraint to maize production for the rural poor in the Guinea and Sudan savannas of Ghana. It can be considered second only to poor soil fertility in reducing yield leading to very high grain yield losses if the drought stress occurs at the most drought-sensitive stages of the crop growth, such as the flowering and grain filling stages. The development of maize varieties targeted to these areas must therefore be tolerant to drought. Such varieties will constitute an important, practical and reliable approach to increasing maize yield and productivity in the area thereby enhancing people’s livelihoods, food security and economic development in the region. The Multi-location testing of drought tolerant and striga resistant/tolerant varieties and hybrids in regional trials through the Drought Tolerant Maize for Africa (DTMA) Project seeks to identify such elite germplasm with high yield potential and tolerance to drought stress. Evaluating varieties across several locations for a few years makes it possible to identify and release such tolerant genotypes to famers within a short period of time.

Objectives:

To provide the National Maize Programme a wide range of germplasm from which to identify and select superior, stable yielding, drought tolerant maize genotypes for release to farmers for cultivation or for population improvement.

Expected Beneficiaries: Scientists, Farmers, Seed Companies, Traders, Industrialists and all stakeholders in the maize value chain.

Materials and Methods

The genetic materials used in this project comprised of extra-early, early and intermediate/late maturing hybrids (single crosses, three way crosses and top crosses) and open-pollinated maize varieties, and were obtained from IITA, Ibadan and local sources. They were developed for grain yield and adaptation to drought and Striga stress factors.

The experimental design used was RCBDor lattice design with three replications across locations. The materials were arranged in variety and hybrid trials and planted in Nyankpala, Yendi and Damongo in the Guinea savanna zone, and Wa and Manga in the Sudan savanna zone of Ghana. Trials were established in the main cropping seasons of these zones. Each plot consisted of two rows of each entry. The rows were 5.0 m long and were spaced 0.75 m apart. Three seeds were sown per hill at an intra-row spacing of 50 cm or 40 cm and the seedlings thinned to two plants per hill at 3 weeks after planting (WAP) to obtain the target population of 53,333 and 66,666 plants per hectare, respectively. Weeds were controlled both chemically (by the use of pre- and post-emergence herbicides) and manually by the use of the hoe. NPK fertilizer was applied at the rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer two weeks after planting and top-dressed with additional N at 30 kg N ha^{-1} four weeks after planting.

Data are collected from the two rows of each plot on plant stand (PLST), plant height (PHT), days to 50% pollen shed (DTA) and silking (DTA), grain yield (GYLD), root lodging (RL) , stalk lodging (SL), husk cover (HUSK), plants harvested (PHARV), ears harvested (EHARV) and grain moisture (Moist) at the time of harvesting. The data were analysed using Statistical System Analyses (SAS, 1996) after conversions of grain yield in kilograms per plot to grain yield in tonnes per hectare (GYLD) at 15% grain moisture. The data were analysed by location and were combined across locations, assuming the random effects model. Genotypes and locations were all considered as random factors in the analysis. The generalized linear model (GLM) procedure (SAS, 1996) was used to test heterogeneity of variances among the genotypes and locations.

Results/Major Findings

Based on their mean grain yield performance at specific locations or across locations and other agronomic traits, the following genotypes were identified under the different maturity groups and selected for either on-farm testing or for further evaluation.

- Extra-early maturing genotypes: - EEWH-48, EEWH-13, EEWH-42, EEWH-17, EEWH-19, EEWH-31, EEYH-32, EEYH-39, EEYH-36, EEYH-18, EEYH-21, EEYH-16 and EEYH-17
- Early maturing genotypes: - EWH-37, EWH-32, EWH-30, 06C4102, SC535, SC529, EWH-8, EWH-40, EYH-29, EYH-5, EYH-15, EYH-16, EYH-47, EYH-17, 2011 TZE-W DT STR synthetic, DTE STR-Y SYN POP C3 and 2011 DTE STR-Y Syn
- Intermediate/late maturing genotypes: - M1425-24, M1425-14 and M1425-5

- Top-cross DT and DTSTR Hybrids Trial:- M1426-14, M1426-24, M1426-5, M1426-17, M1426-10, M1426-2 and M1426-3

Four promising drought and striga tolerant top-cross hybrids, TZE-W Pop STR C5 x TZEI 7, TZE-Y Pop DT STR C4 x TZEI 17, M1126-2 and M0926-8, identified under this project in 2012 were proposed to the National Variety Release and Registration Committee (NVRRC) for release for cultivation by farmers in Ghana. They passed the release requirements of the committee and were formally released in April 2015 as TZE – Y Pop DT STR C4 x TZEI 17: **CSIR- Kunjor-wari**; TZE – W Pop DT STR C4 x TZE I 7: **CSIR- Suhudoo**; M1126-2: **CSIR- Wari-kamana** and M0926-8: **CSIR- Kpari-faako.**

Conclusions/Recommendations

Results of combined analyses across locations allowed identification of high yielding varieties and hybrids with stable performance across locations from each regional trial. These varieties and hybrids are suitable candidates for further testing in national performance and on-farm trials to confirm consistency and performance for release. The results have also identified high yielding varieties and hybrids with specific adaptation to particular locations in the three regions of Northern Ghana that can be further tested to confirm their performance. The results would also aid selection of promising parents with stable performance for breeding and provide useful information to select few representative test locations for conducting future regional trials.

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West Africa Seed Program (Breeder Seed Production of Maize, Rice and Sorghum)

Principal Investigator: Alidu Haruna
Collaborating Scientists: I. D. K. Atokple, Wilson Dogbe, M.S. Abdulai and Gloria Boakyewaa Adu
Estimated Duration: Three Years
Sponsors: CORAF/WECARD
Location: Nyankpala, Sakpe and Damongo

Background Information and Justification

Improved seeds are first and foremost, the source of most food and as such are the most crucial components of agriculture. Apart from being a key issue in addressing agricultural development and food security, it is also a commodity that can promote economic development and entrepreneurship. With the passage and promulgation of a new seed law in Ghana, private sector participation in the production of foundation seed has been liberalized. The private sector has taken advantage of this and many private seed companies are springing up. This therefore calls for the up-scaling of breeders' seed production to meet the demands of seed companies and farmers for foundation and certified seeds production in Ghana and beyond. In this regard, CORAF/WECARD under the West Africa Seed Program (WASP) supported CSIR-SARI to produce breeder seeds of maize, sorghum and rice.

Objectives
To multiply and produce breeders' and pre-basic seeds of open-pollinated varieties and parental lines of released hybrids for foundation and certified seeds production

Expected Beneficiaries: - Scientists, Seed Companies, Seed growers and Farmers.

Materials and Methods
Breeder seed fields of maize were established at Damongo, Nyankpala and Sakpe. The isolated half-sib ear-to-row crossing block procedure for maintaining and producing breeder's seed of an open-pollinated variety was used. Plant spacing was 0.75m between rows and 0.45m within rows. An isolation distance of 450 m was ensured to maintain genetic purity. Seed from individually shelled 100-200 F_2 ears, saved as progenitors of the breeder's seed was planted as individual female rows (ear-rows) in a half-sib crossing block. The male rows were planted with a bulk seed by compositing equal quantities of seed from all ears. A planting system of 1 male row alternating with 3 female rows was used.

Off-types, variant and diseased plants were removed from the field before tasseling. All plants in the female rows were detasseled before they shed pollen. Plants in the male rows that do not fit the description of the variety were also detasseled. True-to-type ears from the female rows were harvested as breeders' seed. The harvest seed was dehusked, shelled, cleaned and dried to moisture of 12%. Clean seed was packed into 50 kg sacks and stored inside a well-ventilated storeroom.

Results
The variety of maize and quantities of breeder seed per variety produced are as indicated in the Table below.

Table 15:*Quantity of maize breeders seed produced*

Crop	Variety	Seed Type	Area (ha)	Quantity Produced (kg)	Remarks
	Wang-dataa	BS	1.0	1,300	Certified
Maize	Bihilifa	BS	0.6	700	Certified
	Ewul-boyu	BS	1.0	400	Certified
Total			2.6	2,450	Certified

Conclusion

Production of seed of open-pollinated maize varieties requires that the crop is sufficiently isolated from potential contaminant crops to maintain varietal purity. Meeting the isolation requirements is a challenge on-station during the main cropping season. Owing to this, the seed production was carried out either during the off season under irrigation or at far distances and this makes the cost of production very expensive.

Support for Agricultural Research and Development for Strategic Crops (SARD-SC)/ Technology Testing and Fine-Tuning.

Principal Investigator: Alidu Haruna
Collaborating Scientists: Gloria A. Boakyewaa, James Kombiok, Flora C. Amagloh Prince A Maxwell and M.S.Abdulai
Estimated Duration: Five Years
Sponsors: Support for Agricultural Research and Development for Strategic Crops (SARD-SC) – IITA
Location: West Gonja and Mion Districts

Background Information and Justification

Maize is of paramount importance in the diets of many Ghanaian. It is the largest staple crop and the most widely cultivated due to its high potential grain yield. Unfortunately, its production in the country is seriously constrained by low nitrogen (low N) among other stress factors, affecting people's livelihoods, food security and economic development. Annual maize yield loss due to low-N stress varies from 10 to 50% (Wolfe et al., 1988). Although the use of nitrogenous fertilizers can improve the situation, availability and cost of fertilizers are also a serious limitation. The use of low N tolerant maize genotypes is the most economically feasible and sustainable approach to stabilize maize yield on-farm.

Maize supplies many macro- and micronutrients necessary for human metabolic needs; however, it lacks B vitamins and the essential amino acids lysine and tryptop han. White maize varieties, which are widely preferred by Ghanaian, lack provitamin A carotenoids and vitamin A is essential for immunity, growth, and eyesight (Nuss ET and Tanumihardjo SA, 2010). High-quality protein sources, such as eggs, meat, dairy pro ducts, and legumes, provide total or complementary sources of the amino acids limited in maize, but many rural poor have limited access to these foods (NRC, 1988). Quality Protein Maize (QPM) has potential to augment healthy growth and protein metabolis m in the rural poor who consume maize on a daily basis. QPM is a nutritionally enhanced crop with the potential as a tool for global health improvement. Rural populations in Ghana may benefit substantially from QPM because of the high rates of daily maize intake coupled with low intake of balanced-protein foods containing essential amino acids. Making simple dietary substitutions of common maize with QPM can augment intake of a more nutritionally balanced protein source which can result in measureable health impacts.

Development of QPM and low N tolerant maize varieties will constitute an important intervention to increasing maize yield and productivity; thereby enhancing people's livelihoods, food security and economic development in Ghana. The Technology Testing and Fine-Tuning activity through the Support for Agricultural Research and Development for Strategic Crops Project seeks to identify high yielding QPM varieties and or low N tolerant maize varieties for cultivation by farmers.

Objectives

To provide the National Maize Programme a wide range of Low N tolerant and QPM maize germplasm from which to identify and select superior stable yielding QPM and low N tolerant maize genotypes for release per se to farmers and or for population improvement.

Expected Beneficiaries: - Scientists, Farmers, Seed Companies, Traders, Industrialists and all stakeholders in the maize value chain.

Materials and Methods

Nine sets of trials comprising three sets each of Early white Quality Protein Maize (QPM) hybrids made up of twenty genotypes, three sets of Aflatoxin Resistant multiple stress tolerant trial made up of sixteen genotypes and Low N multiple stress tolerant populations made up of twelve genotypes were established across three locations each in the West Gonja and Mion Districts.

A two row plot per entry of the Early White QPM hybrids and the Low N multiple stress population trials were established. Each row measured 5m long and 0.75m between rows. The design was a Randomized Complete Block design with three replications. One row per plot, measuring 5m long and 0.75m between rows, of the Aflatoxin Resistant 3-way cross hybrid trial was established on a 4 x 4 lattice design with three replications. Data was collected on Grain yield, Days to 50% anthesis, Days to 50% silking, Plant and ear heights, Root and stalk lodging, Plant and Ear aspect and major diseases (streak, blight, rust and curvularia)

Results/Major Findings

Six top performing genotypes, two from the Early white QPM multiple stress tolerant trial (EWQPMH-5 and EWQPMH-2), two from the Aflatoxin 3-way cross hybrid trial (M1461-13 and M1461-15), and two from the low N multiple stress populations trial (LNE DMRSR Y Syn and LNE DMRSR W Syn) were identified as possible candidates that could be released to farmers in Ghana for commercial production. These will be advanced to on-farm research while all the trials will be repeated at all locations to authenticate and provide supporting data to be able to make informed choices.

Conclusions/Recommendations

The rural populations may benefit substantially from QPM varieties because of the high rates of daily maize intake coupled with low intake of balanced-protein foods containing essential amino acids. Making simple dietary substitutions of common maize with QPM can augment intake of a more nutritionally balanced protein source which can result in measureable health impacts. The use of technologies that maximally utilize available nitrogen with low N tolerant maize varieties can be an economically feasible and sustainable approach to stabilize maize yield on-farm. The development, deployment and use of low N maize varieties can therefore be of great advantage to the rural resource poor maize farmer.

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Demonstration of Drought/Striga Tolerant Maize Varieties in Integrated Maize Production Technologies in Eight Districts of Ghana

Principal Investigator: Alidu Haruna
Collaborating Scientists: M.S. Abdulai, Gloria Boakyewaa Adu and Alhassan Lansah Abdulai
Estimated Duration: Three Years
Sponsors: GIZ
Locations: On-farm.

Background Information and Justification

Maize production is constrained by recurrent drought, increasing rainfall variability, *Striga hermonthica* parasitism and low soil fertility. Economic impact of these constraints on maize production is very high. Drought coinciding with flowering and grain filling in maize can reduce grain yield by 50% and 21%, respectively. Annual maize yield loss due to low-N stress varies from 10 to 50% (Wolfe et al., 1988). *Striga hermonthica* accounts for an estimated 7 billion tons in loss of cereal yield each year. Yield losses in maize may range from10 to 100% depending on the genotype grown, climatic conditions, soil fertility status and levels of infestation (Lagoke 1998; Kroschel 1999). Drought stress and low soil-N aggravate *Striga hermonthica* parasitism on maize.

Yield loss due to low N is caused by little or no application of inorganic fertilizers by farmers, rapid mineralization of organic matter in the soil and frequent bush burning and extensive land-use intensification which has led to serious land degradation and nutrient depletion with Nitrogen being the most depleted nutrient. Although the use of nitrogenous fertilizers can improve the situation, availability and cost of fertilizers are also a serious limitation. The use of technologies that maximally utilize available nitrogen with host plant tolerance/resistance is the most economically feasible and sustainable approach to stabilize maize yield on-farm. The combined use of organic manure and inorganic fertilizer is a highly favoured option for maize production. Several studies have shown that 30-50 kg/ha of NPK fertilizer when combined with 4 to 5 t/ha of inorganic manure will approximate grain yields of 100-120 kg of inorganic N alone (Crasky and Iwuafor, 1999).

Demonstration trials were carried out in 16 communities in the Northern and Brong-Ahafo regions using the drought/striga tolerant varieties with combined use of organic manure and inorganic fertilizer technologies. These trials were aimed at showcasing the ability of drought/striga tolerant maize varieties to reduce climate-related yield losses of the small-scale resource poor farmers in the savanna and forest-savanna transition zones of Ghana where drought, *Striga* infestations and low soil fertility are major constraints to maize production.

Objectives

i. To increase production and productivity of maize per unit area by adapting drought and *Striga* tolerant maize varieties to recommended scientific and sustainable management practices in maize production
ii. To reduce poverty, improve food security, income and livelihoods of small-scale resource poor farmers in the Savannah and forest-savanna transition zones of Ghana.

Expected Beneficiaries: - Scientists, Farmers and Seed producers.

Materials and Methods

Demonstration fields were established on lead farmers' lands in each of the 16 communities in the intervention Districts of the Adaptation of the Agro-Eco-Systems to Climate Change (AAESCC). There were 16 demonstration fields across 16 locations (communities). Each demonstration field, measuring 46 m x 46 m (2116 m^2), was ploughed and harrowed and divided into four blocks each measuring 46m x 10m with a 2m walk way between them. Four levels of fertilizer were applied. These included:

1. No inorganic fertilizer nor organic manure (Control),
2. Sole fertilizer (250 kg NPK/ha +120 Kg SA/ha; recommended rate of inorganic fertilizer)
3. ½ rate of inorganic fertilizer + ½ rate organic manure (2 t/ha)
4. Sole organic manure (4 t/ha of fertisol)

These were randomly assigned to the blocks, and each block was sub-divided into four (4) plots each measuring 10m x 10m with 2m walk way between sub-plots. Four varieties of maize (three drought/striga tolerant varieties and a farmer's variety) were randomly assigned to these sub-plots. Planting was on the flat and garden lines were used to ensure straight row planting and optimum plant population. Rows were 0.75 m apart. Within rows, plant stands were 0.45m apart with two plants per stand. The experimental design was a split plot arrange in a Randomised Complete Block Design (RCBD) with two replications. The locations served as replications within Districts. Treatments were a 4 x 4 factorial (4 levels of fertilizer; 4 varieties of maize).

The organic manure was applied and incorporated well into the soil before planting while the NPK was applied at 2 leaves stage or 8 – 10 days after planting. The plots receiving inorganic fertilizer were top-dressed with appropriate amounts of sulphate of ammonia 35 to 40 days after planting. For the control block neither inorganic fertilizer nor organic manure was applied.

Data was collected on Grain yield, Days to 50% anthesis, Days to 50% silking, Plant and ear heights, Root and stalk lodging, Plant and Ear aspect, Striga count and score at 8 and 10 weeks after planting and grain moisture at harvest.

Results/Major Findings

The sole fertilizer technology gave significantly the highest mean grain yield per hectare whilst the control and the sole organic manure gave significantly the lowest mean grain yield per hectare across districts. Mean grain yields per hectare of Ewul-boyu, Sanzal-sima and the Farmers' variety were significantly higher in Chereponi than all the other Districts. The farmers' variety was significantly taller than the others across the eight districts while Wang-dataa was significantly shorter than all others across the eight districts.

Wang-dataa was the most preferred variety in Atebubu, Chereponi, Pru and Bunkpurugu-Yunyoo Districts. Its preference at Atebubu and Pru Districts was based on its earliness in maturity while that of Chereponi and Bunkpurugu-Yunyoo Districts was based on both its earliness in maturity and tolerance to striga, as striga is menance in these Districts. Fifty-two percent of the farmers across the eight districts of the AAESCC preferred the sole fertilizer technology as against 31% for the combined organic manure and inorganic fertilizer technology and 15% for the sole organic manure. Farmers cited the bulkiness and availability of the organic manure in sufficient quantity when needed as limitations to the use of technologies involving sole organic manure or combinations of organic manure and inorganic fertilizer. The sole fertilizer technology was the most preferred in seven districts out of the eight districts of the AAESCC intervention used.

Conclusions/Recommendations

The 2015 trials will be conducted on the same fields and plots used for the 2014 trials to establish the performance of the organic manure plots after one year since it is established that organic manure has a residual effect in the soil.

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Development of High Yielding Adapted Maize Hybrids for the Guinea and Sudan Savanna Zones of Ghana: Breeder and Foundation Seeds Production of Maize Varieties

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: Nyankpala and Sakpe

Background Information and Justification:
The lack of availability of improved seeds has very often been cited by farmers and other stakeholders as a major constraint affecting maize productivity and production in Ghana. Seeds are first and foremost, the source of most food and as such are the most crucial components of agriculture. Thus, seeds of improved varieties would need to be multiplied, distributed and cultivated by farmers for benefits of the improved varieties to be realized. In general, improving smallholder farmers' access to high quality seeds of improved high yielding varieties may be considered as one major approach to achieving increased productivity and production of maize, leading to poverty alleviation and food security enhancement in the country. To meet the demands of maize farmers for certified seeds of improved maize varieties, there is the need to up-scale breeders' and pre-basic seeds production of these improved varieties in the country.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Specific Objectives:

i. Create farmer awareness of newly released maize hybrids in Ghana.
ii. Develop and release high yielding maize hybrids with multiple tolerance/resistance to biotic and abiotic stresses (drought, *Striga hermonthica* and low soil nitrogen).
iii. Enhance farmer's access to high yielding *Striga hermonthica* and drought tolerant, and nitrogen use efficient maize hybrids

Expected Beneficiaries: Farmers, Seed companies, Input dealers and Traders.

Materials and methods:
The project established foundation seed production plot of GH110 and breeder seed production plot of Wang-Dataa at Sakpe in the Mion district of northern region of Ghana. The isolated half-sib ear-to-row crossing block procedure ((Badu-Apraku *et al*., 2014)) for maintaining and producing breeder's seed of an open-pollinated variety was used for the breeder seed production of Wang-dataa. An isolation distance of 400 m was ensured to maintain genetic purity since the breeder's seed provides the source of the first and subsequent increase of foundation seeds. The breeder's seed production began with the seed of individually shelled ears, saved as progenitors of the breeder's seed. Seeds from these ears were planted as individual female rows (ear-rows) in a half-sib crossing block. The male rows were planted with a bulk made-up by compositing equal quantities of seed from all ears. A planting system of 1 male row alternating with 3 female rows was used. All plants in the female rows were detasseled before they shed pollen. Prior to harvest, 4-8 plants in approximately 50% of the ear-rows that meet the varietal description for plant traits were selected and tagged, two-to-four ears that best fit the ear and grain characteristics of the variety were selected from the tagged plants in each family and were saved as progenitors of breeder's seed. All other true-to-type ears from the remaining ear-rows were harvested and saved as breeder's seed of the variety.

The single cross of Mamaba, GH110, involves Entry 6 and Entry 70 as the female and male parents, respectively. Parental inbred line maintenance and purification were carried out in a nursery at Nyankpala, while foundation seed production was carried out at Nyankpala. The female and male parents were grown in the same field, but isolated from other fields by 400 m. The parents were sown in 1:3 ratio for male and female rows, respectively. Detasseling of all female rows was done. All off types, diseased and volunteer crops were removed from both male and female parental lines before flowering. Ear selection procedures used were similar to those describe above. Certification standards for both breeder and foundation seed plots were maintained under the guidance of the monitoring team from Seed Multiplication unit of the Plant Protection and Regulatory Services Division of the Ministry of Food and Agriculture in Ghana.

Results/ Major Findings: About 200 kg breeder seeds of Wang-dataa and 50 kg foundation seeds of GH110 were produced.

References:
Baffour Badu-Apraku, Robert Ayeibi Asuboah, Bamidele Fakorede, Baffour Asafo-Adjei, 2014. Strategies for Sustainable Seed Production in West and Central Africa. IITA, Nigeria. 36-50 pp

Production and Promotion of Breeder and Foundation Seeds of Improved Stress Tolerant Maize Varieties and Hybrids (Sub-project 4 of SARD-SC Maize Commodity Project).

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Alidu Haruna, James Kombiok and Prince Maxwell Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Africa Development Bank/IITA
Locations: Nyankpala, Sakpe, Sang and Salankpang

Background Information and Justification:
The lack of availability of improved seeds has very often been cited by farmers and other stakeholders as a major constraint affecting maize productivity and production in Ghana. Seeds are first and foremost, the source of most food and as such are the most crucial components of agriculture. Thus, seeds of improved varieties would need to be multiplied, distributed and cultivated by farmers for benefits of the improved varieties to be realized. In general, improving smallholder farmers' access to high quality seeds of improved high yielding varieties may be considered as one major approach to achieving increased productivity and production of maize, leading to poverty alleviation and food security enhancement in the country. To meet the demands of maize farmers for certified seeds of improved maize varieties, there is the need to up-scale breeders' and pre-basic seeds production of these improved varieties in the country.

Objective: To bridge the gap of the shortfall in certified seed availability in Ghana by increasing and maintaining the physical and genetic purity of breeders' and pre-basic seeds of adapted improved varieties of maize in the country.

Expected Beneficiaries: Farmers, Seed companies, Input dealers and Traders.

Materials and Methods:
A total of 11.5 acres of breeder and foundation seed production plots of five varieties were established by the project at Sakpe, Sang and Salanpkang in the Mion district. The isolated half-sib ear-to-row crossing block procedure for maintaining and producing breeder's seed of open-pollinated varieties (OPV) were used (Badu-Apraku *et al.,* 2014). Breeder seeds of Sanzal-Sima and Obatanpa were produced. An isolation distance of 400 meters was ensured to maintain genetic purity since the breeder's seed provides the source of the first and subsequent increase of foundation seeds.

Foundation seeds of Wang-Dataa, Sanzal-Sima and Ewul-Boyu were produced. Foundation seed was produced through open-pollination in isolated fields, away from any source of pollen contamination. An isolation distance of 350 meters were maintained. Bulked breeder's seed of the OPV were grown and all off-type plants were rogued before flowering. Also, rogueing for ear and seed traits were done before and during harvesting. Foundation seed of hybrids generally involves production of single crosses by growing male and female parents in the same field, but isolated from other fields by 350-400 meters. Parental inbred line maintenance and purification were carried out in a nursery at Nyankpala following the procedures described by Badu-Apraku *et al*. (2014). Foundation seed production of Mamaba was carried out at Sakpe. GH110, the single cross of Mamaba involves Entry 6 and Entry 70 as the female and male parents, respectively. These parents were sown in 1:3 ratio for male and female rows, respectively. Detasseling of all female rows was done. All off types and diseased plants were removed from both male and female parental lines before flowering. Certification standards for both breeder and foundation seed plots were maintained under the guidance of the monitoring team from Seed Multiplication unit of the Plant Protection and Regulatory Services Division of Ministry of Food and Agriculture in Ghana.

Results/Major Findings: A total of 1330 kg of seeds was produced, Table 16 presents the quantities of individual varieties produced by the project.

Table 16: *Quantities of seed of varieties produced by the project.*

Variety	Variety type	Class of seed	Quantity produced (kg)
Wang-Dataa	OPV	Foundation	300
GH110	Hybrid	Foundation	50
Sanzal-Sima	OPV	Foundation	250
Ewul-Boyu	OPV	Foundation	300
Sanzal-Sima	OPV	Breeder	280
Obatanpa	OPV	Breeder	50
Entry 5	Inbred line	Breeder	100

References:

Baffour Badu-Apraku, Robert Ayeibi Asuboah, Bamidele Fakorede, Baffour Asafo-Adjei, 2014. Strategies for Sustainable Seed Production in West and Central Africa. IITA, Nigeria. 36-50 pp

Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: Multi-Location Evaluation of Early and Intermediate Maturity Groups of Maize Hybrids Tolerant to Drought (Advance Yield Trials).

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: On-station (Nyankpala, Yendi, Damongo, Manga and Tumu)

Background Information and Justification:
Maize is Ghana's number one staple crop, accounting for 55% of total cereal production. About 85% of maize produced is used for human consumption, while the remaining 15% is used as feed for animals (mainly poultry) (Angelucci, 2012). Maize consumption is projected to increase due to population growth and increasing per capita income. The vast majority of maize is produced by small scale farmers, most of whom grow maize on marginal lands with low inputs under rain-fed conditions throughout the country. Under these conditions, maize yields average approximately 1.7 MT/ha as against an estimated achievable yield of 6.0 MT/ha (MoFA, 2011). The Guinea and Sudan savannah ecologies of Ghana are high yield potential zones for the production and productivity of maize due to the prevalence of high solar radiation, low night temperatures and low incidence of diseases. However, maize production in these zones is seriously constrained by several biotic and abiotic stresses. Prominent among the stresses are drought, *Striga hermonthica* parasitism and low soil nitrogen (low-N). An annual yield loss from each of these stresses in the savannah zones of Sub-Saharan Africa is estimated at about 10-80% of total maize production (Edmeades *et al*. 1995; Kroschel, 1999). Under farmer field conditions, Striga parasitism, drought stress and low-N stress occur simultaneously and the combined effect of these stresses is very devastating posing great threat to maize production and food security in affected areas. In order to increase productivity of maize at small-scale farmer level, maize varieties for cultivation in savannah zones should have desirable level of tolerance to the above stresses. This activity was conducted to evaluate promising drought tolerant early and late/intermediate maturity groups of hybrids in drought-prone areas in northern Ghana to identify the most superior candidates for on-farm trials and release for production by farmers.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Expected Beneficiaries: Male, female and youth in the maize value chain

Materials and Methods:
Two separate experiments comprising 28 early maturing hybrids and 15 intermediate maturing promising drought tolerant hybrids were planted at Nyankpala, Yendi, Damongo, Manga and Tumu. Trails were established in the main cropping seasons of the Guinea (Nyankpala, Yendi, Damongo and Tumu) and Sudan Savanna zones (Manga). Randomized complete block design was used in both trials, the early maturing hybrids were replicated three times whiles intermediate maturing hybrids trial was replicated twice. Each plot consisted of two rows of each entry. The rows were 5.0 m long and spaced 0.75 m apart. Plants within rows were spaced 0.4 m and 0.5 m for early maturing and intermediate maturing varieties, respectively. All recommended agronomic practices for maize production at all locations were observed. Data was recorded at all evaluation sites for number of days from planting to 50 % anthesis (DA) and 50% silking (DYSK), anthesis-silking interval (ASI), plant height (PH) and ear height (EH), number of plants (PHARV) and ears harvested (EHARV) per plot, ears per plant (EPP), plant aspect (PASP), ear aspect (EASP), root lodging (RL) and stalk lodging (SL), ear rot (ER), field weight and grain moisture. Analyses of variance were performed for all traits measured

using PROC GLM in SAS (SAS, 2001). Also, the mean grain yields of top seven grain yielding hybrids were subjected to genotype main effect and genotype by environment interaction (GGE) biplot analyses ((Yan *et al*. 2001) to determine the stability of the hybrids across locations for grain yield and also to target the individual hybrids to specific zones.

Results/Major Findings:
In the early maturing hybrids trial, the differences among genotypes and locations were significant for most traits measured except for: ASI, DA, DYSK and EPP for genotypes; EHARV, EPP, grain yield (GYLD) and PHARV for locations. Genotype x location (G x E) interaction effects were significant for DYSK, grain yield (GYLD), PASP, RL and SL. Grain yield ranged from 2.74 t/ha in TZEI 7 x TZEI 26 to 9.92 t/ha in TZEI 25 x TZEI 124. The most outstanding hybrids in terms of grain yield were TZEI 25 x TZEI 124, TZE-W POP DT STR C4 x TZEI 7, TZEI 60 x TZEI 86, Local check (Tintim), TZE-Y POP DT STR C4 x TZEI 17, TZEI 16 x TZEI 157 x TZEI 129, TZEE-W POP STR C5 x TZEEI 21 and TZEE-W POP STR C5 x TZEEI 29. The GGE biplot analyses identified TZEI 25 x TZEI 124 as the highest yielding hybrid in Nyankpala; TZEE-W POP STR C5 x TZEEI 29 as the top-ranking hybrid at Manga. The hybrid, TZEI 16 x TZEI 157 x TZEI 129 and TZE-W POP DT STR C4 x TZEI 7 were the highest hybrids at Damongo. In ranking of genotypes based on the mean yield and stability, TZEI 60 x TZEI 86 was the highest yielding and most stable hybrid, implying that its ranking was highly consistent across locations and thus, an ideal hybrid for production in the three locations.

In the intermediate maturing hybrids trial, the combined analyses of grain yield across locations showed the differences among genotypes and locations to be significant for grain yield. Grain yield ranged from 2.08 t/ha in M1026-1 to 11.00 t/ha in M1026-8. The following hybrids were selected for further testing: M1026-8, local Check (Tintim), M1126-1, M1026-4, M0826-1, Oba Sup 2 and M0926-11.

Conclusions/Recommendations
In the early maturing hybrids trial, the observed significant G x E interaction effects for grain yield suggested that grain yields of the hybrids varied across test locations. This indicates the presence of special environments within the test locations, thus the need to select hybrids with specific adaption to those environments. The hybrids, TZEI 25 x TZEI 124, TZEE-W POP STR C5 x TZEEI 29, and TZEI 16 x TZEI 157 x TZEI 129 and TZE-W POP DT STR C4 x TZEI 7 would be suitable for cultivation in Nyankpala, Manga and Damongo, respectively. For selection for broad adaptation in maize production, an ideal genotype should have both high mean performance and high stability, thus, TZEI 60 x TZEI 86 is the ideal genotype for production across all test locations and other locations within the same agro-ecological zones. The non-significant G x E interaction effects for grain yield observed in the intermediate maturing hybrids trial suggested that any superior genotype selected in one of the test locations would also be suitable for production in other locations in the same agro-ecological zones. The experiments will be repeated in 2015 cropping season and all superior genotypes identified will be tested on-farm.

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Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: Hybrid Maize Seed Production Training

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: Nyankpala

Background Information and Justification:

Maize cropping systems in Ghana are characterized by low productivity due to continuous use of traditional low yielding open pollinated maize varieties (OPVs). Maize yields average approximately 1.7 MT/ha as against an estimated achievable yield of 6.0 MT/ha (MoFA, 2011). The development, adoption and commercial use of locally adapted maize hybrids in Ghana holds the key to increased productivity in the country, since hybrids are known to yield higher than OPVs. The successful adoption of improved varieties particularly hybrids depends on their comparative advantage over local varieties commonly grown by farmers. The assurance of stable performances of hybrids over the years depend greatly on the ability of seed producers and other key actors in the seed value chain to produce and supply seeds with the highest genetic purity to farmers. Hybrids seed production unlike OPV maize seed production which is relatively easy requires additional field practices that are critical to success. Therefore, strengthening the capacity of actors in the seed value chain to effectively fulfil their role in seed production is crucial to the adoption of newly released hybrids being promoted. The project continues its efforts to build the capacity of technical officers directly involve d in seed production to enhance quality of certified seeds available to farmers.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Specific Objectives:

i. Create farmer awareness of newly released maize hybrids in Ghana.

ii. Develop and release high yielding maize hybrids with multiple tolerance/resistance to biotic and abiotic stresses (drought, *Striga hermonthica* and low soil nitrogen).

iii. Enhance farmer's access to high yielding *Striga hermonthica* and drought tolerant, and nitrogen use efficient maize hybrids

Expected Beneficiaries: Male, female and youth in the maize value chain particularly farmers, seed producers, farmers, input dealers and marketers

Materials and Methods:
The first training designed to provide participants with theoretical backing of some critical production strategies and techniques needed in hybrid maize seed production was organized on 28th August, 2014. This training course was attended by twenty-three (23) participants from the private and public seed sectors in northern Ghana. The topics treated included the following: Types and classes of seed; Hybrid seed production Agronomy, Maintenance of inbred parents, Field and laboratory requirements for seed certification, Seed processing, packaging and storage. The topics were facilitated by researchers drawn from the Council for Scientific and Industrial Research (CSIR) and Ministry of Food and Agriculture (MoFA), Tamale. The training employed a participatory approach whereby participants were allowed to express themselves and also share their experiences and challenges in seed production/marketing in Ghana.

Results/Major Findings:
All 23 participants successfully completed the hybrid seed production training. Training materials on all topics discussed were given to participants for their personal use after the training. Twenty-one (21) of the participants were men and 2 were women. Table 17 presents the sector analysis of participants at the training.

Table 17: *Sector analysis of participants*

Institution	Number of participants
Maize Breeding Institute	2
Private Seed Companies	9
Crop Services - Ministry of Food and Agriculture	9
Community Based Seed Producers	3

Conclusion/Recommendation:
The training provided a good opportunity for participants to gain a better understanding of the concept and principles of hybrid maize seed production. A training workshop to take participants through practical aspect of hybrid seed production techniques, particularly on agronomy of hybrid maize seed production, maintenance of inbred parents, and field and laboratory requirements for seed certification should be organised for the same participants. Such training would provide participants with field practical exercises and hands-on experience on these important topics.

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Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: Low-N Multiple Stress Tolerant Populations Trial (Preliminary On-station Trials)

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: On-station (Nyankpala, Yendi, Damongo, Manga and Tumu)

Background Information and Justification:
Maize production in the savannahs of Ghana is constrained by biotic (Striga infestation, disease and pest) and abiotic (drought and low-N) stresses that limit the growth, development and economic yields of maize. Genotypic differences for grain yield observed in the absence of stress are largely unrelated to differences observed in the presence of severe stress (Ceccarelli and Grando, 1991). This indicates that different physiological mechanisms may be associated with high yield in favorable conditions and high yield in unfavorable conditions. Genotypes selected for high performance in stress-free conditions likely do not maintain those same high yields under stress partly due to lack of natural genetic variation of traits advantageous in

stressful environment (Murphy *et al*., 2005). Variation for quantitative characters is under the control of many genes and the contribution of the genes can differ among environments. Breeding programmes thus need to examine potential varieties more suited to low-yielding conditions in which varieties would be selected that have more advantageous adaptations in stress conditions such as delayed leaf senescence, improved nutrient economy, local environmental fitness, consistent yield, and pest/disease resistance (Tiffany *et al*., 2011), thus, increasing the profitability of production under marginal production areas. The main objective of this activity was identify superior maize genotypes with tolerance to low soil nitrogen (Low-N), *Striga hermonthica* and drought stress to serve as source germplasm for introgression of desirable alleles into breeding populations for improvement.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Expected Beneficiaries: Male, female and youth in the maize value chain

Materials and Methods:
Ten intermediate maturing low soil nitrogen (low-N) multiple stress tolerant maize populations and two local checks (locally released OPV and hybrid) were evaluated at Nyankpala and Manga under three N levels. The N rates used were 0, 30, and 90 kg N ha^{-1}. The germplasm used in this study was collected from IITA and local sources. The experimental design used was 3 x 12 split plot design arranged in randomized complete block design (RCBD) with the three nitrogen levels as main-plot factor and the 13 varieties as sub-plot factor. The main plots (blocks) were separated from each other by 5 m alley. Each plot consisted of two 5 m long rows with 0.75 m between rows and 0.40 m between plants. One-half of the nitrogen as Urea was applied at 2 weeks after planting (WAP), while the remaining half was top-dressed at 6 WAP. Phosphorus and potassium were applied basally at the rate of 60 kg ha^{-1} of each nutrient.

Data was recorded at all evaluation sites for number of days from planting to 50 % anthesis (DA) and silking (DYSK), anthesis-silking interval (ASI), plant height (PH), ear height (EH), number of plants (PHARV) and ears harvested (EHARV) per plot, ears per plant (EPP), plant aspect (PASP), ear aspect (EASP), root lodging (RL), stalk lodging (SL), ear rot (ER), field weight and grain moisture. In addition, Stay-green characteristics (LDTH) was scored for varieties evaluated at 70 days after planting. Separate analyses of variance (ANOVA) were performed on all data collected for each location using PROC GLM in SAS (SAS Institute, 2001). Combined ANOVA across locations and test environments was performed for grain yield and all measured traits. Least Significant Difference test were used to assess the differences between means of varieties. Nitrogen use efficiency (NUE) was calculated according to Moll *et al*., (1982),

Results/Major Finding:
The combined analysis of variance (ANOVA) for genotypes across the three nitrogen levels revealed significant ($P \leq 0.05$) difference among genotypes for all traits measured except for ASI, EASP and PASP. The mean square values for Genotype x Location x Nitrogen

interactions (G x L x N) were not significant for all traits measured except for RL. The non-significance of G x L x N interactions for grain yield and the other traits indicated that the stability in response of the genotypes to nitrogen applied at the three N rates across the two locations for those traits. All genotypes evaluated showed appreciable increases in yield in response to increases in nitrogen level from 0 - 30 - 90 kg N ha^{-1}. The mean grain yield of genotypes recorded under 0 kg N ha^{-1}, 30 kg N ha^{-1} and 90 kg N ha^{-1} were 2.28, 6.33 and 9.11 t/ha, respectively. Yield reductions under 0 kg N ha^{-1} in comparison to 90 kg N ha^{-1} treatment and 30 kg N ha^{-1} in comparison to 90 kg N ha^{-1} treatment ranged from 71 to 79% and 22 to 31%, respectively. Check 1 (Tintim), LNP Syn-Y and TZLIC6-LN Syn had the highest yield under 0 kg N ha^{-1} and 30 kg N ha^{-1}. Averaged across test environments (i.e. location by nitrogen levels), Check 1 (Tintim), TZPB-LN Syn, LNP Syn-W and LNP Syn-Y were the top four grain yielders. The lowest grain yields were recorded by Check 2 (Obatanpa), LN-E-DMRSR-Y Syn, TZE3-DTC2-LN Syn and TZE31-DMRSR-LN Syn. Nitrogen stress delayed both pollen shed and silking, but the delay in silking was relatively longer under 0 kg N ha-1 as compared to the other N levels. The mean days to silking of genotypes under 0 kg N ha^{-1}, 30 kg N ha^{-1} and 90 kg N ha^{-1} were 64, 58 and 58 days, respectively. Similarly, EPP decreased with reduction in N applied among genotypes, average EPP recorded for genotypes under 0 kg N ha^{-1}, 30 kg N ha^{-1} and 90 kg N ha^{-1} were 0.74, 0.99 and 1.02, respectively. Differences among genotypes observed for grain yield were not significant for nitrogen use efficiency (NUE) but were significant at each N level. NUE for most genotypes were higher at 30 kg N ha^{-1}. Multi-trait selection index involving grain yield, DYSK, EPP, LDTH and PH was used to select the following genotypes as tolerant to low-N, LNP Syn-W, LNP Syn-Y, TZE31-DMRSR-LN Syn and TZLIC6-LN Syn.

Conclusions/Recommendations :

The results of this study showed that increased grain yield under nitrogen stress was associated with shorter days to silking, and reduced leaf senescence and barrenness. LNP Syn-W, LNP Syn-Y, TZE31-DMRSR-LN Syn and TZLIC6-LN Syn would be desirable to be used as source germplasm to improve grain yield and associated traits for low-N tolerance of other varieties. Drought and low soil nitrogen are related with both leading to poorly developed root systems (S. O. Ajala *et al.,* 2007*)*. Bänziger *et al*. (1999) showed that improvement for drought tolerance also resulted in specific adaptation and improved performance under low-N conditions, suggesting that tolerance to either stress involves a common adaptive mechanism. The genotypes evaluated in this study will be evaluated under drought stress to determine if such relationship between drought and low-N tolerance do exist in the genotypes studied, to gather information to be used in the selection of genotypes with combine tolerance to drought and low-N for population improvement.

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Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: Evaluation of Early Maturing White and Yellow Maize Inbred Lines under Stress and Non-Stress Environments

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: On-station (Nyankpala and Kwadaso)

Background Information and Justification:
Drought, low soil nitrogen (Low-N) and Striga infestation remain the major abiotic and biotic stresses limiting maize production in the Guinea and Sudan Savannah zones of Ghana. Therefore, the development and use of maize germplasm with tolerance to multiple stresses are crucial for an increase in maize productivity. There is a crucial need for national breeding programmes to continue assessing the breeding values of potential stress tolerant parents for developing new and locally adapted hybrids. Before hybrid development, prospective parent selection is a prerequisite, genetic diversity among inbred lines is important as genetically diverged parents are able to produce high heterotic effects (Mian and Bahl, 1989). The availability of precise information on the level of genetic diversity in maize inbred lines available in a breeding programme could make it easier to identify lines that would produce crosses possessing high levels of heterosis, enabling the development of high yielding hybrids without testing all possible hybrid combinations among the potential parents (Moll *et al.*, 1965). This activity was undertaken to assess the breeding value of 100 early maturing maize inbred lines for grain yield and superior agronomic performance under artificial Striga infestation, low-N environment and optimal growing conditions as parents for hybrid development.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Expected Beneficiaries: Male, female and youth in the maize value chain

Materials and Methods:

One hundred early maturing white and yellow inbred lines were evaluated in three separate experiments at Nyankpala and Kwadaso. Germplasm used in the experiments were collected from the international institute of tropical Africa (IITA). In the first experiment, the lines were evaluated for agronomic performance under artificial Striga infestation at Nyankpala. A 10 x 10 lattice design with two replications was used. The experimental units were one-row plots, each 3m long with an inter-row spacing of 0.75 m and intra-row spacing of 0.40 m. Each entry was infested with seeds of *S. hermonthica*. The Striga infestation method of IITA maize programme was used (Kim 1991). In the second experiment, the lines were evaluated under low-N (30 kg ha^{-1}) environment at Kwadaso. Also, the lines were evaluated under optimal growing conditions [High-N (90 kg N $ha^{-1)}$ and Striga-free environment] in a third experiment at Nyankpala. The same experimental design and plot size described in the first experiment were used in the second and third experiments. Data were recorded on low-N, optimal and Striga infested plots at all sites for number of days from planting to 50 % anthesis and 50% silking, plant and ear heights, number of plants and ears harvested per plot, plant aspect, ear aspect, field weight, grain moisture at harvesting and, root and stalk lodging. Stay-green characteristics were scored for the lines evaluated on low-N plots at 70 days after planting. In addition, host plant damage syndrome ratings and emerged Striga counts were made at 8 and 10 WAP (weeks after planting) in the Striga-infested plots.

Separate analyses of variance (ANOVAs) were performed for all data collected across locations for each research environment using General Linear Model (GLM) of GenStat Statistical package edition 12. Subsequently, combined analysis across locations and environments was done. The base indices described below were used to separately select inbred lines with superior performance under Striga infestation and low-N environments. Base Index (BI) for Striga tolerance = [(2 x GYLD) + EPP – (STRAT1 + STRAT2) – 0.5 (STRCO1+ STRCO2)]. Where GYLD is the grain yield of Striga-infested plots, EPP is the number of ears at harvest in the Striga-infested plots, STRAT1 and STRAT2 are Striga damage rating at 8 and 10 WAP, and STRCO1 and STRCO2 are the number of emerged Striga plants at 8 and 10 WAP. Base Index (BI) for Low-N tolerance = [(2 x Yield) + EPP – ASI – PASP – EASP - LDTH], Where PASP is the plant aspect, EASP is the ear aspect, EPP is the ears per plant, ASI is anthesis-silking interval, and LDTH is the stay green characteristic (leaf death scores) recorded for lines evaluated under Low-N. Under both Striga infestation and induced low-N each trait was standardized, with a mean of zero and standard deviation of 1 to minimize the effects of different scales.

Results/Major findings:

Significant genotypic differences were observed among the lines for most of the traits measured, indicating that significant progress could be made from selection of inbred lines for improvement in most traits measured for Striga and low-N tolerance except for anthesis-silking interval, days to anthesis and silking, Striga count at 8 and 10 WAP and Striga damage rating at 8 WAP under Striga infestation, and except for plant aspect, ear aspect, plant height, stalk lodging and anthesis-silking interval under low-N environment. Averaged across environments, mean grain yield of the lines was 768.01 kg/ha. Mean grain yield of the lines was significantly higher under optimal growing conditions (1273.04 kg/ha) followed by low-N environment (837 kg/ha) and under Striga infestation (686 kg/ha). About 49% of the inbred lines evaluated were identified to possess some level of tolerance to Striga. Fifteen of these lines, TZEI 146, TZEI 485, TZdEI 121, TZEI 460, TZEI 16, TZdEI 37, TZEI 127, TZEI 13, TZEI 136, TZEI 461, TZEI 365, TZEI 25, TZEI 474, TZdEI 216 and TZdEI 272, sustained lower Striga damage symptoms at 10 WAP (scores lower than the group mean of 5) and above mean grain yield under Striga infestation. Also, 47% of the inbred lines evaluated were identified to have some level of tolerance to low-N. Out of the 47 inbred lines characterized as low-N tolerant, 19 of them including the lines listed below had higher grain yields and good leaf death scores: TZdEI 283, TZEI 365, TZdEI 69, TZEI 35, TZEI 449, TZEI 157, TZEI 468, TZEI 472, TZEI 485, TZEI 465, TZEI 13, TZdEI 222, TZEI 470, TZdEI 238, TZEI 476, TZdEI 272, TZEI 462, TZEI 3B and TZEI 376. Heritability (broad sense) estimates for days to silking (0.77), plant height (0.71), leaf death characteristic (0.64) and ears per plant (0.67) were high under low-N environment, this revealed that major portion of variation observed among the inbred lines for these traits would be transmitted to progenies to make selection of parents for improved tolerance to low-N effective. Similarly, the moderate to high heritability estimates for STRAT1 (0.47) and STRAT2 (0.47) and ear aspect (0.77) under Striga infestation is an indication that selection for these traits to improve Striga tolerance would be effective.

Conclusions/Recommendations :
The inbred lines evaluated proved to have adequate levels of variation for grain yield and other traits measured under Striga infestation and Low-N to allow selection of inbred lines for improvement in most of the measured traits for Striga and low-N tolerance. This reveals the potential of the lines to be used as parents for Striga and low-N tolerant hybrids. Based on the results of this experiment, thirty elite lines comprising eleven (11) lines with combined tolerance to Striga and low-N (TZEI 485, TZEI 13, TZEI 365, TZdEI 40, TZEI 157, TZEI 8, TZEI 472, TZEI 25, TZEI 470, TZdEI 272, TZdEI 283); Twelve (12) Striga tolerant lines - TZEI 127, TZEI 146, TZdEI 121, TZdEI 216, TZEI 461, TZEI 136, TZEI 16, TZdEI 124, TZEI 56, TZEI 497, TZdEI 37, TZdEI 260 and seven (7) low-N tolerant lines - TZEI 449, TZEI 10, TZdEI 69, TZdEI 238, TZEI 7, TZEI 379 and TZEI 323 were selected for further studies.

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Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: On-Farm Demonstration of Newly Released Maize Hybrids and Related Technologies in Northern Ghana

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017)
Sponsors: Alliance for Green Revolution in Africa (AGRA)
Locations: On-farm (West Gonja, Chereponi, Gushegu, Garu-Tempane, Sissala East, Sawla-Tuna-Kalba districts)

Background Information and Justification:
Maize is well adapted and grows in most of the ecological zones of Ghana. It provides a major source of calories in many parts of Ghana. In the savannah zones of northern Ghana, It has nearly replaced traditional staple crops like sorghum and pearl millet. An average maize grain yield on farmers' fields is about 1.7 t/ha as against an estimated achievable yield of about 6.0 t/ha (MoFA, 2011). Maize cropping systems in Ghana and the rest of SSA are characterized by low productivity due to continuous use of traditional low yielding open pollinated varieties (OPVs). Generally, hybrid maize varieties are known to yield higher than OPVs due to their improved genetics and nutrient use efficiency. The development, adoption, and commercial use of hybrid maize in Ghana holds the key to improving maize productivity and promoting food security in the country. Three broadly adapted intermediate maturing hybrids (Aseda, Tintim and OpeƐburo) with moderate tolerance to drought were released by CSIR-Crops Research Institute (CRI) in 2012 to boost maize production in the country. However, farmer access and awareness of the varieties are limited. The project in collaboration with CRI and Ministry of Food and Agriculture (MoFA) conducted an extensive demonstration of the hybrids in five districts in northern Ghana to popularize the hybrids in northern Ghana whereby promoting their adoption by farmers and stakeholders.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Specific Objectives:

i. Create farmer awareness of newly released maize hybrids in Ghana.
ii. Develop and release high yielding maize hybrids with multiple tolerance/resistance to biotic and abiotic stresses (drought, *Striga hermonthica* and low soil nitrogen).
iii. Enhance farmer's access to high yielding *Striga hermonthica* and drought tolerant, and nitrogen use efficient maize hybrids.

Expected Beneficiaries: Male, female and youth in the maize value chain

Materials and Methods:

On-farm demonstration plots of three broadly adapted intermediate maturing maize hybrids (Aseda, Tintim and OpeƐburo) were conducted in 30 communities in northern Ghana. Lead farmers from 6 communities each in Chereponi, Gushegu, Garu-Tempane, Sissala East and Sawla-Tuna-Kalba districts were provided with seeds of the hybrids for demonstration. The varieties were planted using Randomized Complete Block Design (RCBD) with six replications at each district (each community was used as a replication). Each lead farmer was allowed to plant the hybrids for testing together with his/her own choice variety as a check. Farmers' varieties used were mainly late to intermediate maturing improved open pollinated maize varieties. A plot size of 10 x 10 m^2 were used. An inter-row spacing of 0.75 m and intra-row spacing of 0.50 m were used. Two seeds were planted per hill. The demonstration plots were established by trained Agricultural Extension Agents (AEAs) and members of participating Farmer Based Organizations (FBOs) in each community, and managed by lead farmers under strict supervision of AEAs. The demonstration plots were also used as learning centers where members of participating FBOs were trained in good agronomic practices for maize production. Farmer field days were organized at maturity when the ears/cobs were well developed but not dry to showcase the superior performance of the hybrids.

Data were recorded separately from each plot at each location for plant height, number of ears and plants harvested per plot, plant vigour score at 4, 6 and 8 weeks, grain moisture, field weight and 1000 grain weight. Plant vigour score at 4, 6 and 8 weeks after planting were scored for each plot using the scores below: 1= weak plants, 2= less vigorous, 3= fairly vigorous and 4 = More vigorous. Mid-season evaluations were conducted in all the districts during which farmers were taken to the maize plots for discussions about the economic benefits of the new improved varieties as well as to rank the performance of the varieties. On average, about 20 male and 20 female farmers in each community were selected to rank the performance of the varieties at maturity and during harvesting based on their own indigenous criteria using the scores below: 1 = least preferred, 2 = less preferred 3=fairly preferred, 4=more preferred and 5 = most preferred. The researchers' recorded agronomic data were subjected to analysis of variance using PROC GLM in SAS (SAS, 2001). Farmers' selection data were analyzed using simple ranking and descriptive methods in accordance with the given value.

Results/Major Findings:

The difference observed among varieties were significant for all traits measured. Location and genotype x location interaction effects were not significantly ($p<0.05$) different for all traits measured except for plant height for locations and grain yield for genotype x location interaction effect. The differences between grain yields of Aseda (7.14 t/ha) and Tintim, and Tintim (6.80 t/ha) and OpeƐburo (6.27 t/ha) were not significantly different. Averaged across districts, the hybrids produced 14% more grain than the control varieties. The increased grain yields of the hybrids as compared to the farmer variety (5.95 t/ha) was associated with early maturity, more number of cobs per plant, good ear filling, and resistant to lodging, At Chereponi, all the three hybrids were liked by male farmers whiles female farmers preferred OpeƐburo. Both men and women farmers in Garu-Tempane preferred OpeƐburo to the other varieties. Tintim was the most preferred variety by both male and female farmers in Gushegu, Sawla-Tuna-Kalba and Sissala East districts except for Gushegu where OpeƐburo ranked first among female farmers. Across districts and gender, farmers did not only seek high yielding varieties but also early maturing and drought tolerant varieties with good standability, as evident in the pattern of varietal preference of farmers across the target districts. Aseda, the most vigorous hybrid in the study out-yielded OpeƐburo by 12.2% in the study, but regardless of its vigorous growth and high yielding potentials, farmers preferred OpeƐburo due to its good standability. A total of five field days were organized (one field day per district). The field days were well attended with over 440 farmers and stakeholders (consisting 211 males and 229 females) participating in events across the five districts.

Conclusions/Recommendations :
The demonstrations provided a good opportunity for participating FBOs to gain a better understanding of the use and economic benefits of hybrid maize varieties as well as to have a hands-on experience of most improved agronomic practices for hybrid maize production. In general, Tintim and OpeƐburo stand a good chance of adoption in northern Ghana. The potential constraints to adoption of the hybrids as indicated by some farmers are the cost of renewing seeds of hybrids every cropping season and the low accessibility of high quality seeds in their communities. It is recommended that members of FBOs be linked to seed producers to enhance the supply of seeds in these districts and also train community based seed producer in participating communities.

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Development of High Yielding Adapted Maize hybrids for the Guinea and Sudan Savanna Zones of Ghana: On-Farm Evaluation of Early Maturing Maize Hybrids

Principal Investigator: Gloria Boakyewaa Adu
Collaborating Scientists: Haruna Alidu, M. S. Abdulai, Kwadwo Obeng-Antwi, S. S. J. Buah, Stephen K. Nutsugah, James Kombiok, Mumuni Abudulai and Prince M. Etwire
Estimated Duration: 3 years (May 2014 - April 2017) **Spons ors:** Alliance for Green Revolution in Africa (AGRA)
Locations: On-farm (Tolon, Binduri and West Gonja districts)

Background Information and Justification:
Maize is Ghana's number one staple crop, accounting for 55 percent of total cereal production. About 85 percent of maize produced is used for human consumption, while the remaining 15 percent is used as feed for animals (mainly poultry) (Angelucci, 2012). Maize consumption is projected to increase due to population growth and increasing per capita income. The vast majority of maize is produced by small-scale farmers, most of whom grow maize on marginal lands with low inputs under rain-fed conditions throughout the country. Under these conditions, maize yields average approximately 1.7 MT/ha as against an estimated achievable yield of 6.0 MT/ha (MoFA, 2011). The Guinea and Sudan savannah ecologies of Ghana are high yield potential zones for the production and productivity of maize due to the prevalence of high solar radiation, low night temperatures and low incidence of diseases. However, maize production in these zones is seriously constrained by several biotic and abiotic stresses. Prominent among the stresses are drought, *Striga hermonthica* parasitism and low soil nitrogen (low-N). An annual yield loss from each of these stresses in the savannah zones of Sub-Saharan Africa is estimated at about 10% to 80% of total maize production (Edmeades *et al.* 1995; Kroschel, 1999). Under farmer field conditions, Striga parasitism, drought stress and low-N stress occur simultaneously and the combined effect of these stresses is very devastating posing great threat to maize production and food security in affected areas. In order to increase productivity of maize at small-scale farmer level, maize varieties for cultivation in savannah zones should have desirable level of tolerance to the above stresses. Participatory varietal selection trials of promising drought/Striga tolerant hybrids identified in previous experiments were conducted with farmers to allow their participation in the selection of superior early maturing drought/Striga tolerant hybrids and also to encourage possible adoption of the hybrids after their release.

General Objective: To increase the productivity of maize at small-scale farmer level by developing high yielding maize hybrids adapted to the northern savannah ecologies of Ghana.

Expected Beneficiaries: Male, female and youth in the maize value chain

Materials and Methods:
Eight early maturing hybrids selected from previous experiments in 2011-2013 were evaluated with farmers in Tolon, West Gonja and Binduri districts in northern Ghana. Germplasm used in this study were collected from IITA and local sources. The mother-baby approach was used. The hybrids, TZEI 25 x TZEI 124, TZEI 60 x TZEI 86, TZEI 129 x TZEI 16, (TZEI 63 x TZEI 108) x (TZEI 59 x TZEI 87), (TZEQI 4 x TZEQI 33) x (TZEQI 24 x TZEQI 25), TZEI 31 x TZEI 18 and (TZEI 17 x TZEI 16) x TZEI 157 were planted in three mother trials across the three districts. Hybrids evaluated in the mother trial were grouped into two sets and evaluated in two separate trials on farmers' fields at two communities in each district. The first set of hybrids [(TZEI 63 x TZEI 108) x (TZEI 59 x TZEI 87), TZEI 25 x TZEI 124, TZEI 129 x TZEI 16 and (TZEQI 4 x TZEQI 33) x (TZEQI 24 x TZEQI 25)] were evaluated at Boko, Tingoli and Agriculture Settlement in the Binduri, Tolon and West Gonja districts, respectively. The second set of hybrids [TZEI 60 x TZEI 86, (TZEI 16 x TZEI 157) x TZEI 129, TZEI 31 x TZEI 18 and TZEI 60 X TZEI 86] were evaluated at Kukuo, Sapeliga and

Frafra settlement No.4 in the Tolon, Binduri and West Gonja districts, respectively. Three lead farmers per community were selected from Farmer based organizations (FBO) to host the baby trials. Lead farmers were provided with seeds of four different maize hybrids per trial for testing together with farmers' own control variety. The experiments were laid out in a randomized complete block design and replicated over three farmers' field in each community. Each experimental plot was 10 × 5 m with a gross area of $50m^2$. Spacing between plant to plant and row to row were 40 cm and 75 cm, respectively. On average, about 20 male and 20 female farmers in each community were selected to rank the performance of the varieties at maturity and during harvesting based on their own indigenous criteria using the scores below: 1 = lest preferred, 2 = less preferred 3=fairly preferred, 4=more preferred and 5 = most preferred. Data was recorded separately from each plot for days to 50% silking, days to 50% anthesis, anthesis-silking interval, plant and ear heights, number of ears and plants harvested per plot, plant and ear aspects, ears per plant, field weight, grain moisture at harvesting and 1000 grain weight. The recorded agronomic data were subjected to analysis of variance using PROC GLM in SAS (SAS, 2001). Farmers' selection data were analyzed using simple ranking and descriptive methods in accordance with the given value.

Results/Major Findings:

The results of the mother and baby trials indicated that grain yield, number of ears and plants harvested, ear and plant heights and ears per plant differed significantly ($p \leq 0.01$) among varieties and locations. Genotype x location interaction effect was significant for all traits except for ears per plant. The significant genotype by location effect suggested that the relative performance of the varieties differed across locations due to the present of special environments within the test sites. Mean grain yield was 7.98 t/ha in the mother trials. Mean grain yield of the first set of hybrids evaluated in baby trials ranged from 5.4 t/ha in (TZEI 63 x TZEI 108) x (TZEI 59 x TZEI 87) to 7.7 t/ha in TZEI 25 x TZEI 124. The hybrids, TZEI 25 x TZEI 124, TZEI 129 x TZEI 16 and (TZEQI 4 x TZEQI 33) x (TZEQI 24 x TZEQI 25) (5.80 t/ha), out-yielded the Farmers variety (5.61 t/ha) by 27.4% to 3.3%. Generally, farmers' varieties used in the baby trials were improved late to intermediate maturing open pollinated varieties. TZEI 25 x TZEI 124 was the first most preferred hybrid by both male and femle farmers across the three districts. Among the second set of hybrids, grain yield ranged from 2.86 t/ha in TZEI 31 x TZEI 18 to 5.88 t/ha in (TZEI 17 x TZEI 16) x TZEI 157. The difference in grain yield produced by (TZEI 17 x TZEI 16) x TZEI 157, (TZEI 16 x TZEI 157) x TZEI 129 (5.84 t/ha) and TZEI 60 x TZEI 86 (4.64 t/ha) was not significant. These hybrids yielded 35.0, 34.6 and 17.7 % higher grains, respectively, over the Farmers' variety (3.82 t/ha), while Farmers' variety out-yielded TZEI 31 x TZEI 18 by 25.1%. The hybrid, (TZEI 16 x TZEI 157) x TZEI 129 was the most preferred variety across districts and gender. Farmers' criteria for selection included early maturity, number of cobs per plant, good ear filling, grain yield, drought tolerant, and good stay green characteristics. Female farmers selection was influenced by grain qualities, especially grain colour, yellow maize was most preferred by women.

Conclusions/Recommendations

In general, the experiments have shown a lot of farmer interest in early maturing hybrids and has helped to identify varieties which are considered superior to the varieties commonly used by farmers. The hybrids, TZEI 25 x TZEI 124, TZEI 129 x TZEI 16 and (TZEI 16 x TZEI 157) x TZEI 129 produced stable and high yields across all test locations and have been selected as potential candidates for release.

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ROOTS AND TUBER CROP IMPROVEMENT

Sweetpotato germplasm evaluation for early root and dry matter yield.

Principal Investigator: Kwabena Acheremu
Collaborating Scientists: K. Asare, E. Abidin, T. Carey, I. Abukari, E. Chamba, J. Adjebeng-Danquah. **Estimated Duration:** 2 years (2014-2015)
Sponsors: SARI Jumpstarting OFSP Project
Location: Nyankpala

Background Information and Justification:

High genetic diversity has been observed among the sweetpotato germplasm, with majority being farmers' varieties (Kapinga *et al.* 1995), existing under different names. In sweetpotato, a lot of germplasm diversity assessments have been based on morphological and agronomic traits as well as reaction to pests, diseases, ability to produce storage roots under inadequate rainfall and other stresses (CIP/AVRDC/IBPGR, 1991). These traits, however, vary a lot with cultivars, environment, stage of growth, and cultural practices (Jarret et al., 1992; Gichuru, 2003) and hence unreliable when correct identification of germplasm is desired. These information is very useful for the optimal design of plant breeding programs, influencing the choice of genotypes to cross for development of new populations (Zhang et al., 2000). In Northern ecology, early root development is very critical in the selection of cultivars.

Objectives:
The objective was to establish the optimum time of harvest of 8 sweetpotato advanced materials with high dry matter and storage root yield.

Expected Beneficiaries:
At the end of the studies, the optimum time of harvest for each released variety as well as markets target will be established.

Materials and Methods:
Eight (8) different clones (TU-1-12, Kuffour, TU-Purple, TU-Orange, Apomuden, Nagungungu (Nav-1), Obari) with a loacal check, Voggu were planted in a 4 x 12 m main plot. The main plots were then splitted into 3 subplots, on which 3 harvesting dates were randomly imposed. The main plots were replicated 3 times and the subplots were harvested at 90, 120 and 150 DAP. The data collected were plant establishment, vine length and vigour, root number, root weight, vine weight, virus incidence, root cracks, weevil incidence and number of plants with roots.

Results/Major Findings:

There was significant ($p< 0.05$) cultivar differences, as well as harvest dates on root yield, number of roots, and dry matter percentage. Nav-1 recorded the highest number of storage roots per the plot area 8.8m^2 at 90 and 120 DAP, with average number of 27 and 44, respectively. However, the number of roots dropped to 16 at 150 DAP. In a similarly pattern, the local check, Voggu-O recorded the relatively the lowest number of marketable storage roots of 14, 22 and 10, respectively at the 3 harvest dates (Table 18). At 120 DAP, Nav-1, Kuffuor, Apomuden and Obari recorded about 1 t/ha of root yield per plant.

The line TU-1-12 recorded the highest number of non-marketable storage roots 93, 120 and 125 at the 90, 120 and 150 DAP, respectively (Table 18). TU-1-12 recorded the lowest (5.42 t/ha) marketable roots yield at 120 DAP (Table 18). Apomuden recorded the lowest (1.12 t/ha) marketable root yield at 150 DAP. This low results could be attributed to the high root damage recorded. The highest marketable root yield (5.37 t/ha) was recorded by obari at 150 DAP. This results is suggest that Obari can be left stored in-ground beyond 120 DAP and harvested at piece meal.

Table 18: *Marketable and Non-marketable storage root yield at different harvesting dates.*

	CRWtha			NCRWtha		
Variety	**90 DAP**	**120 DAP**	**150 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
Apomuden	5.51	10.93	1.12	2.7	3.55	11.73
Kuffour	5.61	13.36	4.63	1.94	1.18	9.17
Nav-1	**7.97**	**16.03**	4.02	**4**	**5.78**	**12.55**
Obari	5.17	13.53	**5.37**	2.13	4.17	11.15
TU-1-12	2.72	5.42	3.6	2.65	5.54	7.84
TU-Orange	1.67	6.08	4.14	2.52	4.66	7.4
TU-purple	5.05	8.87	4.14	2.5	2.75	6.99
Voggu-O	3.68	7.25	2.62	2.25	2.99	6.89
Mean	*4.7*	*10.2*	*3.7*	*2.6*	*3.8*	*9.2*
CV(%)	*31.9*	*31.9*	*31.9*	*30.6*	*30.6*	*30.6*
Lsd	*3.03*	*3.03*	*3.03*	*2.1*	*2.1*	*2.1*

CRW tha= Marketable/commercial roots weight in tonnes per hectare, N0NCR= Non-marketable/Non-commercial roots weight in tonnes per hectare, DAP= Days after planting

Conclusions/Recommendations :

There was a general pattern of growth and yield of the sweetpotato evaluated. Genotypes Kuffour, Nav-1, which are orange-fleshed varieties, and Obari, a white type, have been identified to have great potential for release in the sweetpotato growing areas in the North. They are shown to be early, high yielding and of relatively high DM%. Above all, well adapted to the northern ecology. On the other hand, TU-Purple recorded relatively high yields, resilience, and high DM, with high anthocyanin, will also be considered for release because of its unique nutritional value.

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Multi-locational evaluation of sweetpotato germplasm for yield stability.

Principal Investigator: Kwabena Acheremu.
Collaborating Scientists: K. Asare, E. Abidin, T. Carey, E. Chamba and I. Abukari
Estimated Duration: 2 years.
Sponsors: SARI Jumpstarting OFSP Project
Location: Nyankpala, Damongo, Manga and Navrongo

Background Information and Justification:
Sweetpotato is one of several crops that farmers can produce to obtain cash income in addition to subsistence food security. Sweetpotato roots are a healthy food because all varieties have high levels of vitamins C and E, several B vitamins, iron, zinc, potassium, and fibre. There is lack of access to virus- and pest-free "clean" planting material, as well as improved varieties adapted to local environments that meet consumer preferences is hampering production. With high sweetpotato germplasm diversity observed among farmers, majority being farmers' varieties (Kapinga *et al*. 1995), existing under different names. The correct identification of germplasm is desired. These information is very useful for the optimal design of plant breeding programs.

Objectives :

1. Characterize 6 sweetpotato clones for yield performance across the Guinea, Sudan and Sahel savannah zones in Northern Ghana.
2. Identify and document their responses to pest and diseases.
3. Register the best performing clones with the National Varietal Release Committee for official release.

Expected Beneficiaries:
The clones are being evaluated at the multi-locations for observation and release as varieties for Northern Ghana.

Materials and Methods:
Four (4) germplasm materials namely, Nav-1, TU-purple, Kuffour, TU-orange and 2 checks, Apomuden (improved cultivar) and farmers' variety were evaluated at Damongo, Manga, Nyankpala and Navrongo. They were established in a randomized complete block design and replicated 3 times in a plot size of 4m x 5m. Data collected include vine establishment, disease and pests incidences, vine vigour, vine weight, root number and yield, dry matter yield. Farmers' acceptability test for boiled roots were also carried out (Data unavailable).

Results/Major Findings:
There were significant ($p<0.05$) differences among the genotypes and across locations, in terms of yield and yield parameters measured. Apomuden recorded the highest (43) number of marketable storage roots (weighing 200g and above) in Nyankpala and 66 in Navrongo, but lowest (4) in Bawku. Nav-1 recorded significantly higher number of marketable roots across the 4 locations. This performance is consistent across the 4 locations and makes Nav-1 adaptable to these locations. Similarly, Nav-1 recorded 17.54, 22.10 and 3.30 t/ha of marketable storage roots in Nyankpala, Navrongo and Bawku, respectively, the highest among the cultivars, except that of Damongo, where Apomuden recorded the highest yield of 10.4t/ha. In the same pattern Nav-l recorded the highest non-marketable root yield of 5.34, 5.45, 2.92 and 4.58 t/ha in Nyankpala, Navrongo and Bawku, respectively.

Conclusions/Recommendations:
The yield potentials of the genotypes were shown in terms of root yields and other parameters across locations, but relatively low in Bawku. Nav-1, which is an orange-fleshed type was the best in terms of root yields in Nyankpala, Navrongo and Bawku. Although, the yield value (8.11t/ha) of Nav-1 in Damongo was not the highest, it was not significantly different from those of Apomuden (10.4 t/ha) and TU-Orange (9.28t/ha), which are also orange-fleshed types. The best genotypes will be identified for official release.

Multi-locational trials will be carried out in Nyankpala, Manga, Damongo and Wa stations using Nav-1, TU-purple, Kuffour, TU-orange, Obari and 2 checks, Apomuden (improved cultivar) and farmers' variety. They will be established in a randomized complete block design and replicated 3 times in a plot size of 4m x 5m. Data to be collected include vine establishment, disease and pests incidences, vine vigour, vine weight, root number and yield, dry matter yield, as well as top biomas.

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Kapinga, R. E., Ewell, P. T., Jeremiah, S. C., and Kileo, R. 1995. Sweetpotato in Tanzania farming and Food Systems: Implications for research. Dar es Salam: Internatonal Potato Centre and Ministry of Agriculture.

Evaluation of cassava clones for yield Stability and adaptability in the Guinea Savannah ecology of Ghana.

Principal Investigator: Kwabena Acheremu
Collaborating Scientists: E. Y. Parkes, B. Pepra, A. Agyemang, J. Adjebeng-Danquah and E. B. Chamba
Estimated Duration: 2 years
Sponsors: IITA (Nigeria)
Location: CSIR-SARI, Nyankpala and CSIR-CRI, Kumasi

Background Information and Justification:

Cassava (*Manihot esculenta*, Crantz) is incorporated into many household diets in Northern Ghana, used mainly as flour from dried chips. It is grown by resource-poor farmers, mainly women, often on marginal lands for food security and income generation. It also has the potential to produce starch for industrial purposes as well as feed for livestock production at a relatively cheaper cost than maize (Nweke *et al*., 1994). It has become an important crop because it is relatively inexpensive to cultivate and survives the 5-6 months of sometimes-absolute dry weather before harvest during the next wet season. The Northern parts of Ghana is noted for its short period of rainfall and interspersed with periods of intermittent drought leading to low productivity of most crops. Yield losses due to water deficits however vary depending on timing, intensity and duration of the deficit, coupled with other location-specific environmental stress factors such as high irradiance and temperature (Serraj *et al*., 2005).

Cassava materials from IITA were received for evaluation in the Savanna ecology for adaptability study. This requires extensive study of the attributes in this unique environment over years before realistic recommendations for favourable performance under this agro-climatic zone can be made.

Objectives :

1. To study the effect of environment on performance of some introduced cassava lines.
2. To identify physiological traits that are related to yield in Northern Ghana.

Expected Beneficiaries:
High yielding cassava varieties that are high in starch content would be developed under the Northern ecology for the starch industry.

Materials and Methods:
Eighteen (16) cassava genotypes received from IITA, together with two local check materials, "Biabasse" and "Eskamaye" were evaluated in the 2013 season. The genotypes that were in 60 cuttings each, except the genotype "IITA TMS IBA 010034" that had 40 cuttings, were received on the 1st June 2013.

The cassava stakes measuring 25-30cm were planted on the 3rd June 2013, using a standard spacing of 0.8m x 1m, giving 4 row plot of 1m apart and 5 plants within row of 0.8m planting distance, giving a total population density of 12,500 plants/ha. The experiment was planted as an Advanced Yield Trial (AYT) in a randomised complete block in three replications.

The work was carried out on the Savannah Agricultural Research Institute research fields at Nyankpala. The land was ploughed and harrowed after which ridges were constructed. Data were recorded on the two central rows for growth parameters. Data taken includes number of leaves as an indicator of leaf retention, plant height, number of roots per plant, root diameter and length, root tuber yield and harvest index which was calculated as the ratio of tuber yield to total biomass. Analysis of variance was performed using Breeding View

Results/Major Findings:

Scientific findings
The correlation table shows positive relationship between root tuber yield and root per plant (0.634) and number of roots harvested (0.681). This indicate that these traits can be targeted when selecting genotypes for improved yield. However, the root yield was negatively correlated with the top weight (-0.501) and harvest index (-0.539). Similarly, the number of roots showed negative correlation with the top weight of plant (-0.227). This implies that, in the growing conditions, there is competition between allocations of assimilates to the roots and the top part of plant.

Field performance of the 18 cassava genotypes.
The ANOVA showed significant differences ($p<0.001$) among the 18 genotypes for the root yield and number of roots per plants. The genotype IBA 020452 recorded the highest root yield (26.17t/ha), which is statistically similar to the yield for genotypes IBA 070134, IBA 010034 and *Eskamaye,* which recorded root yields of 25.17, 24.83 and 24.83 t/ha respectively . The root yield of *Eskamaye,* one of the locally released cassava materials was only 1.33 t/ha lower than that of the highest genotype. The local farmer preferred variety *Biabasse* recorded root yield of 21.0 t/ha, which was also not statistically different from that of the highest yielding genotypes. The lowest yield (13.5 y/ha) value was recorded by the genotype IBA 061635.

The genotype IBA 010034 recorded 11 roots/plant, which was the highest number among the genotypes. This number was not statistically different from those recorded by "Eskamaye", IBA 020431, IBA 070134, IBA 30572, IBA 9102324 and IBA 980505, which recorded a value of 10 roots /plant each. The lowest of 5 roots/plant was recorded by IBA 061635. The highest HI of 84% were recorded by IBA 950289 and IBA 011371 among the genotypes.

Conclusions/Recommendations :
Eight (8) of the introduced cassava materials were outstanding compared to the local farmer preferred variety *Biabasse*. However, *Eskamaye,* one of the locally released cassava materials among the genotypes in the study compared favourably with the IBA 020452 and IBA 070134, the highest genotypes in terms of recorded root yield of 26.17 and 25.17 t/ha, respectively, over 24.83 t/ha, the difference which was not statistically significant. Their relatively better performance in number of roots per plant and other growth parameters makes them locally adapted genotypes for improved performance under the Northern conditions.

Future activities / the way forward
The study has been repeated this 2014 season to further evaluate their performance that will enable us make an informed decision with regards to the best adapted genotypes in Northern Ghana

Yam Improvement for Income and Food Security in West Africa (YIIFSWA) (Agronomic model trial)

Principal Investigator: Emmmanuel Chamba (PhD)
Collaborating Scientist: Emmanuel Amponsah Adjei
Estimated duration: 5 years
Sponsors: IITA/Bill and Melinda Gates Foundation
Location: Multi-locational

Background information and Justification:
Yam (*Dioscorea rotundata*) is a major staple in West Africa and forms part of household diets of the people of northern Ghana. Globally, over one hundred million (100, 000 000) people depend on yam as a staple food worldwide. It is a dependable food security crop and has a socio-cultural importance to the people of Africa. It contribute significantly to the national Gross Domestic Product (GDP), generate income and employment to small scale farmers and value chain service providers in terms of processing as well as local and international service providers in yam. Despite the important role yam plays in the socio-economic lives of humankind, the yam production is constrained by a number of factors and notable among them are unavailability of quality planting seed yam, low yield, low soil fertility due to continuous cultivation, high cost of labour, susceptibility to insect pest and diseases, inadequate market

and high postharvest losses. The yam improvement programme is aimed at developing improved yam varieties and agronomic packages suitable for production and processing of yam

Objectives: To evaluate and scale out yam production technologies with improved and local varieties.

Expected beneficiaries: All actors in the yam value chain

Materials and Methods:

Trial location and models

The trial was conducted in 9 communities in three districts namely Tolon (in Kpalsogu, Tuunayilli Kukuo communities), Mion (Salankpang, Sanzee Sang communities) and East Gonja districts (Adamupe, Bagabaga and Salaga communities). The trial in a community consisted of 5 models with different fertilizer treatments.

Table 19: Models with fertilizer treatments

Model 1	Model 2	Model 3	Model 4	Model 5
Treated seed with fungicide and insecticide	Treated seed with fungicide and insecticide	Treated seed with insecticide and fungicide	Treated seed with insecticide and fungicide	Farmers' Practice
Fertilizer: 45-45-60 $N:P_20_5:K_20$ kg/ha (6 bags/ha of50kg NPK plus 29kg of potash)	Fertilizer: 45-45-60 $N:P_20_5:K_20$kg/ha plus **Agrolyser** Micronutrient fertilizer	Fertilizer: 30-30-30 Kg NPK/ha; plus 15Kg/ha of Mg and 20Kg/ha S as MgSO4 (4 bags/ha of 50kg f NPK plus 3 bags of Epson salt)	Fertilizer: 15-9-20 $N:P_20_5:K_20$ kg/ha + 5 kg/ha MgO + 8 kg/ha S + TE (5 bags/ha of 50kg Yara Winner NPK formulation)	
Weed control: Terbulor 500 EC 1 L/ha, + Glyphosate 2.5 l/ha	Weed control: Terbulor 500 EC 1 L/ha, + Glyphosate 2.5 l/ha	Weed control: Terbulor 500 EC 1 L/ha,+ Glyphosate 2.5 l/ha	Weed control: Terbulor 500 EC 1 L/ha, + Glyphosate 2.5 l/ha	

Varieties and Planting

Fifty mounds with a spacing of 1.2 m x 1.2 m were prepared per model. With the exception of the control model, yam setts were treated with 100 mls of cymetox super, 24 g Topsin M and 100 g of wood ash in 60 liters of water to protect the yam setts against rot and termites attack. Yam setts of average size of 350g were planted on a mound and the mound mulched. Yam variety *Chenchinto* was planted in Mion and Tolon districts and Pona in East Gonja district. Planting was done on 10/06/2014, 19/06/2014 and 25/06/2014 respectively, at Tolon, Mion and E. Gonja districts.

Weed control

Weeds were controlled with Terbulor 500 EC (pre-emergence herbicide) at a rate of 1 l/ha, and gylyphosate (post-emergence herbicide) was applied at a rate of 2.5 l/ha after planting and 6 weeks after planting (WAP) respectively.

Fertilizer application

All fertilizers with the exception of agrolizer and Epson salt were split applied at eight and 10 WAP. The fertiliser was applied in five holes of about 3-5 cm deep around the top portion of the mound about 25-30 cm from the tip of the mound and covered with soil.

Agronomic data

Agronomic data collected were sprout count, disease and pest scores, number of seed and ware yam, weight of seed and ware yam. Farmers were selected from the community and categorized on gender and age as elderly men, young men, elderly women and young women evaluated plant and tuber characteristics at the vegetative stage and at harvest. Tubers from the models were ranked by the farmer groups.

Results/Major findings:

Percentage lost after 8 WAP

Percent loss of seed yam at eight WAP ranged from 0 – 25% in Tolon and East Gonja districts and 0-50% in Mion district. The farmer practices recorded the high percentage across the districts. Generally, percent loss of seed yam was high particularly in the Mion district due to late planting.

Weights of seed and ware yam

Seed yam yield was highest with Model 1 among districts with the exception of Mion District which indicated a yield of 1,912 kg/ha. East Gonja recorded the highest weight of seed yam as 4,138 kg/ha and all the models recording seed yam yields significantly higher than the farmer practice. At Tolon and Mion districts seed yam yields were the same as that of the Farmer practice.

Fresh yam weight in each District ranged from 1,946 kg/ha (Mion) to 6,922 kg/ha (Tolon). Generally, fresh tuber yields were higher with the application of the models than the Farmer practice although statistically they were the same except in East Gonja where the application of models gave yields significantly higher than the Farmer practice. Fresh tuber yields were highest in the Tolon district with a mean of 5,977 kg/ha. Soils in the Tolon district have been classified as low in fertility and the response of yam to fertilizer application in particular would have accounted for the high response yam to the models.

Ranking of fresh tubers

In 2014 Farmers evaluation, the overall preference of farmers in the three districts was Model 4 (first position and Models 1 and 3 (both in second position). The results showed that farmers preferred the models consisting of seed treatment, fertilizer application and herbicide application over their own practice. Some of the reasons considered for selection of a model included size of tuber, number of seed yam, marketability of tubers, and potential for multiplication for seed yam, disease-free, smooth skin, appealing in appearance, and nice shape for tubers, larger size tubers, and potential for high yield.

Table 20: *Seed yam weight (kg/ha) in the district*

Model	District		
	Tolon	Mion	East Gonja
	weight of seed yam (kg/ha)	weight of seed yam (kg/ha)	weight of seed yam (kg/ha)
1	3687	1912	3470
2	2540	2563	3422
3	2202	2117	4135
4	1428	2053	3326
5	2499	2092	2691
MM	2471	2147	3409
CV%	17.2	10.4	17
LSD (0.05)	2558	1214	1349

Table 21: *Tuber weight (kg/ha) of ware yam in the district*

Model	District		
	Tolon	Mion	East Gonja
	Weight of ware yam (kg/ha)	Weight of ware yam (kg/ha)	Weight of ware yam (kg/ha)
1	6922	1946	3344
2	5931	1588	3896
3	6730	2122	3879
4	6785	2680	5314
5	3516	2847	3688
MM	5977	2237	4024
cv%	13.6	21.7	13.3
LSD (0.05)	1881	1656	2426

Conclusions and Recommendations:

All project beneficiaries were excited about the demonstration and results obtained from the models in the various communities. Most of them remarked that the activities for the project gave them the opportunity to learn simple models with new fertilizer treatments for yam cultivation. Ranking by farmers clearly showed the differences in the effect of the fertilizer treatments with the control or farmers' practices in yam cultivation. Model four was overall preferred by farmers and that can be seen form the yield of the seed and fresh tubers.

Yam Improvement for Income and Food Security in West Africa (YIIFSWA)
(Economic Analysis of the Effect of Fertilizer Application on the Performance of Yam)

Principal Investigator: Emmanuel. B. Chamba (PhD)
Collaborating Scientist: Emmanuel Amponsah Adjei
Estimated duration: 5 years
Sponsors: IITA/ Bill and Melinda Gates Foundation (BMGF)
Location: Multi-locational

Background information and Justification:

Objectives: To evaluate and scale out yam production technologies with improved and local varieties.

Expected beneficiaries: All actors in the yam value chain

Materials and Methods:
The farmer preferred model from two years (2012-2013) of evaluation of the agronomic model was scaled up in Tolon, Mion and East Gonja Districts to 1000 yam mounds per district. The model/Improved Technology (IT) composed of seed yam treatment with fungicide Topsin M and wood ash, 30-30-30 kg/ha, 15 kg/ha of Mg and 20 kg/ha S as MgSO, and weed control using Terbulor 500 EC at 1l/ha (pre-emergence herbicide) and Glyphosate at 1.0 -1.5 l/ha (post-emergence herbicide). The model was compared with the Farmer Practice (FP) without seed treatment, fertilizer and herbicide application. The IT was imposed on 800 mounds and the FP on 200 mounds at a spacing of 1.2 m x 1.2 m. Data was collected for tuber yield and its components and for cost benefit analysis estimated on the IT and FP.

Results/Major findings:
Harvest components
The numbers and weights of seed yam and ware yam of IT and FP in the three districts showed significant differences. The number and weight of both seed yam and ware yam were significantly higher with the IT than the FP (Table 1).

Cost benefit analysis

Tables 1 and 2 shows the cost benefit analysis of the scale up trial in the three district. The total cost incurred for the IT was identified to be 1,089 GH₵/ha whilst the FP cost 450 GH₵/ha. The net benefit was identified to be 4,003 GH₵/ha for the IT across the districts with a Marginal Rate of Returns (MRR) of 196% indicating a high profit making in the use of the IT as compared to the PF with a net benefit of 2,752 GH₵/ha. This also means that, for every cedi a farmer invests in moving from their practice to improved technology, they gets back their cedi plus an additional GH₵1.96.

Table 22: Agr onom ic model and Farmers' practice scaled up in three districts

Model	Stand /144 m^2	Wt. of seed Yam (kg/ha)	Wt. of Ware Yam (kg/ha)	Total Yield (kg/ha)
Improved Tech	94	4511	2292	6803
Farmers' Tech.	69	3063	279	3341
Mean	81	3787	1285	5072
S.E.D	15.4	184	462	1604

Table 23: Cost benefit analysis for Improved Technology and Farmer practice

Variables	Improved Technology		Farmers' Technology	
	Seed yam	Ware Yam	Seed yam	Ware Yam
Mean Yield (kg/ha)	4511	2292	3063	279
Adjusted yield (10%)	4060	2063	2757	252
No. of seed yam	8120	1844	6116	762
Gross benefit ₵/ha	3248	1844	2440	762
Total gross benefit ₵/ha	5092		3202	
Cost of 15:15:15 and application ₵/ha	440		-	
Cost of $MgSO_4$ and application ₵/ha	178		-	
Cost of seed treatment ₵/ha	83		-	
Cost of herbicide and application ₵/ha	88		-	
Manual weed control ₵/ha	300		450	
Total cost that vary ₵/ha	1089		450	
Net benefit ₵/ha	4003		2752	
Marginal Rate of Return (%)	196			

NB: 1 ware yam = 1 GhC and 100 seed yam = 40 GhC

Technology developed

Farmers in the various districts of trial implementation appreciated the technology developed from the yield and observed from the seed and fresh yam.

Technology transfer

In all about 600 farmers were reached in the 3 districts with the technological package.

Conclusions and Recommendations:

It is realized from the trial that, every farmers stand the chance of benefiting from the technology if executed well in the farmers' field. It is recommended that the technology is implemented in more communities in each district to transfer the technology to more farmers and also take place on the farmers' field.

Increasing Productivity and Utilization of Food Yams in Africa (IPUFYA)

Principal Investigator: E. B. Chamba (PhD)
Collaborating Scientist: Alhassan Sayibu and Emmanuel Amponsah Adjei
Estimated duration: 5 years
Sponsors: Ministries of Food and Fisheries (MAFF) and International Institute for Tropical Agriculture (IITA)
Location: Multi-locational

Background information and Justification:

Yams (*Dioscorea* spp) are native to the old world tropics with wild species found in both Africa and Asia (FAO, 1985). West Africa produces over 90% of the total world production of 20-25 million tons annually (Obeng-Ofori, 1998). Ghana produced over six million metric tons of yams in 2011 which accounted for over 1.6 million US Dollars, making it the number one foreign exchange earner in terms of agricultural commodities (FAO, 2013).

Staking of yam vines is known to promote tuber yield. Most of the work on staking has been reported on tuber yield obtained at the end of the growing season. So far, there has not been much work done on the effect staking has on yield of seed yams. In shifting agricultural systems, yams are almost invariably planted first in the cropping cycle, immediately after clearing the fallow. In areas where fallow length has been reduced due to land pressure, yams are less frequently grown as the soil is regarded as insufficiently fertile for them. Yet, very little research has been done to quantify the amount of organic and inorganic fertilizer needed for sustainable yam production on a physically degraded soil in the northern part of Ghana.
This reports on work done to assess the effects of staking, fertilizer and spacing on yam yields in the Northern Part of Ghana.

Objectives: To increase productivity of yam through generation of scientific knowledge and technologies to meet needs arising from decreasing soil fertility caused by continued soil cultivation without nutrient replenishment in high poverty areas.

Expected beneficiaries: All actors in the yam value chain

Materials and Methods:

The experimental design was a factorial experiment in Randomized Complete Block Design and replicated three times. A combination of five levels of fertilizer (4 bags winner, 4 bags winner + fertilsols, 8 bags Winner, 8 bags Winner + fertisols and no fertilizer), two levels of spacing (1.2 m x 1.2 m and 1 m x 1 m) and two levels of staking (staking and no staking) were the treatments. Plot sizes were 6.0 m x 4.8m and the yam variety Pona with seed weight of 300 – 350 g/sett was treated and planted. Winner fertilizer (15N:9P20K:95S: 1.8MgO+ TE) was split applied at 8 and 12 weeks after planting. Fertisol (organic fertilizer) was applied at 8 weeks after planting. Soils samples were taken before planting and at harvest.

Preference analysis where farmers preferences for descriptors of the yam plant and tuber or not and the reasons for the preference was carried out at the vegetative phase and at harvest. The descriptors included sprouting percent, plant vigour, number of stems per stand, magnitude of canopy cover, leaf texture, leaf size, leaf colure, leaf shape, presence or absence of thorns, flowering ability, insect damage and disease infection. Farmers also conclude by scoring the genotype as good, very good, fairly good and not good. Insect pest and disease score was taken at the vegetative phase to assess the incidence and severity. Agro morphological data such as plant height, number of stem, internode length, and stem diameter was taken using tape measure and a measuring stick. SPAD reading was taken to assess the chlorophyll content of leaves for each treatment.

Results/Major findings:

The effect of fertilizer treatments on the weight of seed and ware yam were not significantly different. The total weight of yam for fertilizer combination (8 Winner + OM) however showed the highest weight of 15,889 kg/ha compared to the other fertilizer combinations. The least was observed for the control in terms of weight of ware yam with a total weight of 12,476 kg/ha.

There were significant differences in the interaction between staking and spacing levels. No staking at a spacing of 1 m x 1 m recorded the height total weight of yam at 15,561 kg/ha and the least weight was noted for staking at a spacing of 1.2 m x 1.2 m with a weight of 13,586 kg/ha.

Table 24: *Fertilizer combination and weight (kg/ha) of seed and ware yam*

Fertilizer	Weight of seed yam (kg/ha)	Weight of ware yam (kg/ha)	Total weight of yam (kg/ha)
No Fertilizer	4321	8155	12476
4 Winner	4398	8792	13190
4 Winner + OM	3741	9107	12848
8 Winner	3944	9788	13732
8 Winner + OM	4894	10995	15889
LSD	NS	NS	NS
cv%	43.8	52.3	34.1
MM	4300	9367	13667

Table 25: *Staking, spacing and weight (kg/ha) of seed and ware yam*

Stake	Spacing	Weight of seed yam (kg/ha)	Weight of ware yam (kg/ha)	Total weight of yam (kg/ha)
Staking	1x1	5290	8470	13760
No Staking	1x1	4394	11167	15561
Staking	1.2x1.2	4231	9355	13586
No Staking	1.2x1.2	3344	8476	11820
LSD		1406	NS	NS
cv%		43.8	52.3	34.1
MM		4300	9367	13667

Conclusions and Recommendations:

The combination of organic and inorganic fertilizers did not show any significant differences with the control. In view of that, the experiment is going to be repeated.

SORGHUM IMPROVEMENT

Evaluation of sorghum hybrids from ICRISAT, Mali in Guinea savanna zone of Ghana

Principal Investigator: K. Opare-Obuobi
Collaborating Scientists: Dr. S. S. J. Saaka, Dr. R. A. L. Kanton
Estimated Duration: 2 years
Sponsors: IITA, AfricaRising Project
Location: Damongo, Nyankpala, Manga and Wa

Background Information/Justification/Introduction:
Sorghum yields range between 500 and 800 kg/ha in the Northern Region and slightly higher (between 700 and 900 kg/ha) in the Upper Regions. Several factors contribute to this including the use of indigenous landrace varieties with inherent low yield potential, lack of a wide diversity of new improved varieties and hybrids, little or no use of fertilizer and low planting densities characteristic of traditional mixed cropping systems (Schipprack and Mercer-Quarshie, 1984; Atokple et. al. 1998). This implies that with the increasing cereal demand for human consumption, sorghum production must be increased by enhancing yield potential per unit area as land holdings continue to diminish due to the increasing human population and urbanization of the agricultural land. The use of sorghum hybrids is one of such technologies which will provide opportunities for both increased productivity through the exploitation of heterosis and access to markets that demand a more standardized product quality through sales of surplus production. To this end, CSIR-SARI under the AFRICA RISING project as short term strategy has evaluated hybrids from ICRISAT for their performance and adaptability in the Guinea savanna agro-ecological zone. The present study was therefore designed to evaluate sorghum hybrids with the aim of identifying and selecting well adapted and high yielding hybrids for increased sorghum production and productivity.

Brief Objectives: Identify and select high yielding hybrids line(s) that are to the Guinea and Sudan savanna agro-ecological zone of Ghana.

Expected Beneficiaries: Farmers

Materials and Methods:
Ten (10) genetic materials including eight (8) hybrids from ICRISAT, Mali and two (2) local checks Kapaala (early maturing, OPV) and Mankariga (late maturing, OPV) were evaluated (Table 1). The trial was conducted in two locations in the region, namely Nyankpala and Damongo in the Northern Guinea Savanna Zone, 09° 25’ N and 00° 58’ W, and 09° 01’ N and 01° 36 W respectively. The trials were planted on the 29th June 2014 in Nyankpala and 3rd July 2014 in Damongo in a Randomized Complete Block Design (RCBD) with four replications. Six-row plots of length 5 m with the inner four rows serving as the net plot for data collection. An inter-row spacing of 0.75 m and intra-row spacing of 0.30 m. Three to four seeds were planted per hole and later thinned to one seedling per stand without transplanting two weeks

after planting. Data collected included grain weight, days to fifty percent heading, plant height, number of empty panicles due to bird damage, number of empty panicles due to midge infestation, number of panicles affected by grain mold and participatory varietal selection with farmers. Data collected was subject to statistical analysis of variance using the GENSTAT Package. Where significant differences existed between means, least significant difference was used too separate means.

Table 26: *Sorghum Hybrids Evaluated*

No	Genotype	Origin
1	Caufa	ICRISAT, Mali
2	Soumalemba	ICRISAT, Mali
3	Sewa	ICRISAT, Mali
4	Mona	ICRISAT, Mali
5	Fadda	ICRISAT, Mali
6	+Grinkan Yerewolo	ICRISAT, Mali
7	Yamassa	ICRISAT, Mali
8	Pablo	ICRISAT, Mali
9	Mankariga (*LL)	CSIR-SARI, Ghana
10	Kapaala (*EL)	CSIR-SARI, Ghana

* LL – Late local, EL – Early local, + Not included in the evaluation due to late arrival of seeds

Major Findings

Grain yield among the genotypes evaluated varied greatly across the two locations. The Caufa with yield of 2466 kg/ha recorded the most yield across locations though not statistical different from yields obtained from Pablo (2362 kg/ha) and Mona (2267 kg/ha) Table 20. Kapaala (E.L) unlike Mankariga (L.L) with yield of 1963kg/ha though early maturing performed better than some hybrid lines (Table 20). Mankariga recorded very low yield due to the heavy infestation of midge insect in both location (Figure 4). Kapaala (early local) with 61 days to heading recorded the least days to heading while Mankariga (late local) recorded the highest number of days to head (116 days).

Table 27: ***Grain yield, biomass yield and days to 50% heading of the hybrid lines evaluated***

Genotype	Grain yield (kg/ha)			Days to 50% Heading		
	Damongo	Nyankpala	Mean	Damongo	Nyankpala	Mean
Caufa Fadda	1792.7	3138.4	**2466 a**	68.5	72.25	70.38 b
Kapaala (EL)	1137.8	2641.3	1890 c	74.25	75.5	74.88 c
Mankariga (LL)	1308.3	2618.2	1963 bc	61.25	60.5	**60.88 a**
Mona	405	47.8	**226 f**	114.25	117.5	**115.88**
Pablo	1369.2	3165.8	2267 ab	70.75	69.75	70.25 b
Sewa	1825	2898.9	2362 a	70	72	71 b
Soumalemba	520.2	1441.3	981 de	73.25	78.5	75.88 c
Yamassa	758.2	1866	1312 d	86.75	104.25	95.5
	373.5	1383.6	879 e	75	79.75	77.38
Mean	1054.4	2133.5		77.11	81.11	

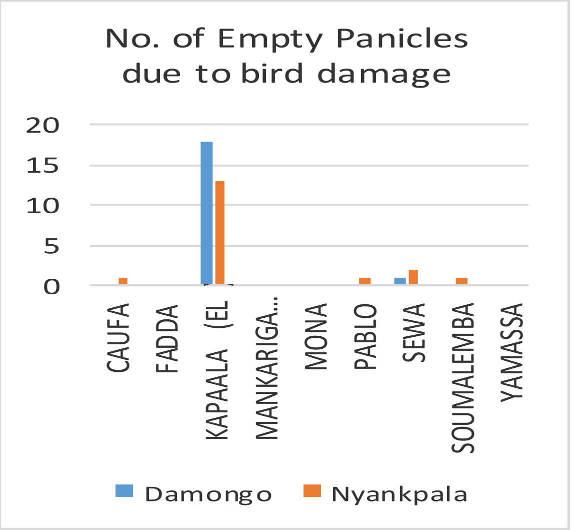

Figure 3: Number of empty panicles due to bird damage

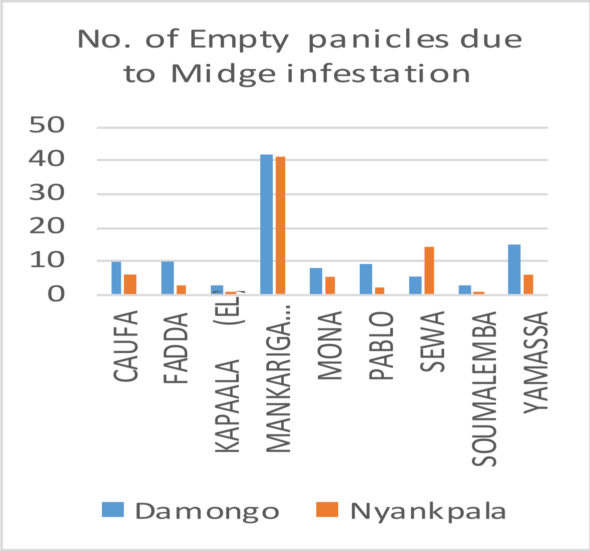

Figure 4: Number of empty panicles due to midge infestation

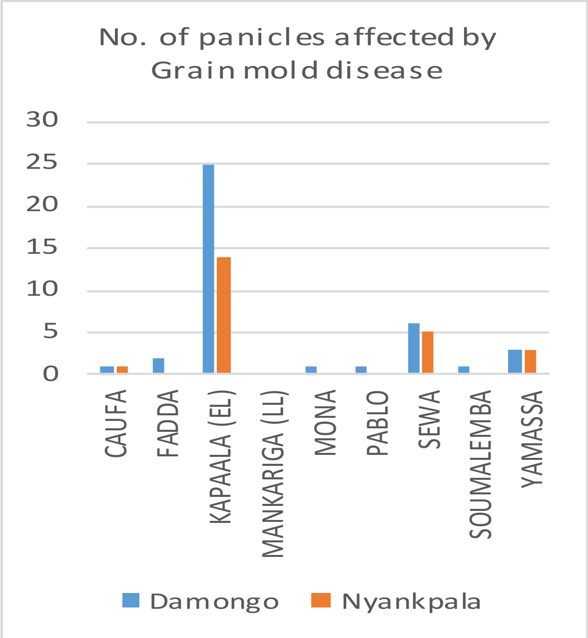

Figure 5: Number of panicles affected by grain mold disease

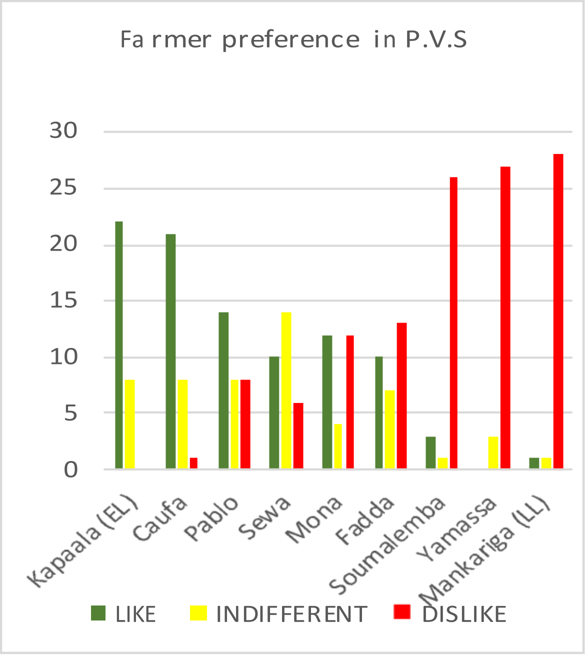

Figure 6: Hybrid selection by some sorghum farmers

Kapaala suffered the most from bird damage largely due to its earliness, plant height and glume covering of the grain. Most of the hybrids evaluated were tall and lodges whenever birds stood on it. This prevented birds from feeding comfortably (Figure 3). Mankariga recorded the most heads infested by midges. This was due to its lateness to maturity as a result of the buildup of the insect on the early maturing lines. Kapaala with it earliness to mature suffered the most from grain mold disease (Figure 5). The early planting made it to mature at a time when the rains were still high. Most of the hybrid lines did not show signs of moldiness with the exception of Sewa which recorded 11 panicles with grain molds. Farmers still preferred Kapaala (E.L) to the hybrids evaluated due to its earliness and grain colour despite it susceptibility to grain mold disease and bird attack. Caufa was the most preferred hybrid followed by Pablo and Sewa due to it thick stalk, resistance to bird attack and earliness to mature compared to Soumalemba, Yamassa and Mankariga.

Conclusion

Caufa, Pablo and Mona were the most promising lines with yields excessing 2 t/ha. Kapaala a commercial variety is still popular with farmers despite its production challenges. Improving the variety to be grain mold and bird resistant will greatly improve yields of farmers.

Evaluation of Kapaala and its open-head derivatives

Principal Investigator: Kenneth Opare-Obuobi
Collaborating Scientists: Peter Asungre
Estimated Duration: 5 years
Sponsors: WAAPP 2A
Location: Damongo, Nyankpala, Manga and Tumu

Background Information/Justification/Introduction:
Kapaala, released in 1996 has since been the most popular commercial variety cultivated within the Guinea and Sudan savanna agro-ecological zone of northern Ghana. Though high yielding the variety is very susceptibility to the grain mold disease due to its compact head or panicle. The panicle architecture tends to promote the proliferation of the disease hence the need to modify the panicle through breeding. In the light of this challenged, Kapaala was crossed to Kadaga (improved landrace) producing the derivatives with open panicle architecture with various height and glume colours. Unlike the closed panicle of Kapaala, its open derivatives are expected to curb the situation by providing less conducive environment for insects (head bugs) thus reducing in the incidence of grain mold disease.

Brief Objectives:
Identify and select grain mold resistant line(s) that are high yielding and adapted to the Guinea and Sudan agro-ecological zone.

Expected Beneficiaries: Farmers

Materials and Methods:
10 genetic materials as shown in table 1 were evaluated in 4 locations with the Guinea and Sudan savanna zones of Ghana. All trials were planted between 2nd June and 10th July 2014 and laid out in RCBD with 4 replications. There were 6-row plots of length 5 m with the inner 4 rows used as the net plot for data collection. Spacing of 0.75 m and 0.30 m inter- and intra-row respectively was used. 4-5 seeds were planted per hole but thinned out to two seedlings per stand two weeks after planting. Data collected included grain yield, days to 50% heading, head bug population, head bug damage, panicle grain mold rating and threshed grain mold rating. Grain damage by head bug was scored on a 1 to 9 rating scale where 1 = all grains fully developed with a few feeding punctures and 9 = most of the grains highly shrivelled and almost invisible outside the glumes. Grain mold scores were taken twice, first at physiological maturity where panicle grain mold rating (PGMR) was progressively scored on a 1 to 5 scale where, 1 = no mold, 2 = 1-10 %, 3 = 11-25 %, 4 = 26-50 % and 5 > 50 % grains molded on a panicle on the tagged panicles in the field. The second, threshed grain mold rating (TGMR), was on the bulked threshed grain according to the method used by Thakur *et al*., 2006b. Data collected were subjected to statistical analysis using the GENSTAT Package. Statistical comparison was done at 5% significance level. Least significance difference (L.S.D) was used to separate line means where significant differences existed among means. Graphical presentation of some measured parameters was done.

Table 28: *Kapaala and its derivatives evaluated in 2014*

No	LINE	Origin
1	SARSORG-T RG 2011-1	Ghana
2	SARSORG-T BG 2011-2	Ghana
3	SARSORG-M RG 2011-3	Ghana
4	SARSORG-M BG 2011-4	Ghana
5	SARSORG-SBG 2011-5	Ghana
6	SARSORG-SRG 2011-6	Ghana
7	KAPAALA	Ghana
8	KADAGA	Ghana
9	SENSORG-2009-1	Senegal
10	SENSORG-2009-2	Senegal

Major Findings

Grain yield of the genotypes evaluated was not significantly different from each other. SARSORG-TRG 2011-1 with grain yield of 1565 kg/ha recorded the highest yield whilst SARSORG-TRG 2011-2 (1015 kg/ha) had the least (Table 21). Kapaala (1405 kg/ha) out performed all the other lines evaluated except SARSORG-TRG 2011-1 with the other parental line (Kadaga) yielding 1021 kg/ha. Days to 50% heading significantly differed among the lines evaluated. SARSORG-TRG-2011-1 headed first with 63 days after planting whilst Kadaga with 71 days after planting headed last among the lines evaluated (Table 22 and 23).

Table 29: *Grain yield of Kapaala and its derivatives evaluated*

Genotype	Grain yield (kg/ha)				
	Damongo	Manga	Nyankpala	Tumu	Mean
SARSORG-T RG-2011-1	2388	1274	1163	1433	**1565**
SARSORG-T BG-2011-2	1570	756	872	1133	1083
SARSORG-M RG-2011-3	1990	1209	879	1267	1336
SARSORG-M BG-2011-4	1431	894	869	1250	1111
SARSORG-SBG-2011-5	1641	875	679	1150	1086
SARSORG-SRG-2011-6	1832	975	879	1233	1230
KAPAALA	2010	1198	646	1767	1405
KADAGA	1454	346	849	1433	1021
SENSORG-2009-1	2379	752	951	1067	1287
SENSORG-2009-2	1911	695	690	763	**1015**

Head bud population varied across three of the trial locations the lines were evaluated. Manga generally recorded high head bug population with Kapaala (245) and Kadaga (225) being the ones with most head bug insects (Figure 1). The open derivatives of Kapaala recorded the least number of head bug insects with SARSORG-TRG-2011-1 having the least head bug population across the three locations. The open nature of the panicles of Kapaala derivatives have contributed in the low number of the head bug population due to free passage of air and low humidity compared to compact panicle of Kapaala. Despite the large number of head bug population on Kadaga in Manga, the variety recorded the least rate of grain damage across the three locations

Table 30: *Days to 50% heading of Kapaala and its derivatives evaluated*

Genotype	Days 50% Heading				
	Damongo	**Manga**	**Nyankpala**	**Tumu**	**Mean**
SARSORG-TRG-2011-1	54.75	73	66	59	**63.19 a**
SARSORG-TBG-2011-2	56.5	74.75	70.5	60.5	65.56 bc
SARSORG-MRG-2011-3	58.5	76.5	71.5	58.5	66.25 cd
SARSORG-MBG-2011-4	55.25	72.5	69.75	60.5	64.5 ab
SARSORG-SBG-2011-5	57.25	75.5	74	62.5	67.31 de
SARSORG-SRG-2011-6	57.5	73.75	69	65.25	66.38 cd
KAPAALA	56.75	78	72.75	65.75	68.31 e
KADAGA	58.5	80.75	71.25	74.75	**71.31 f**
SENSORG-2009-1	59.75	71.75	71.75	63.25	66.62 cd
SENSORG-2009-2	58.75	75.5	73.75	61.75	67.44 de

(Figure 7 and 8). With a rate of 1 (no molds observed) for panicle grain mold and threshed grain mold rating across the 3 locations, Kadaga (improved landrace) was the most resistant variety to grain mold disease (Figure 9 and 10). This could be attributed to the hardness of its grains making it difficult for insects to feed on it thus no moldiness in its grains.

Damongo generally recorded the highest rate of grain mold disease despite its low number of head bugs recorded across the three locations. This could be attributed to the high relative humidity and rainfall in the location. This indicates that high relative humidity is a major player in the proliferation of the disease. Kapaala recorded between 10 - 25 % grain mold disease across the site locations and was high in Damongo (Figure 9). Regardless of the environmental condition, Kadaga recorded no molds in its grains either in the panicles or threshed grains.

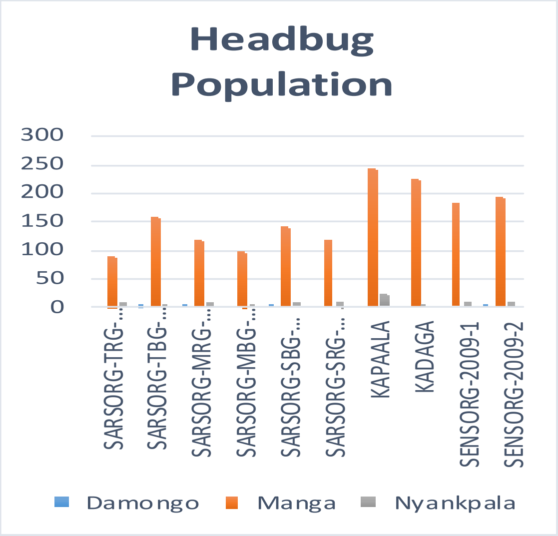

Figure 7: Head bug population in 3 of the trial sites

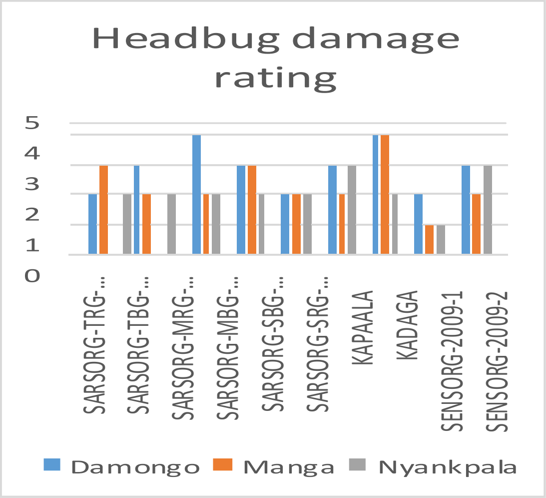

Figure 8: Head bug damage rating in 3 of the trial sites

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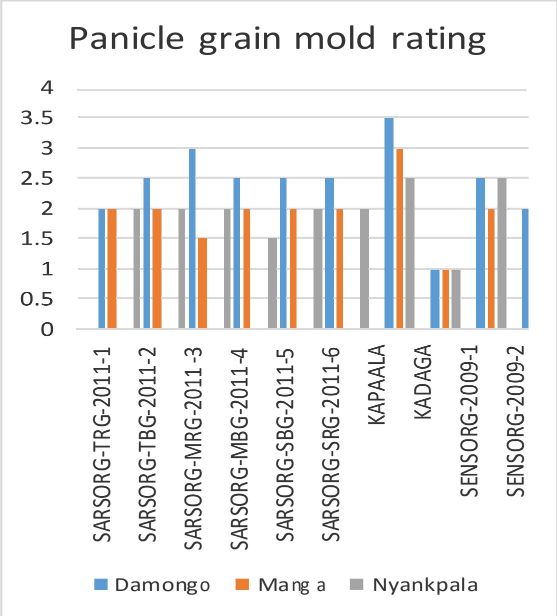

Figure 9: Panicle grain mold rating in 3 of the trial sites

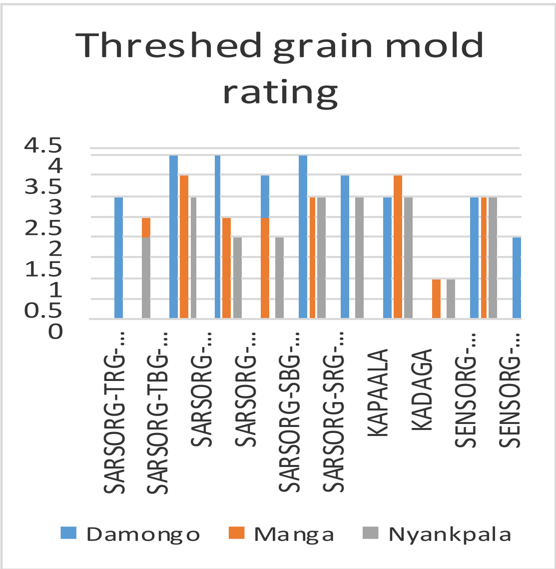

Figure 10: Threshed grain mold rating in 3 of the trial sites

Conclusion:
SARSORG-TRG-2011-1 was the most promising line regarding grain yield, biomass yield and days to 50% heading. With respect to grain mould disease, Kadaga was resistant to the disease but all the open derivatives of Kapaala were susceptible except SARSORG-TRG-2011-1 which showed some level of resistance.

Evaluation of sorghum hybrids from WIENCO Ghana, and Pioneer USA

Principal Investigator: Kenneth Opare-Obuobi
Participating Scientist: Peter Asungre
Estimated Duration: 1 year
Sponsors: WIENCO, Ghana
Location: Damongo, Nyankpala, Manga and Tumu

Background Information/Justification/Introduction:
Sorghum yields in Ghana persistently have been low over the years on farmers' field. The average yield of 0.9 t/ha is far below the world average of 1.4 t/ha. Among the numerous factors affecting production, is the cultivation of indigenous landraces which are inherently low yielding. The use of sorghum hybrids which makes use of heterosis will create opportunities for increased productivity and access to markets that demand a more standardized product quality through sales of surplus production. In addressing this challenges, CSIR-SARI with as short term strategy has evaluated hybrids from WIENCO, Ghana and Pioneer, USA for their performance and adaptability in the Guinea and Sudan savanna agro-ecological zone. The present study was therefore designed to evaluate sorghum hybrids with the aim of identifying and selecting well adapted and high yielding hybrid(s) for increased sorghum production and productivity.

Brief Objectives: Identify and select high yielding and well adapted hybrid line(s) in the Guinea and Sudan agro-ecological zones of Ghana.

Expected Beneficiaries: Farmers

Materials and Methods:
Seven (7) genetic materials (Table 24) including two (2) hybrid lines from WIENCO, Ghana; two (2) hybrid lines from Pioneer, USA, two (2) commercial varieties and an improved landrace. The trial was conducted in three different locations across northern Ghana; namely Damongo, Nyankpala, Manga and Tumu. All trials were planted between 17th June and 12th July 2014 and were laid out in Randomized Complete Block Design (RCBD) with four replications. There were six-row plots of length 5 m with the inner 4 rows used as the net plot for data collection. Spacing of 0.75 m and 0.30 m inter- and intra-row respectively was used. Four to five seeds were planted per hole but thinned out to two seedlings per stand two weeks after planting. Data collected included grain yield, days to 50% heading, panicle weight, and

plant height at physiological maturity. Others included number of panicles infested by midge and number of empty panicles due to bird damage. Data collected were subjected to statistical analysis using the GENSTAT Package. Statistical comparison was done at 5% significance level. Least significance difference (L.S.D) was used to separate line means where significant differences existed among means. Graphical presentation of some measured parameters was done.

Table 31: *Hybrid lines and their origin evaluated*

No.	LINE/ VARIETY	TYPE	ORIGIN
1.	PAN 606	Hybrid	WIENCO, Ghana
2.	MARCIA	Hybrid	WIENCO, Ghana
3.	XSW 2134	Hybrid	PIONEER, U.S.A
4.	XSW 256	Hybrid	PIONEER, U.S.A
5.	KAPAALA	Commercial variety (OPV)	Ghana
6.	DORADO	Commercial variety (OPV)	Ghana
7.	KADAGA	Improved landrace (OPV)	Ghana

Major Findings

XSW 2134 with grain yield of 2627 kg/ha and panicle weight of 3956 kg/ha was significantly yielded higher than the other lines evaluated (Table 25). Dorado and Kapaala with 2034 kg/ha and 1838 kg/ha respectively comparatively performed well against the other hybrid lines though not significantly different (Table 25). Kadaga had the least grain and panicle yield of 1265 kg/ha and 2223 kg/ha respectively (Table 25). Days to 50% heading significantly varied among the lines evaluated with XSW 256 heading the earliest with 59 days after planting (Table 26). Kadaga headed last with 71 days after planting across trial locations (Table 26). The height of a variety determines the convenien ces with which harvesting can be undertaken. All the hybrid lines evaluated with a height range from 119 – 138 cm including Dorado (128 cm) is considered short and much easier to harvest than Kadaga and Kapaala. Harvesting is made easier when the panicle of the plant is not above the shoulder level of the harvester.Rega rding midge infestation, the hybrid lines from WIENCO- Ghana; Pan 606 and Marcia recorded the highest number of panicles with midge (Figure 11). Bird damage is one of the major constraints to sorghum production. Pan 606 and Kadaga suffered the least from bird damage but the hybrids from Pioneer (XSW 2134 and XSW 256) suffered the most across the three trial locations (Figure 12).

Table 32: *Grain yield and panicle weight of the hybrid lines evaluated*

Genotype	Grain yield (kg/ha)				
	Damongo	Manga	Nyankpala	Tumu	Mean
Pan 606	2078.33	1351.67	1693.33	2168.33	1823 b
Marcia	2193.33	1251.67	991.67	1313.33	1437 c
XSW 2134	3038.33	2270	2650	2551.67	**2627 a**
XSW 256	1995	1518.33	2550	2188.33	2063 b
Kapaala	2095	1176.67	2035	2043.33	1838 b
Dorado	2883.33	1638.33	1705	1955	2045 b
Kadaga	1396.67	828.33	1181.67	1651.67	**1265 c**
% CV					18.7

Table 33: *Days to 50% heading and biomass yield of the hybrid lines evaluated*

Genotype	Days to 50% Heading				
	Damongo	Manga	Nyankpala	Tumu	Mean
Pan 606	63.75	71.25	68	71.25	68.56 e
Marcia	64.5	72.25	76	69.75	70.62 f
XSW 2134	56.5	65.75	58.75	61	60.5 b
XSW 256	56.5	62.75	56.75	59	**58.75 a**
Kapaala	57	71.75	62.75	69.25	65.19 c
Dorado	60.25	70	71.25	68	67.38 d
Kadaga	57.75	88	61.5	75.25	**70.62 f**
% CV					2.4

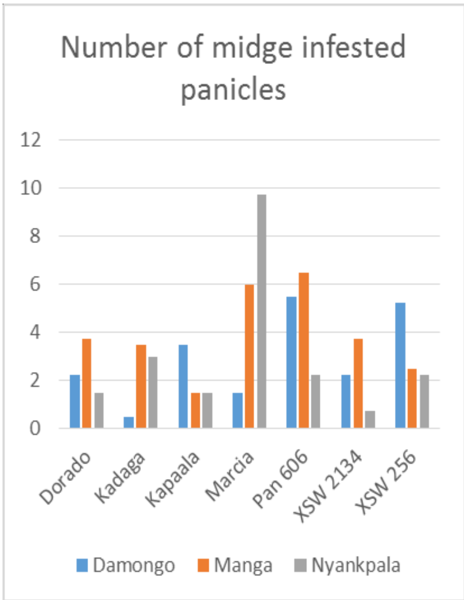

Figure 11: Number of panicles infested with midge insect

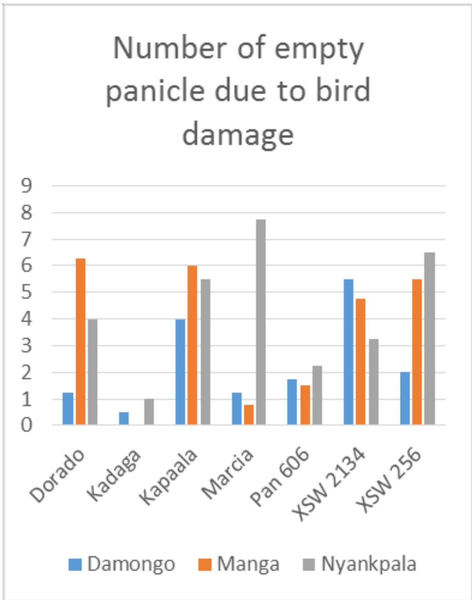

Figure 12: Number of empty panicles due to bird damage

Conclusion:

The hybrid lines from Pioneer, USA performed well and were the most promising lines especially XSW 2134 with its earliness to ty to bird maturity, high grain and biomass yields despite its susceptibility to bird damage. Kadaga, the improved landrace was the most resistant variety to bird attack with the hybrid line Pan 606 being the most preferred hybrid in terms of the bird resistance.

VEGETABLE IMPROVEMENT

Enhancing Productivity, Competitiveness and Marketing of Traditional African Vegetables for Improved Income and Nutrition in West and Central Africa (*TAVs for Income and Nutrition in WCA*)

Principal Investigator: Mashark S. Abdulai
Research Team: S. S. J. Buah, Stephen K. Nutsugah, Richard Y. Agyare, Emmanuel Ayipio and Samuel K. Bonsu
Estimated Duration: 3 years (November 2013 – December 2016)
Sponsors: CORAF/WECARD Thro' AVRDC
Locations: Nyankpala and Wa

Expected Beneficiaries: Farmers, Seed producers, Input dealers and Traders

Introduction
African traditional vegetables such as okra, onion, pepper, tomato, amaranths, roselle and pumpkin are essential component of diet and household. These vegetables are important cash crops particularly in the dry season where commercial production is carried under irrigated conditions around dugouts, small irrigation dams and along river banks. On arable lands, they may appear as sole crops, intercropped or as boarder plants. They are an essential component of human diet for the supply of vitamins, minerals and certain types of hormones precursors in addition to protein, energy and dietary fiber. Regular consumption of vegetables is known to decreased risk of chronic degenerative diseases due to the presence of different antioxidant molecules such as carotenoids, particularly lycopene, ascorbic acid and vitamin C and E, and phenol compounds, particularly flavonoids. Leafy vegetables are known to be rich in iron and pro-vitamin A. However, due to lack of knowledge on the economic and nutritional importance of TAVs, most farmers have shifted to the cultivation of exotic vegetables which require high inputs and are low in vitamins and minerals as compared to TAVs (Voster *et al*. 2007). It is therefore imperative to promote the cultivation and marketing of these TAVs for improving the livelihood and nutritional security of resource-poor vegetable farmers in northern Ghana.

General Objective: To increase the productivity and marketing of Traditional African Vegetables (TAVs) for improved income and nutrition in northern Ghana.

Specific Objectives:

i. Evaluate and select high yielding TAVs adaptable to the guinea savannah zones.
ii. Demonstrate water management and good agronomic practices for increased yields.
iii. Promote the cultivation and utilization of TAVs by small-holder farmers
iv. Increase farmers access to high yielding and adaptable TAVs to enhance their livelihoods

Several activities were carried over by the vegetable improvement section in Northern Ghana. Traditional African vegetables that were evaluated include African eggplant, Amaranth, okro and roselle. Water management and weed control using different mulching materials were evaluated using okro and roselle varieties. Vegetable farmers in the project communities were trained in nursery management practices and postharvest handling on some of the TAVs. Participatory varietal selection and field days were organized for the farmers to make their selection of preferred TAV and other technologies.

Activity 1: Evaluation of African eggplant genotypes

Materials and Methods:
The experiment was conducted at the research field of Savanna Agricultural Research Institute, Nyankpala in the Guinea savanna zone of Ghana. The experimental design used was Randomized Complete Block Design with three replications. Seeds were nursed on raised beds sterilized by heat sterilization method. Nursery management practices such as watering, shading, weed control, thinning out, diseases and insect pests control were carried out appropriately. The seedlings were transplanted onto prepared plots at six weeks after nursing. Plot size measuring 3 m X 2.25 m was used for the experiment. The seedlings were transplanted onto prepared ridges at a spacing of 0.75 m X 0.60 m. Watering was done immediately after transplanting to ensure good crop establishment. The eggplant genotypes that were evaluated were AB 2, DB 3, Lushoto and TZ SMN 2-8. Fertilizer application was carried in split dose at two and six weeks after transplanting with NPK (15-15-15) at a rate of 100 kg/ac. Top dressing was done with sulphate of ammonia at eight weeks after transplanting at a rate of 50 kg/ac. Insects were periodically controlled by spraying with *PAWA* (20 g/l lamda cyhalothrin). Weeding and reshaping of ridges were carried out manually with the hand hoe. Diseases were controlled by applying fungicides such as Topsin M (70 WP). Data was collected on plant height (cm), fruit length (cm), fruit width (cm), number of fruits, yield per plant (kg) and yield (t/ha).

Results/Major Findings:
The mean values for plant height, fruit length and width, number of fruits, yield per plant and yield (t/ha) are presented in table 27. Significant ($P \leq 0.05$) genotypic variations were observed for plant height, number of fruits, yield per plant and yield (t/ha). There were however no significant genotypic difference among the genotypes for fruit length and fruit width. The highest yielding genotype was DB 3 (29.40 tons/ha) while Lushoto had the lowest yield (4.70 tons/ha). Plant height ranged from 51 cm to 89 cm with an average of 70.80 cm. Genotype DB 3 showed its superiority over the other genotypes in relations to all the parameters measured except fruit width. The experiment would be repeated in the 2015 growing season to validate the results.

Table 34*: Agronomic, yield and yield components of eggplant genotypes*

Genotype	Plant height (cm)	Fruit length (mm)	Fruit width (mm)	No. of fruits	Yield per plant (kg)	Yield (t/ha)
AB 2	51.00	47.50	85.30	17.30	0.17	14.90
DB 3	89.00	63.50	73.60	90.70	0.33	29.40
Lushoto	69.70	55.00	65.30	14.70	0.05	4.70
TZ SMN 2-8	73.70	46.20	60.00	84.00	0.23	20.00
Mean	70.80	53.10	71.10	51.70	0.19	17.30
LSD	22.32	NS	NS	27.02	0.10	8.99
CV (%)	15.80	29.20	23.70	26.20	26.10	26.10

Activity 2: Evaluation of Amaranth genotypes

Materials and Methods:
The experiment was located at the research site of the Vegetable Section of SARI in Nyankpala. The experimental design used was Randomized Complete Block (RCB) with three replicates. Amaranth seeds were nursed on heat sterilized beds. Nursery management practices such as watering, weed control, thinning out and insect pest control were properly carried out. The seedlings were transplanted onto raised beds measuring 3 m long and 2.25 m wide at a planting distance of 30 cm X 30 cm. The amaranth genotypes that were evaluated were A2004, AH TL, AM NKGN, IP 5 and Madiira 2. NPK (15-15-15) was applied at a rate of 100 kg/ac three weeks after transplanting. Top dressing with sulphate of ammonia (SA) was carried out at six weeks after transplanting. Weeds were controlled by hand weeding with a manual hoe. Insects were controlled with *lamda cyhalothrin* (20g/l). Parameters that were measured include plant height (cm), plant girth (mm), leaf length (cm), leaf width (cm) and leaf weight (g). Ten plants in the middle rows were periodically harvest and weighed with an electronic scale.

Results/Major Findings:
There were no genotypic differences ($P \leq 0.05$) in the amaranth genotypes for plant girth, leaf length and yield (t/ha). However significant differences were observed among the genotypes for plant height and leaf width. Plant height ranged from 57.30 cm to 108.00 cm with an average of 92.10. Genotype AH TL (8.75 cm) had the widest leaf width while genotype AM NKGN (4.86 cm) had the least leaf width. Although there no statistical difference in yield (t/ha), Madiira 2 had the highest yield of 34.30 t/ha while A2004 had the least yield of 21.30 t/ha. The trial will be repeated to next season to validate the results.

__Table 35__: Agronomic and yield components of Amaranth

Genotype	Plant height (cm)	Plant girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
A2004	108.00	19.70	16.23	7.79	21.30
AH TL	76.60	14.10	14.74	8.75	24.10
AM NKGN	93.60	18.90	12.55	4.86	29.40
IP5	57.30	17.10	13.94	6.63	23.30
Madiira 2	124.80	23.10	13.59	6.30	34.30
Mean	92.10	18.60	14.21	6.87	26.50
LSD	39.42	NS	NS	2.71	NS
CV (%)	22.70	30.60	15.90	21.00	45.90

Activity 3: Evaluation of Okro genotypes

The experiment was conducted in a Randomized Complete Block Design with three replications. Each replication was made up of two blocks consisting of five plots per block. Plot size measuring 3 m long and 3 m wide with an area of 9 m^2 was used. The field was ploughed, harrowed and ridged with a tractor. The okro varieties evaluated were Koni, Sasilon, ML OK 10, ML OK 16, ML OK 35, ML OK 37, TZ SMN 10-3, TZ SMN 86, TZ SMN 98 and Ex Makutopora. The seeds were soaked in water overnight before they were planted at two seeds per hill. A spacing of 0.75 m X 0.50 m was used. Weeds were regularly controlled with a manual hoe to reduce competition from weeds. Fertilizer application was carried out at two and six weeks after emergence using NPK (23-10-5) at a rate of 100 kg/ac. The plants were top dressed with sulphate of ammonia at a rate of 50 kg/ac. Insect pests were controlled with *lamda cyhalothrin* (20g/l) using a knapsack. Data were collected on six tagged plants on the middle row of each experimental plot. Parameters measured were plant height (cm), stem girth (mm) fruit length (cm), fruit width (mm), number of fruits and fruit weight.

Results/Major Findings:

Significant ($P\leq 0.05$) genotypic variations were observed for all parameters measured (Table 29). Plant height varied from 37.30 cm to 86.00 cm with genotypes ML OK 35 and Koni having the shortest and tallest heights respectively. Genotype TZ SMN 10-3 had the longest fruit length (15.00 cm) while genotype Koni (33.10 mm) had fruits with the widest width. Fruit number ranged from 27.7 (ML OK 10) to 103.30 (Ex Makutopora) with a mean of 76.50. Fruit yield varied from 1.03 t/ha to 7.27 t/ha. The highest yielding okro genotype was Sasilon while ML OK 10 had the lowest fruit yield. An extensive study would be conducted on these promising genotypes next season to validate the results.

Table 36: Agronomic and yield characteristics of okro

Genotypes	Plant height (cm)	Stem girth (mm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
Ex Makutopora	74.70	22.02	9.43	24.57	103.30	4.23
Koni	86.00	19.58	8.74	33.10	85.70	3.90
ML OK 10	62.50	22.31	10.03	27.13	27.70	1.03
ML OK 16	81.00	21.83	13.93	22.17	93.30	2.96
ML OK 35	37.30	18.90	12.00	22.23	60.70	1.69
ML OK 37	77.70	23.13	9.60	30.17	75.70	2.64
Sasilon	85.70	20.79	11.58	28.57	102.00	7.27
TZ SMN 10-3	69.20	23.72	15.00	20.75	60.70	2.08
TZ SMN 86	40.90	18.59	10.03	20.46	78.30	2.94
TZ SMN 98	44.00	18.94	11.90	22.78	78.00	2.32
Mean	65.90	20.98	11.23	25.19	76.50	3.11
LSD	18.19	3.76	2.76	2.72	21.25	0.95
CV (%)	16.10	10.40	14.30	6.30	16.20	17.80

Activity 4: On-Station evaluation of okro genotypes under different mulching conditions

Materials and Methods:

Water and weed control are the most challenging factors in vegetable production. Therefore, different mulches were used to grow okro. Apart from the control of water and weeds the experiment was carried out with the aim of assessing genotypic variation of okro genotypes under grass and plastic mulch conditions. The okro genotypes were evaluated under these two mulch conditions side by side for easy comparison. Three similar trials were planted. The experimental procedure was the same as already described above in activity 3 except the inclusion grass mulch and plastic mulch and a bare plot. For the grass mulch trial, the plots were mulched two weeks after emergence. Under plastic mulch, the plastic material was laid on the plots before planting was done.

Results/Major Findings:

Preliminary data analyses of the experiment under mulching with grass are presented in Table 30. There were significant ($P \leq 0.05$) differences among the okro genotypes for all parameters measured except stem girth. Plant height ranged from 51.00 cm (ML OK 35) to 93.00 cm (Sasilon). Genotypes TZ SMN 10-3 (16.40) and Koni (34.62) had the highest fruit length and fruit width respectively. Fruit yield ranged from 1.50 t/ha (ML OK 10) to 7.20 t/ha (Sasilon) with a mean of 3.34 t/ha. The effect of mulch with grass generally gave a positive response on the parameters measured as compared the no mulching experiment under activity 3. Though the effect of the grass mulch was observed in periods of dry spell, weeding in this trial was difficult. The grass mulch also harboured many soil arthropods particularly termites.

The results of the experiment under plastic mulch are presented in Table 31. Sasilon (132.10 cm) had the highest plant height while ML OK 16 (78.80 cm) had the lowest height. Stem girth ranged from 28.20 mm to 34.47 mm with a mean of 32. 28 mm. Significant (P≤ 0.05) genotypic differences were observed for all the parameters measured. Fruit yield ranged from 1.84 t/ha to 6.88 t/ha with a mean of 3.49 t/ha. Though the mean yield was high under the plastic mulch as compared to the grass mulch, there was yield reduction in genotypes such as Sasilon and TZ SMN 86. In general, mulching with plastic improved the growth of the okro plants by maintaining high soil moisture. No weeding was done under the plastic mulch throughout the growing season. The data will be combined and analysed across the mulching materials when the experiment is concluded in the dry season.

In conclusion, okro genotypes responded positively to mulch either with grass or plastic mulch. The experiment will be repeated in the dry season where water is a limiting factor for the effects of the mulch materials to be clearly appreciated.

Table 37: *Agronomic characteristics of okro genotypes under grass mulch*

Genotypes	Plant height (cm)	Stem girth (mm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
Ex Makutopora	64.10	23.84	11.23	24.57	123.70	5.00
Koni	82.70	21.85	10.20	34.62	94.70	4.53
ML OK 10	89.30	26.90	10.47	24.96	44.30	1.50
ML OK 16	55.80	23.54	15.13	21.14	92.30	2.60
ML OK 35	51.00	21.93	12.57	22.71	70.70	1.83
ML OK 37	71.20	23.29	10.13	31.70	74.00	2.65
Sasilon	93.00	20.73	13.77	28.21	114.70	7.20
TZ SMN 10-3	81.00	22.36	16.40	21.85	62.00	2.11
TZ SMN 86	66.40	23.45	11.33	21.63	94.70	3.34
TZ SMN 98	80.40	23.34	12.87	21.38	80.70	2.64
Mean	73.50	23.12	12.41	25.28	85.20	3.34
LSD	32.84	NS	2.78	2.60	14.93	0.52
CV (%)	26.00	18.10	13.10	6.00	10.20	9.20

Table 38: *Agronomic characteristics of okro genotypes under plastic mulch*

Genotypes	Plant height (cm)	Stem girth (mm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
Ex Makutopora	125.20	29.76	12.27	23.73	127.30	5.17
Koni	122.80	30.67	11.20	34.57	103.00	4.85
ML OK 10	103.70	30.98	10.63	24.70	59.00	1.84
ML OK 16	78.80	34.47	15.20	20.57	95.70	2.67
ML OK 35	94.50	30.10	12.85	22.57	80.00	2.12
ML OK 37	124.30	33.16	10.53	31.57	79.00	2.84
Sasilon	132.10	28.20	13.90	26.70	122.30	6.88
TZ SMN 10-3	115.70	31.44	16.93	22.17	72.70	2.55
TZ SMN 86	105.30	31.50	11.53	21.67	91.30	3.29
TZ SMN 98	109.30	32.52	13.90	21.67	94.00	2.70
Mean	111.20	32.28	12.90	24.99	92.40	3.49
LSD	42.92	5.96	1.73	2.62	19.00	0.66
CV (%)	22.50	11.10	7.80	6.10	12.00	11.10

Activity 5: On-farm demonstration of okro genotypes under different growing conditions

Materials and Methods:
This experiment was carried out in three communities (Libga, Dufa and UDS-Nyankpala). This on-farm-researcher managed trial was carried out with the aim of demonstrating these promising okro genotypes as well as mulching. Three separate experiments were laid out in an RCBD with the communities serving as replications. The first experiment was under bare soil conditions. The second and third experiments were carried out under grass and plastic mulches respectively. The field was ploughed and harrowed with a tractor. Plot size of 5 m x 1 m was used. Planting distance of 0.75 m x 0.50 m was used. Seeds of okro were soaked in water overnight before planting at two seeds per hill. The plants were later thinned to 1 plant per hill. The okro genotypes that were evaluated were AAK, NOKH 1002, NOKH 1003, NOKH 1004 and Sasilon. NPK (15-15-15) and sulphate of ammonia were applied at 100 kg/ac and 50 kg/ac respectively. Agronomic practices such as weeding and insect pest control were carried out appropriately. Data were collected on plant height (cm), fruit length (cm), fruit width (mm), number of fruits and fruit weight (g).

Results/Major Findings:
The result of the demonstration under normal soil conditions is presented in table 32. Significant ($P \leq 0.05$) genotypic differences were observed for all parameters measured. Genotype Sasilon was the tallest among the genotypes. NOKH 1004 had the longest fruits while NOKH 1002 had fruits with the widest width. Fruit number ranged from 10.5 (AAK) to 32.5 (Sasilon). Sasilon had the highest yield of 6.04 t/ha while AAK had the lowest yield (1.08 t/ha).

The results of the second experiment are presented in table 33. Plant height ranged from 52.4 cm to 70.40 cm. Significant (P≤ 0.05) differences existed among the okro genotypes for all traits measured. Variations in fruit length, fruit width, fruit number and yield followed a similar trend as in the first experiment. However these were higher in the grass mulch than the bare soil conditions.

Significant (P≤ 0.05) genotypic variations were observed for all parameters measured except plant height (Table 34). Although there was no significant difference among the genotypes, plant height was generally higher under the plastic mulch than the other two growing conditions. NOKH 1004 (18.75 cm) had the highest fruit length while Sasilon (27.05 mm) had the highest fruit width. Fruit yield was comparatively higher under mulching with plastic than the other two conditions. Sasilon had the highest yield of 10.55 t/ha while NOKH 1002 (4.46 t/ha) had the lowest yield. These experiments would be modified and repeated in the next cropping season.

Table 39*: On-farm Agronomic performance of okro under normal conditions*

Genotypes	Plant height (cm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
AAK	39.00	9.40	17.80	10.50	1.08
NOKH 1002	57.60	12.35	20.48	18.50	3.07
NOKH 1003	40.00	17.00	16.55	20.00	4.47
NOKH 1004	51.20	17.95	19.74	24.50	4.79
Sasilon	58.80	17.55	20.15	32.50	6.04
Mean	49.30	14.85	18.95	21.20	3.89
LSD	11.40	0.74	0.23	2.82	0.33
CV (%)	12.30	2.70	0.60	7.10	4.50

Table 40: *On-farm agronomic performance of okro under grass conditions*

Genotypes	Plant height (cm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
AAK	64.80	13.70	20.85	14.50	2.23
NOKH 1002	75.20	14.70	24.69	24.50	4.94
NOKH 1003	52.40	17.04	15.52	23.00	4.77
NOKH 1004	61.40	18.18	20.71	28.50	5.01
Sasilon	70.40	17.15	24.45	37.00	8.59
Mean	64.80	16.15	21.25	25.50	5.11
LSD	14.00	3.14	3.34	3.49	2.08
CV (%)	11.50	10.3	8.30	7.30	21.6

Table 41: *On-farm agronomic performance of okro under plastic conditions*

Genotypes	Plant height (cm)	Fruit length (cm)	Fruit width (mm)	No. of fruits	Yield (t/ha)
AAK	78.80	17.80	23.21	23.00	5.19
NOKH 1002	72.50	16.90	20.87	20.00	4.46
NOKH 1003	62.50	18.00	19.66	24.50	6.82
NOKH 1004	73.50	18.75	21.40	33.50	7.38
Sasilon	78.00	17.45	27.05	40.00	10.55
Mean	73.10	17.78	22.44	28.20	6.87
LSD	NS	0.91	2.23	4.54	0.45
CV (%)	12.60	2.70	5.30	8.60	3.50

Activity 6: On-Station evaluation of Roselle genotypes for high and stable yield

Materials and Methods:
The trial was carried out at the research field of the Vegetable section. It was laid out in a Randomized Complete Block Design with three replicates. Land preparation which involved ploughing, harrowing and ridging was carried out with a tractor. Experimental area of 258 m^2 (12 m x 21.5 m) was used for the experiment. Each replication consisted of two blocks with four plots per block. Plot size measuring 3 m x 3 m was used. Seeds of roselle were planted at a spacing of 0.75 m x 0.50 m with 2 seeds per hill which was later thinned to 1. The genotypes used for the experiment were Dah Rouge, Ilafia, Marche de Bozola, Samadah, Morogoro, Navrongo, Local 1 and Local 2. NPK (15-15-15) was applied at two weeks after emergence at a rate of 100 kg/ac and supplemented with 50 kg/ac sulphate of ammonia. Weeding was carried out with a hand hoe. Ridges were reshaped as and when necessary. *Lamda cyhalothrin* (20g/l) was used to protect the crop from insect damage. Data were collected on six tagged plants in the middle row of each experimental plot. Parameters such as plant height (cm), stem girth (mm), leaf length (cm), leaf width (cm) and fresh leaf weight (g) were measured.

Results/Major Findings:
The results of this experiment are presented in Table 35. Genotype Morogoro (185.00 cm) had the tallest plant height while Marche de Bozola (63.80 cm) had the shortest plant height. Stem girth ranged from 10.72 mm to 38.07 mm with a mean of 23.67 mm. Navrongo had the longest (14.43 cm) and widest (14.50 cm) leaf. Significant genotypic differences were observed for all parameters measured. Local 2 had the highest yield of 21.25 t/ha while Samadah (3.62 t/ha) had the lowest yield. The experiment would be repeated to confirm the results obtained.

Table 42: Agronomic characteristics of roselle

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	94.70	16.59	10.82	8.90	4.96
Ilafia	93.10	15.70	8.51	10.23	6.66
Local 1	128.00	26.57	12.90	11.60	5.87
Local 2	146.30	28.63	13.00	13.73	21.25
Marche de Bozola	63.80	10.72	8.71	9.43	9.66
Morogoro	185.00	31.26	13.12	13.62	18.11
Navrongo	179.10	38.07	14.43	14.50	9.61
Samadah	89.30	21.80	9.80	8.50	3.62
Mean	122.40	23.67	11.41	11.31	9.97
LSD	17.14	4.15	2.13	1.97	7.53
CV (%)	8.00	10.00	10.90	9.90	43.10

Activity 7: On-Station evaluation of roselle genotypes under grass and plastic mulch

Materials and Methods:
Two separate trials were carried out side by side to assess the impact of mulching on the performance of roselle. One experiment was carried out under grass mulch and the other was conducted under plastic mulch condition. The experimental procedure for these two separate experiments is the same described in activity 6 except that in the case of the plastic mulch no weed control was done.

Results/Major Findings:
The results of the experiment under grass mulch condition are presented in table 36. Significant ($P \leq 0.05$) genotypic differences existed among the 8 roselle genotypes for all parameters considered. Morogoro (185.00 cm) was the tallest while Marche de Bozola (63.80 cm) was the shortest. Stem girth ranged from 10.28 mm to 31.70 mm as obtained by Marche de Bozola and Navrongo respectively. Navrongo had the highest leaf yield of 18.60 t/ha as compared Samadah (5.10 t/ha). Navrongo out yielded Local 2 which had the highest yield of 21.25 t/ha when it was evaluated under bare soil conditions in activity 6.

The results of the experiment under mulching with plastic material are presented in table 37. Fresh leaf weight (yield) ranged from 8.00 t/ha (Ilafia) to 40.60 t/ha. The mean yield under plastic mulch is over 100% and 200% more than the mean yield under grass mulch and bare soil conditions respectively. Significant genotypic variations were observed for all the parameters measured. Generally, mulching with plastic material positively influenced the growth and yield of roselle. Weed competition was eliminated as the weeds could not grow under the plastic sheet.
These experiments would be repeated in the next cropping season to validate the results obtained.

Table 43: Performance of roselle under grass mulch

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	94.70	20.52	10.60	8.47	7.00
Ilafia	93.10	16.83	9.88	11.77	7.00
Local 1	128.00	27.26	11.26	9.70	6.60
Local 2	146.30	23.37	13.12	14.27	10.60
Marche de Bozola	63.80	10.28	10.70	10.07	10.40
Morogoro	185.00	31.27	12.30	14.20	14.90
Navrongo	179.10	31.70	11.73	13.07	18.60
Samadah	89.30	21.94	10.19	8.63	5.10
Mean	122.40	22.90	11.22	11.27	10.00
LSD	17.15	3.56	1.88	2.17	8.61
CV (%)	8.02	8.90	9.60	11.00	49.00

Table 44: Performance of roselle under plastic mulch

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	83.70	19.42	11.62	9.83	17.70
Ilafia	106.00	18.65	12.76	13.05	8.00
Local 1	132.00	26.90	14.51	14.72	16.40
Local 2	136.10	24.66	12.37	12.87	17.60
Marche de Bozola	89.00	14.69	11.70	12.20	14.30
Morogoro	186.30	31.73	12.47	14.73	40.60
Navrongo	161.70	33.36	12.59	13.95	34.60
Samadah	97.30	20.08	13.47	12.63	14.50
Mean	124.00	23.69	12.69	13.00	20.50
LSD	22.63	5.32	1.94	2.81	9.89
CV (%)	10.4	12.80	8.70	12.30	27.60

Activity 8: On-farm demonstration of roselle genotypes under different growing conditions

Materials and Methods:

This demonstration was carried out in three communities (Libga, Dufa and UDS-Nyankpala). This on-farm-researcher managed trial was carried out with the aim of demonstrating these roselle genotypes and the different mulching technologies. Three separate experiments were laid out side by side in a Randomized Complete Block Design with the communities serving as replications. The first experiment was carried out under normal soil conditions (no mulching). The second and third experiments were carried out under grass and plastic mulches respectively. The field was prepared by ploughing and harrowing with a tractor. Plot size of 5 m x 1 m was used. Planting distance of 0.75 m x 0.50 m was used. The five roselle genotypes evaluated were Dah Rouge, Local 1, Morogoro, Navrongo and Samadah. Seeds of roselle were planted at two seeds per hill. The plants were later thinned to 1 plant per hill. Weed control was manually done in the bare and grass experiments. However no weed control was done in the plastic experiments. Insect pests were controlled with *lamda cyhalothrin* (20g/l). Data were collected on plant height (cm), stem girth (mm), fruit length (cm), fruit width (mm) and fruit weight (g).

Results/Major Findings:
The results of the experiment under normal soil conditions are presented in table 38. Significant genotypic variations existed among the genotypes for the parameters considered. Morogoro was superior to the other genotypes in the parameters measured except leaf length. Yield ranged from 30.40 t/ha (Samadah) to 47.90 t/ha (Morogoro).

The results of the trial under grass mulch condition are presented in table 39. Local 1(95.30 cm) had the highest plant height while Navrongo (65.20 cm) had the lowest height. The genotypes were significantly different in the parameters measured except leaf length. Morogoro emerged as the highest leaf producer as it had a yield of 50.80 t/ha while Navrongo (26.70 t/ha) was the poorest among the genotypes.

Table 40 shows the results of the experiment carried out under plastic mulch condition. The genotypes were not significantly different from each other in plant height. Yield ranged from 18.00 t/ha to 83.70 t/ha. Navrongo had the highest yield under plastic conditions. Some of the genotypes were not consistent in their performance under the different conditions. The experiment would be repeated to confirm the results obtained.

Table 45: *Agronomic characteristics of roselle under normal soil conditions*

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	73.50	18.48	12.54	12.74	37.50
Local 1	78.70	19.94	16.35	16.35	33.40
Morogoro	93.60	25.16	14.72	16.68	47.90
Navrongo	64.90	15.25	14.65	10.65	19.60
Samadah	72.80	17.46	14.27	14.13	30.40
Mean	76.70	19.26	14.51	14.11	33.80
LSD	24.90	1.90	2.86	3.71	18.86
CV (%)	17.20	5.20	10.50	14.00	29.70

__Table 46:__ Agronomic characteristics of roselle under grass mulch conditions

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	88.40	16.75	12.76	13.01	44.80
Local 1	95.30	16.85	14.67	14.95	36.40
Morogoro	93.40	16.20	14.35	17.08	50.80
Navrongo	65.20	12.90	15.05	12.40	26.70
Samadah	79.60	12.53	15.20	14.06	37.60
Mean	84.38	15.05	14.41	14.30	39.30
LSD	6.25	0.81	NS	3.22	10.39
CV (%)	3.90	2.90	10.00	11.90	14.10

***Table 47:** Agronomic characteristics of roselle under plastic mulch conditions*

Genotypes	Plant height (cm)	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Yield (t/ha)
Dah Rouge	85.90	15.36	12.26	9.38	18.00
Local 1	85.00	19.89	15.70	15.35	31.70
Morogoro	108.10	22.19	13.20	15.92	33.50
Navrongo	105.30	22.19	13.65	15.32	83.70
Samadah	82.60	23.08	11.90	10.03	37.80
Mean	93.40	20.54	13.34	13.20	40.90
LSD	NS	0.31	1.57	1.12	36.43
CV (%)	15.80	0.80	6.30	4.50	47.30

Training workshop on Nursery management and Postharvest handling of TAVs

The training workshop was organized on the 25th of September, 2014 with the aim of educating vegetable farmers on good nursery management practices and post-harvest treatment to reduce losses from farmer's field and enhance the shelf-life of the vegetables and seed production. This training workshop was carried out at the research field of the Vegetable Section in Nyankpala in order to make the farmers have a practical experience of what was discussed. A total of thirty vegetable farmers made up of twenty men and ten women from Nyankpala, Libga and Duufa were involved in the training exercise. These farmers who were involved in the training are expected to share the knowledge and the experience they acquired with their community members so as to increase their vegetable production and enhance their livelihoods through the income from the sale of their produce. Experience farmers among them were selected and trained how to produce their own seed if the need arises.

Nursery Management:

The training was carried out in a participatory manner where the farmers were asked to briefly describe how they establish and maintain their nurseries. It was found out that most of the farmers make beds that are too wide and do not sterilize their beds before nursing leading to the build-up of pathogen levels in the soil. Although farmers knew about nursing in rows, they preferred having rows that are closely spaced. They also nursed by putting a lot of seeds in each row which causes overcrowding after and easy spreading of diseases after emergence. They also preferred broadcasting crops such as jute mallow and amaranth instead of nursing in rows and transplanting. The farmers were then taken through good nursery management practices which involve making proper nursery bed, soil sterilization and aeration, seed treatment, row nursing with wide row spacing and proper management of the nursery after emergence. The farmers were taken through bed preparation where bed width of 1 m was demonstrated for easy working on the bed. Dry grass was burnt on the bed to kill most of the pathogens in the soil. The bed was aerated by constantly turning and mixing the soil with garden rake. Soil sterilization method such as solarization using transparent polythene sheets was also demonstrated to the farmers. Nursing in rows with row spacing of 25 cm was demonstrated on the bed. This wide row spacing makes it easy to uproot weeds, loosen the soils and apply fertilizer to boost the growth of the seedlings. Nursing in seed boxes with steam sterilized soil and cow-dung was also demonstrated to the farmers. The farmers were advised to nurse their seeds thinly to reduce overcrowding and wasting of seeds. Nursing in seed boxes is advantageous in that the seedlings can be protected from harsh environmental conditions as it can be easily moved from one place to another and the soil can be well sterilized. The farmers were also advised to develop the habit of using seed dressers to treat their seeds to control seed borne pathogens as it was realized that treating seeds with seed dressers is not a common practice among the farmers. They were also trained on how to ensure good moisture conditions to minimize damping off incidence in their nurseries. Shading, thinning, pricking out, weed control, insect control and timely transplanting of seedlings were demonstrated to the farmers. They farmers were asked to carry out these practices on time in order to produce strong disease free seedlings before transplanting them on the field.

Post Harvest Treatment:
Post-harvest handling of agricultural produce is very important as it affects the quantity and quality of the produce before reaching the final consumer. The purpose of this training exercise was demonstrate to farmers a simple cost effective method of treating some of the vegetables to extend the shelf-life of these vegetables. This section of the training was led by a post-harvest and food preservation engineer. The farmers described some of the strategies they have been using to preserve their vegetable produce. Some of these practices include drying on cement floor, drying on roof top and boiling for some minutes before drying. They expressed their frustration with their current methods of drying because the quality of the produce such as colour and taste are affected. The farmers were trained on the solar blanching technique which is a simple method of drying fruit and leafy vegetables. The method involves drying the vegetables on a black polythene sheet covered with a transparent polythene sheet for about 2 hours. This method of drying is fast, easy and maintains the natural colour of the produce. A demonstration was made with leafy vegetables such as amaranth and roselle and fruit vegetables such as okro and pepper. The farmers were happy about this technology as the polythene is cheap, readily available in the market and easy to use.

Participatory Varietal Selection (PVS)

Scientific trials conducted by research institutes sometimes do not yield the desired results for the farmers. Most of the time the traits used by the scientist is not appreciated by the farmers. For this reason, the scientist decided to make the farmers make their own selection. This will help the scientists reduce the number of varieties being handled for efficiency. Participatory varietal selection is very important in adaptive trials as the end-users (farmers) are involved in the cultivar development process. With this approach, the farmers identify their preferred variety based on their observation. After the training exercise, the farmers were asked to observe the various variety trails and chose their preferred varieties. They were asked to rank the varieties and also give the reasons why they prefer those genotypes. With leafy vegetables such amaranth and roselle, the farmers prefer varieties with many branches, broad leaves and are late flowering. For amaranth, all the thirty farmers ranked Madiira 2 as the number one variety they preferred. The farmers ranked local 2 as the best roselle variety followed by Dah Rouge and Samanda. Most of the farmers selected AB2 as the best eggplant variety followed by TZ SMN 2-8. They ranked the varieties based on shape, size and colour of the fruits. Four of the male farmers have agreed to help to produce seed of the selected varieties.

Field Day:

A field day was organized on the 26th of September, 2014 with the aim of promoting indigenous African vegetables such as okro, eggplant, roselle and amaranth. It was also carried out with objective of promoting soil water and weed management practices such as plastic (black polythene) and grass mulch. Sixty farmers from 6 communities (Nyogluu, Libga, Bihi, Naayilli, Sakpalgu and Zaazi) with 10 farmers from each community were involved in the field day. These sixty farmers were also asked to select their preferred varieties for amaranth, roselle and eggplant varieties. These farmers also selected Madiira 2, Local 2 and AB2 as their preferred amaranth, roselle and eggplant varieties respectively. They also observed okro varieties under plastic, grass mulch and bare conditions. The farmers were excited to see the growth and yield difference for the three growing conditions and concluded that the plastic mulch supported the growth of the okro varieties better than the grass mulch and the bare conditions. They were also happy to see that the plastic mulch can be used to control noxious weeds such as *Cyperus rotundus*. They indicated that though the grass mulch was good in maintaining the moisture content of the soil, it harboured a lot of termites and crickets. The same observations were made concerning roselle under plastic, grass mulch and bare conditions. The farmers were happy to see amaranth varieties that have been nursed and transplanted as this is not a common practice in area.

In general, the farmers that were involved in the training workshop and field day were happy to have been part of the programme as they acquired a lot of knowledge from the training workshop. They added that more of such training programmes should be carried out on different areas of vegetable production. The research team will also make a follow up to see if the farmers are implementing the knowledge they acquired and update them with new innovations. They were also thankful to CORAF through AVRDC for funding this important project that will enhance the competitiveness TAVs and improve their livelihoods.

Seed Production:
Unavailability of seeds of improved TAVs have often been cited by farmers and stakeholders along the vegetable value chain as a major problem contributing to the low productivity and utilization of TAVs in northern Ghana. Therefore, seeds of improved TAVs would have to be multiplied and distributed to farmers within and outside the project communities. Seeds of the roselle, okro and African eggplant produced during the 2014 cropping season are indicated in table 41.

Table 48: Seed production during the 2015 cropping season

Crop	Variety	Quantity (g)
Roselle	Samadah	8500
	Dah Rouge	4200
	Morogoro	9050
	Local	3145
	Navrongo	650
	Local (Alidu)	1780
	Total	**27,325**
Okro	NOKH 1003	2575
	NOKH 1002	1350
	NOKH 1004	525
	Koni	1865
	Sasilon	955
	ML OK 10	85
	ML OK 35	73
	Ex Makutopora	295
	TZ SMN 98	55
	TZ SMN 10-3	60
	ML OK 16	62
	ML OK 37	70.5
	TZ SMN 86	85.5
	AAK	350.8
	Total	**8,406.8**
African eggplant	DB 3	265
	AB 2	200.5
	TZ SMN 2-8	56
	Total	**521.5**

Results/Major Findings:

About 27 kg, 8.5 kg and 0.5 kg of okro, roselle and African eggplant seeds, respectively, were produced.

References:

Voster, H.J.I., van Rensburg, W.J., van Zijl, J.J.B and Sonja, V.L. (2007). The importance of Traditional Leafy Vegetables in South Africa. African Journal of Food Agriculture Nutrition and Development. Vol. 7(4): 1-13 pp

LEGUMES IMPROVEMENT

Multi-locational evaluation of advanced early and medium maturing soybean lines for grain yield in diverse agro-ecologies of Northern Ghana.

Principal Investigator: N.N. Denwar
Collaborating Scientists: F. Addae-Frimpomaah, S. S. Buah, J. M. Kombiok, M. Abudulai, and R. A. L. Kanton.
Estimated Duration: 5 years
Sponsors: Soybean Innovation Lab/USAID
Locations: Nyankpala, Manga, Yendi and Damongo

Background Information and Justification

Soybean (Glycine max (L.) Merill) utilization is gaining popularity in Ghana because of its numerous potentials that rank it even better than cowpea in the supply of high quality protein. There is therefore, an increasing cultivation of the crop in the cropping systems of the savannah zone of Northern Ghana. Ogoke et al. (2004) reported an increasing cultivation of soybean in the West African moist savannah. Soybean performance, like any *crop* however, varies with the environment (Aremu and Ojo, 2005), therefore several varieties have to be evaluated in multiple environments for the identification of suitable genotype for specific environments. Differential genotypic responses of crop varieties to variable environmental conditions especially those associated with changes in ranks of genotyp es limit accurate yield estimates and identification of high yielding stable genotypes. Under the Feed the Future Program of the United States Government SARI is collaborating with the University of Illinois under the Soybean Innovation Lab with funding from USAID to develop better improved soybean varieties that would help farmers improve on their yield and income levels. With the gradual emergence of a vibrant seed industry in Ghana research institutions like SARI have never been in a better position to deliver improved varieties to the populace in a winsome and sustainable position.

Objectives

The objectives of the study were to determine the yield and other agronomic performances of elite early and medium maturing soybean lines across various locations in northern Ghana and thereby identify location-specific and broadly adapted lines.

Expected Beneficiaries: Farmers, seed companies, poultry industries, food and cosmetics companies.

Materials and Methods

Ten advanced early and fifteen medium maturing soybean lines were planted at four locations. The four locations were Nyankpala, Yendi, Manga and Damongo. These lines were selected from preliminary evaluations of genotypes obtained from the International Institute of Tropical Agriculture (IITA) in 2013. The plantings were done in mid- July 2014 using a randomized complete block design with four replicates. Each plot consisted of four rows of 5 m long, with

75 cm (medium) and 60 cm (early) between and 5 cm within row spacing. Two seeds were initially planted per hole but later thinned to one three weeks after seedling emergence. Pre-emergence herbicides were applied immediately after planting. Fertilizer was applied two weeks after sowing at the rate of 25- 60-30 kg/ha of N-P_2O_5-K_2O, respectively, and manual weeding done two times. Data was taken from the two middle rows of each plot. Data recorded included number of days to 50% flowering, plant height at 50% flowering, number of nodules per plant, height at maturity, days to maturity, 1000 seed weight and grain yield. Data collected were subjected to analysis of variance using Genestat version17. Means were separated using Duncan Multiple Range Test.

Results/Major Findings

The analysis of variance for the early lines revealed no significant difference for grain yield for the lines at Damongo whereas it showed significant difference ($P \leq 0.05$) among the lines at Manga. Again, poor grain weight were observed across the lines at Damongo (706.7-1066.7kg/ha) while Manga recorded high yield (666.3-1813.3kg/ha) in all the lines. Nyankpala (640- 1440kg/ha) and Yendi (1133.3 – 1733.3 kg/ha) followed in that order after Damongo respectively. None of the lines maintained its yield throughout the locations indicating the effect of the environment on the lines. In general, 70% of the lines at Manga and Yendi recorded grain weight of 1000kg/ha and above. Grain weight varied significantly depending on the line and the location. With the exception of Manga, the analysis of variance was highly significant for grain weight between the locations. Of the four locations, Yendi had the highest grain weight for the ten lines ranging from 800 to 2000 kg/ha which might be attributed to high germination percentage observed which led to more plant stand at harvest. On the other hand, Nyankpala recorded poor grain yield ranging from 666.7 to 1200kg/ha. The poor grain weight at Nyankpala might be attributed to intermittent drought at time of pod filling. Comparing the four locations, the following varieties were the best five for grain yield, TGX 1990-93F (2000kg/ha), TGX 1844-19F (1866.7kg), TGX 1834-5E (1866.7 kg/ha) and TGX 1844-22E (1866.7kg/ha). For the medium maturing lines, pod yield was significantly different among lines at Damongo but not Nyankpala. The check variety (Jenguma) performed similarly for Nyankpala and Damongo, proving to be better adapted. Yields averaged a tonne per hectare.

Conclusions/Recommendations

Yield performance of the early lines was average but one line yielded over 2 tons/ha. Environmental differences were important in the performance of the lines even though the trend among lines did not differ among locations. Lines yielding over 1.8 tons/ha would be selected for further evaluation. Yield levels among medium lines was below average across all locations and could be due to unfavourable rainfall pattern at the time of grain filling.

References

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Ogoke, I.J., Ibeawuchi, 1.1, Ngwuta, A.A., Tom, C.T., Onweremadu, E.U. (2009). Legumes in the cropping systems of southeastern Nigeria. Journal of Sustainable Agriculture 33: 823-834.

Field evaluation of aflatoxin resistant groundnut lines for pod yield in Northern Ghana.

Principal Investigator: N.N. Denwar
Collaborating Scientists: F. Addae-Frimpomaah, S. S. Buah, J. M. Kombiok, M. Abudulai, and R. A. L. Kanton.
Estimated Duration: 5 years
Sponsors: Peanut and Mycotoxin Innovation Lab/USAID
Locations: Nyankpala

Background Information and Justification

Groundnut is the fifth most important crop in Ghana after cacao, maize, cassava, and yam in terms of area coverage (565,354ha). The crop is grown all over the country from the dry savannah regions to the moist forest areas and the coastal savannah zone along the coast. Over 80% of Ghanaians consume groundnuts once or more each week, making it a very important food crop in the country. However, due to poor handling of the crop from production through processing and storage, it gets contaminated with aflatoxins. Aflatoxins are one of the most potent toxic substances that occur naturally. These are a group of closely related mycotoxin produced by the fungi *Aspergillus flavus* and *A. parasiticus*. Aflatoxicosis is poisoning that result from ingestion of aflatoxins in contaminated food or feed. In order to make minimize the risk of contamination farmers are encouraged to cultivate aflatoxin resistant lines. Through its collaboration Texas A&M University under Peanut and Mycotoxin Innovation Lab (PMIL), SARI obtained a number of aflatoxin resistant lines from ICRISAT for evaluation.

Objectives

The objectives of the study were to determine the yield and other agronomic performances of elite groundnut lines with resistance to aflatoxin and to identify superior lines for further evaluation.

Expected Beneficiaries: Farmers, seed companies, poultry industries, food and cosmetics companies.

Materials and Methods

The experimental design was a Randomized Complete Block Design (RCBD) with four replications. Each block (rep) contained 14 advanced breeding lines and one local variety serving as a check. There were 15 plots within each block with a size of 2 m x 3 m. One seed per hill was planted with a spacing of 50 cm inter-row and 15 cm intra-row. Weeds were controlled with herbicides and manual weeding. Pre- emergence herbicides were sprayed immediately after planting and manual weeding was done at two weeks and five weeks after emergence. Triple super phosphate was applied.

Results/Major findings
The aflatoxin tolerance varieties showed some potential of high yields even though plant establishment was poor (due to removal by birds) coupled with late planting which was due to the delay in the on-set of rains. Six of the varieties had kernel yield above 1.1 t/ha. Progress was made in the crossing program with crosses among various lines advanced to the third generation. Large seed size, leaf spot resistance, high oleic and aflatoxin resistance are some of the key traits been introgressed

Conclusions/Recommendations
All of the aflatoxin resistant lines yielded below the local check, Nkatiesari, indicating that for farmers to accept these lines yield must be raised through breeding while maintaining the aflatoxin resistance.

Improving Food Safety, Food Quality and Income of Poor Actresses and Actors of the Peanut Value Chain in West Africa by reducing Aflatoxin" (GestAflAr).

Principal Investigator: N.N. Denwar
Collaborating Scientists: Mumuni Abudulai, S.S.J Buah, Issah Sugri, Edward Martey, Prince M. Etwire
Estimated Duration: 3years
Sponsors: CORAF/GESTA FLAR

Locations: Throughout Northern Ghana

Background Information and Justification
The Project "Improving Food Safety, Food Quality and Income of Poor Actresses and Actors of the Peanut Value Chain in West Africa by reducing Aflatoxin" (GestAflAr) is a West and Central African Council for Agricultural Research and Development (WECARD/CORAF) funded project launched in 2013.Consistent with the mandate of the Savanna Agricultural Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI), the objective of the project is to contribute to poverty reduction among all the actors in the groundnut value chain by reducing aflatoxins and improving the competitiveness of the crop.

Objectives
The main objective of the training component was to educate farmers on the dangers of consuming aflatoxin contaminated foods and to training them in management strategies to minimize aflatoxin contamination in the field and in storage.

Expected Beneficiaries: Farmers, seed companies, groundnut exporters and the food industry.

Materials and Methods

The training team employed a variety of adult learning techniques to engender full participation of trainees and for effective transfer of knowledge and skills. Such techniques included:

Presentation by the facilitators

The training manual prepared by the trainers was presented through the use of a PowerPoint presentation. The facilitators used less text and technical materials, pictorial and graphical materials were however heavily relied on for the presentation. The facilitators encouraged participants to comment and provide feedback during the presentation.

Demonstrations

Demonstrations were used to buttress key concepts

Group Discussion and Role Play

The purpose of the group discussion and role play was to give participants the chance to brainstorm on aflatoxin concepts. The trainers facilitated the group discussion process as well as the role play.

Plenary Discussions

The purpose of the plenary sessions was to obtain participants views and opinions on the various issues presented.

Results/Major findings

Over 400 farmers and Agricultural Extension Agents (AEAS) of the Ministry of Food and Agriculture (MoFA) were trained in the dangers and management strategies to minimize aflatoxin contamination in groundnuts in the field and in storage. Trainees were drawn from four districts: Kasena Nankana East (Navrongo), Bulsa North (Sandema), Savelugu (Savelugu) and Wa Municipal (Wa). An Innovation Platform comprising various stakeholders was established in Wa to form the forum for continuous education, planning and execution of various strategies towards the realization of aflatoxin-free groundnut and groundnut products along the groundnut value chain.

Conclusions/Recommendations

In conclusion, the training program was successfully conducted. The expression of appreciation and the interest shown in participating in the training sessions were indications of beneficial impacts of the training. Attendance was very good. The participatory learning strategy adopted ensured that participants were actively involved in the training activities. Participants are therefore expected to apply the knowledge gained in their farm operations.

Smallholder farmers need to be supported and encouraged to deliver quality, aflatoxin free produce to consumers. The project team therefore intents to engage in regular monitoring and follow ups, in order to mentor farmers to adopt methods that can eliminate or reduce aflatoxin contamination.

COWPEA IMPROVEMENT

Breeding for high yielding Improved Cowpea Varieties with Resistance to thrips, pod sucking bugs and *Striga gesnerioides* in Northern Ghana

Principal Investigator: Mohammed Haruna
Collaborating Scientists: *I.D.K. Atokple, M. Abudulai, J.M. Kombiok, B.D.K. Ahiabor A.N. Wiredu, Y.E. Owusu & Issahaku Memunatu*
Estimated Duration: 3 years
Sponsors: AGRA
Location: Nyankpala, Manga, Wa & Navrongo

Project rational/Background:

Cowpea is the second most important legume crop in northern Ghana after groundnut and serves as a cheap source of protein and income but yields are low, averaging 0.8MT/ha on farmers fields. The dry grain with about 23-25% protein serves as a cheap source of protein for both rural and urban consumers whereas livestock benefit from the residue left over after the grain is harvested. It is predominantly cultivated by poor resourced small scale farmers with average farm size of about 0.5-1.1 ha.

Despite the low productivity, Ghana is the fifth highest producer of cowpea in Africa (Abate et al. 2012). Cowpea yields in this country are the 4th highest in the world, after Peru, Cameroon and Uganda (Abate et al. 2012). Ghana also has the fastest growing production of the crop in Africa. Annual rates of growth for cowpea area, yield and production for the period from 1985-1987 to 2005-2007 were -0.1%, 39.6%, and 39.8%, respectively. It has been projected that the rate of growth for cowpea production during the period between 2010 and 2020 would be 11.1 % (Abate et al. 2012).

Currently, there are dynamics in consumption habits, a trend that indicate changes in the role of the grain legumes in the livelihood systems of smallholder farmers. The urban population who are conscious about their health are shifting from protein sources based on animal meats to crop sourced proteins, thus, leading to rising demand for grain legumes in the urban areas, resulting to elevation of the grain legumes especially cowpea as "cash crop" in the rural smallholder systems.

Despite the importance of cowpea on the livelihood of smallholder farmers and the good adaptation in northern Ghana, its production is constrained by several biotic and abiotic stress factors. The root parasitic weed, *Striga gesnerioides* causes extensive cowpea grain yield reduction in northern Ghana. Grain yield losses of up to 80% are estimated on susceptible cultivars (Singh and Emechebe, 1990). There is a positive correlation between the menace of Striga infestation and low soil fertility (Muleba *et al*, 1997). Host plant resistance is the most practical and economic strategy to control this weed. One of the objectives of the project was to incorporate *Striga* resistant genes into the genetic background of recommended cowpea cultivars.

Flower thrips caused by *Megalurothrips sjostedti* is perhaps the most important insect pest on cowpea in Ghana and is found in almost everywhere that cowpea is cultivated. They cause considerable damage in areas where there has not been any chemical intervention though losses are yet to be quantified. Studies elsewhere indicate that total crop loss could result from severe infestation from this insect. The adult thrips which are minute insects feed in the flower buds and flowers. Severely infested plants do not produce any flowers and when populations are very high, open flowers are distorted and discoloured. The flowers then fall early with the result that pods are not formed. Flower thrips attack flower buds and destroy the buds leading to reduction in the number of pods per plant and subsequently seed yield. It has been estimated 50-100% yield loss can occur during severe infestation (Adidgbo *et al*, 2007). A local variety "Sanzei" was identified to possess antibiosis resistance to flower thrips and it was used in this project as a donor parent to transfer the resistant genes into existing improved susceptible varieties.

Soil infertility remains the major constraint to sustainable agricultural production in northern Ghana. Farmers in this region apply mostly chemical fertilizers to improve the soils which are costly and often unavailable. The Ghana government in 2008 spent about GH¢20m on subsidizing fertilizer under the fertilizer subsidy program (FSP) but farmers still apply less than the rate required per hectare due to their low income status. Policy makers and farmers would therefore welcome any strategy that seeks to turn around the general soil fertility constraint in the north into a resource for sustainable agriculture. As a nodulating leguminous crop, cowpea can source its N requirements from either the soil or through a process called Biological Nitrogen Fixation (BNF) or both. The N contributed through BNF benefits the cowpea crop as well as component and succeeding cereal crops leading to reduction in the quantity and amount of money that would have been spent on chemical fertilizers. Under this project, a number of cowpea genotypes were screened for high nitrogen fixation using the N solute or xylem ureide technique to quantify nitrogen fixation in tested genotypes.

Materials and Methods

The study employed integrated breeding methods by using the participatory approach in the selection of advanced varieties (Participatory Variety Selection) and generating recombinant lines through hybridization to create variability with regard to these traits for further selection. Field demonstrations and community seed production schemes were conducted to introduce farmers to elite lines which are higher yielding with resistance to aphids, *thrips* and *striga*.

One hundred and eighty six (186) cowpea germplasm were introduced and evaluated for higher yielding with resistance to aphids, thrips, pod sucking bugs and *striga gesnerioides*. This was done in collaboration with local seed companies and farmer based organizations (FBOs) leading to awareness creation, learning and technology dissemination to accelerate the adoption developed varieties. Crosses were done to integrate farmer preferred traits such as earliness, bold/large seed size (20 cm or more), white seed coat with black-eye helium in addition to thrips, and pod sucking bugs and *striga* resistance. Twenty (20) of such crosses were advanced to F_4 generation and they will constitute entries of advanced yield trials. Various media were used for variety dissemination and promotion such as farmer field days, farmer' network, publications and presentation in conferences and workshops.

The participatory approach adopted in the research has enhanced the selection process and accelerated the processes of propose release of four high yielding candidate cowpea lines with combine resistance to aphids and *striga gesnerioides*.

Results and Discussion

Germplasm introduction and preliminary evaluation

Three sets of trials comprising 12 early, 12 medium and 12 dual-purpose lines were introduced from IITA and evaluated on-station at Nyankpala. IT07K-299-6 and IT07K-273-2-1 were selected based on yield earliness and seed colour and size.

Cowpea Advance yield trials (CAYTs)

Promising lines selected from preliminary evaluation in 2013 cropping season were constituted into advanced yield trials (CAYT) at Damongo, Nyankpala and Yendi. They consisted of early maturing (CAYT 1) and medium/late maturing (CAYT 2) lines. Yield stability test of candidate cowpea lines proposed for release was carried out at Nyankpala to evaluate their yield performance against existing varieties (Fig. 15).

Cowpea advance yield trial 1. (Early maturing lines)

This trial consisted of 12 best performing early maturing lines selected from preliminary evaluation last year. The lines showed genotypic differences in days to flowering (DFF), maturity and pod yield. The average maturity of these lines was 67 days but 4 lines matured below the average indicating that they were early maturing. Lines within this maturity group should mature between 60-65 days. The increase in maturity days could be due to changes in photoperiod and high temperature during the crop's phenology and thus prolonging the period of vegetative growth. IT07K-299-6 gave the highest pod yield of 1.8tons per hectare. Songotra, the local check recorded the least pod yield (945 kg/ha) among the lines tested (Figure 13&14). Average grain yield was 1065 kg/ha with a range of 837-1542 kg/ha. Five lines gave grain yield higher than the average. The genotype that recorded the highest grain yield was IT07K-299-6 (1.5 t/ha) and Songotra, the local check recorded the lowest grain yield of less than a ton.

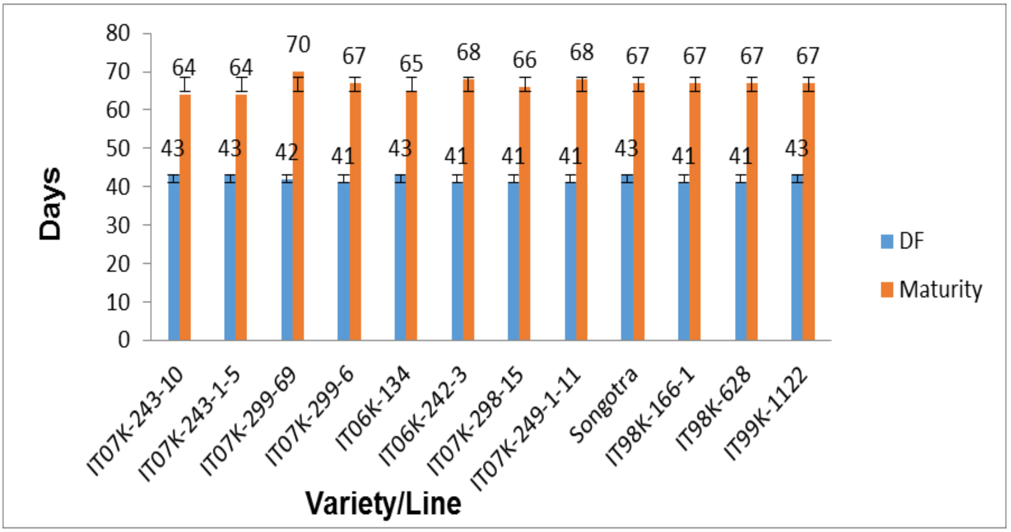

Figure 13: Flowering and maturity days of 12 early cowpea lines tested at N'la, 2014

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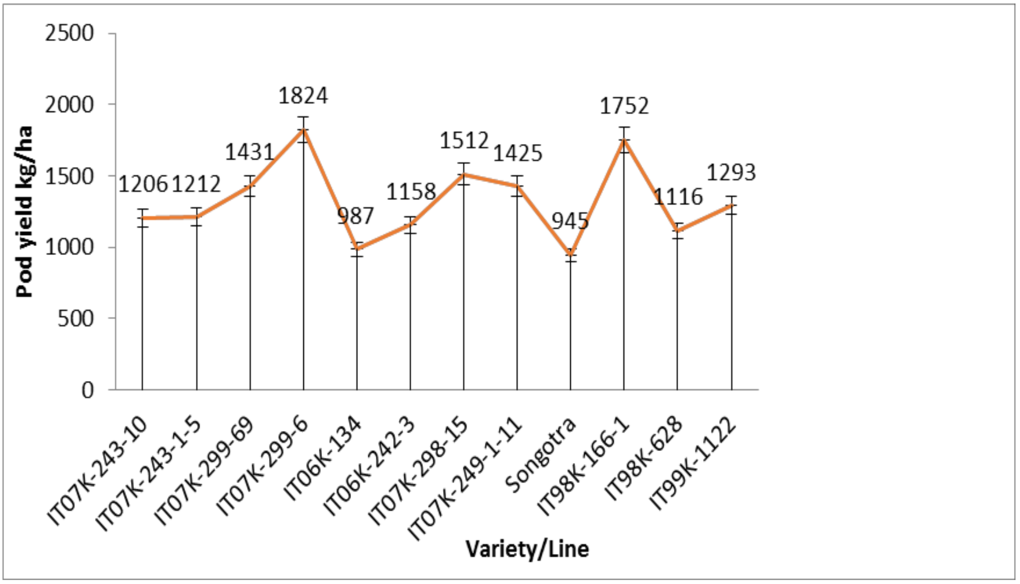

Figure 14: Pod yield of 12 early maturing lines at N'la. 2014

Cowpea advance yield trial 2. (Medium/late maturing lines)

Fourteen (14) medium maturing cowpea lines were evaluated at Nyankpala for yield and yield attributes. Best performing lines will be advanced to multi-location yield trials next cropping season to test their performances under varied environments. There was significant difference ($p \geq 0.05$) between the genotypes for grain yield. The average grain yield was 1188 kg/ha with range of 943 – 1600 kg/ha. However, three of the lines recorded grain yield more than the check variety, Padi-tuya. IT07K-304-9 gave the highest grain yield of 1600 kg/ha and the least yield of 943 kg/ha was recorded by IT99K-7-21-2-2 (Table 42).

Table 49: *Performance of 14 medium maturing cowpea lines tested at N'la, 2014*

Variety/Line	DFF	Days to maturity	Pod yield kg/ha	Grain yield kg/ha
IT07K-187-24	44	68	1471	1130
IT07K-188-49	44	71	1897	1290
IT07K-211-1-8	42	71	1420	957
IT07K-292-10	41	68	1550	960
IT07K-304-9	43	68	2047	1600
IT07K-304 - 44	42	71	1233	950
IT06K-137-1	42	68	1683	1370
PADI-TUYA	44	70	1807	1423
IT86D-610	45	70	1623	1270
IT97K-1069-6	41	74	1803	1497
IT97K-390-2	41	74	1580	1027
IT99K-7-21-2-2	41	74	1193	943
IT99K-529-2	43	72	1483	1130
ITOOK-1263	43	68	1653	1083
Mean CV	**43**	**70**	**1603**	**1188**
(%) LSD	**1.8**	**0.38**	**29.3**	**28.8**
(0.05)	**1.1**	**0.4**	**672**	**489.6**

DFF = Days to 50% flowering

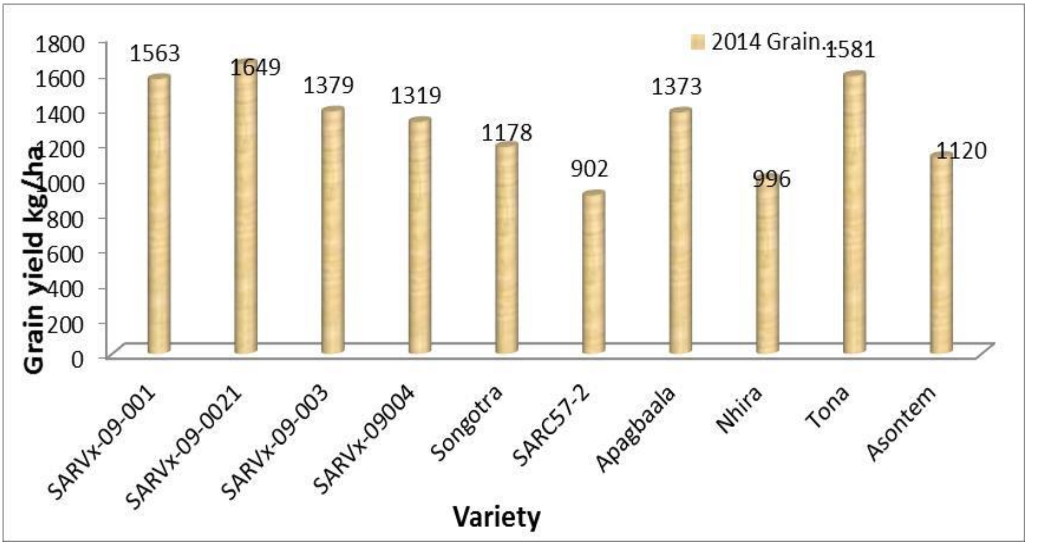

Figure 15: Grain yield of 10 aphis/striga resistant lines tested at Nyankpala in 2014

Screen adapted varieties for high nitrogen fixation to enhance soil fertility and crop productivity.

Nitrogen fixing potential of proposed varieties for released was assessed using the N solute method. With this method, the relative concentration of N solutes (allantoin, allantoic acid, amino compounds and nitrates) in the xylem sap reflects the sources of nitrogen being assimilated by the legume (Unkovich *et al*, 2008). Xylem sap samples were taken and analysed for ureides and nitrate concentration using the procedure developed by Herridge *et al,* 1988.

Results showed very high percentage nitrogen derived from the atmosphere (%Ndfa) for the four candidate varieties than their parents (Fig. 16). About 70% - 82% of nitrogen intake was from fixation whereas the parents varieties fix maximum of 65% indicating that the proposed varieties when released for cultivation can significantly fix substantial quantities of nitrogen to improve upon the poor nitrogen deficient soils of northern Ghana for sustainable agriculture.

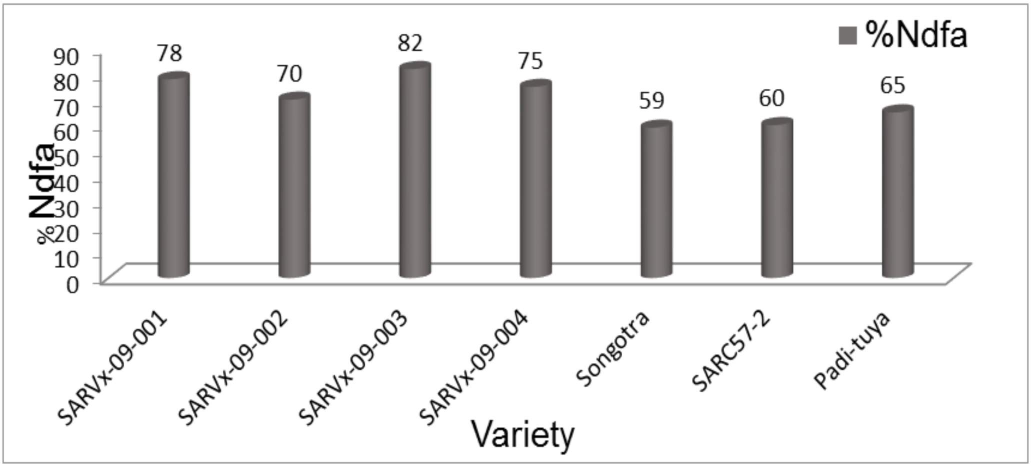

Figure 16: *Percent nitrogen fixed by candidate varieties and parents at N'la., 2014*

Achievements

During the 3 years of the project implementation, 186 cowpea germplasm consisting of introductions, advance lines of crosses and landraces were collected across northern Ghana. Twelve demonstrations were conducted in five districts (Tolon, Savelugu, East Mamprusi, West Mamprusi and Bawku west) of northern Ghana. About 300 hundred farmers including 100 women farmers benefited from the participatory on-farm evaluations and demonstrations which were platforms for awareness creation, learning and knowledge sharing and dissemination.

Average of 535 kg breeder seed of release varieties and elite lines were produced every year to supply foundation seed producers and to permit the dissemination and diffusion of improved varieties. Four varieties which combine resistance to aphids and *striga gesnerioides were* proposed for release in 2014. The first field inspection was done by the national variety release and registration committee (NVRC) on 24th September, 2014. A second and final field inspection of the varieties is expected soon before they can be released and given a national recognition as varieties for cultivation. After the varieties have been released, they would be registered in a reputable journal and in the national variety catalogue.

Lessons learned

The results so far indicated that high yielding cowpea varieties with resistance to thrips and *striga gesnerioides* can be achieved but pod sucking bugs resistance varieties were difficult to develop or select because pod suckers are a complex and they cause damage on cowpea plants at different periods within the crop's pod formation stages. I therefore, suggest that a particular pod sucker should be targeted most probably the important and common ones in Ghana. I have also search through literature but could not get work on resistance to pod sucking bugs generally. Previous works on resistance to pod sucking bugs targeted a particular pod sucker such as *Riptortus dentipes* or *Nezera viridula* which are reported to be the most damaging pod-sucking pest on cowpea in Ghana.

The studies revealed that selection criteria varied within the farmers during the PVS. Whilst male farmers selection of good varieties was on higher number of pods per plant, larger seed size and white black-eye, the female farmers selection criteria was in addition to these characteristics, varieties that could cook faster (less energy to cook) such as those with thin seed coat tester.

Improving the livelihood of smallholder farmers in drought-prone areas of Sub-Saharan Africa and Asia through enhanced grain legume production and productivity

Principal Investigator: *M. Haruna*
Collaborating Scientists: *I.D.K. Atokple, M. Abudulai, A.N. Wiredu, Y.E. Owusu & Issahaku Memunatu*
Estimated Duration: 3 years (2014-2017)
Sponsors: USAID
Location: Nyankpala, Manga, Wa & Navrongo

Project rational/Background:
Farm level yields of cowpea on area basis has remained low (600-800kg/ha) compared to research fields (1600-2500 kg/ha). Among the several factors that account for the low productivity include lack of farmer access to high yielding varieties, biotic and abiotic stresses and improper cultural practices in its cultivation. Despite the fact that CSIR-SARI has developed and released for cultivation improved cowpea varieties suitable for the interior savanna, diagnostic surveys have shown that rural farmers invariably do not have access to these improved varieties. This is due to the fact that the seed industry in Ghana has been privatized and dealers find it unattractive to open sale outlets in these hinterlands. Hence, phase two of the Tropical Legumes project's activities were initially tailored on promotion, dissemination and diffusion of drought tolerant cowpea lines developed in Phase 1. This involved introducing to farmers the new drought tolerant varieties and train selected farming communities on improved techniques in the cultivation of cowpea through on-farm participatory research and demonstrations. However, since this was the first year of project implementation, adaptation studies was carried out on these materials before embarking on promotion and dissemination.

Objective(s)
The major objective of the project was to enhance the competitiveness of grain legumes (cowpea) for increase income and nutrition security of smallholder farmers in the dry lands of sub-Saharan Africa.

Specifically to:

a. Develop sustainable seed production and delivery system for reaching smallholder farmers in drought prone areas.
b. Establish partnerships to upscale the promotion, dissemination and diffusion of resources (varieties developed) from previous phase.

Materials and Methods

Ten drought tolerant cowpea lines selected after evaluating sixteen lines that were developed by IITA during phase 1 of the project were used to establish on-station and farm participatory variety selection (FPVS) trials at three sites in the northern region of Ghana to create farmers awareness, introduce farmers to these varieties and identify farmers' preferred traits to facilitate the adoption of the lines. The on-station trial was under the scientist management and the on-farm trials were managed by farmers with scientist supervision. Treatments for the on-station trial were 10 drought tolerant lines including a check variety whereas five drought tolerant lines including farmers' own variety constituted treatments for the on-farm trials. Experimental design for both on-station and on-farm trials was randomize complete block with three replications. Planting was done at spacing of 60 cm x 20cm and fertilizer was applied at rate of 25-60-30 of urea, triple single supper phosphate (P_2O_5) and muriate of potash (K_2O). *Lambda cyhalothrin* (Karate 2.5 E.C) at rate of 60mls per 15litres knapsack sprayer was applied to effectively control insect pests at the vegetative, pre-flowering, flowering and pod development stages. The treatments were assigned to four row plots in a block. Plots were 4 meters long by 1.8 meters wide. Plants were spaced 60 centimeters between rows and 20 centimeters within rows. Data was collected in the two inner rows for analysis.

Results and Discussion

Participatory farmers from were brought to the on-farm trials to observe the performance of the treatments at vegetative growth stages and at harvest and to select their preferred lines as part of a learning and technology dissemination process. The farmers were organized into four groups. Two high performing lines (IT99K-1122 and IT98K-628) were preferred and selected by all four farmer groups indicating that farmers will readily adopt these varieties when released. Among the criterion used by farmers in selecting good performing lines were grain and biomass yield, colour of the seed coat and size of the seed. Varieties with bold or large grain size and white seed coat were preferred.

Variety maintenance

It is mandatory for breeders in the public research institutes to produce breeders' seed of released varieties to supply foundation seed growers and also to maintain the genetic purity of these varieties over time. During reporting period we embarked on breeder seed production of all released varieties and elite cowpea lines (Table 2). This was done under the supervision of the breeder.

Table 2. Characteristics of cowpea varieties and quantity of breeder seed produced, 2012

Crop	Variety Name	Yield potential		Maturity (days)	Quantity of seed produced (Kg)	Special Attribute
		Grain yield (kg/ha)	Fodder yield (kg/ha)			
Cowpea	Songotra	2,000	3,600	60-65	200	High yielding, *striga* resistance
Cowpea	Padi-tuya	2,400	5,400	65-70	350	Higher grain and fodder yields, moderately resistant to aphids and *striga*
Cowpea	Apagbaala	2,500	3,200	55-60	150	Highly tolerant to heat/drought
Cowpea	Baawutawuta	2,200	4,200	75-80	50	Highly resistant to *striga gesnerioides*

THE WAY FORWARD

Though AGRA-Cowpea project has ended, we shall continue to identify/develop and screen more genotypes for resistance to the major biotic and abiotic stress factors which the project seeks to address. About 20 F4 generations of crosses that combine important traits such as drought tolerance, earliness, *Striga* and *thrips* resistance have been developed and would be advance to yield trials this season. Second field inspection plot of the candidate cowpea varieties proposed for released will be established during this cropping season to invite the NVRS for the second and final field inspection. The programme shall continue to improve the genetic makeup of selected genotypes through hybridization to incorporate traits relevant for the attainment of the cowpea programme research objectives. Research will be conducted to upscale the promotion, dissemination and diffusion of already developed technologies (varieties) through establish partnerships with existing legumes projects especially the new AGRA project on *rhizobium* inoculants production. The production of breeder and foundation seed of *Padi-tuya, Songotra, Apagbaala* and *Zaayura* would be enhanced to meet the seed requirement of the cowpea out scaling project.

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SOIL MICROBIOLOGY

Putting Nitrogen Fixation to Work for Smallholder Farmers in the Northern Region of Ghana

Principal Investigator: Rev.-Dr. Benjamin D.K. Ahiabor
Collaborating Scientists: Nil
Estimated Duration: 1 year
Sponsor: IITA, Ibadan, Nigeria
Location: Northern Region, Ghana

Background and Justification:
Cowpea and groundnut are the principal grain legume crops and source of dietary protein for human nutrition in Ghana. These legume crops are able to nodulate with rhizobium bacteria in the soil and benefit the plant through biological N2 fixation. Besides these two legumes is the more recently introduced soybean whose production has fast caught up with those of cowpea and groundnut and has even almost outstripped the production of cowpea and groundnut in many places. Farm-household average yield outputs of soybean, groundnut and cowpea have been found to be 737 kg grain/ha, 712 kg pod/ha and 365 kg grain/ha. These are woefully low and therefore agronomic interventions need to be introduced to close the yield gaps and to raise these yields to an average of at least 2 t/ha for all the three crops on farmers' fields.

During the reporting period under review (April, 2014 to March, 2015), both on-station and on-farm experiments geared towards the development of variety x inoculants x nutrient management recommendations for soybean, cowpea and groundnut were conducted. These included various varieties of soybean inoculated or not inoculated or a single variety of each (soybean & cowpea) inoculated or not in combinations with different nutrient amendments like TSP, KCl, and Boost Xtra. For groundnut, the input requirement trials included the combinations of lime (CaO) with other nutrient amendments like TSP, KCl, and Boost Xtra.

Objectives:

Activity 1 objective: To determine the growth, yield and biological nitrogen fixation (BNF) responses of different soybean varieties to rhizobium inoculation with or without P fertilizer application

Activity 2 objective: To determine the response of cowpea (Songotra) to *Rhizobium* inoculation and manure

Activity 3 objective: To determine the growth, yield & biological nitrogen fixation (BNF) responses of soybean, cowpea and groundnut to integrated applications of P (TSP), K (KCl) and Boost Xtra at different locations

Expected Beneficiaries
Farmers, Agro-input Producers, Agro-input Dealers, Legume Processors, Certified Seed Growers, Agricultural Researchers, Academia

Materials & Methods

Activity 1: Evaluation of different soybean varieties for yield and biological nitrogen fixation (BNF) in the Northern Region

Test varieties, trial locations and implementers
Three soybean variety trials involving the varieties Jenguma, Afayak, Suong Pungun, and Songda were established on-farm at Zakoli (Yendi Municipality) and Nangunkpang (Karaga District) and on-station at Nyankpala (Tolon District) in the Northern Region (Table 42). Apart from the Nyankpala and Zakoli trials which were established and managed by SARI and SARI & EPDRA (Evangelical Presbyterian Development and Relief Agency), respectively, all the other soybean variety trials were implemented jointly by SARI and the respective district directorates of the Ministry of Food and Agriculture. The trials were established on June 24, 2014, July 3, 2014 and July 7, 2014 at Zakoli, Nyankpala and Nangunkpang, respectively.

Table 50: Locations of the trials in the Northern Region

rial type	Mandate area	Community	No. of trials	Responsible partner institution
Soybean variety trial	Yendi Municipality	Zakoli	1	SARI, EPDRA
	Karaga District	Nangunkpang	1	SARI, MoFA
	Tolon District	Nyankpala (on-station)	1	SARI

At every location the land was ploughed with a tractor and then harrowed with a hoe after which the fields were demarcated into plots according to the type of trial. Soybean plots were 4.5 m long and 3 m wide giving a plot area of 13.5 m^2. The trials were laid leaving an alley of 1.5 m between inoculated and un-inoculated plots within a replicate and a distance of 2.0 m between two replicates. The distance between two plots within a row was 0.5 m. Planting was done at a spacing of 50 cm between rows and 10 cm between plants at 2 seeds per hill (this gives 400,000 plants/ha). There were nine lines or rows per plot.

Weedy fallow plots were included in the lay-out to allow the sampling of the natural re-growth (weeds) as reference plants for the assessment of biological nitrogen fixation (BNF) of the test legumes by the Total N Difference method.

A split-plot arrangement in a randomized complete block design at four replications was used for the soybean variety trials at all locations with inoculation as main plot and soybean variety as sub-plot. The soybean varieties used were Jenguma, Afayak, Songda, Suong Pungun.

All the plots received basal applications of organic manure (fertisoil) at a moderate rate of 4 t/ha (= 5.4 kg/plot) and P and K in the forms of TSP and KCl, respectively at the rates of 30 kg P (= 202 g TSP/plot) and 30 kg K /ha (= 81.0 g MoP/plot). The organic manure (fertisoil) was broadcast and incorporated in the soil by shallow tillage 1-2 weeks before planting whereas the P and K fertilizers were band-placed 2-3 weeks after sowing (WAS) in a trench dug 5 cm away from the hill and 5 cm deep and covered after application.

The soybean seed was inoculated with the commercial inoculants *Rhizobin* (Bradyrhizobium strain 532c) before sowing. Appropriate quantity of water was used to moisten the seed and stirred well and the inoculants added at the rate of 5 g/kg seed. The mixture was stirred thoroughly after which the inoculated seed was air-dried in the shade for at least 30 minutes before planting.

A pre-emergence herbicide "Buta plus" was applied at planting to control weeds on the fields. Subsequent manual weeding with a hoe was done as and when necessary. The crops were monitored and sprayed against insect pests as and when necessary by the staff from the Entomology Section of SARI according to recommended spray regimes.

Data collected during the reporting period under review included, shoot biomass, root biomass, and nodulation at full pod fill (R4) stage, yield and some yield components. Biomass sampling and nodulation assessment were done at full pod stage (R4) by indicating the sampling area and five (5) hills of plants (i.e. 10 plants) were selected randomly for sampling after counting and recording the total number of plants in the indicated sampling area. The field (fresh) weight of the 10 plants was determined and a sub-sample of five plants were then taken from the ten plants, weighed and then oven-dried at 80°C for 48 h to constant weight and the weight recorded.

The roots cut from the five plants were washed and air-dried and the nodules removed and counted before oven-drying them at 80°C for 48 h to constant weight and the weights recorded.

Harvesting: All the varieties were harvested 19 WAP apart from Soung Pungun which was harvested a week earlier. Harvesting was done when all the pods turned brownish or tan. All the plants within the 3 inner rows were counted and recorded. These plants within the 3 inner rows were harvested in all treatment by uprooting the plants with the hand. 10 plants were then selected at random for each treatment and the pods detached from the plants, weighed and counted and the average pod number per plant (i. e. pod load) was calculated. The pods were then threshed and winnowed to obtain the grains which were sun-dried for about 1 week and their weights measured on a digital scale. One thousand (1000) seeds were then counted from the dried grains for all the treatments to determine seed size which was recorded as 1000-seed weight.

Activity 2: Determination of appropriate input requirements for cowpea in northern Ghana
Objective 2: To determine the response of cowpea (Songotra) to *Rhizobium* inoculation and manure

The cowpea variety, Songotra was used for this trial. This trial was installed at Tusani (Yendi Municipality), Tong (Karaga), and Nyankpala. In the Northern Region, SARI and EPDRA or MoFA collaborated to establish and manage the trials. At every location, soil sampling and land preparation were done as reported under activity 1. The trial plots were 4.2 m long and 3 m wide and the planting distance was 60 cm x 20 cm at three seeds per hill and thinned to two per hill (i.e. 166667 plants/ha). The cowpea variety used was Songotra and there were seven lines or rows per plot. Weedy fallow plots were included in the lay-out to allow the sampling of the natural re-growth (weeds) as reference plants for the assessment of biological nitrogen fixation (BNF) of the test legumes by the Total N Difference method.

A split-plot arrangement in a randomized complete block design at four replications was used for the cowpea-fertisoil trials at all locations with inoculation as the main plot and fertisoil rate as sub-plot An alley of 0.5 m was maintained between two adjacent plots whereas the distance between each set of replicates was 1.5 m.

Basal applications of TSP (30 kg P/ha = 188 g TSP/plot) and MoP (KCl) (30 kg K/ha = 75.6 g MoP/plot) were applied to all plots in bands in a trench dug 5 cm away from the hill and covered after application.

The manure (fertisoil) was applied as a treatment at four different rates of 0, 2, 4 and 6 t /ha (= 0, 2.52, 5.04, 7.56 kg/plot) by broadcasting and incorporating into the soil on July 23, 2014, July 28 and August 2, 2014 at Tusani, Tong and Nyankpala, respectively. The respective planting dates were August 01, July 28 and August 12, 2014, respectively.

Inoculation of cowpea was done using the one-step method. Sugar solution (20%) was prepared by using a 100 ml measuring cylinder into which 80 ml of water and 20 g of sugar were measured and thoroughly mixed giving a 20% (w/v) sugar solution. A small quantity of the sugar solution was sprinkled on the seeds to moisten them before mixing the seeds with the inoculants (strain BR3267) obtained from EMBRAPA, Brazil. The inoculated seeds were air-dried briefly and then sown.

Data collection
Data collected during the reporting period under review included, shoot biomass, root biomass and nodulation at full pod fill (R4) stage, yield and some yield components.

Activity 3: Determination of appropriate input requirements for soybean, cowpea, and groundnut in northern Ghana

Objective: To determine the growth, yield & biological nitrogen fixation (BNF) responses of soybean, cowpea and groundnut to integrated applications of P (TSP), K (KCl) and Boost Xtra at different locations

Soil sampling, land preparation and field lay-out

These activities were carried out similarly as in the soybean variety and cowpea/inoculants /fertisoil trials. The plot sizes for the soybean input trials were 4.5 m x 3.0 m and those for both cowpea and groundnut input trials were 4.2 m x 3.0 m at all the locations. Weedy fallow plots were laid to allow the sampling of the natural re-growth (weeds) as reference plants for the assessment of biological nitrogen fixation (BNF) of the test legumes.

Test varieties, trial locations and implementers

The legume varieties used in the soybean, cowpea and groundnut input trials were Jenguma, Songotra and Samnut 22, respectively. The trial locations are shown in Table 43 below.

Table 51: Locations, trial type, dates of planting and implementers of soybean, cowpea and groundnut input trials in the Northern Region in 2014

Type of trial	Mandate Area	Community	No. of trials	Responsible partner institution
Input trials	Yendi Municipality: Soybean/Cowpea/Groundnut (TSP/KCl/BoostXtra)	Zakoli, Tusani, Gundogu	9	SARI, EPDRA
	Cowpea + Fertisoil	Tusani	1	
	Karaga District: Soybean/Cowpea/Groundnut (TSP/KCl/BoostXtra)	Nangunkpang, Karaga, Tong	9	SARI, MoFA
	Cowpea + Fertisoil	Tong	1	
	Tolon District: Soybean/Cowpea/Groundnut (TSP/KCl/BoostXtra)	Nyankpala (On-station)	3	SARI
	Cowpea + Fertisoil	On-station	1	
	Total		24	

Experimental design and treatments

The soybean, cowpea and groundnut input trials were installed using a split-plot arrangement in a Randomized Complete Block Design (RCBD) at four (4) replications across all the locations. Inoculation was the main plot and the fertilizer type was the sub-plot for soybean and cowpea whereas lime (CaO) at 500 kg/ha (630 g/plot) was the main plot and fertilizer type as sub-plot for groundnut. The fertilizer types used were TSP (30 kg P/ha), KCl (30 kg K/ha), Boost Xtra {a foliar fertilizer; at 4 L/ha (121 ml/5L of water)} and the treatment combinations for the input trials on the three legumes across all the locations were: Control, TSP, KCl, Boost Xtra (BX), TSP+KCl, TSP+BX, KCl+BX and TSP+KCl+BX. Generally, TSP and KCl treatments were imposed two weeks after sowing across the regions by depositing them in trenches dug 5cm away from the hill (band application) and covered with soil. Boost Xtra was applied at flower initiation and subsequently at two weeks interval after the first application till full pod stage.

A weed fallow treatment of same plot size was provided for each crop. Insect infestation (influence of biophysical factors) was monitored and controlled on all the test crops by the staff of the Entomology Section of SARI.

Farmer Field Day

A farmer field day was held on 13th September, 2014 at Karaga**.** This field day was organized jointly with the AGRA Soil Health Project on inoculants production. The field day was generally a day-long event held at an input trial (involving soybean, cowpea & groundnut) and AGRA's soybean demonstration field at Karaga in the Karaga District. The objective of the farmer field day was to empower farmers with knowledge and skills to enable them increase their productions. The programme was organized to sharpen the farmers' ability to make critical and informed decisions that renders their farming profitable and sustainable.

Content of the Field Day

Farmers were taken through the treatments on the field for them to appreciate the performance of the technologies on the field. The method of inoculation of soybean & cowpea seeds was demonstrated to the farmers who were also educated on the application of mineral and organic fertilizers. The participants were taught the correct method, the mode and time of application of these fertilizers. They were particularly asked to dibble or drill and burry all mineral fertilizers to ensure that when it rains water doesn't carry the fertilizers to other fields.

Results/Major Findings

Inoculation had no positive effect on all the parameters measured in all the varieties. Pod yield (weight) even seemed to have been suppressed by inoculation. The variety Afayak appeared to have a higher nodulating capacity (28 nodules/plant; 112.4 mg nodule/plant) than the other varieties tested especially Jenguma (20 nodules/plant; 66.9 mg nodule/plant) and Songda (18 nodules/plant; 79.4 mg nodule/plant) with Jenguma being the least in terms of nodulation. Suong Pungun had 20 nodules/plant and nodule dry weight of 102 mg/plant. Jenguma had a higher pod load (116 pods/plant) than the other varieties and this might be due the interaction between this variety and inoculation. Root dry biomass production did not depend on inoculation nor on type of variety but Afayak produced the highest dry shoot biomass (9.1 t/ha) though the value was similar to that of Jenguma (7.8 t/ha) with Songda and Suong Pungun having similar biomass yields of 6.7 t/ha and 6.2 t/ha, respectively.

Inoculation again had no effect on the growth and yield parameters of Jenguma in the various input treatments. When Jenguma was subjected to the application of the various fertilizer inputs, only the combination of TSP with Boost Xtra significantly stimulated a higher nodulation (36 nodules/plant; 119.3 mg nodules/plant) compared with the control though these were statistically similar to the other input combinations except the KCl + BX treatment (25 nodules/plant; 76.1 mg nodule/plant). Root yield in Jenguma responded to TSP+KCl (829 kg/ha) and TSP+KCl+BX (797 kg/ha) treatments when compared to the control (694 kg/ha) as well as to KCl only (626 kg/ha), BX only (699 kg/ha) and KCl+BX (618 kg/ha) treatments. This indicates that TSP was the input responsible for the positive root yield responses under these treatments. However, the fact that TSP only treatment produced similar root growth to the control treatment indicates that the P in TSP required some other nutrient elements to balance it in order to fully express its effect on root growth in Jenguma. Neither inoculation nor input addition enhanced shoot dry biomass production in Jenguma and application of a combination of KCl and BX (i.e. KCl + BX) even suppressed shoot growth (6.03 t/ha) when compared to the control treatment (9.6 t/ha).

Pod and grain yields of Jenguma were greatly enhanced with P fertilizer application, whether alone or combined with other nutrients {Pod: Control (2.84 t/ha), TSP (3.39 t/ha), TSP+BX (3.50 t/ha), TSP+KCL (3.52 t/ha), TSP+KCL+BX (3.84 t/ha); Grain: Control (1.36 t/ha), TSP (1.66 t/ha), TSP+BX (1.55 t/ha), TSP+KCL (1.68 t/ha), TSP+KCL+BX (1.70 t/ha)}. Jenguma grain size was, however, not affected by rhizobium inoculation or input application.

Though Rhizobium inoculation tended to enhance nodulation and root growth in cowpea, it tended to suppress shoot growth when the crop was fertilized with fertisoil. Application of 6 t/ha of fertisoil had a significant positive effect on root growth in cowpea (401 kg/ha) when compared with the control (309 kg/ha) and even though the same rate produced bigger seeds than the 2 t/ha and 4 t/ha treatments, seeds from the 6 t/ha treatment were of the same size as those from the control. Single combinations of BX with either TSP or KCl significantly stimulated shoot biomass growth when cowpea was subjected to the various input applications.

Groundnut root growth was increased by all the inputs applied to groundnut in contrast to the other parameters measured which were not increased by any of the inputs applied. However, application of lime, whether singly or in combination with the fertilizer inputs did not produce any benefit to groundnut.

Conclusions/Recommendations

Generally, rhizobium inoculation did not have any remarkable effect on the test crop varieties either alone or in integration with the fertilizer types used as expected. This might be attributed to the low quality (3.6 x 10^5cells/ml) of the inoculants used as against the recommended cell count of 1.0 x 10^9 cells/ml). Wherever any effects were produced by the inputs applied, they were by either TSP or TSP in combination with KCl or BoostXtra. It is therefore recommended that the trials be repeated in the 2015 growing season using a very high quality inoculants. This should be done using only TSP and TSP-combined inputs used last year because where any effects were produced by the inputs applied, they were by either TSP or TSP-combined fertilizers.

SOIL FERTILITY

Boosting maize-based cropping system productivity in northern savannah zones of Ghana through widespread adoption of Integrated Soil Fertility Management

Principal Investigator: Drs. Mathias Fosu & SK Nutsugah

Collaborating Scientists: Drs. BDK Ahiabor & SSJ Buah, F Kusi & WK Atakora

Estimated Duration: February 1, 2010 - November 30, 2014

Sponsors: The Alliance for a Green Revolution in Africa (AGRA)

Location: Northern, Upper West & Upper East regions

Background

Northern Ghana, considered as the breadbasket region of the country has over 40% of the agricultural land. However, the area is plagued with high levels of food insecurity and poverty. This is a major concern to the government and its development partners. The main reason for the extreme poverty and high food insecurity is that the bulk of the population are small-scale resource-poor farmers who rely mainly on rain fed agriculture to improve their livelihoods under low farm input conditions. The soils of the area are degraded and infertile. To address this problem, an important intervention is the need to increase the wide-scale use of improved seeds and fertilizers within the context of integrated soil fertility management.

The important food crops in Ghana are maize, rice, sorghum, millet, cassava and legumes such as groundnut and cowpea. Among the cereals, maize is the most important with about 750,000 ha allocated to the crop annually. Cowpea and groundnut are very important legume food crop with soybean becoming important as cash crop. Ghana meets only 51% of its maize needs, and only 25% of its rice supplies (MOFA, 2007). The yields of these crops are however low because of low soil fertility and low application of external inputs. Integrated Soil Fertility Management (ISFM) is the approach advocated by AGRA to improve the fertility status of African soils. ISFM practices include appropriate fertilizer and organic input management in combination with the utilization of improved crop varieties, and adaptation to local conditions. This approach has great potential to increase food production in northern Ghana but the technology needs to be widely disseminated to the small-scale farmers.

The purpose of this project was to contribute to increased food production and poverty alleviation in rural communities in northern Ghana through strengthening partnerships and the capacity of farmers' organizations, agro-input dealers and research and development (R&D) to promote ISFM technologies.

Objectives:

1. To increase productivity of maize-legume cropping systems through scaling up proven ISFM technologies
2. To strengthen farmers organization and extension systems for wide scale dissemination of ISFM technologies
3. To monitor and assess impacts of ISFM technologies on small-scale agricultural productivity and livelihood of rural people
4. To update and refine profitable fertilizer recommendations for maize and grain legumes in northern Ghana (Sudan and Guinea savannah zones)

Activities

Nineteen key activities involved in the boosting of maize-based cropping system productivity in northern savannah zones of Ghana through widespread adoption of Integrated Soil Fertility Management (ISFM) were implemented during the three years and on cost-extension period.

Objective 1: To increase productivity of maize-legume cropping systems through up-scaling proven ISFM technologies

Activities

Demonstrations, FFS and On-farm testing of selected ISFM options across two different agro-ecological zones (Guinea and Sudan savannah), focusing on soil nutrient requirements, nutrient use efficiency, biological nitrogen fixation and crop productivity.

Monitoring soil health and establishing the costs, benefits and tradeoffs required for ISFM practices involving grain legumes in small-holders' cereal-legume intercrops and rotations.

Field days and exchange visits to display the advantages of ISFM relative to current practices.

Radio and TV documentaries and production of technical leaflets on ISFM

Training in composting and fertilizer use

Testing of ISFM options

A set of best-bet and best fit ISFM options, including germplasm, fertilizer management, and agronomy components that are also responding to market demands, were tested with partners in the first year for each of the Action Sites. These options will be evaluated with farmer associations at two levels: 1) Farmer managed demonstration plots with selected range of different options to be implemented at selected sites; 2) Farmer Field Schools (FFS) made up of preferred ISFM option(s) selected by individual farmer associations in the three northern regions.

Demonstrations

There was a total of 100 demonstrations per year with 50 demonstrations per year for Northern region, 20 for Upper East and 30 for Upper West Region.

The demonstrations were installed with partners, maintained by farmer associations and managed by researchers and MoFA extension officers on 0.5 to 1.0 ha plots depending on number of components. Each year, 2.5 t of maize seeds, 1.6 t of cowpea seeds and 1.6 t of soybean seeds were required for the demonstrations. Total fertilizer required per year for the demonstrations is 37.6 t. All these resources were provided by the project. However, sowing, weed control and other management operations were performed by farmers through their association, including farmers field schools.

Farmer Field Schools (FFS)

Community-based Farmer Field Schools were organized for farmer groups within a community. There were about 20 to 30 farmers forming FFS group. Each year, 2.0 t of maize seeds, 1.5 t of cowpea seeds and 1.5 t of soybean seeds were required for the Farmer Field Schools. Total fertilizer required per year for the Farmer Field Schools was 15 t. All the inputs and facilitation costs for organizing the Farmer Field Schools were provided by the project. However, farmers provided the land, did the planting, weeding, fertilizer application, harvesting and processing and other activities that were required for running the Farmer Field Schools.

The test crops were maize in rotation or intercropped with cowpea or soybean with application of fertilizer, compost and manure. The high lysine maize *Obatampa* was promoted within the project along hybrids that were released. Four cowpea varieties developed by SARI and IITA that are adaptable to intercrop systems was promoted within the project and linked up with AGRA's PASS to produce and distribute certified seeds to farmers at low cost.

The project provided all the seeds and fertilizer for the demonstrations and also paid for the preparation of the land. Planting, weeding, harvesting and processing operations were done by farmers. The farmers also provided the land for the demonstrations. The contribution of farmers ensured that they owned the demonstrations and supported them actively.

Monitoring soil health and financial analysis for ISFM practices involving grain legumes in small-holders' cereal-legume intercrops and rotations

The economic returns to different ISFM and grain legume production strategies were calculated to determine profitability in light of increasing fertilizer prices. Total costs were computed from the cost of fertilizer applied, cost of seeds, labour and other miscellaneous costs or fees. Gross returns were calculated from crop yield and commodity prices. Profit was the difference between returns and costs.

Monitor changes in soil health resulting from ISFM practice (1 MSc student)

AGRA's Soil Health program identifies low soil fertility and low use of external inputs as the main causes of low agricultural production in Africa. As this program seeks to promote agricultural production and enhance development through poverty alleviation, soil health maintenance and improvement was paramount. Basal information on soil health was obtained at the beginning of the program. Subsequently, the physical, chemical and biological indicators of soil health were monitored through rigorous soil testing as follows:

Physical: Erosion hazard, percent gravel, bulk density, aggregate stability and infiltration rates will be monitored annually.

Chemical: The levels of N, P, K, Ca, Mg, S, B, would be monitored annually. Soil acidity (pH), OC were also be monitored.

Biological: The level of soil macrofauna (earthworms, termites etc.), parasitic weeds such as striga (*S. hermontica, S. gesneroides, and S. asiatica*) were monitored.

Biological nitrogen fixation (BNF) in the soil was monitored in legume plots from nodule assessment. One MSc student was funded separately by AGRA to collect this data.

Farmer field days and exchange visits

Two farmer field days and exchange visits were organized per village for members of farmer associations at vegetative and crop harvesting phases to observe effect of selected ISFM technologies on crop production and productivity. Farmer forums at the end of each field visit were important feature in this activity.

Radio and TV documentaries and technical leaflets production

Radio and TV programs on ISFM were produced. All farmers have radio and would be reached easily using the radio. Technical leaflets were produced and distributed through agro-input dealers and AEAs.

Training in composting

The organic carbon content especially in northern Ghana is very low, usually less than 1.0%. Soil health management in this area must go hand in hand with the incorporation of organic matter into the soil. Use of crop residues has been very limited in this area as it has several competing uses including use as fuelwood, handicraft production (basket weaving), dry season animal feed etc. Compost production is practiced to some extent in northern Ghana and large potential exists for widespread production and use. The main limitation is lack of adequate knowledge in production and handling. About 500 households were trained within the project to produce and use compost.

About 120,000 households are expected to adopt the ISFM technologies by the end of the project. The 120,000 households required about 45,000 t of fertilizer for maize and 9,451 t for soybean making a total of 54,451 t per year. About 3,000 t of maize seed and 1000 t each of cowpea and soybean seeds were required annually.

Some farmers acquired their inputs through the FBO/agro-dealer network. The project supported farmer associations in establishing networks and developing protocols for such transactions. In communities where fertilizer use is very low because of extreme poverty, small packages were supplied to a number of farmers especially women farmers as entry point for ISFM up-scaling. The Project linked up AGRA PASS for supply of seeds to FBOs at cost. Project funds set for credit support were also used to help all farmers in the target area access credit from local banks.

Objective 2: To strengthen farmers organization and extension systems for wide-scale dissemination of ISFM technologies

Activities

i. Training in ISFM Technologies. Both farmer associations and extension agents (including NGOs) will be trained in ISFM technologies

ii. Training in extension communication and technology dissemination methods. This training will be for extension agents and leaders of FBOs

iii. Training in FBO management. This training will be for leaders of farmer associations.

iv. Training in management of demonstrations. This training will be for extension agents and leaders of farmer associations.

v. Motivation. The project will sign MoU with MoFA extension agents for good delivery for which they will be paid per diems. Motor bikes will be provided for regional liaison officers who will be agricultural extension agents that will have region-wide supervisory role. They will also receive 'top up' allowances from the project. A number of local coordinators will also be supplied with bicycles to facilitate movements. The project will also sponsor meetings of FBOs where necessary and facilitate reporting through provision of basic supplies such as stationery.

The project liaised with IFDC, AfNet, MCA-Ghana and other organizations offering training similar to what this project was doing, whenever possible. About 50 persons were trained at each training session and a total of about 5000 stakeholders were trained over the 3 years of the project. Other topics covered within the training were identified by the local coordinators. Information leaflets on ISFM products, technology packages, specifications and timing were produced and distributed to trainees and other stakeholders.

Objective 3: To monitor and assess impacts of ISFM technologies on small-scale agricultural productivity and livelihood of rural people

Activities

i. Develop and adapt PM&E training materials for use in implementation sites

ii. Design a PM&E system at the project and community level that can be used to monitor and evaluate the performance, process and impacts on livelihood.

iii. Build capacity of communities and teams to establish and facilitate PM&E processes

iv. Identify local and scientific indicators for monitoring livelihood and environmental impacts of ISFM.

v. Conduct baseline studies to collect data on the baseline situation of developed indicators
vi. Develop tools and methods for collecting and analysing data on indicators

Objective 4: To update and refine profitable fertilizer recommendations for maize and grain legumes in northern Ghana (Sudan and Guinea savannah zones)

Activities

i. Identify and select benchmark soils for fertilizer recommendations
ii. Conduct participatory yield response trials or adaptive trials
iii. Soil testing in the field with simple but calibrated kits

Identify, select and map benchmark soils and make fertilizer recommendations

Benchmark soils are the most important soils on which selected crops are grown. Their identification, selection and mapping are essential for making location specific fertilizer recommendation for the crops selected. Some work was started by Soil Research Institute under the Soil Fertility Management Action Plan to map out benchmark soils and make fertilizer recommendations. This work was not completed due to lack of funds. One MSc student was used to work with Soil Research Institute to review the work done and fill important gaps to complete the mapping and fertilizer recommendations with the use of crop models and the involvement of Prof. Gerrit Hoogenboom of University of Florida, USA.

Conduct participatory yield response trials with farmers and fertilizer importers.

Participatory fertilizer trials were conducted at the action sites to validate the fertilizer recommendations. Economic analysis was key component of the validation. Fertilizer recommendations would be made for the selected agro-ecologies and disseminated as part of the package for ISFM promotion. The project collaborated with AfNet, YARA and CHEMICO to develop suitable fertilizer blends for farmers at different sites depending on recommendation.

Soil testing in the field with simple but calibrated test kits and participatory yield response trials

Soil test kits are not used in Ghana but they offer a quick and less expensive way of diagnosing nutrient deficiencies for efficient and targeted fertilizer use. The kits for soil nutrients typically rely on filtered extraction followed by colored reactions, and then the results are read from a color chart. Leaf or some other organ extract of the plant may be analyzed to confirm deficiencies for growing crops. Soil test kits need calibration for specific locations and this was done for the selected agro-ecologies of Ghana. These analyses are generally quantitative and reliable. However, complex and unexplained nutrient relations were investigated through laboratory analyses conducted at the SARI or SRI soil chemistry laboratories. There was an opportunity to also use 1 MSc Student.

Achievements

The AGRA Soil Health project started in 2010 cropping season in Upper East, Upper West and Northern regions and was expected to end on 31st January, 2013. However, due to availability of residual funds and non-completion of some activities, '**no cost extension**' was approved for the period 1st February, 2013 to 31st January, 2014 and then subsequently from 1st February, 2014 to 30th November, 2014 to complete the project activities. The main achievements of the project since its inception in February 1, 2010 include the following scientific findings:

Averaged across all districts, the fertilizer rate NPK 60-40-40 gave maize yield of 2.4 t/ha. Adding 15kgN/ha over the recommended N rate did not significantly increase the yield of maize except in UER. Applying half the recommended rate of fertilizer (NPK 30-20-20) resulted in maize yield of 1.4t/ha which was significantly higher than yield with no fertilizer but similar to national average for maize yield, (MoFA, 2008). Where no fertilizer was applied, the yield was less than 0.5t/ha.

Obatanpa (medium maturing OPV) out-yielded the medium maturing hybrid maize Etubi significantly at all levels of fertilization except where no fertilizer was applied. The full fertilizer rate gave rise to yield above 3t/ha for Obatanpa but the yield of the hybrids was below 2.5t/ha. The yield of unfertilized maize whether hybrid or OPV was about 0.5 t/ha

The yield of short season drought tolerant maize varieties, Aburohema and Omankwa, were similar when compared at specific nutrient levels. However, both varieties had lower yields compared with the medium maturing variety, Obatanpa at fertilizer rate of NPK 60-40-40. The yield without fertilizer was about 0.5t/ha and similar for all varieties.

Mixture of farmyard manure at 2.5t/ha or commercial organic fertilizer (Fertisoil) at 3t/ha with half the recommended rate of mineral fertilizer or 26 kgN/ha resulted in maize yield above 3t/ha which was significantly higher than maize yield (2.2 t/ha) with full recommended rate of mineral fertilizer alone. In some communities the yield with the organic and inorganic fertilizer mixtures was as high as 4t/ha.

Inoculation of soybean with rhizobium without addition of P and K significantly increased soybean yield over the un-amended control. Rhizobium inoculation alone on-station on acidic soil increased soybean yield by 36% and increased soybean yield on near neutral soil on-farm by 43%. The yield of soybean with addition of NPK 0-60-30 on-station and on-farm was 67% and 16%, respectively. The lack of synergy between rhizobium inoculation and PK fertilization on-farm is not clear.

Technology Developed

Integrated soil fertility management technologies were transferred in **150** communities in **35** districts in northern Ghana. Eighteen thousand (**18,000)** farmers were reached through demonstrations, FFS and Field days.

Rhizobium inoculation was also transferred to farmers. For the first time, a good number of soybean farmers inoculated their soybean seeds before planting.

Conclusions/Recommendations

When best practices are followed for fertilizer application, maize yield of up to **3 t/ha** can be achieved with inorganic fertilizer and up to **4 t/ha** with organic and inorganic fertilizer mixtures at recommended rates. Inoculation of soybean with rhizobium can increase yield by 30-40%.

The soil fertility improvement technologies increased **maize** yield from **1.2t/ha to 3 t/ha** on average. This yield increase for **117,000 farmers** surveyed had injected **GH¢163,800,000** into the Ghanaian economy during the project life span.

Soybean yield was increased from **0.8 t/ha to 1.5t/ha** with inoculation. This technology injected additional **GH¢10,000,000** in the economy from **20,000 farmers**.

Cowpea inoculant technology was promoted in SARI and increased yield of cowpea from **0.45t/ha to 1.2 t/ha**. Integrated over **26,000 farmers**, contribution to the economy is **GH¢18,200,000**. It is hoped that inoculant technology would reduce nitrogen fertilizer import by nearly **25%** if farmers rotate cereals with legumes. The total savings from fertilizer import is estimated at **$30,000,000**. SARI with support of AGRA would put up an inoculant factory this year and capable of producing **GH¢250,000** worth of inoculants per season.

The assembling of minimum data set needed to predict fertilizer recommendation for maize production in Northern Ghana was concluded during 2014 as shown in Fig. 13.

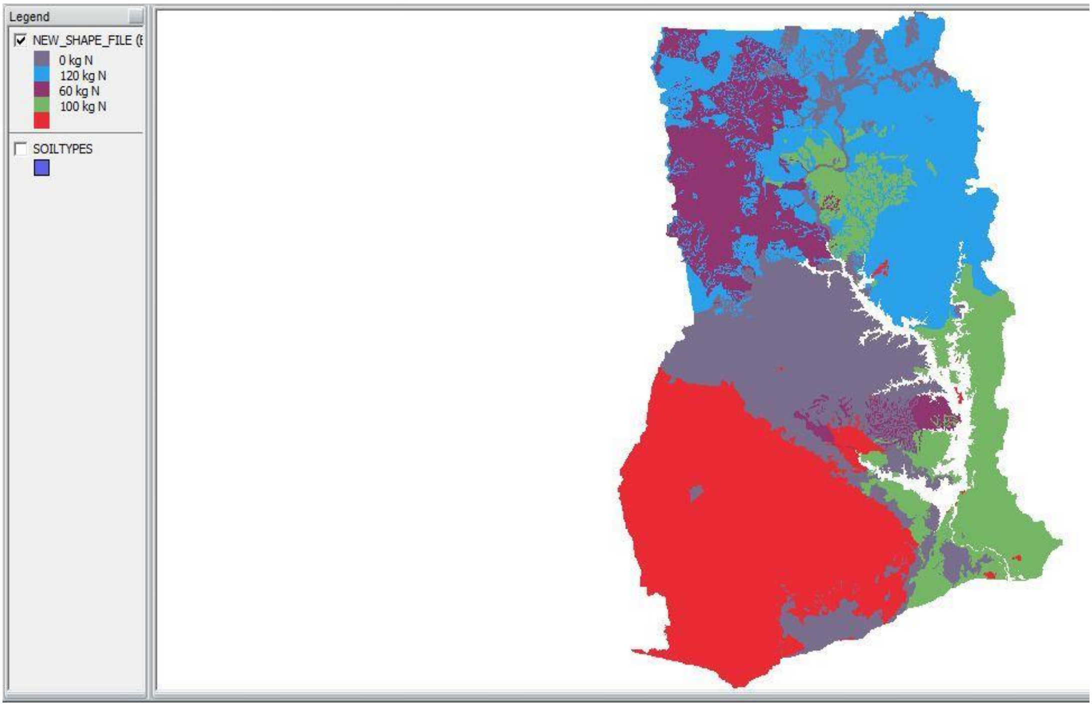

Figure 17: Recommended N fertilizer for Ghana

The model result indicated 0-120 kgN/ha is suitable for maize production in Ghana. However, it indicated 120 kgN/ha as the most efficient rate to be applied in most part of northern Ghana.

The Table below gives a stepwise summary of the actual achievements of the project against planned project objectives, outputs and outcomes as they are set out in the approved proposal.

OBJECTIVE (List each objective)	**ACTIVITY (Describe what has been done, how and when.)**	**OUTPUT (Provide quantifiable indicators of what has resulted or been produced and when.)**	**OUTCOME (Indicate who has used the immediate outputs, what steps have been taken to ensure their use, what benefits have resulted from using them, quantify the benefits as much as possible.)**

Objective 1: Increase productivity of maize-legume cropping systems through scaling out proven ISFM Technologies	Activity 1.1: Establish ISFM demonstrations and Farmer Field Schools. Five different demonstrations on fertilizer rates (organic and inorganic, crop rotation, maize varieties including hybrids, use of rhizobium inoculum on soybean)	Output 1.1.1: One hundred and thirty-seven (137) demonstrations installed and managed by 137 FBOs and monitored by project team in 30 districts in the 3 northern regions	1.1: 1: About 4,000 farmers acquired in-depth knowledge on ISFM practices and 25,000 farmers linked to demonstrations through their households
	Activity 1.2: Establish Farmer Field Schools (FFS).	Output 1.1.2: Eighty-seven (87) FFS established; About 2,612 farmers trained in ISFM at FFS	Outcome 1.1.2.1: Over 2,600 farmers improved their skills in ISFM; interest of farmers in project increased
	1.3: Training of Agrodealers on ISFM, Agro-input business management, product knowledge and legis lation concerning products in collaboration with IFDC/GABIC, PPMED & Environmental Protection Agency (EPA)	1.3.1: Eighty-five (85) Agrodealers from 10 districts were trained 1.3.1.2: DECO!, private sector SME organic fertilizer producer trained in business plan development in collaboration with Engineers without Borders	1.3.1.1: Eighty-five (85) agrodealers acquired knowledge on ISFM, agro inputs and legislations regarding importation and sales of various agro-chemicals 1.3.1.2: DeCO! acquired knowledge in business management Outcomes 1.3.1.3: 6,000 bags of fertilizer was s upplied to farmers Outcome 1.3.1.1: 6,000 bags of fertilizer was supplied to farmers
	Activity 1.3: Negotiation for Credit for farmers from Stanbic Bank	Output 1.3.1: Two thousand (2,000) farmers received a total of GH₵ 270,000.00 =	

		US$ 185,000.00 as credit	
	Activity 1.4: Radio broadcast on ISFM on regional FM stations in English and 8 major local languages in northern Ghana	Output 1.4.1: Twenty-eight (28) radio broadcast were done on AGRA SHP, ISFM, Storage and marketing in 8 local languages	Outcome 1.4.1.1: Large number of people including politicians, opinion leaders and farmers learnt about AGRA SHP, ISFM, Storage and marketing
	Activity 1.5: Field Days for farmers and the general public	Output 1.5.1: Forty-six (46) Field Days were held which was attended by about 4000 people	Outcome 1.5.1.1: Non participating farmers, policy makers and other stakeholders gained knowledge on ISFM technologies and their effect on crop yield
	Activity 1.6: Exchange visits conducted for farmers in all the three regions	Output 1.6.1. Twenty-four (24) exchange visits held	Outcome 1.6.1.1: About six hundred and thirty farmers updated their knowledge on ISFM practices, AGRA SHP, ISFM, produce storage and marketing.
	Activity 1.7: Produce and distribute 4 videos on maize	Output 1.7.1: One thousand-five hundred copies of 4 videos produced and distributed to MoFA, FBOs and others	Outcome 1.7.1.1: Reference document for the enhancement of extension delivery
	Activity 1.8: Produce and distribute leaflets and production guides for maize, soybean, cowpea and groundnut.	Output 1.8.1: About 10,000.00 leaflets and production guides distributed.	Outcome 1.8.1.1: Reference manual for extension delivery
	Activity 1.9: Show training videos on land preparation, seed selection, planting, weed control,	Output 1.9.1: About 3,264 farmers made up of 1,575 males, 971 females and 718 children watched the	Outcome 1.9.1.1 Knowledge of Farmers and AEAs improved on land preparation, seed selection, planting, weed control,

	harvesting and storage in all the 3 regions Activity 1.10: Assemble all data collected over project period Activity 1.11: Produce manuscripts from data generated	video shows Output 1.10.1: Data base created and submitted to AGRA Output 1.11.1: Write s hop organized and 5 manuscripts developed	harvesting and storage Outcome 1.10.1.1: AGRA using data base Outcome 1.11.1.1: Project staff working on 5 manuscripts. Additionally, 5 manuscripts already published
Objective 2: Strengthen Farmer-based organizations and Extension systems for wide scale dissemination of ISFM Technologies	Activity 2.1: SARI AGRA SHP Team trained in market facilitation by Engineers without Borders and ADVANCE Activity 2.2: Produce and distribute training manuals to FBOs and AEAs	Output 2.1.1: Seven (7) SARI staff trained in market facilitation. Output 2.2.1.: Five hundred (500) copies of manual on "Organizational strengthening and Enterprise development for FBOs" produced and distributed.	Outcome 2.1.1.1: Capacity of 7 SARI staff strengthened in market facilitation Outcome 2.2.1.2: Capacities of FBOs strengthened in governance and credit management
Objective 3: Monitor and assess impacts of ISFM Technologies on small-scale agricultural productivity and livelihood of rural people	Activity 3.1: Study benefits of ISFM and adoption rate as influenced by credit and crop insurance in northern Region. Study carried out by Innovative Poverty Action (IPA), an NGO in collaboration with SARI AGRA SHP team Activity 3. 2:	Output 3.1.1: Fifteen (15) farmers from 3 communities in 3 districts studied for impact of ISFM and change in farmer behavior Output 3.2.1: One	Outcome 3.1.1.1: More partnerships formed Outcome 3.1.1.2:

	Conduct final adoption/impact survey.	impact assessment report and one Journal publication on adoption of ISFM in northern Ghana	Knowledge on ISFM technologies and their effect on crop yield available to guide farmers
Objective 4: Update and refine profitable fertilizer recommendations for maize and grain legumes in northern Ghana	Activity 4.1: Benchmark soils characterized in Northern, Upper East and Upper West Regions	Output 4.1.1: Ten (10) benchmark soils from 37 sites were described in 6 districts in Northern Ghana	Outcomes 4.1.1.1: Project staff and other stakeholders informed about benchmark soils in Northern Ghana
	Activity 4.2: Soil Map generated for surveyed districts	Output 4.2.1: Soil maps produced for 3 districts	Outcomes 4.2.1.1: Project staff and other stakeholders awareness of properties of Benchmark soils
	Activity 4.3: Run simulations and develop GIS map of fertilizer recommendation domains	Output 4.3.1: DSSAT files generated for benchmark soils.	Outcome 4.3.1.1: Farmers using fertilizer recommendation domain of 120 kgN (2 bags of 50 kg + 20kg Urea) which translates to 11 bags of Ammonia and 5 bags of Urea/ha

Challenges in carrying out the project - New Directions

- Difficulty in moving and housing large numbers of AEAs for training
- Very bad roads in project areas and lack of adequate hotel accommodation for project staff in most districts
- Some MOFA AEAs have too many responsibilities and are unable to give the project full attention

Measures to deal with Challenges

- More decentralized monitoring put in place to cut down on travelling
- Decentralized training
- Basic tools procured for MOFA staff implementing project activities in their operation zone
- Training cut down to accommodate funds obligated and disbursed

Lessons learned

In the absence of MoFA extension agents, Junior and/or Senior High graduates in some communities were effective in supervising demonstrations with some training. Performance of MOFA staff increased with frequency of monitoring by SARI staff. Quarterly review meetings were planned to deal with any lapses observed in the implementation process.

The project developed ISFM technologies which include the use of hybrid seeds, organic and inorganic fertilizer and/or combination of half rate each of organic and inorganic fertilizer. The project relied on the collaboration with MoFA staff that helped to mount several ISFM technology demonstrations in the project action sites. Demonstrations remained the focal point of direct contact with farmers within FBOs that participated in the project. Furthermore, technology dissemination was carried out using radio broadcast, Farmer Field Schools, community video shows of good agronomic practices.

Four maize varieties were used for the demonstration namely Obatanpa, Etubi, Omankwa and Aburohema.
The following fertilizer combinations can be recommended and/or promoted at farm level for maize and legume: NPK 80-60-60, NPK 90-60-40 and NPK (100-120)-40-40.
The 2009 SHP 005 project successfully demonstrated that the following technologies can be promoted in the project action sites:

- Use of farm video van to disseminate information on good agronomic practices
    - Use of both organic and inorganic fertilizer to boost maize yield
    - Use of legume-cereal rotation to improve soil fertility

Working closely with our strategic partners to implement the ISFM technologies has been largely successful. The strategy used combines the application of soil fertility management practices, participatory extension methods, innovation financing and establishing linkages with agro-input dealers and produce markets.

The partnership will build on this strategy through the establishment of local Innovation Platforms in which farmers, extension staff and private sector identify issues, prepare and implement action plans for the demonstration and dissemination of ISFM technologies in future work.

Update and refine of site-specific fertilizer recommendation for maize in Ghana

Principal Investigator: W. K. Atakora
Collaborating Scientists: M. Fosu, M. Asante, A Nurudeen, F. Tetteh, S. Dwomoh, F. Kusi, J. Kugbe
Estimated Duration: 3 year
Sponsor: AGRA
Location: Northern Region, Ghana

Introduction

Maize is the most important cereal crop produced in Ghana and it is also the most widely consumed staple food in Ghana with increasing production since 1965 (FAO, 2008; Morris *et al*., 1999). In Ghana, maize is produced predominantly by smallholder resource poor farmers under rain-fed conditions (SARI, 1996). Low soil fertility and low application of external inputs are the two major reasons that account for low productivity in maize. The soils of the major maize growing areas in Ghana are low in organic carbon (<1.5%), total nitrogen (<0.2%), exchangeable potassium (<100 mg/kg) and available phosphorus (< 10 mg/kg) (Adu, 1995, Benneh *et al*. 1990).

From 1969 to 1972, UNDP/FAO carried out series of fertilizer trials with Ministry of Food and Agriculture (MoFA) under UNDP/FAO Ghana Project "Increased Farm Production through fertilizer use." Fertilizer recommendations were therefore made for maize and other crops. Soil conditions have changed over the years and the old recommendations are not the most efficient today hence the need to update fertilizer recommendations for maize (and other crops) in Ghana. It is therefore necessary to quickly update fertilizer recommendation for maize using modern tools that will not only evaluate the profitability of crop productions but also the quality of the environment within which crop production is carried out, and combine crop, soil and genetic components of crop production. Decision Support System for Agro-Technology

Transfer (DSSAT) model is one of such tools. The objectives of this study is to use DSSAT and other softwares to model fertilizer recommendations for specific sites in Ghana.

Methodology

This recommendation work covered all regions in Ghana except communities mostly in Western, Eastern and Greater Accra Regions of Ghana.

Minimum data set, which includes weather, crop genetic coefficients and soil fertility status for selected communities, located as polygons on the shape file (Figure 13) were collected and analyzed between 2010 and 2014. Soil information used for creation of a unique file needed to run the model included total nitrogen, phosphorus, potassium, organic matter/organic carbon and cation exchange capacity. Secondary weather data was collected from meteorological station across the seleted areas and all the weather files necessary to run the model was created using Weatherman incorporated in the DSSAT model. These were however incorporated into the Climate Information and Analysis Tools (CIAT) and also Arc GIS with a unique identification number. The model was therefore run on combination of information that was supplied by each polygon which comprise soil identification code, weather identification code, meteorological station identification code, GPS coordinate and a record number for each community represented on the shape files as polygons to arrive at a recommendation. The use of crop growth simulation models such as CERES-Maize model incorporated into Decision Support System for Agro Technology Transfer (DSSAT), Climate Analysis information Tools (CIAT) and ArcGIS are useful tools for assessing the impacts of crop productivity under various management systems. Therefore, for this study, it was used to predict fertilizer recommendation for maize (*Zea mays* L.) under different agro-ecological conditions in Ghana. Site specific information obtained on soil, weather as well as crop genetic cultivar coefficients were merged together to predict the most efficient total nitrogen required by *Obaatanpa* maize to obtain maximum and economic yield. The cultivar coefficient was calibrated with data collected from field experiment conducted at Kpalesawgu in Northern Region in 2010.

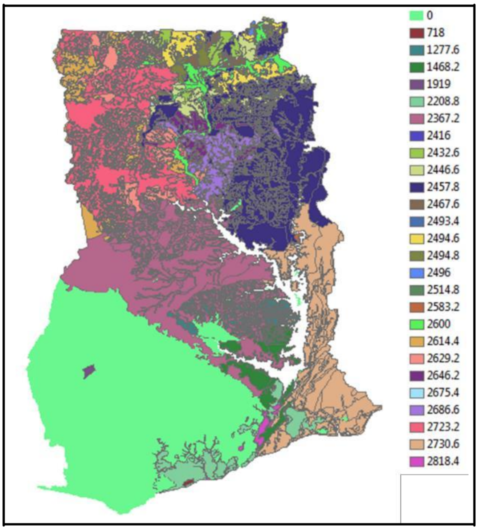

Figure 18: Yield response of maize on application of NPK 100-40-40 kg.ha-1.yr-1

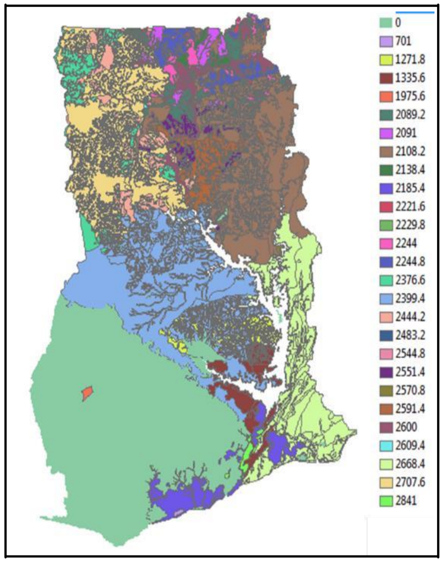

Figure 20: Yield response of maize on application of NPK 60-40-40 kg.ha-1.yr-1

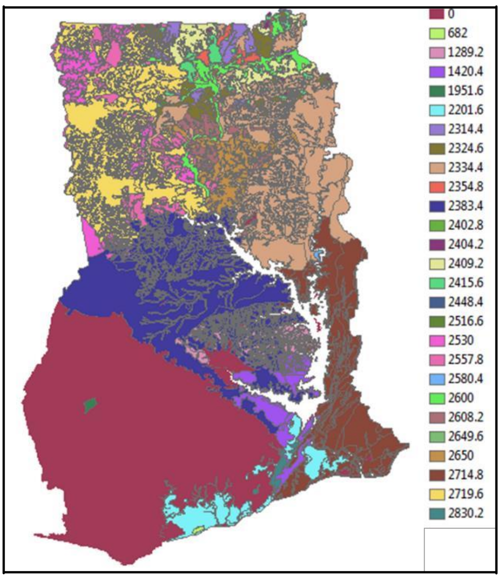

Figure 19: Yield response of maize on application of NPK 80-40-40 kg.ha-1.yr-1

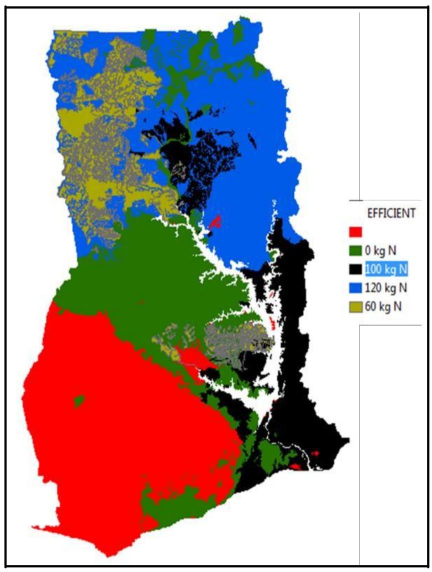

Figure 21: Most Efficient fertilizer recommendation across the country

Results and Discusions

The results showed NPK 0-40-40, 100-40-40, 120-40-40 and 60-40-40 $kgha^{-1}.yr^{-1}$, as the most efficient fertilizer recommendation for maize in the transitional, Volta Region, Northern and Upper West Regions of Ghana respectively while yield obtained ranges between 700 and 3000 $kgha^{-1}$.

However, application of N between 60 and 100 $kg.ha^{-1}$ resulted varying grain yield. Application of 100 $kgha^{-1}$N did not show any significant difference ($P > 0.5$) in grain yield compared to yield obtained when 60-80 $kgha^{-1}$ N was applied. In all grain yield obtained ranged between 600 $kgha^{-1}$ for poorly drained soil, low annual rainfall areas and 2850 $kgha^{-1}$ for areas with favorable conditions when 80 $kgha^{-1}$ N was applied. However, this was not total significantly different from when 60 $kgha^{-1}$ N was applied. The differences in grain yield with N levels could be attributed to differences in initial N content and also weather conditions at various locations. Although, N is required in higher amounts in all locations, the transitional zone contain adequate amount that is economically feasible according to the Gini coefficient method to produce maximum grain yield and that resulted in no N recommended.

Reference

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POST HARVEST

Reducing post-harvest losses in cowpea and maize through improved on-farm storage operations in the Northern region of Ghana.

Principal Investigator: Abubakari Mutari
Collaborating Scientists: Issah Sugri, Francis Kusi
Estimated Duration: Two years
Sponsors: IITA AfricRISING
Location: Northern Region

Table 52: Summary of communities where experiments were established

Region	District	Communities	Number of participating farmers	Total participating farmers
Northern Region	Tolon	Tibonaayili and Gbanjong	2 for maize 1 for cowpea	3 3
	Savelugu Nanton	Tibali and Botingli	2 for maize 1 for cowpea	3 3
Total		**4**	**12**	**12**

Background Information and Justification

Managing pests of stored grains may also be exacerbated due to intensification and introduction of hybrid cultivars. Stored grains can be damaged by insect pests if they are not properly conditioned and protected. In Ghana, most cereals (maize, rice, cowpea, soybean, millet and sorghum) are harvested toward the cessation of rainy season and stored during the drier months of the year. The conditions favourable for grain storage are as well suitable for insect pest reproduction. Currently, most cereal grains are bulked from small-scale producers who practice different levels of farm hygiene. Pre-harvest pest infestation of notorious storage pests such as larger grain borer (*Prostephanus truncates*), lesser grain borer (R*hyzopertha dominica*), maize weevil *(Sitophylus zeamais)*, rice weevil *(S. oryzae)*, granary weevil *(S. granaries)* cowpea weevil (*Callosobruchus maculatus*) as well as mycotoxins accumulation, may have occurred. Indiscriminate use of common grain protectants such as Actellic (Pirimiphos methyl), bioresmethrin (pyrethroid) phostoxin, Gastox (Aluminium phosphate) and Wander77 powder is widespread among small-holder farmers. Most farmers acquire agro-chemicals from non-accredited informal sources without training on responsible use of chemicals. Due to increasing consumer rights, environmental and health issues, there is the need for integrated production and postharvest practices that give quality food produce with minimal effect on consumers and environment. Integration of appropriate pre-harvest operations, integrated pest management and good warehouse sanitation to minimize pest damage must be preferred to indiscriminate use of chemicals.

Objectives

1. To evaluate and demonstrate the appropriate use of jute sacs, Purdue Improved Cowpea Storage (PICS) sacs and hermitic plastic tanks with/without grain protectants for prolong storage in beneficiary communities.
2. To evaluate the effect of selected treatments on insect pest incidence, physico-chemical and sensory properties of maize and cowpea

Expected Beneficiaries : Small scale farmers

Materials and Methods : A total of 12 on-farm postharvest storage demonstrations to serve as learning centers for farmers were established in 4 communities in the Tolon and Savelugu - Nanton districts of the Northern region. Training and Farmer Field Schools were organized on good storage management, integrated pest management, proper drying and appropriate use of grain protectants in all the communities.

Maize and cowpea grains were bulked from selected farmers during the harvesting season in October to November 2013. For each package, 40kg of maize and 20kg of cowpea were stored in jute and Perdue Improved Cowpea Storage (PICS) sacs with/without grain protectants. Jute is a natural fiber whiles the PICS sacs has 2 inner plastic layers which provides hermitic conditions for content stored. Two common grain protectants, Actellic Super EC and phostoxin, were applied at recommended rates of the manufacturers. Actellic Super EC is food-grade chemical containing 80g Pirimiphos-methyl and 15g Permithrin/L as emulsifiable concentrate. The application dose provided by the manufacturer is 300ml in 15L of water per 20 maxi bags of maize. Phostoxin is a food-grade fumigant

Bi-monthly sampling of grain and participatory assessment of grain quality during with the stakeholders was carried out. Data collected included weight and number of damaged and undamaged grains (used in calculating weight loss), number of live and dead insects present at sampling. The data collected were then statistically analysed in order to arrive at a scientific conclusion on the data.

Results/Major Findings : Jute sacks were found to be least in conferring protection to grains against storage pest attack whether the grains were treated with chemicals or not.
PICS and the plastic polytanks were able to prevent damage due to pest infestation. It was observed that the few damaged grains found in these storage materials could be due to latent infestation from the field. However, these did not proceed further as the hermetic conditions in the storage made it unconducive for the survival of the pests.

Conclusions/Recommendations : From the experiments, it could be observed generally that, weight loss was higher in the grains (both maize and cowpea) stored in jute sacks whether they were treated with grain protectants or not. There was relatively minimal losses with the PICS and the plastic drums irrespective of the treatment imposed on the grains though this did not follow a particular trend. It could be concluded therefore that the storage material used for the produce to a large extent determined the quantum of weight loss but not necessarily the treatment.

NUTRITION

Evaluation of a small-scale postharvest technology (Zero Energy Cool Chamber – ZECC)

Principal Investigator: Flora C. Amagloh
Collaborating Scientists: Lizanne Wheeler (WFLO), Lisa Kitinoja (PEF), Francis Amagloh (UDS)
Estimated Duration: 1 year
Sponsors: Postharvest Education Foundation (PEF), World Food Logistics Organization (WFLO)
Location: CSIR - SARI

Background Information and Justification
The ZECC is a small-scale postharvest technology for farmers, traders, processors and consumers. It is designed to minimize the challenge of the short shelf-life of produce, especially fruit and vegetables. The ZECC can keep produce at a temperature of 10-15°C below ambient temperature, while maintaining a relative humidity of about 95%. This implies longer shelf-life, resulting in more profits for farmers, processors and marketers. In addition, there is no need to rely on electricity or any other form of power to keep the produce.

Objectives: The objectives of the study were to:

1. store tomatoes in the ZECC at 10-15°C below ambient temperature and 95% relative humidity
2. extend shelf-life of the tomatoes in the ZECC for one week, without significant deterioration (appearance and quality), compared to tomatoes stored in ambient conditions

Expected Beneficiaries: farmers, processors, marketers of highly-perishable fruits and vegetables

Materials and Methods: Fresh tomatoes that had just arrived from a farm in the Upper East Region were obtained from a tomato market queen in a local market. The tomatoes were transported in a plastic crate overnight to the experimental site. Percentage loss was determined as:

$$\frac{\text{(Weight of damaged tomatoes)}}{\text{(Total weight of tomatoes)}} \times 100$$

The good quality tomatoes were sorted and graded based on the visual quality rating scale (9= excellent, 7= good, 5= fair, 3= poor, 1= extremely poor) and randomly packaged into 12 plastic crates, weighed and labelled as: ZECC: 1,2,3,4,5,6 for ZECC treatment and AMB: 1,2,3,4,5,6 for ambient treatment. The six crates for each of the two treatments were then arranged in their treatment locations according to the map below:

Table 53

Crate #1	Crate #3	Crate #5 - Datalogger
Crate #2 - Datalogger	Crate #4 - Datalogger	Crate #6

Crates # 2, 4 and 5 in each treatment location were used as sample crates.

Results/Major Findings

Table 54: *Trial 1*

Parameters	**Crate 2**				**Crate 4**				**Crate 5**			
	ZECC		**AMB**		**ZECC**		**AMB**		**ZECC**		**AMB**	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Temp (°C)	30.0	24.3	30.3	32.9	30.4	25.9	30.6	33.0	30.4	25.1	30.1	34.0
Weight (kg)	13.0	5.3	12.5	7.15	11.2	5.0	13.4	8.1	13.3	4.2	13.3	8.3
Visual quality	7	25% =3 75% =1	7	8%= 5 19% =3 73% =1	7	38% =3 62% =1	7	14% =5 23% =3 63% =1	7	17% =3 83% =1	7	18% =5 23% =3 59% =1
Crate RH (%)	65	99	52	54								

Table 55: *Trial 2*

Parameters	Crate 2				Crate 4				Crate 5			
	ZECC		**AMB**		**ZECC**		**AMB**		**ZECC**		**AMB**	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Temp (°C)	30.3	27.1	30.3	33.5	30.3	27.3	30.2	33.6	30.3	25.8	30.4	34.2
Weight (kg)	7.1	6.9	8.8	5.4	6.8	6.4	7.6	5.7	6.9	6.7	7.3	6.7
Visual quality	7	73% =7 21% =5 6%=3	7	66% =5 30% =3 4%=1	7	72% =7 23% =5 5%=3	7	65% =5 35% =3	7	68% =7 32% =5	7	62% =5 31% =3 7%=1
Crate RH (%)	63	100	58	57								

Table 56: *Trial 3*

Parameters	Crate 2				Crate 4				Crate 5			
	ZECC		**AMB**		**ZECC**		**AMB**		**ZECC**		**AMB**	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Temp (°C)	29.7	26.2	29.7	31.5	29.8	26.8	29.9	32.0	29.6	25.9	29.8	31.3
Weight (kg)	5.1	5.1	5.7	4.9	6.1	5.9	5.9	3.4	5.1	4.8	5.3	4.3
Visual quality	7	31% =7 24% =5 40% =3 5%=1	7	45% =5 34% =3 21% =1	7	42% =7 18% =5 36% =3 4%=1	7	35% =5 25% =3 40% =1	7	41% =7 22% =5 37% =3	7	3%=7 23% =3 27% =1
Crate RH (%)	67	100	60	64								

Generally, the ZECC was able to reduce the temperature of the tomatoes by about 4°C while the tomatoes stored in ambient conditions generally increased in temperature by about 3°C. In Trial 1, the tomatoes was attacked by rats during storage in the ZECC, hence after the trial, they had deteriorated from a Grade 7 (good) to mostly Grade 1(extremely poor) and a few Grade 3 (poor). However, in the ambient storage in Trial 1, there were a few Grade 5 (fair) tomatoes in addition to Grade 3 and Grade 1.

In Trials 2 and 3, in which rat infestation had been overcome by placing a gauze barrier over the ZECC, it was observed that the ZECC tomatoes had a better quality than the ambient tomatoes. In Trial 2, all the ZECC crates were able to maintain a high percentage of Grade 7 tomatoes (73%, 72% and 68% in Crates 2, 4 and 5 respectively) while none of the ambient crates had Grade 7s at the end of the one week storage period. A similar trend occurred in Trial 3, where, with the exception of Ambient Crate 5 which had 3% Grade 7, the other ambient crates had only Grade 5, 3 and 1. Comparing this to the ZECC, there were 31% (Crate 2), 42% (Crate 4) and 41% (Crate 5) of Grade 7 tomatoes at the end of the storage. In this experiment (Trials 2 and 3), there was a direct correlation between temperature and percentage deterioration, for e.g. ZECC Crate 5 of Trial 2 recorded the lowest temperature of 25.8°C and the lowest deterioration rate, resulting in the tomatoes being 68% Grade 7 and 32% Grade 5 with no Grades 3 and 1.

Relative humidities increased considerably in the ZECC crates while not much difference was recorded in the ambient crates. The ZECC crates had a relative humidity (RH) of as high as 100%, inferring complete saturation. This condition can cause mould growth in the stored produce. However, tomatoes require RH of about 95% and temperature of about 15°C if the shelf-life is to be extended to one week.

Conclusions/Recommendations
While the ZECC promises to be a good technology for extending the shelf-life of perishables, it is recommended that the trials should be repeated in the dry harmattan season when the relative humidities are lower.

References

Publications (at the end of all activities or last page)
Journal articles and Book Chapters; Conference/ Workshop Papers/Proceedings; Abstracts, Newsletters, Thesis, etc.

Diversification of Household and Industrial Utilization of Maize in the Mion and West Gonja Districts

Principal Investigator: Flora C. Amagloh
Collaborating Scientists: B. Maziya-Dixon (IITA), J.K. Addo (CSIR-CRI), M. A. Boateng (CSIR-CRI)
Estimated Duration: 3 years
Sponsors: African Development Bank, IITA
Location: CSIR – SARI, Mion and West Gonja Districts of Northern Region

Background Information and Justification

The project seeks to diversify the uses of maize, both at the household level and at the industrial level. Two districts each have been chosen in the Ashanti Region, Brong-Ahafo Region and Northern Region. CSIR – Crops Research Institute is responsible for the Ashanti and Brong-Ahafo regions while the Northern Region is being handled by CSIR-SARI. Focus Group Discussions (FGDs) were carried out in three randomly chosen communities in each district and the aim of this was to identify which maize products are of commercial value, and whether there was the need to develop new products and package existing ones appropriately to make them appealing to consumers, while generating income for processors and marketers.

Objectives: The objectives of the FGDs were to:

1. capture information on different maize uses in the communities with a focus on products with commercial value/market potential
2. identify community members who process and sell maize-based products
3. identify potential needs for diversification

Expected Beneficiaries: community members, food processors, marketers of maize-based products

Materials and Methods: FGDs were conducted in 6 communities in the Savanna, 3 in each district. Communities chosen in Mion were DC Kura, Puriya and Gunsi. The West Gonja communities were Agric. Extension, Mempeasem and Achubunyor. The participants were mainly farmers, traders, and processors.

Results/Major Findings

Ranking of crops cultivated in the communities

Regarding crop importance and area under cultivation, maize ranked first in all three West Gonja communities. On the other hand, in the three Mion communities, maize ranked second to yam (Table 49).

Table 57: *Ranking of crops in communities*

CROPS	COMMUNITIES					
	Mion			**West Gonja**		
	DC Kura	Puriya	Gunsi	Agric. Ext.	Mempeasem	Achubunyor
Maize	2	2	2	1	1	1
Yam	1	1	1	6	5	3
Millet	3	8	10	X	X	7
Sorghum	8	7	5	2	X	X
Rice	9	3	6	X	7	X
Cassava	4	4	7	7	3	2
Groundnut	6	5	3	3	2	4
Cowpea	5	9	8	4	6	8
Soybean	7	6	4	8	4	X
Vegetables (eg. Tomatoes, pepper, okra)	X	10	12	X	X	6
Leafy vegetables	X	11	X	X	X	X
Bambara groundnut	X	12	9	5	X	5
Pigeon pea	X	X	11	X	X	X

Forms in which maize is utilized at the household and commercial level, availability and affordability

Maize is utilized in the communities in forms ranging from raw flour, roasted and milled fermented and unfermented dough, roasted grains, dehulled and boiled grains. These forms are processed into products like kenkey, banku, tuozaafi (TZ), infant food (Weanimix), maasa, apiti, porridge, pito, nyomeka, kaafa, apapransa and yaakana.

In all 6 communities, TZ, kenkey, banku and porridge are popular household products, while some products are consumed in specific communities, e.g., kaafa is processed in Gunsi both at the household and commercial levels, nyomeka (steamed maize flour) is peculiar to Agric Ext., and yaakana (maize flour made into balls and boiled) is processed in Puriya households.

Generally, porridge, kenkey and maasa are maize products that are processed for sale across all the communities. These products are easily available, affordable and acceptable to community members. Table 50 below shows the forms in which maize is utilized in the 6 communities, both at the household and commercial levels and Table 51 shows the preference ranking of commercial maize products in the communities. Porridge, kenkey and maasa are very popular commercial products in the communities.

Table 58: *Forms of maize utilization*

Form	Type of product	Household/ Commercial	Comments	Community
Fermented/ unfermented corn dough	porridge	both		All
	kenkey	Mostly commercial		All
	banku	both	Usually mixed with cassava dough	All
Corn flour	Tuozaafi (TZ)	household		All
	maasa	commercial	Deep-fried balls added to porridge; usually eaten for breakfast	All
	apiti	both	Maize flour, moulded and fried	Achubunyor, Agric. Ext, Gunsi
	yaakana		Maize flour, moulded and boiled	Puriya
Roasted corn flour	infant food	Mostly household	Mixed with groundnuts, soybeans etc.	All
	apapransa	household		Puriya, Gunsi
Roasted grains	snack	household	Salted and mixed with groundnuts	DC Kura
Malted and fermented	pito	commercial	Community members prefer sorghum	DC Kura, Agric. Ext
Dehulled and boiled grains	snack	household	Popular among West Gonja communities only	Achubunyor, Mempeasem, Agric. Ext.

Table 59: *Preferred commercial maize products in the communities*

DISTRICT	COMMUNITY	1st	2nd	3rd	4th
Mion	DC Kura	pito	porridge	maasa	kenkey
	Puriya	kenkey	maasa	porridge	
	Gunsi	porridge	kenkey	banku	kaafa
West Gonja	Agric. Ext.	banku	kenkey	maasa	pito
	Mempeasem	porridge	kenkey	maasa	
	*Achubunyor	X	X	X	X

* Community members in Achubunyor had the same level of preference for kenkey, porridge, banku, apiti, Weanimix and maasa

Processing Methods

The community members narrated the processes involved in the preparation of some commercial maize-based products as indicated in Table 52.

Table 60: *Processing methods*

	PRODUCT	PROCESSING METHOD
1	Ga kenkey	Clean and soak maize grains for 2-4 days, drain, mill, add water and mix to form dough. Allow dough to stand for a full day or overnight to ferment. Precook half of the dough, add salt and mix with the remaining fresh dough, mould into balls, wrap with dried maize husks and boil the balls till cooked
2	Maasa	Clean and soak grains for 1-3 days (some communities soak for a day, drain and cover with moist jute sacks to germinate) drain, mill together with preferred spices, make porridge from part of the dough, add remaining dough and mix; then leave it overnight. Add sugar, stir, mould and deep-fry
3	Porridge (koko)	Clean, soak grains for 1-3 days, drain, mill together with spices, add water to make dough, ferment dough for a day (optional), add water, filter through cloth, cook by stirring continuously till it boils
4	Banku	Clean and soak grains for 2-3 days, drain, mill, make dough, leave overnight to ferment (optional), add cassava dough (about a third to half of the quantity of corn dough), add water to form a thick paste and stir till cooked. Water is added bit by bit while cooking until the dough softens
5	Pito	Clean and soak dried maize grains, drain and put into cane basket or cover with jute sack to sprout, sun dry, mill, soak in water to ferment, and boil to brew
6	Apiti	Winnow dried grain, grind, add sugar and mix together, while incorporating small amounts of water. Mould and deep-fry
7	Kaafa	Clean and soak grain for 2 days to soften, grind, sieve, soak in excess water overnight, decant water, boil with fresh water to cook. Mould when cooked

Members of the various communities who process and/or sell the maize-based products were identified and their contacts documented. Table 53 below shows the number of processors per community and what products they process and sell. Gunsi had the highest number of maize processors (11) and Puriya had the least (3). Interestingly, both Gunsi and Puriya are in the same district. Of the 2 women who sell porridge in Achubunyor, one does it in the morning and the other in the afternoon. From Table 53, it can be observed that kenkey is the most popular commercial product followed by porridge and masa. Roasted maize and apiti are processed only in one community each.

Table 61: *Number of processors/marketers identified in each community*

District	**Community**	**Porridge**	**Kenkey**	**Banku**	**Maasa**	**Apiti**	**Pito**	**Roasted maize**	**Kaafa**	**Total**
Mion	DC Kura	1	2	1	1	0	1	0	0	**6**
	Puriya	0	2	0	1	0	0	0	0	**3**
	Gunsi	3	5	1	0	1	0	0	1	**11**
West Gonja	Agric Ext.	0	1	1	2	0	1	0	0	**5**
	Mempeasem	2	2	0	1	0	0	0	0	**5**
	Achubunyor	2	1	1	1	1	0	1	0	**7**
Totals per product		**8**	**13**	**4**	**6**	**2**	**2**	**1**	**1**	**37**

Proposed Products for Diversification

The study revealed that products such as Weanimix and maize flour for TZ could be packaged for the market. This will make the products appealing to consumers while generating income for processors and marketers. Some communities also expressed interest in learning how to process some maize-based products which are popular in Southern Ghana, e.g. ekuegbemi in Achubunyor, apapransa in Agric. Ext., wasawasa in Puriya and Gunsi, akple in Gunsi

New products like maize biscuits, bread were also suggested by some community members.

Conclusions/Recommendations: Maize is widely consumed in the communities but there is the need to develop appropriate packaging for the products to make them more appealing to high-end consumers, while generating income for the community members.

References

Publications (at the end of all activities or last page)

Journal articles and Book Chapters; Conference/ Workshop Papers/Proceedings; Abstracts, Newsletters, Thesis, etc.

NORTHERN REGION FARMING SYSTEMS RESEARCH GROUP

The Northern Region Farming Systems Research Group (NR-FSRG) is tasked with analyzing the farming systems of the Northern Region with the view to generating appropriate innovations that could bring about improvement in the livelihoods of the people. The group has out-stations at Damongo, Yendi and Salaga. The work focuses on characterizing and describing the farming systems of the region, identifying and prioritizing constraints to increase sustainable agricultural production and generating suitable interventions to address the prioritized problems of the farmers through adaptive on-farm as well as on-station research. Besides, the team also has oversight responsibility of coordinating Research, Extension and Farmer Linkage Committee (RELC) activities in the NR. This report highlights activities carried out in 2014 cropping season.

COTTON IMPROVEMENT

Confined Field Trial of Roundup Ready cotton varieties in Ghana

Principal Investigator: E.B Chamba
Collaborating Scientists: Ramson Adombilla, Michael Mawunya
Estimated Duration: 2 years
Sponsors: MONSANTO
Location: CSIR-SARI, Nyankpala and CSIR-SARI, WA

Background and Justification:
Weed is a major constraint to cotton production in that it reduces seed cotton yields, lint quality and farmer income. Manual hand weeding has been the predominant weed control practice but several constraints including limited cash, labour unavailability especially at peak seasons limit among others the effective use of the control method. The spraying of chemical herbicides is an alternative method to hand weed control. Research has shown that herbicides produce greater yield at less cost than the typical practice of hand weeding. Since the mid-1980s Monsanto Company has been developing genes to confer crop tolerance to glyphosate [N-(phosphonomethyl) glycine] and as a result Roundup Ready cotton varieties expressing vegetative tolerance to over-the-top applications of glyphosate herbicide are now commercially available. This gives cotton farmers an additional tool to use against the problem of weed infestation. There is the need to evaluate the performance of Roundup Ready cotton varieties under the Ghanaian cotton growing environment. Thus two main studies were carried out for the evaluation.

Objectives:

1. The Efficacy trial was to evaluate the efficacy of two glyphosate formulations [Round up® PowerMax (540 g a.e./l) and Roundup® Turbo 450K (450 g a.e./l)] on weeds when applied on FK MON 88913 and/or FK MON 88913 × MON 15985.

2. The Selectivity trial was to assess the selectivity of two formulations of glyphosate [Roundup® PowerMax (540 g a.e./l) and Roundup® Turbo 450K (450 g a.e./l)] applied on MON 88913 and/or MON 88913 × MON 15985 cotton.

Expected Beneficiaries: Cotton Producing Companies and Cotton farmers
Materials and Methods:

a) Efficacy trial

The study was conducted as an on-station confined field trial. The genetically modified (GM) cotton varieties MON 88913 (with herbicide tolerant trait) and MON 88913 × MON 15985 (with both herbicide tolerance and insect pest protection traits) were planted. The farmer variety FK 37 (conventional cotton) was used as control. Glyphosate products used were; Roundup PowerMax 540 g a.e./l at 2.0 l/ha and Roundup Turbo 450K (450 g a.e./l) at 2.4 l/ha. The reference product was Roundup 360SL (360 g a.e./l) and was applied at 3.0 l/ha. Nine treatments comprising combinations of varieties and herbicides were used (appendix 1). The experimental design was randomized complete block design with 4 replications. Plots were 4 rows of 10 m length with inter-and intra-row spacing of 0.8 x 0.4 m. The trial area was surrounded by a 5 m fallow, 12 m zone planted to conventional cotton and a 25 m isolation zone with crops not sexually compatible with cotton. The herbicides products were applied twice- at 25 days after emergence and 30 days after the first application. Agronomic practices were followed as in the protocol and insects pest controlled. MON 88913 × MON 15985 variety was sprayed three times and all other variety was sprayed six times. Data was collected from plants within the 2 middle rows.

b) Selectivity trial

The experimental sites and design were similar to those of the efficacy trial. However, the treatments were 13 in number (appendix 2) and herbicide products were applied at single and double rates.

Results/Major findings:

Mean seed cotton yield for the efficacy trial ranged from 47.30 to 1607.50 kg/ha at Nyankpala. The unweeded control gave the lowest yield and the farmer practice the highest. The first herbicide application was late due to delays in obtaining permits for the herbicides from the regional Environmental Protection Agency (EPA). Plants on the herbicides plots were stressed as a result of severe competition from weeds before the first application and that probably accounted for the yield trend. There was effective weed control with the application of the herbicides. Generally the mean seed cotton yield was higher although not significant with the single trait variety MON 88913 than the double trait variety MON 88913 × MON 15985 and seed cotton yield was highest with Roundup Ready 360 SL (360 g.a.e. /l). Results of mean seed cotton yield at Wa was similar to that of Nyankpala except that the yields were comparatively higher at Nyankpala. The late planting at Wa (5 August 2014) probably accounted for the lower seed cotton yields at the site.

The selectivity trial had no observable herbicide damage on the two cotton varieties even when the herbicide concentration was doubled at both locations. Similar to the efficacy trial, mean seed cotton yield was higher for single trait variety MON 88913 and recommended herbicide rate. Over 2.0 and 1.0 tons /ha of seed cotton respectively were obtained at Nyankpala and Wa with single trait variety MON 88913 and recommended herbicide rate. Yields of MON 88913 x MON 15985 with the recommended rate of herbicide was over 1.0 ton/ha at Nyankpala and less than 1.0 ton/ha at Wa. Furthermore, the single trait variety MON 88913 obtained higher number of open bolls at harvest than the double trait MON 88913 x MON 15985 at both locations and probably accounted for the trend in yield.

Table 62: *Treatments for efficacy trial at locations*

Trt code	Trait	Treatment
1	MON 88913 × MON 15985	Untreated Control
2	MON 88913 × MON 15985	Hand Weeded Control
3	MON 88913 × MON 15985	Roundup PowerMax (540 g.a.e./l) at 2.0 l/ha
4	MON 88913 × MON 15985	Turbo 450k (450 g.a.e/l) at 2.4 l/ha
5	MON 88913 x MON 15985	Roundup 360SL (360 g.a.e/l) at 3.0 l/ha
6	MON 88913	Roundup PowerMax (540 g.a.e./l) at 2.0 l/ha
7	MON 88913	Turbo 450k (450 g.a.e/l) at 2.4 l/ha
8	MON 88913	Roundup 360SL (360 g.a.e/l) at 3.0 l/ha
9	Farmer variety FK 37 (conventional cotton)	Pre-emergence herbicide (Alligator 400 EC) only

Table 63: *Treatments for selectivity trial at locations*

Trt code	Trait	Treatment
1	MON 88913	hand weeded control
2	MON 88913	Roundup PowerMax (540 g.a.e./l) at 2.0 l/ha+ hand weeding
3	MON 88913	Roundup Turbo 450k (450 g.a.e./l) at 2.4 l/ha+ hand weeding
4	MON 88913	Roundup 360SL (360 g.a.e./l) at 3.0 l/ha+ hand weeding
5	MON 88913	Roundup PowerMax (540 g.a.e./l) at 4.0 l/ha+ hand weeding
6	MON 88913	Roundup Turbo 450k (450 g.a.e./l) at 4.8 l/ha+ hand weeding
7	MON 88913	Roundup 360SL (360 g.a.e./l) at 6.0 l/ha+ hand weeding
8	MON 88913 x MON 15985	Roundup PowerMax (540 g.a.e./l) at 2.0 l/ha+ hand weeding
9	MON 88913 x MON 15985	Roundup Turbo 450k (450 g.a.e./l) at 2.4 l/ha+ hand weeding
10	MON 88913 x MON 15985	Roundup 360SL (360 g.a.e./l) at 3.0 l/ha+ hand weeding
11	MON 88913 x MON 15985	Roundup PowerMax (540 g.a.e./l) at 4.0 l/ha+ hand weeding
12	MON 88913 x MON 15985	Roundup Turbo 450k (450 g.a.e./l) at 4.8 l/ha+ hand weeding
13	MON 88913 x MON 15985	Roundup 360SL (360 g.a.e./l) at 6.0 l/ha+ hand weeding

Conclusion:
The preliminary results have shown that the herbicides products effectively controlled weeds in the two GM cotton varieties without affecting crop health even when the herbicide concentration was doubled. Further studies have to be conducted to evaluate and confirm the efficacy of the herbicide products.

Effect of topping on the growth and yield of cotton

Principal Investigator: E.B Chamba
Collaborating Scientists: Ramson Adombilla
Estimated Duration: 2 years
Sponsors: Cotton Improvement Programme
Location: CSIR-SARI, Nyankpala

Background and Justification:
Topping (the breaking of the terminal shoot of the cotton plant) is a common practice among some cotton farmers. Farmers are of the view that topping improves seed cotton yield and in some cases reduce pest incidence. A farmer participant in the 2013 Bt cotton demonstrations topped the conventional field that was being compared with the Bt cotton field. It turned out to be the only site out of six that the seed cotton yield of the conventional cotton was higher (although not significant) than the seed cotton yield of the Bt field and thus necessitated the need for studies into the subject of topping.

Objective:
The objective of the study was to determine the effects of different stages of topping on the seed cotton yield of cotton.

Expected Beneficiaries: Cotton Producing Companies and Cotton farmers

Materials and Methods:
The trial was conducted on-station at CSIR-SARI, Nyankpala. The experimental design was a randomized complete block design with 4 replications. The five treatments were topping at 65 days after planting (DAP), 75 DAP, 85 DAP, 95 DAP and no topping as control. Topping on individual plants was done below the uppermost node with secateurs. Plot sizes were 4 rows of 10 m length with inter and intra-row spacing of 0.9 x 0.3 m. Alleys of 1.0 m separated plots. Agronomic practices were followed and insect pests controlled.

Results/Major findings:
Mean seed cotton yield ranged from 2072.70 to 2485.50 kg/ha with the no topping control giving the lowest yield and topping at 65 DAP the highest yield. There were no statistical differences among treatment neither was there differences among the number of opened bolls,

boll weight and lint percent. The experiment has shown that there could be yield advantage in topping and it should probably be done earlier than 65 DAP in subsequent studies.

Conclusions/Recommendations :
Seed cotton yields were similar for treatments. Topping earlier than 65 days after planting should be considered in subsequent studies.

Effect of planting dates on growth and yield of cotton

Principal Investigator: E.B Chamba
Collaborating Scientists: Ramson Adombilla
Estimated Duration: 2 years
Sponsors: Cotton Improvement Programme
Location: CSIR-SARI, Nyankpala

Background and Justification:
Cotton is one of the major cash crops in Ghana. It is a perennial plant that is produced as an annual and therefore very responsive to environmental conditions (Yucel and Gormus, 2002). The optimum sowing date for a cultivar in a region is considered to be the most important manageable factor in cotton (Bozbek et al., 2006). However, farmers in the cotton growing areas of northern Ghana are unable to predict sowing dates properly due to the inconsistent rainfall pattern over the years caused by the increasing change in climate. According to Ali et al. (2009), early sowing of cotton expresses higher yield potential than late sowing. In view of the immerse effect of sowing date on seed cotton yield, the study was conducted to determine the optimum sowing period of promising cotton varieties under the climatic conditions of Northern region.

Objective:
The objective of the study was to determine the response of three cotton varieties to different planting dates.

Expected Beneficiaries : Cotton Producing Companies and Cotton farmers

Materials and Methods :
The trial was conducted on-station at CSIR-SARI, Nyankpala. The experimental design was a 3 x 4 factorial treatment arrangement in a randomized complete block design with four replications. The 12 treatments comprised a combination of three varieties and four planting dates. The varieties were FK 37 (farmer variety), SARCOT 1 and SARCOT 5 and planting dates were 21 June, 5 July, 17 July and 6 August, 2014. Plot sizes were 8 rows of 10 m long with inter-and intra-row spacing of 0.9 x 0.3 m. Good agronomic practices were followed and

insect pest controlled accordingly. Data was collected from the 4 middle rows, managed and analyzed using the statistical package GenStat 12 edition.

Results/Major findings:

The mean seed cotton yield ranged from 435.20 to 2303.09 kg/ha (Table.56). SARCOT 5 planted on 5 July gave the highest yield and FK 37 planted on 6 August, the lowest. Except for SARCOT 1, the varieties recorded higher yields when planted on 5 July. SARCOT 5 planted later on 17 July recorded higher yield than planting of farmer variety (FK 37) on 21 June and SARCOT 1 on 5 July indicating that SARCOT 5 can be planted as late as 17 July but planting of FK 37 and SARCOT 1 later than 5 July should be avoided. SARCOT 5 could be the candidate variety to fit into the decreasing number of rainy days per year.

Table 64: *Mean seed cotton yield, kg/ha as affected by variety and planting date*

Planting date	Varieties			Planting date means
	FK 37	SARCOT 1	SARCOT 5	
21-June	1631.83	1717.94	2066.81	1805.53
5-July	1824.31	1485.70	2303.09	1871.03
17-July	1299.94	1234.62	1645.33	1393.30
6-August	435.20	546.89	768.65	583.58
Variety means	1297.82	1246.29	1695.97	

Planting date: LSD at P = 5%: 290.25 kg/ha; Variety: LSD at P = 5%: 251.36 kg/ha

Conclusions/Recommendations:

Planting date and variety had a significant effect on the mean seed cotton yield. With the exception of SARCOT 1 the varieties recorded higher yields when planted on 5 July. However, the yield of SARCOT 5 planted as late as 17 July is comparable to planting FK 37 and SARCOT 1 on 21 June and 5 July.

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RICE IMPROVEMENT

Africa Rice Breeders Task Force (ARBTF) Trial-2014

Principal Investigator: Dr. Wilson Dogbe
Collaborating Scientists: Samuel Oppong Abebrese
Estimated Duration: 3 years
Sponsors: WAAPP
Location: Nyankpala, Libi and Manga

Background Information and Justification:
Rice has become a major staple food in Ghana. The per capita rice consumption is around 63kg per annum (JICA, 2007) and keeps rising steadily. Ghana spends over $ 500 million annually on importation (MoFA, 2010). The availability of improved higher yielding varieties is key for farmers to increase production and productivity.

Objective:
To evaluate for yield and other important agronomic traits of 13 lines advanced from multi-sites analysis of Africa rice breeder's taskforce trials in 2012 in Northern Savanna agro-ecological zones of Ghana.

Expected Beneficiaries: Small holder rice farmers, Ghana's economy

Materials and Methods:
The trials were laid out in a Randomize Complete Block Design (RCDB) with four replicates at three locations Nyankpala, Libi and Manga. Data were taken on yield, yield components and other important agronomic traits.

Results/Major Findings:
The yield across locations for 2014 is presented in Table 57. Entries (WAB 2081-WAC B-TGR4-B and WAB 2056-2-FKR2-5-TGR1B) have proved very promising. They were the top 2 yielders in 2013 and have maintained same positions in 2014.

Conclusions/Recommendations: The trial to be repeated the third time in 2015 to select suitable entries for on-farm. Further field testing should be proceeded by milling and sensory evaluations

Table 65: *Yield (t/ha) across locations*

Variety	Nyankpala	Libi	Manga	Mean Across
JASMINE 85 (CHECK)	2.84	2.75	6.63	4.07
WAB 2081-WAC2-2-T GR2-WAT B3	3.72	2.85	7.32	4.63
WAB 2098-WAC2-1-T GR2-WAT B2	3.14	2.81	6.64	4.19
WAB 2081-WAC B-TGR4-B	6.18	3.54	8.35	6.02
WAB 2056-2-FKR2-5-T GR1-B	4.57	4.26	8.69	5.84
DKA-M2	3.33	4.41	8.00	5.25
WAB 2076-WAC1-T GR1-B	4.06	3.75	8.67	5.49
WAB2098-WAC3-1-T GR1-4	4.20	3.27	7.23	4.90
WAB2125-WAC B-1-TGR3-WAT B1	4.50	2.86	7.99	5.12
FAROX 508-3-10-F43-1-1	3.80	4.20	7.95	5.32
IR841 (check)	4.66	3.10	9.59	5.79
FAROX 508-3-10-F44-2-1-1	4.04	3.06	5.58	4.23
TXD 88	3.28	3.21	4.46	3.65
WAB 2060-3-FKR1-WAC2-TGR4-B	3.21	3.19	6.79	4.40
Mean	3.97	3.38	7.42	4.92
P-Value	0.003	<0.001	<0.001	
LSD	1.40	0.66	1.98	
CV	24.60	13.80	18.70	

References

Ministry of Food and Agriculture, 2010. Agriculture in Ghana: Facts and figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Japan International Cooperation Agency, 2007. The study on the production of domestic rice in the republic of Ghana. Draft final report. Nippon Koei Co Ltd.

AGRA-PVS Evaluations

Principal Investigator: Wilson Dogbe
Collaborating Scientists: Samuel Oppong Abebrese
Estimated Duration: 3 years
Sponsors: WAAPP
Location: Nyankpala, Libi, Manga

Background Information and Justification: Rice has become a staple food in Ghana. This is a result of the rapid change in lifestyle and food habit; particularly in urban centers (Nyanteng, 1987; Balasubramanian *et al.*, 2007). Ghana produces 30-40% of its rice needs (MoFA, 2010) and spends over 500 million US dollars annually on importation (IRRI, 2012). The per capita rice consumption is around 63kg per annum and keeps rising steadily (JICA, 2007). There is therefore the need to increase local production to contribute to foreign currency saving and improve farmers' incomes. The rice program of the CSIR-SARI develops and evaluate new rice genotypes to identify yielding varieties for farmers to improve production and productivity. Against this background, twenty (20) genotypes were obtained from CRI- AGRA sponsored rice program in 2010 for evaluation in the savanna agro-ecological zones of Ghana.

Objectives: To evaluate twenty (20) genotypes obtained from CRI- AGRA sponsored rice program for yield and general adaptability in the northern savanna agro ecological zones of Ghana.

Materials and Methods: The trials were laid out in Randomize Complete Block Design (RCBD) with 4 replicates at 3 locations, Nyankpala, Libi and Manga

Results/Major Findings:
The entries over the years have not been able to demonstrate yield superiority over the local checks. IR841 (AGRA) was selected from this collection and probably affirms it superiority. Though not statistically significant, IWA 10 and Sahel 210 were able to out yield AGRA in 2014.

Table 66: Yield (t/ha) across locations

Variety	Nyankpala	Libi	Manga	Mean Across
Jasmine 85	2.77	2.09	2.29	2.38
Sahel 201	2.10	3.67	3.27	3.01
Sahel 209	2.74	3.04	2.31	2.70
Sahel 210	4.21	3.40	3.18	3.59
WAS 127-12-1-2-3	1.93	2.57	2.00	2.17
WAS 127 -12-1-6-3-1	3.28	2.31	2.69	2.76
Variety	**Nyankpala**	**Libi**	**Manga**	**Mean Across**
Nerica-L-19 ex Togo	2.83	2.32	2.62	2.59
Nerica-L-20	3.01	2.80	2.27	2.69
Nerica-L-41	4.51	2.85	2.18	3.18
Nerica-L-42	2.85	2.89	2.51	2.75
DKA4	2.52	1.60	2.51	2.21
Marshall	2.69	3.57	2.93	3.07
Jasmine 85	3.04	2.63	2.91	2.86
IR841	3.54	3.20	2.91	3.22
IWA 10	4.25	3.43	2.53	3.40
NIL2	3.34	2.73	2.46	2.84
NABOGU	2.25	*	2.31	2.28
Mean	3.05	2.82	2.58	2.82
P-Value	0.08	<0.001	0.33	
LSD	NS	0.72	NS	
CV	37.30	17.90	21.90	

Conclusions/Recommendations : IWA 10 and Sahel should be considered for on-farm trial.

References

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Breeding rice for Drought Tolerance in the Northern Savanna zones of Ghana

Principal Investigator: Dr. Wilson Dogbe
Collaborating Scientists: Samuel Oppong Abebrese
Estimated Duration: 3 years
Sponsors: WAAPP
Location: Nyankpala

Background Information and Justification: Erratic rainfall pattern as a result of climate change has made drought the number one abiotic constraint to rice production in the rainfed ecology. The rainfed ecology constitutes about 78% of the total rice production ecology in Ghana (MoFA, 2010). Developing drought tolerant rice varieties is the most viable strategy to safeguard rice production in the rainfed ecology. The CSIR-SARI rice program initiated drought tolerance breeding in 2013. Twenty (20) drought tolerant lines were introduced from IRRI. Another 20 were alos introduced from Mali. The IRRI materials were planted in replicated yield trial to assess thier performance under normal rains. Fifteen grams (15 g) rice seeds obtained from Mali were multiplied to obetain adequate seeds for droutght stress experiments.

Objectives

- Screen to identify drought tolerant parent from the introduced materials.
- Incorporate Drought tolerance into 2 farmer preferred drought susceptible varieties

Expected Beneficiaries: Small holder rice farmers, Ghana's economy

Materials and Methods: Introduce new drought tolerant rice genotypes. Screen the introduced materials for drought tolerance under both and controlled uncontrolled conditions to identify suitable drought tolerant parents. Make crosses to improve the drought tolerance of 2 locally farmer preferred varieties. The IRRI materials with enough quantities of seeds were evaluated in replicated yield trials under normal rainfall in 2014. Fifteen grams (15 g) of seeds obtained from Mali were also multiplied to obtain adequate seeds for both field controlled and uncontrolled screenings.

Results/Major Findings: Recorded yield for IRRI materials is presented in Table 59. Amount of seeds obtained from multiplying the 15 g seeds from Mali materials is also presented in

Table 60. The IRRI materials have appreciable yields under normal rainfall. Enough seeds have been obtained for the Mali materials for controlled field screening.

Table 67: *Yield (t/ha) at Nyankpala for IRRI materials*

Variety	Yield (t/ha)	**Variety**	Yield (t/ha)
UPL RI 5	4.37	IR 74963-2-6-2-5-1-3-3	4.40
UPL RI 7	4.91	IR 77298-14-1-2-10	3.33
N22	1.25	IR 79913-B-179-B-4	4.73
KALIAUS	0.51	IR 77298-5-6-18	3.14
KALIA	0.95	IR 74371-54-1-1	4.30
IR 80411-49-1	4.16	VANDANA	2.98
IR 81412-B-B-82-1	4.35	WAY RAREM	3.59
IR 74371-46-1-1	4.53	APO	4.03
IR81023-B-116-1-2	4.67	AGRA	4.80
IR 74371-70-1-1	5.79	**Mean**	**3.77**
IR 72667-16-1-B-B-2	4.03	**P-Value**	**<0.001**
IR 55419-04	4.25	**LSD**	**1.401**
		CV	**26.3**

Table 68: *Amount of seeds (kg) obtained from multiplication of the 15 g of Mali materials at Nyankpala*

Variety	**Grain Yield (kg)**	**Variety**	**Grain Yield (kg)**
SIK 350-A150	1.2	DKA-M 8	0.5
SIK 353-A10	0.1	DKA-M 9	1.0
DKA 1	0.8	DKA-M 11	1.4
DKA 3	0.3	DKA-M 13	1.1
DKA 4	1.0	MLI 6-1-2-3-2	0.8
DKA 21	1.2	MLI 20-4-1-1-1	0.4
DKA 22	0.7	MLI 25-1-2	0.6
DKA 23	0.8	MLI 25-3-2	0.5
DKA-M 2	0.5	MLI 20-4-3-1	0.5

Conclusions/Recommendations : The materials are to be screened for controlled drought. Make crosses to improve the drought tolerance of 2 locally preferred drought susceptible varieties

References

MOFA (Ministry of Food and Agriculture), (2010) Agriculture in Ghana: Facts and figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Hybrid Rice Breeding

Principal Investigator: Samuel Oppong Abebrese
Collaborating Scientists: Dr. Wilson Dogbe
Estimated Duration: 3 years
Sponsors: WAAPP/WACCI
Location: Nyankpala

Background Information and Justification:
Ghana produces 30-40% of its rice needs and spends over $ 500 million on importation annually (MoFA, 2010). Hybrid rice technology is one of the promising, sustainable, and proven technologies for enhancing rice productivity, with a yield advantage of 15–30% over inbred varieties (Virmany *et al*, 2003). To find out the prospect of hybrid rice in Ghana, the rice program of the CSIR-SARI began a rice breeding program with these two objectives:

Objectives:
1. To develop/introduce high yielding hybrids for evaluation and release to farmers.
2. To identify maintainers and restorers from local germplasm that could be used for hybrid development.

Expected Beneficiaries: Small holder rice farmers, Ghana's economy

Materials and Methods: Eight hybrids were evaluated against two inbred checks (Gbewaa and AGRA) for yield and other important agronomic traits in a Randomized Complete Block Design (RCBD) with three replicates at four locations Nyankpala (field), Nyankpala (micro plot), Navrongo and Golinga. Eighty-five (85) local germplasm maintained at the CSIR-SARI rice program were screened with functional markers linked to fertility restoration to identify potential maintainers and restorers. Testcrosses were carried out to confirm potential maintainers and restorers.

Results/Major Findings: Yield across locations are presented in Table 61. There were no significant difference between the tested hybrids and the inbred checks across locations. Though some hybrids yielded higher than the checks, their recorded percent yield advantage was not above the 20% required for the commercialization of hybrids. The molecular screening identified 30 potential restorers and 55 potential maintainers. Twenty-three (23) testcrosses were made between selected lines and two CMS lines introduced from AfricaRice. A testcross nursery has been established for the resulting F_1s. Results yet to be ready.

Table 69: Yield (t/ha) across locations

Variety	Nyankpala Yield (t/ha)	Navrongo Yield (t/ha)	Golinga Yield (t/ha)	Nyank (micro-plot) Yield (t/ha)
AGRA RICE	4.49	5.50	5.69	6.08
GR-1	5.37	5.06	5.58	7.48
GR-2	3.71	5.63	5.60	6.80
GR-3	4.77	6.76	5.61	7.84
INDAM 100-001	4.27	6.11	5.85	6.27
INDAM 100-012	3.02	3.24	5.69	6.79
INDAM 200-022	6.12	1.48	6.02	6.52
JASMINE 85	4.38	6.20	5.07	6.51
S71680676	5.16	5.66	6.48	7.30
S72180002	5.00	5.66	6.42	6.80
Mean	**4.63**	**5.13**	**5.8**	**6.84**
LSD	**NS**	**NS**	**NS**	**NS**
CV	**34.9**	**35.7**	**15.8**	**11.7**

Conclusions/Recommendations . More hybrids are to be tested to identify superior hybrids for commercialization. Hybrids are known to respond better to higher Nitrogen. The hybrids are to tested with higher doses of N 120N and 150N to ascertain their yield

References

Ministry of Food and Agriculture, 2010. Agriculture in Ghana: Facts and figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Virmani SS, Sun ZX, Mou TM, Juahar Ali A. and Mao CX (2003). Two line hybrid rice breeding manual. International Rice Research Institute. Los Banos (Philippines). 88p.

Agricultural Value Chain Mentorship Project

Principal Investigator: Wilson Dogbe
Collaborating Scientists: Robert Owusu, Prince Maxwell Etwire, Abdul Basit Tampuli, Mr. Inusah Baba, Edward Martey
Estimated Duration: 3.5 years (May 2011 to February 2015)
Sponsors: DANIDA through AGRA
Location: 16 Districts in Northern Region of Ghana

Background

MAJOR FINDINGS /ACHIEVEMENTS
The achievements can be captured under the three main outcomes of the project

- Improved Entrepreneurial Capacity of FBO's and their Member farmers
- Improved Capacity of institutions to upscale Integrated Soil Fertility Management (ISFM)
- Increased awareness and use of ISFM technologies among smallholder farmers.

Outcome 1: Improved Entrepreneurial Capacity of FBO's and their Member farmers
The AVCMP revived many dormant FBOs by assisting them to put in place the necessary leadership structure. This happened alongside training on leadership and group dynamics and assisting them in the drafting of Constitutions, formal registration and drafting of business plans
FBO record keeping has improved through the use of symbols. FBOs can now prepare crop partial budgets as well as profit and loss accounts using symbols.

Collective activities of FBOs like bulk procurement of inputs, mutual labour support for weeding and for other agronomic activities, and welfare activities has increased.
Over 60% of beneficiary FBOs is now operating active bank accounts with some community banks. FBOs Access to equipment services, inputs and aggregators has improved.

Outcome 2: Improved Capacity of institutions to upscale Integrated Soil Fertility Management (ISFM)
The four partner radio stations (Bishara, Savanna radio, radio kitawoln and Simli radio), aired 360 discussion programs and documentaries on ISFM reaching an estimated 36000 listeners. Eleven print materials on ISFM were produce and distributed to more than 11200 farmers. ISFM drama was performed in 8 project districts attracting more than 2000 farmers. The video was later filmed and shown to more than 30000 viewers in project communities using the award wining tricycle video van.

A video van innovated by CSIR-SARI and Countrywise communication to reach remote project communities was nominated and won two awards (Gold and Chairmans Award) at the 2013 International Video Communication Association CLARION awards in the United Kindom. SARI and Countrywise were presented the award at the event held in London.

According to the Director of Radach Memorial Centre the partnership has had significant impact on the career development of his personnel and the image of his business. The CEO of Countrywise Ghana shared similar sentiments.

Outcome 3: Increased awareness and use of ISFM technologies among smallholder farmers

An estimated 28000 farmers from 260 communities received awareness on ISFM through the use of the award wining tricycle video van innovated by CSIR-SARI and Countrywise Communication Gh., 2500 farmers through the on-stage ISFM drama show, and about 6000 through the OFD's. Listeners to 360 radio programs on ISFM aired by partner radio stations during the project life were estimated at 36000. Twelve thousand one hundred farmers were reached through the printed ISFM materials. Even though the most preferred means according to the survey was the use of OFD's, it came out as the most expensive (Table 62). The most cost effective means in terms of the number of farmers reach per cedi was found to be drama as a video followed by print and radio. Farmers participation in OFD was found to have positive impact on productivity. Average yield increase as a result of farmer's participation in AVCMP demonstrations were 71% for rice, 32% for soybean and 26% for maize (Table 63.).

Table 70: *Empirical Analysis of Awareness Creation Techniques*

Awareness creation strategy	Number of beneficiaries reached per year	Total Cost (GHC) per program/year	Cost per beneficiary (GH¢)
Drama filmed and showed as video	15000	22050	1.47
Print materials	12100	21659	1.79
Radio	6000	26000	4.33
On stage drama	2400	14880	6.2
Farmer learning Center (FLC)	600	16500	27.5
Individual OFD's	4000	125000	31.25

Table 71: Effect of farmers' participation in ISFM demonstration on yields (kg/ha) for rice, soybean and maize

Yield level	Type of Farmer			
	Farmers who participated in demos		Non demo participants	
	No of farmers surveyed	Yield (kg/ha)	No of farmers surveyed	Yield (kg/ha)
RICE				
Max	75	4259	75	2511
Min	75	1402	75	822
Mean	75	2747	75	1611
SOYBEAN				
Max	75	1382	75	990
Min	75	554	75	296
Mean	75	839	75	637
MAIZE				
Max	15	2750	15	2261
Min	15	853	15	622
Mean	15	2056	15	1626

Reasons attributed to increased yield recorded by farmers were adherence to recommended practices as taught during PLAR-ISFM trainings at the demo sites eg dibbling to ensure optimum population, and timely weed control and fertilizer management. Some farmers observed that even though they were not able to afford the recommended fertilizer rate the timely application and burying of fertilizer made the difference in yield especially for rice. For soybean some farmers said the timely harvesting made the difference.

LOWLAND AGRONOMY

Development of low input sustainable rice cultivation system in flood plain in Africa

Principal Investigator: Inusah Baba
Collaborating Scientists: Dr. Hirohiko Morita, Dr. Wilson Dogbe, Abraham Fuseini
Estimated Duration:
Sponsors: JIRCAS
Location: Buibe (Zaw)

Evaluation of weed emergence and growth pattern in no-tilled and tilled rice fields in the fourth year, using Fields 1 and 2 - F1 & F2 (2014) 1ml / m2 of herbicide, glyphosate (41% a.i.) mixed with 200ml of water was sprayed at one week before ploughing. At one week after glyphosate application, plough or till (cultivate) except for no-tillage plots (A) was practiced, with fertilizer application in standard rate and method of SARI. After land preparation, on 3rd July seed paddy of c.v. 'Jasmine85' was sown at a rate of 2g/2m in row seeding in standard way of SARI.

Weeds in $0.2m^2$(0.5 x 0.4m) and rice plants on 1m (0.5m x 2rows) were collected on 11th September to identify the species, density of plants and DMW

Results

Ground total of seeds was not different between two places and that in Weed free plot was approximately 2/3 of Weedy plot in both places. However, number of seeds of grasses, particularly of *Paspalum scrobiculatum*, was smaller in less weedy place Sown at August than in weedy place sown at July. A large number of seed of *Cleome viscosa* was collected in less weedy place.

As short seed longevity was reported in *P. scrobiculatum* and *Digitaria ciliaris* , it was considered as a factor causing the phenomenon observed in 2013, that the seed bank size of these grass species was decreased in less weedy place through herbicide treatment and hand-weeding.

Results Through the observation of weed flora in/around Field 3 and Field 4, it was considered that the DB could cover the weed and plant species growing in the habitats including F3 and F4. Around 10 species including species given below could be added to the DB. Infestation of *Chromoleana odorata* and *Tithonia diversifolia* , Pan-tropical noxious invasive species was observed, along the main road at south of Chiranda, near Kintampo and Kumasi, respectively.

Warning Invasion of these species to Northern Districts should be monitored.

No. Slide Family Scientific name :

184. Pedaliaceae *Sesamum indicum* L. Dicot. broadleave Annual Upland
185. Malvaceae *Malvastrum coromandelianum* Garcke. Dicot. broadleave Perennial Upland
186. Leguminosae *Crotalaria retusa* L. Dicot. broadleave Annual Upland
187. Euphorbiaceae *Acalypha segetalis* Müll. Arg. Dicot. broadleave Annual Upland
188. Amaranthaceae *Pupalia lappacea* A. Juss. Dicot. broadleave ? Upland
189. Gramineae *Eragrostis tenella* Roem. Et Schult. Grass Annual U & Rice

190/ Leguminosae *Alysicarpus vaginalis* DC. Dicot. broadleave A & P Upland

Figure 22: Pupalia lappacea (left) and Sesamum indica (right).

Effect of priming, soil moisture & elevation on Yields of rice in the Flood Plains of the White Volta at ZAW

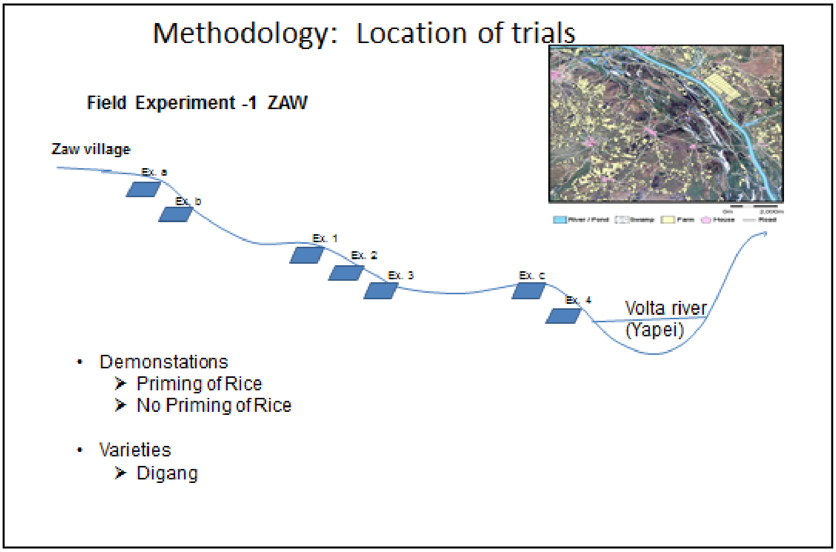

Figure 23: Location of Trials

Treatments :

1) Priming (12 hrs) & 2) No Priming; Plot size: 32m X 32m =1024 Number of plots: 9 X2;=18 plots; Rice Variety: Digang (110 days maturity)

Cultivation method used: Disc plow was proceeded by broad cast of rice seeds and then hand leveling

Determination of Parameters: Soil moisture (profile probe 100-400 mm)

Germination, Plant height, Yields of whole plots were the parameters measured

Objective 1. To get real yield of a relative productivity index map

Results

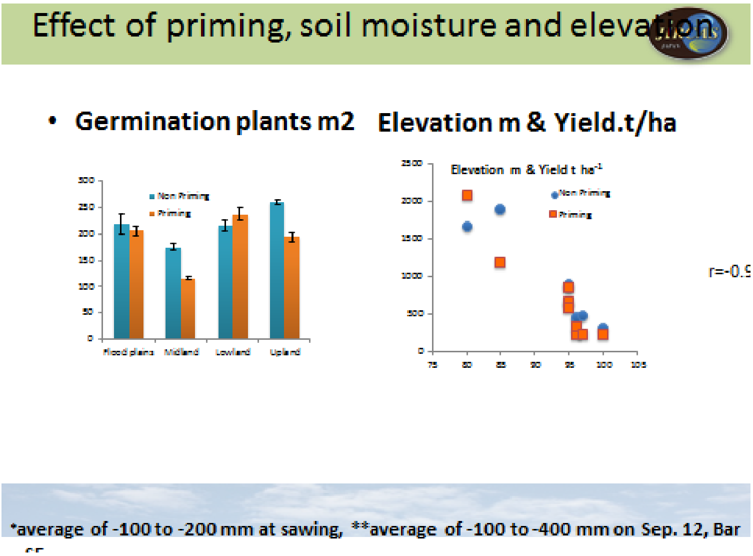

Figure 24: Effect of priming, soil moisture and elevation

Outcome 1was the construction of a model productivity index map to be read as:
The index was matched off as follows.

0.7→2.0 (t/ha)、 0.4→0.3 (t/ha)

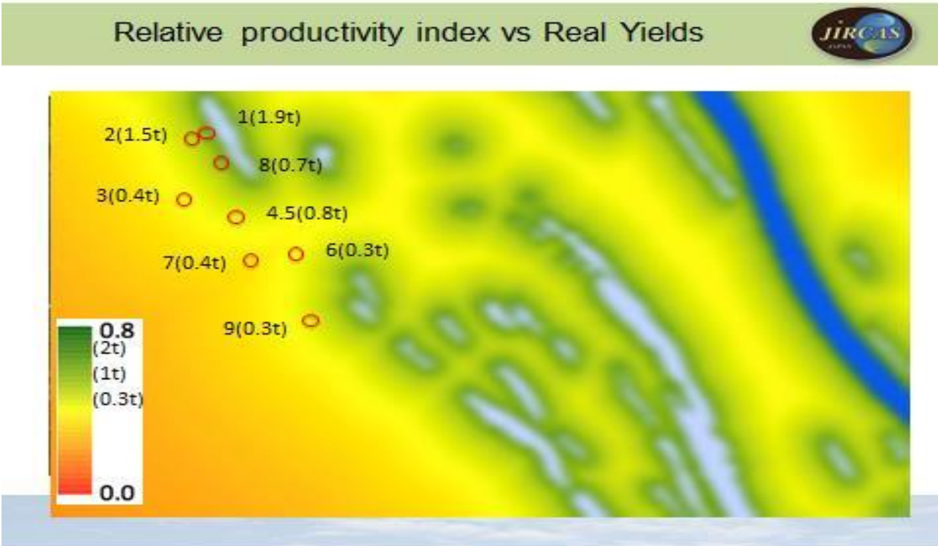

Figure 25: Relative productivity index vs Real Yields

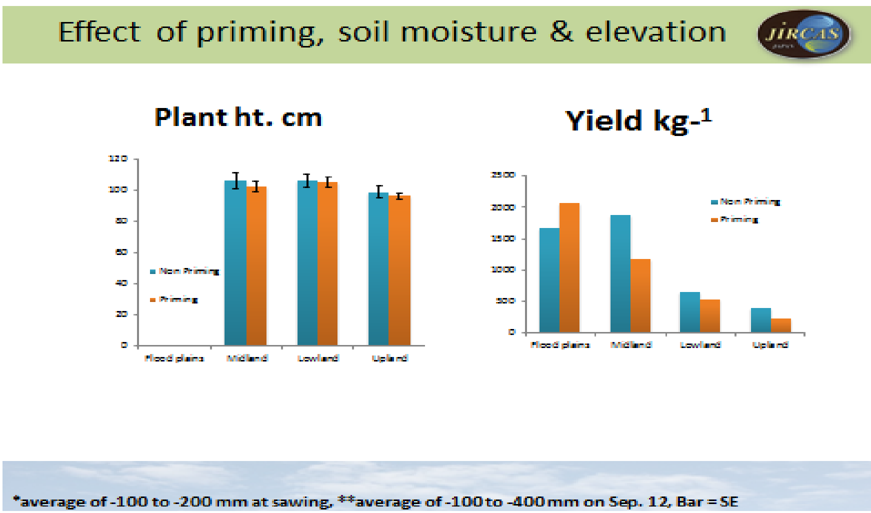

Figure 26: Effect of priming, soil moisture and elevation

Conclusions

Soil moisture was correlated more strongly.

Yields were correlated most strongly to elevation.

Priming was **not** effective under the practical conditilions at Zaw WhiteVolta Flood Plains

UPLAND AGRONOMY

Introduction

The Upland Agronomy is charged with the responsibility of carrying out adap tive or on-farm trials of all mandate crops except cotton, rice and root and tuber crops. In order to provide adequate backstopping of the on-farm trials, the section also carries out limited number of on-station agronomic trials were carried out at Nyankpala, Yendi, Damongo and Walewale.

Three major activities were carried out in 2014. These were made up of:

- Intercropping studies involving Jatropha and some food crops (cereals and legumes) funded by the European Union

- Yield of Jatropha as affected by Three different methods of propagation also funded by the European Union

- The Productivity of maize and rice as affected by different levels of newly formulated fertilizers (Funded by YARA, Ghana).

Yields of Cereals (Maize and Sorghum) and legumes (cowpea and Sorghum) as affected by Jatropha in intercropping systems

Principal Investigator: J. M. Kombiok
Collaborating Scientists: S. K. Nutsugah, Jerry Nboyine, Haruna Abdulai, Ramatu Alhassan
Estimated duration: 4 years (2010 – 2014)
Sponsors: European Union
Location: Nyankpala

Background and Justification

Jatropha has always been used in the Northern part of Ghana as a border plant or as a life fence of gardens and other portions of the house or farms for some time now. It has never been considered as a crop until of late when the issue of it being one of the plants used to produce fuel in some countries. This has however encouraged entrepreneurs and governments of some countries to initiate the establishment of Jatropha plantations with the aim of producin g fuel.

With the inception of an EU-Sponsored Jatropha Project which is a community development project in 2009, SARI among other things was mandated to carry out field trials involving jatropha. One of the trials was to find out how compatible Jatropha is as an intercrop plant with food crops. This is because farmers in the sub-region practice intercropping widely of which Jatropha will not be left out if it is accepted as a bio-fuel crop. It was therefore based on this reason that it became necessary in 2010 to introduce a long term intercropping systems involving the Jatropha plant and the commonly grown legumes (Soybean and Cowpea) and cereals (Maize and Sorghum).

Objective
To determine the best cereal (maize and sorghum) and legume (soybean and cowpea) as inter-cropping partners in terms of grain yield with Jatropha.

Beneficiaries : Scientists, Agric. Extension staff and farmers

Materials and methods
The two sets of trials involving legumes and cereals were conducted at the Savanna Agricultural Research fields, Nyankpala since 2010 and repeated till date. Each of the trials was laid in a Randomized Complete Block design (RCBD) and replicated three times. Regular weeding was carried out on both trials to make sure the plants were weed free at most of the stages of crop growth.

Treatments:
a. Jatropha/cereal inter cropping system

Crops: maize, Sorghum and Jatropha

- i. Sole Jatropha spaced at 2 by 3 m
- ii. Sole maize
- iii. Sole sorghum
- iv. Jatropha/ maize
- v. Jatropha/sorghum.

b. Jatropha/Legume intercropping system

Crops: Soybean, cowpea and Jatropha

- i. Sole Jatropha spaced at 2 by 3 m
- ii. Sole Soybean
- iii. Sole Cowpea
- iv. Jatropha/ Soybean
- v. Jatropha/Cowpea

Results of intercropping trials in 2014

Yields of Cereals (Maize and Sorghum) and Jatropha
The yields of both cereals (maize and sorghum) show that there were significant differences between the yields in the sole systems of the cereals and their inter crops suggesting that the presence of Jatropha in the system significantly reduced the yields of these food crops. There was over 36 % reduction in maize yields when it was intercropped with Jatropha while for sorghum it went up as high as 43 %. It was however found that there were no significant differences in jatropha yields between the sole and when intercropped with each of the cereals.

b. Yields of legumes (Soybean and cowpea) and Jatropha

Comparably, the yields of both legumes were very low and this could be due to high insect infestation in the cowpea and the intermittent drought that existed during the pod filling stage of the soybean. Even though the yields were low, there were no significant differences in yields between the sole systems of both cowpea and soybean and their intercrops. Similarly, the yields of jatropha both in the sole and when intercropped with the legumes (cowp ea and soybean) were similar suggesting that the presence of the food crops in Jatropha had no negative influence on the yield of Jatropha

Conclusions

From the results of intercropping Jatropha with cereals and legumes, it can be concluded that when Jatropha was intercropped with cereals (maize and Sorghum) in the spacing of 3 by 2 m, yields of the cereals were significantly reduced but for legumes (soybean and cowpea) there was no significant reduction in yield. However, the yield of Jatropha was not affected by both the legumes and cereals in the trials indicating that there were no negative influences of the food crops on the yield of Jatropha.

Yield of Jatropha as affected by three different methods of propagation in the Savanna Zone of Ghana

Principal Investigator: J. M. Kombiok
Colaboratting Scientists: S. K. Nutsugah, Jerry Nboyine, Haruna Abdulai, Ramatu Alhassan
Estimated duration: 4 years (2010 – 2014)
Sponsors: European Union
Location: CSIR – SARI Research farm, Nyankpala

Background and Justification

Jatropha can be propagated using the seeds (direct seeding), use of cuttings from mature plants as well as nursing the seeds and transplanting the seedlings on the field. All the propagation methods have their merits and demerits. Direct seeding has been found to lower production cost as there is no money spent in raising the seedlings in the nursery. With the use of seedlings, the establishment of nurseries, funds are needed for labour and other capital equipment like water pumps and pipes which are absent if direct seeding is used. However, with poor land preparation and poor seed quality, farmers tend to lose greatly if care is not taken to intensify the monitoring of the planted seeds to re-fill early and to remove weeds.

Also the use of cuttings even though does not require nurseries; it also requires funds and techniques for labour in cutting and conveying the cuttings to the fields. However, it is advantageous to use seedlings and cuttings because growth and development of the plants continue from the stages/ages of the seedlings and the branches cut which make the plant develop faster than the direct seeding method.

Objective
The objective was to establish a trial using the three propagation methods to determine which of them give(s) the best performance in terms of yield.

Expected Beneficiaries: Scientists, Agric. Extension staff and farmers

Materials and Methods
The long term trial which was established in 2010, is made up of three planting methods: i) direct seeding, ii) planting using cuttings and iii) using seedlings as the third option
Each the propagation method was considered a treatment which was each laid in a randomized block design and replicated three times.
Rows were spaced at 3 m and planting within rows was 2 m for each of the treatments (seeds, seedlings and cuttings) and cultural practices such as thinning out in the case of the direct seeding to making sure it was one plant/stand. Weeds were also removed regularly using a hand hoe.

Results
The results in 2014 showed that the direct seeding treatment recorded the highest number of branches/plant resulting in the highest pod yield. The transplanting method was next in value which recorded 26 branches/plant and a pod yield of over 2.8 tons/ha. However, there were no significant differences in the number of branches and fruit yield between the direct seeding and the transplanted methods (Table 64).

Table 72: *Jatropha yield and number of branches as affected by the planting method*

Treatment	Number of branches	Pod yield (kg/ha)
Direct Seeding	28	2952.10
Transplanting	26	2856.25
Cuttings	18	1876.56
LSD $_{(0.05)}$	6	192.20

However, planting using cuttings resulted in significantly lower number of branches and fruit yield than from the direct seeding and the transplanting methods. Number of branches/plant is one of the components of yield of Jatropha and therefore it was not surprising that the higher the number of branches, the higher the pod yield recorded.

Conclusion
The results for the first year of yield data analysis show that the performance of jatropha in terms of yield is higher for both the transplanted and the direct seeding methods than the use of cuttings.

It is recommended that the trial is repeated for several years to confirm or otherwise of this result since this was just one year data.

The productivity of maize and rice as affected by different fertilizer combinations in four agro-ecological zones of the Northern Region of Ghana

Principal Investigator: J. M. Kombiok (Agronomist)
Collaborating Scientists: M. S. Abdulai, Iddrisu Sumani, Haruna Abdulai
Estimated duration: 2 years (2014-2015)
Sponsors: *YARA, Ghana Ltd*
Locations: Nyankpala, Damongo, Yendi and Walewale

Background and Justification

The traditional ways of replenishing soil nutrients through bush fallow can no longer be practiced as arable lands are now limited due to increased population in Ghana. However, low soil fertility continues to be a constraint affecting crop production in the country. The farmers in the northern Ghana are therefore unable to obtain reasonable yields of most of the crops without fertilizer application especially the cereals (maize and sorghum), which are considered to be their staple food crops.

One of the ways to replenish the soil with its nutrients is by fertilizer application which YARA Ghana Company Ltd has always been the lead organization in formulating and distributing balanced nutrition fertilizers for both cereals and legumes to farmers to increase the productivity of the major crops in order to ensure food security. As these formulated products are new to the farmers and have never been used in this part of Ghana, it became necessary to test these fertilizers within our environmental set-up for the first time using maize by rice as test crops.

This on farm testing is always done in order to confirm or otherwise the validity of these formulations before they could widely be distributed to farmers across the region to help raise their crop yields. It is based on this reason that that YARA Company Ltd in collaboration with CSIR-SARI decided to set up adaptive trials at four sites (districts) representing the different ecological zones of the Northern region.

Objective

The objective of the trial was therefore to validate the performance of maize and rice in terms of grain yield as affected by the application of newly formulated fertilizers by YARA Ghana.

Materials and Methods

Experiment 1 (Maize)

The experiments involving maize and rice were conducted at four sites representing different Agro-ecologies of Northern region. These are Nyankpala, Walewale, Damongo and Yendi. At each site, the experiment was laid in Randomized Complete Block Design (RCBD) with 5 treatments (plots) replicated three times giving a total of 15 plots per site.
These are:

1. Actyva@250kg/ha+Actyva@125kg/ha.
2. Actyva@125kg/ha+Actyva@250kg/ha.
3. T15@250kg/ha + Amidas@125kg/ha.
4. T15@250kg/ha + SOA@125kg/ha.
5. No fertilizer(control)

Note: SOA is Sulphate of Ammonia and T15 is triple 15

The mode of application of the basal fertilizers was the same for all the types of fertilizers. Both the Triple 15 and the Actyva which were used as basal application were buried by the side of the maize seedlings about 2 weeks after planting. The top-dressing was also done by opening up holes near the plants as deep as 5 cm and putting the Actyva, Amidas and the sulphate of Ammonia and covering the holes with soil just before the plants tasseled.

Data collected included plant establishment (germination %), Plant height at harvest, 100 grain weight and grain yield (per hectare) but only grain yield will be reported here.

(a) Results and discussion of the maize trials

The results of maize grain yields at four sites as affected by the application of basal and top-dressing of different types of fertilizers at all the sites show that the application of Actyva at 250kg/ha and top-dressed by actyva at 125kg/ha gave the highest grain yield of maize compared to the rest of the treatments.

It was further observed that the highest maize grain yields which were obtained at Nyankpala, Yendi and Walewale from the first treatment (Actyva@250kg/ha+Actyva@125kg/ha) was similar to the yields obtained from the application of actyva at 125kg/ha as basal and top-dressing with actyva at 250kg/ha (T2) as well as the application of T15 at 250kg/ha and top-dressing it with Amidas at 125kg/ha (T3). However, at Damongo this was different. Eventhough the highest grain yield of maize was also obtained from T1 at Damongo, it was s ignificantly higher than in T2 and T3. However, the lowest maize grain yields were obtained from the treatment where no fertilizer was applied to maize (T4) at all the 4 sites.

(b) Results and discussion of the Rice trials

The treatments used for the rice trial were different from the treatments used for the maize trial above. Below are the treatments for the rice crop as follows:

1. Actyva@125kg/ha+ Actyva@125/ha+Amidas 125kg/ha
2. T15@125kg/ha+T15@125/ha+Urea125kg/ha
3. T15@125kg/ha+T15@125/ha+A midas125kg/ha
4. Actyva@125kg/ha+Actyva@125/ha+Urea@125kg/ha
5. No fertilizer (Control)

The methodology so far as land preparation, planting and all the cultural practices except the planting distances are concerned were all similar to that carried out in the maize trial.

The results show that Actyva at 125kg/ha, top dressed with Actyva at 125kg/ha and followed by Amidas gave the highest yields at all the four locations . Also, the lowest rice yields at all the locations were obtained when no fertilizers were applied to the rice crop.

At all the locations except at Damongo, the highest rice yields were obtained from Actyva@125kg/ha+Actyva@125/ha+Amidas@125 kg/ha, T15@125 kg/ha+ T15@125/ha + Urea @125 kg/ha and T15@125 kg/ha+T15@125/ha+Amidas @125 kg/ha which were statistically similar, while the application of Actyva@125kg/ha+Actyva@125/ha+Urea @125 kg/ha treatment gave significantly higher rice yields than no fertililizer applied (Control), but lower than the first three treatments above.

At Damongo however, all the treatments gave significantly different rice yields with the no fertilizer application resulting in the lowest rice yields. This could be due to the abundant and regular rainfall experienced at Damongo which helped each of the treatments to be able to express their potentials. The lowest yields obtained from the no application (control) suggests that the soil is low in nutrients and might require the application of external inputs such as fertilizers (organic and in-organic) before a farmer can get reasonable crop yields

Comparatively, Damongo had more rain followed by Nyankpala, Yendi and the least and more erratic rainfall was observed at Walewale and that might have resulted in the low rice yields observed at that location.

Conclusions

In preliminary conclusion, at Damongo, there were significant differen ces in maize yields with the application of the various treatments (T1, T2, T3 and T4). The application of T1 resulted in the highest grain yield while T4 gave the lowest yields. The application of the same treatments at Nyankpala, Yendi and Walewale did not result in any significant yield differences in maize yields. However, the lowest yields were also obtained at all the sites when no fertilizers (Treatment 4) were applied to the maize crop.

Similarly for rice, with the exception of Damongo, the first three treatments for the rice trial also gave high but statistically similar rice yields also indicating that the application of any of the three treatments will give similar yields.

In both trials, the no application of fertilizers (control) resulted in the lowest rice grain yields at all the location.

The two trials will be repeated next cropping season to either confirm the results or otherwis e since the result of only one cropping season is not adequate enough to draw conclusions.

FIELD ENTOMOLOG Y

The goal of the entomology program of the Northern Region Farming System Research Group is to identify insect pest problems of major food and fibre crops and develop appropriate technological options for their management to improve food production and qua lity for enhanced food security in a sustainable environment.

Four major activities were carried during 2014 as follows:

1. Effect of time of planting (early and late) and pre-harvest management practices on agronomic performance, incidence and severity of aflatoxin mycotoxin
2. Effect of calcium on pod filling and aflatoxin mitigation in peanut
3. Effect of drying techniques on aflatoxin contamination of peanut
4. On-station evaluation of peanut germplasm for yield potential and tolerance to aflatoxin

Effect of time of planting and pre-harvest management practices on agronomic performance, incidence and severity of aflatoxin mycotoxin

Principal Investigator: Mumuni Abudulai
Collaborating Scientists: J.B. Naab, Israel Dzomeku, Ahmed Seidu, and D. L. Jordan
Estimated duration: 4 years (2014 – 2017)
Sponsors: USAID Peanut Mycotoxin Innovation Laboratory
Location: On-farm (Kpalbe and Zankali)

Introduction

Groundnut is an important component of diets in Ghana with production most prominent in northern regions, where conditions are also favorable for aflatoxin development (Craufurd et al., 2006). Aflatoxin, caused by *Aspergillus flavus*/*parasiticus* fungus is a potent toxin and carcinogen. Aflatoxin levels are often high in peanut and other crops in northern Ghana (Craufurd et al., 2006). Peanut in the supply chain continues to contain aflatoxin at levels exceeding those defined as safe for human consumption. Inefficient and marginally effective production and pest management strategies are responsible for some of these high levels of contamination. Late sowing can also exposure the crop to droughts which exacerbate aflatoxin (Craufurd et al., 2006).

Objective

To determine the effects of time of planting and field management practices on incidence and severity of aflatoxin mycotoxin

Materials and Methods
This study was conducted on-farm at Zankali and Kpalbe in the Northern Region. In each village, eight (8) cooperating farmers were selected for a comparative study of current Farmer Practices (FP) versus researcher managed intervention practices/integrated pest management (IPM) throughout the production cycle of peanut. The most popular peanut *cv* Chinese grown in northern Ghana was used in the study. Treatment plots were planted in two blocks of early *(June)* and delayed *(July)*. Early planting was done from 6-18 June across locations while the delayed planting was done from 10-24 July 2014. Farmer Practice and intervention practice plots were planted side by side in 20-row by 20 m long plots. Researcher managed plots were protected against leaf spot diseases using chlorothalonil applied at 2 l ha^{-1} and against soil arthropods using in-furrow applications of chlorpyrifos at the rate 2.2 kg ai ha^{-1}.

The treatments were sampled for aflatoxin analysis using the protocol designed by the Food Science Laboratory at KNUST. Data also were taken on number of pods per plant, number of matured pods, pod yield, percentages of scarified and bored pods by soil arthropods, leaf spot severity. Leaf spot severity rating was based on the Florida scale of 1-10.

Summary of Results and Discussions

Kpalbe
The results showed that the number of pods per plant, number of matured pods and pod yield were significantly higher in the IPM than the FP. These yield parameters also were significantly higher in the June than in the July planting times. Interaction of planting date and management practices was significant for number of pods per plant and number of matured pods. The number of matured pods per plant and number of pods per plant were significantly higher in the IPM plots and in the June planting times.

Zankali
As at Kpalbe, the results showed significantly higher number of pods per plant, number of matured pods per plant, and pod yield in the IPM than FP. Severities of early and late leaf spot diseases were significantly lower in the IPM than FP plots. Also percentages of soil arthropod scarified and bored pod damages were significantly lower in the IPM than FP plots. For this location, the effect of planting time was significant only for leaf spot disease severities and pod yield. Severities of early and late leaf spots were significantly lower in the July than in the June plantings. Leaf spot diseases are more pronounced during wet weather. The June planting had a longer exposure to more humid weather than the July planting, which explains the high severities recorded in the June than in July. Pod yield was significantly higher in the June planting time compared to the July planting time..

The results for aflatoxin contamination levels in the various treatments were not available at the time of writing this report.

Effect of Calcium on Pod Filling and Aflatoxin Mitigation in Peanut

Principal Investigator: Mumuni Abudulai
Collaborating Scientists: J.B. Naab, Israel Dzomeku, Ahmed Seidu, and D. L. Jordan
Estimated duration: 4 years (2014 – 2017)
Sponsors: USAID Peanut Mycotoxin Innovation Laboratory
Location: On-station at Nyankpala

Introduction

Poor soil fertility and susceptible cultivars create high risk conditions for contamination by aflatoxinin in groundnut. Although groundnut is able to fix some amount of atmospheric nitrogen, it requires well fertilized soils for optimum performance. It performs best in soils that are rich in calcium. Calcium deficiency leads to high percentage of aborted seeds (empty pods or "pops") and improperly filled pods. Also, calcium is the only nutrient that is known to limit *Aspergillus* growth and Aflatoxin contamination in groundnut.

Objective.

To evaluate the effect of calcium on pod filling and aflatoxin mitigation in peanut

Materials and Methods

The test was conducted on-station at Nyankpala. Treatments comprised of two peanut varieties (Chinese and Nkatiesari) in whole plots and calcium treatment (treated and untreated) in subplots. The treatments were laid in split-plot in a randomized complete block design and replicated three times. Calcium was applied as YARA legume fertilizer (O-18-13-29 NPKCaO) at flowering around the root zone at a depth of 3-5 cm at the recommended rate of 370.5 kg ha^{-1}.

Samples were taken after harvest and sent to the Food Science Laboratory at KNUST for aflatoxin analysis.

Summary of Results and Discussion

The effects of variety and calcium were significant for number of pods per plant, and pod yield as well as on early and late leaf spot disease severities. The effects of calcium only were significant for percentages of pods with scarified and bored pod damage. Significant interaction effects of variety and calcium treatment was measured for pod yield and for both early and late leaf spot severities.

Pod load was significantly improved while scarified and bored pod damages were significantly reduced in calcium treated plots. These resulted in significantly improved pod yield. Pod yield in calcium treatment improved three-fold over untreated control. The numbers of pods per plant and pod yield were significantly higher in Nkatiesari than Chinese. Severities of early and late leaf spot diseases were significantly lower in calcium treatment and in Nkatiesarit compared with Chinese. Also, pod yield was significantly increased in calcium treatment and higher in Nkatiesari. The results for aflatoxin contamination levels in the various treatments were not available at the time of writing this report.

Effect of drying techniques on aflatoxin contamination of peanut

Principal Investigator: Mumuni Abudulai
Collaborating Scientists: J.B. Naab, Israel Dzomeku, Ahmed Seidu, and D. L. Jordan
Estimated duration: 4 years (2014 – 2017)
Sponsors: USAID Peanut Mycotoxin Innovation Laboratory
Location: On-station

Introduction

Poor post harvest handling during drying expose the pods and kernels to aflatoxin contamination in groundnut. Poorly dried pods and kernels with moisture content above 8% are more prone to contamination by aflatoxin. Also pods that are dried on the bare ground are more likely to come into contact with the aflatoxin causing fungi that are in the soil and thus get contaminated by aflatoxin.

Objective

To evaluate drying techniques for their efficiency in minimizing aflatoxin contamination in groundnut

Materials and Methods

The tests were conducted on-station at Nyankpala. Three different drying methods viz traditional drying on the ground, drying on tarps, drying on A-frame (See Figure 1) were compared for their effect on aflatoxin contamination in the peanut varieties chinese and nkatiesari. Samples were taken after drying for two weeks to a 5-6% moisture level and deposited at KNUST for aflatoxin analysis.



Drying on A-frame

Drying on tarp

Drying on bare ground

Figure 1. Drying techniques evaluated to minimize aflatoxin contamination in groundnut.at Nyankpala**.**

Summary of Results and Discussions

No results of aflatoxin analysis for contamination levels at the various drying techniques were available at the time of writing this report.

On-station evaluation of peanut germplasm for yield potential and tolerance to aflatoxin

Principal Investigator: Mumuni Abudulai
Collaborating Scientists: J.B. Naab, Israel Dzomeku, Ahmed Seidu, and D. L. Jordan
Estimated duration: 4 years (2014 – 2017)
Sponsors: USAID Peanut Mycotoxin Innovation Laboratory
Location: On-station

Introduction
Groundnut yields in Ghana are low averaging less than 1000 kg/ha compared to an average of 2500 kg/ha obtained in developed countries. Early and late leaf spot diseases caused respectively by *Cercospora arachidicola* S. Hori and *Cercosporidium personatum* Berk. & M.A. Curtis, are major diseases of groundnut that can reduce yield by as much as 50% (Shokes and Culbreath 1997).

Also most of the groundnut cultivars grown in Ghana are susceptible to the *Aspergillus* fungi and hence aflatoxin contamination. High levels of contamination are often reported in groundnut grown in northern Ghana

Objective
To screen groundnut cultivars and genotypes for their yield potential and tolerance to aflatoxin. This will enable us to select for and advance cultivars that are resistant and better adapted to the farming conditions of northern Ghana.

Materials and Methods
Field tests were conducted at Nyankpala to evaluate 20 peanut genotypes and cultivars (Table 65) for yield potential and tolerance to aflatoxin. The genotypes were also evaluated for leaf spot resistance on the Florida scale of 1-10 and yield. The genotypes included those from ICRISAT and released varieties from CSIR-SARI and CSIR-CRI. There were three replications of each genotype.

Samples from the harvest are also yet to be sent to KNUST for aflatoxin analysis. The most promising lines from this test will be aimed for release, multiplication, and distribution to farmers and will be tested in the villages outlined in Experiment 1.

***Table 73**: List of peanut genotypes or cultivars and origin evaluated for yield potential and tolerance to aflatoxines in Nyaankpala, 2014.*

Entry	Identity of genotype or cultivar
1	NC 7
2	F-MIX
3	NKATIESARI
4	ICGV-IS 96814
5	ICGV-IS 92096
6	ICGV 97188
7	ICGV-86024
8	ICGV 86124
9	F-MIX × SINK-24
10	ICGV (FDRS)-20×F-MIX-39
11	CHINESE
12	GM 155
13	GM123
14	GM656
15	ICGV 86015
16	Otuhia
17	Yenyawoso
18	PC 79-79
19	TS 32-1
20	DOUMBALA

Summary of Results and Discussions

The results showed significant difference among the cultivars in percentage scarified pods and pod yield. No significant differences were measured in leaf spot severities, percentage bored pod damage and number of pods per plant. Percentages of scarified pods were significantly lower in ICGV-97188, Is-32-1, Fmix x Sink 24, ICGV 86124 and Yenyawoso compared to the cultivars. Yields were significantly higher in ICGV 86015, GM 155, ICGV IS 96814, Nkatiesari, PC-7979, NC 7 and Fmix x Sink 24 compared to the other cultivars.

The results for aflatoxin contamination levels in the cultivars were not available at the time of this report

SOCIO-ECONOMICS

Improving Food Safety, Food Quality and Income of Poor Actresses and Actors of the Groundnut Value Chain in West Africa by reducing Aflatoxin (GestAflAr) – Reference Survey of Groundnut Actors

Principal Investigator: Edward Martey
Collaborating Scientists: Nicholas Denwar, Prince M. Etwire, Alexander N.Wiredu, SSJ Buah, Mumuni Abudulai, Issah Sugri
Estimated Duration: Two (2) months
Sponsors: CORAF/WECARD
Location: Northern, Upper East and Upper West Regions

Background Information and Justification
In the 2008-2013 strategic plan of CORAF/WECARD, non-staple crops have been considered as a sector that can play an important role in achieving the objective of this operational plan which is a sustainable improvement in productivity, competitiveness, and agricultural markets in WCA. Based on this plan, the following two projects were identified and funded: "Improving food safety, food quality and income of poor actresses and actors of the groundnut value chain in West Africa by reducing aflatoxin (GestAflAr)"; and "Facilitating sustainable intensification of smallholder cocoa farming systems in West and Central Africa". Burkina Faso, Ghana, Mali and Senegal are major groundnut producers in West Africa. Groundnut is consumed in various forms throughout the regions and is one of the main sources of income for millions of poor actresses/actors. The presence of aflatoxin in groundnuts produced in Burkina Faso, Ghana, and Mali has serious implications on health and food security. The study was carried out to generate relevant information on the awareness and level of aflatoxins across the groundnut value chain in northern Ghana. Finally, the project also seeks to establish an innovation platform, build capacity and foster collaboration among the stakeholders represented on the platform for joint action.

Objectives
The specific objectives of the project are to:

- Establish a baseline information on the level of aflatoxin awareness among groundnut value chain actors in the study area
- Generate inventory of information on groundnut practices among the value chain actors in the study area

Expected Beneficiaries

- Groundnut farmers, traders and processors
- Ministry of Food and Agriculture
- Non-governmental Organizations
- Private Sectors engaged in groundnut business

Materials and Methods

The study was undertaken in northern Ghana. The study relied mainly on primary data collected through household survey. The selection of the respondents followed a multi-stage sampling technique. Both purposive and random sampling techniques were employed to sample 500 respondents consisting of 320 producers, 90 traders and 90 processors in northern Ghana. Key informant interviews were also carried out to establish key information on the groundnut value chain. Descriptive statistics like frequencies and mean were used to describe the various actors as well as their knowledge on aflatoxin.

Results/Major Findings

The results show the sampled actors of the groundnut value chain are relatively young which implies that the actors can stay in business for the next three (3) decades all things being equal. A typical household in northern Ghana consists of 11 members on the average of which 5 members each are economically active and educated. The average production volume of groundnut per household in northern Ghana is 570.29 kg out of which 40.66 kg is affected by aflatoxin.

With respect to the traders, an average of 63kg of groundnut is processed per week and the total annual household income is GH¢3,994 out of which GH¢667 is generated from the sale of groundnut. The average quantities of shelled and unshelled groundnut purchased by the sampled traders are 3,931.72 kg and 1,785.43 kg respectively whereas 781.66 kg is exported. The average market price per kilogram of groundnut is GH¢2.45. On the average, 224.34 kg of the purchased groundnut is infested with aflatoxin.

A large proportion of farmers produce groundnut using traditional methods of production. Most of the producers buy seed from the open market whereas others purchase from research institution and friends. Almost all the producers do not apply fertilizer on groundnut plots and do not treat the seeds before sowing. The use of bare ground and cemented platform in the house are the most common structures used for drying groundnut before threshing.

Prevention of mycotoxins is a challenge as recorded by 70 percent of the sampled processors. Majority (90%) of the processors in Upper East do not have knowledge of mycotoxin prevention. It is also observed from the study that almost 70 percent and 52 percent of the traders have observed fungal growth on purchased and stored groundnut respectively. The use of mud and wood in the construction of storage structure is common among the female producers whereas the males resort to the use of cement and mud. The storage structure usually has a multi-purpose use as indicated by 89% of the respondents. Sorting of the groundnut was the common practice across a large section of the farm households in the prevention of aflatoxin.

Based on findings and results of the reference survey, the project team conducted farmer trainings on ways of reducing aflatoxins in groundnuts. The training workshop was organized in order to explain aflatoxin to participants; expose participants to the harmful effects of aflatoxin to humans, animals and plants; educate participants on the economic importance of aflatoxin contamination; train participants on methods to minimizing aflatoxin contamination; and finally enlighten participants on the importance of aflatoxin-free crops. Following the training is the establishment of innovation platform in the Upper West Region that brought together all the various stakeholders to deliberate on ways of making groundnut sub-sector a competitive business.

Conclusions/Recommendations

The study which set out to reduce aflatoxin along the groundnut value chain commenced with a reference survey of key actors. Results of the study have shown different levels of farming and storage practices among the key actors. Most of the actors are aware of the aflatoxin but unable to effectively control it. Based on the survey results, training modules were designed to address the specific needs of the actors. About 400 actors and 49 extension officers across the three regions in the northern Ghana have been trained on farming and storage practices to enhance their skills in the reduction of aflatoxin. An innovation platform has also been established to bring together stakeholders for dialogue and joint action.

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Impact of Agricultural Value Chain Mentorship Project on Technical Efficiency and Income of Smallholder Farmers in Northern Region of Ghana

Principal Investigator: Edward Martey
Collaborating Scientists: Wilson Dogbe, Prince M. Etwire, Alexander N. Wiredu
Estimated Duration: Two (2) months
Sponsors: AGRA/DANIDA
Location: Northern Region

Background Information and Justification

The CSIR-Savanna Agricultural Research Institute (CSIR-SARI), International Fertilizer Development Center (IFDC), and the Ghana Agricultural Associations Business Information Centre (GAABIC) are grantees implementing the Agricultural Value Chain Mentorship Project (AVCMP) funded by the Danish International Development Agency (DANIDA) through the Alliance for a Green Revolution in Africa (AGRA).

The AVCMP has 3 main sub components: A) Productivity B) Input Access and C) Market Access. CSIR-SARI is responsible for the implementation of the productivity component of the Project, which has the objective of improving entrepreneurial and technical skills of Farmer

Base Organisation (FBOs) and their member farmers to upscale ISFM technologies for rice, soybean and maize production. The productivity component just like the other two components is designed to achieve 3 main outcomes 1. Increase smallholder farmers' access to farm inputs (seeds and fertilizers) and ISFM technology; 2. Improve capacity of national institutions to upscale ISFM; and 3. Increase awareness on and use of ISFM technologies among smallholder farmers. Capacities of key stakeholders have been built through the implementation of project activities such as trainings, demonstrations, and partnership with the media to improve the facilitation and scaling up of ISFM technology adoption in the target zones. In order to justify the investment in the AVCMP, an impact study was necessary to establish empirical evidence on the extent to which the project has influenced farmers' technical efficiency and farm income. The present study sought to assess the impact of the AVCMP on the efficiency and farm income of smallholder farmers in Northern Region and also make policy recommendations.

Objectives

The specific objectives of the project are to:

- Determine the impact of the project on the technical efficiency and income of farmers in the study area.

Expected Beneficiaries

- Farmer Based Organization
- Ministry of Food and Agriculture
- Research Institutions
- Non-governmental Organization

Materials and Methods

The study was undertaken in the Northern Region of Ghana. The study relied mainly on primary data collected through household survey. A multi-stage sampling technique was employed in the selection of the respondents. In all, a total of 200 respondents were interviewed. The study combined both qualitative and quantitative analytic tools. Regression techniques such as probit, propensity score matching and stochastic production frontier were used for analysis. Descriptive statistics subjected to the Students t-test was also utilized for analysis.

Results/Major Findings

About 26 percent of the sampled farmers participated in the AVCMP. Based on the results, it is observed that significant differences exist in the means of sex, age, use of production credit, access to extension services, and technical efficiency of participants and non-participant farmers. Participant farmers are relatively younger; receive more production credit, and have higher access to extension services. The area and output from soybean is however almost the same for both participant and non-participant farmers.

It is observed that most of the non-participant farmers recorded a technical efficiency score of less than 0.5. Beyond less than 0.5, the participant farmers recorded relatively higher efficiency score across the categories of efficiency scores. Majority (29%) of the participant farmers recorded efficiency score between 0.51 and 0.60. Non-participant farm households on the average recorded a relatively higher income (USD70.83) compared to the participant farm households (USD56.80).

Participation in AVCMP was determined by years of farming experience (5%), number of years of education (10%), use of production credit (5%), access to extension services (5%), number of training received (5%), total labour allocated for soybean production (5%), and access to electricity (10%). Results from the propensity score matching show that farmers' participation in farmer mentorship project impacts positively on farmers' technical efficiency and farm income by 28 percent and USD18 respectively although the latter is not significant.

Conclusions/Recommendations

This study provided empirical evidence of the impact of participation in AVCMP on technical efficiency and farm income of soybean farmers in Northern Region of Ghana. It showed that participation in the project increases technical efficiency significantly. The impact of participation on farm income may be realized in the long run with continuous use of the knowledge acquired from the mentorship project. The main recommendation is that, there should be conscious efforts to enhance participation in such projects/programs by designing the programmes in such a way that it addresses specific needs of the farmers. Agricultural project implementation must be harmonized to create synergy and avoid duplication of efforts, as well as donor and farmer fatigue. There is the need for continuous exposure of farmers to improved technologies, builds capacity, and facilitates access to credit and market to increase productivity.

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Empirical Analysis on the Capacity of ACMP Stakeholders in Northern Region

Principal Investigator: Edward Martey
Collaborating Scientists: Wilson Dogbe, Prince M. Etwire, Alexander N. Wiredu
Estimated Duration: Two (2) months
Sponsors: AGRA/DANIDA
Location: Northern Region

Background Information and Justification

The CSIR-Savanna Agricultural Research Institute (CSIR-SARI), International Fertilizer Development Center (IFDC), and the Ghana Agricultural Associations Business Information Centre (GAABIC) are grantees implementing the Agricultural Value Chain Mentorship Project (AVCMP) funded by the Danish International Development Agency (DANIDA) through the Alliance for a Green Revolution in Africa (AGRA).

The AVCMP has 3 main sub components: A) Productivity B) Input Access and C) Market Access. CSIR-SARI is responsible for the implementation of the productivity component of the Project, which has the objective of improving entrepreneurial and technical skills of Farmer Base Organisation (FBOs) and their member farmers to upscale ISFM technologies for rice, soybean and maize production. The productivity component just like the other two components is designed to achieve 3 main outcomes 1. Increase smallholder farmers' access to farm inputs (seeds and fertilizers) and ISFM technology; 2. Improve capacity of national institutions to upscale ISFM; and 3. Increase awareness on and use of ISFM technologies among smallholder farmers. Capacities of key stakeholders have been built through the implementation of project activities such as trainings, demonstrations, and partnership with the media to improve the facilitation and scaling up of ISFM technology adoption in the target zones. The study sought to assess the capacity of stakeholders with respect to participation in the AVCMP.

Objectives

Specifically, the study sought to

- Establish level of capacity of stakeholders prior to AVCMP intervention,
- Identify various types of interventions benefitted from AVCMP and with what outcomes
- Establish level of improvement in capacity of stakeholders after AVCMP intervention and make recommendations for present and future collaborations.

Expected Beneficiaries

- Farmer Based Organizations
- Media Personnel
- Ministry of Food and Agriculture
- Non-governmental Organizations

Materials and Methods

The study was undertaken in northern Region of Ghana. The approach employed in the realization of the objectives of the study are desk study, sampling of zones, development of survey instrument, recruitment and training of enumerators, data collection, analysis and report production.

Results/Major Findings

The results show that farmers have benefited from myriads of agricultural development projects which have impacted positively on some of the farmers' technical abilities. A large section of the sampled farmers have knowledge on the AVCMP. However, the level of awareness varies significantly across the sampled zones. Farmers have expressed high level of satisfaction in the project implementation despite some few bottlenecks which needs to be addressed. The demonstrations on the various GAPs have been rated to beneficial by majority of the farmers. In terms of satisfaction, majority (59%) mentioned that they were satisfied whereas 39 percent of the farmers were very satisfied. However, 2 percent and 1 percent of the farmers were indifferent and not satisfied with the demonstrations respectively. About 63 percent of the farmers mentioned high cost of adoption as the major constraint in the use of farm technologies. Unavailability of inputs such as fertilizer and improved seed also served as a constraint to 22 percent of the farmers. Difficulty to adopt without supervision and labour were other constraints to adoption of good agricultural practices. Business development among farmer based organization is not well understood though some of the farmers are using the business modules.

About 40 percent of the farmers assessed their collaboration with research institute to be very good whereas 20 percent rated their collaboration to be excellent. Variation in terms of assessment was recorded across the zones with Tolon recording the lowest collaboration effort with research institutions. Farmers' collaboration with financial institutions has been cordial despite the challenges financial institutions have with the farmers. According to the farmers, financial institutions have provided them with loans, whereas others who apply for credit where turned down due to several reasons. Most of the farmers have also enjoyed partnering the NGOs in the area of agricultural development.

The media has played a major role in creating awareness of farm technologies. About 18 percent and 23 percent of farmers rated their collaboration with the media to be excellent and very good respectively. The strong collaboration was attributed to education on good farming practices, good understanding of the content of message and appropriate feedback as well as good display of farm technologies. The AEAs and some of the media personnel rated their collaboration with the project to be between 51 percent and 70 percent whilst other media personnel rated their collaboration to be greater than 71 percent.

Despite the efforts being put in ISFM dissemination, motivation of staff, organization of farmers, and inadequate means of transportation continues to be a major challenge among all the respondents. The challenge has impacted on some of the collaborators such that they are not able to continue disseminating all the ISFM technologies to farmers. However some of the respondents are doing quite well in their dissemination efforts.

Conclusions/Recommendations

The capacity survey revealed that membership of farmer organization enhances farmers' access to technology and market information. Education on the other hand impacts positively on technology adoption. Generally, the study has revealed that farmers have knowledge of the AVCMP and have also benefited from trainings and farm demonstrations on good agricultural practices. Technical competences with respect to farming as a business and some GAPs of the farmers have been enhanced as well as other stakeholders. Lack of staff motivation, regular meetings and funding are the major constraints militating against the ISFM dissemination efforts of the media and AEAs. Farmers in Tolon and Chereponi must be given much attention with regard to demonstration on good farming practices. High cost of adoption of good farm practices has been found to be a major constraint to adoption rate. Awareness needs to be further created especially among farmers in all the zones. Per the study, it is very important that the various stakeholders work together to avoid duplicity of efforts. In addition, it is strongly recommended that periodic training organized for the media personnel and the AEAs in order to upscale the dissemination of ISFM in the target areas.

FBO Development under AVCMP

Principal Investigator: P.M Etwire
Collaborating Scientists: Dogbe W., R. Owusu, A. B Tampuli, E. Martey, N. A Jinbahni, R. Akimo, W. Kutah, B. Inusah, A. Siise, E.O. Krofa and E. Halolo
Estimated Duration: Completed (May 2011-March 2015)
Sponsors: DANIDA through AGRA
Location: Northern Region of Ghana

Background Information and Justification
The Alliance for a Green Revolution in Africa (AGRA) has awarded the AVCMP support grant to the International Fertilizer Development Center (IFDC) and its collaborating partners, the Ghana Agricultural Associations Business and Information Centre (GAABIC) and Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR).

The Productivity component is contributing to address the following underlying factors to low agricultural productivity, and income, food insecurity and poverty in the Northern Region of Ghana:

i. Low use of improved seeds and fertilizers
ii. Poor soil health
iii. Low agricultural land use and poor crop management practices by farmers
iv. Inadequate extension services and weak-research extension linkages.
v. Poor farmer access to cultivation equipment services
vi. Limited access to credit due to high interest rates and stringent collateral requirements and low investment in agriculture

Objectives
The overall goal of the AVCMP is to contribute towards the Government of Ghana's objective of achieving food security and becoming an agro-industrial economy by strengthening the capacity of agro-dealers, SMEs, Farmer Based Organizations and farmers in the agricultural sector of Ghana throughout the value chain turning it to a highly productive, efficient, competitive and sustainable system. The objective of the productivity component being implemented by CSIR-SARI is to improve entrepreneurial and technical skills of Farmer-Based Organizations and their member farmers to scale up application of Integrated Soil Fertility Management (ISFM) technologies for rice, maize and soybean cropping systems while also strengthening their linkages with actors across the agricultural value chain specifically agro-dealers, SMEs, commercial banks, seed and fertilizer producers and suppliers, and extension agents.

Expected Beneficiaries
Farmer based organisations and their member farmers
Agricultural Extension Agents
Agro-based SMEs

Materials and Methods
AVCMP has 3 main intervention areas: A) Farmer mentorship B) Mentorship of agro input dealers and C) Mentorship of SMEs. The main activities of IFDC and GAABIC focus on Intervention areas B and C with linkages to intervention area B. CSIR-SARI is responsible for the mentorship of farmers (FBOs) of the Project.

Results/Major Findings
During the project lifecycle, a total of 16452 registered farmers participated directly in the project. Numbers of these beneficiaries disaggregated by district, crop and sex is presented in the table below.

Table 74: *Agricultural Value Chain Mentorship Project Beneficiaries disaggregated by districts, Crop and Gender*

District	Crop			Sex		Total
	Maize	Rice	Soy	Female	Male	
Bunkprugu-Yunyoo	351	29	160	201	339	540
Cenral Gonja		158	94	108	144	252
Chereponi			1877	894	983	1877
East Gonja		65	552	261	356	617
East Mamprusi	534	96	205	303	532	835
Gushegu	182	10	44	48	188	236
Karaga	433	147	294	371	503	874
Kpandai	15	73	754	365	477	842
Nanumba North	410	16	770	547	649	1196
Nanumba South		35	114	68	81	149
Saboba			2649	889	1760	2649
Savelugu Nanton	668	349	168	542	643	1185
Tamale Metro	441	403	88	438	494	932
Tolon Kumbungu	465	584	23	535	537	1072
West Mamprusi	560	353	490	660	743	1403
Yendi		78	1715	805	988	1793
Total	**4059**	**2396**	**9997**	**7035**	**9417**	**16452**

All registered farmers either benefited from, linked to or participated directly in at least one of the following project activities; Farmer training, demonstrations, radio discussion programs, yield cut studies, inputs, tractor services, market linkages etc.

A platform, dubbed District Event was organized at the beginning of the production season throughout the project lifespan. This event brought together the various actors working along the rice, maize and soya bean value chains in the Northern Region who also been working directly with the AVCMP. Each event comprised of FBO representatives, agro-dealers, aggregators, tractor services providers and MoFA staff. Apart from the FBOs, each representative of the other groups made short presentation about their activities, the communities they are, the farmers they are working with and their roles in the value chains. The MoFA staff took the opportunity to explain the modalities for acquiring input under the government subsidy program. There was an open forum session where plenary discussions on issues affecting the value chains were discussed. As a result of these events, 443 farmers were able to procure 1,341 bags of fertilizer in bulk. The team was able to closely and intensively mentor a total of one thousand seven hundred and eighty (1780) farmers in 85 FBOs in 8 project districts as shown below.

Table 75: *Number of FBO's and farmers trained*

District	**Number of FBOs**	**Number of farmers**		
		Male	**Female**	**Total**
Yendi	8	252	107	359
Tamale	6	87	96	183
Savelugu	15	252	96	348
West Mamprusi	10	134	65	199
Tolon-Kumbungu	29	175	143	315
East Gonja	7	70	49	119
East Mamprusi	6	70	49	119
Karaga	4	94	44	138
Total	**85**	**1131**	**649**	**1780**

Major topics discussed during the mentoring sessions were: Farmer groups and their importance, stages of group development, characteristics of strong groups, causes of poor group dynamics, strategies for improving group dynamics, leadership, factors and principles of leadership, acquiring leaders, leadership styles, functions of specific group leaders, conflict in groups, causes and effects of conflict and dealing with conflicts.

Socio Economic Evaluations under DTMA

Principal Investigator: P.M Etwire
Collaborating Scientists: T. Abdoulaye, E. Martey, K. Obeng-Antwi, R.A.L Kanton, M. S. Abdulai, S. S. Buah, H. Haruna, A.N. Wiredu
Estimated Duration: Completed
Sponsors: IITA
Location: Upper West and Brong-Ahafo Regions of Ghana

Background Information and Justification
Maize (*Zea mays* L.) is one of the most important food cereals in the developing world. It is not only the largest staple crop in Ghana but also the most widely cultivated crop accounting for 50-60% of total cereal production. Additionally, maize is the largest commodity crop in the country second only to cocoa (Millennium Development Authority, MiDA, 2010). Therefore, the importance of maize to the economy of Ghana cannot be overemphasized. The crop is a major source of food, feed and cash for many households in Ghana.

Ghana is, however, not self-sufficient in the production of maize because its production is faced with a number of constraints including low soil fertility, erratic rainfall pattern, drought, inadequate lack of access to certified seed, poor agronomic practices, among others. It has therefore become important to develop and disseminate maize varieties that are high yielding and tolerant to the major stresses in the country in order to boost its production. The Council for Scientific and Industrial Research of Ghana (CSIR) has been collaborating with the International Institute of Tropical Agriculture (IITA) in developing and evaluating improved maize varieties suitable for various agro-ecological systems in Ghana. Two CSIR institutes, namely Savanna Agricultural Research Institute (CSIR-SARI) and Crops Research Institute (CSIR-CRI) are responsible for developing improved maize varieties for the northern Guinea savannah, and forest and transitional zones, respectively.

Since 2008, promising high yielding, drought and striga tolerant maize varieties are being evaluated in participatory on-farm trials and demonstrations. These trials serve as important tool to showcasing the potential of new maize varieties to farmers. Additionally, the participatory on-farm testing of the varieties is also a means of facilitating rapid dissemination and adoption of these improved maize varieties by farmers.

Objectives
Farmer characteristics, institutional factors and more importantly DT maize characteristics are key factors influencing the dissemination of the DT varieties. This study focused on the preferred and non-preferred traits of DT maize varieties. Specifically, the objectives of the study were;

1. Identify farmer-preferred and non-preferred hybrids and open-pollinated varieties.
2. Identify reason for farmer preference on non-preference of the DT varieties.

Expected Beneficiaries
Maize farmers
Maize breeders and agronomist
All other actors along the maize value chain

Materials and Methods
The study collected data on trait (and variety) preferences of farmers on DT maize varieties being promoted. The evaluation was done when the crop was still on the field. Farmers (consisting of 20 males and 20 females) in each community viewed all the plots before they were made to select the variety/plot they like most and the variety/plot they dislike most from the entire plots. The research team then conducted a careful discussion with female and male participants on why they liked or disliked a plot/variety based on the counts of like and dislike. Chronologically, the research team;

- Explained the objective of the on-farm trial and the purpose of the variety/trait preference ranking
- Allowed farmers to view all the plots before making their choices
- Allocated one "I like card" to each farmer.
- Asked the farmers to drop the card on the plot they like most
- Asked for reason for preference
- Allocated one "I don't like card" to each farmer
- Allowed the farmers to place their cards on the plot they do not like most
- Asked for reason for none preference

A total of 120 farmers (60 females) from 3 communities in 3 districts participated in the study.

Results/Major Findings
Farmers' Preference Assessment
Kintampo South District
The most preferred farmer varieties in Kintampo South District are presented in the figure below. M1126 was the most preferred varieties by both men and women farmers. There was however slight gender differences on farmers ranking of their second and third most preferred varieties. Whereas male farmers preferred M0926-2 and M1026-7 as their second and third most preferred maize varieties, the opposite was true for female farmers. Farmers' preferences were influenced by cob size, number of ears per stock, beautifulness of the grain and ability of the plant to tolerate lodging.

The least preferred varieties selected by maize farmers in Kintampo South District is presented in the figure below. Both male and female farmers showed non-preference for the same preference in similar proportions. The least preferred varieties selected were TZEI-124 X TZEI-25, TZE-Y DT STR C14 and TZE-W-POP. Nearness of cob to the ground, small cob size and short height of plant thereby making the crop susceptible to rodent attack, were reported by the farmers to be the main reason for non-preference.

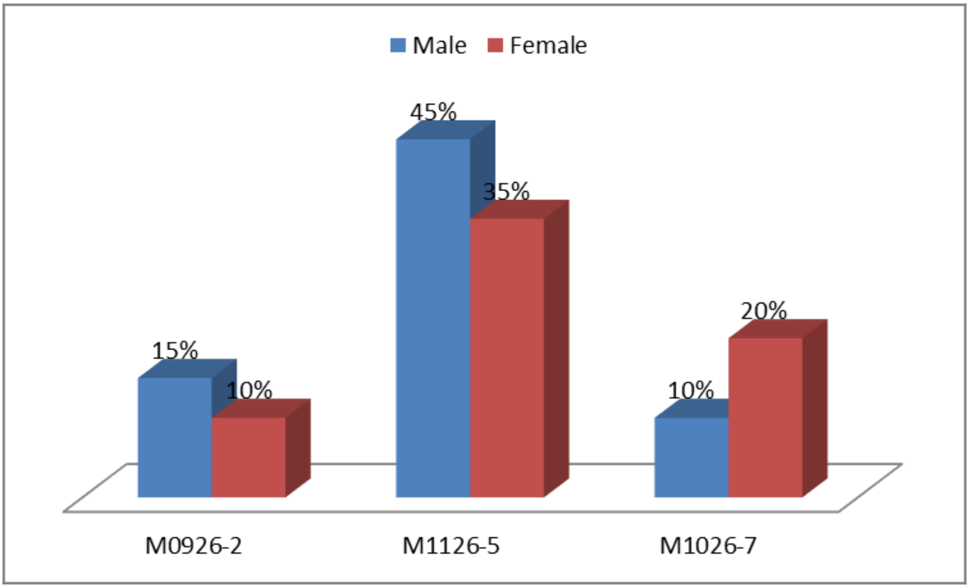

Figure 27: Most preferred farmer varieties in Kintampo

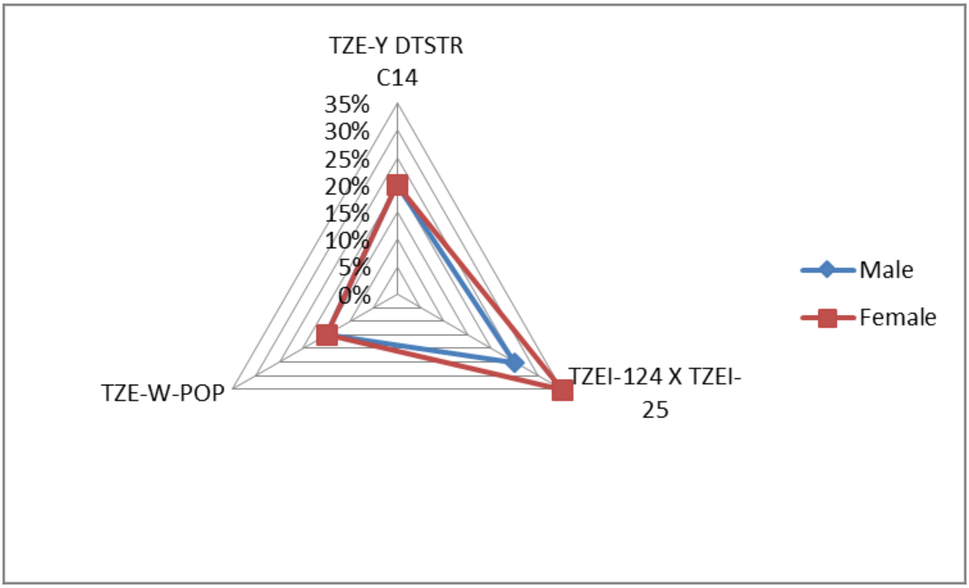

Figure 28: Least preferred farmer varieties in Kintampo

3.2.2 Techiman Municipality

In Techiman Municipality, male and female farmers only agreed on the third most preferred variety (M0826-1). The most preferred variety selected by males (11C170) was ranked second by females and vice versa as shown in the figure below. Tall plants with big cobs, plants with two ears per stock and plants with broad leaves that produce good cobs were what the farmers looked for in showing preference.

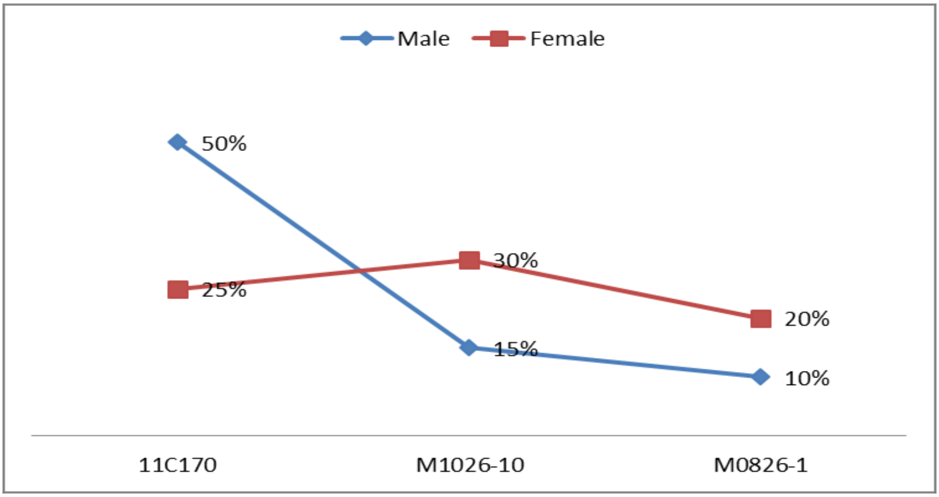

Figure 29: Most preferred farmer varieties in Techiman

The least preferred variety selected by farmers in the Techiman Municipality was TZEEI-21 as presented in the figure below. Males selected TZEEI-4 and 11C175 as their second and third least preferred varieties respectively, with females selecting TZEEI-15 and 11C175 as their second and third least preferred varieties respectively. Short plant height making the crop easily susceptible to rodent attack, small cob size and unattractive cobs with small grains were the reasons for non-preference.

3.2.3 Sissala West District

Farmers preference for DT maize varieties in Sissala West is presented in the figure below. Male farmers selected TZEEI 29 X TZEEI 49 as their most preferred variety because it is drought tolerant, has good grain filling, uniform cob size as well as big stalks. This variety was selected as the third most preferred variety by females. TZEE Y POP STR CS X TZEEI 82 was selected by females as their most preferred variety due to its ability suffer less from lodging, early maturing and attractive grain colour. This variety was selected by males as their second most preferred variety. Whereas DT STR W SYN 2 was selected by males as their third most preferred variety (due to its cob size, striga and drought tolerance), abontem was selected by females (since it is early maturing, has attractive grain colour and has high potential market demand due to its earliness and colour).

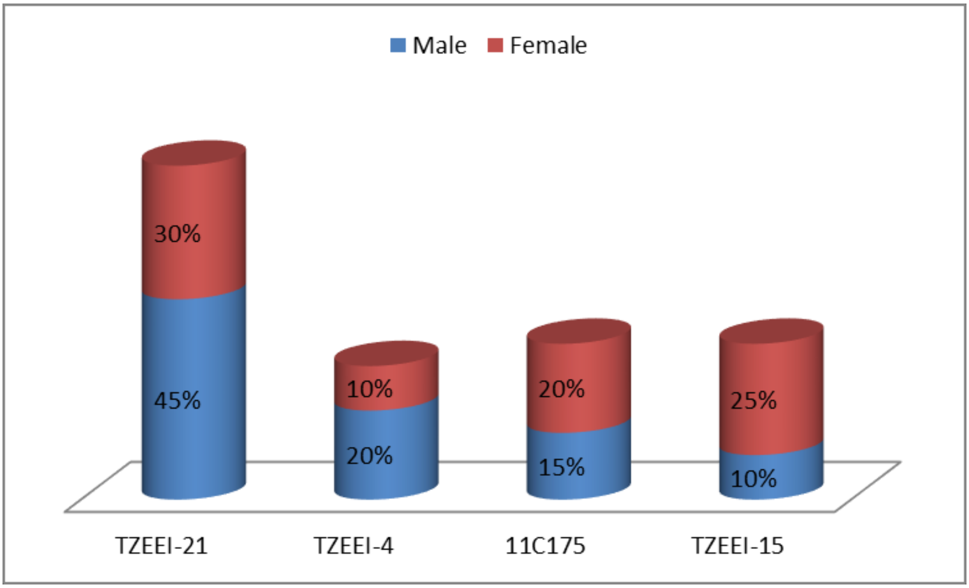

Figure 30: Least preferred farmer varieties in Techiman

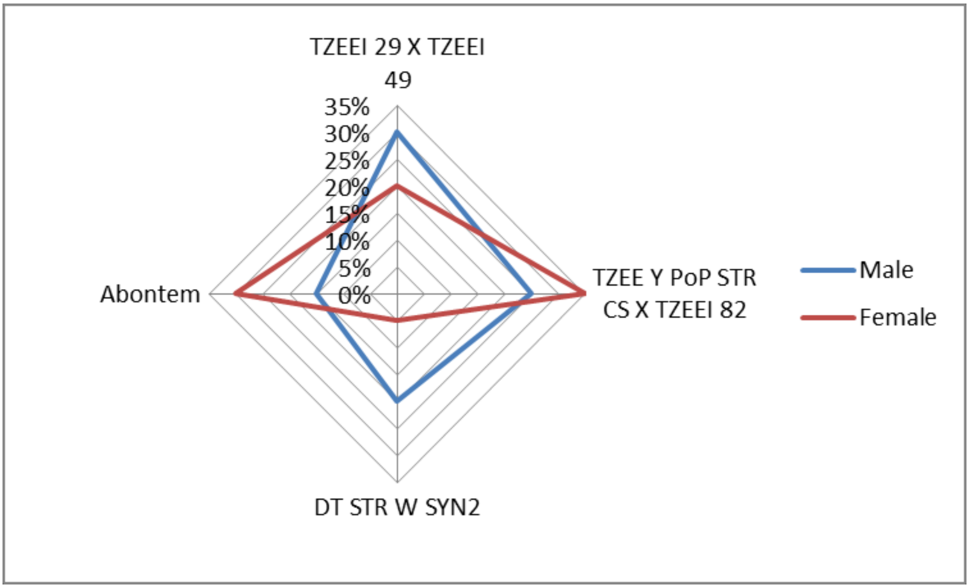

Figure 31: Most preferred farmer varieties in Sissala

Male farmers in Sissala West District selected 2000 SYN-EE as their least least preferred maize variety as presented in the figure below. High lodging potential and small cob size was the reason for non-preference. Both male and female farmers selected TZEEI 29 X TZEEI 21 as their second least preferred variety due to its high lodging potential and thin stalks that could easily breakdown under intense rainfall or wind. The least preferred maize variety selected by females was TZEEI 8 X TZEEI 24 due to its small cob size, grain and thin stalk.

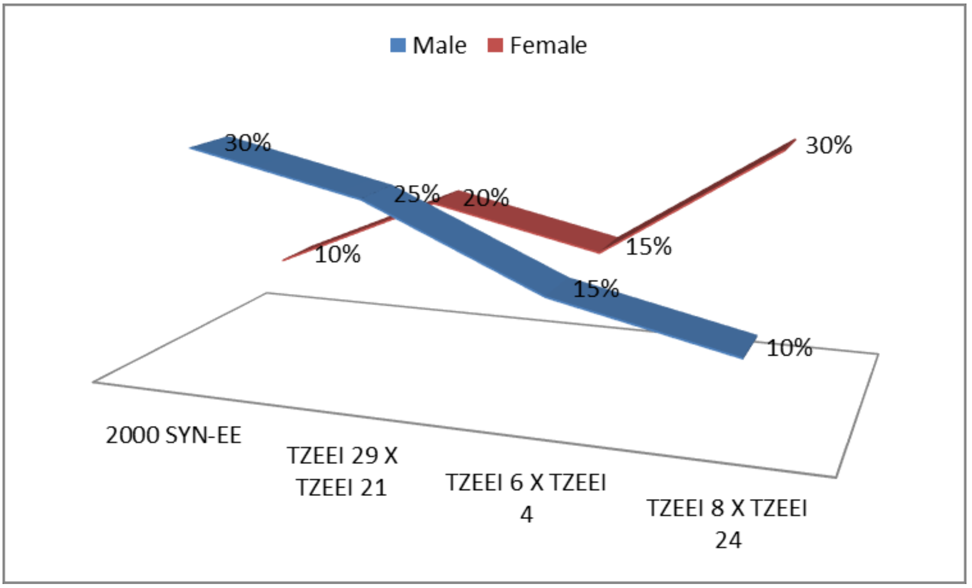

Figure 32: Least preferred farmer varieties in Sissala

Conclusions/Recommendations

Maize varieties that are early maturing and drought tolerant are most preferred by farmers in the savannah and transition zones of Ghana respectively. Breeding for other important maize traits such as striga tolerance, high yielding, resistance to lodging among others, should also take into account earliness, drought tolerance and women considerations.

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Establishing and Facilitating Innovation Platforms (IPs): The Case of Savelugu IP in the Northern Region of Ghana

Principal Investigator: P. M. Etwire
Collaborating Scientists: Jocelyn Davies, Ibrahim D. K. Atokple, Ernest Asiedu, Tony Webster, Lamissa Diakite and Kenneth Opare-Obuobi
Estimated Duration: Completed (2012-2014)
Sponsors: AusAid through CORAF/WECARD
Location: Northern Region of Ghana

Background Information and Justification

The seed system in Ghana faces a variety of technological, institutional, policy, legal and socioeconomic constraints which significantly reduce the supply and flow of improved seed to farmers. The lack of market infrastructure for seed, seed specialists and technical staff, seed laboratory equipment, conditioning centers, funding to maintain breeder seed and seed multiplication units among others are the primary constraints to seed multiplication and distribution (Ndjeunga et al., 2006; Alemu *et al*., 08; Etwire et al., 2013). Consequently, adoption of improved crop varieties is quite low with associated low productivity.

A survey of the seed system by Etwire *et al*., (2013) shows that opportunities exist for increasing the efficiency of seed production and marketing through the hybrid system of the formal and informal seed sectors in collaboration with relevant national and international Non-Governmental Organisations (NGOs), civil society and research institutions. There however appears to be little or no evidence of strong vertical integration between inputs and product markets. Appropriate linkages between seed and grain producers as well as grain producers and processors, are necessary to drive the private sector entry into the seed industry (Hossain *et al*., 2001).

Objectives

This case study highlights the establishment of an Innovation Platform (IP) at Savelugu (Northern Region, Ghana) demonstrating the implementation of the Integrated Agricultural Research for Development (IAR4D) approach in building a foundation for resolving some of the constraints associated with the seed system in Ghana.

Expected Beneficiaries: All actors of the agricultural value chain

Materials and Methods

Data for the case study was obtained from varied sources including experiences and observations of members of the Innovation Support Team (IST), baseline survey and published sources. The IST is basically R&D (research scientists and agricultural extension agents) stakeholders of the platform who initiated, facilitates and backstops the operations of the IP. Different sections of the case study were written by different IST members based on a combination of their own reflections as well as experiences of a cross section of the IP solicited through key informant interviews.

Results/Major Findings

In order to establish the IP, there was the need to bring together the various actors of the cereal and legume value chains within the district that have a common goal. The IST in consultation with Agricultural Extension Agents of the Ministry of Food and Agriculture (AEAs) based in the district invited interested value chain actors to deliberate on the formation of an Innovative Platform (IP) where they can share their concerns, opportunities and challenges as well as build a consensus on how best to tackle those challenges. The IST with assistance from the AEAs convened and facilitated the first IP meeting, on 4th October 2012. The IP is composed of various actors including farmers, traders, input dealer, agricultural extension agents, researchers, tractor service providers, Seed Company and processors.

The goals and priorities of the IP are to:

i) Make improved seed readily available by partnering Heritage Seed Company through an out-grower scheme
ii) Increase crop production by adopting the use of good agronomic practices and improved crop varieties.
iii) Increase income levels through seed and grain production

A total of 118 farmers have had direct access to certified seed of cowpea, sorghum and soybean through the IP. An additional 96 non-IP members have had indirect access to these certified seeds through their interactions with the benefitting farmers. The livelihoods of 57 farmers (41 males and 16 females) who partnered Heritage Seed Company as out-growers were able to get additional income to support their household expenditure (the remaining 63 farmers who registered in 2014 did not report any additional income). Two farmers were for example able to buy a motorbike each through a combination of the additional income from the seed production and their savings.

IP members have developed a sense of ownership and are changing behaviours to operate in a more business like way. With the executives in place, the business linkage with Heritage Seed Company would continue with facilitations from the IP executives. The IP is also being sensitized by the IST (with backstopping from the GRAD support team) to undertake a joint economic or income generating activity such as cultivation of an IP seed farms in each of the four communities to keep the IP running after the term of the project. This is in addition to levying of each member to generate funds to keep the IP functional.

Conclusions/Recommendations

Working with the IP has provided first-hand information on the opportunities and challenges that stakeholders face. This provides room for interaction and instant feedback for researchers to set research priority areas which will meet farmers' needs. This is better than the usual approach of researcher-extension-farmer linkage which is one-way directional and only involves few actors of the value chain. Other aspects such as relationships between actors have been enhanced. There is much cordiality to the extent that farmers are now interacting with researchers even on non-IP meeting days.

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UPPER EAST REGION FARMING SYSTEMS RESEARCH GROUP (UER-FSRG)

AGRONOMY PROGRAMME

General Introduction

The Upper East Region Farming Systems Research Group (UER-FSRG) was established in May 1993 and based at the Manga Agricultural Research Station about 4 km South-East of the Bawku Municipal. The Team currently has a membership of five Research Scientists made up of two Agronomists, 1 Entomologist, 1 Post Harvest specialist and 1 Socio-economist. The Team also has two Research Scientists on study leave. The team also has four Technicians and four supervisors. The Group has oversight responsibility for the Co-ordination of Research, Extension and Farmer Linkage Committee (RELC) activities in the region. The Team also coordinates a number of projects jointly with colleagues at Nyankpala on the AGRA Soil Health Project, Rice Sector Support Project. The Team also provides backstopping to technical staff of non-governmental organizations such as the CARE International Climate Change Project, NORTHFIN Foundation onion bulb size improvement Project in the Bawku West District, Garu Presbyterian Agriculture Station, Bawku East Women Development Association and Action-Aid Ghana for the improvement of food security in the region.

AGRONOMY

Effects of contrasting sources of organic and inorganic fertilizers on the growth, development, yield and its components of maize in a dry agro-ecology in northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Prasad, P. V. V., Ansoba, E., Peter, A.Asungre, Lamini, S and Mahama, G.
Estimated Duration: The Project has ended
Sponsors: WAAPP2A/SANREM
Location: Manga Station

Background information and Justification

Maize (*Zea mays* L.) is now an important food crop in the Upper East Region, both in terms of the mouths it feeds and also in terms of areas devoted to its cultivation fast out stripping the traditional staple crops of millet and sorghum contrary to what used to pertain in the region before the mid-2000. However, low soil fertility has always been identified by farmers in the 3 northern regions of Ghana as the number one constraint to increased and stable cereal productivity and production in the savanna agro-ecologies. Loss of soil organic matter, plant nutrients, low water infiltration and water holding capacity of soils are among the factors that have resulted in poor soil productivity (FAO-RAF, 2000). The use of organic manure and compost has been shown to improve the soil organic matter content (Adani, *et al*., 2007; Soumare *et al*., 2003), water infiltration and retention (Agassi et al., 2004; Bationo *et al*., 1998) and the available water content of soils by 58-86% (Celik *et al*., 2004).

Objective: To determine the most optimal source of organic and inorganic sources of fertilizer for increased and stable maize production in the Savanna agro-ecologies of northern Ghana.

Expected Beneficiaries

Maize growers in northern Ghana, the general public and the Ghana Government as the country would save hard earned foreign currency on maize exports

Materials and methods

The experiment was conducted at the Manga Agricultural Research Station near Bawku, in the Upper East Region (11^o 01' N, 00^o 16' W, 249 m above sea level). The mean annual rainfall of the experimental site was mm, it is mono-modal, starting in June and ending in October. The experimental factor was different sources of organic and chemical fertilisers. Sources of organic fertilizers are: Cowdung, Poultry dropping, Goat dropping, Sheep dropping, Compost, Town waste and Fertisoil and the sources of the chemical fertilizers are: 15:15:15; 21:10:10:2S; Actyva (23:10:5:3S:2Mg:0.3Zn). The experimental design was a randomised complete block with 4 replicates. Plot size for each treatment will be 4.5 m x 5 m. The test crop was maize variety CSIR-Abontem, an extra early maturing variety, which is drought tolerant, *striga hermonthica* resistant and has quality protein. Maize was hand sowed by dibbling on 11^{th} July 2014, on ridge seedbeds made by bullocks at 0.75 m wide and maize seeds sowed at 0.40 m between hills at a depth of 5 cm using 3 to 4 seeds per hill and thinned to plants per hill at exactly 2 weeks after sowing (WAS). Components were taken throughout the season. All other agronomic practices were as recommended for maize in Ghana. Maize was harvested at on 27^{th} October 2014, growth, development, grain yield and its component were subjected to standard statistical analysis.

Results/Major Findings

Both grain and straw yields were very low under town waste and higher under Actyva (N_{23}:P_{10}:K_5:3S:2MgO:0.3Zn), poultry manure, sheep droppings, NPKS (20:10:10:2), NPK (15:15:15) and Fertisol (Table 68). Generally the chemical fertiliser treatment plots recorded greater maize grain yields compared to their organic sources counterparts. However, maize fertilised with compost, poultry manure and sheep dropping produced the highest ($P < 0.05$) grain yield under the organic sources. Maize straw yield followed a similar trend like their grain counterparts with Actyva (N_{23}:P_{10}:K_5:3S:2MgO:0.3Zn) and NPKS (21:10:10:2) recording the highest straw yield followed by poultry manure, sheep droppings, Fertisol and NPK (15:15:15).

Table 76: *The mean growth, grain and straw yields response of maize to soil fertility management options in 2014.*

Fertility option	Days to tasseling	Plant height (cm)	Stem girth (mm)	Stover yield (kg/ha)	Grain yield (kg/ha)	Harvest index	1000-kernel weight (g)
NPKS (20:10:10:2)	57.25	183.6	16.31	5833	3983	0.404	27.34
Actyva	57.25	174.9	16.87	5917	3566	0.381	26.35
Compost	57.00	170.2	15.48	3917	3075	0.425	24.33
Cow dung	59.00	162.4	14.36	3500	2008	0.349	22.79
Fertisol	55.50	178.6	17.45	5042	3475	0.405	24.92
Goat manure	59.00	172.3	15.38	3417	1966	0.362	25.07
NPK (15:15:15)	58.25	179.8	16.72	5167	3492	0.407	27.36
Poultry	58.00	184.1	16.38	4583	3375	0.428	26.76
Sheep manure	56.25	180.5	16.29	4750	2800	0.362	25.81
Town waste	59.25	155.4	13.52	2833	2017	0.414	24.02
Urea	60.25	170.9	15.01	3583	2025	0.360	22.30
LSD	NS	13.73	2.209	1740.4	1388	NS	NS
C.V. (%)	3.7	5.5	9.7	27.4	33.4	16.3	10.3

NS means not significant at 5% level of probability.

Poultry manure and sheep droppings recorded the highest straw yield amongst the organic sources followed by compost and cow dung. Generally, the chemical sources of fertiliser produced higher straw yields as compared to their organic counterparts with the exception of Urea, which produced the lowest straw yield amongst the chemical fertilisers.

Conclusion

The chemical sources also produced superior grain and straw yields than their organic counterparts. 23:10:5:3S:2Mg:0.3Zn; 21:10:10:2S and 15:15:15 were the best sources of chemical fertilizer, whilst Poultry manure; Sheep dropping and Cow dung were also the best sources among the organic soil amendments evaluated in the current study.

Effect of crop rotation using grain legumes on the growth, development, yield and its components of maize in a semi-arid agro-ecology in northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Prasad, P. V. V., Ansoba, E., Peter, A. Asungre, Lamini, S and Mahama, G.
Estimated Duration: 3 years
Sponsors: WAAPP2A/SANREM
Location: Manga Station

Background information and Justification

Crop rotation is well known for its yield improvement effect on crop yield and reduction of financial risk (Nel and Loubser, 2004), consequently it is recommended as a countermeasure for financially sustainable crop production (Ferreira *et al*., 2001). Earlier attempts by the Ministry of Food and Agriculture, Global 2000 and other non-governmental organisations, who started the promotion of maize production, supported farmers with highly subsidized fertilisers. These endeavours appreciably increased maize yield to about 1.2 t ha^{-1} as against the average maize yield of 0.6 t ha^{-1} under peasant farmers' practice of using 200 kg ha^{-1} of NPK (UER-IFAD/LACOSREP, 1992). Average maize yields per unit of land have fallen in Africa since the 1970s partly because maize production has expanded into drought prone areas, semi-arid areas and partly due to declining soil fertility (Gilbert *et al*. 1993). With appropriate tillage and rotation maize roots can also absorb water from the subsoil at 40 to 50 cm depth (Ghuman and Lal, 1991).

Objective: To determine the best grain legume rotation partner for increased and stable maize production in the Savanna agro-ecologies of northern Ghana.

Materials and methods

The experiment was conducted at the Manga Agricultural Research Station near Bawku, in the Upper East Region (11° 01' N, 00° 16' W, 249 m above sea level). The experimental treatments are as follows: Cowpeas, Groundnuts, Soybeans, Pigeon peas, Mucuna and a control plot of maize after maize, which is the farmers practice. The test crop was maize variety CSIR-Omankwa. The experimental design was a randomised complete block with 4 replicates. Plot size for each treatment will be 4.5 m x 5m. Maize was sowed on ridges made by bullocks at 0.75 m wide and maize seeds sowed at 0.40 m between hills using 3 to 4 seeds per hill and thinned to plants per hill at exactly 2 weeks after sowing (WAS). All agronomic practices are as recommendd for maize production in Ghana. Maize was harvested at harvest maturity, yield and its components would be taken for statistical analysis. All crop data were subjected to analysis of variance (ANOVA) and where there were significant differences among treatments, means were separated using the LSD test at the $P = 0.05$ level.

Results/Major Findings

Grain yield was significantly (P<0.01) influenced by treatment. Maize after groundnuts produced the highest grain yield followed closely by maize after cowpea and maize after pigeon pea whilst maize after maize produced the lowest grain yield (Table 69). Maize after a grain legume produced significantly (P<0.01) greater grain yield compared to maize following maize. Maize after a grain legume produced appreciably higher grain yields as compared to the average well fertilized maize yields reported in the Region, which is in the range of 1,200 kg ha^{-1} to 1500 kg ha^{-1}. All treatments with the exception of maize after maize and maize after greengram produced grain yields that were above the trial mean. Maize straw yield followed a similar, trend like their grain counterparts with maize after groundnut producing the highest straw yield followed by maize after cowpea and greengram whilst maize after maize recorded the lowest straw yield. Straw yield of maize after groundnut; cowpea greengram and pigeon pea was significantly (P<0.01) higher than that obtained for maize after maize (Table 68).

Table 77: *Effect of crop rotation of maize with grain legumes on maize grain yield and its components in a semi-arid agro-ecology in northern Ghana during the 2014 cropping season*

Maize legume rotation	Cobs at harvest	100-kernel weight (kg/ha)	Harvest index	Grain yield (kg/ha)	Straw yield (kg/ha)	Rainfall use efficiency (kg mm^{-1} ha^{-1})
Maize-Cowpea	89	26.25	0.45	2093	2567	3.25
Maize-Greengram	76	21.98	0.40	1788	2547	2.77
Maize-Groundnut	84	27.17	0.45	2137	2600	3.31
Maize-Mucuna	82	26.95	0.46	1642	1917	2.55
Maize-Pigeon pea	85	24.62	0.48	2020	2233	3.13
Maize-Soybean	82	26.14	0.47	1792	1983	2.78
Maize-Maize	69	23.65	0.44	1040	1283	1.61
Mean	81	25.25	0.45	1787	2157	2.77
s.e.d.	6.39	1.70	0.072	286	339	0.44
C.V. (%)	11.20	9.5	12.20	22.6	22.3	22.6

Conclusion

This season is the first cycle of rotation and maize grain yields were highest when maize followed groundnut; cowpea and pigeon pea as compared to the other rotation. Maize following maize gave the lowest grain yields due to the depletion of soil nutrients as compared to the grain legumes that have the ability to fix soil nitrogen and also the addition of crop residue to the soil for improve in growth of the preceding maize crop.

Introduction of ICRISAT Sorghum Trials for Adaptation to Northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Saaka S. J. Buah and Kenneth Opare-Obuobi
Estimated Duration: 2 years
Sponsors: USAID/AfricaRising
Locations: Manga Station and Bonia near Navrongo

Background information and Justification

Sorghum (*Sorghum bicolor L.*) is one of the most important staple cereals in northern Ghana, in terms of area cropped to sorghum and the number of people who consume. However, the lack of improved varieties has led to a decline in sorghum yields and a drop in area of cultivation of this important cereal over the years. Farmers and the Ministry of Food and Agriculture (MoFA) Staff and Non-governmental Organisations (NGOs) participating in the Annual Review and Planning Sessions have always identified the lack of improved crop varieties as the next most important constraint only next to low soil fertility. However, the case of sorghum is even more desperate as compared to other cereal crops such as maize and rice, which have over 15 or more varieties released by the National Variety and technical Committee for massive cultivation. Research efforts at breeding stable, high yielding and disease resistant/tolerant varieties is crucial if current production levels are to be increased to meet the ever increasing demand for pearl millet.

Objective: To test, adopt and to recommend promising sorghum hybrids for adaptation by sorghum farmers increased sorghum productivity and production in Ghana.

Materials and methods

An on-station field trial was established at the Manga Agricultural Research Station. Land preparation was done by the Station's pair of bullocks on 12th June 2014 and the field was laid out and planted on the 25th of July. Thinning to two plants per stand was done on the 27th of June 2014 to maintain the optimal plant population as recommended for maize in Ghana. Basal fertiliser in the form of compound fertiliser 15:15:15 was applied on the 9th of July 2014 at the rate of 30 kg nitrogen; 30 kg phosphorus in the form of (P_2O_5) and 30 kg potassium in the form of (K_2O) were applied. Hand weeding was done on 16th of July 2014 and top-dressed with sulphan a new nitrogen fertiliser formulation with high nitrogen content and sulphur than the usual sulphate of ammonia on the 6th of August 2014. Due to continuous rains, the ridges have been reduced in size and therefore have to be re-shaping and prevent plants form root lodging. Data on plant establishment, assessment of germination, plant height, stem girth measurement, determination of chlorophyll content using a SPAD Meter, were all taken. Farmers' appreciation of panicle and grain desirability data were taken on 27th of November 2014 after harvest. The Directorates of the Ministry of Food and Agriculture for the Binduri District and Bawku Municipal would asked to invite farmers to participate in the assessment of the sorghum hybrids. Sorghum growth, development, grain and straw yields were subjected to appropriate statistical analysis.

Results/Major Findings

500-grain weight was influenced significantly ($p<0.001$) by genotype with the Early Local producing the boldest and Sewa the smallest grain. The Early Local; Soumalemba and Mona produced considerably bolder grain compared to those produce d by the rest of the genotypes. The conversion of dry matter from biomass to grain was considerably low for all genotypes. However, there were significant ($p<0.001$) differences amongst genotypes with regards to harvest index. The Early Local recorded significantly the highest harvest index than compared to the rest of the treatments except for those recorded for Sewa and Fadda. Agronomic score was significantly ($p<0.001$) affected by genotype with Caufa and Fadda recording the highest score and followed closely by Sewa and the Late Local.

Table 78: *One thousand kernel weight, harvest index, agronomic score grain yield, average panicle and grain appreciation at Manga Station in 2014*

Sorghum hybrids	1000-kernel weight (g)	Agronomic score	Grain yield (kg/ha)	Average panicle appreciation	Average grain appreciation
Caufa	21.56	8.0	1767	2.8	3.5
Fadda	20.44	8.0	2675	3.0	2.7
Grinkan Yerewolo	18.76	7.3	1600	3.3	3.3
Mona	24.40	4.0	1033	2.8	3.3
Pablo	23.32	6.3	2067	2.8	3.5
Sewa	17.92	7.0	2075	3.8	3.5
Soumalemba	25.64	2.5	2317	4.3	4.0
Yamasa	20.44	2.5	1517	3.0	4.0
Early Local	27.40	4.0	1650	2.5	3.8
Late Local	19.92	7.0	1458	3.3	4.0
Mean	22.00	5.7	1816	3.1	3.6
LSD	0.627	3.13	612	1.09	0.96
C.V. (%)	7.90	38.1	23.20	24.0	18.70
P<0.00	0.001	0.002	0.001	0.08	NS

Grain yield was significantly ($p<0.001$) affected by genotype. The highest grain yield was produced by Fadda and followed closely by Soumalemba, whilst Mona produced the lowest grain yield (Table 70). Only the exotic genotypes; Fadda; Soumalemba; Sewa and Pablo produced grain yields that were higher than that recorded for the trial mean. The mean sorghum grain yield recorded in this study is far greater than the average sorghum grain yields generally reported in the country, which stands at around less than 1000 kg per hectare.

Conclusion

There is the need to repeat the trial in 2014 to enable us draw to confirm or reject the current findings. If the best four genotypes, namely Pablo; Serwa; Fada and Soumalemba should be consistent in their grain yields, then we would recommend them to the National Variety and Technical Committee for release to boost sorghum production and productivity in Ghana.

Integrated soil fertility management effect on grain and fodder yields and soil chemical and physical properties in soybean-maize rotation in northern Savanna of Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Saaka S. J. Buah
Estimated Duration: 5 years
Sponsors: USAID/AfricaRising
Locations: Manga Station and Bonia near Navrongo

Background information and Justification
Maize (*Zea mays* L.) is now an important food crop in the Upper East Region, both in terms of the mouths it feeds and also in terms of areas devoted to its cultivation fast out stripping the traditional staple crops of millet and sorghum contrary to what used to pertain in the region before the mid-2000. However, poor soil fertility has always been identified by farmers in the 3 northern regions of Ghana as the number one constraint to increased and stable cereal productivity and production in the savanna agro-ecologies. Crop rotation is well known for its yield improvement effect on crop yield and reduction of financial risk (Nel and Loubser, 2004), consequently it is recommended as a countermeasure for financially sustainable crop production (Ferreira *et al*., 2001). Average maize yields per unit of land have fallen in Africa since the 1970s partly because maize production has expanded into drought prone areas, semi-arid areas and partly due to declining soil fertility (Gilbert *et al*. 1993).

Objective: To determine the best grain legume rotation partner for increased and stable maize production in the Savanna agro-ecologies of northern Ghana.

Expected Beneficiaries: Maize growers in Ghana, the general public and also the Government of Ghana.

Materials and methods
The experiment was conducted at the Manga Agricultural Research Station near Bawku, in the Upper East Region (11º 01' N, 00º 16' W, 249 m above sea level). The experimental treatments are as follows: Soybean with no soil amendment (Control); soybean with inoculant only; soybean with inoculant plus PK (60 kg P_2O_5/ha and 30 kg K_20; soybean with inoculant plus fertisol; soybean plus inoculant plus PK plus fertisol and soybean plus recommended fertiliser rate (25-60-30 as N P_20_5 and K_20) and the control maize after maize. The test crop was maize variety CSIR-Omankwa. The experimental design was a randomised complete block with 4 replicates. Plot size for each treatment will be 4.5 m x 5m. Maize was sowed on ridges made by bullocks at 0.75 m wide and maize seeds sowed at 0.40 m between hills using 3 to 4 seeds per hill and thinned to plants per hill at exactly 2 weeks after sowing (WAS). All cultural practices were as recommended for maize production in the country. Maize was harvested on the 30th of October 2014. Maize was harvested at harvest maturity, yield and its components would be taken for statistical analysis. All crop data were subjected to analysis of

variance and where there were significant differences among treatments, means were separated using the LSD test at the $P = 0.01$ or 0.05 levels.

Results/Major Findings

The 100-kernel weight recorded by maize that was rotated with inoculated soybean and fertisol was significantly ($p<0.05$) higher than that recorded under the rest of the treatments with the exception of maize after inoculated soybean, plus P and K and recommended fertiliser of soybean treatment (Table 71).

Table 79: *Integrated soil fertility management effect on grain yield and its components of maize in the Sudan savannah agro-ecology in the 2014 cropping season*

Treatment	Mean cob diameter (cm)	No. of cobs harvested	100-grain weight (g)	Harvest index	Grain yield (kg/ha)	Straw yield (kg/ha)
Control	40.86	82	23.61	0.50	3388	3250
Maize after soybean	39.85	71	22.81	0.52	2479	2333
Maize after inoculated soybean	40.39	80	24.28	0.58	3046	2250
Maize after inoculated soybean + Fertisol	43.22	85	26.61	0.54	4117	3458
Maize after inoculated soybean + PK	42.17	81	24.13	0.52	3625	3292
Maize after inoculated soybean + PK + Recommended Fertiliser	43.11	86	24.87	0.52	3625	3221
Maize after soybean + Recommended fertiliser rate	40.56	81	24.02	0.57	3121	2333
Mean	40.56	81	24.33	0.54	3329	2877
LSD	2.49	9.21	1.90	0.049	796	321
C.V. (%)	4.00	7.70	5.30	6.20	16.10	19.20

Harvest index of maize recorded in this study were generally, comparable to those usually reported for maize in the literature. Maize after inoculated soybean recorded the highest harvest index, which is significantly ($p<0.05$) greater that those recorded when maize was followed by maize; maize after sole soybean and maize after inoculated soybean plus P and K with recommended fertiliser for soybean (Table 71). Generally, maize grain yields reported in this study were far higher than those reported across the region. Maize planted after inoculated soybean with application of fertisol produced the highest grain yield whilst maize after sole soybean gave the lowest (Table 71). Generally, maize following inoculated soybean that has received a soil amendment gave higher yields than their counterparts that were neither inoculated nor inoculated without a soil amendment. Maize following inoculated soybeans with fertisol produced yields that were significantly greater than those produced when maize followed sole soybean or when soybean was given the recommended fertiliser rate. Maize that followed inoculated soybean with the application of a soil amendment resulted in considerably higher maize yields than their counterparts and also greater than the trial mean. Maize straw yield followed a similar, trend to that of maize grain yield, with maize after inoculated soybean and application of fertisol producing the highest straw yield followed by maize after inoculated soybean with P and K (Table 71). Straw yield recorded by maize after inoculated soybean with fertisol was significantly ($p<0.01$) greater than those recorded by maize after inoculated soybean; maize after non-inoculated soybean and maize after soybean with recommended fertiliser rate (Table 71).

Conclusion
These results suggests that, in addition to the inoculation of soybean it is important to add a soil amendment; such as fertisol; P and K and the recommended fertiliser for soybean so as to obtain good maize grain and straw yields. Though these preliminary results hold promise for increased and stable maize yields in northern Ghana, there will be the need to repeat the study so as to enable us confirm or reject these current results.

On-farm evaluation of extra-early and medium drought tolerant maize for Africa (DTMA) varieties and hybrids in a semi-arid agro-ecology in northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Saaka S. Buah; John K. Bidzakin, Alidu Haruna, Gloria Boakyewa
Estimated Duration: 5 years
Sponsors: USAID/AfricaRising
Locations: Garu-Tempane and Binduri Districts

Background information and Justification
Maize (*Zea mays* L.) is one of the most important food cereals in the developing world (CIMMYT, 1990). However, production is lower than demand and bridging the gap requires large increases in production mainly through yield improvement (Crosson & Anderson, 1992). In sub-Saharan Africa, maize is produced mainly under rainfed conditions which are characterized by highly variable rainfall, both in quantity and distribution. Consequently, the crop frequently suffers from moisture stress at some stage during its growth period (Johnston *et al*., 1986) with the ultimate result of reduced yields. In the three northern regions of Ghana, farmers participating in the Annual Planning Sessions under the auspices of the Research Extension Farmer Linkage Committee (RELC) have always identified low soil fertility, insufficient and erratic rainfall as the major constraints to maize production in the area. Although several water harvesting techniques, such as tied ridges, have been proposed to address the problem of water stress, their efficiency could be enhanced with by drought-tolerant varieties which can use the harvested rainwater more efficiently. Participatory Variety

Selection (PVS) is a more rapid and cost-effective way of identifying farmer-preferred cultivars if a suitable choice of cultivars exists (Witcomebe *et al*., 1996).

Objectives:

i. evaluate drought-tolerant maize varieties and hybrids on farmers' fields;
ii. solicit farmers impressions in the selection of the best drought-tolerant maize varieties or hybrids;
iii. determine the economic benefits of planting drought-tolerant maize compared with farmers' varieties.

Materials and methods

In 2014, field trials were conducted at Garu-Tempane and Binduri Districts of the Upper East Region (in the Sudan Savanna agro-ecology). The trials evaluated drought-tolerant maize varieties and hybrids under the Drought Tolerant Maize for Africa (DTMA)/International Institute of Tropical Agriculture (IITA) and the International Centre for Wheat and Maize Research (CIMMYT) Mexico initiative. Farmers were selected based upon their previous experience in conducting on-farm adaptive trials with the Savanna Agricultural Research Institute Station at Manga and their willingness to collaborate in this particular study. The Mother and Baby concept of on-farm experimentation was adopted whereby all the maize entries were tested in a replicated trials in one farmer's field, which is the Mother trial while 2 or 3 entries were planted by 5 other farmers in each of the 2 Districts for the Baby trial. The extra-early hybrid maize were: TZEE-W Pop STR C5 x TZEE I21; TZEE-Y Pop STR C4 x TZEEI 17; TZEE 6 x TZEEI 4; TZEE-Y Pop STR C5 x TZEEI 82; TZEEI 29 x TZEEI 24; TZEEI 29 x TZEEI 49; TZEEI 18 x TZEEI 24; TZEI 7 x TZEI 76; CSIR-Abontem and the Farmers variety and for the medium maturity hybrid maize tested were: M 0926-8; M 1026-3; M 1026-10; PAN 12; PAN 53 and the Farmers' variety. The randomised complete block design was adopted for the mother, with 4 replications; whilst for the baby trials the design was an incomplete block, with three farmers each serving as a replicate. Plot dimensions for the mother trial was 4.5 m x 5m and the baby trial was 18 ridges by 10m long. This comprised of 6 ridges spaced at 0.75m apart and 5 m long with data recorded from the 4 central ridges with the outer rows serving as guard rows for the mother trial. All agronomic practices with regards to maize production as recommended were adhered to. The trials were harvest on the 30th of October 2014. The data was then subjected to statistical analysis.

Results/Major Findings

The cobs produced by the Farmers' variety and the CSIR-Abontem were significantly bigger than those produced by TZEE-Y Pop DT STR C4 x TZEEI 17; TZEE 6 x TZEEI 4; TZEEI 8 x TZEEI 24; TZEE-Y Pop STR C5 x TZEEI 82 and TZEEI 29 x TZEEI 49 (Table 72). There were significant ($P<0.05$) differences among treatments with regards to 100-kernel weight. The CSIR-Abontem and TZEE-W Pop STR C5 x TZEEI 21 produced significantly ($P<0.05$) the boldest kernels than all the improved genotypes (Table 72). The Farmers' variety produced kernels that were significantly ($P<0.001$) bigger than those produced by TZEE-Y Pop DT STR C4 x TZEEI 17; TZEE 6 x TZEEI 4; TZEE-Y Pop STR C5 x TZEEI 82; TZEEI 29 x TZEEI 24 and TZEEI 8 x TZEEI 24. Maize harvest indices this year were generally higher as compared to those recorded in 2013 cropping season. There were no significant (P<0.0.05) differences amongst genotypes with regards to maize harvest index. However, TZEEI 8 x TZEEI 24 recorded the highest harvest index and TZEE 6 x TZEEI 4 the lowest (Table 72). Maize grain yields this year were generally greater than those reported in the 2012 and 2013 cropping seasons. The Farmers' variety produced the highest grain yield followed closely by the TZEE-W Pop STR C5 x TZEEI 21 and TZEE-Y Pop STR C5 x TZEEI 82, whilst TZEEI 8 x TZEEI 24, produced the lowest grain yield (Table 72).

Table 80: *Stand count at harvest; cobs harvested; cob length; cob girth; 1000-kernel weight; harvest index and grain yield of extra-early drought tolerant hybrid maize evaluated on-farm at the Garu-Tempane District in northern Ghana in 2014*

Hybrid maize	Stand count at harvest	No. of cobs harvested	Cob length (cm)	Cob girth (cm)	1000-kernel wt (g)	Harvest index	Grain yield (kg/ha)
TZEE-W Pop STR C5 x TZEEI 21	85	84	11.5	39.87	304	0.62	4104
TZEE-Y Pop DT STR C4 x TZEEI 17	82	82	15.5	32.63	235	0.62	3681
TZEE 6 x TZEEI 4	70	70	13.5	38.19	219	0.51	3806
TZEE-Y Pop STR C5 x TZEEI 82	71	70	14.3	38.06	246	0.60	4090
TZEEI 29 x TZEEI 24	70	69	11.3	38.92	250	0.63	3959
TZEEI 29 x TZEEI 49	79	78	11.8	38.09	266	0.64	3826
TZEEI 8 x TZEEI 24	58	58	14.0	35.14	210	0.65	3633
TZEI 7 x TZEI 76	52	51	14.5	39.91	286	0.61	3703
CSIR-Abontem	54	53	14.0	42.39	304	0.63	3920
Farmers'variety	64	63	15.3	42.47	289	0.60	4192
Mean	68	68	13.6	38.57	257	0.61	3891
LSD (1%)	16.80	17.2	1.30	3.64	26.90	0.125	695
C.V. (%)	16.90	17.40	6.60	6.50	7.2	14.10	12.30

Conclusion

TZEE-W Pop STR C5 x TZEEI 21 and TZEE-Y Pop STR C5 x TZEEI 82 produced considerably greater grain yields than the rest of the hybrids tested. If these two hybrids should repeat their superior performance in the 2015 season they would be recommended to the National Variety Release and Registration Committee for release to increase maize productivity and production.

Participatory Varietal Selection of Improved Rice Crop (Gbewaa) Under Different Nitrogen Levels in the Upper East Region of Ghana

Principal Investigator: Julius Yirzagla
Collaborating Scientists: Mrs Benedicta Atosona, Mr Jonathan Agawini, Mr Alem Albert
Estimated Duration: 5 years (2012-2016)
Sponsors: AfricaRISING Project
Location: On-farm (Nyangua, Samboligo and Bonia in Upper East Region)

Background Information and Justification

In the Upper East Region of Ghana, the weaknesses of rice farmers as identified in 2012 Rice Yield Gap Survey, included the use of local rice varieties or impure improved varieties and inadequate fertilizer use (AfricaRISING 2012). These farmers therefore need to maintain seed quality and appropriate agronomic practices (N supply) for enhanced productivity of paddy yields. It is against this background that the present on-farm adaptive trial was initiated to evaluate the performance and acceptance of a new improved rice variety, Gbewaa receiving different N rates under farmers' conditions using the mother-baby trial approach.

Objectives

i. To increase the speed of adoption of an improved rice variety (Gbewaa) by involving farmers in variety needs assessment, selection and testing of the new lowland cultivar
ii. To sensitize farmers on the economic benefits of the rice varieties receiving optimal N application

Expected Beneficiaries

Rice farmers, traders, aggregators

Materials and Methods

Mother baby trials were established in Bonia, Nyangua and Samboligo in the Upper East region (UER). In all, 12 farmers were involved and each farmer was provided with 5kg of seed of Gbewaa rice varieties and also provided same quantity of farmer variety. At each location the 2 varieties were evaluated using researcher-managed mother and farmer-managed baby trial design.

Results/Major Findings

Paddy yield was generally low for the farmer variety and or non-fertilised treatments compared to Gbewaa and or fertilized treatments across the 3 locations. The farmers provided quantitative feedback on their evaluation of technologies (treatments) through technology rating. Qualitative feedback was obtained from meetings between farmers and researchers and comments recorded at field days. The mother trials were evaluated more informally during discussions held at field days. This made it possible to integrate the farmers' assessment.

Conclusions/Recommendations
The trials were successfully implemented with farmers actively involved in each stage of the evaluation processes. By facilitating hands-on experience for farmers, the mother and baby trials provided a relatively rapid approach to adopting improved varieties and soil management (N supply) technologies.

References
AfricaRISING Annual Report 2012

Quality Rice Development Project (QRDP)

Principal Investigator: John Kanburi Bidzakin
Collaborating Scientists: Mr. Julius Yirzagla, Dr. Wilson Dogbe, Mr. Williams Atakora, Dr. SK Nutsugah, Mr. Michael Maweya, Mr. Isaah Sugri ,Mr. Inusah Baba and Mr. Robert K. Owusu.
Estimated Duration: 3 years (2014-2016)
Sponsors: AGRA
Location: On-farm (Northern and Upper East Region)

Background Information and Justification
The Ghanaian rice market is increasingly driven by premium rice, with growing demand of 40% per annum while the medium segment is shrinking at 4% per annum. Urban consumers in particular, prefer rice that is clean, perfumed, low percentage of breakage, and nice colour (mostly white). Locally produced rice fail to meet consumer preference characteristics while imported rice continue to dominate the markets. It is against this background that the Quality Rice Development Project was initiated by AGRA to contribute to Government of Ghana's objective of achieving food security and improved livelihood of smallholder farmers in the rice value chain by strengthening their capacity for sustainable and competitive quality rice production

Objectives

i. To increase productivity of rice in smallholder farming systems in the Northern and Upper East Regions of Ghana,
ii. Strengthen institutional and organizational capacity of Farmer Organizations (FBOs) to enhance access to services and
iii. To increase marketing of locally produced rice by smallholder farmers in the Northern and Upper East Regions.

Expected Beneficiaries: Rice farmers, traders, aggregators, processors and input dealers

Materials and Methods
Conduct of field demonstration, capacity needs assessment of Farmer-based organizations (FBOs), training processors and marketers on agricultural marketing and distribution

Results/Major Findings
Field demonstrations were successfully conducted, training of trainers, farmer field schools and fields days were successfully organized for the Extension staff, FBOs, processors etc during the 2014 cropping season. By facilitating hands-on experience for farmers, the demonstration fields provided a rapid approach to adopting quality rice production technologies. Farmers were trained on Good Agronomic Practices and Integrated Soil Fertility Management (ISFM) through Farmer Field Fora (FFF) concept. Farmers where reached using community video screening (Farm video van). Scientists and extension officers were trained on the rice advice software. Communication materials were produced.

Conclusions/Recommendations
The demonstrations and the training programmes were successfully implemented with all stakeholders (FBOs, processors, marketers etc) actively involved. The pro

Multi-locational evaluation of red rice genotypes

Principal Investigator: Dr. Wilson Dogbe
Collaborating Scientists: Julius Yirzagla, Jonathan Agawini, Albert Alem, Benedicta Atosona.
Estimated Duration: 4 years (2011-2014)
Sponsors: RSSP
Location: On-station (Nyankpala, Libi and Manga)

Background Information and Justification
Rice has become a symbol of food security world-wide. Red coloured caryopsis (the dehulled rice grain) has a particular place in the Ghanaian society. This is due to the unique role it plays in most Ghanaian culinary preparations in most cultures. More importantly, red coloured caryopsis genotypes of rice have comparative nutritional and health advantages; good source of iron and zinc; anthocyanins (the pigment that gives leaves and grains the deep iron red, blue and purple colours) have anti-oxidant properties which lower the risk of heart problems. Research into the yield potential and agronomic attributes of red rice will thus lead to improved food security and health status of rice farmers.

Objectives
To evaluate the yield potentials and general agronomic adaptability of eight red rice genotypes (including one control) to the rice growing ecologies of northern Ghana.

Expected Beneficiaries: Rice farmers, traders, aggregators, processors and input dealers

Materials and Methods
Multi-locational trial at three locations (Nyankpala, Libi and Manga) in an RCBD fashion with four replications.

Results/Major Findings
The top three yielding genotypes across location based on the results of 2014 are jasmine 85 (red), Matigey and GH 1837

Conclusions/Recommendations :
The trial will continue in 2015

FIELD ENTOMOLOG Y

Deployment of the cowpea aphid Resistance gene for cowpea Improvement in Ghana

Principal Investigator: Francis Kusi
Collaborating Scientists: M. Zakaria, S. Lamini, A.Y Agyare, F.J. Awuku and G. Rashida
Estimated Duration: 3 years
Sponsors: Kirkhouse Trust
Location: Nyankpala and Manga

Background Information and Justification

The project activities during the reporting period include genotyping of five BC4F1 populations using the SNPs platform for background selection. The five BC4 populations were developed between SARC1-57-2 and each of IT99K-573-1-1, IT99K-573-3-2-1, Nhyira, Asetenapa and Zaayura. These genotypes were identified as susceptible to cowpea aphid which the current project seeks to improve using SARC 1-57-2 in marker-assisted backcrossing. The background selection aimed at selecting individuals that has recovered greater percentage of the recurrent parents in course of the marker-assisted background selection. The selected individuals were multiplied and are currently being evaluated in multi locations (Tumu in Upper West, Manga in Upper East and Golinga in Northern Regions).

Objectives

i. To improve field resistance of 5 cowpea varieties to cowpea aphid
ii. To evaluate the improved lines in multi-location trials

Expected Beneficiaries

The project will benefit cowpea farmers, consumers, traders and transporters. The improved varieties will also serve as breeding materials for cowpea breeders within and outside Ghana.

Materials and Methods

The following protocol was used for the background selection:

- The parents were sent in zip-lock bags containing desiccant packs for genotyping to identify polymorphic markers
- The BC4F1s populations were tested rigorously for aphids resistance, prior to the aphid infestation, leaf samples were collected and sent for genotyping
- The final selections (in the BC4F2) were tested with aphids just to be sure that they are still resistant, and then fix the aphid resistance in the BC4F3

Results/Major Findings

The data were received under the following headings:

- SNP name

- SNP flanking sequences/calls
- positions on cowpea consensus genetic map and
- SNP genotypes

150 SNPs were found to be polymorphic between Zaayura and SARC 1-57-2 and spaced at least 0.5 cm from each other throughout 11 linkage groups of the cowpea consensus genetic map.

Some of them also flank aphid-resistance QTLs from an IITA line that was mapped in a different cowpea population grown in California, whose relationship to our resistance (SARC1-57-2) is not known. The plant with label number 148 (Table 73) was found to be resistant and has recovered 95% of the recurrent parent's background. Although there were other resistant plants like 145, 180 and 337, they had recovered relatively lower percentage of 93% and 92% of the recurrent parent's background.

Table 81: *SNPs results on background selection*

Plant	% Recurrent BG	Aphid
214	100%	R
272	97%	
446	96%	S
148	95%	R
190	95%	S
280	94%	S
239	94%	S
441	94%	S
145	93%	R
180	93%	R
337	92%	R

Conclusions/Recommendations

The breeding work will continue to further improve the improved lines that are susceptible to Striga with the Striga resistance gene in a marker-assisted backcrossing. However, the five improved varieties are currently being evaluated in multi-location trials in the three regions in the north.

Feed the Future Legume Innovation Lab for Climate Resilient Cowpea

Principal Investigator: Francis Kusi
Collaborating Scientists: IDK Atokple, M. Haruna, M. Zakaria, S. Lamini, A.Y. Agyare, F.J. Awuku and G. Rashida
Estimated Duration: 4 years
Sponsors: USAID (University of California Riverside)
Location: Nyankpala and Manga

Background Information and Justification

The climate resilient project's activities will include the development of genetic resources including DNA sequencing of 30 diverse cowpea accessions relevant to African breeding, discovery of at least 25,000 SNP markers, and design of a high-density genotyping assay. In addition, SNP genotyping will be performed on about 1000 biparental recombinant inbred lines. This will support construction of a new consensus genetic linkage map and refinement of QTLs. In addition, up to 48 location-specific preferred breeding accessions will be chosen by each host country partner (including Ghana). Seed of the chosen accessions will be increased in the host countries and each accession will be sampled for tissue that will be SNP genotyped. Host country partners will conduct preliminary phenotyping to gather data on these and other materials for the purpose of refining and expanding each partner's set of preferred breeding accessions.

Objectives

i. To identify polymorphic SNPs markers for important triats
ii. To improve the breeding capacities of NARS
iii. To enhance access to breeding materials of the partner institutions

Expected Beneficiaries: Breeders, consumers, farmers, traders and transporters

Materials and Methods

Genotyping of 44 preferred breeding lines on SNPs platform

CSIR-SARI sent samples of leaf tissue of 44 preferred breeding lines to UCR. DNA extraction was done by the UCR Team and genotyping on SNPs platform has been completed and the results shared with us.

The flapjack software was used on the results to check similarity matrix which has shown relative closeness or otherwise of our lines and 'if condition' on excel also used to select SNP markers that show polymorphism among the lines

Screening for drought and other traits

Both seed box and field screening methodology were used to evaluate the 44 preferred breeding lines for drought. In the seed box screening, the seedlings were watered up to two weeks after planting, when the first trifoliate leaves started to emerge. Watering was stop at this stage to impose drought stress for 15 days. The seedlings were then classified into resistant and susceptible groups. Watering was then resumed 15 days after the drought stress and the seedlings were further assessed based on their rate of recovering from the damage caused by the drought stress.

Results/Major Findings

Although, the lines were classified into resistant and susceptible groups, all the lines screened eventually survived the drought stress, however, the difference was observed in the rate of recovery and the effect on days to flowering, maturity and grain yield. The results were confirmed by the field screen. The field planting was done with the few rains in September for good germination and crop establishment. The terminal drought coincided with the advanced vegetative stage prior to flower bud initiation. Single row of 2 m long in 3 replication of the 44 lines in RCBD. Two plots were established in 2 weeks interval to ensure that at least one of them will suffer the terminal drought.

Conclusions/Recommendations

Nineteen of the cowpea lines were found to be tolerant to drought, these will be further screen by prolonging the water stress period. Those that will be selected will serve as donors to improve the field tolerance to drought of elite cowpea lines in Ghana using marker-assisted breeding.

The 44 lines are currently on the field been evaluated for their heat tolerance. The lines have been subjected to both the high day and night temperatures in March and April to assess the effect of heat on their growth and development.

Legume Innovation Lab: SO1.A5 Genetic improvement of cowpea to overcome biotic stress and drought constraints to grain productivity

Principal Investigator: Francis Kusi
Collaborating Scientists: IDK Atokple, M. Haruna, M. Zakaria, S. Lamini, A.Y. Agyare, F.J. Awuku and G. Rashida
Estimated Duration: 4 years
Sponsors: USAID (University of California Riverside)
Location: Nyankpala and Manga

Background Information and Justification

The primary project focus is to 1) discover insect tolerance and resistance QTL for cowpea breeding; 2) increase African and US cowpea productivity by improved varieties with resistance to insect stresses, drought tolerance or disease resistance; 3) expand farmer marketing opportunities with improved cowpea varieties with desirable grain characteristics; and 4) provide training and capacity building in modern cowpea breeding. The project's plan includes the FTF focus countries Ghana and Senegal, and also Burkina Faso, which offers regional importance from an agro-ecological perspective for cowpea yield gain in the Sudano-

Sahel region. Strategically, these countries represent the primary agro-ecologies underpinning cowpea production in this region.

Objectives
In addressing these primary constraints, the objectives are well aligned with Feed The Future research strategic priorities of 1) crop resistance to heat, drought, salinity and flood; 2) West African Sudano-Sahelian systems with emphasis on insect-resistant cowpea; and 3) grain legume productivity.

Expected Beneficiaries: Breeders, consumers, farmers, traders and transporters

Materials and Methods
Among the activities under this project is testing the genetic relatedness of five sources of cowpea aphid (Aphis craccivora) resistance. Field observations in Africa and California indicate differential effects of resistance sources on aphid populations from different cowpea production areas. Cowpea lines IT97K-556-6, KvX295-2-124-99, an IITA wild donor line, UCR01-11-52/SARC1-57-2, and 58-77 representing a set of resistance donor genotypes plus known susceptible control lines were seed-multiplied and used in uniform screens in locations across all project NARS (Burkina, Ghana, Senegal) and California.

The uniform test design for the aphid resistance assessment was developed by the project team during 2013. We adopted a field–based screen developed in California. This is being used in conjunction with a screenhouse-based assay developed by SARI, Ghana in which 5 aphids are placed on a one-week-old seedling.

Leaf samples of over 200 individual plants from Thrips/Striga population were sent and received in good form at UCR for genotyping on the SNPs platform. The entire population have also been phenotyped for Thrips and Sriga at Manga station of CSIR-SARI

Results/Major Findings
A preliminary screening of some of these lines from our lab at Manga has shown different sources of genes for aphid resistance. The way forward is to confirm these and other sources of resistance and start a crossing program to pyramid these genes.

Four individuals out of 9 that were found with no Striga attachment also recorded Thrips population of 2, 6, 7 and 10 out of ten flowers sampled. These are currently being evaluated to validate the results and the five improved lines will be the recipients of these genes and markers are finally identified for these genes.

Conclusions/Recommendations
Collaboration in the characterization (molecular fingerprinting) of the aphid sampled from the different zones has been established with University of Illinoi. Samples of aphids, parasitic wasp, Thrips, Maruca and pod sucking bugs from the project site in Upper East Region have been sent to US for genotyping. The results from the different West African countries on the

project is expected to explain the variation in the performance of the different sources of aphid resistant cowpea lines in different zones.

Increasing access to Frafra Potato Germplasm Diversity by Farmers and Breeders in Ghana

Principal Investigator: Francis Kusi and Stephen K. Nutsugah
Collaborating Scientists: I Sugri, A. Peter, RAL. Kanton, M. Zakaria, S. Lamini
Estimated Duration; 3 years
Sponsors: WAAPP 2A
Location: Manga

Background Information and Justification
The frafra potato project seeks to out-scale integrated crop and pests management strategies to frafra potato growers. Increase frafra potato production by deploying elite varieties to farmers, increasing scale of production by stem cutting technology, to collect and document germplasm of frafra potato and multiplication and evaluation of frafra potato varieties with farmer participation. The activities carried out during the reporting period include multiplication of frafra potato germplasm, demonstrations to out-scale proven technologies for frafra potato production. Other activities include frafra potato morphological characterization, demonstration of planting frafra potato by stem cutting, farmer field school, field days. A survey was also conducted to identify current on-farm storage operations of Frafra potato and critically develop strategies to improve postharvest storage of the tubers. Postharvest handling and evaluation of storage methods to prolong the food quality of months after harvesting was studied.

Objectives

i. Provide training and extension services on integrated crop and pests management strategies to frafra potato growers
ii. Increase frafra potato production by deploying elite varieties to farmers
iii. Collection and documentation of frafra potato in areas identified as geographical gaps in collection
iv. Development of database of frafra potato germplasm
v. Multiplication and evaluation of frafra potato varieties with farmer participation

Expected Beneficiaries: Breeders, consumers, farmers, traders and transporters

Materials and Methods

i. A survey to identify current on-farm storage operations of Frafra potato and critically develop strategies to improve postharvest storage of the tubers.

ii. Germplasm Multiplication: Collections from PGRRI, farmers in Upper East and Upper West Regions were multiplied at Manga station of CSIR-SARI
iii. On-Farm Demonstration to out-scale proven technologies for frafra potato production to farmers.
iv. Frafra Potato Morphological Characterization, gathering data on agronomic and yield parameters.
v. Demonstration of planting Frafra potato by stem cutting. The technology was out-scaled to Frafra potato farmers as one of the means to solve the constraint of inadequate planting materials that has limited their scale of production.
vi. Farmer field school (FFS) and field days: the germplasm multiplication site and the demonstration site were used to organise field days and FFS to train the farmers.
vii. Postharvest handling evaluation: Post harvest evaluation is currently on-going at Manga station which is looking at different crop residues as storage materials and the use of partial evaporative cooler to extend the food quality of frafra potato months after harvest.

Results/Major Findings
Planting of frafra potato by stem cutting is one of the success stories of the project. The technology has been identified as one of the major means to solve the constraint of inadequate planting materials that has limited the scale of production of most of the farmer. There are also good number of farmers who are not into frafra potato farming just because of lack of planting materials. The technology on planting by stem cutting is therefore a major intervention towards increased Frafra potato production in Ghana.

The demonstration of the improved technologies for frafra potato production saw an increase in tuber yield of over 100% in the improved technology field over the farmer practice. The increased in tuber yield was as result of combined effects of recommended spacing, timely weed control, fertilizer application, pests and diseases management and timely harvesting

The survey found that storage in earth pots mixed with sorghum or millet husk is the dominant method. The small tubers are mixed with ash or millet husk or sorghum husk, put in airtight clay pots or gourds and stored in a cold room. The pot is open only prior to planting in the next season. The second dominant storage methods is where the setts are wrapped in a thatch mat and hanged under tree shade or under shade of summer hut. The nature of damage during prolong storage ranged from sprouting (41.1%), excessive shriveling (18.1%) and tuber rot (8.5%). Despite the high losses incurred, farmers use only indigenous methods to reduce losses.

A total of 51 germplasm of frafra potato were multiplied and characterised at Manga station during the reporting period. These were collected from Plant Genetic Resource Research Institute (PGRRI) Bunso, farmers in Upper East and Upper West regions. The data on morphological characterisation of these lines together with agronomic and yield parameters are being compiled for analysis. The project team anticipate to select at least 10 promising lines which will be critical evaluation in a participatory approach and release as variety. Ten demonstrations were established on-farm to demonstrate proven technologies for frafra potato production, planting by stem cutting was also demonstrated to the farmers. The farmers were trained on the demonstration plots using farmer field school approach. Field days were also held both at the demonstration sites and the germplasm multiplication site. A total of 2,525 farmers were reach out by the project during the reporting period.

Conclusions/Recommendations

Evaluation of postharvest handling and storage using different crop residues and storage under ambient temperature and under partial evaporative cooler condition are currently on-going. The preferred lines from the two regions and PGRRI will be put into participatory evaluation trials in the communities as part of the effort to release elite varieties for the farmers. The demonstration of the proven technologies, including the stem cutting propagation method will also be out-scaled to 20 communities.

PEARL MILLET IMPROVEMENT

Deployment of improved early maturing genotypes of Pearl millet to farmers

Principal Investigator: P. A. ASungre
Collaborating Scientists: R. A. L. Kanton, I Sugri
Estimated Duration: 5 Years
Sponsors: WAAPP 2A/SARI core
Location: Upper East Region

Background Information/Justification/Introduction:
Pearl millet is among the important staple cereals in northern Ghana. However, the lack of improved varieties and proper intensification systems led to a decline in pearl millet yields over the years. Research efforts in breeding stable, high yielding and disease resistant/tolerant varieties as well as appropriate agronomic packages are crucial if current production levels (<1 t/ha) are to be increased to meet the ever increasing demand for food in the region. Rainfall amounts on annual basis continue to fluctuate with souring temperatures due to climate change. The ability of pearl millet to reliably produce under hot, dry, low and erratic rainfall conditions on infertile soils of low water-holding capacity where other crops generally fail, makes it a better choice for the region. The CSIR-SARI has developed early maturing, insects, pests and diseases resistant pearl millet varieties which are being evaluated for subsequent release for production.

Objective:
To release and intensifying the promotion and utilization of improved pearl millet varieties developed by the CSIR-SARI.

Expected Beneficiaries:
Food and commercial farmers and input dealers of Upper East Region **.**

Materials and Methods:
Five (5) improved genotypes of early millet developed over the years using recurrent selection and subjecting the materials to very high selection pressures were used. These are Bongo Short head, Tongo Yellow, Arrow head, Bristled head and SOxSAT. Manga nara was used as a local check. A complete dossier on all five improved genotypes developed over five years and tested across all the districts of Upper East region was compiled following the required guidelines was subjected to intense editing and critique to ensure that the document could stand the test of time. The dossier contained information on morphological characteristics, economic importance, sensory evaluation, preference by farmers and proximate analysis among others.

One acre each of breeder seed field of the proposed genotypes was planted at the Manga station during the 2014 cropping season. This was done following the recommendation that seed field should be at least 30 meter apart to prevent cross pollination or contamination. The seeds will be made available to selected seed growers in the region for multiplication for increased seed production.

Major finding/Results

The complete dossier was submitted to the NVRRC as part of the requirement for inspection 24th September 2014. Issues that were pointed out during the first visit were addressed and presented again on the 30th March 2015 for final inspection.

Breeder seeds of all five candidate genotypes (SOXSAT, Arrow, Tongo Yellow, Bongo Short-head and Bristled head) and three late millet lines (Langbense, Salma I and Salma III) were processed and stored at Manga.

Table 82: *Breeder seed production in 2014 at Manga*

Genotype	Breeder seed produced (Kg)
Bongo Short-Head	56
Tongo Yellow	98
Bristled Long-Head	72
Arrow Head	54
SOxSAT	48
Salma I	45
Salma III	51
Langensi	41
Total Seed	**465**

Conclusion/Recommendation

Final inspection fields were established in Manga during the 2015 cropping season. It was expected that the NVRRC would visit the field in July, 2015 for the final inspection and recommendation for release. The outcome would pave the way for breeder seed of the improved genotypes to be produced each year to meet the demand of farmers and seed growers.

Evaluation of Pearl millet hybrids for adaptation to the semi-arid agro-ecology of northern Ghana

Principal Investigator: Asungre Anabire Peter
Collaborating Scientists: IDK Atokple, SK Nutsugah, K Oboubi, and RAL Kanton
Estimated Duration: June, 2012 - December, 2014
Sponsors: SARI & Sugars Project
Location: Manga and Nyankpala

Background Information/Justification/Introduction:
Pearl millet is one of the most important cereal crops in the Upper East Region of Ghana where it serves as a hunger-breaker immediately after the long dry season and is the only cereal that reliably provides grain and fodder under dry conditions on shallow, acidic and sandy soils with low fertility and low water holding capacity. Over the years, farmers have been growing their local materials which have lost their potentials due to long period of use without improvement. Hybrid millets have not been used in Ghana as a way to mitigate the poor performance of the open-pollinated varieties (OPV) farmer variety. Pearl millet breeding in Ghana has concentrated on the development of OPVs. A new initiative is underway to evaluate hybrids adapted to the West African sub region as these are likely to have at least 25-30% grain yield advantage over OPVs (Andrews and Rajewski 1990, 1991; Dave 1986). It was therefore in the light of this that this evaluation was carried out.

Materials and Method:
The experimental materials were GB 8735, ICTP 8203, Tabi-B9, NBH 4599, NBH 4903 and Bongo Short Head (check). The experimental design was Randomized Complete Block with 4 replications. Bullocks were used to ridge the experimental field during land preparation. The plots consisted of 6 rows of 5 m length. Inter-row spacing was 0.75 m and intra-row spacing was 0.30m. Four to six seeds were planted per hill and later thinned to one plant per hill to obtain a plant population density of approximately 44,445 plants/ha. Split application of fertilizer was done at a rate of 40 kg N/ha and 30 kg P_2O_5 and 30 kg K_2O per hectare. Some standard agronomic practices and data as recommended for pearl millet production in Ghana were strictly adhered to and included growth and development, yields and pests and diseases data.

Major Findings/Results: All materials except GB 8735 showed resistance to downy mildew disease which was significant in 2013 (Fig. 29).

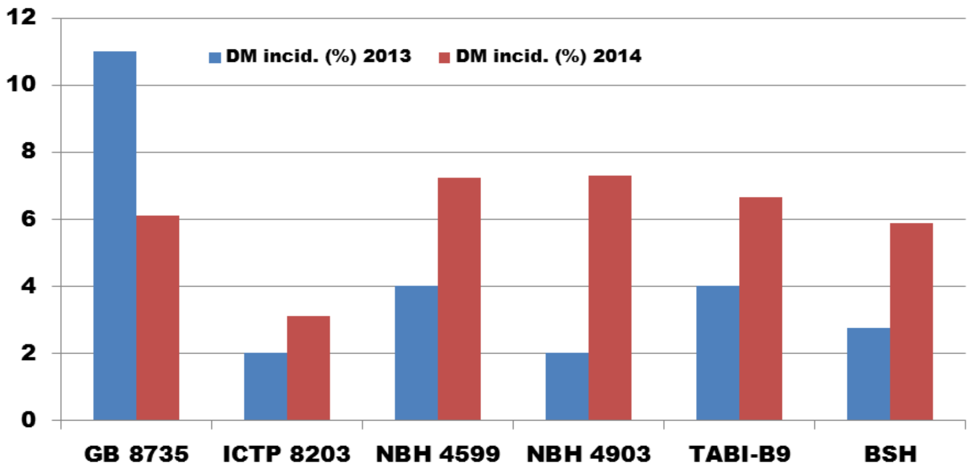

Figure 33: Response of the material to Downy mildew incidences over two years in Manga

However, in 2014 ICTP 8203 had significantly lower incidence compared with all the others. The introduced materials were not significantly different from the local check for the trait of downy mildew resistance even though the hybrids tended to show more incidence than the rest in 2014 season. On the average, all the materials including the check showed resistance to downy mildew over the two year period even though GB 8735 recorded an average value above 10% in the 2013 season. In 2013, TABI-B9, NBH 4903 and ICTP 8203 had seed size less than 10 cm while in 2014 it was only NBH 4903 (Table 75). Again NBH 4903 and ICTP 8203 were similar in grain size but different from the others while mean grain yield for TABI-B9 was significantly lower than the others.

Andrews and Rajewski (1990, 1991) and Dave (1986), report that good hybrids will yield 20 to 30% more than the best open-pollinated cultivars of comparable maturity. Grain yield levels of up to 5.3 t/ha have been recorded for hybrids (Christensen et al. 1984). All the others did not show significant variation in grain yield among themselves in 2013. However the yields for all the materials were low in 2014, recording yield less than one ton per hectare except the two hybrids. Since 2012 NBH 4599 (2.1, 1.7 & 1.1t/ha) and NBH 4903 (2.6, 1.6, & 1.0t/ha) have consistently recorded yield above one ton per hectare. The results indicate that these two hybrids can compete favourably with the improved local check for grain and stover yields, and thousand seed weight (Tables 75).

Table 83: *Performance of hybrid millet under the ecology of northern Ghana*

Var/Year	Grain yield/ha (kg)	Grain yield/ha (kg)	1000 seed wt (g)	1000 seed wt (g)	Panicle girth (cm)	Panicle girth (cm)	Panicle length (cm)	Panicle length (cm)
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
GB 8735	1468	958	10.99	11.11	8.98	9.30	22.23	24.85
ICTP 8203	1297	938	7.92	10.11	7.08	7.75	31.98	27.15
NBH 4599	**1709**	**1108**	**10.50**	**11.64**	**10.23**	**9.35**	**23.90**	**24.70**
NBH 4903	**1555**	**1000**	**9.05**	**10.46**	**9.60**	**9.40**	**25.85**	**26.40**
TABI-B9	727	650	7.75	9.15	6.38	6.55	34.00	34.75
BSH	1773	1246	11.97	10.81	11.15	10.45	12.03	16.15
Mean	*1421*	*983*	*9.70*	*10.54*	*8.90*	*8.80*	*25.00*	*25.67*
Lsd (0.05)	*515***	*ns*	*1.42***	*ns*	*0.64***	*1.12***	*4.22***	*5.55***
CV%	*24.1*	*25.5*	*9.7*	*19.5*	*4.7*	*8.4*	*11.2*	*14.4*

Conclusions/Recommendations
The results have clearly shown the impressive performance of the hybrids NBH 4599 and NBH 4903. Their superior grain yield can be further tested on-farm to validate the results and possibly recommended for release.

Preliminary Yield Trials for Early, Medium & Late maturity groups

Principal Investigator: PA Asungre
Collaborating Scientists: F Kusi, S Lamini, RAL Kanton
Estimated Duration: 3 Years
Sponsors: WAAPP 2A
Location: Manga Research station

Background Information and Justification: In 2010, a total of 126 pearl millet germplasm was collected throughout Upper East, Upper West and Northern regions of Ghana. Initial characterisation was done in 2011 and 2012. 30 core selection of the accessions were put into early, medium and late maturity groups for further characterization and evaluation work on-station under Preliminary Yield Trials at the Manga station.

Objective: To evaluate the available pearl millet landraces adoption by farmers

Expected Beneficiaries:
Food and commercial farmers and input dealers of Upper East region and other interest groups as well as neighbouring countries.

Materials and Method
Thirteen genotypes each of the early, medium and late maturity groups constituted from the 2011 characterisation work, were composed into three different trials based on maturity groups. The experimental design was Randomized Complete Block with 2 replications. Bullocks were used to ridge the experimental field during land preparation. The plots consisted of 4 rows of 3 m length. Inter-row spacing was 0.75 m and intra-row spacing was 0.30m. Split application of fertilizer was done at a rate of 40 kg N/ha and 30 kg P_2O_5 and 30 kg K_2O/ha.

Major Findings/Results:

PYT – Early maturity group
The results (Table 76) show that there were no significant differences among the genotypes in respect of threshing per cent. However downy mildew incidence (%), grain yield, panicle girth and thousand seed weight all were highly significant. The improved genotypes tended to record relatively lower values of downy mildew than the accessions though not statistically significant. Again Bongo Short head, SOXSAT and Tongo Yellow gave average yields above one ton per hectare. One of the accessions failed to germinate after a number of refilling.

PYT – Medium maturity group
The medium maturity group did not show any statistical difference among the accessions for traits such as downy mildew, grain yield, panicle length, thousand seed weight and threshing per cent (Table 77). Seven out of the thirteen accessions had average grain yields above thousand kilograms. All the accessions with grain yield values less than thousand kilograms recorded values less than the overall average of 937 kg ha^{-1}. SARMIL 095, with the least yield value of 341 kg ha^{-1} also had the least threshing percentage of 34.40%. Except SARMIL 05 whose thousand seed weight was less than 10g (9.86), all other accessions had values ranging from 10.66g for SARMIL 09 to 12.94g for SARMIL 124. The range for Panicle length was 21.5 cm and 26.8 cm with an overall mean of 23.8 cm.

PYT – Late maturity group
With the late group it was observed that except for grain yield and panicle length, there were no significant differences among the accessions for downy mildew, thousand seed weight and threshing percentage (Table 78). Grain yield among the accessions showed varied levels of significance with yields as low as 528 kg ha^{-1} (SARMIL 024 and SARMIL 036) to as high as 2,222 kg ha^{-1} (SALMA III). Except for SARMIL 024 which had downy mildew incidence of 19.3%, all the others had values less than 10.0%. The three improved late millet genotypes (Langbense, Salma I & III) all had grain yield values of 2000 kg ha^{-1} and above.

Table 84: *Performance of Early maturing group in 2014 at Manga*

	Genotype	DM Incidence %	Grain Yield per ha (kg)	Panicle girth (cm)	1000 Seed Weight (g)	Threshing %
1	SARMIL 077	15.18	128	6.94	13.5	41.7
2	SARMIL 085	11.02	235	10.77	15.7	58.2
3	SARMIL 092	10.16	151	10.6	14.4	38.9
4	SARMIL 102	9.79	512	8.3	14.4	56
5	SARMIL 104	8.15	517	12.56	18.7	61.7
6	SARMIL 113	10.93	99	8.34	13.2	50.5
7	Arrow	3.77	666	8.32	12.3	60.4
8	Bristled	2.82	653	11.36	16.8	47.3
9	BSH	3.65	2018	11.33	13.1	67.6
10	SS	2.19	1008	9.29	12.8	55
11	TY	2.92	1762	11.47	18.7	71.9
12	FV	3.81	906	11.83	16.5	63.3
	Grand Mean	*7.3*	*721*	*10.04*	*17.34*	*56*
	LSD(0.05)	*3.91***	*674.7***	*2.263***	*2.57***	*NS*
	CV%	*25.2*	*42.5*	*10.2*	*6.7*	*18.2*

****=p<0.01, *=p<0.05, ns=Not Significant, BSH=Bongo Short Head, SS=SOXSAT, TY=Tongo Yellow, FV=Farmer Variety**

Table 85: *Performance of Medium maturing group in 2014 at Manga*

	Genotype	DM Incidence %	Grain Yield per ha (kg)	Panicle Length (cm)	1000 Seed Weight (g)	Threshing %
1	SARMIL 02	4.72	1381	26.8	10.88	43.7
2	SARMIL 05	7.76	792	24.4	9.86	52.7
3	SARMIL 09	4.39	1009	23.4	10.66	40.4
4	SARMIL 110	7.72	803	22	11.18	51.9
5	SARMIL 121	11.74	398	24.5	12.83	42.5
6	SARMIL 124	7.87	903	23.4	12.94	54.4
7	SARMIL 016	4.13	1100	25.4	10.98	59
8	SARMIL 044	6.61	1107	21.8	12.48	57.4
9	SARMIL 053	7.03	706	21.5	10.09	47.8
10	SARMIL 070	3.88	1441	23.8	11.88	55.4
11	SARMIL 082	3.7	1004	22	12.29	54.8
12	SARMIL 091	6.12	1194	27.8	12.21	51.4
13	SARMIL 095	4.18	341	22.6	11.15	34.4
	Grand Mean	*6.14*	*937*	*23.8*	*11.49*	*49.7*
	LSD(0.05)	*NS*	*NS*	*NS*	*NS*	*NS*
	CV%	*39*	*34.6*	*15.4*	*16.3*	*18.4*

****=p<0.01, *=p<0.05, ns=Not Significant**

Table 86: Performance of Late maturing group in 2014 at Manga

	Genotype	DM Incidence %	Grain Yield per ha (kg)	Panicle Length (cm)	1000 Seed Weight (g)	Threshing %
1	LANGBENSE	3.0	2111	23.30	9.70	56.9
2	SALMA I	3.6	2000	25.30	11.75	55.0
3	SALMA III	2.2	2222	25.75	10.84	60.1
4	SARMIL 024	19.3	528	20.25	10.89	40.4
5	SARMIL 026	3.8	1167	24.00	11.09	53.9
6	SARMIL 036	6.1	528	16.80	7.09	45.8
7	SARMIL 050	4.9	1583	24.80	9.18	50.8
8	SARMIL 054	9.2	1000	28.20	9.85	54.4
9	SARMIL 060	3.5	1222	21.90	8.49	30.0
10	SARMIL 064	7.6	878	22.20	11.26	52.9
11	SARMIL 069	4.9	583	24.70	10.18	43.6
12	SARMIL 074	5.2	611	22.60	10.70	40.8
13	SARMIL 084	8.3	1017	23.50	10.29	59.7
	Grand Mean	*6.3*	*1188*	*23.33*	*10.10*	*49.6*
	LSD(0.05)	*NS*	*1005.4**	*4.91**	*NS*	*NS*
	CV%	*94.4*	*39.2*	*9.7*	*13.7*	*21.5*

**=p<0.01, *=p<0.05, ns=Not Significant
**=p<0.01, *=p<0.05, ns=Not Significant, BSH=Bongo Short Head, SS=SOXSAT, TY=Tongo Yellow, FV=Farmer Variety

Conclusion/Recommendations :

The results indicate that the improved early and late genotypes are superior to the core selection from the accession. However, there are traits that can be explored from the core selection for further breeding purposes. The medium maturity group has a good number of accessions with yield potentials that can be advanced further through selection against downy mildew. The three late maturing genotype (Langbense, Salma I & Salma III) are being prepared for on-farm evaluation during the 2015 cropping season.

Breeding Local Pearl millet varieties for resistance to diseases and bird attacks

Principal Investigator: PA Asungre
Participating Scientists: RAL Kanton, S Lamini, F Kusi, I Sugri
Estimated Duration: 6 Years
Sponsors: SARI Core and WAAPP 2A
Location: Upper East Region

Background Information and Justification
Bird and Insect attack on Pearl millet has been a major hindrance to large scale production of the crop in the its natural ecology. As an early maturing crop that often matures in July-August every year, it is prone to bird and insect attack due to unavailability of feed for such pests at the time. To be able to overcome this problem, a breeding programme was started to introduce the bristle trait found in one local genotype, which has been prepared for release in the region into some other genotypes. These other genotypes have equally good traits and are accepted by most farmers in the region.

Objective: To Develop varieties resistant/tolerant to abiotic and biotic factor militating against millet production in the region

Expected Beneficiaries:
Pearl millet breeders and curators and other interest groups within and outside Ghana.

Materials and Method: Using Full sib and half sib crosses, a number of F1 were generated form BSH x Bristled head and Soxsat x Bristled head. The work is transfer the bristle trait to the BSH and Soxsat genotypes. Some of the desired F1 plants were used to backcross with the parents to generate new populations. These are being screened through selection to come out with the best five for further evaluation

Results and findings:

1. The F5s (BSH x Bristled) are going through segregation process as part of getting disease resistant and high yielding millet varieties for adoption by farmers. This process will continue till a fairly stable population is achieved with the bristles fixed on the heads

2. Backcross work on F2 seeds (bristled SOXSAT) of Bristled x SOXSAT to produce BC1 using both half-sib and full-sib methods completed and seed harvested. Another cycle to produce BC2 under irrigation is on-going at the Manga station. The essence is introgress to bristle trait into the SOXSAT variety to control bird and insect attack
3. A new population of brown-seeded BSH is at the F3 stage as well

Conclusion/Recommendations: The Breeding programme is on-going as it is a process through which new and interesting traits can be discovered for more break-through in breeding work. Some of the line would be subjected to intensive selection pressure to come out with good materials for evaluation and further testing.

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POST HARVEST

Participatory evaluation of some improved storage methods to reduce postharvest losses in maize and cowpea

Principal Investigator: I. Sugri
Participating Scientists: M. Abubakari, A. Larbi, S.S.J. Buah, S.K Nutsugah, M. Zakaria
Start Date: June 2013
Estimated Duration: 3 Years
Sponsors: IITA/Africa Rising
Location: Upper East and Northern Region

Introduction
Insect pests continue to be a major constraint in the production of food and fibre crops. Attack of these pests can result in complete crop failure if not properly managed. Most of the insects in storage are carried over from the field due to delayed harvesting, poor drying and handling at storage. Stored-product arthropods can cause serious postharvest losses up to 20% if the produce is not properly conditioned for storage. These losses represent a huge mass of grain that could be made available for food without use of additional land, seed, labour, water and other inputs. Most storage methods are unable to protect the produce from biological, physical and environmental hazards such as insect pests, rodents, disease pathogens, water imbibition and fire, among others. These pests therefore have to be controlled for improved yields and quality in order to improve income and livelihood of farmers.

Objective: To conduct participatory on-farm evaluation of different storage methods and grain protectants for prolong storage of maize and cowpea.

Beneficiaries : The study was expected to deploy and disseminate some improved methods to farmers in order to reduce on-farm storage losses. The communities include Bonia, Tekuru and Samboligo in the Upper East region (UER) and Gbanjong, Tibognaayili, Duko and Tabali in Northern region (NR).

Materials and Methods
A total of 21 experimental set ups consisting of 12 farmers from 4 communities in Northern Region (NR) and 9 farmers in Upper East Region (UER) were established. Initial samples were obtained and subsequent sampling was conducted in February, May 2014 and November, 2014. Data collected included moisture content, weight and number of damaged and undamaged grains for calculating weight loss, and insect count.

Results
Losses in maize
The estimated postharvest losses (%) of maize after 12 months of storage in NR and UER are summarized in Tables 79 and 80 respectively. After 4 months of storage, grain stored in PICS

sacs and plastic drums recorded no or very minimal damage. By 12 months after storage across communities, grain stored in PICS sacs and plastic drum recorded similar low losses (%). High losses were observed in the jute sacs irrespective of the method of grain protection across locations and communities. The treatment effect showed no significant difference between phostoxin and actellic, but the two types of protection were consistent better the control. Some variation in losses was noticed between Northern and Upper East regions. Weight loss in jute sacs, the common method of storage ranged from 39.5 to 77.2% at 12 MAS across communities in NR. Somehow lower range of 0.95 to17 % was recorded at 12 MAS in the UE.

Table 87: *Estimated postharvest losses (%) in maize after 12 months of storage in UE region*

Storage method	**Type of grain protection**	**Communities**			**Total**
		Bonia	Tekeru	Samboligo	
Jute sacs	Control	6.64	1.08	17.94	8.55
	Actellic Supper	0.95	0.39	0.56	0.63
	Phostoxin	0.46	2.08	7.56	3.37
PICS sacs	Control	1.38	0.1	0.4	0.63
	Actellic Supper	0.37	0.93	0.14	0.48
	Phostoxin	0.27	0.89	1.18	0.70
Plastic drum	Control	0.07	0.31	1.70	0.69
	Actellic Supper	0.37	1.2	0.56	0.66
	Phostoxin	0.00	0.87	7.56	0.38
		1.15	0.87	3.35	1.79
LSD 0.05 (Community * Storage method * protection)= NS					

Table 88: *Estimated postharvest losses (%) in maize after 12 months of storage in Northern Region*

Method of storage	**Method of protection**	**Communities**			
		Botingli	Gbanjong	Tibali	Tiborgnayili
Jute	Control	69.8	75.6	39.5	70.5
	Actellic	72.6	74.4	61.8	67.2
	Phostixin	76.3	77.2	56.5	69.7
PICS	Control	0.00	0.50	0.00	0.29
	Actellic	0.19	0.20	0.50	0.19
	Phostixin	0.00	0.19	0.00	0.23
Plastic drums	Control	0.00	0.31	0.40	0.19
	Actellic	0.00	0.30	0.00	0.21
	Phostixin	0.00	0.30	0.00	0.70
	LSD 0.05 (Community * Storage method * protection)= 4.5				

Losses in Cowpea

The extent of reduction in postharvest losses (%) of cowpea after 12 months of storage is summarized in Tables 81 and 82. The results and trend of infestation were similar to the study involving maize. Overall, the method of storage was the most critical determent of grain quality after the 12 months period. By 12 months after storage across communities, grain stored in PICS sacs and plastic drum recorded low losses of 0.00 to 18.2%. Across communities high losses (46.1 to 99.9 %) were observed in the jute sacs irrespective of the method of grain protection. The treatment effect showed no significant difference between phostoxin and actellic, but the two types of protection were consistently better than the control. The high losses (up to 18 %) in the two hermitic method (PICS sacs and plastic drums) could be due to pre-storage infestation which is related to poor pre-harvest operations including delayed harvesting and inadequate drying.

Table 89: *Estimated postharvest losses (%) in cowpea after 12 months of storage in UE region*

Storage method	Type of grain protection	Communities			Total
		Bonia	Tekeru	Samboligo	
Jute sacs	Control	99.9	99.9	17.7	72.3
	Actellic Supper	73.8	72.4	46.1	64.1
	Phostoxin	95.0	62.3	62.3	73.2
PICS sacs	Control	8.4	9.8	3.94	7.37
	Actellic Supper	5.02	0.22	5.12	3.45
	Phostoxin	0.26	0.24	4.2	2.94
Plastic drum	Control	8.3	7.3	13.2	34.5
	Actellic Supper	7.6	0.25	0.37	2.8
	Phostoxin	0.26	0.26	2.62	1.1
		22.6	15.5	17.3	29.1
	LSD 0.05 (Community * Storage method * protection)= NS				

Table 90: *Estimated postharvest losses (%) in cowpea after 12 months of storage in Northern Region*

Method of storage	Method of protection	Communities			
		Botingli	Gbanjong	Tibali	Tiborgnayili
Jute	Control	72.8	78.1	60.2	72.3
	Actellic	74.4	74.4	52.8	76.5
	Phostixin	72.9	57.8	71.1	68.5
PICS	Control	0.00	5.8	2.7	1.0
	Actellic	0.00	11.4	0.00	12.1
	Phostixin	0.00	7.0	0.00	10.9
Plastic drums	Control	0.00	9.2	6.8	17.9
	Actellic	0.00	10.5	0.00	18.2
	Phostixin	0.00	4.1	5.5	0.00
	LSD 0.05 (Community * Storage method * protection) = 6.62				

Conclusion

To a large extent therefore, the method of storage was the most critical determent of grain quality after the 12 months period. The response of the two hermitic method (PICS sacs and plastic drums) suggest the critical role of good pre-harvest operations and clean grain prior to storage. Grain infestation in hermitic storage units is highly related to pre-storage grain quality. It appears that programmes initiated by the Ministry of Food and Agriculture (MoFA) to develop long term programmes to assist farmers to reduce storage losses through dissemination of improved postharvest technologies have several challenges. Our interactions showed that farmers were aware of the peculiar high losses in cowpea storage, but they showed generally poor knowledge of the appropriate control strategy to adopt. Ongoing programmes such as the IITA- Africa Rising Project and WAAPP2A may need to provide access to particularly PICS sac to reduce current on-farm losses in the intervention communities

Prevalence study for aflatoxins contamination in maize and groundnut in farm stores

Principal Investigator: I. Sugri
Participating Scientists: M. Osiru, A. Larbi, S.S.J. Buah, S. Lamini, Y. Asieku
Start Date: June 2013
Completion Date: June 2014
Sponsors: ICRISAT/IITA/Africa Rising
Location: Upper East and Upper West Regions
Collaborating Institutions: CSIR-SARI, IITA/ICRISAT/Africa Rising, MoFA

Introduction
Maize and groundnut are essential component of the diet for many households in Ghana. However, aflatoxin contamination in maize and groundnut grain is still a major food safety concern due to a myriad of pre-to-postharvest factors. Aflatoxin contamination in grain is considered as a major non-tariff barrier to international trade since agricultural products that exceed the permissible levels of contamination (4-15ppb) are banned. About $1.2 billion in commerce is lost annually due to AF contamination, with African economies losing $450 million each year (IITA, 2013). The fungi responsible for the production of toxins are mainly *Aspergillus flavus*, *A. parasiticus* and *A. nomius* (Waliyar *et al*., 2008). Factors influencing high incidence of aflatoxins include poor agricultural practices during planting, harvesting, drying, transportation and storage (Moss, 1998). The extent of contamination may vary with geographic location, agronomic practices, and the susceptibility of commodities to fungal invasion during pre-harvest, storage, and/or processing operations.

Objective: To assess aflatoxin contamination in maize and groundnut value chain in order to determine consumer risk to aflatoxins in Ghana.

Materials and methods
The study was conducted in 6 districts in the Upper East and Upper West Regions of Ghana from November to December 2013 to assess AF levels under farmer storage conditions. A total of 240 respondents in 24 communities were covered, and grain maize (240 samples) were obtained for AF analysis. Grain samples (240 samples) were obtained from farmer storage

units: granaries, cribs, barns, bags or silos of the respondents. The samples, each weighing up to 50-100g, were analysed for total aflatoxin at the Plant Pathology Laboratory of ICRISAT, Mali, using the Indirect Enzyme Linked Immunosorbent Assay (ELISA) method.

Results

Aflatoxin prevalence in maize

Generally, wide variations within and across communities and districts was noticed (Fig. 31). Though no regional variation was noticed, AF prevalence in Garu-Tempane and Wa-West districts was generally high compared to counterpart districts. The general range was from 0.011 to 308ppb. Overall proportion of samples based on various standards for safe limits of total AF (ppb) is summarized in Table 83. Using various standard limits, up to 189 samples (78.8%) fell within EU Standards of <4ppb, 220 samples (91.7%) fell under USA Standards of <15ppb and 224 samples (92.9%) had AF levels within safe limits by the WHO Standard of <20ppb. However, these samples were obtained within 2 months after harvest.

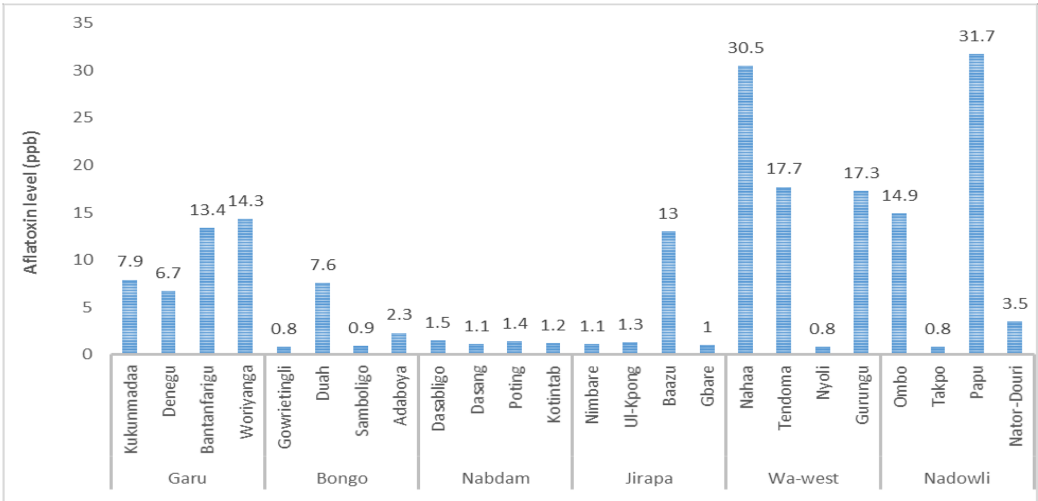

Figure 34: Afflatoxin prevalence (ppb) in maize samples from 24 communities

Table 91: *District analysis of the proportion of samples considered safe for consumption based on various safe limits for total aflatoxins (maize)*

Districts	EU Standard (<4ppb)	USA Standards (<15ppb)	WHO standards (<20ppb)	Animal Feed (20 to 100ppb)	Excessive Levels (> 100ppb)
Bongo	33 (82.5)	38 (95)	39 (97.5)	1 (2.5)	-
Garu-Tempane	11 (27.5)	33 (82.5)	34 (85)	6 (15)	-
Nabdam	40 (100)	40 (100)	40 (100)	-	-
Jirapa	38 (95)	39 (97.5)	39 (97.5)	-	1 (2.5)
Nadowli	37 (92.5)	37 (92.5)	37 (82.5)	1 (2.5)	2 (5)
Wa-West	30 (75)	33 (82.5)	34 (85)	3 (7.5)	3 (7.5)
Total Freq.	189	220	223	11	6
Overall (%)	78.8	91.7	92.9	4.6	240

(a) Values in parenthesis are valid percentages (%) of responses; (b) number of respondents was 40 per district; (c) 240 samples were collected in November to December 2013; about 4-8 weeks after harvest.

Aflatoxin prevalence in groundnut

A similar trend was noticed in groundnut across communities and districts (Fig. 32). The prevalence range was from 0.2-1546.9ppb with wide variations occurring within and across communities and districts (Table 84). Based on various standards for safe limits of total AF (ppb), up to 173 samples (72.1%) fell within EU Standards of <4ppb. Another 216 (89.6%) samples fell under USA standards of <15ppb. Cumulatively, 223 samples (92.9%) had AF levels within safe limits by the WHO Standard of <20ppb. However, these samples were obtained in less than 2 months after harvest.

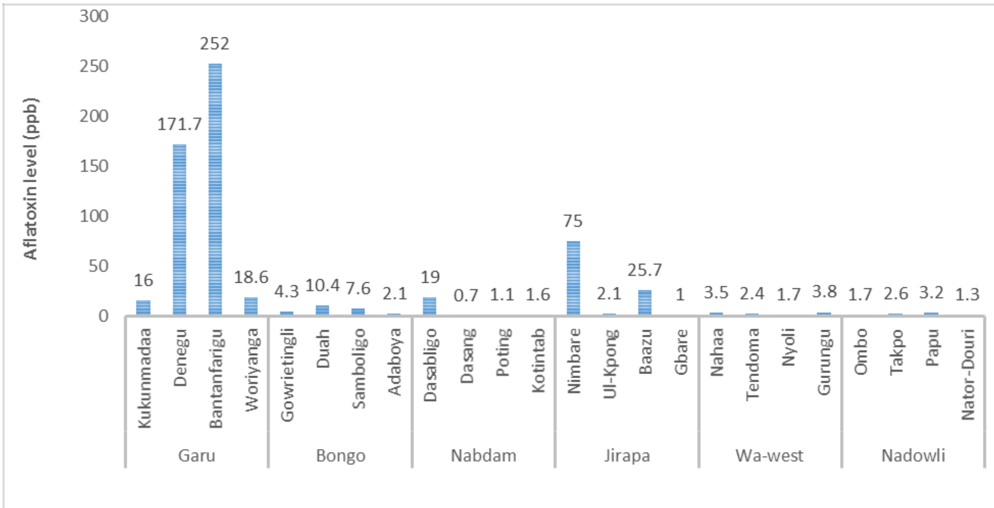

Figure 35: Afflatoxin prevalence (ppb) in groundnut samples from 24 communities

***Table 92**: Proportion of total aflatoxins based on various standards (groundnut)*

District	EU Standard (up to 4ppb)	USA Standards (up to 15ppb)	WHO standards (up to 20ppb)	Animal Feed (up to 100ppb)	Excessive Levels (> 100ppb
Bongo	26 (65)	38 (95)	38 (95)	40 (5)	
Garu-Tempane	3 (7.5)	21 (52.5)	27 (67.5)	9 (22.5)	4 (10)
Nabdam	39 (97.5)	40 (100)	-	-	-
Jirapa	35 (87.5)	38 (95)	-	-	2 (5)
Nadowli	38 (95)	40 (100)	-	-	-
Wa-West	32 (80)	39 (97.5)	40 (100)	-	-
Freq.	**173**	**216**	**223**	**11**	**6**
%	**72.1**	**89.6**	**92.5**	**4.6**	**2.9**

(a) Values in parenthesis are valid percentages (%) of responses; (b) number of respondents was 40 per district; (c) 240 samples were collected in November to December 2013; about 4-8 weeks after harvest.

Conclusion

Integrated approaches consisting of food safety awareness campaigns and strengthening collaboration among stakeholders in maize/groundnut value chains will be necessary to achieve reasonable success. . Although quite substantial information exist on risk of AF, the respondents did not generally perceive AF as a critical food safety issue. This is contrary to the several fragmented projects on AF management which were being implemented by different agencies in those districts. Thus requiring the need for greater collaboration among the partners to achieve considerable progress in this regard. The Food and Drugs Board, the main food regulatory agency in Ghana, should be strengthened to provide periodic testing for AF in grain markets in addition to food safety education.

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SOCIO-ECONOMICS

Quality Rice Development Project (QRDP)

Principal Investigator: John Kanburi Bidzakin
Participating Scientists: Wilson Dogbe, Williams Atakora, S. K. Nutsugah, Julius Yirzagla, Michael Maweya, Isaah Sugri and Inusah Baba
Estimated Duration: 36 months (January 2014 – December 2016)
Sponsors: AGRA
Location: Northern and Upper East Regions

Objectives
The goal of the project is to contribute to the Government of Ghana's objectiv e of achieving food security and improved livelihood of smallholder farmers in the rice value chain by strengthening their capacity for sustainable and competitive quality rice production.

The specific objectives of the project are: (i) To increase productivity of rice in smallholder farming systems in the Northern and Upper East Regions of Ghana**,** (ii) Strengthen institutional and organizational capacity of Farmer Organizations (FBOs) to enhance access to services and (iii) To increase marketing of locally produced rice by smallholder farmers in the Northern and Upper East Regions.

Materials and Methods: To achieve these objectives, Farmers will be trained in good agricultural practices (GAP) including ISFM using demonstrations. Further, farmers will be sensitized and trained on the benefits to be derived from using high quality premium rice variety seeds. They will be linked to sources of quality seeds and other inputs. Access to appropriate financing for farmers will be given important consideration in the project. Value chain financing through partnership with aggregators and processors offers a good opportunity. In order to improve the quality of milled rice and hence its price, farmers will be linked to aggregators and processors and trained in post-harvest handling, processing, branding and packaging of rice. In undertaking project activities, the inclusion of women at different levels of the rice value chain is crucial to food security and the increase of family income.

CSIR-SARI, AMSIG Resources and TRIAS Ghana are the main partners to implement this project with each partner addressing one objective. CSIR-SARI who will lead the project will also address issues related to objective 1 that includes access to quality seeds, building the capacities of farmers in good agronomic practices for quality rice production and creating awareness on Integrated Soil fertility management (ISFM). TRIAS will deal with Farmer Organization capacity building issues in objective 2 and AMSIG Resources will address market related issues in objective 3 including post-harvest management, processing and marketing. The project will work with other partners like Premium food, Irrigation Company of Upper Region (ICOUR), Bontanga irrigation Nucleus Farmers and FBO's with at least 10,000 farmers, aggregators, rice processing companies, and local rice marketers along the rice value chain. The project will use the following promising models

Results/Major Findings

Objective One: To increase productivity of rice in smallholder farming systems in the Northern and Upper East Regions of Ghana

- Forty-four On-farm demonstrations fields were established
- All demonstration sites were visited and soil sampling done
- 2870 farmers in 18 project communities were trained on GAP
- Trained 10 Scientist and 15 AEAs on Rice Advice Software
- Identification and production of 2200 extension materials
- Identify 4 quality seed producers and distributors and linked them to farmers
- Created awareness on the importance and the profitability of the use of quality seeds and other inputs through field demonstrations and community video shows (1841 farmers participated)

Objective Two: Strengthen institutional and organizational capacity of Farmer Organizations (FBOs) to enhance access to services

- 144 FBOs comprising of three thousand six hundred and eighteen farmers (3,618) were profiled
- Needs assessment of FBOs was carried out to identify capacity gaps
- Formation of apex (district level) rice producer groups in Bontanga and Golinga schemes
- Training of apex Leadership on FBO Management
- Training of Trainers (TOT) on Group Development and Leadership Dynamics
- Community level training of Group Executives on Group Development and Leadership Dynamics
- Facilitate the formation and strengthening of women rice processors groups
- Training of processors on group development and leadership dynamics
- Training of Trainers (TOT) in Business Development Services and Financial Management
- Community level training of Group Executives on Business Development Services and Financial Management
- Provide technical assistance to RCBs to design adapted and appropriate financial products for FBOs

Objective Three: To increase access to market for locally produced rice by small holder farmers in the Northern and Upper East Regions

- Trained Farmers On Improved Harvesting, Post-Harvest, Storage Techniques and Quality Management
- Training of Rice Farmers in favorable lowland and Irrigation Sites
- Facilitation of Access to Post-Harvest Management Equipment
- Train Aggregators, FBOs, and Processing Units on the use of ESSOKO and MFarms as a Management Tool
- Identify and Select Sites for Aggregation Points in Consultation with FOs and Processors

- Trained Farmers in Contracting, Collective Marketing and Piloted the E-Zwich Payment System
- Training in inventory credit and Warehouse receipt system
- Trained Producers and marketers in collective Agricultural marketing and distribution
- Training in procurement and contracting
- Training in Packaging and Branding
- Training in Improved Parboiling Methods

Conclusion:
We will continue with this activities in the next quarters and also expand our activities by bringing on board more communities to benefit from the project. Two small scale enterprises involved in rice processing capacities will be enhanced by supporting them with two 1.5MT/Hour rice mills.

UPPER WEST REGION FARMING SYSTEMS RESEARCH GROUP

The Upper West Region Farming Systems Research Group (UWR-FSRG) is based at the CSIR-SARI Wa Station in the Wa Municipality. Currently the team has a membership of three research scientists, Soil Scientist, Entomologist and Agricultural Economist. The team's work focuses on characterizing and describing the farming systems of the region, identifying and prioritizing constraints to increase sustainable agricultural production and generating suitable interventions to address the prioritized problems of the farmers through adaptive on-farm as well as on-station research. Besides, the team also has oversight responsibility of coordinating the Research, Extension and Farmer Linkage Committee (RELC) activities in the UWR. This report highlights activities carried out during 2014 cropping season.

AGRONOMY

Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in cowpea-maize rotations

Principal Investigator: S.S. J. Buah
Collaborating Scientists: Asamoah Larbi (IITA/Africa RISING-Ghana)
Estimated Duration: 2013-2016
Sponsors: IITA/Africa RISING
Location: Goriyiri, Nadowli District, Upper West Region

Background Information and Justification
Crop rotation involving cereals and grain legumes has been shown to increase grain yield, alter soil stored water, increase soil N, improve soil physical properties (Bagayoko *et al*., 1992; Gakale and Clegg, 1987), and reduce yield variability. Organic nutrient resources such as manure has been showed to improve soil physical properties, increased water and nutrient holding capacity (Sweeten and Mathers, 1985), improved soil nutrient levels (Binder *et al*., 2002), and increased grain yields. An experiment was initiated in 2013 to evaluate integrated soil fertility management effects on grain and fodder yields of maize and soil chemical and physical properties in a 2-yr cowpea-maize rotation in Goriyiri in the Upper West region of Ghana.

Objectives
Specific objective were to:

(i) Evaluate the response of cowpea to organic, mineral fertilizers as well as *Rhizobium* inoculants in rotation with maize;
(i) Evaluate the performance of maize when grown in rotation with cowpea that received different soil amendments.

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, seed producers, nutritionists, policy makers as well as NGOs.

Materials and Methods

In 2013, Integrated Soil Fertility Management (ISFM) trial involving cowpea-maize rotation was initiated in 2013 in Goriyiri in the Upper West Region to evaluate the response of cowpea to organic (fertisoil) and mineral fertilizers as well as *Rhizobium* inoculants in rotation with maize. The experimental design was randomized complete block design with four replications and seven treatment combinations: (i) no soil amendment (Control); (ii) seed inoculation only; (iii) inoculants plus 60 kg P_2O_5 and 30 kg K_2O/ha; (iv) inoculants plus fertisoil; (v) inoculants plus PK plus fertisoil and (vi) recommended fertilizer rate (25-60-30 kg/ha as N, P_2O_5 and K_2O. The 7th treatment was a continuous maize plot. The 2013 cropping season was the set-up year in which cowpea response to the various treatments was measured. However, rotation effect of maize following cowpea that received the different fertilizer treatments was evaluated in the second year (2014 cropping season) alongside continuous maize in 2014.

Farmers in the region do not usually apply fertilizer to cowpea hence the no soil amendment or control represented the farmers practice. *Rhizobium* inoculants (5g/kg of seed) and 1.5 t/ha of fertisoil were applied at planting. In all trials, 60 kg P_2O_5/ha as Triple Superphosphate (TSP) and 30 kg K_2O as Muriate of Potash (MOP) were applied at planting to plots that received fertilizer P and K. Recommended fertilizer rate was 25-60-30 kg as N, P_2O_5 and K_2O/ha was added to cowpea in 2013.

In 2014, planting of maize was delayed until third week of July due to pre-season drought. Maize was sowed in rows spaced 0.75 m apart and 3 seeds of maize were sowed at 0.40 m between hills and later thinned to 2 plants per hill at 2 weeks after sowing (WAS). Fertilizer was applied at a rate of 84-38-38 kg/ha as N, P_2O_5 and K_2O, respectively. Nitrogen fertilizer was split applied to increase N efficiency. Recommended cultural practices were carried out on time. Farmers were actively involved in the planning, implementation and monitoring processes. Maize was harvested at physiological maturity. Grain yield and its components as well as all agronomic data were subjected to analysis of variance (ANOVA) and where there were significant differences among treatments, means were separated using the LSD test at the $P \leq 0.05$).

Results/Major Findings

The soils in the savanna zone are generally low in plant available N and P; hence the use of N and P fertilizers in this zone would increase crop yields. The effects of the preceding cowpea on maize grain yields were measured in 2014 at Goriyiri. On average, maize grain yield ranged from 2611 to 4333 kg/ha (Table 85). Maize following cowpea that received soil amendment in the previous year tended to have higher yields than maize following itself or maize following cowpea that did not receive any fertilizer. Highest maize yield was obtained when maize followed inoculated cowpea plus fertilizer NPK. This was followed by a combination of inoculants, mineral fertilizer (PK) and organic fertilizer (fertisoil). Maize following inoculated cowpea + fertisoil had comparable yields as maize following inoculated cowpea + PK and fertisoil. Preliminary results of this study corroborates the fact that maize grain yield could be increased if grown in rotation with cowpea with appropriate fertilizer addition rather than growing maize year after year. Maize grain yield was more associated with cob weight (r = 0.99) than cob number (r = 0.65). In addition, grain yield was positively correlated with harvest index (r = 0.94).

Maize plants on the no fertilizer treatment plots looked less vigorous as the soils at this site looked less fertile and the presence of several trees shaded the crops and probably affected photosynthesis and ultimate plant growth. This coupled with late planting of the experiment as a result of pre-season drought significantly reduced grain yields at this site. The soils collected from these sites are yet to be analyzed. More data is required to confirm cowpea response to *Rhizobium* inoculation in the Guinea savanna zone and preceding effect of cowpea treated with various soil amendments on subsequent maize yields in a two year maize-cowpea rotation.

Table 93: *Some agronomic traits of maize as influences by soil amendment in a cowpea-maize rotation experiment at Goriyiri, Nadowli district, UWR in 2014.*

Treatment‡	DFT	DFS	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
Maize following cowpea with no fertilizer	50	53	1,57	2900	4334
Maize following cowpea treated with inoculants only	48	51	1.93	3467	4656
Maize following cowpea treated with inoculants + fertilizer P and K	47	52	1.81	3289	4570
Maize following inoculated cowpea + fertisoil	47	52	1.76	3877	4426
Maize following inoculated cowpea + PK+ fertisoil	47	52	1.90	3978	4534
Maize following inoculated cowpea with fertilizer NPK	47	50	1.79	4333	5102
Maize following maize with recommended rate of fertilizer for maize	49	52	1.49	2611	4798
LSD (0.05)	2	NS	NS	1241	NS
CV%	2.7	2.2	12.1	23.9	14.6

DFT = days to 50% tassel emergence, DFS = days to 50% silk emergence; NS= not significant at 5% level of probability

‡P and K were applied at the rate of 60 kg P_2O_5/ha and 30 kg K_2O/ha, respectively to cowpea in 2013; Recommended fertilizer rate for cowpea was 25-60-30 kg as N, P_2O_5 and K_2O/ha and fertisoil was applied at the rate of 1.5 t/ha.

Conclusions/Recommendations

The 2013 season was the setup year as such rotation effect could only be measured in 2014. Preliminary results showed that maize following cowpea that received soil amendment in the previous year tended to have higher yields than maize following itself or maize following cowpea that did not receive any fertilizer. Highest maize yield was obtained when maize followed inoculated cowpea plus fertilizer NPK. More data are required to confirm cowpea response to *Rhizobium* inoculation in the Guinea savanna zone and preceding effect of these treatments on subsequent maize yields.

Evaluation of Sorghum Hybrids for Yield Potential in the Upper West Region

Principal Investigator: S.S. J. Buah
Collaborating Scientists: R.A.L Kanton, Eva Weltzien-Rattunde (ICRISAT-Mali, Bamako), Asamoah Larbi (IITA)
Estimated Duration: 2013-2015
Sponsors: ICRISAT-Mali/Africa RISING
Location: Wa, Upper West Region

Background Information and Justification

Sorghum (*Sorghum bicolor L.*) is one of the most important staple cereals in northern Ghana. However, limited availability of improved varieties and/or hybrids has led to a decline in sorghum yields and a drop in area of cultivation over the years. Research efforts at breeding varieties and/or hybrids with high and stable yields as well as disease resistant/tolerant varieties is crucial if current production levels are to be increased to meet the increasing demand for sorghum grain. It is against this backdrop that elite sorghum hybrids were evaluated in on-station trials in Upper West region in order to identify the most adapted hybrids for release.

Objectives

Specific objectives were:

(i) To familiarize farmers with available sorghum hybrids and varieties with staple and high yield in order to facilitate the adoption of the varieties
(ii) To demonstrate and promote the application of modern technologies for the production of promising sorghum varieties and hybrids

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, seed producers, brewery industry, policy makers as well as NGOs.

Materials and Methods

A field experiment was initiated in 2013 and continued through 2014 at CSIR-SARI research station in Wa in the UWR to evaluate the performance of sorghum hybrids for adaptation to the northern savanna agro-ecology systems. Ten (10) hybrids were evaluated at Wa and Piisi both in the Upper West region. These hybrids were compared alongside the commonly cultivated local sorghum (cv. *Kadaga*) in the area. The experimental design was an Alpha design, V = 10; k = 2 and r = 4. The hybrids were sown in six rows of 5 m in length and 0.75 m apart. The field was ploughed and harrowed at least 2 weeks before planting. The previous crop was soybean. Three seeds per hill were planted at 0.40 m apart and later thinned to two plants per hill. Basal fertilizer application in the form of compound fertilizer 15:15:15 was applied at the rate of 38-38-38 kg/ha as N, P_20_5 and K_2O and top-dressing was done 4 weeks after planting at the rate of 26 kg N/ha using Urea. Weeding was done twice. The rains were late and when they finally arrived they were followed by a prolonged dry spell, which resulted in delayed implementation of some cultural practices on schedule.

Data were collected from the centre 2 rows. The data taken included seedling vigour, plant stand after thinning, days to half bloom (days to 50% flowering), plant height (cm), farmer preference, number of panicles harvested, number of empty panicles from midge, number of empty panicles from bird damage, panicle weight at harvest (g/plot), straw weight (kg/plot), grain weight (g/plot) and 100 kernel weight (g). Harvest index was computed from primary data. However, only data for half bloom, plant height, 100- kernel weight, harvest index values and grain yields are reported in this report.

Results/Major Findings

In general, pre-season drought adversely affected sorghum growth and development as well as ultimate yield in Wa and Piisi. Genotypic differences were detected for days to half bloom, plant height, grain yield and harvest index (Table 86). Days to heading for the sorghum hybrids ranged from 63 to 92 days. Mona, Caufa and Kapaala on one hand flowered earlier than the rest of the genotypes. In Wa, the local early check, Kapaala was severely affected by bird damage. Moreover, it had poor seedling establishment due to poor seed quality. Days taken to panicle exertion followed a similar trend like days to 50% flowering, with significant differences among the sorghum genotypes. Plant height among the hybrids was quite variable. The shortest genotypes were the early local (Kapaala), Grinkan-Yerewolo and Sewa. In Wa, plant height of six genotypes (Soumalemba.Caufa, Mona, late local, Pablo and Yamasa) was higher than 3 m. Grain yield in Wa ranged from 544 kg/ha for the early local to 2478 kg/ha for Pablo. Low yields associated with the early local was as a result of a combination of poor seedling establishment and bird damage as it was the earliest to flower and produce grain. Grain yield was positively correlated with plant population at harvest (r = 0.75), number of panicles per hectare (r = 0.60) and panicle weight (r = 0.92).

At Piisi, the experiment was established on the demonstration farm of a local NGO, Agri Access. Genotypic differences were detected for plant height, panicle weight and grain yield (Table 87). The shortest genotypes were the early local (Kadaga), Grinkan-Yerewolo and Sewa. At Piisi, plant height of six genotypes (Caufa, Soumalemba, Mona, late local, Pablo and Yamasa) was higher than 3 m. Mean grain yield for the sorghum genotypes ranged from 400 kg/ha for Grinkan-Yerewolo to 1478 kg/ha for Caufa. In general, Soumalemba, Grinkan-Yerewolo, Sewa and early local (Kadaga) had similar but lower yields (< 1000 kg/ha) when compared to late local, Mona and Caufa which recorded mean grain yields of more than 1200 kg/ha. Grain yield was positively correlated with plant height (r = 0.66), plant population (r = 0.67), number of panicles (r = 0.78 and panicle weight (r = 0.94). Farmers general preferred early maturing sorghum genotypes because of the erratic rainfall pattern. Grinkan -Yerewolo. Soumalemba and the local variety were the most preferred by farmers whilst Yamasa was the least preferred. Most farmers appreciated the grain quality of Soumalemba but expressed fears about its ability to withstand drought considering the fact that it is late maturing. Kadaga was preferred for its brown grain that is preferred for brewing the local beer called *Pito*.

Table 94: *Days to 50% panicle emergence, plant height and grain yield of sorghum genotypes evaluated in Wa, 2014*

Sorghum hybrids	Days to 50% heading	Plant height (m)	Grain yield (kg/ha)
Early Local (Kapaala	70	1.92	544
Fadda	80	2.51	1411
Caufa	76	<3	978
Mona	75	<3	1288
Late Local (kyere)	63	<3	1400
Sewa	83	1.65	1156
Pablo	74	<3	1322
Soumalemba	92	<3	2478
Grinkan-Yere wolo	81	1.73	767
Yamasa	80	<3	700
LSD (0.05)	2.0		518
C.V. (%)	1,5		27.6

Table 95: Plant height, panicle weight and grain yield of sorghum genotypes evaluated in Piisi, 2014

Sorghum hybrids	Plant height (m)	Panicle weight (kg/ha	Grain yield (kg/ha)
Pablo	<3	1811	1078
Yamasa	<3	1833	1189
Grinkan-Yere wolo	1.69	800	400
Caufa	<3	2567	1478
Fadda	2.49	1867	1133
Soumalemba	<3	1667	989
Mona	<3	2144	1344
Early Local (Kadaga)	1.77	833	578
Late Local (kyere)	<3	1667	1289
Sewa	1.86	1267	533
LSD (0.05)		815	546
C.V. (%)		34.0	32.6

Two NGOs (Agri-Access and Concern Universal) operating in the UWR have shown interest in evaluating sorghum hybrids in the region. Thus, Agri-Access evaluated some sorghum hybrids from ICRISAT-Mali with 15 farmers in the UWR. They also produced seed of Soumalemba (270 kg), Fadda (150 kg) and 667 kg of Kapaala seed. In addition, 500 kg of Fadda seed have been produced at the Babile Agricultural Station by the MoFA extension staff and Fadda fodder have been stored for an intended livestock feeding trials. Concern Universal also got funding from Alliance for a Green Revolution in Africa (AGRA) for the development a sorghum value chain in northern Ghana. These two NGOs are interested in screening sorghum hybrids and sorghum seed production so as to make quality seed available to sorghum producers who intend to produce grain for the brewery, Guinness Ghana Ltd.

Conclusions/Recommendations

Farmer's general preferred early maturing sorghum genotypes because of the erratic rainfall pattern. Grinkan-Yerewolo. Soumalemba and the local variety were the most preferred by farmers whilst Yamasa was the least preferred. Most farmers appreciated the grain quality of Soumalemba but expressed fears about its ability to withstand drought considering the fact that it is late maturing. Kadaga was preferred for its brown grain that is preferred for brewing the local beer called *Pito*. The promising hybrids will be selected for on-farm trials in 2015.

On-farm Testing and Demonstration of Drought Tolerant Maize Varieties and/or Hybrids

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Collaborating Scientists: R.A.L Kanton, Prince M. Etwire, Alidu Haruna, M.S. Abdulai, K. Obeng-Antwi (CSIR-CRI)
Estimated Duration: 2008-2015
Sponsors: IITA/DTMA Project
Location: Goriyiri in the Nadowli District, Chinchang in the Sissala East District, and Silbelle and Sorbelle in the Sissala West district

Background Information and Justification

The Maize Improvement Program of Ghana has been collaborating with the International Institute of Agriculture (IITA) over the years to develop and evaluate improved maize varieties and hybrids suitable for various agro-ecological systems in Ghana. Since 2008, promising high yielding and drought tolerant maize varieties and hybrids selected based on trial results were evaluated in farmer participatory on-farm trials and demonstrations. These trials served as important vehicle to showcase the effectiveness of new technology to farmers. Additionally, the participatory on-farm testing of the varieties could also facilitate the rapid transfer and adoption or acceptance of these drought tolerant maize varieties by farmers. The mother-baby on-farm testing approach has been widely adopted by the Drought Tolerant Maize for Africa (DTMA) Project as a strategy for testing and promoting the release and adoption of maize varieties and hybrids. It is a new approach consisting of a central researcher-managed "mother' trial comprising all tested varieties and satellites or "baby' trials, which are farmers managed and test a subset of varieties from the mother trial. Through this process, several drought tolerant varieties have so far been released in Ghana.

Objectives

The objectives of the on-farm testing were:

(iii) To familiarize farmers with available drought tolerant varieties with staple and high yield in order to facilitate the adoption of the varieties

(iv) To demonstrate and promote the application of modern technologies for the production of promising drought tolerant maize varieties and hybrids

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.
Secondary beneficiaries: dependents of the farmers and researchers, seed producers, policy makers as well as NGOs.

Materials and Methods

In 2014, nine mother trials (4 extra-early and 5 medium trials) and eighteen baby trials (10 extra-early and 8 medium trials) composed of improved extra-early and intermediate maturing open pollinated varieties (OPVs) and hybrids were evaluated by CSIR-SARI, Wa station in partnerships with MoFA and farmers in four districts (Wa municipal, Sissala East, Wa East and Jirapa) in the Upper West region using the mother and baby methodology. The mother baby trials is a new approach consisting of a central research er-managed “mother’ trial comprising all tested varieties and satellites or “baby’ trials, which are farmers’ managed and consist of varieties from the mother trial.

The intermediate maturing genotypes consisted of 10 hybrids and 2 checks. The extra-early genotypes consisted of 9 hybrids and a local check. In addition to DT varieties/hybrids developed at IITA, two hybrids from the CSIR-CRI in Ghana and three hybrids from Pioneer Seed Co Ltd were included in the medium mother trials. Results of analyses of these data sets for each trial conducted in each district are summarized in this report.

Mother Trials

In 2014, nine sets maize mother trials managed by researchers, comprising extra-early (80-85 days to maturity) and intermediate/medium maturing (110 days to maturity) varieties and hybrids were planted in farmers’ fields at Jirapa-Da-Uri in the Jirapa district, Siriyiri in Wa West district, Chinchang in the Sissala East district as well as Kpongu and Wa in the Wa Municipal with funding from the DTMA project. There was no sufficient seed for the early maturing varieties hence no trial was conducted involving this maturity group. The mother trials consisted mostly of elite varieties involving yellow and white source populations obtained from IITA which were compared with a local check. The extra-early mother trials were planted between 16th and 27th July, 2014 while the intermediate mother trials were planted between 3rd July 2014 and 1st August 2014. The intermediate maturing mother trials consisting of 4 hybrids from IITA, three hybrids from CSIR-CRI in Ghana, three hybrids from Pioneer Seed Co Ltd and two local checks were planted in Wa.

The local checks for all maturity groups were the best available varieties in the location, which differed among locations. A randomized complete block design (RBCD) with four replications per site was used for the mother trial of each maturity group. Each plot consisted of 6 rows, each 5.0 m long, spaced 0.75 m apart. Row and hill spacings were 0.75 and 0.40 m, respectively. Three maize seeds were planted per hole in each trial. The maize crop was thinned to two plants per hill about 2 wk after emergence to give a final population density of 66,600 plants/ha. Observations recorded in the mother trials included days to 50% silking and anthesis, plant height, ear number, percentage root and stalk lodging, grain yield and grain moisture content (%), Grain yield was calculated based on 80% (800 g grain /kg ear weight) shelling percentage and adjusted to 150 g/kg moisture content. In addition, data were collected on host plant Striga damage score and the number of emerged Striga plants were made at 8 and 10 wk after planting (WAP). Striga-tolerant plants normally retain green leaves and exhibit restricted mild purplish chlorosis, with little effect of Striga on ear and stalk development. Highly susceptible plants, on the other hand, show grayish leaf colour and leaf scorching after initial leaf wilting. These symptoms are usually accompanied by poor development of stalk and ear, resulting in lodging. About 64 kg N/ha was split applied at planting and at about 35 DAP. Recommended cultural practices were followed. The total fertilizer rate was 64-38-38 kg/ha as N, P_2O_5 and K_2O, respectively.

Field days were organized at planting and when the maize plants reached physiological maturity so farmers could view the experiments. At one week before harvest, interested farmers were invited to see the varieties and to 'vote' for the ones they liked. The farmers walked through the trial and indicated the plots containing the varieties they liked. Researchers viewed the participants' choices as "votes" and assumed that the higher the percentage of farmers voting for a maize variety, the more potentially valuable it was to them. Then they met to discuss what they thought were the important criteria for selecting a given variety. The criteria were ranked and top ranking criteria were used. Each criterion was scored on a scale of 1 to 5 (1 = very good, 2 = good, 3 = average, 4 = poor and 5 = very poor) for each variety. The research team also independently evaluated both mother trials for yield and other agronomic traits. Analysis of variance was done for each location.

Satellite or baby trials

Eighteen baby trials composed of improved extra-early and intermediate maturing open pollinated varieties (OPVs) and hybrids were evaluated. Ten (10) sets of baby trials for extra-early maturity group and eight (8) intermediate sets of maize hybrids were conducted on farmers' fields at Chinchang n the Sissala East district. Farmers' fields near to mother sites were selected for each baby trial. Farmers evaluated a subset of three varieties from the mother trials alongside their local varieties which were the best available variety at each evaluated site, which differed among locations and farmers. Three drought tolerant hybrids from both extra-early and intermediate sets were respectively, evaluated alongside the farmers' varieties as local checks. Planting was done between 13th and 31st July, 2014. The data presented for farmers' variety are, not necessarily from one variety but the mean of several farmer varieties. Farmers managed all plots similarly. Overall, the genotypes tested were the same as those grown in the mother trial and each genotype was tested by four farmers. Each plot measured 20 x 20 m. Farmers evaluated the genotypes at physiological maturity.

Results/Major Findings

Planting was significantly delayed until July due to prolonged pre-season drought. However, after mid-July, we experienced wet conditions. Wet conditions reduced seedling emergence of the trials and this necessitated refilling. The variable weather affected plant growth and development and ultimate grain yield at most sites. In general, highly variable rainfall from year to year makes it difficult for farmers to plan, and the wrong decision on which crop to plant, and when to plant it, may lead to disaster for a household

Mother and baby trials for extra-early maturing genotypes

Mother trials for extra-early maturing genotypes

Nine hybrids were tested alongside a check (Abontem) in a mother trial at Chinchang in the Sissala East district. In this extra-early mother trial, the genotypes flowered in 47-52 days after planting, producing dry grains in about 85 days (Table 88). Three hybrids (TZEEI 29 x TZEEI 21, TZEEI 29 x TZEEI 49 and TZEE W POP STR C5 x TZEEI 21) were the earliest to flower while two other genotypes including TZEEI 7 x TZEEI 26 and TZEE Y POP STR C4 x TZEEI 17 were the latest to flower (Table 88). Differences among the varieties for plant height, aboveground biomass production and grain yield were not statistically significant. However, grain yield ranged from 2119 to 2898 kg/ha. Grain yield tended to be highest for TZEE Y POP STR C5 x TZEEI 82, TZEE Y POP STR C4 x TZEEI 17 and TZEE1 29 x TZEE1 21 which had grain yields above 2.8 t/ha. Grain yield was correlated with harvest index (r = 0.58) but had no significant correlation with plant height. Also grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.46). In addition, no significant differences were detected among the genotypes for Striga counts at 10 weeks after planting (10 WAP). The Striga emergence counts were generally very low, probably because the fields were not Striga endemic plots.

Table 96: *Extra- early maturing varieties evaluated in a mother trial at Chinchang, Sissala West district, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
TZEE1 29 x TZEEI 21	47	51	1.68	2887	5617
TZEE1 29 x TZEEI 49	47	50	1.57	2553	4511
TZEE W POP STR C5 x TZEEI 21	47	50	1.62	2300	4107
TZEE Y POP STR C5 x TZEEI 82	50	52	1.68	2898	5084
TZEE Y POP STR C5 x TZEEI 67	49	52	1.63	2791	3911
TZEE1 6 x TZEEI 4	50	52	1.62	2119	4680
TZEE1 8 x TZEEI 24	48	52	1.64	2279	2956
TZEE Y POP STR C4 x TZEEI 17	51	53	1.57	2862	3978
TZEEI 7 x TZEEI 26	52	54	1.70	2788	4302
Abontem	49	52	1.61	2172	3711
Lsd(0.05)	1.0	1.0	NS	NS	NS
CV(%)	1.0	1.6	4.6	27.6	21.2

NS= not significant at the 0.05 and 0.01% level of significant

At Dokpong in Wa, nine hybrids were evaluated alongside a local check (Abontem) in a mother trial (Table 89). The genotypes flowered in 48-56 days after planting. The hybrid (TZEE1 29 x TZEEI 49) was the earliest to flower while TZEEI 7 x TZEEI 26 was the latest to flower (Table 89). Differences among the varieties for plant height were not statistically significant. However, genotypic differences for grain yield were significant. Grain yield ranged from 2276 to 4658 kg/ha. Grain yield was significantly highest for TZEE1 29 x TZEEI 49 and least for TZEE1 8 x TZEEI 24. All genotypes, except TZEE1 8 x TZEEI 24 and TZEEI 7 x TZEEI 26 had yields above 3 t/ha. Grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.83). In addition, Striga emergence counts were generally very low.

Table 97: Extra- early maturing varieties evaluated in a mother trial at Dokpong, Wa municipal, 2014

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)
TZEE1 29 x TZEEI 21	50	54	1.91	3556
TZEE1 29 x TZEEI 49	48	52	1.87	4658
TZEE W POP STR C5 x TZEEI 21	50	55	1.92	3769
TZEE Y POP STR C5 x TZEEI 82	52	55	1.80	4160
TZEE Y POP STR C5 x TZEEI 67	50	55	1.83	3876
TZEE1 6 x TZEEI 4	50	54	1.77	3236
TZEE1 8 x TZEEI 24	53	57	1.86	2276
TZEE Y POP STR C4 x TZEEI 17	51	55	1.66	4160
TZEEI 7 x TZEEI 26	56	60	1.91	2844
Abontem	51	55	2.63	3164
Lsd(0.05)	3	3	NS	1590
CV(%)	3.2	3.6	6.8	25.9

NS= not significant at the 0.05 and 0.01% level of significant

At Jirapa, six hybrids were evaluated alongside a local check (Abontem) in a mother trial. The genotypes flowered in 48-50 days after planting (Table 90). The earliest hybrid to flower was TZEE W POP STR C5 x TZEEI 21 while the latest two hybrids to flower were TZEE Y POP STR C5 x TZEEI 82 and TZEE Y POP STR C4 x TZEEI 17. Differences among the varieties for plant height and grain yield were not statistically significant. However, grain yield ranged from 2347 to 3911 kg/ha. Grain yield tended to be highest for TZEE Y POP STR C4 x TZEEI 17. Grain yield was correlated with harvest index (r = 0.44) but had no significant correlation with plant height. Also grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.71). The Striga emergence counts were generally very low, probably because the fields were not Striga endemic plots.

Table 98: Extra- early maturing varieties evaluated in a mother trial at Jirapa, Jirapa District, 2014

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
TZEE1 29 x TZEEI 21	48	52	1.29	2939	2681
TZEE1 29 x TZEEI 49	49	52	1.10	2347	2193
TZEE W POP STR C5 x TZEEI 21	47	50	1.06	2999	3007
TZEE Y POP STR C5 x TZEEI 82	50	53	1.20	3129	2430
TZEE Y POP STR C5 x TZEEI 67	49	52	1.20	2529	2148
TZEE Y POP STR C4 x TZEEI 17	50	52	1.19	3911	3881
Abontem	49	53	1.50	3307	2978
Lsd(0.05)	NS	NS	NS	NS	1086
CV(%)	3.2	2.6	1.0	27.6	22.1

NS= not significant at the 0.05 and 0.01% level of significant

At Siriyiri in the Wa West district, eight hybrids were evaluated alongside two local checks (Abontem and farmer variety) in a mother trial (Table 91).

Table 99: *Extra- early maturing varieties evaluated in a mother trial at Siriyiri, Wa West District, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)
TZEE1 29 x TZEEI 21	50	54	1.90	2406
TZEE1 29 x TZEEI 49	48	52	1.87	2027
TZEE W POP STR C5 x TZEEI 21	50	55	1.91	1920
TZEE Y POP STR C5 x TZEEI 82	52	55	1.80	1470
TZEE Y POP STR C5 x TZEEI 67	50	55	1.83	1446
TZEE1 6 x TZEEI 4	50	54	1.77	1671
TZEE1 8 x TZEEI 24	53	57	1.92	2074
TZEE Y POP STR C4 x TZEEI 17	51	55	1.68	1695
Farmer variety	56	58	1.89	901
Abontem	51	55	2.15	1564
Lsd(0.05)	3	3	NS	NS
CV(%)	3.2	3.6	6.8	38.3

NS= not significant at the 0.05 and 0.01% level of significant

The genotypes flowered in 48-56 days after planting. The hybrid (TZEE1 29 x TZEEI 49) was the earliest to flower while the farmer variety was the latest to flower (Table 91). Differences among the varieties for plant height and grain yield were not statistically significant. However, grain yield ranged from 902 to 2406 kg/ha. Grain yield tended to be highest for TZEE1 29 x TZEEI 21 and least for farmer variety. It is worthy of note that this experiment was planted on 27th July 2014, which is considered quite late for planting maize in at location.

Baby trials for extra-early maturing genotypes

Five varieties were evaluated in ten baby trials in Sissala East district. The genotypes, on average flowered in 47- 52 days after planting (Table 92). Differences among the varieties for plant height, grain yield and biomass production were statistically significant. The farmer varieties were the latest to flower and were also the tallest as such were more prone to lodging. Mean grain yield ranged from 2357 to 3058 kg/ha. The highest yielding hybrid was TZEE W POP STR C5 x TZEEI 21while the farmers' varieties on average, produced the least grain yields. Some of the improved varieties and the farmers' variety had similar yields. This was not surprising because the farmers' varieties that were included in these experiments were mostly not extra-early maturing varieties. Moreover the farmer varieties were probably improved varieties previously bought from seed dealers or supplied by other development organizations over the past years. Hence, the word "farmer variety" should be used with caution as the use and/or recycling of improved seed is a common practice in Ghana. Furthermore, the variable weather conditions in 2014 affected seedling establishment hence the optimum plant stand was not achieved for most varieties.

Table 100: *Extra- early maturing varieties evaluated in Baby trials in Sissala East District, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
TZEE1 29 x TZEEI 49	47	51	1.59	2919	3676
TZEE Y POP STR C5 x TZEEI 67	49	52	1.74	2800	3678
TZEE Y POP STR C5 x TZEEI 82	47	49	1.66	2525	3371
TZEE1 29 x TZEEI 21	47	50	1.70	2649	3041
TZEE W POP STR C5 x TZEEI 21	46	51	1.67	3058	3661
Farmer variety	52	55	1.96	2357	4425
Lsd(0.05)	6	6	0.10	645	660
CV(%)	3.3	2.0	4.9	19.8	14.6

Mother and baby trials for intermediate maturing varieties

Mother trials for intermediate maturing genotypes

Intermediate maturing mother trial was planted at Chinchang in the Sissala East district in 2014. The varieties flowered in 50-53 days after planting and producing dry grains in about 110 days (Table 93). The farmer variety was the latest to flower and also was the tallest genotype. No Significant differences were detected among the genotypes for grain and dry matter production. However, grain yield ranged from 1913 kg/ha for Obatanpa to 3733 kg/ha for M1216-3. Obatanpa tended to produce the least grain yield. Aboveground dry matter production followed a similar trend. Grain yield was correlated with biomass yield (r = 0.32) and harvest index (r=0.67). In addition, grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.51). The hybrid M0926-8 was released as Kpari-faako in April 2015.

Table 101: *Intermediate maturing varieties evaluated in a mother trial at Chinchang, Sissala East district, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
P 4063 W	50	53	1.78	3118	4091
P 4082 W	50	53	1.78	3093	4302
P 3966 W	50	53	1.91	2812	3667
M1216-3	51	54	1.87	3733	4920
M1227-12	52	55	1.79	2667	4489
M1026-10	53	56	1.75	2649	4400
M1026-3	52	56	1.82	2969	4542
M0926-8	53	56	1.75	3378	4800
Etubi	50	53	1.65	2165	4031
Obatanpa	53	56	1.79	1913	2449
M1124-10	51	54	1.73	2908	3529
Farmer variety	53	55	2.16	2080	7153
Lsd(0.05)	1	1	0.17	NS	NS
CV(%)	1.6	1.4	5.7	43.9	31.1

NS= not significant at the 0.05 and 0.01% level of significant

At Dokpong in Wa Municipal, the genotypes in the intermediate maturing mother trial flowered in 48-56 days after planting (Table 94). The drought tolerant OPV, Ewul-boyu flowered latest. Plant height ranged from 1.79 m for Etubi to 2.4 m for P 3966 W. Significant differences were detected among the genotypes for grain and dry matter production. Mean grain yield ranged from 3867 kg/ha for Etubi to 6800 kg/ha for P 4063 W. Four hybrids (P 4063 W, P 3966 W, M1227-12 and M1026-3) which had grain yields above 6.0 t/ha significantly outyielded Etubi, a released hybrid in Ghana. Aboveground dry matter production followed a similar trend. Grain yield was correlated with harvest index (r=0.81). In addition, grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.62).

Table 102: *Intermediate maturing varieties evaluated in a mother trial at Dokpong, Wa, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
P 4063 W	52	62	2.24	6800	4013
P 4082 W	54	64	2.01	4987	3913
P 3966 W	54	64	2.40	6480	3980
Ewul-boyu	56	67	2.08	4293	4657
M1227-12	47	62	2.37	6106	4117
M1026-10	48	62	2.08	5760	4287
M1026-3	49	62	2.15	6320	4478
M0926-8	49	63	2.04	4266	5247
Etubi	50	62	1.79	3867	4120
Obatanpa	48	63	2.10	5013	3237
Aseda	53	64	1.95	4560	3883
Tintim	51	61	2.00	4960	6250
Lsd(0.05)	3	2	0.29	2214	2051
CV(%)	3.6	2.6	9.6	29.1	32.8

At Kpongu in the Wa Municipal, the genotypes in the intermediate maturing mother trial flowered in 54-57 days after planting (Table 95). There were no significant differences among the genotypes for days to mid-anthesis. Plant height ranged from 2.15 m for Etubi to 2.8 m for P 4063 W. Significant differences were detected among the genotypes for grain yield. Mean grain yield ranged from 2702 kg/ha for farmer variety to 5227 kg/ha for P 4063 W. Three hybrids (P 4063 W, P 3966 W and M1227-12) which had grain yields above 4.0 t/ha outyielded the farmer variety significantly. Data were not recorded aboveground dry matter production at this site. Grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.80).

Table 103: *Intermediate maturing varieties evaluated in a mother trial at Kpongu, Wa Municipal, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)
P 4063 W	57	60	2.82	5227
P 4082 W	57	59	2.46	4551
P 3966 W	55	57	2.39	4764
M1227-12	55	58	2.33	4836
M0926-8	55	58	3.53	3947
Obatanpa	54	57	2.62	4373
Etubi	56	60	2.15	3769
Farmer variety	57	60	2.47	2702
Lsd(0.05)	NS	NS	0.35	2052
CV(%)	3.2	4.5	8.0	27.4

NS= not significant at the 0.05 and 0.01% level of significant

At Siriyiri in the Wa West district, there were no significant differences among the genotypes for plant height and days to mid-anthesis (Table 96). Significant differences were detected among the genotypes for grain yield. Mean grain yield ranged from 1268 kg/ha for M1026-10 to 2109 kg/ha for M1026-3. Two hybrids (M1026-3 and P 4082 W) which had grain yields above 2.0 t/ha at the Siriyiri site outyielded the least yielding hybrid, M1026-10 significantly. Data were not recorded aboveground dry matter production at this site. Grain yield was more associated with cob weight (r = 0.98) and biomass yield (r = 0.75).

Table 104: *Intermediate maturing varieties evaluated in a mother trial at Siriyiri, Wa West district, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
P 4063 W	58	60	1.52	1908	1985
P 4082 W	58	61	1.72	2097	2325
P 3966 W	58	61	1.52	1564	1644
M1227-12	61	62	1.42	1578	1704
M1026-10	58	60	1.45	1268	1555
M0926-8	59	61	1.68	1564	1733
M1026-3	59	63	1.55	2109	2237
Obatanpa	58	61	1.65	1541	1571
Etubi	60	63	1.37	1505	1911
Farmer variety	62	64	1.53	1647	1718
Lsd(0.05)	NS	NS	NS	700	NS
CV(%)	2.8	2.8	10.2	24.3	22.8

NS= not significant at the 0.05 and 0.01% level of significant

At Jirapa in the Jirapa district, there were no significant differences among the genotypes for days to mid-anthesis (Table 97). Plant height ranged from 1.4 m for Etubi to 2.1 m for P 4063 W. Significant differences were detected among the genotypes for grain yield. Mean grain yield ranged from 2963 kg/ha for Etubi to 5452 kg/ha for P 4063 W. Two hybrids (P 4063 W and P 3966 W) which had grain yields above 5 t/ha at the Jirapa site significantly outyielded Etubi, a hybrid released for commercial production in Ghana. Data were not recorded aboveground dry matter production at this site. Grain yield was correlated with biomass (r=0.86). Also, grain yield was more associated with cob weight (r = 0.99) than number of cobs per hectare (r = 0.54).

Table 105*: Intermediate maturing varieties evaluated in a mother trial at Jirapa, Jirapa district, 2014*

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass (kg/ha)
P 4063 W	60	62	2.13	5452	6111
P 4082 W	61	63	1.92	4279	5852
P 3966 W	62	65	1.80	5369	6356
M1227-12	59	61	1.80	4492	5496
Obatanpa	60	63	1.99	4030	5548
Etubi	58	63	1.40	2963	3541
Farmer variety	62	65	1.80	4113	5156
Lsd(0.05)	NS	NS	0.19	2118	NS
CV(%)	2.6	2.5	6.0	27.2	36.5

NS= not significant at the 0.05 and 0.01% level of significant

Baby trials for intermediate maturing genotypes

Four intermediate maturing hybrids were evaluated in eight baby trials in Sissala East district only. The hybrids, on average flowered in 50-52 days after planting (Table 98). Differences among the varieties for plant height, grain yield and biomass production were statistically significant. On average, the farmer varieties (local checks) were the latest to flower and were also the tallest as such were more prone to lodging. The local checks were the best available intermediate maturing varieties at each site, which differed among locations. The data presented for farmers' variety are, therefore, not necessarily from one variety but the mean of several varieties. Mean grain yield ranged from 2685 to 4747 kg/ha. The highest yielding hybrid was M1026-3 while the farmers' varieties on average, produced the least grain yield. Grain yield was correlated with biomass yield (r = 0.81). Also grain yield was more associated with cob weight (r = 0.93) than number of cobs per hectare (r = 0.35).

Table 106: Intermediate maturing maize genotypes evaluated in Baby trials in Sissala East District, 2014

Genotype	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
M0926-8	50	53	1.68	3805	4565
M0926-10	50	54	1.86	4031	5359
M1026-3	51	54	1.86	4747	6433
M1227-12	50	54	1.92	4093	5295
Farmer variety	52	56	2.07	2685	5110
Lsd(0.05)	1	2	0.36	1699	2073
CV(%)	1.5	1.8	10.3	24.4	21.2

NS= not significant at the 0.05 and 0.01% level of significant

Farmer assessment of the varieties

In 2014, three field days were held in 3 communities (Chinchang in Sissala East district, Jirapa in Jirapa district and Dokpong in Wa municipality. In all, 283 participants (126 males and 57 females) attended the field days. Through the field days, good agricultural practices for maize production are also reaching other farmers not directly involved in the project in the region. Maize farmers evaluated the varieties and hybrids and regarded them very positively. Several of the farmers have a long tradition of cultivating maize. Farmers' preference criteria were based on earliness, cob size, grain colour, disease and drought tolerance and productivity of the variety. The study showed that farmers valued many characteristics in maize varieties, especially traits related to consumption. Among women, yellow maize is in particular demand and this has a higher price than white maize in the region.

In Sissala East a farmer, Yakubu Adama who has participating in DTMA On-farm trials and community seed production in previous years was given the opportunity to share his experience on the demonstration with his colleague farmers. On his part, he said he has benefited a lot form DTMA interventions in his community. He added that through the DTMA Project activities, he now cultivates Abontem and Aburohemaa on about 4 ha each due to their ability to tolerant drought spells as well as its yield potential. Yakubu told his fellow farmers that because he gets good grain yield from these varieties he has been able to acquire a motorbike and some roofing materials to complete his house. In addition, he said in 2014 he gave out about 240 kg of seed of each variety to other farmers who express interest to grow them. He advised other farmers to adopt the drought tolerant maize varieties being promoted in the face of climate change.

In varietal selection, 42 participants selected variety M0926-8 as the first choice, TEE129XTZEE149 as their second choice, and 26 of them also selected TZEEY POP STR C5 X TZEE182 as their first choice, 24 selected TZEI 7 X TZEI 26 also as their second choice; backed by reasons such as high yield potential, drought tolerant, no lodging. They express interest to grow these varieties, and appeal to SARI to make available these varieties, they also request for more on-farm trials to be conducted in the community in order to have access to this improved technologies.

The field days organized at all the sites drew much attention and participation from farmers. The assessment exercise suggested that the TZEE Y POP STR C5 x TZEEI 82 and TZEEI 29 x TZEE1 49 were the most preferred extra-early maturing hybrids. Farmers also preferred extra-early yellow maize variety, because it could be planted with the early rains and sold or eaten fresh. Among the intermediate varieties, M0926-8, M1227-12, P 3966 W and P4063W were the most preferred varieties. It seems farmers like a range of varieties (i.e., a range of diversity). All the IITA varieties were considered to be better than the local checks (farmers' varieties) and the locally released hybrid, Etubi.

In decreasing order of importance, the criteria that were most frequently cited by farmers for preference of a variety at all locations were heavier ears (bigger cobs), earliness, drought tolerance and endosperm colour. In general, farmers have expressed interest to grow these varieties, and have appealed to SARI to make available these varieties, they also requested for more on-farm trials to be conducted in the community in order to improve farmer access to these genotypes. It is obvious, poor access to hybrid seed and a lack of specialized knowledge coupled with the necessity to purchase hybrid seeds every year are the most binding constraints to adopting hybrid maize. Farmers who participated in the baby trials testified that the varieties appeared to performed similarly or better than their local varieties even under their circumstances in the baby trials.

Conclusions/Recommendations

In this study, mean yields from researcher-managed trials as well as some of the varieties and hybrids were higher than the national average yield of 1.7 t/ha as a result of the use of improved seed and good agricultural practices for maize production. Moreover, farmers recognized that improved varieties and/or hybrids often perform better if accompanied by recommended cultural practices. The results of both the mother and baby trials for the extra-early and intermediate maturing genotypes suggested that some IITA hybrids were relatively stable in grain yield performance. In general, extra-early and early maturing yellow maize is preferred for its earliness and yellow endosperm. Additionally, many of the improved drought tolerant varieties and/or hybrids from IITA evaluated in this study performed similarly as or better than the best available local varieties in the various locations under rainfed conditions. Moreover, most of the IITA elite genotypes are also known to show good performance when Striga infestation and drought conditions occur simultaneously. Thus, the DT maize hybrids should be vigorously promoted for adoption by farmers in drought prone and Striga endemic areas in the Savanna zone of Ghana. Through the project, farmers gained access to the diversity of drought tolerant maize genotypes.

Developing Community-Based Climate Smart Agriculture through Participatory Action Research in the Jirapa-Lawra Districts of Ghana.

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Estimated Duration: 2011-2015
Sponsors: CCAFS/ICRAF
Location: Jirapa and Lawra districts.

Background Information and Justification
Climatic extreme events such as droughts with varying magnitude, complexity, and economic impacts have become a common feature in Ghana. The vulnerability of Ghana's agriculture to climate change is largely due to its dependence on rainfall, particularly in the semi-arid northern Ghana which is the hardest hit by increasing frequency of drought. In general, increasing frequency of drought has depleted the asset base of smallholder farmers. They and their families commonly go hungry for several months even in 'normal' years. Feeding the growing population over the next decades requires radical agricultural transformation to respond to climate change and sustainably increase productivity and income while conserving and managing ecosystem services. Climate-smart agriculture (CSA) which is emerging as a new paradigm in agricultural development is defined as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals has gained increasing attention as a pathway to this transformation. It seeks solutions that improve agricultural productivity, reduce farm level vulnerability to climate change, and sequester carbon. To cope with the challenges of climate change, agricultural production must adapt and become resilient to changes. In general, sustainable crop production initiative can be achieved through good farming practices that are based on improving efficiencies and managing biological processes. The sustainability of crop production systems presupposes that the risks and vulnerabilities arising from climate change are also addressed. Climate-smart crop production provides management options to farmers to both adapt to, and mitigate climate change.

In order to address the negative effects of climate change, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) seeks to develop up-scalable options of climate smart agriculture through improved understanding of mitigation and adaptation opportunities in agriculture among smallholders in West Africa. In December 2011, ICRISAT and ICRAF signed a partnership agreement to implement the project ***"Developing community-based climate-smart agriculture through participatory action research in five benchmark sites in West Africa".*** Work plans were developed in 2012 for participatory action research at the CCAFS benchmark sites. Some activities were planned and implemented during the first year and some activities are still on-going. The activities planned and implemented during the

2014 cropping season included: land rehabilitation trials, natural assisted regeneration, tree planting, and crop varieties testing. Capacity building activities involving long term training of graduate students and farmers' exchange visits.

Objectives

The general objective of the project is "to test and validate, in partnership with rural communities and other stakeholders, a scalable climate-smart model for agricultural development that integrates a range of innovative agricultural risk management strategies".

The project also aims to improve the ability of land managers and farmers to adapt, and contribute to the mitigation of climate change. It focuses on two main components:

(i) Up scaling of proven best-bet and site specific climate-resilient soil, land, water and nutrient management practices and technologies and

(ii) Targeted capacity strengthening of farmers, community-based organizations and other relevant stakeholders to better understand and integrate climate change and variability into agricultural management decisions.

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, Ghana Meteorological Agency and NGOs.

Materials and Methods

During the regional planning and review workshop that was jointly organized by ICRAF and CCAFS in March 2013 in Ouagadougou, Burkina Faso, participants developed country specific workplans for participatory action research at the CCAFS benchmark sites. These activities were continued in the 2014 Work Plan of SARI as agreed with ICRAF during the regional planning and review workshop in Tamale in 2014. The activities included the following:

(i) Carry out community participatory technology development (PTD) workshops to identify and prioritize climate change adaptation and mitigation technologies.

(ii) Follow-up to plan and design adaptation and mitigation options according to farming systems and land use for implementation.

(iii) Test basket of technologies selected by communities for implementation at field scale with households

(iv) Organize farmers' field day to visit trials and share their perceptions with researchers.

(v) Identify adapted tree species for wood production and fruit tree of choice and assist the communities in establishing and evaluating them

(vi) Organize workshops to empower local level institutions with information, knowledge and capability to address longer term issues such as climate change

(vii) Organize training sessions for community leaders on participatory development planning.

(viii) Organize farmers' field days and evaluation of technologies

This report covers the activities that were implemented by objectives, the achievements, challenges encountered and some suggestions on the way forward.

Results/Major Findings

Carry out community participatory technology development (PTD) workshops to identify and prioritize climate change adaptation and mitigation technologies

One-day community participatory technology development (PTD) workshop was held in each of Doggoh and Bompari communities. CCAFS activities started in the village of Doggoh in 2012 while Bompari was only included in 2013. The objective was to identify and prioritize key climate change related issues to be addressed. Present were research staff, extension, local NGOs, representative of the Forestry Services Department for Lawra, the local government representative, Chief, elders and people of Doggoh and Bompari. Based on the community validation workshop, the community agreed to carry out a number of On-farm trials to evaluate adaptation and mitigation options as proposed in objective 2 of the Workplan. The community agreed to test combinations of minimum tillage, crop rotations and application of organic and inorganic fertilizers i.e. integrated soil fertility management.

On-farm trials

A total of 63 on-farm trials (27 at Doggoh and 36 at Bompari) comprising no-tillage practices; crop diversification; maize-cowpea rotations; soil and water management/conservation practices; integrated nutrient management; growing drought and *Striga* tolerant crop varieties; intercropping cowpea with Jatropha (energy crop), improved crop cultivation technique and agroforestry were planted in 2014. In response to the prevalence of drought and the projected increase in their frequency, drought tolerant maize varieties (Omankwa and Aburohemma) were introduced to farmers in the project sites. In addition, we introduced early maturing cowpea varieties (Apagbaala and Sogotra) as well as low shattering and promiscuous soybean variety (Jenguma) which requires no inoculation or little mineral fertilizers to produce high grain yields, an emphasis on sustainable agricultural practices.

Field selection for on-farm trials started in May and planting was mostly done in July. At Doggoh 21 males and 6 females implemented the trials while 30 males and 6 females implemented the trials at Bompari. Preseason drought delayed most planting until second week of July which is considered very late for planting of crops in both communities. In addition, there was drought immediately after planting which lasted for over three weeks and that delayed refilling and fertilizer application.

Farmer field days were organized in October at Doggoh and Bompari to showcase the CSA technologies being implemented by farmers in the two communities. A total of 109 famers attended the field days. This also served to increase the visibility of the CCAFS project and also to give non-participating farmers the opportunity to learn more about the CSA practices and technologies.

Generally, integrated use of small amounts of organic (1.5t/ha manure) and mineral fertilizer gave the highest maize yields although this treatment had similar yields as the full rate of mineral fertilizer. Overall, a combination of 1.5 t/ha of manure and half rate of mineral fertilizers resulted in 191-911% and 142-204% increase in grain yield when compared with manure at 3 t/ha and no fertilizer treatment, respectively. Also, continuous manure fertilized maize gave lower maize yields than maize following cowpea with mineral fertilizer applied to the maize only, indicating a lower resource use efficiency under the continuous maize.

Averaging over fertilizer treatment at Doggoh, grain yield of no-till soybean was 15 and 51% higher than that of tilled soybean in 2013 and 2014, respectively. At Bompari, mean grain yield of no-till maize was 48 and 68% higher than that of tilled maize in 2014 and 2013, respectively. Regardless of tillage method, fertilizer application significantly increased maize and soybean yields. Averaging over tillage systems, the application of 275 kg/ha of Yaralegume fertilizer resulted in soybean yield increases of 60% (194 kg/ha more) in 2013 and 66% (474 kg/ha) in 2014 when compared with no fertilizer treatment. Mean grain yield of maize was 140% and 252% higher with NPK fertilizer (64-38-38 kg/ha as N, P_2O_5 and K_2O respectively) treatment in 2013and 2014, respectively. In addition, fertilizer application resulted in 353% (1226 kg/ha more) and 620% (3173 kg increase in grain yield of drought tolerant maize varieties in 2013 and 2014, respectively with Omankwa having the highest yield of 2256 kg/ha. No-till system showed cost savings due to reduced labour mainly for weed control. We conclude from these studies that no-tillage with fertilizer, whether for maize or soybean, generally has shown advantage in yield and economic returns and that farmers can get better returns to the money invested in herbicide and fertilizer for producing maize and soybean under no-till than with their traditional practice even on savanna soils testing low in plant available nutrients..

Soil and water conservation practices (zai, tied ridges and earth bunds) were tested against the local practice of flat planting as control. All were managed according to local extension recommendations, and the benefits were measured in terms of grain yield. The study revealed that on these shallow and coarse textured soils, maize yield responses were higher in 2014 cropping season with better rains than in 2013 cropping season with low and poorly distributed rains. However, Zai and tied ridges provided no benefit at Doggoh in both years. When compared with flat planting, zai and earth bunds resulted in 30% (490 kg/ha) and 54% (660 kg/ha) increases in grain yield of maize at Bompari in 2014 only, which points to the yield effects of improved water harvesting in the zai and earth bunds. The grain yields accrued due to water conservation treatments were higher under fertilized than unfertilized conditions on both soils indicating the synergetic effects of soil water and NPK nutrients on yield of maize. Added mineral fertilizer at the rate of 64-38-38 kg/ha as N, P_2O_5 and K_2O, respectively, markedly increased grain and aboveground dry matter production at both sites across years. On average, added fertilizer increased grain yields by 62 to 190% at Doggoh. Similarly, added fertilizer increased yields by 67 to 303% at Bompari. Thus, in both years and across sites, fertilizer application had a greater impact on maize grain and biomass production than any corresponding soil and water conservation treatment.

Capacity building, communication and knowledge dissemination

Objectives 4 and 5 involved capacity building of researchers, extension and farmers as well as communication and knowledge dissemination. Capacity building activities included training community members on Integrated Soil Fertilizer Management (ISFM) practices, soil and water conservation management, farm selection/record keeping and hazard of felling trees. A total of 165 farmers (98 males and 67 females) were trained in seedling production and grafting of mango by Forestry Services Department in October 2014 at Doggoh and Bompari respectively. The purpose was to enhance the knowledge of farmers in the climate smart villages in seedling production and mango grafting.

Some staff of Ghana Metrological Agency, Accra also visited the two climate smart villages (Bompari and Doggoh) to conduct farmers' need assessment with regards to climate information services to be implemented in 2015. The GMET staff said the essence of the meeting was to provide information related to the weather; that is the starting and ending of the rains, the length and peak period to be able to determined which crop varieties to grow and the appropriate time to plant. This was also used to monitor pest and diseases on the field. According to farmers, they are more interested in the following:

- The onset of the rains (early and late)
- When to plant
- Length of the season
- Peak of the season
- End of the season (cessation date)

In addition CCAFS signed an agreement with ESOKO in Ghana to improve smallholder farmers' capacity to better manage climate-related risks and build more resilient livelihoods in Northern Ghana. The activity is on-going. The specific objectives of the agreement were to upscale proven climate-smart technologies and practices through ESOKO platform in Northern Ghana and also test and pilot the communication of seasonal forecast and CSA technologies and practices (agro-advisories) through mobile phone to better manage climate-related risk and build more resilient livelihoods. Esoko conducted training on scaling up climate smart agriculture technology using mobile phones for 619 farmers (393 males and 228 females) in the CCAFS communities in the two districts. This activity will continue in 2015. The gender integration will be factored into the activity. Gender integration consists of ensuring that seasonal forecast and agro-advisories needs of women and other disadvantaged groups are taking into consideration and that these services reach and benefit these groups towards improved agricultural decision making in the face of climate change.

Content delivery and support was the major activity undertaken during the period under consideration. Major contents given to beneficiaries were: Market price alerts, climate smart agricultural advice, weather forecast and voice messages on best agricultural practices. The climate smart agricultural advice sent out was also converted to voice and sent out to beneficiaries of the scaling up climate smart agriculture technology Program in the language of their (farmers) choice

Mainstreaming gender into CCAFS activities

On the gender front, climate change does not discriminate, but the fragile group of persons, particularly women, suffers the most because their activities are directly linked to their livelihood. Gender Climate Smart Women Groups have been trained on the use of stone lining, compost, stone bunding for soil and water conservation and they have adapted these practices for rice and maize production on fields that are prone to erosion. Emphasis is also placed on interventions that are likely to be more beneficial to women, including nutrition education (Training on soybeans weanimix and apprapras an utilization) and village savings and loans groups.

It is clear that men and women have varying abilities to adapt to climate shocks and longer-term climate change because of differentiated access to entitlements, assets, and decision-making; this ability to adapt is further complicated by gender and social differences. In order to overcome resource constraints and maximize the participation of the resource-poor women, the project also introduced interventions designed to provide immediate short-term income and food benefits, allowing farmers to plant trees that would generate other substantial benefits in the longer-run. Additional interventions included training on soybean utilization in diverse local dishes.

In both communities men control access to land through customary tenure, and, as a result, are often considered the main decision-makers in terms of crop management, especially for long-term crops (such as trees) or food crops such as maize, sorghum and millet. Women may have greater authority over cash crops such as groundnut and soybean. We recognized that local level institutions are central to the scaling up and sustainability of the project in the long-term. The project therefore continued to try to address this issue by working with the chiefs and elders to ensure that women's rights to fertile land are recognized and enforced. We encourage men and women to come together and engage in decision making so as to open up opportunities for collaboration and cooperation. This involves supporting continued dialogue at both household and community levels; about the roles of women in supporting agricultural innovation, while working to reduce structural deficits (access to resources) and encouraging more male support.

In order to increase benefits for women, community-based extension volunteer and/or the gender desk officer of the project often visit women who for some reasons may not be able to, or choose not to attend community meetings. Working separately with women may not be the best way and may not overcome male dominated decision-making. The project provided opportunities for men and women to work together and this did not exist previously. The need for men and women to jointly engage in project level decisions has been very beneficial. In both communities, this change is helping men see that women should .have a greater role in community and household decisions. Thus women now actively participate in group decision-making in the project communities. Men are not excluded from the training activities of the Gender Climate Smart Women Groups as they are also permitted to participate in all training activities for the groups. Through several training trainings activities, husbands and wives now engage in discussions about planning and farm management. Women in the Doggoh community where the project started in 2012 described this as a shift towards working more as a household "unit.

There (3) members of the Ghana team (the country coordinator, gender desk officer and an NGO representative) attended a regional workshop on *mainstreaming a gender learning agenda in CCAFS research in West Africa* in Dakar, Senegal from 26th to 29th August 2014. Earlier in the year, the gender desk officer received training on mainstreaming gender into CCAFS-PAR activities under the project in India.

CCAFS Platform activities

A workshop on Climate Smart Agriculture (CSA) was organized by Ghana CCAFS Platform in Wa. This was aimed at enhancing participants knowledge on the vulnerability of Ghana's Agriculture and Food system to climate change and the need for action, to develop multi-level linkage of stakeholders on climate change adaptation and mitigation, to synchronize knowledge across levels in order to identify CSA technologies for profiling and improve the flow of knowledge and resource through the network of the actors and to advocate for policy and budgetary support for sectoral adaptation and mitigation. This workshop was followed by the establishment of two platforms in Jirapa and Lawra districts. CCAFS activities also featured prominently during a durbar to climax the annual farming festival (Kobina festival) of the chiefs and people of the Lawra Traditional area on 29th of September, 2014. The Farmers Platforms has been adopted and institutionalized as a permanent feature of the Kobine celebrations. The 2014 theme was on ***"Sustainable Land and Water Management - Key to Agriculture".*** The paramount chief of Lawra traditional area invited the CCAFS team and some collaborating farmers to dialogue on CSA. Discussions centered on climate change, its potential impact and ways to overcome or minimize its effects. This activity over the years has made the project more visible and also gave non-participating farmers the opportunity to learn more about effect of climate change as well as how to adapt or mitigate these effects. Meanwhile, in both communities, farmers were encouraged to practice crop rotation with legumes and also avoid burning of crop residue and the bush.

Project Outputs

- Three (3) improved drought tolerant maize varieties identified and evaluated
- Four (4) best fit indigenous water conservation practices (Zai, bunding, tie ridging and no-tillage) identified as efficient
- Four (4) water conservation practices (Zai, bunding, tie ridging and no-tillage) designed, tested and validated
- 100 households trained to use integrated water management options
- 146 farmers trained in compost preparation and use
- 234 farmers trained on land reclamation and soil fertility management practices
- One (1) sustainable agroforestry system(Jatropha + cowpea) tested and validated
- 10 women groups using improved mud stoves to reduce felling of trees;
- Stakeholders trained and behavioral changes established

- Three (3) broadcastings done to inform more farmers on climate change and the role of local convention on mitigation strategies.
- Capacity of 128 (115 women and 15 men) members of Gender Climate Smart Groups enhance on reducing post harvest losses to help reduce and enhance food security at the CCAFs sites
- 105 women trained on soybeans weanimix and apprapras an utilization
- two community nurseries established for sustained tree seedlings productions
- Monitoring and Evaluation tools have been used to evaluate behavioural change in the 5 beneficiary communities.
- Monitoring and Evaluation tools have been used to evaluate behavioral change in the 5 beneficiary communities.
- Proven climate-smart technologies and practices through ESOKO platform are up-scaled in Northern Ghana
- Effectiveness and efficiency of using mobile phone approach to communicate seasonal forecast and CSA technologies and practices (agro-advisories) to improve adaptation capacity are tested and

Challenges

(i) One challenge during the reporting period was the difficulty of having all partners together because of other official duties with their organizations. For instance it was difficult sometimes to have all members together to undertake a CCAFS activity because of other responsibilities.

(ii) In the on-farm trials, keeping the crop residue is a challenge due to bush fires and free animal grazing.

(iii) Annual bush fires and the long dry season pose a serious threat to survival of the trees transplanted.

(iv) All the funds were not received for the implementation of all 2014 activities

Conclusion and Recommendations

- Practices and approaches can be used by land managers and/or farmers, but climate change adaptation and mitigation options cannot be implemented from a "purely technical" standpoint alone. They also rely on the social support of the population involved. It is crucial that land managers/farmers be supported by being given options and opportunities, sustained by institutions and policy.
- Strong policies as well as tools and institutions at country level are essential to counteract the effects of climate change in agricultural production systems and the livelihood of the rural population.
- There is the need for strong government commitment to develop and/or adapt agricultural policies to take into consideration climate change, its potential impact and ways to overcome or minimize its effects.
- There is the need to lobby government to include climate change in agricultural policy frameworks;

- Climate change should be mainstreamed in national and local agricultural development plans;
- It must be noted that local expertise offers an immense repository of knowledge — not only about biophysical aspects of agricultural production, but also of the needs of communities and farmers.
- We intend to increase the number of women participating in local, national and regional dialogues on CSA.

Enhancing Soil Health in Northern Ghana: Inoculants Production, Distribution and Utilization through Private-Public Partnership (2013 AGRA SHP 025

Principal Investigator: B.D.K. Ahiabor
Collaborating Scientists: S.S. J. Buah and F. Kusi
Estimated Duration: 2013--2017
Sponsors: *Alliance for a Green Revolution in Africa (AGRA)*
Location: Five districts (Wa West, Wa Municipal, Jirapa, Sissala West and Sissala East)

Background Information and Justification
Grain legume yields in the savanna zone are generally low and this may be attributed to the unavailability of improved seed, use of seed of low yielding crop varieties as well as declining soil fertility. The AGRA Soil Health Project therefore aims at increasing access of smallholder farmers to inoculants and increase adoption, grain yields of legumes and cereals and finally increase livestock production to improve the livelihood of smallholder farmers. The project seeks to address factors such as soil fertility, high cost of mineral nitrogen fertilizer, lack of production facility for rhizobium inoculants, inadequate qualified or skilled human resource base required for inoculants production and inoculants quality control. The project is being funded by Alliance for Green Revolution in Africa (AGRA). The project partners in the Upper West region include CSIR-SARI, Ministry of Food and Agriculture (MoFA), Seed Producers Association of Ghana (SEEDPAG) and Methodist Agricultural Program (MAP), a local NGO. The project seeks to reach a total of 20,000 farmers across northern Ghana with 40% of those being women which translate to 5000 women.

Objectives
The project aims at improving farmers' access to improved seed and fertilizer as well as improved maize production technologies in order to reduce poverty and improved food security, incomes and livelihoods of small-scale resource poor farmers in northern Ghana

Expected Beneficiaries
Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, seed producers, policy makers as well as NGOs. Through field days which were carried out in the region during various stages of crop development, current maize and soybean production technologies are also reaching other farmers not directly involved in the project.

Materials and Methods

The project started in 2014 and was implemented in 5 communities in 5 districts (Siriyiri in Wa West, Wa in Wa Municipal, Chinchang in Sissala East, Gwollu in Sissala West and Jirapa in Jirapa districts) in the region. Four farmers from 4 FBOs planted the demonstrations. Each of 5 districts planted 6 demonstrations (2 each on soybean, cowpea and groundnut) in each community. In 2014, the regional team comprising SARI and MoFA personnel carried out the following activities: selection, registration and sensitization of FBOs, procurement of inputs (seed and fertilizers), training of 20 agricultural extension agents (AEAs) on integrated soil fertility management (ISFM), data collection and effective extension communication.

Dissemination campaigns included the following

1. *Demonstrations on ISFM*
2. *Field days*
3. *Training of trainers*
4. *Community outreach programs (radio broadcast)*
5. *Feed back (reporting to farmers).*

Establishment of Demonstrations on ISFM

- Demonstrations on soybean involved soybean response to fertisoil, seed inoculation and fertilizer P
- Demonstrations on groundnut involved groundnut response to lime, organic fertilizer and fertilizer P application
- Demonstrations on cowpea involved cowpea response to seed inoculation, organic fertilizer and fertilizer P fertilizer

Prior to the implementation of project activities, agricultural extension staff from the five District Agricultural Development Units and collaborating farmers were sensitized on project activities. The roles and responsibilities of each partner (farmers, AEAs and Project team) were outlined. The collaborating farmers provided land for the demonstrations and also took care of planting, fertilizer application, weeding and harvesting. The AEAs monitored day to day trial implementation and data collection while the research team monitored the implementation of the trial at different stages. The project provided seed and fertilizer for the experiment.

Results and discussion

Farmers field days: Three field days were held in 3 communities (Chinchang in Sissala East district, Jirapa in Jirapa district and Wa in Wa municipality (283 participants 126 males and 57 females) (Table 99). Through the field days, good agricultural practices for soybean, groundnut and cowpea production are also reaching other farmers not directly involved in the project in the region. Other participants at the field days included, 17 input dealers, 5 pressmen, 10 groundnut processors and 1financial institution (Sinapi Aba).

Table 107: *Number of farmers participating at each field day in each location*

District	Location	Field day Date	Male	Female	Total
Jirapa	Jirapa	9/10/14	33	16	49
Sissala East	Chinchang	13/10/14	53	31	84
Wa	Wa	14/10/14	40	10	50
Total			126	57	183

During the field days, collaborating farmers said they were happy will the good crops on their demonstration plots but told their fellow farmers that the demonstrations really requires a lot of time, dedication and extra patience to achieve such great results of crop performance. At Jirapa, the collaborating farmer told his fellow farmers that the achievement was due to the support given to him by his family and the constant monitoring by the AEA. Majority (85%) of the farmers at the field days said that a combined application of *Rhizobium* inoculants and TSP fertilizer appears to give higher soybean yields based on the visual observation of the number and size of pods. Groundnut treated with TSP and lime was most preferred by 95% of the farmers compared to the rest of the treatments

Technologies explained/taught to participants during the field day event:

- Seed inoculation of soybean and cowpea and sources of supply
- Good Agricultural Practices for cowpea and groundnut production. These practices included appropriate land preparation, use of quality seed planting in rows at the recommended spacing, appropriate planting depth, efficient fertilizer application, weed management, IPM strategies to manage pests and diseases of these crops and recommended insecticide and method of application for cowpea production. For fertilizer application, emphasis was on right type of fertilizer, right quantity applied at the right place and at the right time.

Farmer exchange visits: One visit to Dokpong by farmers and AEAs from all the 5 project districts and communities ***Technologies explained/taught to participants during the farmer exchange visits:***

- Seed inoculation of soybean and cowpea and sources of supply
- Good Agricultural Practices for cowpea and groundnut production. These practices included appropriate land preparation, use of quality seed planting in rows at the recommended spacing, appropriate planting depth, efficient fertilizer application, weed management, IPM strategies to manage pests and diseases of these crops and recommended insecticide and method of application for cowpea production. For fertilizer application, emphasis was on right type of fertilizer, right quantity applied at the right place and at the right time.

Topics discussed during radio broadcast included: Seed inoculation of soybean - types of inoculants, inoculants storage and handling, the need to inoculate, application of inoculants and some tips on inoculation. Radio programs on Groundnut production were also hosted by an NGO called MADE (Market Development for Northern Ghana). They used the Radio script prepared by AGRA SHP 005 as a reference material. L languages used were English and Sissali. All radio stations in the region have been given copies of the AGRA SHP 005 radio scripts to use for radio programs

Capacity building

We attended a number of stakeholder meetings with legumes value chain actors to create awareness on use of inoculants. These minutes included the following:

- CARE International Pathway Project in Lambussie-Karni district - Training of project staff, AEAs and community extension agents in the use of inoculants for soybean production (Number of participants 44 – 4 males and 40 females)
- Groundnut Innovation Platform in Wa East and Wa municipal (30 males 15 females)
- Training of 40 extension staff on Soybean production and seed inoculation of soybean during a RELC Technical Review session.
- Meeting with MADE, an NGO supporting groundnut production in the region.
- Meeting with staff of Antika Seed company

A number of trainings were organized for representatives of FBOs, Agro-input dealers, AEAs and Agricultural-based NGOs. These included the following

- Training of farmers on seed inoculation of soybean during planting in various communities (197 males + 118 females = 315 participants).
- Training of AEAs in ToT on seed inoculation of soybean (2 NGO members (Methodist Agric Project), 4 SARI staff and 5 MoFA staff) – 9 males + 2 females = participants.
- Training of 17 agro-input dealers (13 males + 4 females).

Topics discussed included

- Seed inoculation of soybean - types of inoculants, inoculants storage and handling, the need to inoculate, application of inoculants and some tips on inoculation
- Fertilizers and their uses – different types of fertilizers (organic, inorganic and biofertilizer), application methods and identification of nutrient deficiency symptoms
- Safe and efficient use of agro-chemicals

Expected output

- The participating FBOs had access to ISFM for soybean, cowpea and groundnut production through trainings and demonstrations.
- Increased availability of technical information on ISFM as well as soybean, cowpea and groundnut production
- Through field days, current ISFM technologies are also reaching other farmers not directly involved in the project.
- Over 250 farmers and 40 AEAs have expanded their knowledge of ISFM and good agricultural practices for soybean, cowpea and groundnut production
- Farmers have indicated their willingness to grow improved varieties of soybean, cowpea and groundnut using ISFM options in 2015.

Challenges encountered

- Pre-season drought followed by very wet conditions during the growing season affected seedling emergence, plant growth and development.
- Meaningful and reliable data collection by the field staff is still a major problem
- The AEA-Farmer ration is too large yet other projects are competing for the AEAs time and therefore pose a threat to the successful implementation of AGRA SHP activities in the region.
- Lack of commitment from some field staff as well as farmers particularly in Sissala West district.

Recommendati ons

Joint monitoring of project activities

- To assess conformity of the implemented work with the research framework developed for the project
- Also to provide recommendation on management of the project as well as the partnerships for achieving the project objectives

Technology parks/Learning centers

- Good sites for research, training and demonstration as well as good interactions between research, extension and farmers
- Regular quarterly review meetings
- This will help rectify some short comings to ensure that the project continues to deliver on its objectives.

Review of field protocols, data collection and analyses.

- This will help rectify some short comings to ensure that the project continues to deliver on its objectives.
- Review of field protocols, data collection and analyses.

Participatory variety selection of new rice in the Upper West Region

Principal Investigator: Wilson Dogbe
Collaborating Scientists: S.S. J. Buah, R.A.L Kanton
Estimated Duration: 2012-2013
Sponsors: AFD/RSSP/MoFA
Location: Wa East, Wa Municipal, Sissala East and Wa, West districts.

Background Information and Justification

Rice is an important staple crop in Ghana but low yields in the northern Guinea savanna of Ghana are common due to erratic rainfall, low soil nutrient levels, use of low yielding varieties and poor crop management practices. Research has shown that adoption of improved varieties by smallholder farmers is low. Reasons attributed to these among others, are that improved varieties are poorly adapted to farmers conditions or do not meet their needs and farmers have limited access to seeds and information about new varieties. There is therefore the need to improve farmer's access and adoption of improved rice varieties. One way of doing this is through participatory varietal selection (PVS) using the mother and baby trial approach. PVS is a method used to increase the speed of adoption of new varieties by involving farmers in variety needs assessment, selection and testing of a wide range of novel cultivars. CSIR-SARI in collaboration with MOFA implemented mother and baby trials under the Rice Sector Support Project (RSSP) at Polee Kpanyaluu valley in 2012 and 2013. The goal of the RSSP is to increase rice productivity and generate income for the rural house hold farmers in northern Ghana through the adoption of appropriate rice production technologies. The project is being implemented in four districts (Sissala East, Wa East, Wa West and Wa municipality) in the UWR. Polee is one of the beneficiary communities in Wa West district.

Objectives
The objective of the PVS trials was to evaluate promising lowland rice varieties in collaboration with farmers and other stakeholders in the rice industry in the varietal selection processes taking into account their preferences. This is to enhance the acceptability of varieties by farmers and consumers.

Expected Beneficiaries
Direct beneficiaries: researchers, agricultural extension agents and rice farmers.
Secondary beneficiaries: dependents of the farmers and researchers, seed producers, policy makers as well as NGOs. Through field days which were carried out in the region during various stages of crop development, current rice production technologies are also reaching other farmers not directly involved in the project.

Materials and Methods
In 2012 and 2013, PVS exercise was carried out in the Polee community in the Wa West district using the Mother and Baby trial approach. The mother and baby trials were installed with MoFA and managed by farmers. Seeds of the improved varieties were provided by CSIR-SARI but the farmers took care of land preparation, planting, weed control and harvesting. They also provided fertilizers for the baby trials. The MoFA extension staff and farmers were trained using a Participatory Learning Action Research (PLAR) procedure before the start of the season and were advised to follow recommended agronomic practices. Agronomic data and farmer preferences of varieties were collected using qualitative (participatory) and quantitative methods. At vegetative and maturity, farmers ranked each trait of interest as better, same or worse than their own variety. Grain yield was measured for each variety at physiological maturity. A field day was organized for farmers at physiological maturity. Farmers evaluated 6 new improved varieties (Exbaika, WAS 163-B-5-3, Perfume irrigated, L2-4, Long grain ordinary 2, WAS 122-13-WAS-10-WAR) which were validated on-station alongside their own local varieties. At the vegetative stage, farmers evaluated the varieties based on tillering ability and plant height. Plant vigour and rapid plant growth were also important. The objectives of the field day were to gain an overall understanding of rice production in the area, identify desirable and acceptable rice varieties with farmers and also identify farmers' considerations in

selecting rice varieties for planting. The 2014 activities were mainly reduced to backstopping the MoFA extension staff in PLAR activities.

Results/Major Findings

In 2012, farmers in Polee have cultivated about 30 ha of rice and 34 ha i cropping season using improved varieties mainly Gbewa rice (Jasmine 85) and Exbaika selected from the PVS carried out by CSIR-SARI. At maturity, the criteria that were most frequently cited by farmers for preference of a variety were plant height, panicle size, grain yield and grain shape. A total number of 76 people (53 males + 23 females) attended a field day organized at Polee. The categories of participants were host farmers, visiting farmers, press men, opinion leaders and MoFA staff. At the field day, participants were asked to select the best varieties) among the various varieties planted. Over the years, most farmers at the Polee site prefer Exbaika and therefore selected it as the best performing variety because of its vigour, good tillering ability, pest resistance and large and healthy panicles. Those farmers who chose Exbaika as their first choice said they did so because of the following reasons:

- The variety is short in height and does not shatter easily
- high yielding and looks nice
- Tillering is good
- The variety does not lodge easily.

In addition, 17 farmers (11M+6F) selected WAS 122-13-WAS-10W while 8 farmers (4M+4F) selected WAS 163-B-5-3. Generally, farmers were happy with the field day as they are now aware that planting quality seed of improved varieties at optimum plant stand and appropriate planting time with adequate control of weeds, pest and diseases as well as timely applicatio n of adequate quantities of fertilizers would maximize rice yield, while the contrary would lead to yield reduction. They also noted that it is much easier to apply fertilizer, weed and execute other agronomic practices if rice is planted in rows as was observed in the mother trial. Also the noted that optimum plant population is an important factor in achieving higher yields

In the 2014 season, 83.2 ha were cultivated by 155 beneficiaries segregated into 34 females and 121 males at five developed valleys (Chogsia, Naaha, Tindoma, Polee and Losse) even though the target for Wa West in 2014 season was 100 ha for which they could not meet due to several reasons. Most of these fields were planted to foundation seed hence certified seed was produced. In all a total of 10.3 t of seed was produced in 2014. Of this lot 125 bags were seed of Gbewa rice. In backstopping PLAR activities, Two training session were organized at 5 communities in Wa West district with a total of 188 participants (125 males + 63 females). The modules selected by the five communities (Polee, Naaha, Losse, Chogsia and Tendoma) were:

- Using good rice seed and Varieties
- Good crop management practices
- Rice field preparation
- Establishing a rice nursery at planting
- Land preparation planning
- Soil quality maintenance

- Intermediary bunding
- Bund maintenance

Some of the experience/ observations made in 2013 were:

- Late water management training to farmers by AEAs and DAOs as a result of late release of funds
- Poor intermediary bunds construction by farmers leading to uneven distribution of water on the field for crop use
- Poor leveling of fields before planting leading poor germination leading to poor plant stand.
- Late ploughing and planting of fields by farmers resulted in low yields in some farmer's fields in some lowlands.
- Weak group work at the valleys by farmer groups leading to non uniformity in their cultural practices hence affect uniform crop development and maturity.
- Seed mixture which affected produce purity at and after harvest

Lessons Learnt

It was learned during PLAR training at Losse that farmers observed that Gbewa rice may not be an appropriate variety for the (Kongbakpeng) valley as germination is reduced. However, the farmers rather prefer Digan as its emergence was much better than Gbewa rice in this valley. It was observed that Loan recovery in kind from beneficiary farmers may be better than in cash as farmers find it difficult to pay off loans in cash.

Conclusion and recommendation

All participants were happy and expressed willingness to adopt or adapt the new technologies to improve their rice productivity and income generation. Across the two seasons, Exbaika was the most preferred variety. This variety seems to meet farmers' expectations in the field. Further assessment for palatability and consumers' acceptance should be conducted. Exbaika is known to be aromatic. It should be a strong criterion for farmers to choose to crop this variety. There is the need to investigate milling and parboiling quality of the new varieties. The technologies demonstrated in the beneficiary community have proven to be successful, hence the need to disseminate such proven technologies to many more farmers in other districts. There has been a spill-over effect where non-project farmers purchased seed of the improved varieties, particularly Gbewa rice and planted on their own in 2013 and 2014. However, because this variety has not been officially released for commercial production, little effort is being made to encourage seed production of the variety. Although there were challenges regarding the constructional work at the lowlands, the demand for rice by farmers in the district has increased as a result of the development of the lowlands by RSSP. In conclusion, the PLAR training sessions for farmers at the cultivated valleys were helpful as it had refreshed farmers with some of the Good Agricultural Practices (GAPS) for rice production and farmers yields have increased significantly.

Evaluation of soybean varieties in the Upper West region

Principal Investigator: Nicholas N Denwar/S.S.J. Buah
Estimated Duration: 2014-2015
Location: Wa

Background Information and Justification

Soybean is an important source of high quality and relatively inexpensive protein and oil, containing about 40% protein (highest for all food crops) and 20% oil (second only to groundnut). Soybean contains such essential amino acids as lysine and tryptophan. As a legume, soybean is capable of fixing biological nitrogen which could benefit a succeeding cereal crop in a rotation. In addition, it is capable of reduce the seed bank of the parasitic weed Striga which often reduces yields of maize, sorghum and millet. However, the yields of current soybean varieties are low and their capacity to stimulate suicidal germination in *S. hermonthica* seeds is also low. Soybean is becoming an important food and cash crop in the rural communities and with the proliferation of soybean processing plants in Ghana of late its potential as a poverty alleviation and wealth creation crop cannot be over-emphasized. This therefore calls for the development high yielding soybean varieties that are adapted to the agro-ecological systems of northern Ghana. This report summarizes results of evaluation of diverse soybean varieties in the Upper West region in 2014.

Objectives

Specific objectives were:

(i) To familiarize farmers with available soybean varieties with staple and high yield in order to facilitate the adoption of the varieties

(ii) To demonstrate and promote the application of modern technologies for the production of promising soybean varieties

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.
Secondary beneficiaries: dependents of the farmers and researchers, seed producers, industry, policy makers as well as NGOs.

Materials and Methods

Field experiments were conducted in 2014 at CSIR-SARI research station in Wa in the UWR to evaluate the performance of soybean varieties for adaptation to the northern savanna agro-ecology systems. In all, four experiments comprising 2 each of early and medium maturity groups were planted. The experiments were

1. Soybean International Observation Trial - 16 entries and 3 replications. Two row plots, 5 m long.
2. Relative yield response of soybean varieties to management by appropriate research technology – 10 entries, four replications and 4-row plots of 5 m in length.
3. Advanced yield test of early maturing soybean lines – 10 entries, four replications and 4-row plots of 5 m in length.

4. Advanced yield test of medium maturing soybean lines – 10 entries, four replications and 4-row plots of 5 m in length.

The experimental design was an RCBD. The hybrids were sown in rows of 5 m in length and 0.75 m apart. The field was ploughed and harrowed at least 2 weeks before planting. Three seeds per hill were planted at 0.05 m apart. Fertilizer was applied at the rate of 25-60-30 kg/ha as N, P_20_5 and K_2O, respectively. Weeding was done twice. The rains were late and when they finally arrived they were followed by a prolonged dry spell, which resulted in delayed implementation of some cultural practices on schedule.

Data were collected from the centre 2 rows. The data taken included seedling vigour, plant stand after thinning, days to half bloom (days to 50% flowering), plant height (cm), plant height, grain yield and yield components.

Results/Major Findings

Planting was significantly delayed until July due to prolonged pre-season drought. However, after mid July, we experienced wet conditions. Wet conditions reduced seedling emergence of the trials and this necessitated refilling. The variable weather affected plant growth and development and ultimate grain yield at most sites. In general, highly variable rainfall from year to year makes it difficult for farmers to plan, and the wrong decision on which crop to plant, and when to plant it, may lead to dire consequences for a household

Soybean International Observation Trial

Sixteen soybean genotypes evaluated in this trial in Wa in 2014. There were significant differences among the varieties for flowering date, pods per plant, grain and biomass production as well as seed weight. The soybean genotypes flowered in 40-48 days after planting. The earliest genotype to flower was TGx 1835-10E-check while the latest to flower was TGx 1987-62F-check (Table 100). The genotype TGx 1995-5FN had while flowers. Differences among the genotypes for plant height were not statistically significant.

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Table 108: *Some agronomic traits of soybean in the Soybean International Observation Trial, Wa, 2014*

Genotype	Days to 50% flowering	Plant height at flowering (cm)	Pods/ plant	100-seed weight (g)	Biomass yield (kg/ha)	Grain yield (kg/ha)
TGx 1987-10F	46	44	31	12.8	4576	1733
TGx 1989-48FN	47	41	42	13.8	5333	2856
TGx 1989-49FN	42	43	43	15.7	5067	1422
TGx 1989-68FN	46	45	83	14.7	4400	1867
TGx 1990-21F	45	48	41	15.7	4445	1956
TGx 1990-40F	43	50	44	14.7	5911	2089
TGx 1990-46F	44	47	57	12.6	5022	2176
TGx 1990-52F	44	53	86	16.1	3556	1511
TGx 1990-55F	47	50	63	13.4	5644	1689
TGx 1990-57F	44	44	37	15.8	5289	1467
TGx 1995-5FN	44	45	44	16.4	4933	1600
TGx 1987-10F-check	47	48	29	13.7	4222	1644
TGx 1987-62F-check	48	47	36	13.6	5467	1867
TGx 1835-10E-check	40	41	28	13.9	2933	1289
TGx 1485-1D-check	41	50	35	12.2	4044	1555
Local check (Jenguma)	46	49	47	12.9	6266	2178
LSD	2.0	NS	26	2.2	1084	532
CV	2.7	11.8	32.9	9.4	13.5	17.9

Biomass production ranged from 2933 to 6267 kg/ha. TGx 1835-10E-check which was the earliest to flower also produced the least aboveground dry matter. Jenguma which was used as a local check produced the highest biomass. This is not surprising as Jenguma is a medium maturing variety but was used as a check among these early maturing genotypes. Seed weight ranged from 12.2 to 16.4 g. TGx 1485-1D-check had the least seed weight while TGx 1990-52F and TGx 1995-5FN produced the heaviest seeds. Mean grain yield ranged from 1289 to 2356 kg/ha. Grain yield was highest for TGx 1989-48FN and least for TGx 1835-10E-check. Four genotypes (TGx 1989-48FN, TGx 1990-40F, TGx 1990-46F and Jenguma) had grain yields above 2.0 t/ha. Grain yield was correlated with biomass production (r = 0.51) but had no significant correlation with plant height, pods per plant or seeds per pod.

Relative yield response of soybean varieties to management by appropriate research technology

Ten soybean varieties evaluated in this trial in Wa in 2014. Differences among the genotypes for grain production were not statistically significant (Table 101). The genotypes flowered in 51- 55 days after planting. Nonetheless, differences among the genotypes for days to flowering, plant height, pods per plant and biomass production were statistically significant. The earliest genotypes to flower were Quarshie, Afayak, TGx 1844-22E and TGx 1448-2E while the latest to flower was Salintuya II. Plant height ranged from 53 to 74 cm. The tallest genotype was Afayak while the shortest were TGx 1844-22E and TGx 1448-2E. Biomass production ranged from 2167 to 4100 kg/ha. Sung Pungun which was among the earliest to flower also produced the least aboveground dry matter. Salintuya II which was the latest to flower produced the highest biomass of 4100 kg/ha. Mean grain yield ranged from 1667 to 2600 kg/ha. Grain yield tended to be highest for Afayak and least for Jenguma. Five genotypes (Afayak, Anidaso, TGx 1844-22E, Salintuya 1 and Salintuya II) had grain yields above 2.0 t/ha. Grain yield was correlated with biomass production (r = 0.59) and plant height (r=0.62) but had no significant correlation with pods per plant.

Table 109: *Some agronomic traits of soybean tested in Wa, 2014*

Genotype	Days to 50% flowering	Plant height at flowering (cm)	Biomass yield (kg/ha)	Grain yield (kg/ha)
Anidaso	54	62	2867	2067
Jenguma	51	54	2634	1667
Quarshie	51	55	2900	1933
Salintuya 1	52	55	2967	2167
Salintuya II	55	65	4100	2100
Afayak	51	74	3567	2600
Songda	52	62	3000	1967
Sung Pungun	52	60	2167	1967
TGx 1844-22E	51	53	2334	2234
TGx 1448-2E	51	54	2534	1933
LSD	2	12	910	NS
CV	2.2	14.3	21.6	21.2

Advanced yield test of early maturing soybean lines

Ten early maturing soybean genotypes were evaluated in this advance yield trial in Wa in 2014. Differences among the genotypes for plant height and seeds per pod were not statistically significant (Table 102). However, differences among the genotypes for days to flowering, plant height, pods per plant and biomass production were statistically significant. The genotypes flowered in 44 - 48 days after planting. The earliest genotype to flower was TGx1903-7F while the latest to flower was TGx1988-3F. Plant height ranged from 51 to 64 cm. The tallest genotype was TGx1987-62F while the shortest was TGx1989-41F. Biomass production ranged from 1783 to 4367 kg/ha. TGx1987-10F produced the least aboveground dry matter. TGx1740-2F produced the highest biomass of 4367 kg/ha. Pods per plant ranged from 44 to 95. TGx1988-3F had the least number of pods per plant while TGx1903-7F had the highest number of pods per plant. Seed weight ranged from 11.8 to 16.3 g. TGx1989-19F had the least seed weight while TGx1987-62F produced the heaviest seeds. Mean grain yield ranged from 1719 to 2734 kg/ha. Grain yield was highest for TGx1740-2F which also had the highest dry matter production and least for TGx1903-7F. Despite having the highest number of pods per plant TGx1903-7F still produced low grain yield. The Six genotypes (TGx1989-41F, TGx1989-20F, TGx1988-3F, TGx1799-8F. TGx1740-2F, TGx1805-8F) had grain yields above

2.0 t/ha. Grain yield was correlated with biomass production (r = 0.88) and plant stand (r=0.43) but had no significant correlation with pods per plant, plant height and seed number. Genotypes with final plant populations higher than the recommended population of 266,700 plants/ha had higher grain yields.

Table 110: *Some agronomic traits of soybean in advanced yield test of early maturing lines, Wa, 2014.*

Genotype	Days to 50% flowering	Plant height at flowering (cm)	Pods/ plant	100-seed weight (g)	Biomass yield (kg/ha)	Grain yield (kg/ha)
TGx1989-19F	47	60	47	11.8	2483	1783
TGx1989-41F	46	51	64	14.0	2267	2050
TGx1989-20F	47	62	73	12.7	3434	2516
TGx1988-3F	48	61	44	14.9	3100	2300
TGx1987-10F	47	63	95	15.8	1783	1750
TGx1987-62F	47	64	88	16.3	1967	1917
TGx1799-8F	47	63	74	13.2	2850	2350
TGx1740-2F	46	59	73	11.8	4367	2734
TGx1805-8F	46	59	88	12.1	2800	2183
TGx1903-7F	44	55	95	12.7	1950	1718
LSD	2	NS	33	1.9	888	738
CV%	3.3	17.3	30.4	9.7	22.7	23.6

Advanced yield test of medium maturing soybean lines

Ten medium maturing soybean genotypes were evaluated in this advance yield trial in Wa in 2014. Differences among the genotypes for plant height, days to flowering and seeds per pod were not statistically significant (Table 103). However, differences among the genotypes for pod load per plant, grain and biomass production as well as seed size) 100 seed weight) were statistically significant. The genotypes flowered in 46 - 47 days after planting. Biomass production ranged from 1500 to 5683 kg/ha. TGx1989-42F produced the least aboveground dry matter. TGx1445-3E produced the highest biomass of 5683 kg/ha. Pods per plant ranged from 48 to 125. TGx1845-10E had the least number of pods per plant while TGx1989-42F had the highest number of pods per plant. Seed weight ranged from 11.9 to 14.3 g with TGx1845-10E having the least seed weight while TGx1989-42F produced the heaviest seeds. Mean grain yield ranged from 1250 to 3017 kg/ha. Grain yield was highest for TGx1834-5E which also had the higher dry matter production and least for TGx1989-42F. Although TGx1989-42F had the highest number of pods per plant as well as heaviest seeds this did not translate into higher grain yields. All the genotypes, except TGx1989-42F had grain yields above 2.0 t/ha. Grain yield was correlated with biomass production (r = 0.59) and plant stand (r=0.41) but had no significant correlation with pods per plant, plant height and seed number. The plant stand of TGx1989-42F was 106,700 plants/ha which was about half the recommended plant population of 266,700 plants/ha and this probably explains its low aboveground dry matter and grain production.

Table 111: *Some agronomic traits of soybean in advanced yield test of medium maturing lines, Wa, 2014*.

Genotype	Days to 50% flowering	Plant height at flowering (cm)	Pods/ plant	100-seed weight (g)	Biomass yield (kg/ha)	Grain yield (kg/ha)
Quarshie	47	60	59	13.1	4300	2550
TGx1844-19F	46	51	51	13.4	4533	2884
Jenguma	47	62	59	12.0	5233	2500
TGx1844-22E	47	62	57	12.5	4933	2733
TGx1834-5E	46	63	55	13.7	4383	3017
TGx1445-3E	47	64	60	13.6	5683	2367
TGx1989-42F	46	63	125	14.3	1500	1250
TGx1990-93F	46	59	67	13.3	3133	2917
TGx1910-6E	46	59	51	12.9	4584	2600
TGx1845-10E	47	55	48	11.9	4883	2500
LSD	NS	NS	26	1.2	706	465
CV%	1.9	17.3	28.5	6.4	11.3	12.7

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