COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

ANNUAL REPORT 2013

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.

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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 2013

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

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FORWARD

The CSIR-Savanna Agricultural Research Institute continued to live up to its mandate of providing farmers in Northern Ghana 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 year 2013 was very productive with the release of five improved drought tolerant maize varieties. With climate change that we are currently experiencing, the quantity and distribution of rainfall which cannot be determined based on the long term weather data available. Plant Breeders are now braced for it, and are gearing towards developing crop varieties from early or extra-early to drought tolerant to enable our numerous farmers get something to feed their households in very bad years. Moreover, as a result of continuous farming, pests and diseases have built up and are becoming resistant to pesticide. Hence efforts are being made to get crop varieties that are tolerant to stresses like pests and diseases, low soil nitrogen and more importantly the parasitic weed – *striga*. The new drought tolerant maize varieties have been deployed into the farming systems of Northern Ghana to give meaning to “Better tools, better harvests and better lives”. Efforts have been intensified towards enhancing production and access to *striga* control in maize to sustainably produce the crop in *striga* endemic farming communities.

The Institute also released three soybean varieties into the farming systems during the year under review. The improved varieties combine earliness with high yielding and good shattering ability as well as good trap trait for *striga* control.

The crop improvement programme is generally making strides in developing crop varieties that fits into the agroecologies of the mandate zone. Pearl millet improvement has had no improved pearl millet varieties beside Manga nara which was released in the colonial era. Research is far advanced for five improved pearl millet varieties to be proposed for consideration for release in 2014.

The soil improvement programme continues to develop innovative strategies to boost maize-based cropping system productivity in northern savannah zones through widespread adoption of integrated soil fertility management. Adoption of best practices by farmers resulted in maize yield of as much as 3-4 t/ha. Further studies on inoculation of soybean with rhizobium also resulted in 30-40% yield increase at farmer level.

With the completion of work on the installation of the facility for confined field trial on developing a *Maruca*-resistant cowpea, the National Biosafety Committee has permitted SARI to conduct the first trial in 2013.

Our scientists continued to mobilize resources through attraction of funding from research proposals/contract research to ensure that the Institute is prepared to take on challenges and build capacities of partners/students in the geographical mandate. All these have resulted in a stronger organization with a more relevant and focused science platform, responsive staff and more effective institutional mechanisms to ensure effectiveness and efficiency in operations, proactive and more strategic partnerships and networks, and an increase in resources that would facilitate the success of its farming systems research programmes.

I would like to thank the staff for their hard work and commitment. I encourage all to work even harder to make sure that SARI succeeds in its vision of making agricultural research responsive to farmer needs and national development. My thanks go to all donors, especially AGRA, DANIDA, USAID, EMBRAPA and others that have supported us during the course of the year. Our appreciation also goes to the Ministry of Food and Agriculture and numerous press houses that helped us disseminate our technologies. We hope that you will enjoy reading this report with much pleasure. 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 7-member Management Board, but chaired by Mr. Alhassan Andani, MD of Stanbic Bank, and a 16-member Internal Management Committee (IMC), chaired by the Director. Membership of the Management Board and IMC are presented below:

In 2013 the Management Board was not in place. Identification of members were still on-going. Individuals whose names have so far come to the fore are presented below. The Board will be inaugurated once the individuals accept the invitation and CSIR Head Office approve of it.

Membership of CSIR-SARI Management Board

No.	Name	Designation
1	Mr. Alhassan Andani,	Private Sector, Chairman
2		D-G's Rep.
3	Dr. N. Karbo	Cognate Director, CSIR-ARI
4	Dr. S. K. Nutsugah	Director, CSIR-SARI
5	Mrs. Gina Odartefio	Private Sector Representative
6	Mr. William Boakye-Acheampong	MoFA, Public Sector
7	Mr. Mohammed Adam Nashiru	Private Farmer

Membership of CSIR-SARI Internal Management Committee

No.	Name	Designation
1	Dr. Stephen K. Nutsugah	Director (Chairman)
2	Dr. James M. Kombiok	Deputy Director
3	Dr. W. Dogbe	Head, Northern Region Farming Systems Research Group
4	Dr. Roger A. L. Kanton	Head, Upper East Region Farming Systems Research Group
5	Dr. S. S. J. Buah	Head, Upper West Region 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
11	Mr. Eric Appiah	Representative, Commercialization and Information Division
12	Mr. Robert K. Owusu	Scientific Secretary, Recorder
13	Mr. Augustine Owusu	Ag. Workshop Manager
14	Mr. Zakaria Seidu Seini	Ag. Farm Manager

15	Rev. G.Y. Nachim	Head, Administrative Division

Staff Strength

Staff strength as at the beginning of April 2013 stood at 461. However, by the end of the year the number had decreased to 451 comprising of 46 Senior Members, 109 Senior Staff and 296 Junior Staff members. Staff distribution and the list of Senior Members and staff are presented. Staff strength was affected variously in the course of the year by promotions, appointments, retirements, resignations and deaths. See table 1 for full details.

The out stations located in Manga and Wa also have a staff total of 50 and 49 respectively. With Manga having 5 Senior Members, 8 Senior Staff and 37 Junior Staff while Wa has 5 Senior Members, 10 Senior Staff and 29 Junior Staff.

Table 1. Promotions, appointments and deaths

	Chief Res. Scientist	Principal Research	Senior Research/SSS	Senior Members	Senior Staff	Junior Staff	Total
Promotion	1	-	-	1	5	16	22
Appointment			-	1	8	11	20
Consideration			-	-	-	-	-
Retirement		-	-	1	1		
Death			-	-	1	3	4

Human Resource Development

The Human Resource Development Committee has received approval for eight (8) staff both local and foreign who qualified for training for 2012/2013 academic year.

No	**Name**	**Course**	**Finish**	***Place**
1	Francis Kusi	Ph.D. Entomology	2015	Univ. of Ghana, Legon
2	Ibrahim A. Zakaria	MSc Soil Science	2014	Kansas State Univ. USA
3	Mukltharu Zakaria	M. Phil Entomology	2014	KNUST, Ghana
4	Alexander N. Wiredu	Ph.D.	2015	Univ. of Hohenhein, Germany
5	Bawah Safiatu Musah	MBA Public Admin.	2014	Lincoln Univ. New Zealand
6	Desmond A. Sunday	MSc	2015	Navrongo, Ghana
7	Kwabena Y. James	Dip	2014	Univ. of Ghana, Legon
8	Sumaila Ayishetu	Dip	2014	Univ. of Ghana, Legon

Table 3. Staff back from training

Name	Grade	Programme
Abubakari Mumuni	Snr. Marketing Asst.	BSc. Marketing
Abihiba Zulai	Snr. Clerk	B.Sc. Accounting
Francisca Abaah	Admin. Assistant	BBA. Sec. Mgt.
Kambe John Baptist	Snr. Works Sup.	HND Mech. Eng.
Thomas Coker-Awortwi	Assistant Accountant	EMBA Strategic Mgt.
Tahiru Fulera	Asst. Res. Scientist	M.Sc. Agriculture
Yahaya Aseiku	Asst. Res. Scientist	M.Sc. Agronomy
Musah Alhassan	Overseer	Cert in Agric
Salifu Tahiru	Overseer	Cert in Agric
Bukari Adamu	Asst. Overseer	Cert in Agric
Azure N. Joseph	Overseer	Cert in Agric

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 & Water Conservation
- Internal Management
- Ground & Compound
- Promotion Screening
- Commercialization Oversight
- Welfare
- Health Fund
- Club House
- Seminar/Field Visit
- SARI Estate Management

National Service

Twenty eight (28) graduates from tertiary institutions in the country undertook their national service at the Institute. The details are presented in Table 3.

Table 3. National Service.

Institution	No.
Kwame Nkrumah University of Science and Technology	2
University of Education, Winneba	1
Tech. University College, Tamale	1
University for Development Studies	15
Tamale Polytechnic	7
University of Egypt	1
IPA, KITA	1
Total	**28**

Staff Distribution among Divisions

Division	Senior Members	Senior Staff	Junior Staff	Total
NR Farming Systems Research Group	10	17	50	77
UER Farming Systems Research Group	5	8	37	50
UWR Farming Systems Research Group	5	10	29	44
Scientific Support Group	23	36	58	117
Commercialization and Information Division • Documentation • Library	2	6	3	11
Accounts	1	13	4	18
Administration Division • Personnel • Transport/Workshop • Farm Management • Estate • Security	2	21	116	139
Total	**46**	**109**	**296**	**451**

LIST OF SENIOR MEMBERS AND SENIOR STAFF

Administration, Accounts, Farm Management and Workshop

Name	Qualification	Area of Specialisation	Designation
Administration			
S. K. Nutsugah	BSc MSc PhD	Agriculture Plant Pathology Plant Pathology	Director
G.Y. Nachim	BA MPhil Post-Graduate Dipl	Sociology and Study of Religions. Sociology PGDTLHE	Administrative Officer
M. Saffiatu	BA	IDS	Principal Administrative Asst
F. Amea	DBS	Secretariat Option	Administrative Asst
Beatrice Osei Akyereko	BA	IDS, Planning	Principal Estate Asst.
I. K. Osman	HND	Sec. & Mgt	Snr. Administrative Asst
Alidu Feruza	HND	Sec. & Mgt	Snr. Administrative Asst
Francisca Abrah	DBS	Secretariat Option	Administrative Asst
Mahami Abukari	MSLC	Asst. Overseer	Messenger

Accounts			
T. K. Coker-Awortwi	EMBA Strategic Mgt.	Accounting	Assistant Accountant
Paul Berko	ICA, B.Ed.	Accounting Accounting	Chief Accounting Assistant
Mohammed Alima	HND BA	Accounting IDS	Principal Acct. Assistant
Wumbei Mohammed	HND	Accounting	Accounting Assistant
Abdulai Baba Al-hassan	BA, IDS	Accounting	Principal Accounting Assistant
R. S. A. Adongo	RSA III Lcc III	Accounting	Principal Accounting Assistant
N. K. Abass	HND	Accounting	Chief Accounting Assistant
A. K. Alhassan	BSc Accounting & Finance	Accounting	Chief Accounting Assistant
Bawa Ford	HND	Accounting	Chief Accounting Assistant
Issah Issifu	Dip. in Com.	Accounting	Chief Accounting Assistant
Sebastian Tigbee	RSA III Dip. in Com	Accounting	Principal Accounting Assistant
Mahama A. Rufai	HND	Accounting	Principal Accounting Assistant
Zulai Abihiba	DBS	Accounting	Senior Storekeeper
Kofi Konadu	HND	Accounting	Prin. Accounting Assistant
Alhassan Abukari	HND	Accounting	Prin. Stores Superintendent
Farm Management			
Zakaria S. Seini	HND	Agric. Engineering	Chief Technical Officer
Emmanuel Odoom	BSc.	Agric. (Animal Science)	
Workshop			
Augustine Owusu	City and Guilds. City and Guilds. MVT	Cert. in vehicle work Cert. in internal combustion engine work Part I & II	Works Superintendent
Benson D. Boamah	Basic Refrigeration and Air Conditioning	NVTI Grade 1	Senior Works Superintendent
J.Y. Wasaal	Jnr Techni	Workshop	Work Superintendent

	Supervisory Mgt.		
G. Akotia	Trade Test Grade 1	Workshop	Works Superintendent
Emmanuel Tetteh	N.V.T.I Grade 1	Workshop	Workd Superintendent
P.A. Anaaba	N.V.T.I. National Craftman	Workshop	Works Superintendent
M. Jabiru	HND	Workshop	Works Superintendent

Upper East Farming Systems Research Group

Name	**Qualification**	**Area of Specialisation**	**Rank**
R. A. L. Kanton	MSc PhD	Agronomy	Principal Research Scientist
E. Y. Ansoba	BSc	Agriculture	Principal Technical Officer
*F. Kusi	MSc	Entomology	Research Scientist
Yirizagla Julius	MSc.	Agronomy	Research Scientist
Issah Sugri	M.Phil	Post Harvest	Research Scientist
*Salifu Wahab	BSc	Agric Economics	Assistant Research Scientist
Peter A. Asungre	BSc	Agric Engineering	Principal Technical Officer
Zakaria Mukhtaru	BSc Agric	Agriculture	Principal Technical Officer
Abdulai Abubakari	HND	Sec & Mgt	Principal Administrative Asst
Musah Adulai	Cert	General Agriculture	Assistant Farm Mgr
Salim Lamini	BSc	Agric Technology	Principal Technical Officer
Albert Alem	Dip.	Agric	Technical Officer
Jonathan Agawini	HND	Agric. Ecology	Technical Officer

Northern Region Farming Systems Research Group

Name	**Qualifications**	**Area of Specialisation**	**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	Agriculture Agricultural Entomology Agricultural Entomology	Principal Research Scientist
Baba Inusah	MSc	Irrigation Agronomy	Research Scientist

A. N. Wiredu	BSc MSc	Agriculture Agricultural Economics	Research Scientist
Afia Serwaa Karikari	MSc	Entomology	Research Scientist
Michael Mawunya	BSc MSc	Agriculture Weed Science	Research Scientist
D. Y. Opare-Atakora	BSc	Agriculture	Assist Research Scientist
Aliyu Siise	BSc	Agriculture	Principal Technical Officer
Jerry Nboyini Ansalma	MSc	Entomology	Research Scientist
B.A. Alhassan	Dip.	Agriculture	Chief Tech. Officer
Richard Agyare	BSc	Agriculture	Principal Technical Officer
Sulemana Daana Alhassan	BSc	Agriculture Technology	Chief Technical Officer
Rakiatu M. Abdulai	HND	Statistics	Principal Technical Officer
Haruna Abdulai	BSc	Agriculture	Principal Technical Officer
I Misbow	Agric College	General Agriculture	Technical Officer
E. O. Krofa	BSc	Agriculture Technology	Chief Technical Officer
Mahama Alidu	Dipl	Horticulture	Chief Technical Officer
Iddrisu Sumani	Diploma	General Agriculture	Chief Technical Officer
Sayibu Zaanyeya	Agric College	General Agric	Asst Farm Mgr
Haruna Bashiru	BSc	Agriculture	Principal Technical Officer
K. Foster Y.	BSc	Agric Technology	Principal Technical Officer
Desmond A. Sunday	BSc	Biomathematics	Principal Technical Officer

Upper West Farming Systems Research Group

Name	**Qualification**	**Area of Specialisation**	**Rank**
J. B. Naab	BSc. PhD	Soil Science Soil Physics	Senior Research Scientist
Samuel Saaka J. Buah	BSc MSc PhD	Agriculture Agronomy Soil Fertility & Plant Nutrition	Senior Research Scientist
S. S. Seini	BSc MPhil	Agriculture Agricultural Entomology	Research Scientist
George Mahama	BSc	Agriculture	Asst. Research Scientist
Asieku Yahaya	B.Ed.	Agricultural Science	Asst. Research Scientist
Nyour Anslem B.	BSc	Agriculture	Principal Technical Officer

		Economics	
Alhassan Nuhu Jimbaani	BSc	Agriculture Economics	Principal Technical Officer
Bavid B. Barton	BA	IDS	Principal Technical Officer
Asiata Alhaji Ali	Dip.		Principal Admin. Asst
Haruna K. Ali	Agric College	General Agric	Principal Technical Officer
Gordon Opoku	BSc	Laboratory Technology	Chief Technical Officer
Ibrahim Hashim	HND	Statistics	Principal Technical Officer
Ali A. Ibrahim	Agric College	General Agric	Senior Technical Officer

Scientific Support Group

Name	Qualifications	Area of Specialisation	Designation
S. K. Asante	BSc MSc PhD	Agriculture Plant Protection Agricultural Entomology	Principal Research Scientist
I. D. K. Atokple	Dip Ed BSc MSc PhD	Education Agriculture Plant Breeding Plant Breeding	Senior Research Scientist
M. S. Abdulai	BSc MSc PhD	Agriculture Plant Breeding Plant Breeding	Senior Research Scientist
M. Fosu	BSc Dip Ed MSc PhD	Agriculture Education Soil Chemistry Soil Chemistry	Principal Research Scientist
N. N. Denwar	BSc MPhil	Agriculture Plant Breeding	Research Scientist
B. D. K. Ahiabor	BSc MSc PhD	Agriculture Plant Physiologist Mycrorrhizology	Research Scientist
Emmanuel Chamba	BSc. MSc. PhD.	Agriculture Agronomy Molecular Biology	Research Scientist
Adjebeng-Danquah Joseph	BSc MSc	Agriculture Plant Breeding	Research Scientist
Fulera Tahiru	BSc MSc	Agriculture Agriculture	Research Scientist
N. A. Issahaku	HND	Agriculture Engineering	Chief Tech. Officer
H. Mohammed	HND BSc	General Agriculture Agriculture	Research Scientist

	MSc	Plant Breeding	
A. L. Abdulai	BSc MSc	Agriculture Agrometeorology	Research Scientist
A. S. Alhassan	Diploma	General Agriculture	Principal Tech. Officer
Abdula A Mohammed	Certificate	General Agriculture	Senior Tech. Officer
M. M. Askia	BSc MPhil	Chemistry Soil Science	Research Scientist
K. Acheremu	BSc MSc	Agriculture Plant Breeding	Research Scientist
A. A. Issah	BSc	Agriculture	Asst. Research Scientist
Abukari Saibu	BSc	Agriculture Technology	Chief Tech. Officer
Mutari Abubakari	BSc MSc	Agriculture Food Safety and Quality Management	Research Scientist
William K. Atakora	BSc MSc	Agriculture Soil Science	Research Scientist
Issah A. Rashid	BSc	Agric Technology	Principal Technical Officer
Haruana Alidu	MSc	Plant Breeding	Research Scientist
Emmanuel Vorleto	HND	Laboratory Technology	Principal Tech. Officer
Freda A. Agyapong	BSc	Agric Technology	Principal Tech. Officer
Prosper Amenuvor	HND	Lab Technology	Technical Officer
Michael Asante	BSc	Agric Technology	Principal Tech. Officer
Ibrahim Sumaila	Agric College	General Agric	Technical Officer
Fuseini S. Issifu	Agric College	General Agric	Asst Farm Mgr
Boakyewaa Adu Gloria (Miss)	BSc MSc	Agric Plant Breeding	Research Scientist
Emmanuel Ayipio	BSc	Agric Technology	Principal Tech. Officer
Ibrahim A. Zakaria	BSc	Agric Technology	Principal Tech. Officer
Abdul Aziz Abdul Latif	BSc	Agric Technology	Principal Tech. Officer
Alhassan Sayibu	BSc	Agriculture	Principal Tech. Officer

Comercialization and Information Division (CID)

Name	**Qualification**	**Area of Specialisation**	**Rank**
Eric Appiah	MBA	Marketing	Marketing Officer

Robert Kwasi Owusu	BSc MSc	Agricultural Postharvest & Food Preservation Engineering	Senior Scientific Secretary
Mumuni Abukari	HND	Marketing	Senior Marketing Asst
Ms. Warihanatu Baako	HND	Marketing	Principal Marketing Asst.
Wilhelm Kutah	BSc	Agric Technology	Principal Tech. Officer
Yamyolya Alhassan	HND	Marketing	Marketing Asst
Issah Issifu	Dip.	Library	Senior Library Asst.
Musah Iddi	Full Technological Certificate	Radio, Television and Electronics Radio, Television and Electronics	Chief Works Superintendant

LIST OF RESEARCH SCIENTISTS AND CONFERENCES/WORKSHOPS ATTENDED IN 2013

Name	Period	Country/Town	Conference/Training/Workshop
Haruna Alidu	21 – 23 Feb.	IITA-Ibadan, Nigeria	Agricultural Research For Development Of Strategic Crops In Africa (SARD-SC) Maize Commodity Launch Workshop
	25 – 27 Mar	Saly Portudal, Senegal	WASP Regional Planning Workshop With Stakeholders in the Seed System
	2 – 6 April	IITA-Ibadan, Nigeria	DTMA Regional Planning Workshop
S.S. Buah	7 – 8 April	Dakar, Senegal	Annual Regional Planning and launching of the ILWAC Project
	2 – 5 April	, IITA-Ibadan Nigeria	Regional Planning meeting of the DTMA Project
	28 – 29 Mar	Ouagadougou, Burkina Faso	Annual Planning meeting Regional Workshop on ‘Developing community-based climate smart agriculture through participatory action research in West Africa’
	18 – 19 Mar	Bondega Bay, California, USA	Program on Climate Change, Agriculture and Food security (CCAFS) Annual Science Meeting
	26 – 28 Feb	Ouagadougou Burkina Faso	Annual Review and Planning Workshop in organized by AusAid//CSIRO-CORAF/WECARD
	7 – 8 Oct	Niamey, Niger	Technical Workshop to review methodology and harmonize work plans for

			the ENRACCA-WA project
	24 – 26 Sept	Addis Ababa, Ethiopia	Africa RISING Learning Event Workshop
	10 – 11 Sept	Tamale	Super Champions for Change Network Meeting
	19 – 23 Aug	Accra	Champion for change leadership course and rapid results approach training, organized by Africa Lead
	10 – 13 July	Accra	Sustainable Intensification Systems Workshop
	24 – 28 July	Elmina Beach Resort Hotel	International training workshop on Gender Analysis and Agri-value chains, organized by AGRA
Robert Owusu	13 – 14 Mar	CSIR_INSTI, Accra	International workshop on rice processing systems in Sub-Saharan Africa
	10 – 14 June	L'Hotel Du Lac, Cotonou, Benin	Sub-Regional Training Workshop on Information and Communication Tools for the Management of Agricultural Research Results and Methods of Monitoring and Evaluation
B.D.K. Ahiabor	20 – 24 May	Wageningen, Netherlands	Writeshop on Scientific Publication
	8 – 17 July	IITA, Ibadan, Nigeria	Training course on Legume Inoculants Technology and Quality Control
	20 – 23 Sept	Lamada Hotel, Nairobi, Kenya	Internal review of Outputs and Outcomes of the N_2africa Project Phase 1
	1 – 2 Nov	Pretoria, South Africa	Annual Review Workshop/Steering Committee Meeting of the Gates Foundation Project on Capacity Building in Africa
	4 – 6 Nov	Hilton Hotel, Nairobi, Kenya	Closing Worshop on N2Africa Project Phase 1
	11 – 15 Nov	GIMPA, Accra	Advanced Managers Training in Research and Data Management for the Council for Scientific and Industrial Research
	14 – 16 Jan	Modern City Hotel, Tamale	Annual Review & Planning Meeting, AGRA-AVCMP
	27 – 28 Jan	CSIR-SRI, Kumasi	Soil Fertility Management Training Workshop
Alhasan Abdulai Lansah	7 – 17 May	Ouagadougou, Burkina Faso	Summer School on "Water for life – source of food security" Impact of climate change and desertification on food security organized by AU-SAFGRAD
	8 – 9 April	Dakar, Senegal	Regional planning and launching workshop

			for the project “Enhancing the Resilience and adaptive capacity to climate change through integrated land, water, and nutrient management in semi-arid West Africa (ENRACCA-WA) organized by CORAF
	25 – 28 Feb	Ouagadougou, Burkina Faso	Annual review and planning meeting for CORAF Seed Systems Project. Organized by CORAF
Mutari Abubakari	27 – 28 Mar	UDS, Tamale	Knowledge management and learning organized by USAID,IOWA State Un
	23 Sept – 12 Oct	Copenhagen. Denmark	Addressing climate change adaptation in development assistance organized by DANIDA

COMMERCIALISATION

Introduction

Commercialization and Information Division (CID) of SARI is made up of the following sections;

- Business Development and Marketing
- Library and Information Services
- Documentation

Staff Strength

The CID was manned by the following staff during the year under review;

- 1 Marketing Officer
- 1 Senior Scientific Secretary
- 1 Assistant Scientific Secretary
- 1 Principal Marketing Assistant
- 1 Senior Marketing Assistant
- 1 Marketing Assistant
- 1 Principal Technical Officer
- 2 Library Assistants
- 1 Electronic Technician/IT Specialist
- 1 Photocopier & Documentation Clerk

Functions performed by CID staff over the year under review

- Identify, promote & determine cost of technologies and services that can be commercialized
- Negotiate sale of technologies and services on behalf of the Institute
- Contribute to & develop long-term Marketing plans and strategies
- Scientific Secretary – Scientific report writing editing & collating scientific publications
- Library Staff – Provide effective access to library collections & resources of the Institute
- IT Staff – Install, configure & optimize operating systems for staff, monitor the performance of systems, services & networks and troubleshoot IT problems

Income generating activities undertaken during the year 2012

- Soil and Plant Analysis (Lab)
- Farm Management Services (Tractor and Combine)
- Rice Processing Centre
- Conference Centre
- Guest House Services
- Photocopying and Documentation Services
- Transport Services
- Seed & Farm Produce

Commercialization Report – 2013

Item	**Gross Income GH₵**	**Expenses GH₵**	**Net Income GH₵**
Project Support	242,168.46	0	242,168.46
Soil/Plant Analysis	59636.00	12,990.00	46,646.00
Tractor Services	16,010.75	12,957.30	3,053.45
Documentation	3,736.01	5,307.25	-1,571.24
Rice Processing Center	70,165.00	34,047.73	36,117.27
Combine Harvester	22,013.54	13,811.19	8,202.35
Seed & Farm Products	16,585.20	9,265.50	7,319.70
Conference Hall	32,679.44	13,105.00	19,574.44
Hire of Vehicle	134,912.00	69,070.70	65,841.30
Guest House	10,833.63	5,565.00	5,268.63
Rent	67,643.51	22,862.63	44,780.88
Total	**687,611.54**	**206,986.30**	**480,625.24**

2012 Commercialization results compared to 2013 results

Year	**Gross Income GH₵**	**Expenditure GH₵**	**Net Income GH₵**
2012	262,299.55	62,209.28	200,090.27
2013	687,611.54	206,986.30	480,625.00
% Change	**61.8 %**	**69.9%**	**58.3%**

Conclusion

It can be gleaned from the above facts that the most pertinent factor is the increase in expenditure figures. Whereas expenditure for the year 2012 was GH₵62,209.28, this increased to a whooping GH₵206,986.30 in 2013 which is a 69.9% increase. It is very imperative that efforts are put in place to reducing this mounting expenditure figures.

DOCUMENTATION AND LIBRARY

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

DOCUMENTATION

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 from the printers the 2010 Annual Report which was sent for printproduction. The Library collected a sizeable number to distribute to other libraries and institutions who are on our mailing list. The 2011 was sent for printing, whilst the collated and typeset 2012 report was distributed to Editorial Committee members and other Scientists for editing.

Coordination of Exhibitions

The Documentation Centre also coordinated the following exhibitions:

- Sixth African Agricultural Science Week. 15-19 July 2013. Accra International Conference Centre.
- Launching of the Agricultural Technology Transfer Project. UDS International Conference Centre, Tamale. 21 Nov 2013
- 4th Ghana Policy Fair, 14 – 18 October. Accra International Conference Centre
- 29th National Farmers Day Regional Celebration. 6th December 2013, Sagnerigu District

Experimental Field Visit

There was no field visit in the year under review. Though a schedule was prepared and reviewed by the Seminar and Field Visit Committee, which was circulated to all Scientists and Technical Staff, there was heavy downpour on five successive Tuesdays, the day we normally have our field visit. Eventually interest waned as Scientists started harvesting their fields

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 get donations from over 40 journals and subscribe to two daily newspaper and one weekly newspaper. The library also stocks theses, seminar and conference papers, as well as journals of Scientists, which are stocked in their various box files (except the theses, which are shelved)

Electronic Resources

The library currently offer 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

So far 755 books were catalogued, classified and shelved according to the class number. These materials have been entered into a database. Within the year the Library recorded 185 clients, who were mostly students from UDS, KNUST, Tamale Polytechnic and other institutions.

Book Donation

Within the year the Library receive over 100 volumes of book and journals, 59 magazines and Newsletters and 13 Reports all through donations.

PUBLICATIONS

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MAJOR ACHIEVEMENTS AND PROGRESS MADE IN RESEARCH PROGRAMMES

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 2012.

AGRO-METEOROLOGY

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: On going
Sponsors: SARI Core funded
Location: Nyankpala, Manga, Wa, Navrongo

Background Information and Justification

Weather is the major determinant of agricultural production and productivity because it has a profound effect on crop growth and all the phases of development cycles. Economies of the interior Savannah of Ghana, the mandate area of CSIR-Savanna Agricultural Research Institute (CSIR-SARI), depend mainly on rain-fed agriculture which is highly sensitive to climate variability and/or extremes. Successful development and deployment of agricultural technologies (crop varieties and appropriate agronomic practices) by CSIR-SARI is prerequisite for optimizing agricultural production in these areas. This requires accurate information on weather elements. The Agro-meteorology unit of the Scientific Support Group (SSG) monitors the pattern of weather elements within the mandate area of CSIR-SARI and maintains a data base for the weather elements. The unit also produces quarterly reports and outlooks 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 is also required for effective delivery on the mandate of CSIR-SARI.

Objectives

1. To produce reference point climatic information for the research stations used by scientists of CSIR-SARI

2. To promote the use of agro-meteorological information by researchers and other stakeholders for agricultural decisions through appropriate packaging and improved accessibility
3. To provide information that can facilitate the development of technologies that enhance the resilience of rural households and adaptation to climate change and variability

Expected Beneficiaries
All research scientists and the multitude of farmers who benefit from their research outputs

Materials and Methods
Data on the weather elements are collected using manual and automated weather stations managed by the unit at Nyankpala, Manga, Wa and Navrongo (Nyangua)

Results/Major Findings

Table 1: Coordinates of Stations used by CSIR-SARI in 2013

Station	Latitude	Longitude	Altitude (msl)
Nyankpala	09°25'N	00°58'W	183
Damongo	09°01'N	01°36'W	260
Salaga	08°33'N	00°31'W	168
Yendi	09°27'N	00°01'W	195
Wa	10°04'N	02°30'W	323
Manga (Bawku)	11°01'N	00°16'W	246

The same stations as for 2012, were used by researchers of CSIR-SARI in 2013. These were located between latitude 09°01'N and 11°01'N and between longitude 00°01'W and 02°30'W. Elevations for the stations were between 168 m and 323 m above mid sea level (msl)

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Materials **and Methods**

Data on the weather elements are collected using manual and automated weather stations managed by the unit at Nyankpala, Manga, Wa and Navrongo (Nyangua)

Results/Major Findings

Table 1). Data on weather elements were collected across the sites using manual and/or automated devices.

General Climate at Nyankpala
In 2013, Nyankpala did not receive any rainfall in January and December while February was the month with the least precipitation. There was a pseudo-start of rains in March which could have aided the making of yam and cassava mounds, but the sustained humid period started in June. The highest precipitation was received in August and the effective rains terminated in October. One precipitation event resulting in 23.3 mm of rain in November had the potential of creating post harvest problems for farmers who were drying their harvests. Records for the

class A evaporation pan showed that January and September had the highest and lowest evaporation figures respectively. Rainfall amounts exceeded evaporation figures from the Class A evaporation pan from June to October in 2013 (Table 2).

Table 2: Monthly patterns for various weather elements monitored at Nyankpala in 2012

Month	Rain (mm)	Pan Evapo. (mm)	Temperature (°C)			Wind m/s	RHmin (%)	RHmax (%)	Sunshine hrs
			min	max	mean				
January	0.0	230.9	15.0	38.0	27.3	1.4	25.1	54.0	9.3
February	2.4	229.8	17.0	41.0	29.6	1.7	28.5	51.7	8.6
March	89.6	196.0	21.0	41.5	31.4	3.9	49.6	64.6	7.9
April	66.8	159.3	22.2	38.0	30.3	3.2	32.5	68.6	7.8
May	30.0	168.2	21.5	37.2	30.0	3.2	59.0	84.5	7.8
June	161.9	140.8	21.0	34.5	27.7	2.9	68.4	89.5	6.8
July	203.8	89.6	21.0	32.5	26.6	1.8	74.5	93.1	5.7
August	217.4	83.2	21.0	32.5	25.9	1.5	75.5	93.0	3.9
September	164.1	79.7	20.5	34.0	26.5	1.2	73.3	92.7	5.3
October	119.7	93.4	21.0	34.5	27.6	0.6	67.4	89.7	8.3
November	23.3	124.6	19.0	38.0	29.0	1.4	52.7	83.2	9.0
December	0.0	163.2	15.0	38.2	27.5	1.9	51.8	67.4	9.0

In 2013, the coldest night temperatures were recorded in January and December, the warmest day temperatures were experienced in March, and August had the lowest mean monthly temperature. January and August were the months with highest and lowest ranges of temperatures respectively. Average wind speed was greater than 2.5 m/s for four months (March to June), less than 1.0 m/s in October, and between 1.2 and 1.9 m/s for the rest of the months. In 2013, monthly means for daily minimum relative humidity (RHmin) ranged between 25.1% and 75,5%. Mean RHmin was lower than 40% for 3 months (January, February and April) and higher than 65% for 5 months (June to October). Monthly means for daily maximum relative humidity (RHmax) was generally higher than 50%, with figures for May to November being higher than 80%. Monthly means of daily sunshine hours ranged from 3.9 hrs in August to 9.3 hrs in January (Table 2). During the period from June to September, when cloud cover was prominent, the monthly means of daily sunshine hours ranged between 3.9 hours and 6.8 hours.

Rainfall for research sites used CSIR-SARI

Table 3 shows the monthly rainfall received at each of the locations where CSIR-SARI scientists conducted experiments in 2013. The humid portion of 2013 started in April for all the sites except Manga where it started in May. August was the most humid month for all the sites, except Salaga where the highest rainfall was received in September. Just like for Nyankpala, the quantity of rain received in October at all the sites was substantial but highly skewed towards the first decad resulting in insufficient moisture to support the completion of grain filling and maturation phases for the full season cereals and crops that were sown late.

Table 3: Monthly rainfall totals for the locations used for research work in 2012

Month	**Damongo**	**Salaga**	**Yendi**	**Wa**	**Manga**
January	0.3	0.2	0.1	0.1	0.6
February	15.9	26.8	7.5	4.9	6.9
March	62.5	97.3	81.5	48.4	13.0
April	100.7	105.5	93.7	98.3	80.4
May	94.2	146.2	111.4	109.9	107.1
June	82.2	102.2	83.5	84.5	77.4
July	115.3	103.0	141.1	154.6	140.1
August	137.4	102.6	148.1	194.5	262.7
September	107.3	148.6	110.7	129.8	136.1
October	95.7	150.4	137.8	88.1	64.6
November	27.7	62.0	24.9	20.7	0.0
December	0.0	6.4	4.5	3.0	0.0
Total	**839.1**	**1051.3**	**944.7**	**936.5**	**888.7**

Rainfall Anomalies for Nyankpala

Monthly rainfall anomalies for Nyankpala were positive for 6 months (March, June, July, August, October, and November) with the highest being in March(> 50 mm). None of the months received rainfall equal to the long term mean. Of the 6 months with negative anomalies at (January, February, April, May, September, and December), May was the most aberrant with a shortfall of more than 80 mm (Figure 1a). The shortfall in May created problems of delayed land preparation and crop establishment for many farmers.

Considering decadal rainfall anomalies, 12 decades were positive, 20 decades were negative, while 4 decades were normal. Eight (8) of the decades with positive anomalies occurred between June and October (the growing season). The first decades of August and September were the two most negatively aberrant (Figure 1b). Though the month of October had a positive anomaly, 65% of the rain in that month was received in the first decade, while 25% and 10% were received in the second and third decades respectively. The amount received in the second decade was normal, but that of the third was below normal. Though above normal rainfall was received in 2013 and the intermittent dry spells during the season had little impact on crop growth anddevelopment, the rains received in October, especially the distribution pattern could not avert the risk of terminal drought. The year 2013 could therefore be described as one with terminal drought, because the rains ceased early and the residual moisture could not carry most full season crops and lately sown fields through the grain filling phases.

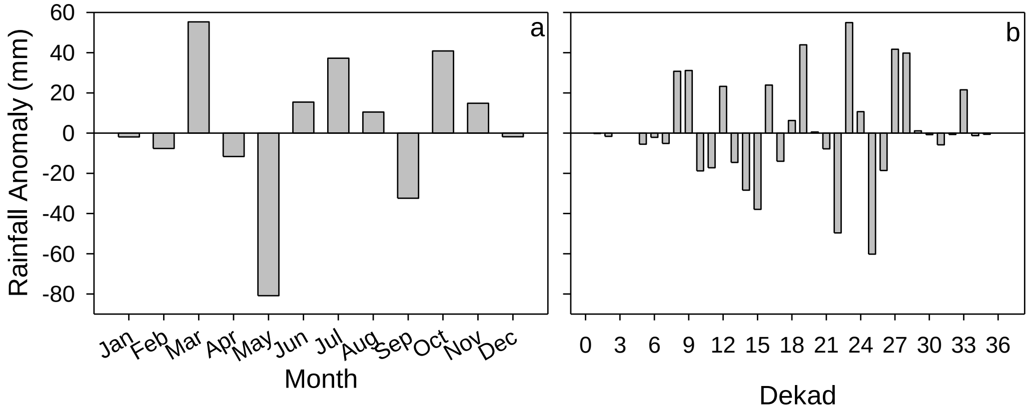

Figure 1: Monthly (a) and decadal (b) patterns of rainfall anomaly for Nyankpala in 2013

Temperature Anomalies for Nyankpala

Seven months (April, May, June, July, August, October and December) had positive anomalies (0.03°C to 0.76°C) for the monthly means of daily minimum temperature (Tmin) at Nyankpala in 2013, while the rest of the months showed negative anomalies (-0.34°C to -0.09°C). Apart from August, all the months falling within the crop growing season had positive anomalies (Figure 2a), implying that crop plants potentially had shorter pheno-phases and development cycles since they were exposed to above normal Tmin.

Anomalies of monthly means for daily maximum temperature (Tmax) were between -1.5°C and 1.6°C. Positive anomalies were observed for February, March, November and December only, and ranged from 1.0°C to 1.6°C. All other months experienced negative anomalies for Tmax (Figure 2b), implying that the range of temperatures experienced by crops grown during the season was lower than normal, since Tmin was positive whiles Tmax was negative during the growing season.

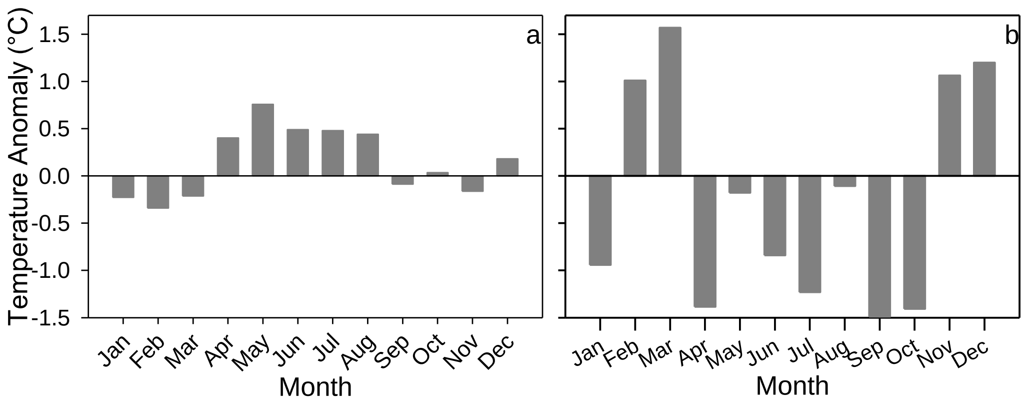

Figure 2: Monthly patterns of Tmin (a) and Tmax (b) anomalies for Nyankpala in 2013

In 2013, the decadal anomalies for Tmin at Nyankpala ranged from -1.6°C to 1.7°C. Respective frequencies for positive, normal and negative were 19, 4 and 13. Tmin values were generally higher than normal for decads falling within April to August, but lower than normal for those within September and October (Figure 3a).

Anomalies for decadal Tmax ranged from -1.8°C to 1.8°C. Respective frequencies were 13, 2 and 21 for positive, normal and negative decadal anomalies of Tmax in Nyankpala for 2013. Decadal anomalies for Tmax during the growing season were generally negative (Figure 3b).

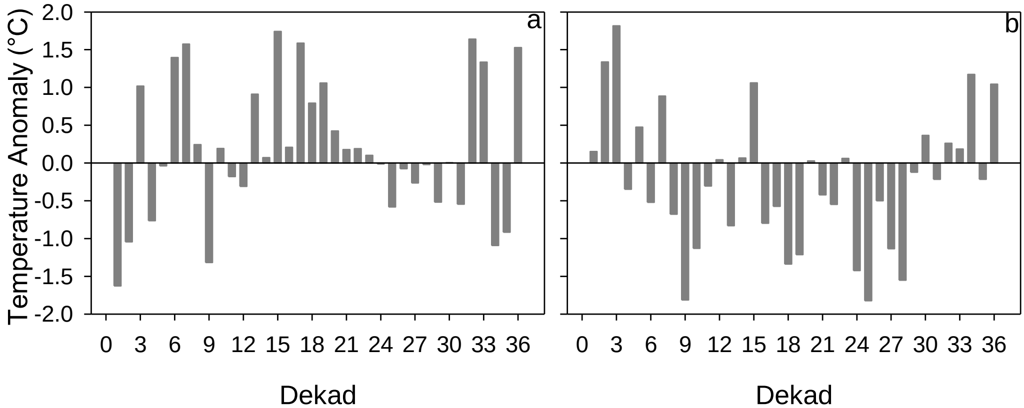

Figure 3: Decadal patterns of Tmin (a) and Tmax (b) anomalies for Nyankpala in 2013

Conclusion and Recommendation

Rainfall amount was above normal, with very minimal deleterious effect of intermittent droughts. October rains play a critical role for the success of crop production at Nyankpala and its catchment. The 2013 season could best be described as a season with terminal drought. The 2013 season had a favourable thermal environment for crop production. Cropping decision must be such as to avoid the coincidence of grain filling and maturation phases of staple cereals with the second (29th) and last (30th) decads in October. Breeding efforts targeting the catchment area should be geared towards the development of heat and drought tolerant cultivars,

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 African 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
Strengthen the resilience and adaptive capacity 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 are rural community groups exposed to the socio-economic and environmental impacts of land degradation. An estimated 2000 households will potentially benefit from improved management of land and water resources, resulting in enhanced land productivity and income generation. Among these, special efforts will be devoted to ensuring that the projects' benefits at least 25-30% of households headed by women. All community members will likely benefit from the successful implementation of the project, as they will use 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
Standard community entry procedures were used to create awareness on the project at the three participating communities. This involved a meeting with the chiefs and elders, opinion leaders as well as members of the communities. Staff of the Ministry of Food and Agriculture (MoFA) led the team to enter all the communities. Literature review to catalogue all possible strategies for integrated land, water and nutrient management. Training of mid-level staff and community members on the causes, impact and response options for climate change. Training of women in soap making as a means of generating off-farm income.

Results/Major Findings
Three functional innovation platforms (one at each site) were formed. All possible integrated soil, water and nutrient management strategies found at each of the 3 sites, the districts, regions, and nationwide were catalogued. Three (3) broad classes including agronomic or biological options, soil management options, and mechanical and engineering options, were identified and presented to community members.

Fourteen (14) mid-level staff (1 female and 13 male) comprising research technicians, AEAs and workers from NGOs were trained on climate change and response options as well as sustainable land, water, and nutrient management (SLWNM) options.

A total of 167 community members (58 females and 109 males) from Silbelle, Demonnaayili and Kpalsawgu were received trained on the causes, impacts and response options of climate change, as well as the SLWNM options that have the potential of being adopted to enhance resilience and adaptation to climate change

Conclusions/Recommendations

Members of participating communities now have a better understanding of climate change issues and the potential benefits of SLWNM. Many farmers have therefore pledged to integrate SLWNM options into their farming practices during the 2014 cropping season. The frontline staffs of the local institutions involved in the project are better equipped to explain the causes, impacts, as well as response options of climate change and deal with problems associated with the use of SLWNM options to enhance resilience to climate change. Twenty (20) women from the Kpalsawgu site are now able to make soap from locally available and affordable ingredients. This has increased the diversity of livelihood options for the women. The project facilitated the acquisition of this skill. Farmers from the Kpalsawgu site have started processing their organic wastes into compost either in heaps or pits.

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. Buah and R.A.L. Kanton
Estimated Duration – 4 years
Sponsors – IITA
Locations – Damongo, Manga, Nyankpala, Wa and Yendi

Introduction

In Ghana, maize is not only the largest staple and most widely cultivated crop, but also the largest commodity crop in the country second only to cocoa (MiDA, 2010). It is a major source of food, feed and cash for many households in Ghana. Over 85% of the rural population grows maize because it fits well into the different farming systems and has great potential for increasing yield under improved management practices compared with other cereal crops. The crop has the greatest potential of combating food security challenges posed by population increase in the country due to its high yield potential, wide adaptability and relative ease of cultivation.

The Guinea and Sudan savannas of Ghana have the highest potential for increased maize production and productivity due to 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 importance to maize production in this region, affecting the livelihood of millions of people, food security and economic development. Yield losses in maize from *Striga* infestation in the area are often significant with estimates ranging from 16% to 100%.

Drought is second only to poor soil fertility in reducing maize yield especially in the developing world, leading to about 15% overall reduction in grain yield in these countries. Grain yield losses can even be greater if the drought stress occurs at the most drought-sensitive stages of the crop growth, such as the flowering and grain filling stages. Global warming, deforestation, and urbanization all stand to increase the severity and frequency of drought in the future, leading to a possible decrease in global food production at the same time that increasing human population demands an increase in the same food supplies.

Maize varieties targeted to the Guinea and Sudan savannas of Ghana must be tolerant to drought and Striga. The development of such maize varieties will constitute an important, practical and reliable approach to increasing maize yield and productivity 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 these stresses. 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 per se to farmers or for population improvement.

Expected Beneficiaries: - Scientists, Farmers, Seed Companies, Traders, and Industrialists.

Materials and Methods

They genetic materials used in this project were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. The materials composed of improved extra-early, early and intermediate/late maturing pollinated varieties (OPVs) and hybrids developed for grain yield and adaptation to abiotic (drought) and biotic (Striga) stress factors. The intermediate/late maturing genotypes consisted of 30 drought tolerant (DT) OPVs, 35 top-cross, and 42 three-way cross DTSTR white hybrids. The extra-early genotypes consisted of 39 white and 31 yellow DT hybrids whereas the early genotypes were composed of 39 white and 35 yellow DT hybrids and 20 white and 20 yellow DT QPM hybrids. In all, twenty-seven (27) sets of regional trials were evaluated across five sites in the mandate area of CSIR-SARI.

The varieties or hybrids included in each of the regional trials were arranged in Randomized Complete Block or alpha lattice designs with three replications. Each variety or hybrid was planted in two rows of 5m length with intra row spacing of 0.5m for the intermediate/late maturing varieties or hybrids and 0.4m for the extra-early/early maturing varieties or hybrids. The trials were planted in Nyankpala, Yendi and Damongo in the Guinea savanna zone and Wa and Manga in the Sudan savanna zone, of Ghana.

Trails were established in the main cropping seasons. The fields were ploughed, harrowed and ridged before planting. Three seeds were sown per hill and the seedlings thinned to two plants per hill at 3 weeks after planting (WAP) to obtain the target population of 53,333 plants ha^{-1}. Weeds on the trial fields were controlled both chemically (by the use of Pre and post-emergence herbicides) and manually by the use of the hoe. NPK 20-20-5 fertilizer was applied at the rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer at two weeks after planting and top-dressed with additional N at 30 kg N ha^{-1}at four weeks after planting.

Data was 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 moisture (Moist) at the time of harvesting. Analysis of variance was computed for grain yield, days to anthesis and silking, anthesis-silking interval, plant height and ear height for individual locations as well as combined across locations. Mean grain yields were used to assess percent increase of DT variety/hybrid over the standard or local check in each trial. Furthermore, Fishers' Least Significant Difference (LSD) provided at the bottom of each table was used to compare the difference between each variety or hybrid and the standard or local check.

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-2, EEWH-13, EEWH-31, EEWH-36, EEYH-17, EEYH-27, EEYH-28, EEYH-36 and EEYH-39
- Early maturing genotypes: - EWH – 26, EWH-29, EWH- 5, EWH-32, EWH- 42, EWH-24, EYH-15, EYH-5, EYH-19, EYH-16, EYH-18, EYH-31, EWQH-8, EWQH-9, EWQH-14, EWQH-15, EWQH-18, EYQH-2, EYQH-6, EYQH-21, EYQH-23 and EYQH-26
- Intermediate/late maturing genotypes: - M1325-5, M1325-10, M1325-23, M1325-29, M1326-1, M1326-3, M1326-13, M1326-15, M1326-16, M1328-12, M1328-14, M1328-16, M1328-22, M1328-23, M1328-35 and M1328-36

Conclusion

Results of the combined analyses across locations allowed identification of high yielding varieties and hybrids with stable performance across locations from each maturity group. 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 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 more regional trials in the future.

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Evaluation of Genotypes for Tolerance/Resistance to *Striga hermonthica* On-Station

Principal Investigator: Alidu Haruna
Collaborating Scientists: -M.S. Abdulai and Gloria Boakyewaa Adu
Estimated Duration – 2 years
Sponsors – IITA
Locations – Nyankpala

Introduction

Striga spieces are not just unwanted weeds growing in fields meant to produce food, but are known to cause serious economic losses to cereal crops such as millet, sorghum and maize. They are reported to infest an estimated 20 to 40 million hectares of farmlands cultivated by farmers throughout sub-Saharan Africa (CIMMYT, 2000). According to Kroschel *et al*., (1999) *Striga* infestation is widespread in the Guinea and Sudan Savannas of Ghana and none of the districts is being free of *Striga*.

Being stress susceptible in general, maize is more vulnerable than sorghum and millet to parasitism by *Striga* with yield losses ranging from 20% to 80% (CIMMTY, 2004). Among the known spieces *Striga hermonthica* severely constrains maize production in sub-Saharan Africa (SSA). In Ghana *Striga hermonthica* has reduced maize yields by about 100% in heavily infested fields forcing farmers to abandon their fields. Apart from the direct yield losses other socio-economic losses include locating farms at increasely longer distances from settlements in an effort to avoid *Striga*-infested fields, shifting cultivation, farm abandonment, or change of cropping pattern.

Several control measures such as hand pulling, crop rotation, trap and catch cropping, high rates of fertilizer application, fallow, seed treatment and host plant resistance/tolerance have been developed to combat the Striga menace. Of these, host plant resistance or tolerance is considered the most affordable and environmentally friendly for the resource-poor farmers of the Guinea and Sudan Savanna Zones of Ghana. This is the preferred method adopted by the maize program.

Objectives
To identify and select high yielding *Striga hermonthica* tolerant/resistant maize genotypes/lines for population Improvement or release per se to farmers for cultivation in the Striga infested areas of the Guinea and Sudan savanna zones of Ghana.

Expected Beneficiaries: - Scientists, Farmers and Seed Companies.

Materials and Methods
They genetic materials used in this project were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. Three types of *Striga* Trials involving RSVT-Early Striga Resistant OPV, Single-cross and three-way cross STR hybrids and Striga Resistant Early Inbred Lines were evaluated in Nyankpala in 2012. The experimental fields were ploughed, harrowed and ridged before planting. 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 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 plants ha^{-1}. The experimental design was Randomized Complete Block Design with three replications.

For the artificial infestation, the *Striga* infestation method developed by IITA maize program that ensures uniform *Striga* infestation with no escapes (Kim 1991; Kim and Winslow 1992) was used. The infested plots were artificially infested with *Striga hermonthica* seeds collected from maize and sorghum fields at the end of the previous cropping season. Infestation was carried out by digging small holes at 40-cm intervals along a ridge and infesting with a sand mixture containing 5000 germinable *Striga* seeds.

In general, a maximum of 60-kg N/ha^{-1} was applied as NPK in a split application at planting and at about three weeks after planting. Apart from striga seed infestation, all other management practices for both striga infested and non- infested plots were the same. Data was 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 moisture (Moist) at the time of harvesting, *Striga* damage rating at 8 and 10 WAP and *Striga* emergence count at 8 and 10 WAP. The data was analyzed using PC-SAS.

Major Findings

Based on their mean grain yield performance and *Striga* damage rating and Striga emergence count at 8 and 10 WAP, TZE-W DT C4 STR C4, 2011 DTMA-W STR, TZE-Y DT C4 STR C4, 1001-9 STR, 1113-3 STR, 0804-7 STR, TZEI 25, TZEI 106, TZEI 157 and TZEI 23 genotypes and inbred lines were identified as tolerant to *Striga hermonthica.*

Conclusion

The identified genotypes are potential varieties for farmers in the striga infested areas of the guinea and sudan ecological zones. They will be tested in national performance and on-farm trials to confirm their performance for release to farmers.

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

List of Scientists Executing Project: - Alidu Haruna, I. D. K. Atokple and Wilson Dogbe
Estimated Duration – 3 years
Sponsors – IITA

Locations – Nyankpala, Sakpe and Damongo

Introduction

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 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.

Major Findings

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

Maize Variety	**Quantity Produced (kg)**	Remarks
Wang-dataa	1,350	Certified
Sanzal-sima	400	Certified
Ewul-boyu	150	Certified
Total	**1,800**	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.

Three Years of On-farm Demonstration of Drought and Striga Tolerant Maize Varieties in Eight Districts in BrongAhafo and Northern Regions

Principal Investigator: Haruna Alidu.
Collaborating Scientists: M.S. Abdulai,,Gloria Boakyewa Adu
Estimated Duration:
Sponsors:
Location:

Introduction
In Ghana, maize is the most important cereal grain in terms of total production and utilization. It is the largest staple crop and the most widely cultivated. Itis the largest commodity crop in the country second only to cocoa (MiDA, 2010).The crop has a potential of combating food security challenges posed by population increase due to its high yield potential, wide adaptability and relative ease of cultivation. Over 85% of the rural populations grow maize because it fits well into the different farming systems and has great potential for increasing yield under good management practices compared with other cereal crops.

Agricultural for both food and export in Ghana is mainly rain-fed. Climate change therefore has a significant effect on Ghana's agriculture. Climate-related yield losses of crops are normally high when adverse weather conditions strike. Drought, increasing rainfall variability and global warming are putting yields at risk and this trend is likely to become more pronounced for the rural poor Ghanaian. Maize which is the most widely cultivated is also the most hardily hit. Adapting maize production to climate change in Ghana should therefore, be of a major concern. In collaboration with CSIR-Crops Research Institute, CSIR – Savanna Agricultural Research Institute (SARI) used germplasm from the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, to develop and release drought and *Striga* tolerant maize varieties last December, 2012.The productivity of maizecould be increased by adopting recommended agronomic practices coupled with climate change mitigating methodsand these drought and striga tolerant varieties.

On-farm demonstration is one of the most important group techniques used to convince and motivate farmers to try a new practice, and to set up long-term teaching-learning situation. Due to its practical nature, it is a useful method to introduce a new technology and practice for a large group of interested people using fewer resources. On-farm demonstrations are very useful as these practically involve the farmers who easily understand and learn the practices demonstrated. On-farm demonstrations were therefore carried out in 16 communities in the Northern and Brong-Ahafo regions using drought/striga tolerant varieties.These demonstrations adopted recommended scientific and sustainable agronomic practices toshowcase the ability of the drought/striga tolerant maize varieties in reducing climate-related yield losses.

Objectives

The main aim of this project is to reduce climate-related yield losses of the small-scale resource poor farmers in savannah and transition zones ofGhanawhere drought and or striga infestations are major constraints to maize production, through the adoption and use of drought and striga tolerant maize varieties. The objectives are:

1. To increase production and productivity of maize per unit area by adopting recommended scientific and sustainable management practices in maize production using drought and striga tolerant varieties.
2. To reduce poverty, improve food security, income and livelihoods of small-scale resource poor farmersin savannah and transition zonesof Ghana.

Methodology

The demonstration method adopted was the result-based one. This serves as an important tool to convince farmers about the value of a new technology or innovation being introduced to them as an option to their existing practice.

Preparation for demonstration

Fields measuring 50m x 40m, were selected in each of the 16 communities in the intervention Districts of the Adaptation of the Agro-Eco-Systems to Climate Change (AAESCC) by Agricultural Extension Agents (AEAs) of the Ministry of Food and Agriculture for establishment of the demonstrations. A lead farmer was entrusted to manage the demonstrations under the supervision of an AEA.The tractor servicessuch as ploughing and harrowing was taken care of by the project. The test seed, fertilizers and herbicidewere also provided through the District Directorates of MoFA. The farmers provided labor for planting, fertilizer application, weeding and harvesting of the demonstration fields. To ensure good management of the demonstrations, AEAs were given a monthly fuel allowance to motivate them.

Layout of DemonstrationPlots

Each demonstration plotof 40m x 50m was ploughed and harrowed and divided into two with a 2m walk way between them. One half presented the farmers’ agronomic practices (Farmers’ practice) and the other half the recommended extension agronomic practices (Improved technology). Each half was subdivided into sub-plots of 18m x 16m with 1m walk way between sub-plots.Planting was on the flat. Plant spacing for the farmers’ practice plots were according to the farmer’s practice.For the improved or high technology, planting was done using a garden line to ensure straight row planting and optimum plant population.Rows were 0.75m apart and plant stands were 0.40m apart within rows with two plants per stand. Each demonstration site had two improved varieties and the farmer’s variety. The improved technology and farmers' practice plots were planted to the same varieties and on the same day but differed in agronomic practices.

Table 1: List of the maizevarieties used for the demonstrations

Variety	**Maturity Group**	**Colour of Grain**	**Type of Stress Tolerance**
Sanzal-sima	Intermediate (110 days)	White	Drought tolerant
Ewul-boyu	Intermediate (110 days)	White	Drought tolerant
Wang-dataa	Early maturing (90 days)	White	Drought and Striga Tolerant
Bihilifa	Early maturing (90 days)	Yellow	Drought and Striga Tolerant

Fertilizer application

Fertilizer was applied at the rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer and top-dressed with additional N at 30 kg N $ha^{-1}$for both the improved technology and farmers' practice plots. For the improved technology, the basal application was at two weeks after planting and top-dressed four weeks after planting. Holes were dibbled about 5cm away from each plant stand and the fertilizer placed in the holes and covered. Time and method of application of fertilizer for the farmers' practiced was according to the farmer's own practices

Data Collection

The following data were collected on both the improved technology and farmers' practice plots from a 10m x 10m area marked out from the inner portion of each sub-plot:

- Plant stand
- Days to 50% anthesis
- Days to 50% silking
- Number of plants harvested
- Number of ears harvested
- Cob or ear weight
- Grain weight
- Farmers' ranking of variety

Field Days

Field days were organised for the farmers to gather information on their appreciation of performance of the maize varieties to tolerance for drought/*Striga hermonthica* infestation. Both male and female farmers from the surrounding communities were invited.The farmers and other stakeholders visited the demonstration plots and the opportunity to learn by seeing the performance of recommended practices adopted by the AEAs in the management of the plots. During questions and answers time, farmers in Northern region identified *Striga* infestation, erratic rainfall, drought and low levels of soil nitrogen asthemajor constraints to maize production whereas, those in the Brong Ahafo region indicated erratic rainfall, "late on-set of rains" in the major season and "early cessation of rains" in the minor season, high temperatures and drought as the major constrains. To mitigate the effect ofthese constrains, the farmers were urged to use improved planting materials tolerant to drought and striga and to also adopt best practices in maize cultivation.

Results

Rainfall and other weather related data were not available at the time of data analyses. No agronomic data were obtained from Gbogdaa, Alhassan Kuraa and Aketen either because the fields were destroyed by animals or the varieties there did not yield anything. The data was analyzed using GenStat software.The analysis of variance indicated that there were significant differences in mean grain yield per hectarebetween locations (0.01) and between varieties (0.05). Lailai had the highest mean grain yield of 3.9 t/ha. The next wasCheranda with mean grain yield of 3.7t/hawhile Famisa had the lowest mean grain yield of 1.4 t/ha. Sanzal-simawas the highest yielding variety(3.2 t/ha)followed by Wang-dataa and Ewul-boyu(2.7t/ha) across locations (Table 2).There was no significant difference in mean grain yield between the farmer's practice and the improved technology. This could either be because the farmers applied directlyto their plots the recommended extension agronomic practices they saw the AEAs applied to the improved technology plots or they are already using such agronomic practices.There was no interaction between practice and location. Within practices, therewere no significant differences in mean grain yield per hectarebetween varieties within the farmer practice. In the improved technology practice mean grain yield per hectare of varieties were significantly different (0.05) with Sanzal-simaproducing the highest mean grain yield of 3.4Tha^{-1}.The next wasWang-dataa(2.8 t/ha) and the farmer's variety producing the leastmean grain yield of 2.4 t/ha(Table 2).

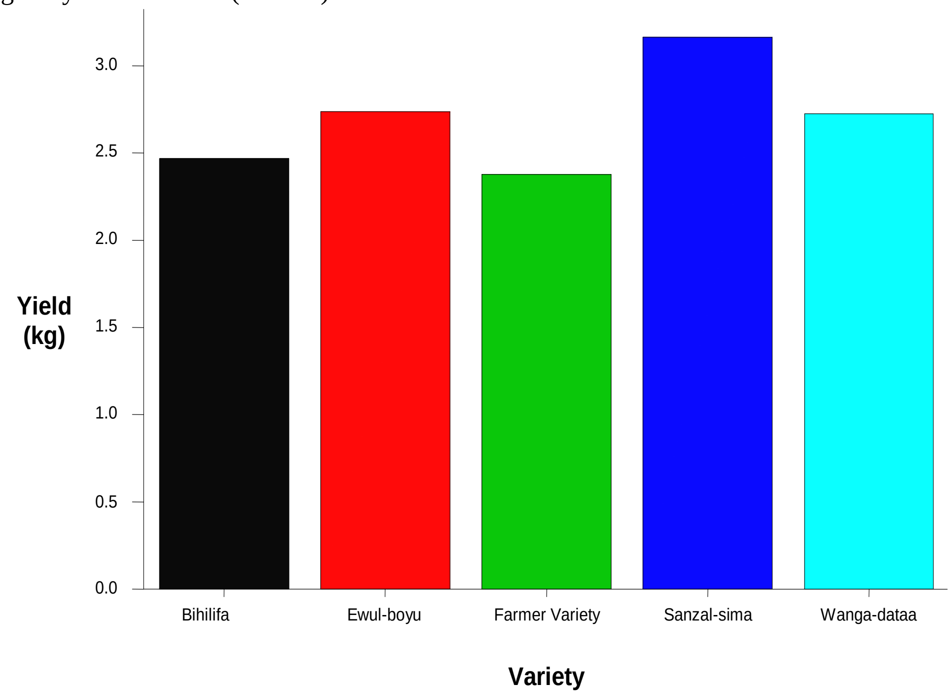


Fig. 26: Mean grain yield per plot of varieties across locations

Table 2: Mean grain yield (t/ha) across locations and per practice

Variety	Across Locations	Farmer Practice	Improved Technology
Bihilifa	2.5	2.4	2.5
Ewul-boyu	2.7	2.6	2.7
Farmer Variety	2.4	2.4	2.4
Sanzal-sima	3.2	2.9	3.4
Wang-dataa	2.7	2.6	2.8
Grand Mean	2.7	2.58	2.76
Lsd (0.05)	0.46	0.62	0.61
			0.25

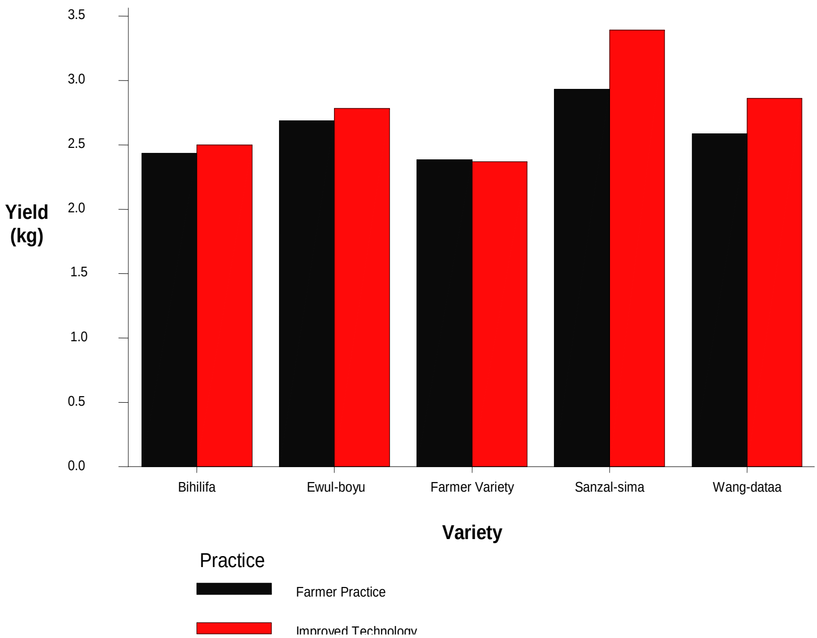
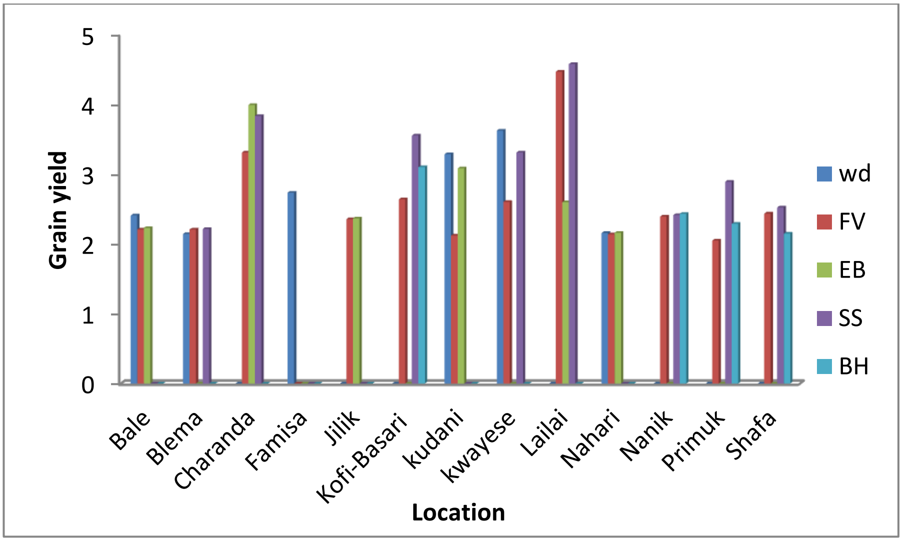


Fig. 27: Mean grain yield of varieties across practices



Wd = Wang-dataa; FV =Farmer Variety; EB = Ewul-boyu; SS = Sanzal-sima; BH = Bihilifa
Fig. 28: Mean grain yield of varieties at each location

Ranking of varieties

The criteria the farmers used to rank the varieties were either by tolerance to drought/Striga or earliness in maturity or both. Based on these criteria varieties were either preferred or not. In Northern region, Sanzal-sima was the most preferred and then by Wang-dataa. In the Brong Ahafo Region, Wang-dataa was ranked highest followed by Sanzal-sima (Fig. 29). In Kudani Bakanu where Striga is a menace only Wang-dataa was able to produce some grain. It was therefore the preferred variety in that community. In Shafa, the farmer's variety and the improved varieties were similar in performance; therefore, they were ranked the same (Fig. 30). In general, Wang-dataa and Sanzal-sima had the highest mean ranking across locations (Fig. 31)

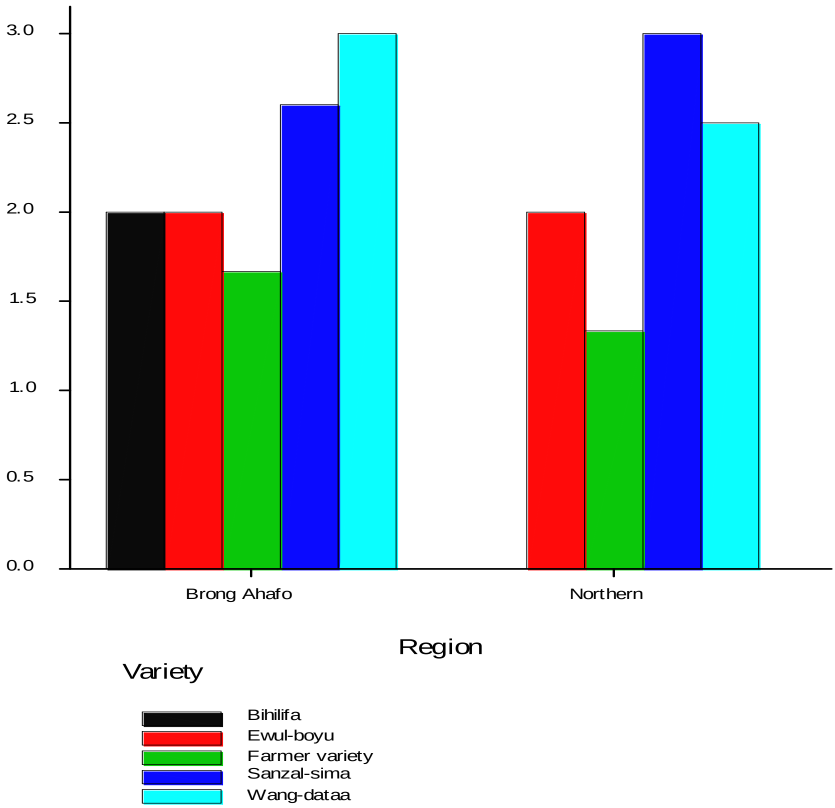


Fig. 29: Farmers' ranking of varieties in the Regions. Taller bars are those genotypes most preferred.

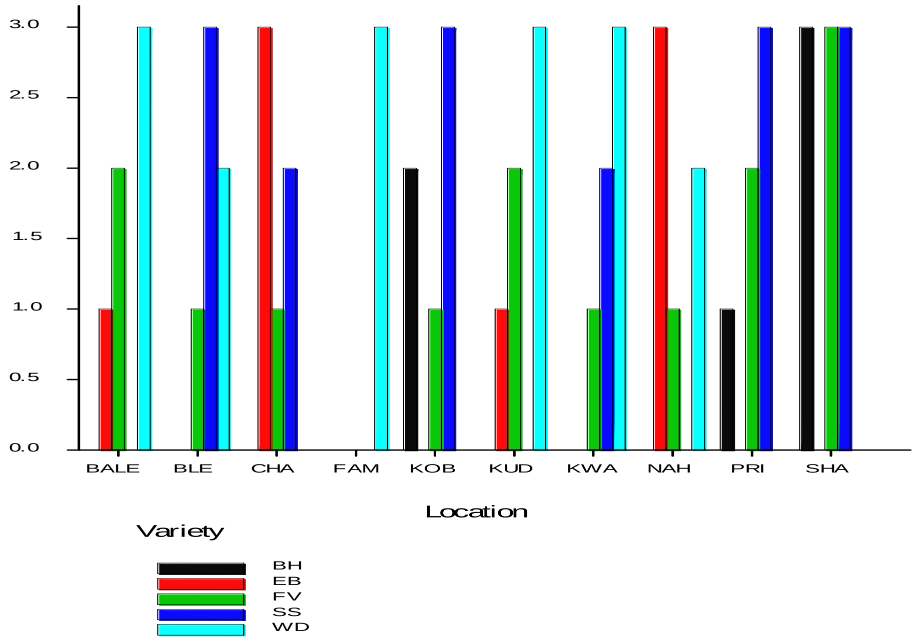
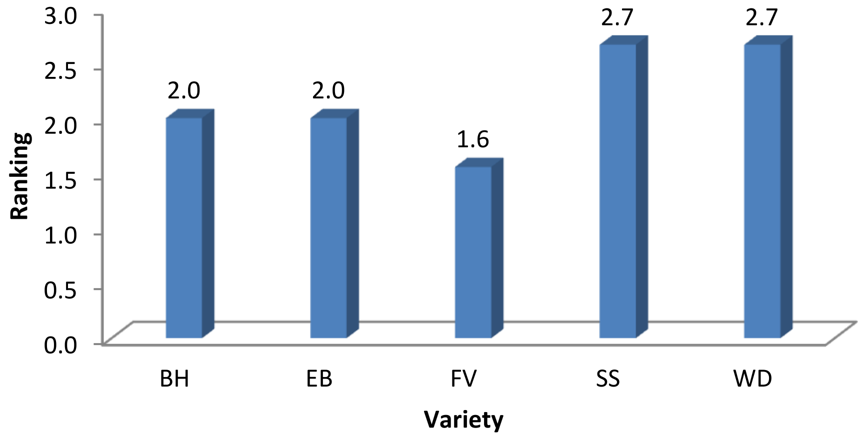


Fig. 30: Farmers' ranking of varieties in 10 communities. Taller bars indicate the most preferred.



BH = Bihilifa; EB = Ewul-boyu; FV =Farmer Variety; SS = Sanzal-sima; Wd = Wang-dataa

Fig. 31: Mean farmers' ranking of varieties across communities.

Table 3: Farmers Preference of Varieties

Community	Most Preferred Maize Variety
Famisah	Wang-dataa
KudaniBakanu	Wang-dataa
Premukyeae	Sanzal-sima
Laillai	Sanzal-sima
Cheranda	Ewul-boyu
Nahari	Ewul-boyu
Blema	Sanzal-sima
Kofi-Basari	Sanzal-sima
Kwayease	Wang-dataa
Bale	Wang-dataa

Seed Production

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. Seeds of improved varieties would need to be multiplied, distributed and cultivated by farmers for benefits of the improved varieties to be realized. 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 was a challenge on-station during the main cropping season. Owing to this,the seed production was carried out during the off season under irrigation. Even with this intervention it was still a very big challenge in meeting the enough isolation distance required. Therefore, seed of Bihilifaand, Tigli could not be produced so were not included for the trials.

The following quantities of seed were produced.

Variety	Quantity (Kg)
Sanzal-sima	200
Ewul-boyu	200
Wang Dataa	200
Total	**600**

Training Of AEAs and Other Stakeholders on how to Conduct Field Demonstration Trials.

The need to improve upon the performance of the extension worker and hence agricultural productivity cannot be over emphasized. AEAs are the potential facilitators of sustainable agriculture and rural development. Hence if AEAs are to improve their on-the-job effectiveness, they must receive continuous in-service training in line with their job needs. This is one way through which they can be provided the knowledge and skills needed to successfully meet the demand of a changing environment on their job. This was recognized and in-service training for AEAs considered as part of this project.It was also recognized that the training needs of the AEAs for the project needed to be assessed. Considering the late take-off of the project and other circumstances beyond the control of the managers of the project, it was decided that performance of the AEAs in the management of the demonstration fields in the first year of the project be used to assess their training needs. At the end of the first year of the project, it was revealed that the main areas of training required by the AEAs and the other stakeholders were technical knowledge in maize production for sustainable high yields, field layout, trial management, management of striga infested fields and reliable data collection and processing. March 12th and 13th2014 were slated for the training of all AEAs and Focal Persons in the intervention Districts of the AAESCC in Tamale.

Challenges

The successful completion of the demonstrations across the communities did not come without challenges. Among the challenges was the allocation of marginal lands made available for the demonstration fields in some of the communities, some fields were not easily accessible in some communities. They were either sited either far from the communities or across streams. In some areas some AEAs had difficulties in assimilating the protocol. Therefore, laying out thedemonstrations, data collection and general management of the demonstrations were poorly done. In some cases, the demonstrations were destruction by animals due to poor protection. Production of seed of maize varieties requires isolation to reduce cross pollination. Meeting the isolation requirements was a challenge on-station during the main cropping season.

Conclusions

The late start of the demonstrations turned out to be a blessing rather than an adversity. This was because a terminal drought set in and this gave the varieties an opportunity to exhibit their inherent characteristics of being drought tolerant.In addition, Striga infested lands which were allocated for the demonstrations also offered the varieties to exhibit their inherent Striga tolerance. These situations offered the farmers the opportunity to practically see the performance of the drought/Striga tolerant varieties as against their own varietiesFarmers selected Ewul-boyu, Sanzal-sima and Wang-dataa as their most preferred varieties across the communities based on either their ability to tolerate drought and Striga or earliness in maturity. The ability of the varieties to grow and produce economically in marginal soils as well as in dry conditions qualify them to be used for mitigating climate change.

Recommendations/Way Forward

We suggest that it would be possible to address all the challenges encountered for excellent conduction the trials during the 2014 main season. Therefore, the demonstration fields should be made easily accessible to other farmers and stakeholders. They should be well protected from animal and human destruction. One way to ensure this is to assure the lead farmers that the fields and proceeds belong to them. Instead of having high technology (improved technology) and farmers' technology, a new factor will be used to replace the farmers' technology. Half rate of organic fertilizer (Fertisoil) and half rate of fertilizer will be compared with full mineral fertilizer with the same varieties at the same locations in 2014.

The capacity of the AEAs will countinue to be built up in how to conducted good demonstrations (Triallayout,data collection, general management of demonstration andStriga infested fields and best practices in maize production for optimum and sustainable yields).In addition to the demonstrations, 10 farmers each from each AAESCC district will be given one kilo-gram of the improved seed to try on their farms in 2014. These will be monitored for their performance and evaluation.

References:

Millennium Development Authority, MiDA, (2012) Available at **http://www.mcc.gov/documents/investmentopps/bom-ghana-english-grain.pdf**

Evaluation of Maize Hybrids and Open Pollinated Varieties under Supplementary Drip and Sprinkler Irrigation Systems in North Ghana.

Principal Investigator: Mashark S. Abdulai

Collaborating Scientists:Haruna Alidu.Gloria Boakyewa Adu
Estimated Duration:
Sponsors: Africa Agricultural Development Company Ltd
Location: On-Station

Introduction.
Maize is now a staple food crop that is gradually replacing sorghum and millet in Ghana due to its high grain yield potential. Apart from local food preparations, the use of maize in industrial beer brewing is becoming very important. With increase in production, maize is likely to be used in the energy sector for the production of alcohol. The stalks are already being used domestically as fire wood. Maize is a cross pollinated crop. Therefore, varieties released usually get contaminated within a couple of years after their release. For this reason, poor plant stand and segregating plant materials are very common on the farmers' fields. Therefore, the need to continuously provide elite and adapted genotypes to the farmers is crucial. This is possible if there is a sustained research program designed to bring in new germplasm to widen the germplasm base and by introgressing, incorporating exotic germplasm and teaming up with the private sector players like AgDevCo that can facilitate in importing new germplasm, equipment and resources. These can then be advertized to the wider public for adoption. Maize demonstrations in assessable locations are among important techniques used to convince and motivate farmers to adopt new varieties. AgDevCo adopted this method to showcase several germplasm obtained from various source at SARI, Nyankpala and Tono, Navrongo in the Northern and Upper East Regions, respectively.Drought, soil nitrogen deficiency and striga infestation are the most serious constraints to maize production in Northern Ghana. These constraints have become less effective with the type of implementation plan adopted by AgDevCo. The use of supplemental irrigation has proved that it is possible to grow maize in North Ghana throughout the year.Therefore, the objective of this project is to make available improved technologies that will increase maize production in North Ghana.

Materials and Methods
Several maize varieties were obtained from the Council for Scientific and Industrial Research, Pioneer HiBred Int., SeedCo, Progene and PANAR through Wienco. The germplasm was made of Hybrids and open pollinated varieties of various maturity periods. The list and characteristics of the germplasm are presented in Table 2.

In Nyankpala, SARI the field was harrowed and planting was done on flat surface. The experimental design was Randomized Complete Block Design. The maize was planted on June 18, 2013. The experimental plots were two rows of 30m long and 0.75m between rows. Each variety was replicated three times. The method of irrigation was drip. In Tono, the design and layout were similar to those of Nyankpala, except that the varieties were replicated twice and the method of irrigation was sprinkler. Fertilizer was applied at the rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer and top-dressed with additional N at 30 kg N ha^{-1} for both the improved technology and farmers' practice plots. For the improved technology, the basal application was at two weeks after planting and top-dressed four weeks after planting. Holes were dibbled about 5cm away from each plant stand and the fertilizer placed in the holes and covered. Weeds were controlled using pre-emergent herbicides and by manual means when the plants had established. The maize was harvested on October 18 and November 9 at Nyankpala and Tono, respectively. The cobs per plot were shelled, weighed and kernel moisture determined.

The data were analyzed using statistical analyses system (SAS, 1996) after conversions of grain yield in kilograms per plot to grain yield in tons per hectare (GYLD) at 15% grain moisture. The data were analyzed 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 and discussions.
The analysis of variance for grain produced per hectare is presented in Table 1. There were significant differences between the locations for mean grain yield per hectare. The mean grain yield in Tono was significantly higher than that in Nyankpala. This was not expected because maize yields are usually higher in the Southern Guinea Savannah zone than Tono. The reason for this high yield could be the type of supplemental irrigation used at Tono.

Table 1: Analysis of variance table across locations for grain yield per hectare.

SOV	DF	SS	MS	F Value	Pr > F
location	1	5.798063	5.798063	3.62	0.063
replication	1	0.072399	0.072399	0.05	0.8325
variety	27	105.3593	3.902196	2.44	0.0034
location*variety	27	97.45711	3.609523	2.26	0.0068
Error	48	76.8145	1.600302		

Maize requires modified air humidity to promote seed set when the temperatures are very high. This kind of weather can be obtained using sprinkler irrigation system that was available in Tono. At the Nyankpala site where drip irrigation system was used, the advantage was that water was saved but the micro-climate was less modified for maize seed set.There were significant differences ($P<0.01$) among the genotypes for grain produced. There were also significant differences for genotype by environment interaction effects for grain produced. This means that the ranking of the genotypes across the sites was different for some of them.

The ten most superior genotypes in Nyankpala compared to their performance in Tono are presented in Table 3 whereas the most superior genotypes in Tono compared to their performance in Nyankpala are presented in Table 4. This confirms that the genotype by location interaction effects were significant.

Table 2: Mean grain produced per hectare at SARI, Tono and across sites

Variety	Source	Maturity	Grain Yield (t/ha)		
			SARI	Tono	Mean
06C4100	SeedCO	87	5.996	6.148	5.850
08C26-1	SeedCO	96	5.571	7.339	6.549
09C26-8	SeedCO	98	5.253	6.634	6.182
11C86	SeedCO	110	4.450	7.790	6.008
11C87	SeedCO	96	7.160	7.099	7.244
30B74	PIONEER	110	6.652	7.775	7.151
30F32	PIONEER	98	4.918	7.267	5.849
30K73	PIONEER	110	5.554	5.411	5.291
30Y87	PIONEER	98	4.806	8.313	6.337
Ewul-boyo	CSIR	95	4.953	6.652	5.546
Obatanpa	CSIR	92	5.371	4.268	4.840
PAN 12	PANAR	98	5.532	5.904	5.655
PAN 53	PANAR	98	6.411	6.380	6.213
PGS161	PROGENE	110	5.644	8.308	6.666
PGS3/4	PROGENE	98	5.062	5.475	4.597
PGS58	PROGENE	92	6.089	7.340	6.591
SC535	SeedCO	92	5.121	7.417	6.562
SC643	SeedCO	98	6.013	7.632	7.078
SC719	SeedCO	110	6.502	8.640	7.742
Sanzal-sima	CSIR	98	5.044	6.484	6.146
TIGLI	CSIR	98	3.556	6.076	4.594
WACCI 1	WACCI	91	4.944	2.398	3.545
WACCI 2	WACCI	91	7.140	2.534	4.711
WACCI 3	WACCI	91	5.410	2.601	3.879
WACCI 4	WACCI	91	5.519	3.298	4.283
WACCI 6	WACCI	91	6.180	4.454	5.191
WACCI 7	WACCI	91	6.250	2.837	4.418
WACCI 8	WACCI	91		2.140	
WACCI 9	WACCI	91	7.639	5.496	6.442
MEANS			5.521	5.932	5.77
$LSD_{50\%}$			2.745	2.456	2.306

Table 3: Mean grain yield in $Mgha^{-1}$ of the most superior genotypes in Nyankpala compared to their performance in Tono.

Genotype	Source	maturity	SARI	TONO	MEAN
1. WACCI 9	WACCI	91	7.639	5.496	6.442
2. 11C87	SeedCO	96	7.16	7.099	7.244
3. WACCI 2	WACCI	91	7.14	2.534	4.711
4. 30B74	PIONEER	110	6.652	7.775	7.151
5. SC719	SeedCO	110	6.502	8.64	7.742
6. PAN 53	PANAR	98	6.411	6.38	6.213
7. WACCI 7	WACCI	91	6.25	2.837	4.418
8. WACCI 6	WACCI	91	6.18	4.454	5.191
9. PGS58	PROGENE	92	6.089	7.34	6.591
10. SC643	SeedCO	98	6.013	7.632	7.078

Table 4: Mean grain yield in $Mgha^{-1}$ of the most superior genotypes in Tono compared to their performance in Nyankpala.

Genotype	Source	Maturity	SARI	Tono	Mean
SC719	SeedCO	110	6.502	8.64	7.742
30Y87	PIONEER	98	4.806	8.313	6.337
PGS161	PROGENE	110	5.644	8.308	6.666
11C86	SeedCO	110	4.45	7.79	6.008
30B74	PIONEER	110	6.652	7.775	7.151
SC643	SeedCO	98	6.013	7.632	7.078
SC535	SeedCO	92	5.121	7.417	6.562
PGS58	PROGENE	92	6.089	7.34	6.591
08C26-1	SeedCO	96	5.571	7.339	6.549
30F32	PIONEER	98	4.918	7.267	5.849
11C87	SeedCO	96	7.16	7.099	7.244

In Nyankpala, the WACCI hybrids were among the superior genotypes in term of grain production (Table 3), whereas, hybrids from SeedCO, PIONEER and PROGENE produced the highest grain in Tono (Table 4). As mentioned in the materials and methods, sprinkler irrigation was used to provide supplemental irrigation in Tono while drip irrigation was used in Nyankpala. These differences in performance could be due to the different irrigation systems. The sprinkler was able to provided adequate moisture for genotypes to perform very well. The

WACCI varieties could also be more adapted to the southern Guinea savannah zone where Nyankpala is located.

Among the hybrids, the following genotypes were identified as being broadly adapted to both locations. They include, 11C87, SC719 and SC643 from SEEDCO, 30B74 from PIONEER and PGS58 from PROGENE. The maturities of the adapted hybrids fall within the intermediate to late category and respond favorably to both types of supplementary irrigation system. None of the drought tolerant open pollinated varieties provided by CSIR performed well enough to be included among the top fifteen genotypes. That was expected since those genotypes could not compete with hybrids growing under optimum conditions.

Conclusion

Planting of the demonstrations at both locations indicated that it is possible to grow maize throughout the year in North Ghana. The observation of the plants and their performance also indicate that sprinkler irrigation created better conditions for growth and seed set of maize. The number of genotypes evaluated seems to be too high for proper demonstration as farmers were not able to remember the performance of all the hybrids. Therefore, larger plots and fewer hybrids should be used. The accuracy of estimation of yield using smaller plot often is compromised by over estimation. Hybrids 11C87, SC719 and SC643 from SEEDCO, 30B74 from PIONEER and PGS58 from PROGENE were identified as broadly adapted to North Ghana. Therefore, these a few other hybrids should be evaluated for confirmation. The capacity of the demonstration field managers should be built to enable them record good data for scientific analyses. For this report only mean grain produced was the only trait that could be analyzed. Other important yield parameters such as accurate days from planting to anthesis, marketable ears, plant height ear types and grain sizes were not measured. These are important because the acceptance of a variety by consumers does not depend only on yield.

ROOTS AND TUBER CROP IMPROVEMENT PROGRAMME

Evaluation of Yellow-Root Cassava Genotypes for High Yields and Earliness in the Guinea Savanna Ecology of Ghana

Kwabena Acheremu, Joseph A-Danquah, E. B. Chamba

Executive Summary:
Cassava plays an important and major role in food security and reducing rural poverty. There is a growing need to select cassava varieties that are early bulking, as well as contributing significantly to resolving the problem of vitamin-A deficiency and also suit the system of keeping animals in the Northern communities and Ghana as a whole. Seven (7) β-carotene cassava genotypes (01/1181, 01/1206, 01/1404, 01/1412, 01/1417, 01/1635 and01/1662) received from IITA together with a check (Biabasse) were evaluated for the best early bulking (harvested at 6 and 9 MAP) genotypes among the β-carotene cassava and to select for high yield and dry matter content, at the Savanna Agricultural Research Institute (SARI) experimental farm at Nyankpala in the Tolon Kumbugu district of Northern Region during the June 2012 to February 2013 season. Genotype 01/1417 recorded the highest (386) number of leaves at 6 MAP, while genotype 01/1635 recorded the highest (154) number of leaves at 9 MAP and emerged the highest recorded overall (262) number of leaves. Genotype 01/1404 recorded the highest number of tubers at 6 MAP and among the highest at 9 MAP, and emerged the overall highest (37) in number of root tubers recorded. Genotype 01/1206 recorded the highest (9.38 kg) root tuber yield at 6 MAP, and the overall best (8.81 kg) in tuber yield at the end of the season. The results of the research showed that genotype 01/1206, 01/1404 and 01/1412 were respectively high yielding among the 7 tested genotypes as they showed early high yielding potential than the check (Biabasse).

Introduction

Project rationale/Background

Cassava (*Manihot esculenta Crantz)* is one of the most important food staples in the tropics and the third most important food, after rice and maize (CIAT, 2011). More than 250 million Africans rely on the starchy root crop cassava as their staple source of calories. A typical cassava-based diet, however, provides less than 30% of the minimum daily requirement for protein and only 10%-20% of that for iron, zinc, and vitamin A. The pro-vitamin-A carotenoid is cheaper sources of vitamin A since they are found abundantly in plants and yellow cassava roots have considerable amount of carotene.

Although cassava is a perennial crop, the storage root can be harvested 6-24 months after planting depending on cultivar and growing conditions (E1- Sharkawy, 1993). It is one of the most drought-tolerant crops, capable of growing on marginal soils. The problem of late bulking and low nutritional value of cassava in Ghana and Northern Region in particular which has a unimodal rainfall pattern and also where the system of keeping animals is mainly extensive could be reduced by selecting cassava varieties with high β-carotene content and bulking early as well which may contribute significantly to resolving the problem of vitamin A deficiency and also suit the system of keeping animals in the Northern communities and Ghana as a whole.

Objectives

The main objective of the study is to select high yielding β-carotene cassava for the major rainy season in Northern Ghana.

Specifically, the study seeks to:

1. Evaluate for the best early bulking variety of cassava among the β-carotene cassava varieties.
2. Select for high yield and dry matter content

Materials and Methodology,

Cuttings of seven (7) yellow root cassava lines (01/1412, 01/1206, 01/1635, 01/1417, 01/1404, 01/1662, 01/ 01/1181) were planted at 1m apart, together with a local check (Biabasse) on 4 ridge plot made at a distance of 1m apart and 7m long at the SARI's experimental fields . A split plot design in a Randomized complete block was used with four replicates where the genotypes served as the main plots and the time of harvest was laid in the subplots. The experimental units composed of 4m x 7m plot within which the subplots were laid were four rows of cassava planted obtaining seven strands in each row. There were two harvest times (i.e. Harvest at 6 months and 9 months after planting respectively). Net plots of 4 plants were used for each harvest for the yield data. GenStat Statistical software Discovery Edition 4, was used for the data analysis

Results and Discussions

Scientific findings

Genotype 01/1417 recorded the highest (386) number of leaves at 6 MAP, while genotype 01/1635 recorded the highest (154) number of leaves at 9 MAP and emerged the highest recorded overall (262) number of leaves. Genotype 01/1404 recorded the highest number of tubers at 6 MAP and among the highest at 9 MAP, and emerged the overall highest (37) in number of root tubers recorded. Genotype 01/1206 recorded the highest (9.38 kg) root tuber yield at 6 MAP, and the overall best (8.81 kg) in tuber yield at the end of the season. The results of the research showed that genotype 01/1206, 01/1404 and 01/1412 were respectively high yielding among the 7 tested genotypes as they showed early high yielding potential than the check (Biabasse).

Table 4.4: Root Tuber yield of Cassava genotypes harvested at 6 and 9 MAP. (Kg)

Genotypes	Harvest 1	Harvest 2	Mean
01/1181	5.43	8.61	7.02
01/1206	9.38	8.25	8.81
01/1404	8.38	7.11	7.74
01/1412	8.03	7.62	7.83
01/1417	5.39	8.50	6.94
01/1635	4.96	5.46	5.21
01/1662	7.59	7.78	7.68
Biabasse	5.30	8.20	6.75
LSD	2.225	2.225	
CV (%)	30.5	30.5	

Technology Developed

Three (3) beta carotene rich cassava lines were identified during the study with respect to earliness as well as root dry matter yield. The genotype 01/1206, 01/1404 and 01/1412 were selected.These genotypes identified during the study were selected based on their performance on the field of the SARI and its environs. Recommendation to farmers outside this environment will be based on a validated evaluation at the various cassava growing areas.

Conclusions/Recommendations

The results of the research showed that genotype 01/1206, 01/1404 and 01/1412 were respectively high yielding among the 7 tested genotypes as they showed early high yielding potential than the check (Biabasse). However, thisresult need to be validated for another year.

Future activities/The way forward

This study will be repeated on-station and carried-out at the on-farm level for on-farm validation.

Effect of Tunnel Screen on Rate of Sweetpotato Vine Multiplication for Increased Food Production and Income

Kwabena Acheremu, Edward Carey, Emmanuel B. Chamba, John K. Bidzakin

Executive Summary:

Sweetpotato produces more food energy per unit area and unit time than any other major food crop and has higher protein, vitamin and mineral contents compared to cassava. It is harvested after a period of about 4-5 months and planting materials must be available for the next growing season, which can be 5-7 months later, especially in those sub-Saharan African regions with extended drought period. Most farmers are losing 4-6 weeks of the growing period at the beginning of the rainy season while they re-establish sufficient vine production for planting, obtaining initial limited planting material from residual plants, re-sprouting roots, or secondary growth of harvested fields, limiting sweetpotato production areas. Low tunnel screen covered was used to assess vine production rate in three (3) harvests of "Apomuden" and "Ogyefo", compared with opened raised beds, as control, in a randomised complete block design experiment with 3 replications in SARI's experimental fields. "Apomuden" recorded the highest average vine lengths of 81.6 and 59.6cm under tunnel cover and on opened beds, at 6 WAP, 65.2 and 64.6 cm the harvest at 11WAP, and 81.3 and 65.7 cm long at 16 WAP, respectively. On the contrary, the opened bed or "control" bed produced higher vine cuttings than the tunnel covered beds, with "Ogyefo" recording the highest average cuttings of 421 plantable vines and "Apomuden" recording an average of 408 plantable vines per $2m^2$ area. However, the difference in number of transplantable vine cutting was not statistically significant. Transplantable cuttings on opened beds for "Apomuden" and "Ogyefo" were higher compared to tunnel cover at 6, 11 and 16 WAP, respectively, irrespective of the highest vine lengths recorded under tunnel cover.

Introduction

Background:

Sweet potato is among the root and tuber crops in which more than two billion people in Asia, Africa, and Latin America will depend on for food, feed, and income by 2020 (Scott *et al*, 2000). It has the third greatest production after cassava and yam and amongst the most widely grown root crops in Sub-Sahara Africa. However, Sweetpotato produces more food energy per unit area and unit time than any other major food crop and has higher protein, vitamin and mineral contents compared to cassava. It serves as human food, animal feed and industrial raw material in the production of sugar syrups, ethanol and flour for confectionaries.

It covers an estimated 2.1 million hectares with an annual estimated production of 9.9 million tonnes of root (Stathers *et al*, 2005). The yield of Sweet potato is potentially high and has aggressive growth against weed problem after establishment. The needs of farmers and breeding objectives are generally classified into yield and yield stability, quality and resistance to biotic and abiotic stress. However, sweetpotato has an additional need of survivability and availability of planting materials. The crop is harvested after a period of about 4-5 months and planting materials must be available for the next growing season, which can be 5-7 months later, especially in those sub-Saharan African regions with extended drought period.

A typical grower in the United States must retain 8% of the previous-year's root yields to generate adequate supply of transplants. This is done a month earlier in the growing period to initiate sweetpotato propagation on beds with cover mulch to raise soil temperature and promote early sprouting and transplant emergence. The mulch is removed when the sprouts reach the soil surface (Wilson and Averre, 1989). In Ghana, most farmers are losing 4-6 weeks of the growing period at the beginning of the rainy season while they re-establish sufficient vine production for planting, obtaining initial limited planting material from residual plants, re-sprouting roots, or secondary growth of harvested fields. This limits sweetpotato production areas. Timely supply and availability of planting material during the beginning of the planting season is necessary to increase food production and income of farmers. This work therefore, is aimed at assessing the effect of tunnel screen on vine multiplication rate of Apomuden and Ogyefo varieties.

Objectives:

The objective of this study was to assess the effect of tunnel screen on vine multiplication rate of "Apomuden" and "Ogyefo" varieties

Materials and Methodology:

Vine cuttings of "Apomuden", (orange flesh) and "Ogyefo", (white flesh) sweetpotato varieties were nursed on a raised bed plots of $2m^2$ during 2012 rainy season. Initial basal compost fertiliser comprising 1:3:1 in volume of rice husk, false yam (*Icacina senegalense*) leaves and cow dung was applied at 20t/ha before planting. Four (4) node vine cuttings of each variety were planted at 0.10 x 0.20m distance, at a population of 50,000 plants/ha, in a split plot arranged in a randomised complete block design and 3 replications at SARI's experimental fields (Plate 1a & 1b)., The beds were covered with 0.5m high tunnel screen, with opened beds as the control plots. Vines were harvested at 6, 11 and 16 WAP. Data was collected at each harvest on plant establishment, vine length, leaf area, number of shoots, and the number of cuttings produced. Ammonium sulphate was applied at 2t/ha ($400g/2m^2$) after each vine harvest. Data was analysed using GenStat discovery Edition 4.

Results and Discussions

Scientific findings:

The results of the study showed significant differences ($p \leq 0.05$) in the 2 varieties with respect to vine length, average number of cuttings/plant and the total number of vine cuttings recorded under the tunnel screen cover compared to the opened bed plots. "Apomuden" recorded the highest average vine length of 81.6 and 59.6cm under tunnel cover and opened beds at 6 WAP, 65.2 and 64.6 cm at 11WAP, and 81.3 and 65.7 cm at 16 WAP, respectively. (**Fig 1**).

On the contrary "Apomuden" produced higher vine cuttings on the opened beds than the tunnel covered beds (**Fig. 3**), with "Ogyefo" recording the highest overall average cuttings of 421 plantable vines and "Apomuden" recording an average of 408 plantable vines per $2m^2$ area. However, the difference in number of transplantable vine cutting yield was not statistically significant.

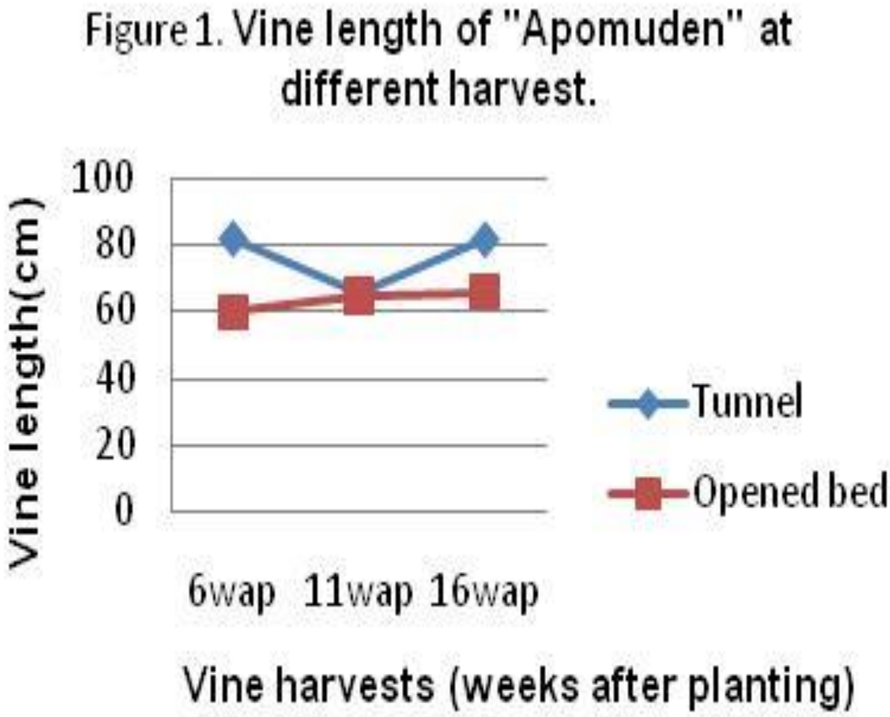


Figure 2. Vine length of "Ogyefo" at different harvest

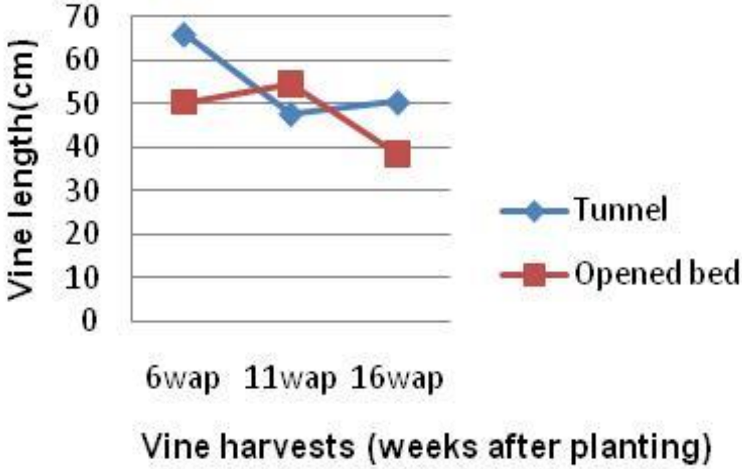
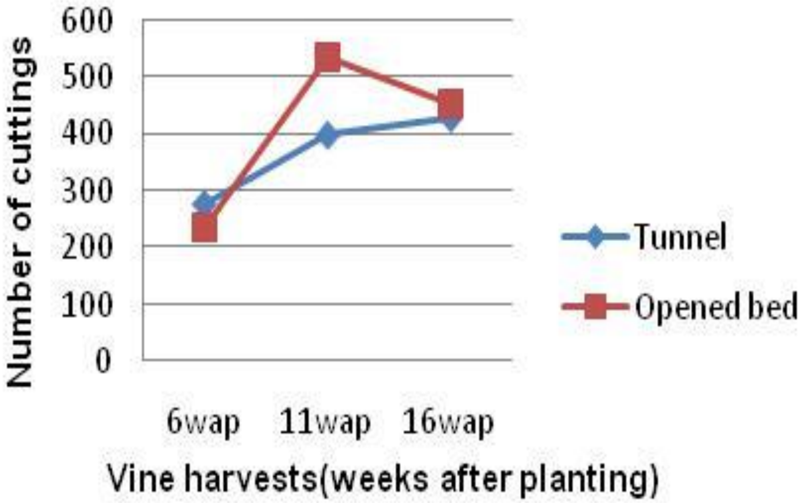
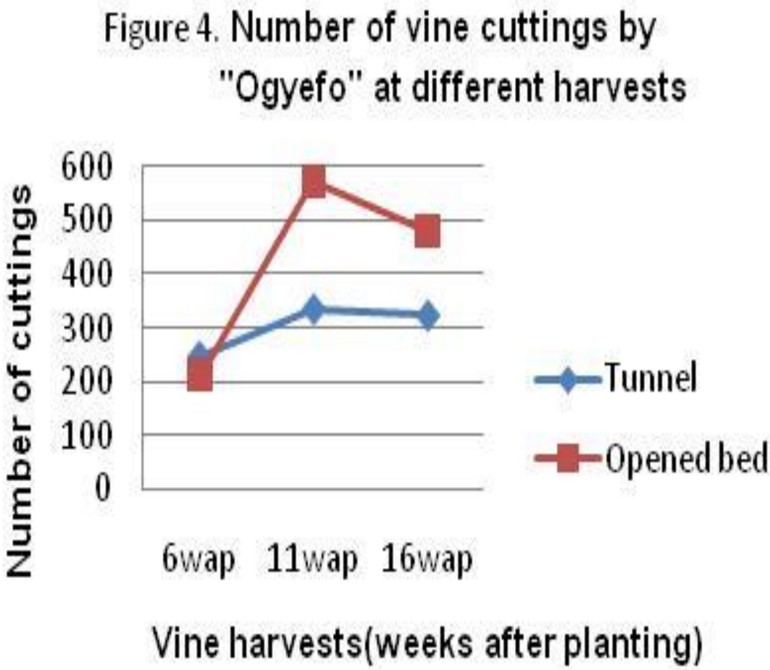


Figure 3. Number of vine cuttings by "Apomuden" at different harvests





Technology Developed:
The study has shown that the open bed method of Vine propagation for seed supply is the most economic method of sweetpotato vine multiplication to increase availability of planting material for increased production.

The open bed method of vine multiplication is the simplest method and has been adopted by small scale planting material producers at the farmer's level. Small to medium scale sweetpotato vine producers will be trained to supply planting materials for increased production and productivity.

Conclusions/Recommendations:
The results showed the effect of the tunnel cover as mulch for Apomuden and Ogyefo in the production of seed transplant for the sweetpotato varieties. Planting at a population of 33,333 plant stands per hectare for sweetpotato roots tuber production, the result of vine cuttings obtained by Apomuden from tunnel cover and opened beds in the first harvest at 6 WAP is enough to supply 42 and 35.3 hectares of land area for cultivation, respectively. At 11 WAP the number recorded is enough to supply 60 and 80.5 hectares more of land, and at 16 WAP, up to 64.2 and 68 hectares seed cuttings can be obtained from tunnel cover and opened beds, respectively. The higher vine lengths recorded under tunnel covered bed for sweetpotato varieties produced longer internodes and less number of four (4) node plantable cuttings.

Future activities/The way forward:
This study will be repeated on-station and to study the effect of vine cuttings on the yield at different vine cuttings stages.

Publications
Abstract Presented at the 9th Trienniel meeting of the African Potato Association held at the Great Rift Valley Lodge, Naivasha, on the 30th June to 4th July 2013.

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Siwek P.and Libik A. 1999. The impact of tunnel covers type on growth and yield of sweet pepper. Int. Agrophysics 13:119-124.

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

Principal Investigator:E. B. Chamba
Collaborating Scientist: Ramson Adombilla
Estimated Duration: Five Years
Sponsors: Bill and Melinda Gates Foundation (BMGF) through IITA

Project locations in Ghana. Following discussions with the objective 6 Leader of YIIFSWA the four districts in northern Ghana were recommended to focus on evaluating yam varieties and technical packages. The districts were Tolon (low fertility environment), Savelugu-Nanton (drought environment), Mion and East Gonja districts.

Collaborating Institutions: The institutions involved with the study include IITA, MOFA, Farmer Organisation Support Centre for (FOSCA)-Africa-AGRA, Catholic Relief Services (CRS), Crop Research Institute (CSIR-CRI) and Natural Resource Institute (NRI, UK)

Introduction: Yam (*Dioscorea* spp.) plays a very important part of the food security and livelihood systems of at least 60 million people in West Africa. Yams rank as the most important source of calories in Côte d'Ivoire and among the top three contributors in Benin and Ghana. The crop also makes a substantial contribution to protein in the diet, ranking as the third most important source of supply. This is much greater than the more widely grown cassava, and even above animal protein sources.

Farmers engage in yam cultivation for household food supply (by far the most important for most farmers); income generation through marketing ware yams; and production of planting material to meet their own needs with some income from the sale of surplus seed yams. It is also important to emphasize that yams traditionally play a significant role in societal rituals such as marriage ceremonies and annual festivals, making the crop a measure of wealth. Yams therefore have significance over and above other crops in the region.

Despite its importance in the economy and lives of many people, yam faces a number of constraints that significantly reduce its potential to support rural development and meet consumers' needs as an affordable nutritional product. Major among the constraints are

a. The unavailability and high cost of high quality disease free seed yam
b. The high levels of on-farm losses of yam tubers (almost 30%) during harvesting and storage, low soil fertility, and high labour costs associated with land preparation and staking.
c. Other constraints included diseases due to viruses, nematodes and fungi (anthracnose). Scale insects and termites were reported to affect the tuber yields in some areas.

The constraints have therefore formed the basis for the interventions in this project to increase yam productivity to improve the livelihoods and food security of smallholder farmers in West Africa.

The proposal has been reorganized into separate seven main objectives and Objective 6 will test, evaluate and disseminate new improved varieties, as well as new and existing improved crop management technologies to increase ware yam productivity.

Objectives of study: The study objective was to evaluate and scale out yam production technologies with improved and local popular varieties.

Expected Beneficiaries:

a. Smallholder yam farms (90% with less than 2 acres)
b. Research partners for further investment by donors
c. The research programmes by the creation of functional breeder seed units and reliable foundation and certified seed yam producers in Ghana.

Materials and Methods: The strategy was to conduct farmer managed trials on farmers' fields. The trials were evaluated by farmer groups and other actors in the yam value chain using the participatory varietal selection approach. Selected varieties and technological packages was planted and managed by additional farmers and farmer groups in subsequent seasons.

The focus of the trial is the evaluation of improved and popular local yam varieties in low fertility and drought environments. The Cheyohi community in the Tolon district was chosen as the low fertility environment and Diare in the Savelugu District as the drought prone environment.

1. **Mother trials for genotype evaluation:** A total of 15 varieties were planted at Cheyohi and Tolon districts using a randomized complete block design in three replicates with 5 seed sett/ plot. At Diare (Savelugu-Nanton district) twenty-two genotypes were planted on single row mounds. The trials were not replicated due to insufficient planting materials. The mother trials consist of local and IITA yam varieties planted with randomized complete block (RCBD)

design with three replications at Cheyohi (low fertility environment) and Diare (drought environment) in the Northern region of Ghana.

2. Baby trials for genotype evaluation: Five promising genotypes from the previous year's evaluations were selected and planted in Baby Trials at Cheyohi and Diare as proposed. At each location three farmers planted five genotypes at three mounds per genotype and agronomic model trials were conducted.

3. Agronomic models trials

The agronomic trial comprised treatments of seed treatment, fertilizer application rates and weed control with herbicides and farmer practice (Table.1). It was carried out in three communities each in Tolon, Mion and East Gonja districts using two yam varieties in each district.

4. Harvesting and evaluation procedure

Research scientists including researchers from IITA, farmer groups and community farmers from trial locations participated in the harvesting and evaluation of the mother, agronomic model trial and baby trials. Fifteen (15) farmers (male and female) harvested, described tubers of varieties, scored and ranked each variety/model on the field the first day. The 15 farmers selected 10 preferred varieties. Farmers from the community validated the selection the second day and this was done in the village to involve many farmers. Preferred varieties and models from mother trials and agronomic models respectively, were selected by participating farmers.

Table 1. Agronomic model treatments

<table>
<tr><th>M1</th><th>M2</th><th>M3</th><th>M4</th></tr>
<tr><td>1.Treated seed with fungicide Topsin M</td><td>1.Treated seed with fungicide Topsin M</td><td>1.Treated seed with fungicide Topsin M</td><td rowspan="3">Local Technology Farmer implemented their practices but are being monitored to obtain information for cost analysis.</td></tr>
<tr><td>2. Applied 15-15-15 NPK fertilizer at 30-30-36 kg/ha</td><td>2. Applied 15-15-15 NPK fertilizer at 60-60-60 kg/ha</td><td>2. Applied 15-15-15 NPK fertilizer at 60-60-60 kg/ha plus 15kg/ha of Mg and 20kg/ha S as $MgSO_4$</td></tr>
<tr><td>3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha</td><td>3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha</td><td>3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha</td></tr>
</table>

Major findings

The total number of participants involved in the evaluation of the trials in 2012 and 2013 was 1,253. The number of male and female participants increased by 26.6% and 145.4% respectively over a one year period. The high increase in the number of female participants in the evaluation is very encouraging especially that women are not currently actively involved in the production processes of yam.

Agronomic models

For the agronomic models there was an agreement for the model selected by farmers in 2012 and 2013. The overall preferred agronomic models in the districts in 2012 and 2013 were models with seed treatment, herbicide and fertilizer applications to their own practices. Generally the Model three was preferred by the farmers. However, in the Mion district farmers preferred to continue with their practices. The result was expected as the Mion district has moderately high soil fertility levels and the varieties may not have responded to fertilizer application.

Some of the reasons considered for selection of a model include number of seed yam, marketability of tubers, potential for multiplication for seed yam, disease free, smooth skin, appealing in appearance, nice shape, larger size tubers, potential for high yield and longer shelf life, higher number of ware yam, attractive colour and shape, absence of hairs and ease in peeling.Generally, yields from models across the years at all locations have been very low and may be attributed to the late planting of trials and the high rate of loss of planted seed yam due to long storage of seed yam before planting.

Mother trial

The overall best varieties preferred by farmers (both female and males) at Cheyohi and Diare are Makrong Pona; the improved Variety from CSIR-CRI, Kumasi, and local landraces, Laribako, Kpuna and chinchito were preferred by farmers in the two communities. Amula was the only variety from IITA preferred by farmers in the two communities although three other IITA varieties were preferred in each of the communities.There were differences in the preferences for yam varieties by the male and female farmers. Whereas the male farmers preferred yam varieties with sizable, exportable tubers with multiple setts with high yielding and good seed yam potentials and not susceptible to rot, their female counterpart preferred varieties that are smooth skinned marketable that are appealing in appears.

Conclusion

Farmers preferred varieties would be further elevated in a multi-location trial in Northern Ghana with the aim of releasing them to farmers.

The agronomic model three would be scaled up in the three districts for further evaluation including cost-benefit analysis.

Farmer Knowledge Survey

Principal Investigator: E. B. Chamba
Collaborating Scientist: Alhassan Sayibu
Estimated Duration: Five Years
Sponsors: Japan Ministry Agriculture, Forestry and Fisheries through IITA

Project locations in Ghana.The project districts were Tolon (low fertility environment), Mion, East Gonja and Nanumba north districts. The districts were chosen based on soil fertility, rainfall distribution and amount, fallow duration, soil use intensity in yam production, and other agro-ecological.

Collaborating Institutions: The institutions involved with the study include IITA, MOFA

Beneficiaries: small-scale resource constrained farmers

Objectives: The main objective of the study was to elicit farmer agro-ecological knowledge in four districts in the Northern region of Ghana with emphasis on soil fertility, yam varieties and their performance in low fertility soil.

Introduction: An important constraint for enhancing yam productivity in West Africa is low soil fertility, both in terms of macro- and micronutrient deficiency. This is because yams are major feeders of nutrients and when grown in low-fertile soils under subsistence conditions as done in smallholder systems of West Africa, yields are low, varying between 9 t/ha and 10 t /ha, compared with a potential yield of 51 t /ha for *D. alata* and 27 t/ha for D. *rotundata.* In order to mitigate these constraints and increase yam production, this project seek to evaluate and select with farmers and consumers yam clones that will adapt to the food and farming systems in the Guinea Savanna Zone of Ghana where yam is extensively cultivated in low fertile soils. Such on-farm trials are very essential because they give the farmer the opportunity to participate in the varietal selection and probably a higher rate of adoption.

Materials and Methods:
Interviews were conducted for four districts: North Nanumba, Mion, Savelugu-Nanton, Tolon and East Gonja. Four farmers as key informants were chosen from 20 farmers per district. The 20 farmers were previously selected during a socio-economic survey to obtain baseline information on yam production system and interviewed. Following analyses of the first round of interview, a second round of interview was conducted to fill in gaps of information and to connect related information that were lacking during the first interview. Also new related issues that emerged during and after the first round interview were addressed.

Major Findings.
The key informants interviewed in the four districts are shown in Table.1. Analysis of the survey results is on-going after which a third round of interview would validate the information gathered during the two rounds of interviews.

Table 1. Key informants interviewed across all locations in the districts.

S/N	District	Community	50 years and above		Below 50 years	
			Male	Femal	Male	Female
1	Tolon	Cheyohi	2	2	2	2
2	Mion	Sang and Salankpang	2	2	2	2
3	Nanumba North	Demon Naayili and Bimbilla	2	2	2	2
4	East Gonja	Masaka and Sissipe	2	2	2	2

Conclusion

The knowledge elicited from farmers together with field trials would be used in further experiments to develop a sustainable soil fertility management programmes in the districts.

SORGHUM IMPROVEMENT

Evaluation of Sorghum Hybrids in northern Ghana

Principal Investigator: Dr. I.D.K. Atokple
Collaborating Scientists: Kenneth Opare-Obuobi
Estimated Duration:
Sponsors: Pioneer Seed Company, USA
Location: Nyankpala, Damongo, Tumu and Manga

Background Information and Justification
Sorghum a major cereal and staple after maize and rice northern Ghana. It is cultivated throughout the savannah agro-ecological zones, covering about 41% of the total land area of the country (Atokple, 1999). The crop has several uses including industrial use, for brewing lager beer. The later has increased over the past decade increasing demand on grain sorghum. Depending on the year, 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. These low yields are due to the cultivation 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 as short term strategy has introduced hybrids from Pioneer, and other West African countries for adaptability test. The present study was therefore designed to evaluate sorghum hybrids with the aim of identifying or selecting well adapted and high yielding hybrids for increased sorghum production and productivity.

Objectives: Identify and selecting well adapted and high yielding hybrids with the Guinea-sudan agro-ecological zone of Ghana.

Expected Beneficiaries: Farmers, seed producers and brewery industry.

Materials and Methods
Six (6) genetic materials (Table 1) including five hybrids and one commercial variety were evaluated at four locations across northern Ghana. All the trials which were planted between 21st and 24th July 2013, were laid out in Randomized Complete Block Design (RCBD) with four replications. There were six-row plots of length 5m and spacing of 75cm and 30cm inter- and intra-row respectively. Four to five seeds were planted per hole but thinned out to two seedlings per stand two weeks after planting. Data collected included days to 50% Flowering,

plant height, panicle length, panicle weight, biomass yield and grain weight and were subjected to statistical analyses using the GENSTAT Package.

Table 1: Sorghum hybrid and varieties evaluated in 2013

No	Line/Hybrid	Type	Origin
1	82G55	Hybrid	PIONEER, USA
2	82W21	Hybrid	PIONEER, USA
3	XSW2134	Hybrid	PIONEER, USA
4	XSW256	Hybrid	PIONEER, USA
5	F1 223	Hybrid	INERA, NIGER
6	Kapaala	Commercial variety	CSIR-SARI, GHANA

Results/Major Findings

The trial at Nyankpala was severely affected by terminal drought that no meaningful data could be obtained from there. Grain yield varied greatly with Yield from Damongo having the highest mean of 1432.2 kg/ ha, followed by Tumu with 1194 kg/ ha. Yields in Manga (480.9 kg/ha) were far lower than the other two locations. This might be due the late planting of the trials (as a result of late arrival of seeds) and the resultant drought conditions. The hybrid 82W21 with a mean yield of 1323 kg/ ha recorded the highest yield with XSW256 following with a mean yield of 1266 kg/ha. Kapaala the local check perform fairly well a mean yield of 1221 kg/ha across the three locations. The hybrid F1 223 perform the least with a mean yield of 519 kg/ha across the various trial locations (Table 2). Pooling the results across the three locations, the studies indicated that locations did not significantly affect days to 50% flowering and plant height (Table 2). These findings have corroborated the assertion that plant height is a qualitative trait with little environmental effects. Also the hybrids/lines tested were photo-period insensitive or day-neutral and would therefore mature about the same time across different locations or latitudes. On the other hand, genotype x location interactions was highly significant ($P < 0.002$) for grain yields (Table 2).

Table 2: Genotype x Location Interactions of the Hybrid/Variety Performance in 2013

Line	Grain weight (kg/ha)				Plant height (m)			
Location	**Domongo**	**Manga**	**Tumu**	**Mean**	**Domongo**	**Manga**	**Tumu**	**Mean**
82G55	1735.7	668.7	883.3	1096ab	1.53	1.41	1.22	1.38b
82W21	1843.7	426.0	1700.0	1323a	1.64	1.46	1.44	1.51a
F1 223	313.7	359.3	883.3	519c	1.45	1.14	1.20	1.26c
Kapaala	1498.7	547.3	1616.7	1221a	1.64	1.54	1.70	1.63a
XSW2134	1520.3	271.0	816.7	869b	1.59	1.38	1.21	1.40b
XSW256	1693.0	661.2	1266.7	1207a	1.35	1.22	1.29	1.29bc
Mean	**1434.2**	**488.9**	**1194.4**		**1.53**	**1.36**	**1.34**	
Lsd (α = 0.05)	**305.7**	**216.2**	**529.5**		**0.1**	**0.1**	**0.2**	**Lsd (α = 0.05)**
	Line	**Location**	**Line* location**		**Line**	**Loca-tion**	**Line*location**	
Fprob.	<.001	<.001	0.002		<.001	<.001	0.117	

Conclusions/Recommendations

82W21 is the most promising hybrid with a mean yield of 1323 kg/ha. Kapaala the check performed fairly well with a mean yield of 1221 kg/ ha. We would like to believe that the optimal potentials of these hybrids had not been expressed for the last two years. It is recommended that the trials are repeated in 2014 completing all plantings by the end of June to observe the potentials of these materials. We wish to propose that the 2014 evaluations be participatory in a mother-baby trial fashion across the three regions.

Evaluation of Sorghum Hybrids in Northern Region

Principal Investigator: Dr. I.D.K. Atokple
Collaborating Scientist: Kenneth Opare-Obuobi
Estimated Duration: 2 year
Sponsors: I.C.R.I.S.A.T.
Location: Nyankpala, Northern region

Background Information and Justification

Sorghum, the fifth most important cereal is staple commonly grown in northern Ghana. It is cultivated throughout the savannah agro-ecological zones, covering about 41% of the total land area of the country (Atokple, 1999). The crop has several uses including industrial use, for brewing lager beer. The later has increased over the past decade increasing demand on grain sorghum. Depending on the year, 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. These low yields are due to the cultivation 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 as short term strategy has introduced hybrids from Pioneer, and other West African countries for adaptability test. The present study was therefore designed to evaluate sorghum hybrids with the aim of identifying or selecting well adapted and high yielding hybrids for increased sorghum production and productivity.

Objectives
Evaluate the yield performance, maturity and adaptability of sorghum hybrids
Expected Beneficiaries: Farmers

Materials and Methods
Twelve (12) genetic materials including eleven (11) hybrids from ICRISAT, Mali and Kapaala a commercial variety used as a check were evaluated (Table 1). The trial was planted on the 30th June 2013 and laid-out in a Randomized Complete Block Design (RCBD) with four replications. Four-row plots of length 5 m with spacing of 0.75 m and 0.30 m inter- and intra-row respectively. Three to four seeds were planted per hole and later thinned to two seedlings per stand two weeks after planting. Data collected included grain weight, days to fifty per cent flowering; panicle weight, panicle length, biomass yield, plant height. 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 1: Sorghum Hybrids Evaluated

No	Genotype	Origin
1	IPSAIS27530	ICRISAT, Mali
2	IPSAGolofing	ICRISAT, Mali
3	Soumalemba	ICRISAT, Mali
4	Sewa	ICRISAT, Mali
5	Mona	ICRISAT, Mali
6	Fadda	ICRISAT, Mali
7	Grinkan Yerewolo	ICRISAT, Mali
8	Caufa	ICRISAT, Mali
9	Yamassa	ICRISAT, Mali
10	IPSAIS6731	ICRISAT, Mali

11	Pablo	ICRISAT, Mali
12	Kapaala	CSIR-SARI, Ghana

Results/Major Findings

The objective of the trial is to evaluate the performance of the sorghum hybrid in the Guinea savannah agro-ecological zone. With respect to grain yield, Mona was significantly different from the other materials evaluated with a yield of 2724 kg/ ha. This was followed by Caufa with 1749 kg/ ha and the least yielded genotype being IPSAIS6731 with 364 kg/ ha. The local check (Kapaala) an OPV significantly yielded more than five of the hybrid genotypes with a yield of 1041 kg/ha (Table 2). For days to fifty per cent to flowering, there were significant differences among the genotypes evaluated. Kapaala, the check flowered 17 days earlier than the earliest hybrid genotype tested (Table 2). Generally, the hybrid flowering between 80 – 100 days after planting except Soumalemba (111 days after planting) could be considered as medium maturing.

Biomass yield was also significantly different among the genotypes. All the genotypes evaluated had over 10 t/ ha of biomass except Pablo which had 8.8 t/ ha. IPSAIS27530 with 18 t/ha had the highest biomass yield followed by Sewa with 17.2 t/ ha. Kapaala (the check) competed fairly with a biomass yield of 11.2 t/ ha (Table 2). Significant difference existed among the genotypes evaluated with regards to panicle weight and length. Mona with a panicle length of 40 cm had the highest panicle weight of 4389 kg/ ha whilst IPSAIS6731 with an mean panicle length of 46 cm had the least panicle weight of 652 kg/ ha.

Table 2: The performance of hybrid sorghum from ICRISAT, Mali in Nyankpala

Genotypes	Grain yield (kg/ha)	DFF	Biomass_ yield (kg/ha)	Panicle weight (kg/ha)	Panicle Length (cm)	Plant height (cm)
IPSAIS27530	538 fg	86.75 bc	18000 a	1484 c	49.26 a	388.5 h
IPSAGolofing	1424 bc	86.5 bc	16867 ab	2751 b	43.35 bc	356.9 gh
Soumalemba	910 def	111.25 f	17022 ab	1645 c	30.41 h	343.5 gh
Sewa	1124 cd	95.5 de	17222 ab	2852 b	32.64 h	199.6 ab
Mona	2724 a	82.75 b	15022 abc	4389 a	40.03 cde	271.7 cde
Fadda	1060 cde	89.5 cde	13733 bcd	1717 c	41.16 cd	280.7 def
Grinkan Yerewolo	756 defg	96 e	13200 cd	1477 c	36.05 fg	237 bcd
Caufa	1749 b	84.75 bc	12222 cde	2898 b	37.28 ef	283.8 ef
Yamassa	645 efg	86.25 bc	11978 cde	1418 c	32.81 gh	225.3 bc
IPSAIS6731	364 g	89.25 bcd	11333 de	652 d	46.43 ab	323.3 fg
Kapaala	1041 cde	65 a	11289 de	1338 cd	21.12 i	155.7 a
Pablo	1022 cde	85.5 bc	8778 e	1849 c	38.14 def	264.9 cde
Fprob.	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
CV	**26.9**	**5.2**	**18**	**24.9**	**6.3**	**11.7**

The check, Kapaala with the least panicle length of 21 cm had an appreciable panicle weight of 1338 kg/ ha resulting in a grain yield of 1041 kg/ ha (Table 2). This implies that, though the hybrids had longer and heavier panicles it did not necessarily result in grain yield. Also in the case of the ckeck (Kapaala) 78 per cent of the panicle weight came from the grain weight whereas the most yielding hybrid Mona only 62 per cent of the panicle weight could be attributed to its grain weight. This means that though Kapaala did not yield as much as Mona, it is a better converter of the plant assimilates into grain production. Grain filling in the hybrids was not fully done as in the check, thus the chaffy nature of the heads of the hybrids.

Conclusions/Recommendations

Grain yields on the average was more than 1 ton/ha (1113.1 kg/ha) but some hybrid genotypes were far below the average yield (IPSAIS27530, Grinkan Yerewolo, IPSAIS673 and Yamassa). The check performed extremely well in terms of converting more than 75% of its panicle weight into grains. Mona was the most promising hybrid with a yield of 2.7 t/ha though that only contributed 62% of the panicle weight. All the hybrids flowering after the 80th day after planting will not be the preferred candidates to choice in years of early termination of the rain. All the hybrids were taller than the check with heavy biomass. With several uses of sorghum biomass in the region, Mona is the most promising genotype among the hybrid with a grain yield of 2.7t/ ha and a biomass yield of more than 15 t/ha. It is recommended that the trail be repeated in 2014 cropping season to ascertain the result. Participatory varietal selection (PVS) with farmers should be conducted to select the most promising lines for on-farm evaluation.

Evaluation of Kapaala and its open derivatives across northern Ghana

Principal Investigator: Dr. I.D.K. Atokple
Collaborating Scientists: Kenneth Opare-Obuobi
Estimated Duration: Till release
Sponsors: WAAPP 2A
Location: Nyankpala, Damongo, Tumu and Manga

Background Information and Justification

Kapaala, a sorghum variety released in 1996 has since been the most popular commercial variety cultivated within the Guinea and Sudan savanna agro-ecological zone of northern Ghana. The main challenge in its production is its susceptibility to the grain mold due to its compact head. The panicle architecture promotes 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 various height and glume shade. Unlike the closed panicle of Kapaala, its open derivatives are less prone to insect attack and the grain mold disease which greatly affect grain yield and quality. The objective of tsix (6) elite lines have been advance and being evaluated for yield performance and resistance to the grain mold disease.

Objectives: Evaluate the six (6) elite lines of the open derivatives of Kapaala for yield performance and grain mold resistance.

Expected Beneficiaries: Farmers and seed producers

Materials and Methods

Ten (10) genetic materials (Table 1) including six (6) opened derivatives of Kapaala, two (2) exotic varieties from Senegal and two (2) local varieties. The trial was conducted in three different locations across northern Ghana; namely Tumu, Manga and Damongo (figure 1). All the trials which were planted between 9^{th} - 24^{th} July 2013 were laid out in Randomized Complete Block Design (RCBD) with four replications. There were four-row plots of length 4m and spacing of 75cm and 30cm inter- and intra-row respectively. Four to five seeds were planted per hole but thinned out to two seedlings per stand two weeks after planting. Data collected included grain weight, days to fifty per cent flowering; panicle weight, panicle length, biomass yield, plant height etc were subjected to statistical analysis using the GENSTAT Package.

Table 1: Kapaala and its derivatives evaluated in 2013

No	LINE	Origin
1	SARSORG-TRG 2011-1	Ghana
2	SARSORG-TBG 2011-2	Ghana
3	SARSORG-MRG 2011-3	Ghana
4	SARSORG-MBG 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

Results/Major Findings

The trial was aimed at identifying high yielding lines that are stable across the agro-ecological zone within northern Ghana for increases sorghum production and productivity. Of the parameters measured, combined analysis of variance for three (3) of them was done across the different locations, namely; grain weight, days to 50% flowering and plant height. For grain weight, there were significant differences among the lines and the interaction between the genotypes and location (Table 2). For the locations there were no significant differences between them. Generally, the mean grain yield was higher in Tumu than the other two locations. Unlike Manga, where the local check, Kadaga and Kapaala were the least, they had the highest yields at Tumu (Table 2). Generally, yields were low and this could be attributed to an intermittent drought which span for about 4 weeks across northern Ghana. This occurred during the reproductive stage of the plant which severally affected yield.

For days to 50% flowering, there were significant differences between the genotypes, locations as well as the interaction between genotypes and location. Days to 50% flowering range from 60 – 67, with Kadaga being the last to flower. The open Kapaala derivatives flowered early across locations than the local checks and the foreign lines (Table 2). The mean height of the lines ranged from 1.623 m to 2.81 m.Kadaga, one of the local checks was significantly taller than the other lines evaluated across the various trial locations. Kapaala was significantly different from four of its derivatives whilst it was the same as SARSORG-MRG-2011-2 and SARSORG-MBG-2011-4.

Table 2: Genotype x Location Interactions of Kapaala and its derivatives in three locations of northern Ghana

Line	Grain weight (kg/ha)				Plant height (m)			
Location	Domo-ngo	Manga	Tumu	Mean	Dom o-ngo	Mang a	Tumu	Mean
SARSORG-TRG 2011-1	1147.29	1355.57	1291.67	1265ab	2.318	2.02	1.623	1.987b
SARSORG-TBG 2011-2	893.75	935.2	1270.83	1033b	2.318	2.007	1.498	1.941bc
SARSORG-MRG 2011-3	1081.67	903.67	1375	1120ab	2.183	2.05	1.678	1.97b
SARSORG-MBG 2011-4	1028.75	1139.53	1500	1223ab	2.333	1.82	1.705	1.952bc
SARSORG-SBG 2011-5	1298.75	1113.77	1687.5	1367a	1.655	1.624	1.59	1.623e
SARSORG-SRG 2011-6	1203.75	1086.97	1145.83	1146ab	1.63	1.813	1.736	1.726d
KAPAALA	640.63	436.4	2333.33	1137ab	1.91	1.863	1.818	1.863c
KADAGA	1048.54	67.43	2416.67	1178ab	2.905	3.14	2.385	2.81a
SENSORG-2009-1	788.75	772.97	1645.83	1069ab	1.715	1.662	1.675	1.684de
SENSORG-2009-2	879.37	800.93	1562.5	1081ab	1.733	1.553	1.66	1.649de
Mean	**1001.13**	**861.24**	**1622.92**		**2.07**	**1.96**	**1.74**	
Lsd (α = 0.05)	**303.725**	**166.357**	**526.067**		**0.0893**	**0.0489**	**0.1546**	
	Line	**Loca-tion**	**Line*location**		**Line**	**Loca-tion**	**Line*location**	
Fprob.	0.56	<.001	<.001		<.001	<.001	<.001	

Conclusions/Recommendations

Grain yields were low among the lines and across, averaging 1162 kg/ha. SARSORG-SBG 2011-5 was the most promising of all the derivatives with an average yield of 1367 kg/ ha. Average grain yield in Tumu (1623 kg/ha**)** was higher than the average yield across locations. This is as result of short drought period they experienced. The open derivatives of Kapaala across the locations flowered earlier than its parental lines (local check). Its earliness makes it a preferred candidate to the parental lines since they will physiological maturity earlier to escape any terminal drought.

VEGETABLE IMPROVEMENT PROGRAM

Vegetables and associated best management practices in maize-based crop production systems to improve income and diets of rural and urban households in Northern Ghana

Principal Investigator: Mashark S. Abdulai
Collaborating Scientists:**S.** S. J. Buah, Issah Sugri, Richard Y. Agyare, Emmanuel Ayipio
Estimated Duration:
Sponsors: USAID Africa RISING thru AVRDC-The World Vegetable Center
Location: On-Station, Wa and Nyankpala

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 pro-vitamin A.Several activities were carried out in 2013. The locations were in Wa, Manga and Nyankpala.

On-Station Evaluation of Okro Varieties

Objectives: To evaluate and identify Okra varieties for inclusion in Maize/Rice-based cropping systems in Northern Ghana.

Experimental procedure

The experimental design was a Randomized Complete Block Design (RCBD) with three replications. Each plot measured 5 m long and 2.25 m wide with an area of $11.25m^2$. The field was ploughed and harrowed after which ridges were made. Okro seeds were soaked in water overnight before planting was done on the ridges. Two seeds per hill were sowed at stake at a depth of about 3cm which was later thinned to one. Planting distance was 0.75 m by 0.5 m. The genotypes evaluated included: ML-OK-10, ML-OK-16, ML-OK-35, ML-OK-37, SASILON, TZ SMN-86, TZ SMN-98, TZ SMN 10-3, Ex- Makutopora, Koni. Weed control was done manually by hand hoe and hand picking at regular intervals to prevent weed competition. NPK (15-15-15) was applied in split application at two and six weeks after emergence at a rate of 100 kg per acre. Top dressing was done with sulphate of ammonia at eight weeks after emergence at a rate of 50 kg per acre. Insect pests were controlled with *PAWA* (20 g/l lamda cyhalothrin). Data were collected on five tagged plants on each experimental plot. The parameters measured included plant height (cm), stem girth (mm), chlorophyll content, number of fruits, fruit length (cm), fruit girth (cm) and yield (t/ha)

Results and discussion

The mean values per variety for plant height (at 2, 4 and six weeks after planting), stem girth (at 2, 4 and six weeks after planting) are presented in Table 1. Within two weeks genotype TZ SMN 98 had grown up to almost 70 cm and by the sixth week it was over two meters tall. This made this variety too tall for the fruits to be harvested. At two weeks genotype Sasilon was 57.7 cm and at six week after planting was 139.9 cm. At that height it was still producing flowers and bearing fuits. There were no significant differences among the plants for girth. Therefore, the taller plants were prone to lodging which resulted in fruit rot. There seemed to be no relationship between chlorophyll content and yield of okra. There was a high and positive correlation between fruit size (fruit length and fruit width), number of fruits and yield (tons/ha). The mean genotypic Chlorophyll content, Fruit length, Fruit girth, Number of fruits, and Yield (t/ha) are presented in Table 2.

Based on the results of this evaluation in Nyankpala, genotypes Sasilon, Ex Makutopora and Koni were identified as the most superior genotypes.

Table 1 Growth and yield characteristics of okro varieties

Treatments	Plant height 2 WAP	Plant height 4 WAP	Plant height 6 WAP	Stem girth 2 WAP	Stem girth 4 WAP	Stem girth 6 WAP
ML OK 37	37.40	100.30	111.50	14.32	23.86	28.39
Ex Makutopora	54.70	113.70	124.10	13.95	20.96	26.32
Koni	33.50	88.00	100.40	14.03	21.50	26.13
ML OK 10	40.70	128.00	137.90	14.49	24.97	29.53
ML OK 16	51.90	155.70	166.50	13.62	27.18	31.81
ML OK 35	30.30	94.00	107.50	13.97	24.84	29.20
Sasilon	57.70	126.60	139.90	15.47	21.17	26.51
TZ SMN 10-3	54.70	164.50	176.40	13.56	29.32	32.40
TZ SMN 86	59.80	126.50	137.10	12.82	21.38	26.35
TZ SMN 98	69.80	197.60	201.50	16.00	29.05	32.84
Grand Mean	49.00	129.50	104.30	14.22	24.42	28.95
LSD (5%)	10.97	29.40	33.10	3.25	4.41	4.05
CV (%)	13.00	13.20	13.80	13.30	10.50	8.20

Table 2 Growth and yield characteristics of okro varieties

Treatments	Chlorophyll	Fruit	Fruit	Number	Yield (t/ha)

	content	length (mm)	girth (mm)	of fruits	
Sasilon	41.99	19.32	30.05	137.7	8.15
Ex Makutopora	37.74	14.98	28.04	124.7	4.19
Koni	45.50	13.01	31.37	101.7	3.51
TZ SMN 86	41.92	15.19	23.10	82.7	2.89
ML OK 16	38.12	16.11	21.43	115.3	2.78
TZ SMN 98	38.77	14.55	24.62	88.0	2.30
ML OK 37	42.68	15.72	27.39	70.3	2.13
TZ SMN 10-3	38.50	18.69	22.26	52.0	1.56
ML OK 35	34.32	17.09	26.39	63.3	1.05
ML OK 10	36.64	14.00	28.33	25.0	0.70
Grand Mean	39.62	15.86	26.30	86.10	2.93
LSD (5%)	4.74	2.85	2.83	37.51	1.64
CV (%)	7.00	10.50	6.30	25.40	32.70

On-Station Evaluation And Participatory Varietal Selection Of Roselle

Objectives: To evaluate and identify Roselle varieties for inclusion in Maize/Rice-based cropping systems in Northern Ghana.

The experiment was carried out at the research field of the Vegetable section. The trial was laid out in a Randomized Complete Block Design with three replications. Plot size measured 4 m long and 3.75 m wide. Each plot occupied an area of 15 m^2.The land was prepared by tractor ploughing, harrowing and ridging. Inter and intra row spacing was 0.75 m and 0.5 m respectively. The eight varieties evaluated were Navorongo, Samadah, Martin, Marche de Bozola, Local, Ilafia, Dah rouge and Morogoro. In Manga the same genotypes (*Morongoro*, *Samandah*, *Llafia*, *Marcha de Bozola*, *Dah Rouge*, *Martin*, *Local* and *Navorongo*) were planted on July 17, 2012. Planting distance was 20X75cm on 2 replicates of 4x9m plots, but data was collected on5mx2row plots. All agronomic practices were observed but no spraying was done. Critical data was collected on plant count at 2 weeks after planting, and harvesting, plant height at 2 weeks, 6 weeks and flowering, days to flower initiation, 50% flowering and 50% fruiting. Fertilizer application was carried out two weeks after emergence with NPK (15-15-15) at a rate of 250 kg/ha. Top dressing was done with sulphate of ammonia at six weeks after emergence at a rate of 125 kg/ha. Insects were periodically controlled by spraying with *PAWA* (20 g/l lamda cyhalothrin). Weeding was done regularly with hand hoe. Reshaping of ridges and other agronomic practices were carried out as and when necessary to ensure a successful crop establishment. Growth parameters were taken on four tagged plants in the middle row of each plot while fresh leaf weight was taken on plot basis. Parameters on which data were taken include; Plant height (cm), stem girth (mm), chlorophyll content, leaf length (cm), leaf width (cm) and fresh weight of leaves (t/ha). Agronomic data was analyzed using Genstat statistical package and LSD (5%) was used to separate the treatment means.Participatory varietal selection was organized involving farmers and market women associated with roselle production and marketing.

Results and discussion

Growth and yield data are presented in tables 3 and 4. Significant variations existed among the varieties for some of the parameters studied. There were no significant differences among the genotypes for yield. Therefore, the farmers made their selection based on traits such as growth habit, resistance to insect pests and yield. The market women on the other hand made their selections based on the color of leaves, size of leaves and leaf texture. The preferred Genotypes were Martin and Samanda (Fig. 2)

Table 3. Agronomic performance of roselle varieties

Treatments	Plant height 2 WAP	Plant height 4 WAP	Plant height 6 WAP	Stem girth 2 WAP	Stem girth 4 WAP	Stem girth 6 WAP
Dah Rouge	34.60	53.50	122.30	12.26	24.34	27.61
Ilafia	72.50	109.90	176.60	16.37	24.30	27.73
Local	50.10	86.90	104.00	9.32	18.66	21.61
Marche de Bozola	73.10	102.90	183.70	16.46	25.09	28.10
Martin	58.10	76.90	166.90	12.84	23.65	26.82
Morogoro	77.70	120.10	212.00	12.29	21.66	25.34
Novorongo	78.10	123.30	204.10	13.43	23.21	27.34
Samandah	36.30	49.10	89.10	9.37	20.28	24.22
Grand mean	60.10	90.30	157.40	12.79	22.65	26.10
LSD (5%)	8.68	16.92	50.23	2.69	7.67	7.68
CV (%)	8.20	10.70	18.20	12.00	19.30	16.80

Table 4. Agronomic performance of roselle varieties

Treatments	Chlorophyll content	Leaf length	Leaf width	Yield t/ha
Dah Rouge	35.52	12.50	11.27	65.30
Ilafia	38.45	13.17	12.23	62.20
Local	36.89	11.17	11.01	30.50
Marche de Bozola	35.27	12.95	10.91	61.40
Martin	39.27	16.30	11.93	79.70
Morogoro	34.66	12.90	11.08	59.20
Novorongo	35.79	12.61	11.33	61.40
Samandah	38.06	12.87	12.85	51.80
Grand mean	36.74	13.06	11.58	58.9
LSD (5%)	3.64	1.94	2.74	25.79
CV (%)	5.70	8.50	13.50	25.00

Table 5: Farmers preference for Roselle varieties

VEGETABLE VARIETY	FREQ	PREFERRED TRAITS
MARTIN	23	green, boil-soft, leafy, calyx
SAMANDAH	10	green leaves and *Bissap* preparation
LOCAL	7	green leaves and *Bissap* preparation
MOROGORO	4	green leaf, boil-hard
LAFIA	3	green and leafy

On-Station Evaluation of African Nightshade

The term "nightshade" refers collectively to a wide ranging group of plants, including poisonous, medicinal and edible species (from the genus Solanum). The broad-leafed African nightshade (*Solanum scrabum*) is widely cultivated in sub-Saharan Africa on small holder plot and in home gardens (Maunda, 1997). It is from the family Solanaceae and have a chromosome number of 2n=72. *Solanum scrabum* is a hexaploid plant (Edmonds and Chweya 1997; Edmonds 1977). African nightshade is sometimes referred to as black nightshade or garden huckleberry. There are numerous African words for the plant, including: mnavu (Swahili), managu (Kikuyu), namaska (Luhya), and osuga (Luo). The growing awareness in recent years of the health promoting and protecting properties of non-nutrient bioactive compounds found in vegetables, has directed increased attention to vegetables as vital components of daily diets (Smith & Eyzaguirre, 2007). For populations in sub-Saharan Africa (SSA), this attention on vegetables as vital dietary components reinforces the significant roles that leafy vegetables especially African nightshade, have long held as important components in African diets; they are indispensable ingredients of soups or sauces that accompany carbohydrate staples. (Maundu, 1997). African nightshade could make a positive contribution to world food production because they adapt easily to harsh or difficult environments, the input required for growing them is lower compared with other crops, and they are highly resistant to pathogens thus requiring fewer chemicals and pesticides (Abukutsa-Onyango et al., 2006). They also play an important role in food security and nutritional balance of both urban and rural populations of sub-Saharan Africa (Shippers 1997). This makes them suitable and advantageous for people living in areas with high population density like Africa especially guinea savannah.The objectives of this study were to evaluate and identify African nightshade varieties for inclusion in Maize/Rice-based cropping systems in Northern Ghana.

Eight varietiesof African nightshade varieties were evaluated at the research field of the Savanna Agricultural Research Institute during the 2013 cropping season. The experimental design was a Randomized Complete Block Design with three replications. Seeds of nightshade were nursed and the seedlings were transplanted on 23rd August, 2013. Nursery management practices such as watering, shading, loosening of soil in the nursery bed, thinning and hardening of seedlings were carried out appropriately to produce healthy seedlings for good crop establishment. The experimental site was ploughed, harrowed and ridged with a tractor.

Plot sizes measuring 2 m long and 2.25 m wide were used. The seedlings were transplanted at a spacing of 0.75 m X 0.5 m on the ridges.The varieties that were evaluated were BG 07, BFS 1, BG 24, Ex Hai, Olevolosi, TZ SMN 55-3, TZ SMN 11-5 and MW 26. All the varieties were provided by AVRDC-The World Vegetable Center.Compound fertilizer, NPK (15-15-15) was applied in split dose at two weeks and four weeks after transplanting at a rate of 100 kg/ac. The plants were top dressed with sulphate of ammonia at a rate of 50 kg/ac. Weeds were controlled manually with the use of hand hoe. Spraying of insecticides (20 g/l lamda cyhalothrin) was done to control insect pests. Ridges were reshaped as and when necessary. Data were taken on five plants selected from the middle row of each experimental plot. Parameters measured included plant height, chlorophyll content, stem girth, leaf width, leaf length and fresh weight of leaves. Data was analyzed using Genstat statistical package and LSD (5%) was used to separate the treatment means.

Results and discussion

The African nightshade is not a common leafy vegetable found in the kitchens of Ghanaians. However, it is very popular in Cameroun and Tanzania where it cherished as a rich man's vegetable. It grows very fast and the leaves and tender shouts are very rich in essential nutrients.The mean genotypic values for plant height, stem girth, chlorophyll content, leaf length and width and yield are presented in Table 7. There were significant differences among the varieties for all the parameters measured. Plant height ranged from 62.90 cm to 92.50 cm with a mean of 35.79cm. Olevolosi was the tallest variety while BG 24 was observed as the shortest variety. Olevolosi (22.16 mm) had the widest stem girth while TZ SMN 55-3 (17.79 mm) had the least stem girth. Leaf length ranged from 10.50 cm to 19.11 cm with an average of 15.58 cm. Leaf width also ranged from 7.46 cm to 12.95 cm with varieties MW 26 and BFS 1 having the least and widest leaf widths respectively. Ex Hai was superior in leaf and tender shoot production (54.70 t/ha).

Table 7. Mean genotypic values for plant height, stem girth, chlorophyll content, leaf length, leaf width and yield.

Genotypes	**Plant height (cm)**	**Stem girth (mm)**	**Chlorophyll content**	**Leaf length (cm)**	**Leaf width (cm)**	**Yield t/ha**
Ex Hai	68.8	19.41	43.84	12.18	9.33	54.7
BFS 1	71.3	21.76	47.99	19.11	12.95	38.9
TZ SMN 55-3	68.3	17.79	42.61	10.50	8.54	36.9
BG 07	72.5	19.99	45.06	11.21	9.24	35.8
Olevolosi	92.5	22.16	45.58	15.09	9.63	35.1
TZ SMN 11-5	79.8	20.52	43.73	11.85	9.28	34.7
BG 24	62.9	18.68	49.18	10.21	7.97	30.9
MW 26	72.5	19.21	45.77	10.49	7.46	20.7
Grand Mean	73.60	19.94	45.47	12.58	9.30	36.00
LSD (5%)	16.39	2.68	3.74	2.16	1.99	22.57
CV (%)	12.70	7.70	4.70	9.80	12.20	35.80

On-Station Evaluation Fo African Eggplant Varieties

The experiment was conducted with the aim of assessing the performance of four African eggplant varieties at the research field of Savanna Agricultural Research Institute. 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, weed control, shading, diseases and insect pests control were carried out appropriately. The seedlings were transplanted onto prepared plots on 5th August, 2013. Plot size was 2 m X 1.5 m. The seedlings were transplanted at a spacing of 0.75 m X 0.6 m. The varieties that were used in the experiment were N 13, AB 2, DB 3 and Oforiwaa.

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). Agronomic parameters measured include plant height (cm), stem girth (mm), chlorophyll content, fruit length (cm), fruit width (cm), number of fruits and yield (t/ha).
Results and discussion

There were significant differences among the varieties for plant height at 2, 4, and 6 weeks after transplanting. Oforiwa was the tallest among the varieties with a height of 116.30 cm. There were also significant differences among the varieties in stem girth at 4 weeks, however, stem girth at 2 and 6 weeks were not significant. Chlorophyll content ranged from 46.90 to 55.80 with a mean of 48.80. Significant differences were observed among the varieties for number of fruits, fruit length, fruit width and yield (Table 8). In this trial, low number of fruits and yield obtained were due late transplanting. The rains stopped before some of the varieties could flower and bear fruits. These conditions adversely affected flower production and fruit formation resulting in the poor performance of the genotypes.

Table 7 Growth and yield characteristics of African eggplant varieties

Genotypes	**Chlorophyll content**	**Fruit no.**	**Fruit length**	**Fruit width**	**Yield (t/ha)**
AB 2	46.90	48.70	3.72	4.50	7.45
DB 3	45.60	45.70	3.34	4.63	7.22
N 13	55.80	32.70	3.74	6.80	9.00
Oforiwaa	46.90	11.70	4.17	3.47	1.50
Grand Mean	48.80	34.70	3.75	4.85	6.29
LSD (5%)	18.96	20.79	0.49	0.85	6.28
CV (%)	19.50	30.00	6.60	8.80	49.90

On-Station Evaluation Of Tomato Genotypes

Eight tomato varieties were evaluated during the 2013 cropping season at the research field of Savanna Agricultural Research Institute, Nyankpala. The experimental field was ploughed, harrowed and ridge with a tractor. Seeds of tomato varieties were nursed in seed boxes filled with two parts of topsoil and one part of fertisol (compost). The soil mix was sterilized by steam sterilization method. Nursery management practices such as watering, shading, diseases and pests control were executed on time to ensure healthy seedlings were produced. The experimental design used was randomized complete block with three replicates. The size of each plot was 3 m x 2.25 m. A spacing of 0.75 m x 0.5m was used. The seedlings were transplanted onto the ridges on 17th July, 2013. Tomato varieties evaluated include S 22, Nayeli, Bebi yereye, LBR 7, Keneya, LBR 17, Abhijay and Pectomech (a commercial variety cultivated by farmers).

NPK Fertilizer was applied in split application at two and four weeks after transplanting with at a rate of 100 kg/ac. Top dressing was done with sulphate of ammonia at six 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). Staking and tying was done to prevent contact between the fruits and soil. Growth parameters measured include plant height, stem girth, days to 50% flowering, days to 50% fruiting, fruit length, fruit width, number of fruits and fruit weight (Table 8).

Table 8: Harvest and yield characteristics of 6 tomato genotypes at Manga

Genotypes	Total fruit count	Number of marketable fruits	Weight of marketable fruits (kg)	Number of rotten fruits	Fruit diameter (cm)	Total fruit weight (kg)	Potential yield t.ha^{-1}
Duluti	36.3	27.7	10.5	8.7	23	13.2	14.6
Kénéyé	235.3	180.3	43.2	55	20	61.3	68.1
LBR 16	123	102.3	66.5	52.7	22	81.9	91.1
LBR 17	136.7	90.3	60.8	46.3	24.7	74.4	82.7
LBR 7	206.7	16.2	110.6	44.7	26.3	134.6	149.6
Tengeru	53.3	37.3	14.2	16	21.7	17.6	19.5
P=0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD(0.05)	12.7	10.8	4.4	4.35	2.27	50.3	5.5
CV(%)	4.0	2.8	0.7	8.8	0.8	1.2	1.2

Monitoring and Evaluation visits

Joint field visits with scientists from the University of Development Studies were held to monitor and evaluate field trials. During these visits, discussions were held with farmers to identify their challenges and how to address them. Two other monitoring visits took place jointly with AVRDC-Mali.

On farm

The main objectives were to introduce to the farmers and conduct participatory on-farm evaluation of the performance of okro, roselle, jute mallow, amaranth and tomatoes. In Nyankpala, seed of the vegetable crops were distributed to contact farmers to grow with the supervision of researchers. However, researcher managed demonstrations were established at Manga Experimental Station and Tekuru in the Kasenna East district of the Upper East Region. In all, 19 okro, 15 roselle and 6 tomato genotypes were evaluated. In three of the Africa Rising communities (Saboligo, Tekuru and Bonia), 30 farmers were provided with up to 10-20 g of seed of some extra early maturing of Okro and roselle genotypes to boost up their local germplasm. All standard agronomic practices such as weeding and field labelling were conducted. Both male and female farmers from 9 communities were assembled at Manga and Tekuru for the Farmer Field Schools (FFS) and Participatory Variety Selection (PVS) in September to October 2013. During PVS sessions, farmers were asked to select their preferred varieties using traits such as seed vigor, plant architecture, yield, multiple harvesting frequency, viscosity, taste, colour, drying quality and marketing potential .Seed of the selected varieties will be multiplied in subsequent cropping seasons to make such genotypes accessible to other farmers. Overall, this study is expected to increase farmers' access to improved tomato, roselle and okro varieties which are high yielding and early maturing.

Seed production

Seed multiplication fields for okra, roselle, tomato, jute mallow, amaranth and pumpkin were established in Nyankpala. The following quantity of seed was harvested from the multiplications. The quantity of seed processed is presented on Table 8 to 14.

Table 8. Seed produced

Okra	VARIETY	weight(g)
	Sasilon	2801
	TZ SMN98	1263
	ML 0K35	550
	EX MAKUTOPORA	784
	TZ SMN 86	999
	KONI	794
	ML OK37	406
	ML OK16	701
	TZ SMN 10-3	270
	ML OK10	253
	NOKH 1003	5270
	NOKH 1004	2850
	NB-55	200
	NOKH-1002	211
	AAK	165

	17517

Table 9.ROSELLE

variety	Wt (g)
Navorongo	5952
Marhce de Bozolla	800
Samanda	1311
Morogoro	1214
Dah Rouge	1738
Local1	176
Local2	100
Alidu1	2416
ilafia	115
	13822

Table 10.African Nightshade

	Wt (g)
TZ SMN 11-5	874
BG 07	1313
MW 26	917
Nduruma	1443
Olevolosi	1326
Ex Hai	899
BFS 1	188
TZ SMN 55-3	452
BG 24	221
	7633

Table 11.Amaranth

AC NL	652
AH TL	616
AC NL (Cameroun)	66
IP 5	682
Madiira 1	709
Madiira 2	786

Ex Zan	716
	4230

Table 12.African eggplant

Manyire Green	1186
TZ SMN 3-10	738
Tangeru White	1168
AB 2	439
NL 3	133
Lushoto	640
TZ SMN 2-8	943
DB 3	20
	5271

Table 13.Pumpkin

TZ SMN 14-4	873
IP 3	742
GKK PKN 33	959
RW PKN 6	871
RW PKN 7	859
TZ SMN 52-7	812
IP 2	836
ML PKN 12	832
GKK PKN 44	703
HRS	745
	8232

Table 14.*Jute Mallow*

Bafia	200
ES	72
ML JM 13	120
IP 5	848
UG (JM 4)	770
IP 2	142
	2152

Technology dissemination

Four Farmers Field Schools (FFS) were organized with 256 farmers from 4 major vegetable producing cluster of communities: Azum-sapielga, Badu, Boku, Tekuru, Bonia, Tampezua, Mognori, Nyorigu, Manga and Nayorko. The participants were taken through good vegetable production practices from nursery and field management to postharvest and marketing operations. Participatory variety selection (PVS) sessions were held with the same 256 farmers at 50% fruiting growth phase. The objective was to identify genotypes and traits which would be suitable for wide adoption in communities. The PVS also assisted to identify unique traits which are essential for future vegetable improvement programs. Selection was based on preference traits such seed vigor, plant architecture, yield, multiple harvesting frequency, viscosity, taste, color, drying quality and market potential.

LEGUMES IMPROVEMENT PROGRAMME

Development of improved soybean varieties adapted to the agro- ecologies and farming systems of the savanna zones of northern Ghana.

Principal Investigator: Nicholas N Denwar
Collaborating Scientists:Mohammed Haruna and Richard Oteng-Frimpong, M Abdulai, J. M. Kombiok, S.S. Buah, R.A. L. Kanton, Zackariah Wohor, Abdul-Rashid Issah and S. K. Nutsugah.
Estimated Duration:
Sponsors:
Location: On Farm

Executive Summary
The three regions of northern Ghana constitute about 40% of the total land mass of the country with a population close to 4 million people, 70% of whom live below the poverty line. Agriculture is the dominant economic activity in the area, employing about 80% of the population. However, agricultural productivity in the area is low, attributable to the over-dependency on rainfed subsistence agriculture and low external inputs application to the inherently infertile soils on continuous cropping systems. As a result, widespread hunger, malnutrition and food insecurity are prevalent leading to high rates of infant mortality and economic decline. 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 has superior amino acid profile in that it contains such essential amino acids as lysine and tryptophan. The crop, being a legume, has considerable capacity to fix biological nitrogen and that stands it in good stead as an integral part of subsistence agriculture. The menace of the parasitic weed Striga further reduces maize yields as resistant maize varieties are non-existent. However, the yields of current soybean varieties are just above break-even levels while the capacity to stimulate suicidal germination in *S. hermonthica* seeds is low. The importance of soybean as a food and cash crop in the rural communities is growing, occupying the third place after groundnut and cowpea. 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 set out to develop, through genetic enhancement and dissemination for adoption among farmers, improved soybean varieties that will have higher grain yields (over 2.0 Mt/ha compared to current farm-level yields of about 1.0 Mt/ha), greatly enhanced abilities as trap-crop against Striga (from 25-36% for current varieties to between 45-50% for new varieties), resistance to pod-shattering, earliness in maturity (80-90 days compared to 115-130 for current varieties) and greater capacity to fix biological nitrogen (10% over the current best varieties). This summary includes the three years of project activities.

Pursuant to this, over 160 lines, comprising early and medium maturing genotypes, introduced from IITA and evaluated in preliminary tests during the project duration. Four early maturing

lines with good yield identified for advanced testing and as parents for crosses. Advanced yield trials of early and medium/late composed and planted at test sites in Nyankpala, Damongo, Yendi and Manga, yearly. Promising lines of various maturities identified and selected for on-farm testing and hybridisation. Four populations developed from 4 single crosses advanced to F_5 and ready for full plot yield testing during the main growing season of 2014. Crosses made among 8 cultivars and promising lines; F_1 seed planted in December 2013 to obtain F_2 seed for main season of 2014. A total of 18.0 ha of released varieties and promising lines have been produced as breeder seed/foundation over the project period (4.5, 4.5 and 9.0 ha for 2011, 2012 and 2013, respectively); over 15 tons of seed produced. Three lines accepted and released by Committee on December 20, 2012. Demonstration plots established at Yendi, Damongo and Wa for farmer education.

Breeder/Foundation seed supply to private seed companies supported by AGRA greatly enhanced; increased availability of certified seed to farmers in northern Ghana. Soybean production in the area steadily increased. Ghana Grains and Legumes Development Board has access to breeder seed for foundation seed production.

On-farm trials conducted in Tolon, West Mamprusi and Yendi Districts of Northern Region; Lawra and Jirapa Districts of Upper West Region. On-farm trials conducted in Tolon, West Mamprusi and Yendi Districts of Northern Region; Lawra and Jirapa Districts of Upper West Region. Under the project functional relationships were established between the programme and 5 private seed companies that also enjoyed grants from AGRA under the PASS scheme. Supply of breeder/foundation seed to these companies has been regular since 2011.

Goal and Objectives

The goal of this project was to contribute to food security, poverty alleviation and wealth creation in Ghana.The general objectives of the project were to contribute to increased agricultural productivity and significant improvement in the livelihoods of small and medium scale farmers and agro-processors through the adoption, cultivation and processing of adapted soybean varieties in northern Ghana.

Specific Objectives

i. To increase the yields of soybean and maize/soybean -based cropping systems through the development and dissemination for adoption of high-yielding and adapted soybean varieties.
ii. To demonstrate improved and sustainable strategies for increased crop yields in maize-based cropping systems using efficacious soybean varieties as trap-crop for *S. hermonthica*.
iii. To train farmers and extension agents in the proper agronomic practices for a profitable soybean and maize production and sustainable soil fertility management in northern Ghana.
iv. To link various stakeholders in the soybean value chain as a means of strengthening the emerging soybean industry in Ghana.

PlannedActivities

Variety Development

Germplasm introduction

- Making of crosses among selected parents and advancement of F_4 generations
- Preliminary evaluation of introduced germplasm.
- Participatory variety selection with farmers and seed companies.
- Advanced yield tests and on-farm testing of elite lines.
- Variety release

Breeder/Foundation seed production

- Provision of breeder and foundation seed to private seed companies.
- Germplasm maintenance

Dissemination of improved varieties

- On-farm tests
- Demonstrations of newly released varieties across northern Ghana.
- Training of farmers and Agricultural Extension Agents.

Methodology

To broaden the gene pool, germplasm was introduced annually from the International Institute of Tropical Agriculture (IITA) for preliminary and advanced evaluation and selection for inclusion in the breeding programme. The main traits of interest included high grain and fodder yield, earliness, resistance to pod shattering, trap-crop ability against *Striga hermonthica*, ability to nodulate with native rhizobia, seed quality, resistance/tolerance to biotic and abiotic stresses and stability. Superior lines were selected and constituted in parentals for hybridisation. F_1 seeds were planted in the screenhouse to obtain F_2 seeds which were then evaluated in the field. Existing filial generations were also advanced. Advanced lines were constituted into full trials and conducted across locations in northern Ghana (Nyankpala, Damongo, Yendi, Manga and Wa) to determine genotype x environment interaction effects. Elite lines were selected for on-farm testing to introduce the potential varieties to farmers for their own assessment and recommendations. Proximate analysis and sensory evaluation of these lines were conducted as part of requirements by the National Variety Release and Registration Committee. After the formal release of varieties, demonstration plots of newly released varieties were established at various locations to introduce them to many more farmers to improve their chances of adoption. To strengthen the seed industry breeder and foundation seed of released varieties was produced and provided yearly, on request, to private seed companies who in turn produced certified seed for sale to farmers. Farmer and extension officer training was leveraged by other AGRA-sponsored projects in the area. Linkages among stakeholders were forged through formal and informal arrangements. A study into the needs of private seed companies was conducted using farm visits and structured questionnaire.

Achievements

Germplasm introduction: Over 160 lines, comprising early and medium maturing genotypes, introduced from IITA were evaluated in preliminary tests during the project duration. Four early maturing lines with good yield potential were identified for advanced testing and as parents in the crossing programme.

Hybridisation Activities

Various crosses were made among selected parents for the introgression of desirable traits. Table 1 gives a brief description of these parental and the generation of seed so far obtained.

Table 1: Description of parental lines used in a crossing programme.

Parental Name	Maturity	Yield Potential (kg/ha)	Trait(s) for introgression	Comments
Jenguma	110-115	2.8	High yield, resistance to pod shattering, tolerance to low soil P	F_4 and F_2 seed ready for evaluation
Quarshie	110-115	2.4	Yield, grain quality, ease of threshability	F_4 and F_2 seed ready for evaluation
Afayak	105-110	2.4	Trap-crop ability against *S. hermonthica*, tolerance to field pests	F_2 seed from crosses ready for evaluation
Songda	110-115	2.0	Trap-crop ability against *S. hermonthica*, grain quality	F_2 seed from crosses ready for evaluation
Suong-Pungun	85-90	1.8	Earliness, shattering resistance	F_2 seed from crosses ready for evaluation
Salintuya-I	110-115	2.4	Yield and grain quality	F_4 and F_2 seed ready for evaluation
Salintuya-II	120-130	3.0	High yield, grain quality and yield stability	F_4 and F_2 seed ready for evaluation
TGX 1805-8F	85-90	1.6	Earliness	F_2 seed from crosses ready for evaluation
TGX 1844-22E	115-120	2.5	Grain/haulm (dual purpose	F_2 seed from crosses ready for evaluation

Advanced yield tests and on-farm testing of elite lines: Advanced yield trials of early and medium/late composed and planted at test sites in Nyankpala, Damongo, Yendi and Manga, yearly. Promising lines of various maturities identified and selected for on-farm testing and hybridisation.

Table 2: Advanced yield test of early maturing soybean lines, Nyankpala, 2013.

Treatment	Heightat flowering (cm)	Days to flowering 50%	Days to maturity	Plant height (cm)	Plants harvested	Grain yield (kg/ha)
TGX1805-5E	45	43	99	56	151	565
TGX1831-32F	44	43	99	57	139	670
TGX1843-3F	43	42	100	59	121	502
TGX1799-8F	44	41	101	59	170	1079
TGX1740-2F	48	43	99	62	155	918
TGX1805-8F	39	42	100	58	140	890

TGX1789-7F	43	43	96	65	168	644
TGX1485-1D	42	43	100	62	123	686
TGX1871-12E	44	39	100	63	142	836
TGX1895-49F	48	43	101	63	138	778
TGX1903-7F	44	42	98	61	195	1035
TGX1909-3F	41	44	101	59	130	441
Grand Mean	43.56	42.4	99.46	60.33	147.7	754
CV	11.9	5.8	2.7	10.5	33.4	27.4
S.e.d	3.655	1.732	1.896	4.495	34.91	145.9
LSD	7.436	3.524	3.857	9.144	71.03	296.8
p>0.005	0.530	0.579	0.362	0.719	0.679	0.001

Table 3: Advanced yield test of medium maturing soybean lines, Nyankpala, 2013

Treatment	Heightat flowering (cm)	Days to flowering 50%	Days to maturity	Plant height (cm)	Plants harvested	Grain yield (kg/ha)
TGX1805-31F	52	49.8	118.5	69	146	902
TGX1827-1E	52.50	50.5	118.5	68.5	202	937
TGX1845-10E	57.75	48	118	74.5	129	1199
TGX1834-5E	51.25	48	116	69.2	158	1444
QUARSHIE	55	48	116.8	71.2	146	1355
TGX1844-19F	55.75	51.5	116.8	75.8	148	953
JENGUMA	59.50	48	119	81	120	4817
TGX1844-22E	56.25	52.1	117	75	161	1327
TGX1846-5E	57.75	48.5	116.8	75.5	170	926
TGX1843-9F	57	52	116.5	72.2	141	1038
TGX1445-3E	53.75	59	118.1	74	168	1261
TGX1829-6F	59.25	49	116.8	79.2	158	860
TGX1807-19F	56.25	52	117.5	75.5	166	826
TGX1910-6E	56.25	48	119.8	75.2	150	1043
TGX1910-14F	57.50	49	116.8	76.8	172	829
Grand Mean	55.85	49.58	117.52	74.2	115.6	1314
CV	10.4	4.3	1.5	11.4	24	142
S.e.d	4.12	1.51	1.23	6	26.4	133
LSD	8.31	3.05	2.48	12.11	53.28	268.5
p>0.005	0.714	0.040	0.135	0.739	0.380	0.375

Demonstration of newly released varieties

Demonstration plots were set up in three districts in the Northern Region namely, Tolon, Damongo and Yendi. A field day was organised at Yendi for farmers to acquaint themselves with the new varieties.

Breeder Seed Production

Table 4: Breeder seed production of released varieties and promising lines of soybean by the Legumes Improvement Program of SARI for 2013.

Location	Variety	Maturity	2013 (kg)
Nyankpala	Jenguma	Medium	1200
	Quarshie	Medium	200
	TGX 1834-5E Afayak	Medium	550
	TGX 1799-8F Suong-Pungun	Early	500
	TGX 1805-8F	Early	80
	Salintuya-I	Medium	300
	Salintuya-Ii	Late	400
	TGX 1445-3E Songda	Medium	200
Total Yield (Mt)			**3.43**

Engagement with Private Seed Companies

One of the most significant outcomes of this project has been the formal links that have been established between research and private seed companies. Hitherto, SARI's breeder seed was supplied only to the Ghana Grains and Legumes Development Board (GLDB), a governmental organization solely mandated to produce foundation seed in the country. However, with the passing of new legislation private entities with the relevant capacity are permitted to produce all categories of seed in an effort to develop the seed industry. Formal memoranda of understanding have indeed been signed between research institutes and some private seed companies for the utilization of new varieties; plans are underway for SARI to have similar arrangements. Seed companies that benefit from breeder/foundation seed from activities of this project include Savannah Seed Services (Nyankpala), Heritage Seeds (Tamale), Lexbok (Tamale), Meridian Seeds (Bolgatanga) and Anthika Seeds (Wa). The project has also enabled production and supply of foundation seed to NGO and individual seed growers.

Summary of Achievements:

Improved Breeding Programme: SARI's soybean breeding programme has greatly improved. Crosses have been stepped up with F_2 generations from 8 single crosses ready for field evaluation during the 2014 season. A small one-hectare irrigation system polytanks and sprinkler facility) has been established and will be operational for evaluating segregating generations throughout the year. Field and office equipment have greatly improved. Germplasm introduction has been enhanced to broaden the gene pool. Hitherto, IITA was the only source of germplasm but now more links have been established for the importation of elite lines for incorporation into the breeding programme.

Variety Release: Under the 3-year project three varieties were released while a fourth is due for on-farm testing. Two of these are excellent trap-crops for *Striga hermonthica* while the third is early maturing (85-90 days) compared to the existing medium maturing ones. This will be most relevant in the Upper Regions of Ghana (less rainfall) but also in the Guinea Savanna zone in years of delayed rains or for double or relay cropping.

Linkage of research to private seed companies: Before this project, SARI's soybean programme had no links with the private sector. Under the project functional relationships were established between the programme and 5 private seed companies that also enjoyed grants from AGRA under the PASS scheme. Supply of breeder/foundation seed to these companies has been regular since 2011. Plans are underway to sign formal memoranda of understanding with each of these for the granting of limited rights to particular varieties released by the programme. The project has also established several linkages with NGOs, FBO, commercial farmers, development projects, etc for the supply of good quality foundation seed.

Improved Variety Dissemination: Following the enhanced capacity to carry out research activities, the project has also enabled more dissemination of new elite lines and varieties through on-farm testing and demonstrations, participatory variety selection, farmer visits and organization of farmer field days.

Exit Strategy: The soybean improvement programme is building on the improved capacity, as a result of AGRA support, to engage the private seed sector, developing demand-driven varieties and leveraging the total development of the soybean value chain to continue in a sustainable path. The programme has increased its visibility and is attracting further support for variety development in collaboration with other national programmes. As commercial agriculture takes hold in Ghana, and indeed in the West African sub-region, demand for improved seed will fuel further variety development, bringing in its wake, the needed funds for research.

Challenges in carrying out the project- New Directions

- Lack of laboratory (seed and research) facilities, research limited to field only. Support needed for basic laboratory and seed processing facilities.
- Lack of mechanical planters, harvesters and seed processors for experimental plots and breeder seed fields; simple machinery needed to enhance quality and efficiency in research and seed production to meet the growing demand for improved seed by private sector.
- Unsecured field: unable to leave crop on the field soon after maturity (for other studies) due to stray animals from surrounding villages. Support needed to fence off an area for breeding activities.
- Lack of irrigation facilities for research during long (8 months) dry season. Support needed to establish a small irrigation facility.
- Narrow source of germplasm (only from IITA): arrangements being made for germplasm introduction from the United States.

- Technical support in modern research methods not emphasized in project formulation; future projects should include knowledge upgrading of researchers and technicians in new innovations in scientific research.
-

Lessons learned

Teamwork and closer collaboration with other projects enhance project performance.

Conclusion

Overall, the project has tremendously improved the soybean breeding programme of SARI through provision of funds for research, vehicle and office equipment, linkages to private seed companies, exposure to and building of working relations with international and national stakeholders in the agriculture sector, among others. However, to build a resilient and sustainable breeding programme it is pertinent to build on the gains so far made by extending this support for a further 3-year period and stepping up human capacity development. Breeding lines so generated during the project period would need be advanced and developed into varieties. As recognition for the increased activities of the programme and the growing importance of soybean in the farm household income and nutrition, SARI recently hired a nutritionist and a breeder to bolster the programme. With an increased visibility, the programme is leveraging its little resources with more proposals for donor support, particularly USAID, under the Feed the Future Programme of the United States of America. The Alliance for a Green Revolution in Africa no doubt is the best thing that has happened to Ghana's agriculture in the past several decades and it will be a fitting tribute to ensure that this investment is protected and nurtured to the logical conclusion.

Acknowledgements

The Soybean Improvement Programme of SARI and, indeed, the Director and staff of the institute, are deeply indebted to the Alliance for a Green Revolution in Africa (AGRA) for the financial support that has greatly improved the programme and putting it on the path of growth. We are very thankful to Dr. Aboubacar Toure (FIAAC), Dr. Issoufou Kapran (PASS), Regina Richardson and Evelyn Anfu of AGRA Ghana, for the tremendous support and encouragement. We wish to acknowledge the participation of staff of the Ministry of Food and Agriculture, Extension and Women in Agriculture, for their enormous contribution towards the on-farm testing and sensory evaluation of elite lines.

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

Principal Investigator: Dr. E. B. Chamba
Collaborating Scientist: Ramson Adombilla
Estimated Duration: Five Years
Sponsors: Bill and Melinda Gates Foundation (BMGF) through IITA

Project locations in Ghana. Following discussions with the objective 6 Leader of YIIFSWA the four districts in northern Ghana were recommended to focus on evaluating yam varieties and technical packages. The districts were Tolon (low fertility environment), Savelugu-Nanton (drought environment), Mion and East Gonja districts.

Collaborating Institutions: The institutions involved with the study include IITA, MOFA, Farmer Organisation Support Centre for (FOSCA)-Africa-AGRA, Catholic Relief Services (CRS), Crop Research Institute (CSIR-CRI) and Natural Resource Institute (NRI, UK)

Introduction: Yam (*Dioscorea* spp.) plays a very important part of the food security and livelihood systems of at least 60 million people in West Africa. Yams rank as the most important source of calories in Côte d'Ivoire and among the top three contributors in Benin and Ghana. The crop also makes a substantial contribution to protein in the diet, ranking as the third most important source of supply. This is much greater than the more widely grown cassava, and even above animal protein sources.

Farmers engage in yam cultivation for household food supply (by far the most important for most farmers); income generation through marketing ware yams; and production of planting material to meet their own needs with some income from the sale of surplus seed yams. It is also important to emphasize that yams traditionally play a significant role in societal rituals such as marriage ceremonies and annual festivals, making the crop a measure of wealth. Yams therefore have significance over and above other crops in the region.

Despite its importance in the economy and lives of many people, yam faces a number of constraints that significantly reduce its potential to support rural development and meet consumers' needs as an affordable nutritional product. Major among the constraints are

d. The unavailability and high cost of high quality disease free seed yam
e. The high levels of on-farm losses of yam tubers (almost 30%) during harvesting and storage, low soil fertility, and high labour costs associated with land preparation and staking.
f. Other constraints included diseases due to viruses, nematodes and fungi (anthracnose). Scale insects and termites were reported to affect the tuber yields in some areas.

The constraints have therefore formed the basis for the interventions in this project to increase yam productivity to improve the livelihoods and food security of smallholder farmers in West Africa.

The proposal has been reorganized into separate seven main objectives and Objective 6 will test, evaluate and disseminate new improved varieties, as well as new and existing improved crop management technologies to increase ware yam productivity.

Objectives of study: The study objective was to evaluate and scale out yam production technologies with improved and local popular varieties.

Expected Beneficiaries:

d. Smallholder yam farms (90% with less than 2 acres)
e. Research partners for further investment by donors
f. The research programmes by the creation of functional breeder seed units and reliable foundation and certified seed yam producers in Ghana.

Materials and Methods

The strategy was to conduct farmer managed trials on farmers' fields. The trials were evaluated by farmer groups and other actors in the yam value chain using the participatory varietal selection approach. Selected varieties and technological packages was planted and managed by additional farmers and farmer groups in subsequent seasons.

The focus of the trial is the evaluation of improved and popular local yam varieties in low fertility and drought environments. The Cheyohi community in the Tolon district was chosen as the low fertility environment and Diare in the Savelugu District as the drought prone environment.

Mother trials for genotype evaluation: A total of 15 varieties were planted at Cheyohi and Tolon districts using a randomized complete block design in three replicates with 5 seed sett/ plot. At Diare (Savelugu-Nanton district) twenty-two genotypes were planted on single row mounds. The trials were not replicated due to insufficient planting materials. The mother trials consist of local and IITA yam varieties planted with randomized complete block (RCBD) design with three replications at Cheyohi (low fertility environment) and Diare (drought environment) in the Northern region of Ghana.

Baby trials for genotype evaluation:Five promising genotypes from the previous year's evaluations were selected and planted in Baby Trials at Cheyohi and Diare as proposed. At each location three farmers planted five genotypes at three mounds per genotype and agronomic model trials were conducted.

Agronomic models trials :The agronomic trial comprised treatments of seed treatment, fertilizer application rates and weed control with herbicides and farmer practice (Table.1). It was carried out in three communities each in Tolon, Mion and East Gonja districts using two yam varieties in each district.

Harvesting and evaluation procedure: Research scientists including researchers from IITA, farmer groups and community farmers from trial locations participated in the harvesting and evaluation of the mother, agronomic model trial and baby trials. Fifteen (15) farmers (male and female) harvested, described tubers of varieties, scored and ranked each variety/model on the field the first day. The 15 farmers selected 10 preferred varieties. Farmers from the community validated the selection the second day and this was done in the village to involve many farmers. Preferred varieties and models from mother trials and agronomic models respectively, were selected by participating farmers.

Table 1. Agronomic model treatments

M1	**M2**	**M3**	**M4**
1.Treated seed with fungicide Topsin M	1.Treated seed with fungicide Topsin M	1.Treated seed with fungicide Topsin M	Local Technology Farmer implemented their practices but are being monitored to obtain information for cost analysis.
2. Applied 15-15-15 NPK fertilizer at 30-30-36 kg/ha	2. Applied 15-15-15 NPK fertilizer at 60-60-60 kg/ha	2. Applied 15-15-15 NPK fertilizer at 60-60-60 kg/ha plus 15kg/ha of Mg and 20kg/ha S as $MgSO_4$	
3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha	3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha	3. For weed control, pre-emergence herbicide Terbular at 1 l/ha and post emergence herbicide glyphosate applied at 1.5 l/ha	

Major findings

The total number of participants involved in the evaluation of the trials in 2012 and 2013 was 1,253. The number of male and female participants increased by 26.6% and 145.4% respectively over a one year period. The high increase in the number of female participants in the evaluation is very encouraging especially that women are not currently actively involved in the production processes of yam.

Agronomic models

For the agronomic models there was an agreement for the model selected by farmers in 2012 and 2013. The overall preferred agronomic models in the districts in 2012 and 2013 were models with seed treatment, herbicide and fertilizer applications to their own practices. Generally the Model three was preferred by the farmers. However, in the Mion district farmers preferred to continue with their practices. The result was expected as the Mion district has moderately high soil fertility levels and the varieties may not have responded to fertilizer application.

Some of the reasons considered for selection of a model include number of seed yam, marketability of tubers, potential for multiplication for seed yam, disease free, smooth skin, appealing in appearance, nice shape, larger size tubers, potential for high yield and longer shelf life, higher number of ware yam, attractive colour and shape, absence of hairs and ease in peeling.

Generally, yields from models across the years at all locations have been very low and may be attributed to the late planting of trials and the high rate of loss of planted seed yam due to long storage of seed yam before planting.

Mother trial

The overall best varieties preferred by farmers (both female and males) at Cheyohi and Diare are Makrong Pona; the improved Variety from CSIR-CRI, Kumasi, and local landraces, Laribako, Kpuna and chinchito were preferred by farmers in the two communities. Amula was the only variety from IITA preferred by farmers in the two communities although three other IITA varieties were preferred in each of the communities.

There were differences in the preferences for yam varieties by the male and female farmers. Whereas the male farmers preferred yam varieties with sizable, exportable tubers with multiple setts with high yielding and good seed yam potentials and not susceptible to rot, their female counterpart preferred varieties that are smooth skinned marketable that are appealing in appears.

Conclusion

Farmers preferred varieties would be further elevated in a multi-location trial in Northern Ghana with the aim of releasing them to farmers.The agronomic model three would be scaled up in the three districts for further evaluation including cost-benefit analysis.

Farmer Knowledge Survey

List of Scientist: Dr. E. B. Chamba, *Breeder*, Alhassan Sayibu, *MSc. Student,*
Estimated Duration: Five Years
Sponsors: Japan Ministry Agriculture, Forestry and Fisheries through IITA

Project locations in Ghana.The project districts were Tolon (low fertility environment), Mion, East Gonja and Nanumba north districts. The districts were chosen based on soil fertility, rainfall distribution and amount, fallow duration, soil use intensity in yam production, and other agro-ecological.

Collaborating Institutions: The institutions involved with the study include IITA, MOFA

Beneficiaries: small-scale resource constrained farmers

Objectives: The main objective of the study was to elicit farmer agro-ecological knowledge in four districts in the Northern region of Ghana with emphasis on soil fertility, yam varieties and their performance in low fertility soil.

Introduction: An important constraint for enhancing yam productivity in West Africa is low soil fertility, both in terms of macro- and micronutrient deficiency. This is because yams are major feeders of nutrients and when grown in low-fertile soils under subsistence conditions as done in smallholder systems of West Africa, yields are low, varying between 9 t/ha and 10 t /ha, compared with a potential yield of 51 t /ha for *D. alata* and 27 t/ha for D. *rotundata.* In order to mitigate these constraints and increase yam production, this project seek to evaluate and select with farmers and consumers yam clones that will adapt to the food and farming systems in the Guinea Savanna Zone of Ghana where yam is extensively cultivated in low fertile soils. Such on-farm trials are very essential because they give the farmer the opportunity to participate in the varietal selection and probably a higher rate of adoption.

Materials and Methods:

Interviews were conducted for four districts: North Nanumba, Mion, Savelugu-Nanton, Tolon and East Gonja. Four farmers as key informants were chosen from 20 farmers per district. The 20 farmers were previously selected during a socio-economic survey to obtain baseline information on yam production system and interviewed. Following analyses of the first round of interview, a second round of interview was conducted to fill in gaps of information and to connect related information that were lacking during the first interview. Also new related issues that emerged during and after the first round interview were addressed.

Major Findings.

The key informants interviewed in the four districts are shown in Table.1. Analysis of the survey results is on-going after which a third round of interview would validate the information gathered during the two rounds of interviews.

Table 1. Key informants interviewed across all locations in the districts.

S/N	**District**	**Community**	**50 years and above**		**Below 50 years**	
			Male	**Female**	**Male**	**Female**
1	Tolon	Cheyohi	2	2	2	2
2	Mion	Sang and Salankpang	2	2	2	2
3	Nanumba North	Demon Naayili and Bimbilla	2	2	2	2
4	East Gonja	Masaka and Sissipe	2	2	2	2

Conclusion

The knowledge elicited from farmers together with field trials would be used in further experiments to develop a sustainable soil fertility management programmes in the districts.

SOIL FERTILITY

Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa (N2Africa)

Sub-titles of project (Experiment 1)

(A) Determination of appropriate input requirements for cowpea, groundnut and soybean in the Northern Region of Ghana

(B) Evaluation of different soybean, cowpea and groundnut varieties for yield and BNF potential in the Northern Region of Ghana

Principal Investigator: Dr. Benjamin Ahiabor
Collaborating Scientists: N. N. Denwar
Estimated Duration:
Sponsors:
Location: On Farm

Executive Summary
Input trials involving soybean (Jenguma), cowpea (Songotra) and groundnut (Chinese) were established between June 14, 2012 and August 20, 2012 in various communities in the Chereponi District, Karaga District, Savelugu-Nanton Municipal and Tolon District in the Northern Region. For each legume, seven treatments were imposed, namely (i) Triple superphosphate (TSP), (ii) Single superphosphate (SSP), (iii) TSP + Fertisoil (iv) TSP + Fertisoil + BoostXtra, (v) Yaralegume, (vi) None (no input) and (vii) Weedy fallow. The weedy fallow was to provide weeds as reference plants in the determination of nitrogen fixed from the atmosphere by the respective legumes. Soybean was additionally inoculated with rhizobium inoculants, *Legumefix* and also an additional treatment, TSP+Urea-Inoculation was included for assessment of the need for inoculation.

In all the locations wherever increases in biomass, pod and grain yields were observed in the legumes, the significant ones were due to either TSP+Fertisoil treatment or TSP+Fertisoil+BoostXtra treatments. For example, the tripartite combination of TSP, fertisoil and BoostXtra significantly favoured biomass, pod and grain yields of Chinese at Nyankpala resulting in increases of 63%, 78% and 78%, respectively over the non-fertilized (None) treatment.

Project rationale/Background
There are presently many productive varieties of various grain legumes with strong BNF efficiency available from local and international research institutes in Africa that are ready for deployment to farmers. It is important that these lines be compared with those currently available and their need for rhizobium inoculants be established. Soybean has quite a specific

requirement for rhizobia and thus a high potential to respond to inoculation. These must be field-tested using inoculants currently available on the market after quality testing. The other grain legumes (cowpea and groundnut) are promiscuous and unlikely to respond to inoculation in most soils without intensive research on strain competition and inoculants delivery systems, but BNF by these promiscuous legumes will respond to other improved agronomic managements. For all the major grain legumes, intensive screening of elite materials for BNF potential needs to be conducted to identify new lines for fast-tracking the release by national regulatory agencies. Widespread field testing was carried out in 2010 and 2011 to assess varietal performance in soils with low N content and low numbers of indigenous rhizobia, and to assess the effects of applying phosphorus, potassium and other mineral nutrients as well as organic manure on the three target legumes.In 2012, a new fertilizer formulation called Yaralegume (0%N-18%P_2O_5-13%K_2O+31%Ca+4%S+2%Mg+0.6%Zn) blended and being marketed by the fertilizer company YARA was included in the assessment.
Low soil fertility will limit crop production of legumes under many circumstances. In highly weathered tropical soils, BNF can relieve the crop from nitrogen deficiency, but it paves the way for other nutrient deficiencies, particularly phosphorus, calcium and sulfur. Furthermore, symbiotic legumes have greater demand for some plant micronutrients and insufficient supply of zinc, molybdenum and boron can result in restrictive "hidden hunger". Indeed, the symbiotic legume needs nutrients in different proportions than other plants that are best satisfied by unique fertilizer blends.
This report details the progress made by SARI in the implementation of activities under the N2Africa project between May and October, 2012 in northern Ghana (Northern, Upper West and Upper East Regions). The preliminary part of this work was reported during the 2013 in-house review meeting at a time when a great part of data was not available. This is here reported as experiment 1. Experiments 2 & 3, however, were carried out in 2013.

Specific objectives:

Input trials

1. To determine the responses of cowpeas, groundnuts and soybean to P fertilizers, organic manure and micronutrients.
2. To determine the response of soybean to *Rhizobium* inoculation with and without P application, organic manure and micronutrients.

Variety trials

1. To evaluate the yield and BNF potential of different varieties of soybean, groundnut and cowpea in different agro-ecological zones of northern Ghana

Expected Outputs

- ❖ Best-fit agronomic practices for maximizing potential benefits of legume and inoculants technologies identified
- ❖ Varieties best-fit for particular niches identified

Methodology

Sites

The trials were established across mandate areas in northern Ghana, covering relevant biophysical gradients. Table 1 shows the locations of both the input and variety trials in the mandate areas in the 2012/2013 growing season.

Table 1. Location of trial sites in the Northern Region

Mandate area (Action site)	**Community/ Location**	**Trial type**
Chereponi District	Komba	Groundnut variety, Cowpea variety, Soybean input
	Jakpa	Soybean variety, Cowpea variety, Cowpea input
	Achuma	Soybean variety, Groundnut variety, Groundnut input
Karaga District	Nangunaayili	Soybean input, Cowpea input, Cowpea variety
	Komoayili	Soybean variety, Groundnut variety, Groundnut input
	Nyebsobga	Soybean variety, Cowpea variety, Groundnut variety
Savelugu-Nantom District	Yong	Groundnut input, Groundnut variety, Soybean input
	Duko	Soybean variety, Groundnut variety, Cowpea input
	Kanshegu	Soybean variety, Cowpea variety
Tolon	Nyankpala (SARI on-station)	Soybean input, Soybean variety, Cowpea input, Cowpea variety, Groundnut input, Groundnut variety

Trial establishment

Input trials

Four soybean input trials were established at Komba, Nangunaayili, Yong and Nyankpala (on-station) in the Chereponi, Karaga, Savelugu-Nanton and Tolon districts, respectively. The variety used for these trials was Jenguma. Cowpea input trials were established with the variety Songotra at Jakpa, Nangunnayili, Duko and Nyankpala in the Chereponi, Karaga, Savelugu-Nantom districts, respectively. Eight groundnut input trials were established with the variety Chinese at Achuma, Komoayili, Yong and Nyankpala

In the input trials, the soybean was sown at three seeds per hill at 50 cm x 10 cm without thinning whilst for the cowpea and groundnut, the seeds were sown at three seeds per hill at 60 cm x 20 cm and thinned to two per hill at two weeks after sowing.

Seven treatments were imposed in the inputs trials, namely (i) Triple superphosphate (TSP), (ii) Single superphosphate (SSP), (iii) TSP + Fertisoil (iv) TSP + Fertisoil + BoostXtra, (v) Yaralegume, (vi) None (no input) and (vii) Weedy fallow. The weedy fallow was to provide weeds as reference plants in the determination of nitrogen fixed from the atmosphere by the respective legumes. In addition to the above-named inputs, soybean was either inoculated with

rhizobium inoculants (*Legumefix*) or not. For the soybean input trials, TSP+Urea (N)-Inoculation was included for assessment of the need for inoculation.
Apart from the SARI on-station input trials which were planted on ridges, at the other locations they were established on the flat.

Variety trials
A maximum of six soybean varieties (Salintuya 1, Jenguma,, Anidaso, TGX1448-2E, TGX1834-5E and Quarshie) were used for variety trials. These trials were sited at Jakpa and Achuma in the Chereponi District, Komoayili and Nyensobga in the Karaga District and Duko and Kanshegu in the Savelugu-Nanton Municipal. A set of similar trials were also established on-station on SARI's research field at Nyankpala in the Tolon District. The seeds were sown at three per hill without thinning on 12th July at Jakpa, 11th July at Achuma, 27th June at Komoayili, 4th July at Nyensobga, 2nd July at Duko, 18th July at Kanshegu and 19th June at Nyankpala.

Before sowing, all plots received basal applications of fertisoil (a poultry manure-base organic manure) at least two (2) weeks before sowing at the rate of 4.0 t/ha (i. e. 5.4 kg/plot) as well as basal applications of P and K in the form of TSP and KCl, respectively at the rate of 30 kg P and 30 kg K /ha. The fertisoil was broadcast and incorporated in the soil by shallow tillage before sowing whereas the TSP and the MoP were applied in bands in a trench made 5 cm away from the plant stands and covered after application at varying days after sowing depending on the site.

Apart from the SARI on-station soybean variety trials which were planted on ridges, they were established on the flat at the other locations.BoostXtra (a foliar fertilizer complex) was also applied to the plants through foliar spraying at 4L/ha. The BoostXtra was first applied at 7 WAP and subsequently at two weeks interval until pod maturity. The composition of the BoostXtra is shown in Table 2.

The soybean seeds sown in the variety trials were either inoculated with *Rhizobium* inoculants (*Legumefix*) or not few hours before sowing. The seeds were moistened with water in any appropriate container and the inoculants then added at the rate of 5 g of inoculants per 1 kg of seed. The mixture was stirred thoroughly and uniformly with a wooden spatula and then spread on a sheet of polythene in the shade and allowed to air-dry for at least 30 minutes to enable the inoculants to stick well onto the surface of the seeds.

Four (4) cowpea improved varieties (Apagbaala, Songotra, Zayura, Padi-tuya) and two (2) cultivars (Omondao and IT90K-277-2) were used in the variety trials. Omondao is a cultivar commonly grown in the Upper West Region whilst IT90K-277-2 is a dual-purpose material obtained from Nigeria. The five (5) cowpea variety trials were located at Komba and Jakpa (Chereponi District), Nangunnayili and Nyensobga (Karaga District), Kanshegu (Savelugu-Nanton Municipal) and Nyankpala in the Tolon district.

Seven (7) groundnut variety trials using Samnut 22, Samnut 23, Chinese, Manipinta, JL 24, Nkatiesari and Bogla were established at Komba and Achuma (Chereponi district), Komoayili and Nyensobga (Karaga district), Yong and Duko (Savelugu-Nanton Municipal) and Nyankpala (Tolon district).

Samnut 22 and Samnut 23 were released varieties received from the TL II System in Nigeria whereas Bogla is a non-released local material which was procured from the open market in Tamale. Both cowpea and groundnut were sown at 60 cm x 20 cm in the variety trials at three seeds per hill and later thinned to two. The plots received 4 t/ha (i. e. 5.04 kg/plot) of fertisoil which was applied in the same way as in the case for soybean. The cowpea and groundnut plants also received similar rates of P and K (as TSP and MoP, respectively) and applied in the same way as for soybean. Apart from the SARI on-station cowpea and groundnut variety trials which were planted on ridges, at the other locations they were established on the flat.

Table 2. Composition (wt/vol) of BoostXtra

Element	**Strength**
Nitrogen (N)	20%
Phosphate (P)	20%
Potassium (K)	20%
Magnesium (MgO)	1.5%
Iron EDTA (Fe)	0.15%
Manganese EDTA (Mn)	0.075%
Copper EDTA (Cu)	0.075%
Zinc EDTA (Zn)	0.075%
Boron (B)	0.0315%
Cobalt EDTA (Co)	0.0012%
Molybdenum (Mo)	0.0012%
pH (10% solution)	4.0-4.5
Density	1.51 SG @ 18^{o}C

Results and discussion

Input trials

Integration of TSP, fertisoil and Legumefix inoculants remarkably enhanced grain yield in Jenguma on-station at Nyankpala but this may not be attributed to inoculation but rather to the effect of the combination of TSP and fertisoil(Table 3). Integrated application of TSP, Fertisoil and BoostXtra remarkably enhanced above-ground biomass production in Songotra at Nyankpala. However, application of TSP alone and combination of TSP and fertisoil with or without BoostXtra significantly increased both grain and biomass yields at Nangunnayili (Table 4). Of all the fertilizers applied to Chinese at the locations covered, only the combination of TSP, fertisoil and BoostXtra significantly favoured biomass, pod and grain yields of Chinese at Nyankpala resulting in increases of 63%, 78% and 78%, respectively over the non-fertilized (None) treatment (Table 5). Though this tripartite fertilizer integration enhanced biomass production at Yong, even the unfertilized plants tended to produce more pod and grain than plants treated with the combination of TSP, fertisoil and BoostXtra at Yong and Achuma.

Table 3a.Above-ground biomass and grain yields (t/ha) of Jenguma in response to application of different fertilizer types at four locations in the Northern Region of Ghana.

Treatment	Nangunnayili		Komba	
	Biomass	Grain yield	Biomass	Grain yield
None-Ino	5.238 b	0.832 b	2.474	0.785
None+Ino	14.006 ab	1.074 ab	3.081	0.909
SSP-Ino	4.549 b	1.208 ab	3.632	0.927
SSP+Ino	4.924 b	1.279 ab	3.610	0.798
TSP-Ino	5.505 b	1.344 ab	4.982	1.072
TSP+Ino	3.593 b	1.604 ab	6.900	1.395
TSP+Fertisoil-Ino	11.205 ab	2.131 ab	6.841	2.017
TSP+Fertisoil+Ino	6.420 b	**2.323 a**	5.248	1.556
TSP+Fertisoil+ BoostXtra-Ino	12.838 ab	1.967 ab	5.734	1.447
TSP+Fertisoil+ BoostXtra+Ino	**22.008 a**	1.989 ab	6.184	1.514
Yaralegume-Ino	6.160 b	1.035 ab	2.939	1.796
Yaralegume+Ino	7.812 b	1.058 ab	8.621	1.533
TSP+N+Ino	11.752 ab	1.665 ab	5.443	1.226
Tukey (5%)	13.281	1.382	6.249 ns	1.471
CV (%)	77.84	47.58	56.58	52.65

*Means followed by the same letter are not significantly different from each other at P = .05

Table 3b.Above-ground biomass and grain yields (t/ha) of Jenguma in response to application of different fertilizer types at four locations in the Northern Region of Ghana.

Treatment	Nyankpala		Yong	
	Biomass	Grain yield	Biomass	Grain yield
None-Ino	4.385 b*	1.6 bc	6.102	2.23
None+Ino	7.404 ab	1.56 c	5.102	2.06
SSP-Ino	4.785 ab	1.76 bc	9.329	2.24
SSP+Ino	4.911 ab	1.87 abc	9.517	1.88
TSP-Ino	6.258 ab	2.45 abc	10.165	2.55
TSP+Ino	6.092 ab	1.87 abc	11.125	2.87
TSP+Fertisoil-Ino	9.956 ab	2.86 abc	8.411	2.54
TSP+Fertisoil+Ino	12.244 a	**3.330 a**	9.089	2.61
TSP+Fertisoil+ BoostXtra-Ino	11.383 ab	3.18 ab	9.222	2.62
TSP+Fertisoil+ BoostXtra+Ino	9.778 ab	3.05 abc	6.586	2.66
Yaralegume-Ino	6.315 ab	1.80 abc	10.603	2.79
Yaralegume+Ino	6.351 ab	1.84 abc	7.257	1.58
TSP+N+Ino	8.414 ab	2.53 abc	13.895	2.58
Tukey (5%)	7.837	1.55	9.966 ns	1.29
CV (%)	49.08	35.56	48.88	24.88

*Means followed by the same letter are not significantly different from each other at P = .05

Table 4a. Effect of different fertilizer types on above-ground biomass and grain yields (kg/ha) of Songotura grown at four locations in the Northern Region of Ghana in 2012

Treatment	Nangunnayili Biomass	Nangunnayili Grain	Jakpa Biomass	Jakpa Grain
None	799 c	855 d	946 b	750
SSP	956 bc	1048 cd	1067 b	667
TSP	1230 b	1383 bc	1443 ab	852
TSP+Fertisoil	2105 a	1758 ab	3162 a	954
TSP+Fertisoil+BoostXtra	2045 a	1885 a	1777 ab	963
Yaralegume	844 c	959 d	1207 b	815
LSD (5%)	375	379	1754	307
CV (%)	78.4	25.0	48.1	36.9

*Means followed by the same letter are not significantly different from each other at *P* = .05

Table 4b. Effect of different fertilizer types on above-ground biomass and grain yields (kg/ha) of Songotura grown at four locations in the Northern Region of Ghana in 2012

Treatment	Nyankpala Biomass	Nyankpala Grain	Duko Biomass	Duko Grain
None	3170 b*	454	1384	1168
SSP	3129 b	343	1054	938
TSP	3215 b	361	933	1005
TSP+Fertisoil	3343 b	435	1858	1238
TSP+Fertisoil +BoostXtra	4361a	458	1308	1299
Yaralegume	3272 b	384	872	872
LSD (5%)	813	191	1140	552
CV (%)	18.2	36.9	59.5	39.4

*Means followed by the same letter are not significantly different from each other at *P* = .05

Table 5. Above-ground biomass and grain yield (kg/ha) of Chinese in response to different fertilizer types at three locations in the Northern Region of Ghana in during the 2012/2013 growing season.

Treatment	Nyankpala		Yong		Achuma	
	Biomass dry wt.	Grain yield	Biomass dry wt.	Grain yield	Biomass dry wt.	Grain yield
None	2045 b*	505 b	1899 c	241	2360	112
SSP	2128 b	703 ab	2424 bc	238	4802	67
TSP	1986 b	715 ab	2602 abc	288	1976	64
Yaralegume	2085 b	676 ab	2878 ab	295	2587	88
TSP + Fertisoil	2879 a	783 ab	3145 ab	227	3505	120
TSP +Fertisoil + BoostXtra	3331 a	897 a	3320 a	222	3622	106
Lsd (5%)	487	163	842	90	3657	72
CV (%)	24.5	32.2	24.8	26.0	72.9	57.7

*Means followed by the same letter are not significantly different from each other at *P* = .05

Variety trials

Rhizobium inoculation increased grain yield in only TGX1834-5E at Komoayili (2.1 t/ha) and in TGX1448-2E on-station at Nyankpala (3.7 t/ha) but this increase was remarkable only in

TGX 1448-2E compared to their non-inoculated counterparts (1.8 t/ha and 2.0 t/ha, respectively) Rhizobium inoculation of soybean did not promote nodulation in any of the varieties tested at all the locations except for Jenguma and Quarshie at Nyensobga and Duko, respectively with respect to nodule dry matter where the responses were highly significant.
No single cowpea variety emerged the best grain yielder at any location except at Nyankpala where Padi-tuya out-yielded all the other varieties (Table 6)

Samnut 23 out-yielded (pod and grain) all the other varieties in the Northern Region (specifically at Nyensobga and Achuma) (Table 7). The most popular groundnut variety grown in northern Ghana, Chinese generally performed very poorly in terms of pod and grain yields at Yong, Duko and Achuma.

Table 6a. Above-ground biomass and grain yields (kg/ha) of six cowpea genotypes grown at five locations in the Northern Region of Ghana in 2012

	Nyankpala		Nangunnayili		Kanshegu	
Variety	Biomass	Grain	Biomass	Grain	Biomass	Grain
Omondao	3094	509 bc	1764 b	972 bc	4990	487 b
Apagbaala	3689	199 e	2745 ab	1463ab	3206	682 ab
Padi-tuya	3466	926 a	3480 a	769 c	3069	561 ab
Songotra	3577	407 cd	2625 ab	1491a	2584	726 ab
Zayura	4329	333 de	3168 a	1269 ab	2373	799 a
IT90K-277-2	3608	676 b	2400 ab	1176 abc	2298	717 ab
LSD (5%)	1324	192	1242	497	3405	296
C V (%)	23.8	61.2	33.7	34.8	75.7	29.1

*Means followed by the same letter are not significantly different from each other at *P* = .05

Table 6b. Above-ground biomass and grain yields (kg/ha) of six cowpea genotypes grown at five locations in the Northern Region of Ghana in 2012

	Komba		Jakpa	
Variety	Biomass	Grain	Biomass	Grain
Omondao	720 b*	690 b	2144 b	777 abc
Apagbaala	1170 a	1028 a	2657 b	645 bc
Padi-tuya	1348 a	556 b	3667 a	574 bc
Songotra	594 b	1005 a	2207 b	1097 a
Zayura	697 b	1065 a	2221 b	977 ab
IT90K-277-2	693 b	1074 a	2522 b	482 c
LSD (5%)	408	281	888	411
C V (%)	47.3	29.6	28.2	46.6

*Means followed by the same letter are not significantly different from each other at *P* = .05

Table 7a.Above-ground biomass and pod dry weights (kg/ha) and grain yield (kg/ha) of six varieties of groundnut grown at different locations in the Northern Region of Ghana in 2012.

	Nyensobga			**Achuma**		
Variety	Bio-mass	Pod	Grain	Bio-mass	Pod	Grain
Samnut 22	5161 a	570 b	401b	5423ab	887 b	502b

Samnut 23	3931ab	989 a	597 a	5597a	1369 a	796a
Chinese	4028ab	211 c	189 c	5754a	230 c	163c
Bogla	3878ab	135 c	92 c	3708b	326 c	217c
JL 24	3787b	128 c	127 c	6052a	307 c	195c
Manipinta	5123a	267 c	213 c	5459ab	424 c	261c
LSD (0.5%)	1291	156	123	1852	279	163
CV (%)	23.3	86.3	73.5	25.4	75.7	69.9

*Means followed by the same letter are not significantly different from each other at *P* = .05

Table 7b.Above-ground biomass and pod dry weights (kg/ha) and grain yield (kg/ha) of six varieties of groundnut grown at different locations in the Northern Region of Ghana in 2012.

		Yong			**Duko**	
Variety	Bio-mass	Pod	Grain	Bio-mass	Pod	Grain
Samnut 22	7480ab*	1173ab	781 ab	3843 a	1256 a	1090a
Samnut 23	4365 c	1245 a	818 a	2259 c	1081ab	785abc
Chinese	5991bc	426 d	303 c	3281abc	437 c	533c
Bogla	7069ab	714 cd	502 bc	4392 a	839abc	735abc
JL 24	5230 bc	723bcd	538 abc	2907bc	591 bc	545bc
Manipinta	8872 a	1095abc	755ab	3596ab	1112 ab	952bc
LSD (0.5%)	2282.4	451.03	319	1321	547	417
CV (%)	30.123	43.520	41.3	31.697	53.3	45.4

*Means followed by the same letter are not significantly different from each other at *P* = .05

Major findings

Integration of TSP, fertisoil and Legumefix inoculants remarkably enhanced grain yield in Jenguma on-station at Nyankpala in the Tolon district but this may not be attributed to inoculation but rather to the effect of the combination of TSP and fertisoil.

Integrated application of TSP, fertisoil and BoostXtra remarkably enhanced above-ground biomass production in Songotra at Nyankpala (on-station). However, application of TSP alone and combination of TSP and fertisoil with or without BoostXtra significantly increased both grain and biomass yields at Nangunnayili.

The tripartite combination of TSP, fertisoil and BoostXtra significantly favoured biomass, pod and grain yields of Chinese at Nyankpala resulting in increases of 63%, 78% and 78%, respectively over the non-fertilized treatment (None). This tripartite fertilizer integration, however, enhanced only biomass production in Chinese at Yong. The unfertilized plants tended to produce more pod and grain than plants treated with the combination of TSP, fertisoil and BoostXtra at Yong and Achuma.

In Chereponi district, Rhizobium inoculation tended to increase biomass in Anidaso at Achuma and in TGX1448-2E at Jakpa. Even though inoculation increased grain yield in TGX 1834-5E at Komoayili in Karaga district and in TGX1448-2E on-station at Nyankpala in Tolon district, this increase was significantly remarkable only in TGX 1448-2E compared to their non-inoculated counterparts.

Generally no single variety of cowpea emerged the best grain yielder at any location except at Nyankpala where Padi-tuya out-yielded all the other varieties. This variety also produced the highest biomass (fodder) at Komba and Jakpa but it was paralleled by Apagbaala at Komba.Samnut 23 out-yielded (pod and grain) all the other groundnut varieties at Nyensobga and Achuma. Pod and grain yield increases of Samnut 23 over Chinese at Nyensobga were 369% and 216%, respectively whereas at Achuma these were 495% and 388%, respectively.

Technology developed

The integrated soil fertility management technologies stated below were observed to have enhanced the above-ground biomass and grain yields of cowpea (Songotra), groundnut (Chinese) and soybean (Jenguma) in many of the locations covered. In some places grain yield increases of up to between 91-108% were obtained:

1) TSP+Fertisoil with or without inoculation

2) TSP+Fertisoil+BoostXtra with or without inoculation

Technology transferred

These technologies were scaled out in the form of on-farm demonstrations under the ADRA-AGRA and the Africa Rising projects in the 2013 growing season

Conclusions/Recommendations

Groundnut yields were generally low due to poor management. While low groundnut yields limit our ability to draw conclusion from the trials, the Samnut varieties appear to produce markedly better than Chinese and JL24. The application of Yaralegume blend did not lead to higher yields than the application of TSP or SSP alone in many of the trials. The application of manure in combination with TSP (manure alone was not tested) often gave considerably higher yields than the application of TSP, SSP or YaraLegume blend. A fascinating question is why did all the three legumes often responded so clearly to manure applications. Soybean grain yields were generally good. Variety tested did not reveal consistent differences between varieties. Only in one out of 10 soybean trials, a significant effect of inoculation was observed. The quality of the inoculants is suspect.

Future activities/the way forward

The project has come to an end.

Effects of Different Rates Of Phosphorus Fertilizer On Soybean {Glycine Max (L.) Merril} Inoculated With Rhizobium

Project rationale/Background

Beside its great potential, soybean production is still limited by low yields resulting in a wide gap between current production levels and the crop's potential. In order to improve production levels, areas to address include development of high yielding varieties, disease and pest control and development of improved cultural practices (Mahamood *et al*., 2008). In Ghana, soybean is mainly cultivated in northern Ghana (Northern, Upper West, and Upper East Regions), Central Region and Volta Region. In northern Ghana, where the largest production occurs in the country, the average yield is about 2.5 tonnes/ha (Awuku, 1991) as compared to that of USA which is 4.6 tonnes/ha (Richard *et al.*, 1994). The low yields in northern Ghana can be attributed to soils which are inherently poor and deficient in organic matter and other vital nutrients such as phosphorus and nitrogen. Studies in parts of Northern, Upper West and Upper East Regions showed that available phosphorus is very low ranging from trace to 6.0 mg/kg soil (Issaka *et al.*, 2004). Phosphorus deficiency can limit nodulation by legumes and phosphorus fertilizer application can overcome the deficiency (Carsky *et al.*, 2001). Availability of phosphorus in the soil influences the efficiency of *Rhizobium* that fixes atmospheric nitrogen in association with nodulating legumesas it is directly involved in growth Biological nitrogen fixation via legume-*Rhizobium* symbiosis is attracting considerable attention of research world-wide because it is economically viable for resource poor farmers and environmentally friendly (Beijiga, 2004; Wolde-Meskel, 2007; Ellafi *et al*., 2011).

Specific objective

The objective of this study is to assess the impact of phosphorus at different application rates and Rhizobium inoculants on the growth and yield of soybean.

Expected Outputs

The optimum rate of phosphorus necessary for increased soybean growth and yield determined

Methodology

A 2 x 4 factorial experiment consisting of two inoculation regimes and four application rates of phosphorus fertilizer as treatments and laid in a Randomized Complete Block Design with four replications was used with a plot size of 2.5 m x 2.5 m. The P treatments were 0 kg P/ha, 15 kg P/ha, 30 kg P/ha and 45 kg P/ha from Yaralegume fertilizer with or without inoculants. Yaralegume fertilizer is composed of 0%N-18%P_2O_5-13%K_2O+31%Ca+4%S+2%Mg+0.6%Zn and was applied two weeks after sowing by burying it in a trench dug about 5 cm away from the plant hill.

The improved soybean variety, Jenguma which was used. For the inoculated treatments, the seeds of Jenguma were inoculated with a commercial Rhizobium inoculants, *Legumefix* (containing 1 x 10^9 cells/g) at the rate of 1 kg seed per 5 g of inoculants before sowing. The sowing was done early in the morning to avoid exposing the inoculants to the direct rays of the sun which might affect the quality of the inoculants. Sowing was done at three seeds per hill at a distance of 50 cm between ridges and 10 cm within ridges. The plants were allowed to grow to maturity under rain-fed conditions while the necessary management practices like weeding were observed as and when required.

Data were collected on shoot biomass, number of nodules, nodule biomass, number and dry weight of pods at maturity, and grain yield. Partial budget analysis for the treatments was also carried out.

Data collected were subjected to a one-way analyses of variance (ANOVA) using the computer statistical package Genstat (2008 Edition) and treatment means compared using the least significance difference (LSD) at 5% probability level.

Results and Discussion

Shoot biomass

Shoot biomass per plot was significantly influenced by Rhizobium inoculations and increasing fertilizer rates (Fig. 1). The highest shoot biomass was obtained in inoculated plants fertilized with 45 kgP/ha whilst plants that received no P application with or without inoculation produced the lowest shoot biomass. Across the P application rates, inoculation increased soybean shoot dry weight by a significant average of 30% over the uninoculated plants. In an earlier work, the authors reported of similar increases in shoot biomass of soybean as a result of increased rates of P from different fertilizer sources (Lamptey *et al*., 2014). The significant increase in shoot biomass due to increased P application rates in the current study also agrees with Asia *et al*., (2005) who reported of a 20.7% increase in biomass yield due to phosphorus application.

Nodulation

Nodule number was significantly higher in inoculated plants and increased with P application rate whether plants were inoculated or not (Fig. 2). Nodule formation in inoculated plants increased by 28%, 39% and 56% by applying 15, 30 and 45 kg P/ha, respectively compared to nodulation in the unfertilized plants whereas inoculation effect was greatest (80%) in the unfertilized treatments compared to 64%, 32% and 30% increases in the 15, 30 and 45 kg P/ha treatments, respectively (Fig. 2). This suggests that Rhizobium inoculation influenced nodulation more positively than P fertilizer. Kumaga and Etub-Bonde (2002) demonstrated from pot studies that nodulation and N_2 fixation of promiscuous soybean may be increased by inoculation with effective *Bradyrhizobia,* a result which was confirmed by Fening & Danso (2002).

Nodule biomass production was enhanced significantly by inoculating soybean with Rhizobium inoculants whether the crop was fertilized with phosphorus or not (Fig. 3). The effect of inoculation was, however, greater in the presence of P and also when higher rates of P were applied but the highest per cent increase (105%) in biomass due to inoculation occurred with P rate of 30 kg/ha. The other increases were 43%, 78% and 88% for 0 kg P, 15 kg P and 45 kg P per hectare, respectively. Figure 3 reveals that in un-inoculated plants the highest biomass of 1.6 g/plant was obtained at 45 kg P/ha application rate but a co-application of inoculants and only 15 kg P/ha was able to produce the same nodulation effect. This means that with respect to nodule biomass (which is an index of biological N fixation if all nodules are active), application of 250 g of inoculants (inoculation rate used in this study was equivalent to 250 g inoculants/ha) could make savings equivalent to 30 kg P (i. e. 381.7 kg Yaralegume) in this study. The positive effect of Rhizobium inoculation on nodulation has been confirmed by Elkoca *et al*., (2010) who recorded a significant increase in nodulation by native soil *Rhizobium* population in single inoculations conducted on a legume. Phosphorus is also known to initiate nodules formation, increase the number of nodule primordial and is essential for the development and functioning of formed nodules (Waluyo *et al*., 2004; Tagoe *et al*., 2008). Several researches have reported that the supply of phosphorus plays important roles in the establishment, growth and function of nodules (Abbasi *et al*., 2008). Both figures 2 and 3 show that the interactive application of phosphorus and Rhizobium inoculants had a greater impact on nodulation than either treatment alone.

Pod production

The number and weight of pods produced by soybean in response to applications with P fertilizer and Rhizobium inoculants are shown in figures 4 and 5, respectively. Rhizobium inoculation remarkably increased both pod number and pod weight but whereas the increases due to inoculation were observed at all the P application rates in the former (Fig. 4), there was no effect of inoculation on pod weight at 15 kg P/ha rate (Fig. 5). Also, whether plants were inoculated or not, pod production generally increased with increasing rates of P application (Fig. 4 & 5) which agrees with Mohan and Rao (1997) and Rani (1999) who reported high numbers of pods per plant in response to high doses of phosphorus. Increased numbers of pods per plant in response to inoculation were also reported by Sable *et al*., (1998) and Hernandez and Cuevas (2003). The increases in pod weight at the different increasing rates of P plus Rhizobium inoculation may have been due to enhanced stimulation of pod filling in such treatments as confirmed by Hernandez and Cuevas (2003) when they reported of significant high numbers of seeds per pod when 100 kg P was applied in contrast to minimum numbers of seeds where no P was applied. Similar results were obtained by Malik *et al*., (2006) who reported of significant effects of phosphorus rates on harvest index of soybeans.

Grain yield

Similar to pod production, grain yield of soybean was significantly influenced by varied phosphorus rates, Rhizobium inoculation and their interaction (Figure 6). The grain yield increased significantly at every higher rate of P application from 0 to 45 kg/ha with or without inoculation. Phosphorus application at 45 kg P/ha plus Rhizobium inoculants recorded the highest grain yield of 1955 kg/ha compared to 897 kg grain per hectare in the unfertilized inoculated treatment which constitutes a yield increase of 118% (Fig. 6). However, though inoculation enhanced grain yield at every P application rate, within the P application regimes Rhizobium inoculation caused the highest per cent grain yield increase (25%) at 15 kg P/ha. Also,These results are in agreement with Stefanescu and Palanciuc (2000) who concluded that phosphorus and inoculation induced a pronounced effect on grain yield. Sable *et al.* (1998) also reported significant increases in grain yield with Rhizobium inoculation.

Economic analysis

Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation by farmers (Das *et al*., 2010). The studies assess the economic benefits of the treatments to help develop recommendation from the agronomic data. This enhances selection of the right combination of resources by farmers in the study area. The results in this study indicated that the inoculated treatments resulted in higher net benefits than the uninoculated treatments for all P fertilizer treatments (Table 1). The implications are that farmers will be better off inoculating soybeans seeds before planting as it will improve incomes of farmers through increased grain yields. The partial budget analysis showed that the application of 45 kg P/ha for both inoculated and uninoculated treatments yielded higher net benefits than all the treatments. The control (no fertilizer) treatment also produced the lowest net benefit for both the inoculated and un-inoculated treatments. This implies that farmers would be better off inoculating their soybean in combination with application of 45 kg P/ha as these increase soybean yields and thus increase incomes.

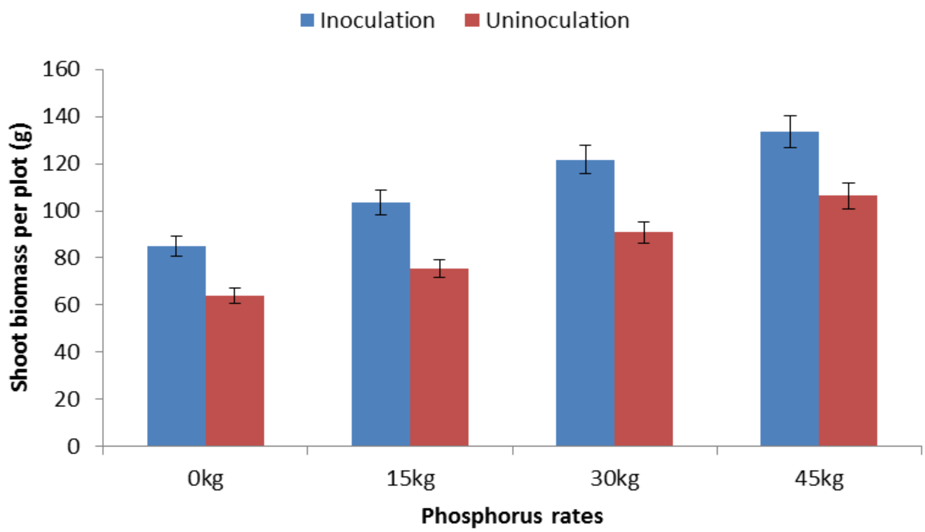

Figure 1: Influence of Rhizobium inoculation and phosphorus fertilizer application rate on shoot dry biomass of soybean at full pod stage.

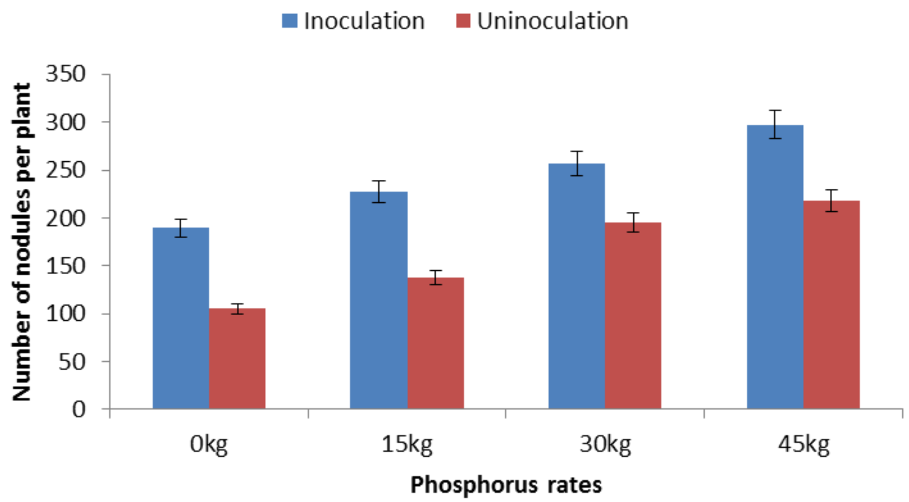

Figure 2: Influence of Rhizobium inoculation and phosphorus fertilizer application rate on number of nodules per plant at full pod stage of soybean.

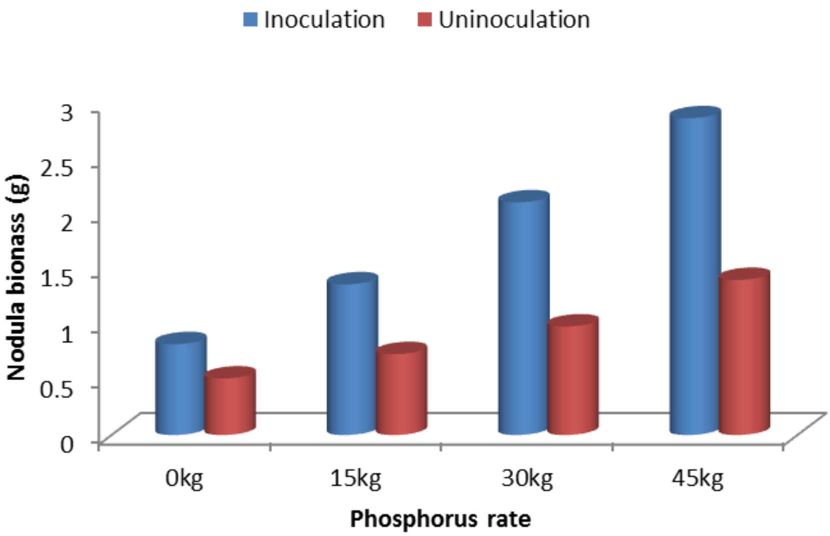

Figure 3: Influence of Rhizobium inoculation and phosphorus fertilizer application rate on nodule biomass of soybean at full pod stage.

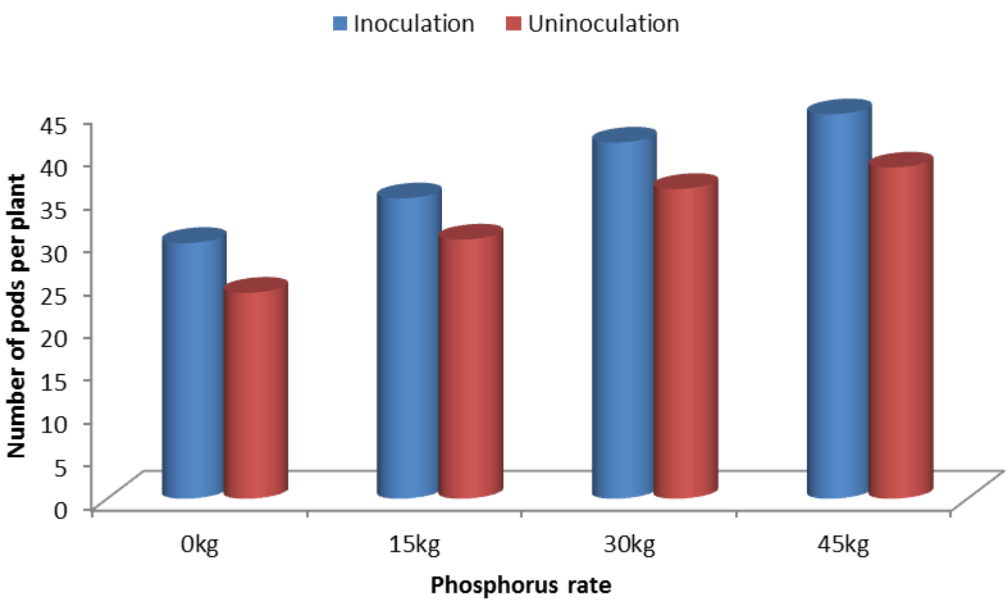

Figure 4: Influence of Rhizobium inoculation and phosphorus fertilizer application rate on number of pods of soybean at full pod stage.

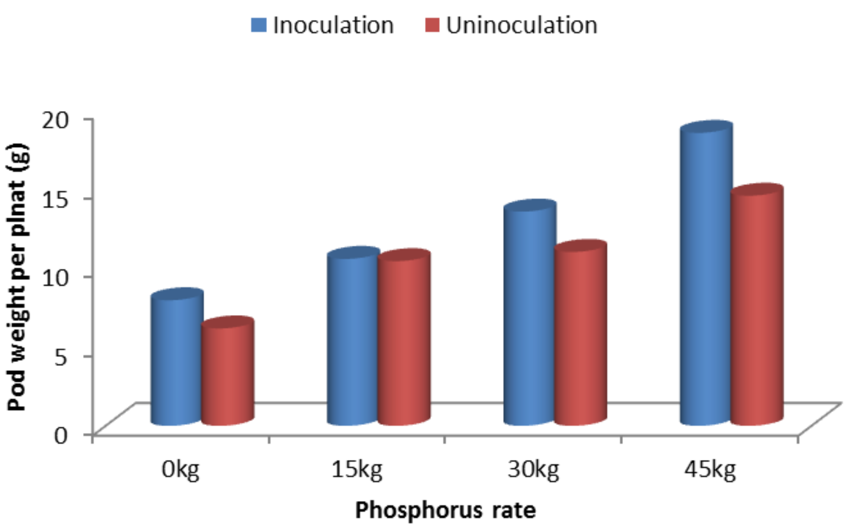

Figure 5: Influence of Rhizobium inoculation and phosphorus fertilizer application rate on pod weight of soybean at full pod stage.

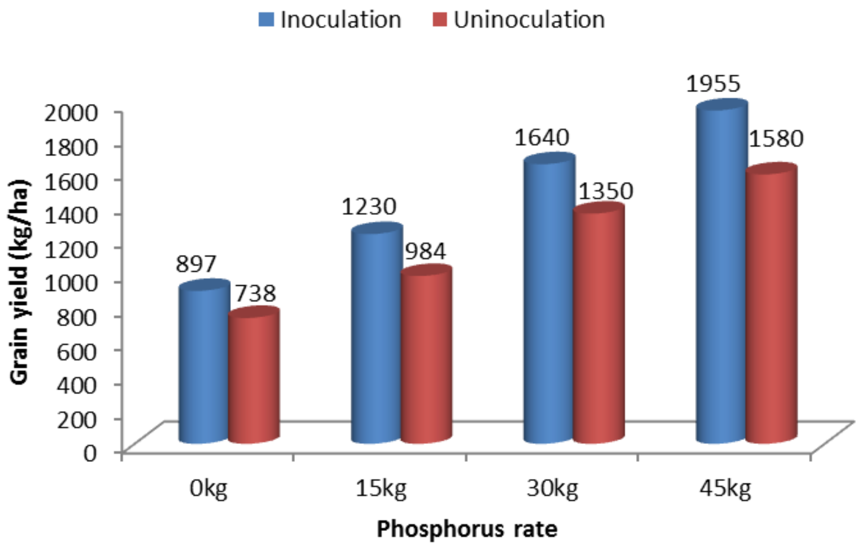

Figure 6: Influence of Rhizobium inoculation and phosphorus fertilizer application rates on grain yield of soybean.

Table 1a: Partial budget for un-inoculated soybean seeds under four different treatments

ITEM	TREATMENT			
	Un-inoculated			
	15 kg P/ha	30 kg P/ha	45kg P/ha	0 kg P/ha
Average yield (kg/ha)	984	1350	1580	738
Adjusted yield (kg/ha)[1]	885.6	1215	1422	664.2
Gross field benefit (₵)[2]	2125.4	2916	3412.8	1594.1
Cost of Yaralegume (₵/ha)	16	33	48	0
Cost of inoculation (₵/ha)	0	0	0	0
Total cost that vary (₵)	16	33	48	0
Net benefit (₵)	2109.4	2883	3364.8	1594.1

[1] Average yield adjusted 10% downwards; Farm gate price of soybean as at December 2012= GH ₵2.40 per kg; Price of 50 kg of Yaralegume as at December, 2012 = GH ₵50.00 and price of inoculants = GH₵15.00/ha.

Table 1b: Partial budget for inoculated and un-inoculated soybean seeds under four different treatments

ITEM	TREATMENT			
	Inoculated			
	15 kg P/ha	30 kg P/ha	45kg P/ha	0 kg P/ha
Average yield (kg/ha)	1230	1640	1955	897
Adjusted yield (kg/ha)[3]	1107	1476	1759.5	807.3
Gross field benefit (₵)[4]	2656.8	3542.4	4222.8	1937.5
Cost of Yaralegume (₵/ha)	16	33	48	0
Cost of inoculation (₵/ha)	15	15	15	15
Total cost that vary (₵)	31	48	63	15
Net benefit (₵)	2625.8	3494.4	4159.8	1922.5

[1] Average yield adjusted 10% downwards; Farm gate price of soybean as at December 2012= GH ₵2.40 per kg; Price of 50 kg of Yaralegume as at December, 2012 = GH ₵50.00 and price of inoculants = GH₵15.00/ha.

Major findings

Phosphorus application at 45 kg P/ha plus Rhizobium inoculation significantly increased growth and grain yield of Jenguma. The economic analysis of the treatments also showed that inoculation of soybean seeds or a combination of inoculation with 45 kg P/ha were more profitable than the application of 45 kg P/ha without inoculation.

Technology developed

Integrated application of phosphorus fertilizer, Yaralegume and Rhizobium inoculation improves soybean productivity

Technology transferred

Technology has not yet been transferred to farmers and other beneficiaries

Conclusions and recommendation

The study recommends inoculation of soybean seeds with Rhizobium inoculants in association with application of phosphorus fertilizer at 45 kg P/ha.

Future activities/the way forward

The developed technology will be disseminated to farmers in on-farm demonstrations during the 2014/2015 farming season.

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Developing Fertilizer Map for the Tolon District of Northern Region of Ghana

Tahiru Fulera (Miss)

Abstract

Soils of northern Ghana are inherently poor in fertility and cannot support crop production especially maize which also happen to be the staple food the region without the application of external input chiefly mineral fertilizer. The recommended rate for the area is though blanket and over two decades old and does not consider variation in rainfall amount and soil characteristics. These however are essential in the prescription of a fertilizer dosage for any particular area, soil and/crop. To curb this, an experiment was conducted at two locations with contrasting soil types in Akukayili with a Pisoplinthic Plinthosol and Cheshegu, a Pisoplinthic Lixisol upon characterisation by the CSIR – Soil Research Institute. Obatanpa maize variety was planted to both soils with six (6) levels of fertilizer imposed including a control and the blanket recommendation for the area. Results showed highly significant difference ($P<.001$) in grain yield among the different levels of fertilizer applied. The control pot yielded the least of about half a ton and the highest rate of 120-90-60 yielded the highest grain of about 2.8 tons/ha and 2.5 tons/ha on Plinthosol and Lixisol respectively.

Introduction

Significant proportion of African Agricultural land is degraded and soil fertility depletion, a manifestation of soil degradation, is currently a serious threat to food security among small-holder farmers. As a result there exists a strong case for greater fertilizer use to enhance Agricultural productivity. Multi-location trials conducted across SSA revealed that baseline yields and yields for different fertilizer treatments increased with increasing soil fertility status (Tittonell et al., 2005; Zingore et al., 2007). Fertiliser use efficiency (i.e. output per unit of fertilizer applied) in the area however is very low because mineral fertilizer use in developing countries has been promoted through blanket recommendation that are based on AEZ (Zingore et al., 2007) and its recommendations has therefore not been adapted to the specific bio-physical conditions of the different soils and agro ecological zones of Africa. The blanket fertilizer recommendation for maize in northern Ghana is 60-40-40 kg/ha N, P_2O_5 & K_2O when indeed three different agro ecological zones defined by different rainfall pattern and several dozen of benchmark soils constitute northern Ghana. Improving the blanket recommendations to account for variability in soil fertility between land units is thus necessary to maximize the benefits of projected increases in fertilizer use (Zingore et al., 2007) and also to ensure the adaptation of technologies to the specific bio-physical and socio-economics circumstances of the small scale farmers. This study thus sort to develop a site specific fertilizer recommendation for maize in the Tolon district which can later be upscale to cover northern Ghana using field experiments, modeling and GIS techniques.

Overall Objective: To develop a fertilizer map for the Tolon district of Northern Ghana

Specific Objectives: (i) To evaluate yield of Obatanpa maize variety under different fertilizer levels on two benchmark soils at two locations,

(ii) To simulate obatanpa yield under different fertilizer levels on all benchmark soils in the Tolon district using the DSSAT software and GIS tools

Materials and Methods

Study site: Location & Climate

The work was conducted at two locations in the Tolon district of the Northern Region of Ghana. The sites were the experimental field of the Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) at Akukayili about 1 km from the CSIR-SARI main office and a farmer's field at Cheshegu also about 5 km the SARI main office. The area lies within the interior northern savannah agro ecological zone of Ghana on latitude 9^{o} 25' 141" longitude 0^{o} 58' 142" and an average elevation of 183m above mean sea level (Lawson et al, 2008). The area has a relatively dry climate with a monomodal rainfall pattern usually starting from April to the end of October. Mean and total annual rainfall of the area is about 1000mm and 1022mm respectively with a variability of between 15 – 20% is recorded in the area (Kasei & Afuakwa, 1991). The dry season is rather prolonged usually from October/November to March/April. Minimum and maximum average monthly temperatures are 25^{o}C and 35^{o}C respectively.

Soil Sampling and Analysis

Soil samples were taken at random at both sites at the beginning of the season before land preparation from a depth of 0-20cm for routine nutrient analysis in the CSIR-SARI soil chemistry laboratory to determine the fertility status of the soils of the two locations.
Profile pits were dug one at each site and stratified soil sampling was done at 10 cm interval from the top soil up to a depth of 150 cm to determine the initial conditions(at planting) including moisture content (%mc), nitrate and ammonium. Bulk density was also determined using a metal ring corer. These parameters are requirements in the DSSAT model.

Land preparation and planting

Fields were prepared by ploughing and harrowing with a tractor when soil moisture was available. The experimental areas were then levelled manually using hand hoes to eliminate depressions that might cause water logging situations during the cause of the trial. Furadan (2, 3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbonate) was applied to ant hills in and around the experimental area to avoid eating of newly emerging and young seedlings. Obatanpa maize variety was used as the test crop and planted two (2) seeds per hill. Cheshegu was followed by spraying with a pre-emergent herbicide just after planting but Akukayili was not sprayed.Planting was done at Akukayili when conditions were favorable following layout of the experimental fields and proceeded a week later at Cheshegu when moisture was available. Thinning and refilling was done a week after planting.Weeding was done at both fields just before fertilizer application. In all, three weeding were carried out in Akukayili and two in Cheshegu.

Two weeks after planting, first fertilizer application (basal) was done with one half of the Nitrogen (N) and all of the Phosphorus (P) and potassium (K) when soil moisture was good. Top dressing of the remaining N was done five weeks after planting.

Experimental treatment & design

The treatments consisted of six (6) different fertilizer combinations (kg/ha N, P_2O_5 and K_2O) laid out in a randomised complete block design (RCBD) with four (4) replications. They included:

T1: 0-0-0; T2: 60-40-40; T3: 80-60-60; T4: 90-60-60; T5: 120-60-0; T6: 120-90-60

Data collected

Growth data taken during the period was plant biomass. Sampling was done at the second but last borders of each plot. Plant samples were put in brown envelops and their weight taken (fresh weight) using a digital scale. Samples were then dried in an oven in the CSIR-SARI laboratory to determine dry matter and for nutrient analysis. Sampling was done at 4 WAP, 6 WAP, 8 WAP and at harvest. Plant height was recorded at flowering and harvest. Maize grain yield was taken at maturity. The harvest area was 2m x 2m in each plot.

Results and Discussion

Table 1 below is monthly climatological data for 2013 for the Tolon district where the two study sites were located. Mean and total rainfall recorded for the experimental year was 89.9 mm and 1079 mm respectively. For the growing period of maize however, mean and total rainfall recorded were 866.9 mm and 173.38 mm respectively. Distribution within the year was fairly good though there periods of dry spells and the longest of about 14 days recorded in August (1^{st} – 13^{th} August, 2013).

Table 1.0: Monthly climatological data for the experimental year (2013)

Month	Rainfall (mm)	Evaporation (mm)	Minimum Temperature	Maximum Temperature
January	0.0	231.9	19.0	35.6
February	2.4	223.2	22.0	37.1
March	89.6	194.8	25.7	37.1
April	66.8	167.1	25.7	36.5
May	30.0	168.2	25.3	34.3
June	**161.9**	**111.0**	**24.3**	**31.3**
July	**203.8**	**89.2**	**23.6**	**29.7**
August	**217.4**	**78.9**	**22.9**	**28.9**
September	**164.1**	**77.6**	**22.6**	**30.2**
October	**119.7**	**97.7**	**23.2**	**32.0**
November	23.3	107.9	23.1	34.7
December	0.0	213.7	21.0	35.2
Mean	**89.9**	**140.7**	**23.2**	**33.6**
Total	**1079.0**	**1547.58**	**-**	**-**

*Bolded months: Growing period of maize

Soil Analysis

Laboratory analysis of the soils of the study sites shows that both soils are very low in soil organic matter with their PH being slightly acidic. Also N, P and K were very low. This implies that soils of the area have very low fertility and cannot support crop growth and development without nutrient amendment in the form of mineral and/or organic fertilizer. Micro nutrients (i.e. Ca and Mg) amount in both soils however were good.

Effect of fertilizer rate on maize plant height

On Pisoplinthic Plinthosol (PP) at Akukayili, plant height at flowering and harvest were highly significantly different ($P<.001$) among the different fertilizer levels. On Pisoplinthic Lixisol (PL), fertilizer level significantly affected the parameter at flowering and the effect highly significant at harvest. The control plots recorded the least plant height indicating the significance of mineral fertilizer on our soils to support crop growth.

Effect of fertilizer rate on grain weight

On both soils, the effect of mineral fertilizer on maize grain yield was pronounced. Highly significant difference ($P<.001$) among fertilizer levels was observed over the control. The blanket fertilizer recommendation widely used in Northern region of Ghana is 60-40-40 kg/ha N, P_2O_5, & K_2O. This has been the recommendation for over two decades now irrespective of the agro ecological zone which is defined by rainfall amount & distribution and soil type. It was observed also that grain yield increased with increasing mineral fertilizer beyond the blanket recommended rate of 60-40-40 kg/ha N, P_2O_5, K_2O. On PP at Akukayili, moving beyond the recommended rate and applying more N and P2O5 significantly affected grain yield. Increasing N levels above 80 kg/ha with 60 kg/ha P_2O_5 however did not significantly increase yield. Increasing phosphorus level to 90 kg/ha significantly increased yield. The absence of K_2O in the soil did not affect grain yield indicating that for the soils studied, deficiency in potassium is not of great concern since soils of northern region are sufficient in the element due to burning. The most significant however are nitrogen and phosphorus which when not replenished in the course of the season can lead to significant yield reduction. It is also evident that increasing phosphorus level up to 90 kg/ha significantly increased yield. In this study, the combination 120-90-60 kg/ha N, P_2O_5, K_2O yielded the highest grain yield of close to 3.0 tons/ha with the control plot yielding only half of a ton irrespective of the soil type. This implies that maize production in the northern part of Ghana cannot address the food security issues of the country going by farmers' cultivation methods of no fertilizer application. Also increasing the dosage by applying beyond the blanket recommendation and applying more N and P up to 120 and 90 kg/ha N & P_2O_5 respectively has seen significant increase in maize grain yield.

WAYFORWARD

In going forward, the experiment will be repeated in 2015 cropping season to establish the optimal fertilizer limit for the different benchmark soils northern Ghana.

POSTHARVEST

Reducing post-harvest losses in cowpea and maize through improved on-farm storage operations

Principal Investigator: Mutari Abubakari
Collaborating Scientists: F. Kusi, Issah. Sugri
Estimated Duration:
Sponsors: IITA AfricaRISING
Location: On-farm
Budget: US$6,600.00

Background

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 truncatus*),lesser grain borer(R*hyzopertha dominica*), maize weevil *(Sitophylus zeamais),* rice weevil *(S. oryzae),* granary weevil *(S. granarius)* 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.

Goal

To deploy and disseminate improved postharvest handling practices and pest management strategies for safe and prolong storage of harvested produce (maize, cowpea and soybean) with minimal influence on food safety and to enhanced marketable quality.

Specific objectives:

1. 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. Evaluate the effect of select treatments on insect pest incidence, physico-chemical and sensory properties of maize and cowpea
3. Facilitate technology dissemination through training workshops for farmer-based organizations (FBOs), farmers, seed growers and Agricultural Extension Agents on good postharvest management, pest control and food safety issues.

Materials and methods

Maize and cowpea grains were purchased from the beneficiary communities for the study. For each treatment, 40kg of maize grain were stored each in jute sacs, PICS sacs and hermitic plastic tanks with/without grain protectants. Similarly, 20kg of cowpea grains were stored as was done for the maize. Two commonly used grain protectants, Betallic Super EC and phostoxin were applied at recommended rates by the manufacturers. Betallic Super EC is food-grade chemical containing 80g Pirimiphos-methyl and 15g Permithrin per litre as emulsifiable concentrate. The application dose provided by the manufacturer is 300ml in 15L of water per 20 maxi bags of maize.

Data collection

Data collection included the following
Weight of grain
Bulk density / true density
Moisture Content (every 2months)
100-kernel weight
Physical quality (wt of broken, mouldy, inert)
Insect count (dead and live) (every 2 months)
Number of bored grains
Insect species identified.

Training, Demonstration and FFF

Farmers were taken through demonstrate appropriate and good storage practices in beneficiary communities.

Experimental Design

Number of districts: 2 districts per region
Number of communities: 2-3 communities per district
Grain sample = 40 kg maize
Grain sample = 20 kg cowpea
Treatment= various combinations for maize and cowpea.
Community = block = 4 communities (2 in the Tolon and 2 in Savelugu District in the NR
Farmers = replication = 3 farmers in each community

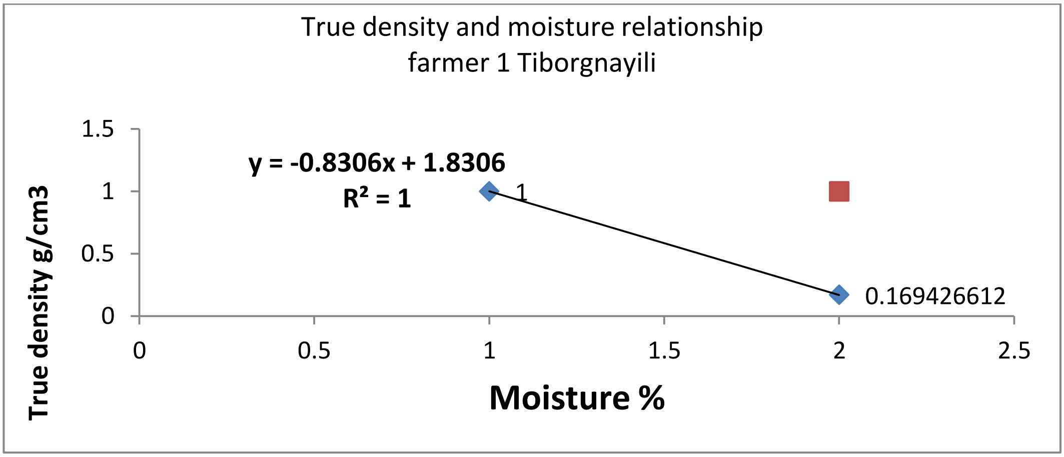
Treatment structure

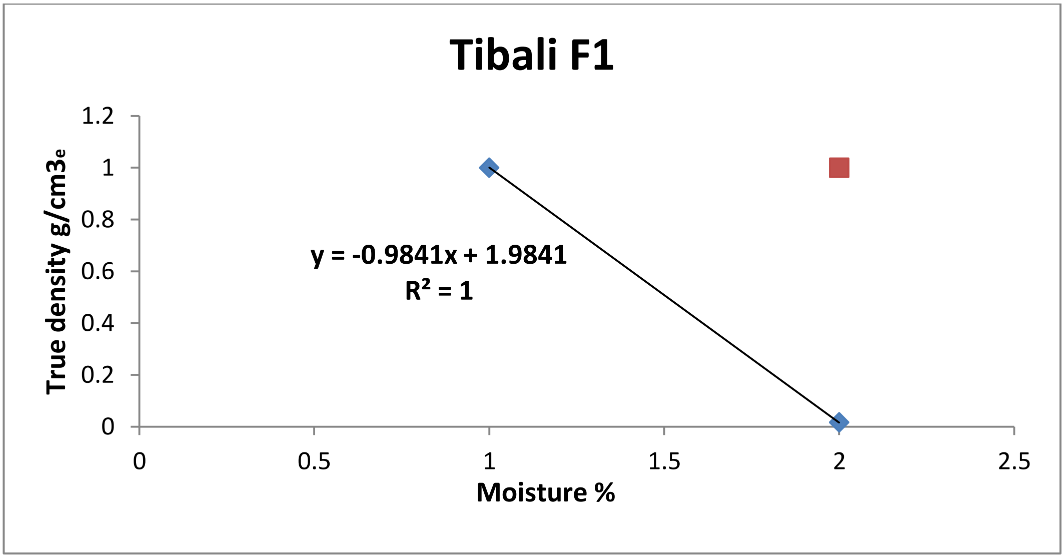
Storage methods	**Storage treatments**		
	Control	**Actellic super**	**Phostoxin**
Jute sacs	only	+ Recommended rate	+ Recommended rate

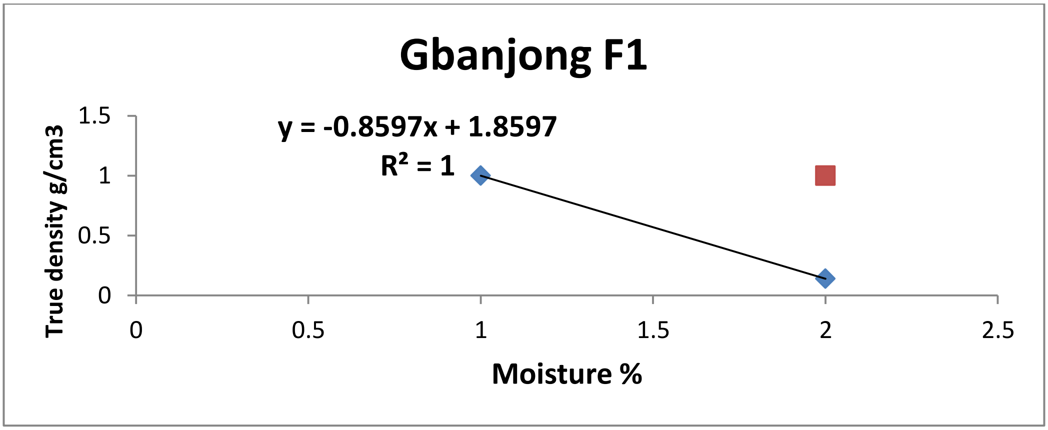
PICS sacs	Only	+ Recommended rate	+ Recommended rate
Hermitic polytanks	Only	+ Recommended rate	+ Recommended rate

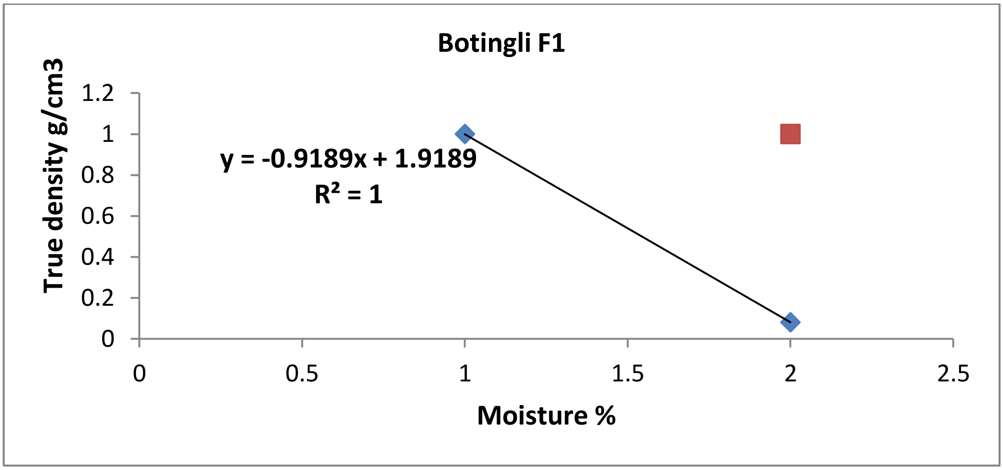
Preliminary Results

Maize









Cowpea

Table 1. Insect count

Treatment	Community			
	Botingli	gbanjong	tibali	Tiborgnayili
C+Jute	0	23	0	13.3
A+jute	0	0.3	0	2
P+jute	0	0	0	13.3
C+PICS	0	2	1	21.3
A+PICS	0	0	1	0.3
P+PICS	0	0	0	0
C+barrel	0	0.3	1	0

A+Barrel	0	0.7	0	1
P+barrel	0	0.3	0	0

Table 2. Damaged grains

Treatment	Community			
	Botingli	Gbanjong	Tibali	Tiborgnayili
C+Jute	373	871	165	464.a
A+jute	622	373	181	149
P+jute	529	340	150	177
C+PICS	404	2343	123	618
A+PICS	93	120	110	197
P+PICS	62	186	135	101
C+barrel	155	5224	125	1701
A+Barrel	0	153	0	449
P+barrel	93	138	91	142

Conclusion

The assessment is on-going and no conclusion can be made at this point

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 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 suitableinterventions 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 of the year under review.

COTTON IMPROVEMENT PROGRAMME

Multi-locational evaluation of cotton genotypes for higher seed cotton yield and lint quality potentials

Principal Investigator: E. B Chamba
Collaborating Scientists: Ramson Adombilla
Estimated Duration: 2 years
Sponsors: Bayer CropScience and Wienco Cotton Company Limited
Location: Nyankpala, Walewale, Bunkpurugu, Natagu and Kpalkore all in the Northern Region and Tumu in the Upper West Region of Ghana

Introduction
Cotton *(Gossypium hirsutum)* is an important and major cash crop in northern Ghana. However, average seed cotton yield remains very low (about 700 kg/ha) compared to that of neighboring cotton producing countries such as Burkina Faso, Cote d'Ivoire resulting in low productivity. The low productivity in the cotton production sector in Ghana is attributed to several factors of which the the lack of improved varieties is one of the key factors. From the preliminary evaluations of cotton genotypes from Bayer CropScience in 2012 a four promising genotypes were selected for further evaluation for potential for high yield and lint quality in Ghana.

Objective of the project
To evaluate six cotton genotypes from Bayer CropScience for higher yield and lint quality potential at six locations in the cotton production belts of Northern Ghana.

Expected beneficiaries
Improved cotton varieties is expected to increase yields and incomes of cotton farmers and Cotton Companies

Material and methods

The genotypes evaluated were AF0903, AF0904, AF0905 and AF0911. FK 37 and Sarcot 5 cotton varieties were used as local checks.A Randomized Complete Block Design with four replications and plot sizes of four rows with inter and intra-row spacing of 90 cm x 30 cm were used. Codal (250g prometryne + 162.5g metolachlor per litre) a pre-emergence herbicide was applied at a rate of 3.5 l/ha right after sowing to prevent the growth of weeds prior to germination of cotton. Chemical fertilizer was applied at a rate of 70N-20P-10K+12S+4MgO+1B+0.3Zn Kg/ha that is a compound fertilizer Actyva (N-P-K-S-Mg-Zn) was applied at a rate of 23N-10P 5K+3S+2MgO+0.3Zn kg/ha after thinning out as basal and top dressed seven weeks after emergence with Sulfan (N-S-B) fertilizer at a rate of 24N + 6S + 1 B kg/ha. Insect pest control was done weekly using, Tithan (a.i Spirotetramat 75g/l and Flubendiamide 100g/l) at 200 ml/ha for control of early season pests and Thunder (a.i Imidacloprid 100g/l and Betacyfluthrin 45g/l) to control mid and late season pests using a matabi knapsack sprayer. Data was collected from the two middle rows and analysed using GenStat 9.2 Edition Software with 95 % confidence level and LSD (least significant difference) of 0.05 to determine the differences between treatment means.

Major findings

Generally the mean seed cotton yield for the genotypes varied from location to location. For instance SARCOT 5 recorded the highest mean seed cotton yield at Nyankpala and Kpalkore and genotype AF0905 at Walewale and Natagu. The control varieties FK 37 and AF0903 were the highest yielders at Bunkpurugu and AF0911 at Tumu respectively (Table.1).

Table 1: Response of each genotype to mean Seed Cotton Yield (kg/ha) at locations

Genotypes	Nyankpala	Walewale	Bunkpurugu	Tumu	Natagu	Kpalkore
AF0903	2781.0a	3018.7ab	4154.9a	3191.2a	1519.9ab	1669.0bc
AF0904	2197.0a	2490.2b	3751.3a	3440.6a	1728.5ab	1737.9bc
AF0905	2909.0a	3302.8a	3856.7a	3178.0a	2185.5a	2156.9ab
AF0911	2357.0a	2600.2ab	3753.7a	3697.2a	1697.6ab	1504.1c
FK 37	2872.0a	2671.9ab	4224.2a	2733.7a	1375.8b	1544.4c
SARCOT 5	2916.0a	3219.2ab	4079.9a	3032.4a	2103.2ab	2290.1a
MM	2672.0	2883.8	3970.1	3212.2	1768.4	1817.1
CV %	16.2	16.6	13.3	12.7	28.5	18.5

MM=Grand mean, CV=Coefficient of variation, alphabets a, b and c shows similarities and differences in means, means with the same alphabet are not significantly different.

Mean seed cotton yields of genotypes were not significantly different from each other at all locations except at Kpalkore where the genotypes out yielded the FK 37 control and the AF0911. Overall, Bunkpurugu and Tumu obtained mean seed cotton yields above 3 t/ha. However, the combined mean seed cotton yield of genotypes across the locations show that yields varied from 2557.6 to 2940.1 kg/ha with FK 37 recording the lowest yield and SARCOT 5 giving the highest yield (Table 2). However, the mean yield and number of open bolls per plant of SARCOT 5 was statistically the same as that of AF0905 which yields were significantly different from those of the other genotypes. Across locations mean seed cotton yields of genotypes AF0903, AF0904 and AF0911 were the same as the yield of FK 37. SARCOT 5 and AF0905 appear to have demonstrated a higher level of stability across the study environments. The performance of AF0905 in terms of yield stability over environments is consistent with the results of 2012 study when seven genotypes were evaluated over three environments in northern Ghana.

Table 2: *Combined mean seed cotton yield, ginning out turn, weight per boll and number of open bolls obtained for each genotype*

Genotype	Mean SCY (kg/ha)	Mean GOT (%)	Mean Weight per boll (g)	Mean NOB/plt
AF0903	2722.5ab	43.8ab	6.6ab	8.2cd
AF0904	2557.6b	43.1b	6.4b	7.8de
AF0905	2931.4a	44.7a	6.5b	9.1bc
AF0911	2601.6b	44.6a	6.9a	7.2e
FK 37	2570.3b	43.9ab	6.5b	15.4a
SARCOT 5	2940.1a	40.1c	6.3b	9.2b
MM	2720.6	43.3	6.5	9.5
CV %	34.7	5.4	10.6	25.8

SCY=Seed cotton yield, alphabets a and b shows similarities and differences in means, means with the same alphabet are not significantly different, GOT= Ginning out-turn, NOB/plt=Number of open bolls per plant

Conclusion

AF0905 like SARCOT 5 has higher yield potential and stable across the cotton agro-climatic zone of Ghana. It is a promising candidate variety and has to be investigated further for future release to cotton farmers.

Evaluation of the efficacy of insect protected Bt cotton in Ghana

Principal Investigator: E.B Chamba
Collaborating Scientist:Ramson Adombilla
Estimated Duration: 3 years
Sponsors: Monsanto
Location: Kpalkore, Walewale, Natagu and Kpalkore all in the Northern Region and Pieng and Pulima in the Upper West Region of Ghana

Introduction

Cotton is attacked in the field by a wide range of insect pests and these include, the bollworm complex comprising the American bollworm, *Helicoverpa armigera* (Hubner);Spiny bollworm, *Earias* spp.;Pink bollworm, *Pectinophora gossypiella*Saunders**;**Sudan bollworm, *Diparopsis watersii* (Rothschild); andthe False codling moth, *Thaumatotibia* (*Cryptophlebia*) *leucotreta* So far insecticide application is the conventional and also the most common means of insect control in cotton in Ghana. Although most of these insecticides are effective for control, they pose health hazards to farmers who use them and contaminate the environment. There is therefore the urgent need for an effective and sustainable insect management system with minimal use of insecticide in cotton production. Bt. Cotton is resistant to most lepidopteran pests due to the production in the plant insecticidal proteins (Cry1Ac and Cry2Ab2 in Bollguard II), specific to caterpillars, due to the insertion into the plant genome of genes from the common soil microbe and insect pathogen *Bacillus thuringiensis* (*Bt*). The Bt cotton has an added advantage over the conventional FK 37 cotton because it receives only two sprays for the late season insect pest (bollworms) over the conventional with six sprays; hence cutting down the cost of insecticide, labour, stress, reduced health risk among others.

Objective of the project

The overall objective of the study was to demonstrate the efficacy of insect protected Bt cotton on farmers' fields and in a replicated trial on a SARI research station.

Expected beneficiaries

Cotton farmers will reduce their cost of production by cutting down the number of sprays against insects with an associated health benefit. An increase in the income levels of farmers due to overall yield increase resulting from effective insect pest control.

Materials and methods

The study was carried out at six locations within the Guinea Savanna zone of the country. The fields for experimentation were leased by farmers to CSIR-SARI. It was a demonstration on-farm and the design consisted of two blocks of 2500 m^2 each with 5m alleys around each block. A border of 12m was observed around both blocks and a 25m isolation distance around the experiment. The varieties planted were Bt cotton with insect protection and the Conventional FK 37 cotton. Each was planted to the 2500 m^2 block and again the Conventional FK 37 planted to the 12 m border as refuge. However, the experiment was surrounded by an isolation distance of 25 m devoid of sexually compatible plant/crop species to cotton. Planting was done between 30 June and 16July, 2013 across locations and a pre-emergence herbicide, Codal gold™ (250g prometryne + 162.5g metolachlor per litre) was applied at a rate of 3 l/ha immediately after planting.However, Rival EC (Trifluralin) was applied at rate of 2 l/ha in addition to Codal at Natagu using the Matabi Knapsack sprayer. Following germination refilling was carried out on plots of conventional FK 37 variety to achieve the desired plant population density. The germination of FK MON 15985 was excellent across all locations and was not refilled. Plant stands were thinned to two plants per hill to obtain the required plant population density. Different fertilizer rates were used at different trial locations. At Yobzeri, Kpalkore, Walewale and Natagu compound fertilizer Actyva (N-P-K-S-Mg-Zn) was applied at a rate of 200 kg/ha (46N-20P 10K+6S+4Mg+0.6Zn kg/ha). Sulfan fertilizer at 100 kg/ha (24N + 6S + 1 B kg/ha) was used to top dress. At Pieng and Pulima the compound fertilizer NPKSB was applied at a rate of 200 kg/ha (60N-60P-40K+24+4 kg/ha) as basal fertilizer and was top dressed with 100 kg/ha Sulphate of Ammonia. The method of fertilizer application was dibbling and covering for both basal application and top dressing. The basal application done fter thinning (15-21 DAP) and the top dresser 42 – 49 DAP. A calendar spraying regime was followed to control insect pests on the conventional FK 37 cotton plots. The plots were sprayed six times; three rounds of spray with Tihan (Spirotetramat 75g/l and Flubendiamide 100g/l) and three rounds of spray with Thunder (Imidacloprid 100g/l and Betacyfluthrin 45g/l) at Yobzeri, Walewale, Kpalkore and Natagu. The Bt cotton plots at Yobzeri and Kpalkore were sprayed two sprays using Thunder (Imidacloprid 100g/l and Betacyfluthrin 45g/l). At Pieng and Pulima, Calfos 720 EC (Profenofos 720g/l at 350 ml/ha), Polytrine C (Profenofos 300 g/l and Cypermethrin 36 g/l) at 500 ml/ha and Cotton Quest (Cypermetrhin 72 g/l and Acetamaprid 16g/l) at 350 ml/ha were applied during the first four sprays, and the final two sprays respectively, for conventional cotton and Cotton Quest for the two sprays on Bt cotton plots. The application rate used was 200 ml/ha. Insect pests were not controlled on the 12 m border planted to conventional FK 37 variety. Weeds on fields were manually controlled as they emerged.

At harvest, the Bt cotton and FK 37 plots were divided into five quadrants and data for yield determination collected from 4 rows of 6 m long in quadrants. A total of 20 plants from the two middle rows per quadrant were tagged for data collection. A sample of 3 kg of seed cotton from both conventional and transgenic plots was taken for lint quality analysis in South Africa. The data was analysed using the statistical package SAS and means separated with two tailed test at 5 % significance.

Following harvest, seed cotton from the conventional FK 37 and Bt cotton plots were packaged separately into primary and secondary containers, labeled, weighed and transported to CSIR-SARI, Nyankpala for storage in separate storage facilities and later transported to Burkina Faso.

Major findings

The mean seed cotton yield of conventional FK 37 ranged from 919.75 (Walewale) to 2444.44 kg/ha (Pulima) and 1092.59 (Walewale) to 2134.92 kg/ha (Pieng) for Bt. Cotton (Table. 1). Generally, Bt cotton yields were higher than yields of conventional FK 37 variety at five of the locations although the differences in yield were not statistically different. At Pulima, the yield of conventional cotton was higher than the yield of Bt cotton and was probably due to the ‘topping’ (breaking of the apical dominance of the crop at boll formation) effect on the conventional variety. The farmer ‘topped’ the conventional cotton and not Bt cotton. Also, Bt cotton recorded the highest mean cotton yield across locations (Table. 2) although the difference was not statistically different that of that of conventional FK. Analyses of mean number of bolls, mean number of opened bolls (Table 2), showed that conventional cotton appeared to have a numerical advantage in terms of number of bolls. However, the number of opened bolls of Bt cotton was higher with higher boll weight and probably accounting for the higher yields of the Bt cotton.

Table 1: *Number of opened bolls/plan, Plant height (cm), Weight/Boll (g) and Seed cotton yield/ha (kg) of the two varieties at each location.*

Location	Variety	Mean No. B/plt	Mean No.OB/plt	Mean Plt.Ht (cm)	Mean Wt/Boll (g)	Mean SCY/ha (kg)
Pieng	Bt cotton	11.25	12.93	120.40	7.37	2134.92
	FK 37	12.95	11.21	118.36	7.03	1666.67
	mm	12.10	12.07	119.40	7.20	1901.00
	sem	0.85	0.86	1.02	0.17	234.10
	P≤0.05	0.05	0.05	0.01	0.02	0.08
Pulima	Bt cotton	7.69	7.56	87.95	8.01	2095.24
	FK 37	7.78	7.26	98.64	7.68	2444.44
	mm	7.74	7.41	93.30	7.85	2270.00
	sem	0.05	0.15	5.35	0.17	174.60
	P≤0.05	0.00	0.01	0.04	0.01	0.05
Walewale	Bt cotton	12.73	12.23	105.71	6.72	1092.59
	FK 37	18.91	6.05	131.19	6.38	919.75
	mm	15.82	9.14	118.40	6.55	1006.00
	sem	3.09	3.09	12.74	0.17	86.42
	P≤0.05	0.12	0.21	0.01	0.02	0.06
Yobzeri	Bt cotton	10.26	5.38	135.64	7.07	1395.83
	FK 37	12.78	4.76	126.40	6.75	965.28
	mm	11.52	5.07	131.00	6.91	1181.00
	sem	1.26	0.31	4.62	0.16	215.30
	P≤0.05	0.07	0.04	0.02	0.02	0.12
Natagu	Bt cotton	13.00	15.85	121.58	6.87	1979.17
	FK 37	16.50	11.51	108.43	6.62	1965.28
	mm	14.75	13.68	115.00	6.75	1972.00
	sem	1.75	2.17	6.58	0.13	6.95
	P≤0.05	0.08	0.10	0.04	0.01	0.00
Kpalkore	Bt cotton	6.64	7.46	86.94	6.40	1159.72
	FK 37	7.78	6.44	89.50	6.08	1006.94
	mm	7.21	6.95	88.22	6.24	1083.00
	sem	0.57	0.51	1.28	0.16	76.39
	P≤0.05	0.05	0.05	0.01	0.02	0.05

No.B/plt=Number of bolls per plant, No.OB/plt=Number of open bolls per plant, Plt.Ht=Plant height at harvest, Wt/Boll=Weight per boll, SCY/ha=Seed Cotton Yield per hectare, FK 37=Conventional cotton variety, mm=Grand mean, sem=standard error of means

Conclusion

The Bt cotton gave higher yields than conventional FK 37 cotton at each location except at Pulima also the difference is not statistically significant. However, with only two sprays with the Bt cotton as against five sprays with the conventional FK the farmer stands to increase income levels with Bt cotton because of the decreased cost of production with Bt cotton.

Recommendations

The results are preliminary and the trials have to be repeated for a year or two to obtain conclusive results.

Table 2: *Across location mean number of bolls, opened bolls, boll weight, ginning turn out and seed cotton yield.*

Genotype	Mean No.B/plt	Mean No.OB/plt	Mean Wt/boll (g)	Mean SCY (kg/ha)
FK 37	12.78	7.87	6.76	1495.00
Bt cotton	10.26	10.24	7.07	1643.00
M.D	2.52	2.36	0.32	148.20
S.e.d	2.13	2.01	0.32	324.50
$P \leq 0.05$	0.26	0.27	0.35	0.66

S.e.d = Standard error of difference, M.D =Mean difference, No.B/plt =Number of bolls per plant, No.OB/plt = Number of open bolls per plant, Wt/Boll = Weight per boll, SCY/ha = Seed cotton yield per hectare, FK 37= Conventional cotton variety,

Effects of different fertilizer formulations and rates on Seed Cotton Yield and lint quality of Cotton in northern Ghana

Principal Investigator: E.B Chamba
Collaborating Scientist:Ramson Adombilla;
Estimated Duration: 2 years
Sponsors: Yara Fertilizer Company Limited
Location: Nyankpala, Walewale, Bunkpurugu, Natagu and Kpalkore all in the Northern Region of Ghana

Introduction

Most soils have deficiencies of at least one nutrient of NPK. The soils require the addition of fertilizers to optimize production of cotton because a major component of profitable cotton production is adequate and balanced nutrients. There is the need therefore to provide cotton farmers with fertilizer combinations and application levels to address the deficiencies in fertility in soils to increase cotton productivity. Following attempts to increase yield through efficient fertilizer use, Yara Ghana in collaboration CSIR-SARI proposed several fertilizer combinations and quantities for testing on farmer cotton variety FK 37 in five communities within the Northern and Upper West regions of Ghana. Formulating the right combinations and quantities of chemical fertilizer will increase seed cotton yield and enhance the quality of lint produced and thereby raising income levels of farmers.

Objective of the project

To evaluate the effects of different fertilizer combinations and quantities on the yield and lint quality of cotton variety FK 37 in Ghana.

Expected beneficiaries

Cotton Companies and Cotton farmers are expected to increase seed cotton yield with the right formulation and type of fertilizer and thereby increase income levels.

Materials and methods

The study was conducted at five locations with seven treatments (Table. 1). The cotton variety used was FK 37. The experimental design was a randomised complete block design with three replications with plot size of 6 rows of 10 m long. Chemical fertilizer was applied at rates based on treatment requirement. The basal application was applied between 15 and 25 days after planting (DAP) and top dressed 40-48 days after planting. However, YaraVita Tracel BZ was applied as foliar to the leaves at 15-25 DAP and at 40-48 DAP respectively. Ecophosphate fertilizer was applied immediately after sowing to respective plots.

Codal (250g prometryne + 162.5g metolachlor per litre) a pre-emergence herbicide was applied using a Matabi knapsack sprayer at a rate of 3.5 l/ha right after sowing to prevent the growth of weeds prior to germination of cotton. Insect pest control was done weekly using, Tithan (a.i Spirotetramat 75g/l and Flubendiamide 100g/l) at 200 ml/ha for control of early season pests and Thunder (a.i Imidacloprid 100g/l and Betacyfluthrin 45g/l) to control mid and late season pests using a matabi knapsack sprayer.

Data was taken from the four middle rows and analysed using GenStat 9.2 edition Software with 95 % confidence level and LSD (least significant difference) of 0.05 to determine the differences between treatment means.

Major findings

Results of the soil analysis indicate low levels of organic matter, total N, available P and exchangeable K at all trial locations (Table. 2) and underscores the need to apply fertilizers containing these elements.

Mean seed cotton yield across locations ranged from 551.3 to 1364.0 kg/ha with YARA 1 recording the highest yield and the control treatment (no fertilizer) application with the lowest yield (Table 3). YARA I appeared to have shown yield stability across the environments the study was carried out. The across location mean seed cotton yield with fertilizer treatment significantly out yielded the control treatment of no fertilizer application although the yields of the fertilizer combinations across locations did not significantly differ from each other.

Planting of cotton was very late. The cotton planting season ends in June in the cotton production zone. However, as a result of late onset of the rainy season most of the locations were planted in July and in Tumu planting was as late as July 13. Consequently, the crop did not attain the full maturity period by the end of the rainy season.

Conclusions

The preliminary studies of the response of cotton to different fertilizers and their combinations have shown that higher yields can only be obtained with the application of fertilizers. The response of cotton to the different fertilizer combinations varied from one location to the other with respect to seed cotton yield and the yield components although the variation was not stastically significant. Considering the very late planting of the trials due to the late onset of the rains the study requires further investigations.

Table 1: *Fertilizer formulations and rates applied as treatments at locations*

Treatment	Fertilizer formulation and rate
Farmer practice	YaraMila Unik 15@ 200 kg/ha basal application and Sulphate of ammonia @100 kg/ha for top dressing
Yara1	YaraMila Winner @150 kg/ha for basal application and YaraMila Actyva@150kg/ha for top dressing. YaraVita Tracel BZ @ 6kg/ha. Apply at the 4 to 6 leaf stage. Repeat at flowering stage and at each growth stage. Water rate of 500-1000 l/ha
Yara 2	YaraMila Actyva @ 200kg/ha for basal application and YaraBela Sulfan + Boron@ 100kg/ha.
Yara 3	Blend (14.24.15) @ 200 kg/ha for basal application and Urea @100 kg/ha for top dressing.
Yara 4	Ecophosphate @ 200 kg/ha for basal application and YaraMila Actyva @ 250kg/ha for top dressing.
Yara 5	T15 + SB @ 200 kg/ha for basal application and Urea @ 100 kg/ha for top dressing.
Control:	No fertilizer

Table 2. Soil chemical analysis analysis

Location	pH (1:2.5 H_2O)	O.C (%)	Total N (%)	P (ppm)	K (ppm)
Bunkpurugu	5.87	0.99	0.06	6.13	45.00
Natagu	4.55	0.87	0.04	2.39	57.00
Nyankpala	5.68	0.51	0.05	4.84	45.00
Tumu	5.72	0.51	0.05	5.82	40.00
Walewale	5.81	0.74	0.05	3.40	46.00

NB: O.C=Organic carbons, N=Nitrogen, P=Phosphorus, K=Potassium

Table 3: Effect of fertilizer treatments on growth and yield components across locations

Treatment	Mean SCY (kg/ha)	Mean GOT (%)	Mean No.OB/plt	Mean Wt./boll (g)
FP	1211.0 ab	44.1 a	12.8 a	5.7 ab
YARA 1	1364.0 a	44.6 a	13.6 a	5.4 ab
YARA 2	1106.3 ab	43.6 a	12.4 ab	5.8 ab
YARA 3	1293.2 ab	44.0 a	12.5 ab	5.9 a
YARA 4	986.3 b	43.4 a	10.0 bc	6.0 a
YARA 5	1240.2 ab	45.0 a	13.0 a	5.3 b
Control	551.3c	43.2 a	9.5 c	5.3 b
MM	1107.5	44.0 a	12.00	5.6
CV %	34.7	5.3 a	27.4	5.4

FP= Farmers Practice, MM= grand mean, CV= Coefficient of variation, alphabets a and b shows similarities and differences in means, means with the same alphabet are not significantly

On-farm Demonstration of Cotton Lines

Principal Investigator: E. B. Chamba
Collaborating Scientists:Ramson Adombilla,Mumuni Abudulai,Jerry Nboyine, Foster Kangben, Quaicoe Kwame, H. Misbaw
Estimated Duration:
Sponsors: Monsanto, Cotton Producing Companies
Location: On Farm
Collaborating Institutions: Monsanto, Cotton Producing Companies and Ministry of Food and Agriculture (MoFA)

Objectives of the Project:

- To evaluate cotton genotypes for higher yield and lint quality potentials in the Northern and Upper West regions.
- To evaluate the effects of different fertilizer combinations and quantities on the yield and lint quality of the most popular cotton variety FK 37in the Northern and Upper West Region of Ghana.
- To determine the efficacy of Bollguard II in Ghana under farmer management

Project Sites: Nyankpala, Loagre-Walewale, Bunkpurugu, Natagu and Kpalkore in the Northern region and Tumu in the Upper West region

Status of Project: Ended but will be renewed for the 2014 cropping season. However, Bt Cotton demonstration is ongoing.

Introduction

In the year 2013 rainfall intensity and distribution pattern adversely affected most cotton trials especially at Loagre-Walewale, Kpalkore and Natagu. Again the poor seed germination of conventional FK 37 cotton resulted in low yields at some locations due to poor plant stand.The number of experimental treatments were Wienco Fertilizer Trial (5 fertilizer combination on FK 37 cotton), Wienco Varietal Trial (4 genotypes), SeedCo. of Zimbabwe (4 genotypes), Bayer Crop Science Ghana (6 genotypes) Yara Fertilizer Company (7 fertilizer combinations on FK 37 cotton), Bt. Cotton demonstration (2 genotypes) and Staymoist experiment (6 combinations). Staymoist (from Lifeline Agro Science Company Limited) is a polymer that swells when in contact with moisture. This helps retain moisture in soils and reduce leaching of minerals. SARI varieties SARCOTS 1 and 5, and farmer variety FK 37 were included as checks.The genotypes were:

- **Wienco Cotton Company (Fertilizer Trial)**: FK 37
- **Wienco Cotton Company (Varietal Trial)**: STAM 159, SARCOT 1, SARCOT 5 and FK 37.
- **Bayer Crop Science:**AF0903, AF0904, AF0905 and AF09011. Check genotypes were SARCOT 5 and FK 37
- **SeedCo:** QUTO 125 and QUTO 128. Check genotypes were SARCOT 5 and FK 37.
- **Yara Fertilizer:** FK 37
- **Staymoist experiment:** FK 37
- **Monsanto BT Cotton demonstration trial:** (FK 37 and FK95BGII)

Results:

Wienco Cotton (Fertilizer Trial): Seed cotton yield across all six locations ranged from 806.69-1314.44 kg/ha with FT3 fertilizer combination yielding significantly higher seed cotton yield (1314.44 kg/ha) while the control treatment of no fertilizer application had a lower seed cotton yield due to no/low nutrient level for effective plant growth. Interestingly, the same fertilizer combination (FT3) obtained a significantly higher plant height of 98.43 cm while ginning out turn and boll weight per plant was insignificantly different for both treatments. However the number of open bolls was higher for FT4 but lower for the control treatment.

Wienco Cotton (Varietal Trial):Seed cotton yield ranged from 1362.31-2378.41 kg/ha. Genotypes obtained seed cotton yields above one ton/ha with Sarcot 5 obtaining a significant yield of 2378.41 kg/ha at Bunkpurugu. The lowest seed cotton was obtained by FK 37 variety at Loagre-Walewale. Combining all two locations, seed cotton yield was significantly higher for Sarcot 5 with 2101.38 kg/ha. It again obtained a significant plant height of 115.31 cm though with the least number of open bolls per plant. Sarcot 1 also performed higher than Stam 159 and FK 37 with 1791.17 kg/ha seed cotton.

Bayer Crop Science (Varietal trial)*:* Seed cotton yield is not significantly different at Nyankpala, Walewale, Bunkpurugu and Tumu but significantly different at Natagu and Kpalkore due to poor nature of the soil. Seed cotton yield ranged from 1375.8 to 4224.2 kg/ha and significantly higher at Bunkpurugu for FK 37. Bunkpurugu and Tumu obtained yields above 3 t/ha because of moisture availability throughout the crops development stage. At Walewale and Natagu AF0905 genotype obtained the highest seed cotton and Sarcot 5 also yielded significantly at Kpalkore and Nyankpala. Seed cotton yield was generally low at Kpalkore and Natagu with 1817.06 kg/ha and 1768.40 kg/ha respectively due to poor soils that led to low water holding capacity thus unavailability of moisture as certain time. Seed cotton yield across all six locations ranged from 2557.7-2940.1 kg/ha. Sarcot 5 obtained the highest yield but significantly similar to AF0905 (2931.4 kg/ha) genotype. Interestingly, FK 37 check had significant number of opened bolls (15.43) per plant but with seed cotton yield of 2570.3 kg/ha.

SeedCo., Zimbabwe (SeedCo. Trial):Seed cotton ranged from 802 to 2698 kg/ha. Bunkpurugu and Tumu obtained mean seed cotton yields above 2 t/ha due to the good soil and the availability of moisture as a result of the frequent precipitation. However, Loagre-Walewale obtained a mean seed cotton yield below 1 t/ha due to the poor germination though experienced at all locations. The combined seed cotton yield is significantly different with Sarcot 5 check obtaining 1958.80 kg/ha while Quto 125 and 128 yielded significantly higher than the check FK 37. Interestingly FK 37 genotype obtained higher GOT at all locations.

Yara Fertilizer Company (Yara Trial): Seed cotton yield ranged from 586.26 to 2025.73 kg/ha. The highest was obtained at Bunkpurugu (2025.73 kg/ha) for Yara 1 fertilizer combination possibly due to the good soils with a pH of 5.87 which is good for cotton production or due to the fertilizer combination. However, a significantly lower seed cotton yield was obtained at Natagu (586.26 kg/ha) for the control of no fertilizer application since plants need adequate nutrients to attain proper physiological maturity with increased yield. Furthermore, seed cotton yield was above one ton at Walewale (1475.51kg/ha), Bunkpurugu (1452.12 kg/ha) and Tumu (1007.24 kg/ha) with pH ranging from 5.72 to 5.87. Nyankpala and Natagu had yields lower than one ton (992.21 kg/ha and 794.93 kg/ha) respectively probably due to the poor soils leading to moisture unavailability at Natagu and uneven plant stand at Nyankpala as a result of poor germination. Seed cotton yield for all five locations ranged from 809.87-1363.97 kg/ha with Yara 1 fertilizer combination yielding significantly higher seed cotton yield (1363.97 kg/ha) while the control of no fertilizer application had a lower seed cotton yield.

Monsanto BT Cotton demonstration trials:Seed cotton yield for the conventional FK 37 cotton ranged from 919.75 to 2444.44 kg/ha and that of FK95BGII cotton ranged from 1092.59 to 2134.92 kg/ha. Pulima obtained a significantly higher seed cotton yield of 2444.44 kg/ha for conventional FK 37 because topping was carried out by the farmer on the conventional plot while Pieng obtained the highest (2134.92 kg/ha) seed cotton for FK95BGII. Generally, the rainfall pattern in Tumu was encouraging that led to moisture availability at most times coupled with the fertile soils. However, Natagu, Kpalkore, Yobzeri and Loagre-Walewale obtained lower seed cotton yields below 2 t/ha mainly due to the pressure imposed by Cotton stainers after boll opening. This necessitated a third spray of the FK95BGII cotton at Natagu. Generally seed cotton yield across all the six locations is higher for FK95BGII cotton with 1642.91 kg/ha while the conventional FK 37 cotton obtained 1494.73 kg/ha. Boll weight, fruiting and vegetative branches are not significantly different. However, FK95BGII produced higher seed percent (54.60 %) than the conventional FK 37 that had higher lint percent of (47.79 %). Interestingly, FK 37 had more bolls and open bolls than FK95BGII but lower seed cotton yield.

RICE IMPROVEMENT PROGRAMME

Rice Sector Support Project

Wilson Dogbe, Michael Mawunya, Ms. Tahiru Fulera, (Miss)

Background

The CSIR - Savanna Agricultural Research Institute (SARI) has since the inception of the Rice Sector Support Project (RSSP) been providing enhanced adaptive research responsive to productive and environmental needs of rice cultivation in the Northern, Upper West, and the Upper East regions of Ghana. The project aims at contributing to reduce poverty in the northern parts of the country by strengthening stakeholders of the rice sector and providing national food security.

The research activities that SARI provides include;

- Coordination of seed production,
- Participatory Learning and Action Research - Integrated Rice Management (PLAR-IRM) training,
- On -farm evaluation of suitable lowland rice varieties and
- Cropping system research program using poly aptitude rice and cover crops.

The methodologies and the implementation of each of the research activities are detailed in this report.

The general objectives of the enhanced adaptive research activities for 2013 were to:

- Coordinate the production of breeder, foundation and certified seeds
- Provide PLAR training of trainers (TOT) and monitoring for DADUs and NGO staff from the participating districts
- Conduct on-farm evaluation of five improved rice varieties in thirteen project districts, using Participatory Varietal Selection (PVS).
- Conduct experiments on Direct-seeding mulched-based cropping (DMC) systems in lowland, midland and upland ecologies

Activity one: Coordination of Seed Production

The Savanna Agricultural Research Institute (SARI) has been coordinating the production of breeder, foundation and certified seeds. For the current season, the breeder and foundation seeds were produced on the SARI rice fields in Nyankpala whereas the certified seeds were produced by some members of the Seed Producers Association of Ghana (Seed PAG).

Methodology

Stakeholder meeting on seed production was organized at the beginning of 2013 cropping season to have updates on seed produced in the 2012 cropping season and to plan and set the production targets for 2013. At the meeting, it was decided that SARI continue to produce the breeder and foundation seeds and supply foundation seed to some seedPAG members in Northern, Upper West and Upper East regions to produce certified seed. It was also agrred that the 2012 targets be maintained for the 2013 season.

Specific Objectives

The following objectives were set for seed production in 2013;

- To produce 0.1ha each of breeder seed of the five rice varieties (Gbewaa, Nabogu, Tox3107, Katanga and Digang)
- To produce foundation seeds of the five varieties.

Implementation of Seed Production

A total of 0.05 ha of breeder seed and 5.32 ha of foundation seed were cultivated to produce 0.16 tons and 9.95tons of seed respectively during the period (**table 1**).

Table1. Breeder seeds produced in 2013

Variety	Target*		Achievement	
	Area (ha)	Production (kg)	Area (ha)	Production (kg)
Gbewaa	0.01	25	0.01	49.3
Nabogu	0.01	25	0.01	24.1
Katanga	0.01	25	0.01	25.6
Tox 3107	0.01	25	0.01	18.8
Digang	0.01	25	0.01	37.9
Total	**0.05**	**125**	**0.05**	**155.7**

*Yield target=2.5 t/ha, seed rate=50kg/ha

Table 2. Foundation seeds produced in 2013

Variety	Target*		Achievement	
	Area (ha)	Production (kg)	Area (ha)	Production (kg)
Gbewaa	2.0	5000	2.0	2100.0
Tox3107	0.5	1250	0.5	625.0
Katanga	0.8	2000	0.8	423.5
Nabogu	1.5	3750	1.5	404.0
Digang	1.0	2500	0.6	505.0
Total	**5.8**	**14500**	**5.4**	**4057.5**

*Yield target 2.5t/ha, seed rate 50kg/ha

Table 3. Certified Seed Production at the regional levels in 2013

Variety	Area cultivated(ha)			Total (ha)
	Northern Region	Upper West Region	Upper East Region	
Gbewaa	44.1	-	2.4	46.5
Nabogu	2.6	-	2.4	5.0
Katanga	3.4	-	2.4	5.8
Tox3107	2.0	-	-	2.0
Digang	-	4.8	-	4.8
Total	**52.1**	**4.8**	**7.2**	**64.1**

Participatory Learning & Action Research –Integrated Rice Management (PLAR-IRM)

Wilson Dogbe, Michael Mawunya, Ms. Tahiru Fulera, (Miss)

There was no PLAR training in 2013 due to budget constraints. However, the plan made by Regional Agricultural Development Unit (RADU) of the Ministry if Food and Agriculture (MoFA) and SARI was to provide training of trainers workshop between 8th and 12th of April 2013. The training was to include newly developed lowland and the type of training was to be demand-driven. The training was to involve Farmer Based Organizations (FBOs), farmers, Agricultural Extension Agents (AEAs) and a monitoring team (details in Appendix 1).

Specific Objectives

- To build capacity of MoFA staff using the PLAR approach and to ensure a wide dissemination of the techniques in the RSSP districts.
- To strengthen the capability of MoFA and other extension service providers to analyse and effectively address environmental vulnerabilities in rice cropping
- To empower farmers in developing their capacities to observe, analyse and experiment
- To strengthen FBO members to become more autonomous, more proactive in developing appropriate technologies in order to improve the sustainability of the systems
- To improve rice cropping performances and farmers' decision making in terms of rice management

Implementation of PLAR

In spite of the constraints mentioned above, SARI was able to offer backstopping on some modules of PLAR in two districts namely, Karaga district (in Tulunga community) and Nanumba North district (in the Yapumba community). Two modules and three modules were monitored in Tulanga and Yapumba respectively.The main modules monitored were 1). Starting the PLAR IRM curriculum 2.Using good seed and rice varieties. Fifteen (15) farmers were trained in Tulunga whilst ten (10) were trained in Yapumba.

On- Farm Evaluation of Lowland Rice Varieties

Wilson Dogbe, Michael Mawunya, Ms. Tahiru Fulera, (Miss)

SARI organized a Participatory varietal selection (PVS) Feedback Workshop. It was held in CSIR-SARI on the 22nd of May, 2013. Fifty-two (52) persons (50 men and 2 females) participated in the workshop. The purpose of the workshop was to obtain information on the achievements and challenges related to the conduct of mother and baby trials. The feedback workshop also helped in panning the 2013 season's on-farm evaluation of the rice varieties.

Methodology

Five rice varieties were used in possible combinations in such a way that each community had at most 2 mother trials and 10 baby trials (Table 3). Mother trials were made up of the 5 rice varieties and were managed under good agronomic practices. Baby trials on the other hand consisted of any two of the 5 selected varieties in all possible combinations. They were managed under farmers' own management condition. Both qualitative and quantitative data were collected on the trials.

Specific objectives:

- -To assess the five lowland rice varieties in comparison with farmers own rice varieties at farmers' management levels.
- To offer farmers the opportunity to select their preferred rice variety.

Table4. Rice varieties used in Mother and Baby trials

Number	**Variety**	**Color Code**
1	Exbaika	Violet
2	Long grain ordinary 2	Transparent
3	Perfume irrigated	Black
4	WAS 122-13-WAS-10-WAR	Yellow
5	WAS163-3-5-3	Blue
6	FARMER VARIERY (FV)	(No color)

Implementation of Mother and Baby Trials

A total of 22 mother trials and 72 Baby trials were planted in 13 districts of the Northern regions (Table 4). Four districts each in the Upper East and Upper West regions also received and planted a number of mother and baby trials. Both trials were planted and harvested in in all 13 districts of the northern regions and the four districts each in the Upper West and Upper East regions. Planting in some of the communities delayed because of drought during the season. Agronomic and farmer preference data were collected and analyzed.

In total, 17 questionnaires ''FAMPAR'' (mainly about ranking the different tested varieties) for the mother trials and 61 for the baby trials have been analyzed (see table5).

Table 5: Number of questionnaire analyzed by district.

District	Number of questionnaires analyzed	
	Mother	Baby
Nanumba South	2	7
Nanumba North	2	5
Yendi	1	10
Sagnerigou	2	9
Tolon	0	1
Savelugu	1	1
East Gonja	1	3
Tamale Metro	2	10
Karaga	2	5
West Mamprusi	2	9
Gushegu	1	0
Kumbungu	1	1
TOTAL	**17**	**61**

The average yields in metric tons per hectare obtained for the mother trials are shown in table 6:

Table 6. Average Yield (t/ha) for mother and baby trails

Type of Trial	Yields(t/ha) per variety					
	WAS163-B-5-3	Exbaika	Long grain ordinary 2	Perfume irrigated	WAS 122-13-WAS-10-WAR	Farmer Variety
Mother trials	3.1	2.8	2.7	2.6	3.0	1.9
Baby trials	1.6	1.6	1.5	1.7	1.6	1.3

The yields for the mother trials were higher than that for the baby trails. There is no significant difference between the varieties tested with the baby trials, whereas, the mother trials showed WAS 122-13-WAS-10-WAR and WAS 163-B-5-3 recording better yields. The Farmer variety was always worse in yield. Figure 1 showed yield reached for each trial. There was 1 or 2 trials per district.

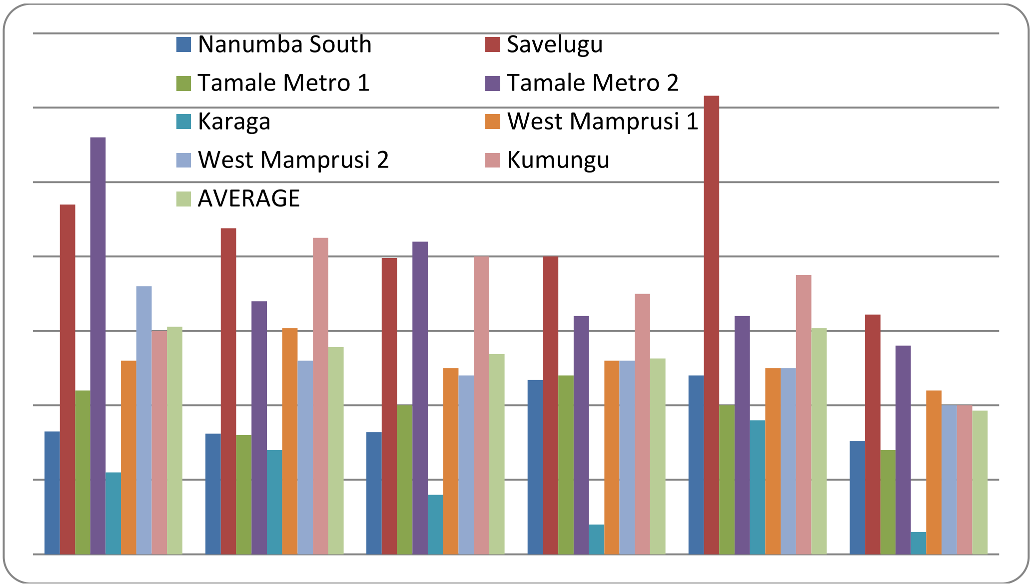


Figure 1.Yield (t/ha) per community - mother trials (1 trial per community)

FAMPAR questionnaire is mainly about ranking the different tested varieties. Chat 1 and 2 shows the average ranking for respectively all the mother trials and all the baby trial. A high rank means better appreciation from the farmer.

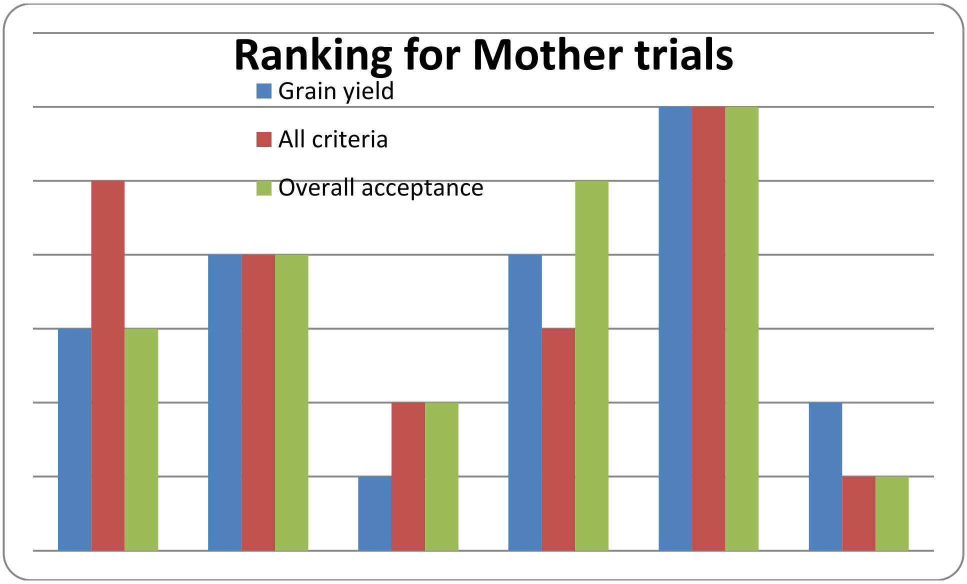


Figure 2. Ranking by farmer for mother trials

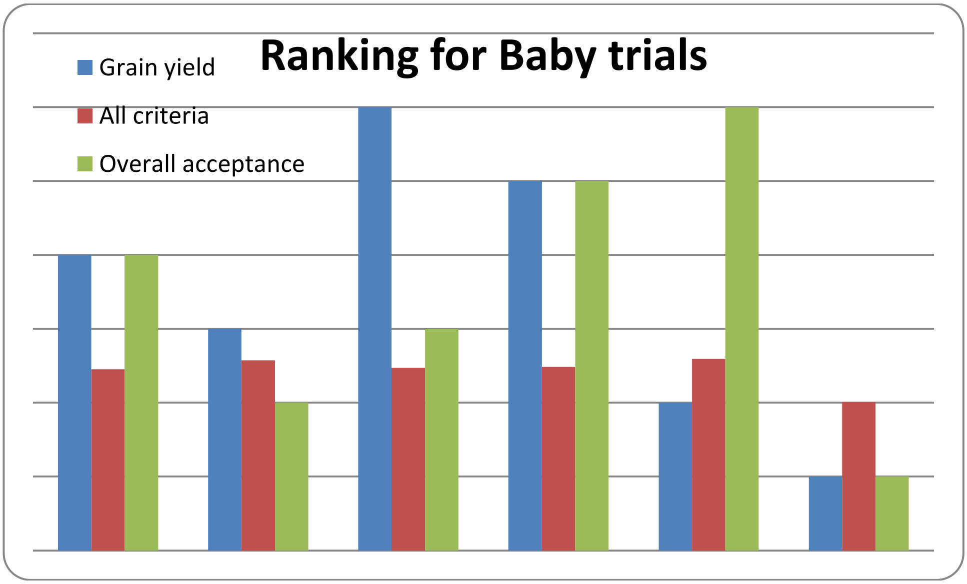


Figure 3: Ranking by farmer for baby trials

The charts above showed according to the farmers that, the farmer variety (FV) is never better than the varieties tested. The rice WAS 122-13-WAS-10-WAR (yellow) is the most appreciated variety.

Cropping system research using cover crop and poly aptitude rice varieties

Wilson Dogbe, Michael Mawunya, Ms. Tahiru Fulera, (Miss)

The Direct seeding mulch-based cropping system (DMC) trials were planted and harvested in the lowland, midland and the upland ecologies of the SARI rice fields in Nyankpala. The lowland and midland were planted to rice and cover crop based systems whereas the upland DMC trial was maize and cover crop based. Besides the DMC trials, a number of cover crop seeds were multiplied for their seeds for future DMC work. The Institute continued also to evaluate the poly aptitude rice varieties.

During the reporting period, CSIR-SARI staff working on the DMC trials received backstopping mission from two Conservation Agriculture (CA) experts, one from Cameroun and the other a French national working in Cambodia. During the mission, the team (CSIR-SARI staff and the CA experts) visited the CSIR-SARI fields to get acquainted with the DMC work being executed by CSIR-SARI. The team also visited some communities in the Northern region and has chosen three communities for an intended DMC work. At the end of the backstopping, the team provided a mission report which stipulates the future direction of the DMC work as being carried out by CSIR-SARI

Methodology for DMC implementation in 2013

<u>DMC Trials</u>

Based on the topography of the SARI rice fields, three stations were identified to fit into lowland, midland and upland ecologies. Each of the ecologies) was planted with a DMC trial. Rice-cover crop intercrop was planted in the lowland and midland. In each of the trials, treatments were under 3-levels of fertilization including. Thus,

- -F0: No fertilizer application:
- -F1: (30-30-15 NPK/ha, split applied at 1st application of 15-30-15NPK/ha + t Top dressing of 15%N using Urea)
- -F2: (60-60-30 NPK/ha, split applied at 1st application of 30-60-30 NPK/ha+ and Top dressing of 30 N using Urea

The cover crops used in the DMC trials included *Stylosanthes guianensis,Crotalariajuncea,Crotalaria spectabilis, Crotalaria rectusa, cowpea, Sesbania sesban and Brachiaria ruziziensis.*

Lowland Ecology

- Rice +(*Stylosanthes* sown at water withdrawal)
- Rice+(*sorghum, sesbania,centrosema finger millet* sown at water withdrawal)
- Rice+ (*Brachiaria*, sesbania, *Centrosema* sown at water withdrawal)
- Rice only (check)
- Rice + (cowpea at water withdrawal)
- Rice +(stylo,brachiaria at water withdrawal)

Midland Ecology

- Rice+ Crotalaria.,Centrosema.,Sesbania at flowering After stylosanthes.,Centrosema Centrosema and Sesbania
- Rice+ Crotalaria.,Centrosema.,Sesbania at maximum tiller After Centrosema stylosanthes.,
- Rice +Crotalaria .,at rice Flowering After stylo and Centrosema
- Rice +Crotalaria .,at rice maximum tiller After stylo and Centrosema
- Rice+Sesbania at rice Flowering After Rice .,Stylosanthes
- Rice +*Sesbaniania* at Maximum tillers After Rice ,stylosanthes)
- Rice +S*tylosanthes* at rice flowering, after Rice +stylosanthes)
- Rice +Stylosanthes rice at max tillers after rice Stylosanthes
- Rice after rice (Check)

Upland ecology

- Maize after maize (check)
- Maize after maize+stylosanthes intercrop
- Maize after covercrop mixtures of (crotalaria,sesbania,brachiaria …)
- Maize after maize+cowpea intercrop
- *Crotalaria juncea*

Cover Crop Seed multiplication

Sixteen (16) cover crop seeds were multiplied on a 25mx36.5m plot located behind the rice improvement office in Nyankpala.. Each cover crop was planted on 5.5m x 8m plot. They included 13 varieties of cowpeas were also planted on the CSIR-SARI field each on a 20m^2 plots. Table 4 shows the cover crop that were multiplied during the 2013 season.

Result and Discussions

Yield data of the lowland and midland DMC trials are yet to be analysed. However, result of upland DMC is shown below (figure1). The result shows differences in the maize grain due to fertilizer levels and the cropping systems. Maize grain yield improved when planted after legume. Table 5 shows quantity of cover crop produced during the 2013 season.

Yield of rice and biomass produced in the lowland ecology

Grain yield for the cropping systems ranged from 413.5kg/ha to 1410.2kg/ha (Table 7). Higher grain yields were observed in cropping systems with legumes and with high fertilizer rates. Similarly, high biomass was produced in cropping systems that received high fertilizer rate (NPK (60-60-30) and cover crops intercrop. Generally, sole rice however produced low rice yield and biomass.

Table 7: Grain yield and biomass yield for different system in the lowland ecology.

Cropping system	Grain yield (kg/ha)			Dry biomass yield (kg/ha)		
	F0	F1	F2	F0	F1	F2
Rice+Stylo	461.1	962.2	1132.2	294.4	655.6	827.8
Rice+cowpea	666.2	1146.6	1312.0	627.8	938.9	955.6
Rice+brachiaria,sesb, centro.	449.7	837.9	1134.9	588.9	938.9	994.4
Rice+sorghum.,sesb.,	321.9	1012.9	1345.5	516.7	805.6	1038.9
Rice+stylo.,brachia	532.2	1171.5	1410.2	530.0	883.3	1016.7
Check (Rice only)	413.5	912.2	1089.2	158.3	502.8	650.0

*F0: No fertilizer, F1: NPK(30-30-15), F2: NPK(60-60-30)

Yield of rice and biomass produced in the Midland ecology

Grain yield and biomass in the midland ecology (Table 9 and 10) showed a similar trend as observed in the lowland. Yields of grain and biomass are high in cropping systems which included rice and cover crops and also that received high fertilizer. Perhaps both parameters may also have been influenced by previous cropping history especially if plots were planted to cover crops in the previous season.

Table 9: Rice grain yield in the Midland

Cropping systems	Grain yield (kg/ha)		
	* F0	F1	F2
Rice+ Crota.,Centro.,Sesbania at flowering After stylo.,Centro., Sesbania	617.2	1226.9	1564.1
Rice+Crota.,Centro.,Sesbania at maximum tiller After stylo.,Centro., Sesbania	548.7	1199.6	1762.0
Rice +Crota .,at rice Flowering After stylo and Centro	448.9	964.9	1288.0
Rice +Crota .,at rice maximum tiller After stylo and Centro	402.8	1011.1	1340.7
Rice+Sesbania at rice Flowering After Rice .,Stylosanthes	379.7	1286.5	1675.4
Rice +Sesbania at Maximum tillers After Rice ,stylo	471.6	1144.6	1568.0
Rice +Stylo at rice flowering, after Rice +stylo	471.7	1568.6	1761.4
Rice +Stylo rice at max tillers after rice Stylo	419.1	1140.0	1459.3
Rice after rice (Check)	326.9	597.4	772.2

*F0: No fertilizer, F1: NPK (30-30-15), F2: NPK(60-60-30)

Table10: Dry biomass as affected by cropping system in the Midland ecology

Cropping systems	Dry biomass (kg/ha)		
	F0	F1	F2
Rice+ Crota.,Centro.,Sesbania at flowering After stylo.,Centro., Sesbania	638.9	1430.6	1902.8
Rice+Crota.,Centro.,Sesbania at maximum tiller After stylo.,Centro., Sesbania	861.1	1701.4	2215.3
Rice +Crota .,at rice Flowering After stylo and Centro	763.9	1465.3	1847.2
Rice +Crota .,at rice maximum tiller After stylo and Centro	652.8	1340.3	2166.7
Rice+Sesbania at rice Flowering After Rice .,Stylosanthes	701.4	1750.0	2055.6
Rice +Sesbania at Maximum tillers After Rice ,stylo	763.9	1500.0	2000.0
Rice +Stylo at rice flowering, after Rice +stylo	784.7	1597.2	2375.0
Rice +Stylo rice at max tillers after rice Stylo	777.8	1340.3	1847.2
Rice after rice (Check)	388.9	458.3	638.9

F0: No fertilizer, F1: NPK(30-30-15), F2: NPK(60-60-30)

Yield of maize and biomass production in the Upland ecology

Maize was planted in the upland DMC trial. Maize yield is presented in Figure.4. High grain yield (2174.1kg/ha) was recorded in cropping system where maize followed maize + stylosanthes intercrop as the previous crop. Also, high fertilizer rate (NPK (60-60-30) resulted in high grain yields in the cropping systems. High biomass (table11.) was recorded in treatments that had previous cover cropping system coupled with high fertilizer rate (NPK: 60-60-30).

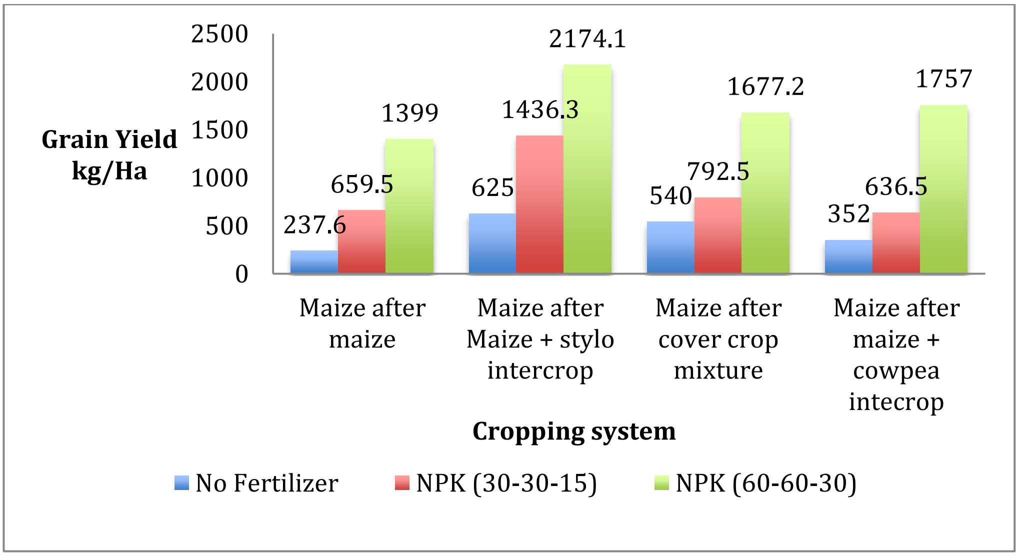


Figure 4: Grain yield for the different cropping system in the upland.

Table 11. Biomass yield for different cropping system in the Upland

	Dry biomass (kg/ha)		
Cropping systems	F0	F1	F2
1. Maize after Maize	3811.11	5577.78	5944.44
2.Crotalaria Juncea after maize+stylo	5833.33	6655.56	8355.56
3. Maize after +cowpea after cover cropmixture	6411.11	6655.56	7055.56
4. Maize+sesbania after maize +cowpea	6011.11	6088.89	8955.56
5.Maize+Brahiaria after maize+cowpea	4555.56	5088.89	8088.89

F0: No fertilizer, F1: NPK(30-30-15), F2: NPK(60-60-30)

Table12. Cover crop seeds produced in 2013

Type of cover crop	Quantity (kg)
Stylosanthes guianensis	2.11
Crotalaria juncea	6.00
Crotalaria retusa	1.25
Crotalaria spectabilis	2.83
Sesbania sesban	7.84
Sesbania (Guadeloupe)	2.01
Mucuna pruriens	16.83
Eleusine- PG5323 (Finger millet)	3.36
Eleusine – PG6240 (Finger millet)	3.28
Centrosema pascuorum	1.44
Brachiaria ruziziensis	7.10
Total	**54.05**

Table 13: Sorghum seeds produced in 2013

Variety	Quantity(kg)
CSP-2	2.76
IRAT 205	1.26
IRAT32	2.59
CEP-1	4.46
Total	**11.07**

Table 14.Cowpea seeds produced in 2013

Varietal code	Quantity (kg)
ECRSP II-1093-5	0.59
ECRSPII-113	0.20
ECRSP II-131	2.67
ECRSP II 867-5	0.60
ECRSP1 141	0.22
ECRSP1 114	0.23
CIT4 IIR-214	0.62
CIT2 120-116/216	0.70
CIT2104-215	0.41
CIT2 -209	0.55
CIT2 141 12-214	0.69
CIT2 117-204	0.15
Total	**7.63**

Monitoring, backstopping and training on DMC experiments by CIRAD.

Wilson Dogbe, Michael Mawunya, Ms. Tahiru Fulera, (Miss)

In April 2011, CSIR/SARI started a partnership with CIRAD to design a research program on poly-aptitude rice and cover crops. In this light, a mission 0f two (2) CIRAD experts, Stéphane Boulakia and Oumarou Balarabé, respectively from France and Cameroun, visited CSIR-SARI from the 24th of October to the 4th of November 2013.

The mission provided monitoring and backstopping of the DMC experiments in Nyankpala station. The experiments included cover crop/rice based experiments situated in lowland and midland ecologies and cover crop/maize based experiment in upland. Training was also provided to the SARI staff working on the DMC by the CIRAD team. In addition the CIRAD team together with SARI staff undertook planning of the 2014 DMC experiments and development of protocols. Furthermore, the mission helped in initiation work in three (3) communities using participatory diagnostic planning for future missions of CIRAD. The following decisions were made at the end of the visit: 1). The on-station DMC experiments will continue to be implemented however with new designs as described in mission report. 2). Specific activities with pilot communities will be implemented in three communities, beginning with a diagnosis. The diagnosis was started in the three communities (Nuodwa, Djelo and Zugu) by SARI in November 2013.

Challenges

Planting of DMC trials was problematic because of lack of appropriate equipment to incorporate dry biomass from previous year.

Conclusion

Almost all the adaptive research activities performed during 2013 by CSIR-SARI were sucessfully completed. Under the coordination of seed production, Breeder and Foundation seeds were produced. On-farm Participatory Varietal Selection trials using mother and baby trials were also sucessfully conducted and harvested during the period. In addition, Direct seeding much based cropping system (DMC) trials as well as the cover crop seed multiplication plots were harvested during the period.The research activities for the next season will be focused even more on on-station DMC experiments and other activities concerning DMC dissemination in the communities.

UNPLAND AGRONOMY

Introduction

There are several units under the Northern Region Farming Systems Research Group (NR-FSRG) and Upland Agronomy is one of such units. The responsibility of this unit is mainly for carrying out adaptive trials (with farmers) of all the crops except cotton, rice and root and tuber crops within the region. In addition to this, the unit also carries out limited number of basic or on-station agronomic trials on all the crops.

For the year under review(2013), out of the four main activities which were carried, only two will be presented here and these are**: (1)** Influence of Minimum Tillage on maize grain yield under different Cropping Systems in the Northern Savanna Zone of Ghana **(JIRCAS) 2.** Cropping systems studies: Inter cropping cereals and legumes with Jatropha **(EU-GHANA)**

For 2014, the unit proposes the repetition of all the four activities and the methodologies of all these have been approved in the previous year's in-house meeting. Some of these are long term trials like the intercropping studies involving cereals, legumes and Jatropha.

Influence of Minimum Tillage on maize grain yield under different Cropping Systems in the Northern Savanna Zone of Ghana

Principal Investigator: J. M. Kombiok
Collaborating Scientists: Haruna Abdulai, Iddrisu Sumani
Estimated Duration:
Sponsors:
Location: On-farm

Introduction

It has been found that the low grain yield of cereals especially maize experienced by farmers in Northern Ghana has been as a result of poor soils (SARI, 2008). For the past decade, low fertility status of soils has been ranked first among the constraints collated from all the districts of northern region of Ghana at the regional planning sessions (RELC, 2010). In Northern Ghana, land preparation for crop production is carried out manually by hand hoe, bullock plough, tractor and to some extent, the slash and burn method (zero tillage) with or without the use of herbicides. Among these tillage systems, the hoe farming method is the most common tillage practice in Northern Ghana.

Of late however, due the intervention by several Non-Governmental Organizations (NGOs) to enhance the food security situation in this part of the country, many more farmers have been acquiring bullocks for land preparation (Ekekpi and Kombiok, 2006). The hand hoe tillage practice which has been described by Ofori (1993) as mainly for weed control probably because it is not deep enough as in bullock and tractor tillage systems suggests that the latter tillage practices can be beneficial in storing soil water for crop production in Northern Ghana.

The effect of the application of organic and in-organic fertilizers separately and in combination of both to enrich the soil of its nutrients for high grain yields of cereals have been for the past years compared and results are available (Ayelew and Dejene, 2012). Similarly, the application of Farm yard manure and in-organic fertilizers separately and in combination of both to maize, showed a significant high fodder yield in the combined treatments over the organic and in-organic fertilizers alone (Oad *et al.*, 2004). Results from experiments in this direction indicate that the best yields of maize were obtained when half the recommended dose of in-organic fertilizer was combined with three tons (3 tons) of animal manure (organic fertilizer) and applied to the soil (SARI 2008).

There is therefore enough information on the role of integrated soil fertility management (ISFM), i.e combined application of organic and mineral fertilizers on the yield of crops in Northern Ghana. However, information on the effect of ISFM on the yield and yield components of maize on different tillage and cropping systems in the northern region of Ghana is scanty.

The objectives of this study were therefore:

- to assess the yield and yield components of maize on the two commonly practiced tillage methods (full tillage and minimum tillage)
- to determine the best intercropping partner in maize in terms of yield and other household uses

Materials and Methods

Location and period of study

The experiment is at one of the sites of the maize-cover crop relay experiment in Ghana (JIRCAS); an on-going experiment which was established in 2011 on the experimental field of the Savanna Agricultural Research Institute (SARI) at Nyankpala located in northern Ghana (Lat 9^0 25"N, Long 1^0 00"W and at 183 m above sea level). The annual rainfall in this area is between 800 and 1200 mm. Maize (*cvObatanpa*) which was obtained from the Crop Breeding Section of SARI was used as the test crop in the trial.

Experimental design and treatments

The experiment was laid out in a split-plot design with four replications. The main plots were 2 tillage systems (blocks) which were made up of manual (full tillage by hand hoe) and minimum tillage (spray with weedicide without ploughing and plant) and five sub-plots which were made up of different cropping systems.

The Treatments were therefore made up of 5 cropping pattern/cropping systems, 2 tillage systems and replicated 4 times.

The cropping patterns were:

1. Maize/mucuna
2. Maize Pigeon pea
3. Maize cowpea
4. Sole maize without mulch

5. Sole maize with mulch

Weed control in the full tillage blocks was carried out by hoe weeding while in the minimum tillage by the use of cutlass making sure that the upper part of the surface soil was not disturbed when the crops were still tender. The other method was the use of knap sack to spray on the weeds before planting and when the crops were advanced in maturity.

Data collection- Crop Parameters

Plant height of maize was determined by randomly selecting four plants per plot. These plants were tagged and their heights taken bi-weekly throughout the growth period and average determined each time. Plant height measurement started at 2 weeks after planting (2 WAP) up to 8 weeks after planting (8 WAP). Before harvesting, the number of lodged maize plants was also counted in each plot to assess the effect of both tillage and fertilizer application on lodging.

After harvesting, the weight of maize straw (stover) was obtained from each net plot by placing in a sack and weighing it with a spring balance and the values expressed on a per hectare basis.

The ears (cobs) of maize from each net plot were sun-dried after harvesting. The dried maize cobs were shelled to obtain grain yield (weight) per plot. Grains of maize were sun-dried to a moisture content of 10% after shelling. The grain yield per plot for each crop was determined and expressed on a hectare basis.

Assessment of Land Equivalent Ratios (LERs) of the intercropping systems

Land Equivalent Ratio (LER) was used to determine whether there was any yield advantage of all intercropping systems. Both the grain and biomass yields were considered as:

$$LER\ (MXD) = \frac{\mathrm{Ymx}}{\mathrm{Sm}} + \frac{Yxd}{Sx} \ldots\ldots\ldots\ldots\ldots\ldots..Equation\ 1$$

where:

Ymx = yield of maize in maize/X intercrop
Yxd = yield of X crop in maize/Sx
Sm = yield of sole maize
Sx = yield of sole crop of any of the crop

Data analysis

Data were subjected to an analysis of variance for a split-plot design using GENSTAT to determine treatment effects. Means were separated using Least Significant Difference (LSD) at 5% level of probability.

Results and Discussion for 2013

Maize stover and grain yield as influenced by tillage system

Maize stover and grain yields were significantly higher when there was full tillage than when minimum tillage was introduced in the study (Table 1). The higher yields of maize could be due to the higher number of tillage operations that loosens the soil for water and air circulation in the fully tilled than the minimum tillage plots. Minimum tillage is the reduction in the number of times the soil is being tilled as compared to conventional tillage method (ploughing/harrow/ridge) before and after the crop is planted. In the Northern part of Ghana, there is only one rainy season which commences in late May and ends in early November with a dry period of about five months which is characterized by the Hamattan winds.

During the dry season, the vegetative matter is dried up and therefore prone to bush fires. The occurrence of bush fires either accidentally or intentionally, clears up all the dry vegetative cover exposing the soil to the Harmattan winds in the dry season and the running water during the rainy season which robs the soil of its nutrients. The exposed soil (bare) is hard and compact and if not loosened, is not easily permeable to water during the onset of rains and this could have affected the uptake of nutrients by the maize crop in the minimum tillage. The burning of the surface mulch has been discouraged, since the full benefits of mulch which include improved moisture infiltration to reduce soil erosion will not be realized in such a situation.

Plant height

Plant height of maize was affected by the type of tillage method used in the study (Table 1). The maize plant height value on the full tillage systems was significantly higher than in the minimum tillage system, there were significant differences between them when these were measured at both the 4 WAP and 8 WAP. However, cropping systems had no effects on plant height in the study as the plant heights were similar in value.

Table1: Maize Grain yields in different tillage and cropping systems at Nyankpala

Factor	Grain yield (kg/ha)	Plant height 4WAP (cm)	Plant height 8 WAP(cm)	Stover yield (kg/ha).	Weeds dry matter (Kg/ha).
Tillage					
Full Tillage	2379.50	52.01	132.88	3538.50	705.50
Minimum Tillage	805.1	45.94	117.94	1570.50	1788.10
Lsd (0.05)	406.84	2.41	5.26	644.74	304.60
Cropping pattern					
Sole maize no residue	2012.80	50.03	127.37	2836.00	1060.20
Sole maize no residue	1750.40	48.48	122.18	3125.50	1408.00
Maize in cowpea	1679.50	49.08	124.37	2804.50	1679.10
Maize in Mucuna	1589.70	51.09	129.45	2003.20	1263.80
Maize in Pigeon pea	923.10	46.21	120.50	2003.20	827.80
Lsd (0.05)	1043.10	NS	NS	NS	723.96

WAP = weeks after planting

Weed dry matter

The result of the study showed that weed dry matter was significantly higher in the minimum tillage than in the full tillage system (Table 1). The lower weed dry matter obtained in the full tillage was however due to the high frequency of weed removal by hand hoe and the effectiveness of it as compared to the minimum tillage system. It has been found that reducing tillage intensity alone as described in Conservation Agriculture without adequately covering the soil as practiced by most farmers is one way of promoting heavy weed infestation on their fields. It was further estimated that over 45 % as the annual yield loss of crops due to weed infestation in heavily infested fields.

At first sight, spraying to kill the existing vegetation in the Northern Savanna zone to plant a crop in Conservation Agricultural system appears like no other weed will ever germinate again. However, two weeks after planting the crop, one finds a huge mass and diversity of weeds vigorously springing up thereby making the first weeding after planting very difficult and laborious since this is done by hand. It has been observed that at times the high infestation of weeds in such a system is due to bad selection of weedicide, low doses of the weedicide and poor spraying techniques.

Maize yields in intercropping systems.

Among the cropping systems studied, the yields of maize was highest in the sole maize without residue followed by sole maize with residue and the third in value was the maize intercropped with cowpea but there were no significant differences observed among these systems. This suggests that to start with, similar maize yields would be obtained in sole maize whether residue was removed or not and whether it was intercropped with cowpea or not. However, the apparent lower yields than in the sole system of the maize inter cropped with cowpea could be due to competition between the maize and the cowpea. Similarly, the yield of sole maize with residue was lower than those without residue probably because of lack of moisture the decomposition was gradual and might have demobilized the nitrogen for the process of decay depriving the maize of the required nitrogen for the crop to produce high grain yields.

On the issue of the maize yields being the lowest in the mucuna and pigeon pea intercrops, it was observed that aside the completion for nutrients within the intercropping system; they also competed effectively for sunlight thereby depriving maize from expressing their full potential in terms of grain yield.

Yields of inter crops and their uses

The grain yield of cowpea, pruned dry matter of pigeon pea and mucuna are presented in Table 2. Cowpea yields and the pruned dry matter of mucuna on full tillage was significantly higher in the full than in the minimum tillage systems. The reasons assigned to these could still be the negative effects of switching from full tillage to minimum which includes the lack of soil permeability of rain water due to high bulk density, lack of access of roots to uptake nutrients from the soil.

Table 2: Yields of intercropping partners of maize at Nyankpala

Tillage	Cowpea grain yield	Mucuna pruned dry matter kg/ha	Pigeon pea pruned dry matter kg/ha.

	kg/ha.		
Full Tillage	197.26	665.10	2816.40
Minimum Tillage	67.94	268.95	2261.70
Lsd(0.050)	83.21	322.82	2177.00

Cowpea grain which contains high protein is used as supplementary feed for both livestock and humans. In northern Ghana, most farm family cannot afford animal protein for the farm family and therefore depend on grain legumes such as cowpea as the only protein source. In addition to providing the family with plant protein, it is also a nitrogen fixing plant and help raise the fertility of the soil if properly rotated or intercropped with cereal crops.

Eventhough the grain of mucuna is not edible, the biomass and the high nitrogen fixing ability of the plant makes it very important to the peasant farmer in the northern savanna zone of Ghana. The heavy biomass and nodules produced by the plant can help increase the organic matter and nitrogen respectively in the soil. Mucuna is also used to suppress noxious weeds like spear grass if used appropriately.

Pigeon pea grain has high protein content and it is used to supplement the protein requirement of the farm family in some parts of the northern region of Ghana. Pigeon pea is an ideal legume for intercropping with cereals. Its slow initial growth affords little competition with the cereal for light or water, and it continues growing into the dry season after the maize crop has been harvested. The leaves that fall from pigeon pea before harvest provide a mulch and can add as much as 90 kg N/ha to the soil that then mineralizes relatively slowly during the subsequent season, releasing N for the next maize crop. Thus a substantial rotational benefit, although not a perfect soil cover, can be achieved for the next season.

Assessment of Land Equivalent Ratios (LERs) of the intercropping systems

When land equivalent Ratios were assessed using both the grain and biomass as yields, it was found that for each of the intercrops, the LER was more than 1 indicating that the intercropping maize with cowpea, Mucuna and pigeon pea had agronomic advantage over the sole maize.

Recommendations and conclusions

From the study, it can therefore be recommended that for soil fertility maintenance, it is necessary to include legumes in the maize cropping system. However, for each of the legumes the following associations are suggested:

i. Mucuna should be used for improved fallow system for farmers who have enough land and can practice one or two years fallow system. Mucuna should not be used for intercropping since the grain is not edible and it compete effectively with maize for nutrients, water and sunlight
ii. Cowpea especially the erect and determinate types should be used for intercropping with maize since it can produce grain for consumption, haulms for livestock feed and can fix nitrogen into the soil to raise the fertility of the soil for further crop production.
iii. Pigeon pea is recommended for use as in alley cropping system. Its grain can be used to supplement the protein requirements of the farm family. It is very important in the crop-

livestock production systems as its biomas can be harvested at about 60 cm, shade dried and fed to livestock during the dry season which still gives some amount of grain later in the year.

In conclusion from this year's results, it is advantageous to intercrop maize with the various legumes since the LER in each case is more than 1. Secondly, these legumes can fix nitrogen to raise the fertility of the soil in the cropping systems and some of them can also be used as feed for humans and for livestock.

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

Principal Investigator: J. M. Kombiok
Collaborating Scientists:,S. K. Nutsugah, Haruna Abdulai, Iddrisu Sumani
Estimated Duration:
Sponsors:
Location: On-farm

Other Collaborators: Ministry of Food and Agriculture,New Energy, Farmers

Introduction

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 its 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 producing fuel.

With the inception of the EU-Sponsored Jatropha Project which is a community development project, 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 inter crop 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 time intercropping systems involving the Jatropha plant and the commonly grown legumes (Soybean and Cowpea) and cereals (Maize and Sorghum).
The objective of each of the trials for the past three years has therefore been to assess the performance of some legumes (soybean and cowpea) and cereals (maize and sorghum) in intercropping systems with Jatropha.

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.

This was replicated three (3) times
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 2013

The planting method trial
The trial which was established since 2010, made up of three planting methods: i) direct seeding, ii) planting using cuttings and iii) using seedlings as the third option. This is the first year (2013) that the Jatropha plants in the trial have produced fruits. The harvested fruits which

were earlier weighed the yield data were now inputted and analysed based on the type of planting method.

The results show that the planting method with the highest number of branches and fruit yield was the transplanting which was not significantly different in the number of branches and fruit yield from that of the direct seeding method (Table 1). However, the planting by cuttings method resulted in significantly lower number of branches and fruit yield than from the direct seeding and by the transplanting methods. The probable reason for the difference could be due to the number of branches per plant of Jatropha and that is why those with higher number of branches gave higher fruit yields.

Table 1: Jatropha yield and number of branches as affected by the planting method

Treatment	**Number of branches**	**Pod yield (kg/ha)**
Direct Seeding	18	2245.70
Transplanting	25	2629.23
Cuttings	12	1589.25
LSD $_{(0.05)}$	9	185.26

Inter cropping and Planting method trials

The cereals (Maize and Sorghum) and Legumes (Cowpea and Soybean) in the intercropping trial were harvested within the last quarter but the inputting of the yield data was done in the quarter under review. For the second year, the Jatropha in the intercrop and in the sole situations were harvested and data collected. These harvested data from the cereals and legumes together with the harvested Jatropha, were in-putted and analysed during the period from January to March. The results are presented in tables 2 and 3 below.

Cereal/Jatropha intercrops

Table 2 shows the results of the yields of cereals and Jatropha both in their sole and their intercrop situations. It clearly shows that there were no significant differences in yield of Jatropha among the three situations (sole, intercropped with maize or intercropped with sorghum). However, for the maize and sorghum, their grain yields in the sole were significantly higher than when they were intercropped with Jatropha. From visual observation, this was mainly due shading of these cereals by the Jatropha plants suggesting the competition for light between the crops and the Jatropha was in favour of the Jatropha

Table 2: Yields of Maize and sorghum as affected by intercropping with Jatropha

Treatment No	Treatment Name	Grain yield (kg/ha)
1	Sole Maize	1200.00
2	Sole Sorghum	2133.33
3	Sole Jatropha	1493.33
4	Maize in Jatropha intercrop	306.67
5	Sorghum in Jatropha intercrop	760.00
6	Jatropha in maize intercrop	1546.67
7	Jatropha in Sorghum intercrop	1400.00
LSD 5 %		**205.714**

Legumes/Jatropha intercrops

The yields of both cowpea and soybean were not affected by intercropping with Jatropha even though the yields of these crops were slightly lower in the intercrops than in their sole situations, they were not significantly different (Table 3). Similarly, the fruit yield of Jatropha in the sole was not different from either intercropped with cowpea or soybean. Comparatively, the yield of Jatropha was lower when it was intercropped with soybean than when it was intercropped with cowpea, however, this did not show any significance difference in both the yield.

Table 3: Yields of cowpea and soybean as affected by intercropping with Jatropha

Treatment No	**Treatment Name**	**Grain yield (kg/ha)**
1	Sole Cowpea	1480.00
2	Sole Soybean	1666.67
3	Sole Jatropha	1253.33
4	Cowpea in Jatropha intercrop	1440.00
5	Soybean in Jantropha intercrop	1613.33
6	Jatropha in Cowpea intercrop	1320.00
7	Jatropha in Soybean intercrop	1133.33
LSD 5 %		**331.27**

SOCIO-ECONOMICS

Baseline Studies and Situation and Outlook Analysis for Groundnut in Northern Ghana

Principal Investigator

Edward Martey, A. N. Wiredu, Richard O. Frimpong, S. K. Nutsugah, P. M. Etwire, Nicholas Denwar

Executive Summary

The Tropical Legumes II project aims at improving the livelihoods of smallholder farmers in drought-prone areas of sub-Saharan Africa and South Asia through grain legume production and productivity. As part of the activities of the project, a baseline and situation analysis studies were conducted to generate relevant information on the groundnut production system in northern Ghana. Result of the situation and outlook analysis suggests that West Mamprusi (Northern region), Bawku West (Upper East Region) and Nadowli District (Upper west region) are three (3) major districts in Northern Ghana with the highest area under groundnut cultivation. The average area under groundnut cultivation in northern Ghana ranges from less than one acre to more than 15 acres. Production trends indicate a general positive growth rate in the volume of groundnut production over the entire study period (1990 – 2006) which is accounted for by area and yield. Highlights from the baseline study revealed majority of the farmers were unschooled with an average household size of 11 members. Decision making about farming activities was found to be male-dominated. About 78% of farmers rely on groundnut seeds saved from last season’s harvest."Dapango” is the most cultivated groundnut variety. The average production volume of groundnut was 23 bags (100kg) out of which 17 bags were sold.On the whole, the daily per capita income of the sampled groundnut producers was less than USD 1 across the three regions. Finally, groundnut contributed nearly 32% of the total household income.

Introduction

The present study aims at generating situation and outlook analysis and groundnut baseline information in Northern Ghana. Groundnut (*Arachis hypogaea*) is one of the most widely grown tropical legumes in the world. It is grown in about 118 countries and occupies more than 22.6 million ha of land. The average annual production is estimated at about 36.4 million MT, with average yield of about 1610kg per ha.West Africa has experienced approximately 5 million metric tons of groundnuts in the last five years (1997-2001) which represents 60% of the African continent's groundnut production and 15% of world production. The production share of West Africa has dropped from 23 to 15% of world production since 1961.Population growth has been a primary factor in the demand for groundnut products in Africa. Secondly the suitability of groundnut products to other products has also contributed to the high demand.Groundnut production in Northern Ghana is very pronounced and contributes about 92% of total national production.Groundnut production in Ghana nearly tripled from 168,200 tons in 1995 to 420,000 tons in 2005 and was primarily due to increase in the area under cultivation which increased from 180,400 ha in 1995 to 450,000 ha in 2005. Some groundnut studies has revealed that lack of credit support, transport limitations, inefficient groundnut marketing channels and systems, restricted markets and marketing opportunities have contributed to limiting the realization of the potential of the producers especially rural women.

Materials and Methodology

The data for the situation and outlook analysis was obtained from secondary sources (Statistics Research and Information Directorate (SRID) of Ministry of Food and Agriculture (MoFA) of Ghana) as well as review of literature. Primary data for the baseline study was collected with a well structured questionnaire through interview of groundnut producing households in Northern Ghana. The data basically captured the general household structure, household resources, groundnut production profile, institutional arrangements, income and expenditure and food security. Qualitative and quantitative methods were both used to analyze the data.

Results and Discussions

Scientific findings

West Mamprusi (Northern Region), Bawku West (Upper East Region) and Nadowli District (Upper West region) are three (3) major groundnut producing districts in terms of area in Northern Ghana. It is both a commercial and subsistence venture for majority of the inhabitants. The area under groundnut cultivation ranges from less than one acre to more than 15 acres. It is purely rain-dependent cropping system. Groundnuts are never grown under irrigation and are planted either in rows or staggered on plots and in some locations on mounds to reduce plant population on the fields. Field preparation is most often done using tractors in large holdings whereas in smaller holdings bullock plough or hand hoeing is the preferred method. Seeding is by hand and in most cases farmers use seed from their own stock or purchase from the local market. Harvesting and plucking of groundnut is done manually.

The result of the trend analysis indicates a positive annual growth rate of groundnut production over the entire study period (1990-2006). Comparatively, the production volume of groundnut in the Upper East is higher than that of Northern and Upper west region within the period 1992 – 2011. The production volumes in all the three northern regions witnessed a decline in 2007 and an increase in production beyond 2007 with the exception of Upper East which has been fluctuating. Area under groundnut cultivation for Upper West is the lowest over the entire study period relative to Northern and Upper East Regions. However, Northern Region has witnessed the highest decline in terms of area under cultivation between 2003 and 2007.

The baseline studies revealed that majority of the farmers have no education and married with an average household size and farming experience of 11 and 15 respectively. Decision making on groundnut production and sale is largely male-dominated. Most of the farmers were non-members of FBO. The average total landholding of a household head in Northern Ghana is 17.58 acres with 4.95 acres under groundnut cultivation. The average distance travelled by farmers form their farms to access an agricultural extension agents in Northern Ghana is 6.67 km. Production of groundnut in Northern Ghana is primarily financed by farmers own savings followed by loan from both formal and informal sources in that order. Decision by farmers in Northern Ghana with respect to groundnut production were influenced by neighbouring farmers, family members/friends, radio programmes, demonstration plots, buyers/buyer agents, seminar/workshops and printed materials in the order of most important to the least important. About 78% of farmers rely on groundnut seeds saved from last season’s harvest whilst 11%

purchased seed from the open market. “Dapango” is the most cultivated variety in the study area followed by “Chinese”. The average production volume of groundnut was 23 bags (100kg) out of which 17 bags were sold. Finally, the daily per capita income of the sampled groundnut producers was less than USD 1 across the three regions. Groundnut contributed nearly 32% of the total household income followed by incomes from sale of cereal grains, petty trading, livestock/fishing, sales of cereal seeds and sales from groundnut seeds in that order. Food security is also a big challenge in Northern Ghana. The average number of months in a year food was reduced by producers in Northern region was 4 whilst it was 3 and 2 for farmers in the Upper east and Upper west regions respectively. The most dominating strategy adopted by majority (62%) of the household heads in Northern Ghana to reduce shock was the sale of animals followed by sale of food.

Conclusion/Recommendation

The results from the study suggest a positive growth rate in groundnut production in northern Ghana over the entire study period (1990-2010). Based on the situation and outlook analysis, rural households engaged in groundnut production especially women must be supported with credit facility and improved seed variety.

The baseline study also revealed exciting results which require the attention of the major stakeholders to ensure the promotion and sustainability of the crop in northern Ghana. Groundnut production is more dominant in terms of area under production in Northern region. Variations exist in the production practices of groundnut per the regions. The seed systems must be given much attention for the sustainability of the crop. In spite of all the challenges associated with the production, the crop has the potential of contributing largely to the food security situation in northern Ghana.

Future Activities/The Way Forward

Future studies must target the value chain of the groundnut sub-sector in Ghana. Specifically, the general seed system, production, processing, commercialization and post-production activities as well as the supporting institutions must be critically examined to identify the strengths and weaknesses of the value chain.

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Ex-post Impact Study of the AGRA Soil Health Project (SHP) in Northern Ghana

Edward Martey, A. N. Wiredu, Matthias Fosu, P. M. Etwire, John K. Bidzakin, Francis Kusi, S.S.J Buah, B.D.K Ahiabor.

Executive Summary

The ex-post impact of the AGRA SHP study indicates a high adoption rate of ISFM technologies among maize farmers. However, there is significant variation in the adoption rate across the community categories. The agreement among the ranked preferences for technologies and varieties is low as indicated by the Kendall's coefficient of concordance value of 0.26. Statistically, ownership of livestock and age of the farmer are the most influential significant determinants of ISFM adoption in northern Ghana. The credit facility of the project must be extended to farmers in other communities.

Introduction

Northern Ghana accounts for over 40 percent of agricultural land in Ghana and considered as the bread basket of the country. The area is however inundated with high levels of food insecurity and poverty. About 80% of the population depends on subsistence agriculture with very low productivity and low farm income. The main reason for the extreme poverty and high food insecurity is the over reliance on rain-fed agriculture under low farm input conditions. In addition, these shortcomings, soil fertility management is sub-optimal. Fertilizer nutrient application in Ghana is approximately 8 kg per ha while depletion rates, which is among the highest in Africa, range from about 40 to 60 kg of nitrogen, phosphorus, and potassium (NPK) per haper year (FAO, 2005). The escalating rates of soil nutrient mining are a serious threat to sustainability of agriculture and poverty reduction in Ghana. Integrated Soil Fertility Management (ISFM) is the approach promoted by AGRA to improve the soil fertility status of African soils. AGRA has demonstrated its commitment to improving the health of the soils in Northern Ghana by funding the Soil Health Project 005 which was implemented by CSIR-Savanna Agricultural Research Institute between 2009 and 2011 prior to its extension.

Materials and Methodology

Data for the study was obtained at two levels. Focus group discussion was adopted to obtain the community level data by category (Project, counterfactual and control communities). Data captured include access to infrastructure and resources. The second level of data was obtained from the households. The household data was captured based on the categories (participant, observer and non-participant households) of the households in the study area. Kendall's coefficient of concordance was run to establish the level of agreement among the ranked preference of crop varieties and technologies by the farmers. Regression analysis was also used to establish the factors that determine ISFM technology adoption.

Results and Discussion

Scientific findings

Majority of the communities visited have access to feeder roads with the exception of one (1) project community and 4 distant communities. Most of roads are however not tarred. The roads enable access to input and output markets, extension services among others. Members of the communities travel an average distance of 7.95 km to participate in nearby markets in the absence of vehicles. However, the beneficiary communities of the AGRA SHP on the average travel a distance of 9.33 km to the nearby market relative to the near and distant communities. The total number of households across the three community categories is 299 with males forming the majority (241) of the household head.

Crop production was shown to be a year round pre-occupation of the households following the rain-fall pattern which generally begins from March-April and ends in November-December. The crop calendar provides a useful guide for timely execution of the field activities of the project. It also serves as a tool for monitoring of farming activities and provides the targeted farmers the opportunity to fully participate and learn from the project.

The focal crops of the AGRA SHP are maize, cowpea and soybean. Farmers in the project intervention areas either grow one or more of these crops subject to their resource constraint. Maize is largely grown among majority of the farmers. The obatanpa variety of maize is mostly grown by majority of farmers. Generally the percentage use of tools and equipment for maize farming is higher among the observer household relative to the other household categories. About 51% and 54% of the participant and non-participant households respectively cultivate maize on rich soils. Soybean and cowpea cultivation occur mostly on soils with low fertility. The situation is more evident among the observer and non-participants households.

The estimated correlation coefficient value of 0.258 indicates that there is agreement among 26% of the respondents in the ranking of the preferences of crop varieties and technologies by farmers in the Northern Ghana. Among the identified preferences, yield, marketability, grain size and drought tolerance are the four most preferred crop characteristics and technologies.

The probit analysis also revealed that farm size, gender, education status, years of farming experience, livestock ownership status, participation status, occupational status and age significantly explains adoption of ISFM technologies in Northern Ghana.

Conclusions/Recommendations

Preferences in the crop varieties and technologies differ among the farmers as indicated by the low level of agreement among the ranked preferences. Uptake of ISFM technologies and improve varieties is increasing among the smallholder maize farmers in Northern Ghana. Maize cultivation is more capital intensive relative to the other focal crops of the project. The beneficiary communities of the project must be scaled up and credit must be extended to other members of the target communities at the right time. Attention must be given to the other focal crops of the project. Training of FBOs and demonstrations must be carried out regularly to enhance farmers' skills.

Future activities/Way forward

The AGRA SHP must further engage the farmer groups actively in farm demonstrations to ensure maximum adoption and use of the technology. The credit component of the project must be strengthened and sustained.

Analysis of the Sweet Potato Production Systems in northern Ghana.

Edward Martey, Prince Maxwell Etwire, Alexander Nimo Wiredu, Esther Wahaga, Kwabena Acheremu

Executive Summary

The baseline survey basically aimed at generating relevant information for characterizing the sweet potato production systems in northern Ghana. The study revealed that production of sweet potato is male dominated. An average of 1.16 acres of land is put under cultivation in 2012 whereas management and ownership is gender sensitive. The average landholding of a household head is 6.9 ha. The sweet potato vines are normally accessed from friends and neighbours. Few experienced vine multipliers exist in the study area. The crop plays a significant role in the area of household food security in northern Ghana.

Introduction

PennState University in collaboration with CSIR-SARI signed a MOU to undertake a study in sweet potato value chain linkages in Northern Ghana under the sub-agreement for the Horticulture CRSP Focus Project "STOPS: Sustainable Technologies for Orange and Purple Sweet potatoes in Ghana". The project aims to promote the use of orange and purple flesh sweet potato in Ghana. Specifically, CSIR-SARI's socioeconomic unit was mandated to characterize the sweet potato production systems in Northern Ghana and also assist Penn State graduate students with data and value-chain follow-up analysis. The study covered all the three northern regions of Ghana namely, Northern Region, Upper West and Upper East Region.

Materials and Methodology

The study covered all the three northern regions of Ghana namely, Northern Region, Upper West and Upper East Region. A total of 540 producers were sampled through a multi-stage sampling technique that combined purposive and simple random methods of sampling. Primary data was collected with the use of survey instrument through farmer interview. Focus group discussion was also carried out to augment the personal interview. Desk study was also conducted to generate useful information for the survey report.

Results and Discussion

Scientific findings

The baseline studies revealed that the average age of a sweet potato producing household head is 48. The percentage of household heads in Northern Ghana who are unschooled or being to preschool and basic school as the highest level of education is 80% and 9% respectively. Most (56%) of the household heads practice Islamic religion followed by 33% who are Christians and 11% being traditionalist About 89% of the sample population are engaged in agriculture as the principal occupation. The average total landholding of a household head in Northern Ghana is 17.30 acres with 10.70 acres under cultivation. Total number of plots owned by a household head on the average in 2012 is 4 whereas 69% of women do not have any farm plots elsewhere apart from the one plot they own. The average landholding of women in 2012 is 2.20 acres. Average area under sweet potato production in 2012 is 1.16 acres. Ownership and management of sweet potato is gender based. Sweet potato production is mainly owned by men as indicated by 96%. Women are normally constrained in terms of access to agricultural resources for production thus the low percentage of ownership. Decision on the amount, type, sale, volume of sale, use of sweet potato proceeds and revenue sharing is largely determined by men. Sweet potato producing household heads have different attitude, perception, practice and knowledge of sweet potato production and usage. About 40% of the farmers agreed that sweet potato is the most reliable food crop during shortage of food and 37% disagree with the assertion. The perception that sweet potato growers are not considered to be men has been proved contrary by the study. With regard to the seed system, 75% of the household head in Northern Ghana obtain sweet potato vines from their own farm whilst 9% obtain the vines from male neighbours. Other farmers and local market are the main source of market information.

The month of October to January is indicative of the period where majority of households consume sweet potato meals twice in a week. The month of November represents the period where most (close to 80%) of the households consume sweet potato meals twice in a week. The month of February to August represent the period where minority of households consume sweet potato meal twice in a week. Majority of the households consume less than 2 meals a day between the periods of May to August. This period is normally characterized by food shortage in the household where most of the farmers depend on other source of food to ensure household food security. The food insecurity situation in the household improves from September to April where food is available in the household.

Farmers have different strategies to mitigate the condition of food insecurity in Northern Ghana. The main coping strategies in overcoming household food insecurity includes sale of assets, purchase of food on credit, allow children to eat more than adults, consume seed stock, eat less preferred food, take smaller meals, skip a meal, skip some meals in a day and rely on relative or friends in that order.

Conclusion/Recommendations

The sweet potato baseline study in Northern Ghana was successfully implemented by CSIR-SARI with PenState University providing financial support. Sweet potato is an important crop due to its diverse use. The study has shown that the crop has the potential of contributing significantly to the household food requirement. However, the objective can be achieved through continuous sensitization on the diverse use of the crop coupled with effective promotion. The use of innovation platform in the promotion of the crop will ensure higher visibility and acceptability. Training of farmers on sweet potato vine multiplication, production, marketing and post-production practices will boost production volumes which will translate into higher farm income.

FBO Linkages under the AGRA SHP in Northern Region

Edward Martey, P. M. Etwire, John K. Bidzakin,B.D.K Ahiabor, Mathias Fosu, Francis Kusi, S.S.J Buah

Executive Summary
As part of the AGRA SHP, FBOs were supposed to be linked to agro-input dealers and aggregators in Northern region to facilitate access to input and output markets. Several approaches including sensitization, reconnaissance visit and linkage formed the key strategies in the realization of the study objectives. Seven (7) FBOs in the Northern Region of Ghana has been linked to both agro-input dealers and aggregators. 37 FBO representatives participated in a one day meeting to strengthen the relationship between FBOs, agro-input dealers, aggregators and the media.

Introduction
The escalating rates of soil nutrient mining are a serious threat to sustainability of agriculture and poverty reduction in Ghana. There are also inefficiencies and bottlenecks in fertilizer distribution networks which limit access, and add to the cost of fertilizer in farming communities. Agro-input marketing is rudimentary and farmer-based organizations are also weak and therefore unable to acquire credit, fertilizer and other inputs in bulk to reduce cost.

Integrated Soil Fertility Management (ISFM) is the approach advocated by AGRA to improve the soil fertility status of African soils. AGRA has demonstrated its commitment to improving the health of the soils in Northern Ghana by funding the Soil Health Project 005 which is implemented by CSIR-Savanna Agricultural Research Institute between 2009 and 2011 and finally extended to 2013.

One of the approaches adopted by the project to ensure that farmers have access to fertilizer and market is the facilitation of the FBO, Agro-input dealer and aggregator network in the Northern region of Ghana where fertility and market opportunities are of great concern to the farmers. The proposed linkages are expected to create a platform where farmers can directly purchase inputs for their production as well as market for their produce. The handholding activities are also expected to foster leadership, group cohesion and good negotiation skills among the farmers. In so doing, the business capacity of the farmers will be enhanced.

Methodology/Approach
The basic approach adopted for the realization of the study objectives includes mobilization stage where the team from SARI was constituted to assist with the handholding activities. Secondly, was the reconnaissance visit to communities to sensitize the FBO members about the project. The visit was also used to authenticate the existence of the FBOs in the communities. The selection of FBOs constituted the third stage. Finally, the actual linkage activities were facilitated by a joint meeting of FBOs, agro-input dealers and aggregators. Follow up on the linkage was done to ensure that it is operational and effective.

Results and Discussions

Scientific findings

Seven (7) FBOs in the Northern Region of Ghana has been linked to both agro-input dealers and aggregators. The farmers were also educated on environmental safety practices. The FBOs has also been linked to Wienco Ghana Ltd to support farmers with inputs for demonstrations. A one day meeting between 37 FBO representatives, Aggregators and the media was held to facilitate the linkage process.

Conclusions/Recommendations

The aggregators and input dealers have expressed much interest in working with well-organized and strong FBOs. The FBO/Input/Aggregator linkage facilitation must be scaled out. The platform where the FBOs and the aggregators are engaged must be sustained. The success of the linkages rest mostly on the willingness of farmers and the facilitating institutions thus the need for the farmers to be well organized, positioned and constantly engage the other players of the agricultural value chain.

Maize Baseline Survey in the West Gonja and Mion Districts of Northern Ghana under the Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC)

Edward Martey, Prince M. Etwire, Abdoulaye. Tahirou

Executive Summary

The thrust of this study was to provide baseline information of the maize-producing households in Mion and West Gonja districts in the Northern Region of Ghana prior to an implementation of a five year maize sector development project dubbed "Support to Agricultural Research for Development of Strategic Crops in Africa". The two districts were purposively sampled for the study because they constitute the intervention districts of SARD-SC in the Guinea Savannah Zone of Ghana. A multi-stage sampling procedure was employed in the selection of 200 households within the two districts. Descriptive analysis was used to describe the maize

Introduction

The Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) is a five (5) year program being implemented by the International Institute for Tropical Agriculture (IITA) with funding from the African Development Bank (AfDB). The program is being rolled out in some selected countries in Africa with focus on some strategic crops namely maize, rice and wheat. The targeted crop for Ghana was maize due to its importance in the diet of many Ghanaians.

Community and producer survey was necessary to determine the baseline situations of maize farmers before the intervention of SARD-SC. The information generated will serve as the basis for impact studies after the end-line survey has been conducted. The main objective of the study is to generate relevant information regarding the present status of the farmers before the interventions are introduced.

Methodology/Approach
The study relied mainly on primary data collected through questionnaire administration. A multi-stage sampling technique was used to sample the farmers from which the data was collected. Data was captured mainly from farmers within the two main categories of communities (Project Community and Non-project community or counterfactual). Quantitative and qualitative method of data analysis was used to analyze the data.

Results and Discussions
Scientific findings
The baseline study highlighted male dominated household head with average age of 47 years and 26 years of farming experience. Almost all the sampled household heads were married and unschooled. However, 4% of the sampled household heads have attained tertiary education in Mion district. About 30% and 39% of the respondents in Mion and West Gona respectively have ever attended training on maize production with different organizations. Crop production serves as the main source of income for majority of the sampled household heads followed by trade. Majority of the farmers were non-members of farmer association. Easy access to inputs and credit were the main motivating factors for joining farmer association. About 84% of the sampled household heads were aware of improved maize variety whilst 59% have actually used the variety. In the last cropping season (2012), 71% of the farmers used the improved variety. Conversely, majority (92%) were not aware of hybrid maize. On the average farmers cultivate 2.75ha of maize and harvest 2119.21kg. Distance from the maize plot to the village, local market, road and main market are 2.72km, 5.53km, 3.37km and 9.17km respectively. The distance impose a high transaction cost which constraint some of the farmers from participating effectively in market. Strategies adopted by most of the farmers against shocks include sale of assets, reduction in food intake and borrowing from family members and friends. The study also revealed that few of the farmers have diversified sources of income.

Conclusions/Recommendations
The baseline survey shows that most of the household heads interviewed were relatively young which is good for ensuring increase in food production in the districts. Most of the farmers need education on the use of improved maize varieties as well as the hybrid maize. The farmers must be encouraged to participate fully on the newly created Innovation Platform for awareness creation of farm technologies and intensive market participation.

Future activities/Way forward
The community analysis has commenced following the completion of the baseline studies. Technology dissemination through farm demonstrations will be carried out in the intervention communities. End line survey will be conducted to determine the impact of the SARD-SC project on the income and productivity of the farmers.

Baseline Survey of the Rice Sector Development Hub in Navrongo, Upper East Region

Edward Martey, A.N. Wiredu, W. Dogbe, P. M. Etwire, A. Arouna

Executive Summary

The present study characterized the rice production system in the northern hub of Ghana. Specifically, the study sought to characterize the rice value chains, describe the nature and access to agricultural resources and improved technologies in the hub. The level of adoption of existing rice technologies in the hubs was also determined. A multi-stage sampling technique was used to sample 200 rice farmers from five distinct communities (Core PVS, Seed, Mechanization, Control and Agronomy) in Navrongo. Other actors of the rice value chain sampled for the study are consumers, traders and processors.

The survey revealed different levels of adoption of crop establishment methods, field management practices, harvest and post-harvest practices. Disaggregation of the results based on gender also revealed significant difference in the adoption of rice varieties. Female farmers mostly cultivate traditional varieties. There were different perceptions among the sampled farmers with regard to the agricultural characteristics of rice varieties cultivated.

The rice value chain consisted of input dealers, producers, traders, processors and consumers with support from financial institutions, research institutions, transport services, policy makers, NGOs and extension services. The media also play a major role in the rice value chain such as dissemination of agricultural information and technology. On the average, millers incur an average operational and maintenance charges of USD257.62 and USD36.90 respectively on a monthly basis. The total average market cost incurred by wholesalers is USD354.60. The average total market cost incurred by retailers is USD41.67. There exist some bottlenecks with the linkages which range from attitudinal to institutional which needs to be addressed in order to ensure that sustainable benefit accrue to all the stakeholders.

Introduction

Rice is increasingly becoming an important strategic crop in the economy of Ghana as it competes with maize. The crop is ranked as the second most important staple crop as it competes strongly with the traditional coarse grains and roots and tubers in the food production and consumption baskets of the country (SRID/MoFA, 2011a). Presently, the crop occupies 11 percent of total area under cereals representing about 5 percent of the total arable land area. In 2010, a total volume of 491,603 MT of rice was produced in the country (SRID/MoFA, 2011).

Presently, per capita consumption of rice in Ghana is estimated at 25 kg per annum. Rapid growth in consumption has further worsened the rice self-sufficiency status of the country. Despite the observed growth in rice production, the current level of production is still unable to meet domestic demand which is increasingly being met by surging rice imports (MoFA/SRID, 2011). Enhancing domestic supply of rice has become an urgent policy issue in Ghana and other sub-Sahara African economies.

The observed expansion in the rice production systems since 2007 is a culmination of years of efforts to transform the rice production systems and the agricultural sector of the country as a whole (Ragasa *et al*., 2013). Through strategic policy reforms the rice production systems in the country have seen the development, deployment and promotion of improved production technologies and facilities. The technologies include high yielding and stress tolerant rice varieties, recommendations for fertilizers and agrochemicals as well as good agronomic practices. Government interventions through the fertilizer subsidy program and the block farm program are also in operations. Other sector specific projects such as the Multinational NERICA Rice Dissemination Program, Afife Rice Project, Lowland Rice Development Project and Rice Sector Support Program are worth mentioning. All these interventions also form part of an overall strategy to mitigate the effect of global food crises (MoFA 2009).

Many factors have contributed to the low productivity of rice sector in Ghana despite the many interventions of rice development projects in northern Ghana. Notable amongst them is low soil fertility, lack of credit access and use of inadequate technologies has contributed to the low productivity of rice (SRID/MoFA, 2011a; Wiredu *et al*., 2010). Other factors such as inadequate use of improved rice cultivation practices, high cost of agro-inputs, poor post-harvest handling and processing as well as marketing challenges continue to pose challenges to the domestic rice industry and the agricultural sector as a whole (Wiredu 2011; Asuming-Brempong *et al*., 2011). Finally, preference for imported rice among consumers is also associated with the perceived poor quality of domestic rice (Tomlins *et. al*., 2005). The situation has the tendency of crowding-out domestic producers (farmers and processors) from the rice value chain which can result in joblessness and income loss. This if not arrested can eventually worsen their food security status and quality of livelihood of the actors in the rice value chain.

In the framework of the implementation of AfricaRice's 2011-2020 Strategic Plan, it has been planned to establish "Rice Sector Development Hubs" in the countries. Rice Sector Development Hubs is one of the three key mechanisms of AfricaRice's 2011-2020 Strategic Plan to boost Rice sector in Africa. The baseline study aimed at contributing to the component on "Situation analysis" by providing a clear description of the farming systems, identify constraints and estimate *ex-ante* the potential impact of the project in the identified Rice Sector Development Hubs (concentration domains). The study was also to generate relevant information to describe the prevailing socio-economic conditions in the hubs.

Methodology/Approach

The study relied mainly on primary data collected through questionnaire administration. A multi-stage sampling technique was used to sample 200 rice farmers from five distinct communities (Core PVS, Seed, Mechanization, Control and Agronomy) in Navrongo. Other actors of the rice value chain sampled for the study are consumers, traders and processors. Secondary data was also used to augment the primary data.

Scientific findings

The result shows that the average age and household size of a rice producer are 46 and 6 respectively. Based on disaggregation of results by gender, female rice producers are relatively older than male rice producers. Access to land for farming activities is normally gender sensitive. Generally, male farmers were more educated than the female farmers. The result is not surprising especially in this hub where females are mostly restricted in terms of education. They are normally assigned to household activities. Family labour was the most important source of labour for almost all the producers in the Navrongo hub. Agriculture is the main form of occupation for about 95% of the sample. The farmers derive their source of livelihood from agriculture.

With respect to farmers' relationship with organization or association, it was observed that 43% of the respondents have received agricultural training. Specifically, about 35% of the farmers have received training on rice production. Majority of these beneficiaries were males. The result of the study shows that 27% and 67% of the respondents have access to electricity and water respectively. About 67% of the respondents have access to mobile phones whilst 27% and 68% of the farmers have access to television and radio respectively.

The Navrongo hub is mostly dominated by lowland without irrigation as recorded by 38% of the total landholding. Irrigated lowlands form 13% of the landholding whilst upland rice ecology forms 27% of the landholding. Most of the rice production occurs at the lowland ecology whilst some NERICA varieties have been introduced to the upland ecology. Surprisingly, traditional varieties, other improved and NARS rice varieties are mostly known by female farmers.According to the result, more female farmers have access to traditional varieties than other improved varieties relative to their male counterparts. Cultivation of traditional and other improved varieties for at least once was higher among the female farmers. Most of the male farmers have access to the NARS varieties relative to the other rice varieties and have cultivated it for at least one season. The possible reason is that the varieties developed by the National Agricultural Research Systems are exposed to farmers by AEAs through farm demonstration. For the past three years, majority of the female farmers have been cultivating traditional and other improved varieties whilst the male farmers have been cultivating the NARS varieties.

The main activities under land preparation well known to the farmers are manual weeding, burning and removal of residue in that decreasing order of knowledge. Most of the farmers prefer manual weeding in the process of land preparation. Farmers in the hub continue to use random method of seed sowing and dibbling irrespective of the numerous trainings on row planting. Manual weeding, herbicide and mechanical methods were the main management methods known to the farmers with regard to field management practices. The survey revealed that manual harvesting is the most practiced method of rice harvesting in the study area as recorded by 65% of the sampled farmers. Sun and mechanical drying are the main methods of drying the harvested rice. Manual winnowing using basket is the most adopted and used method of winnowing followed by the mechanical process. Traditional method of parboiling is the predominant method of rice processing known and used by 31% of the farmers.

Conclusions/Recommendations

The rice value chain consists mainly of input suppliers, producers, traders, processors and consumers. Other supporting stakeholders are research, policy agencies, financial institution, NGOs, transport services and extension services. The media is also becoming an important tool for the communication of most of the activities of the stakeholders.

The baseline survey revealed that most of the sampled farmers fall within the economic active age group of the country which is good for ensuring increase in rice production with the right investment. Majority of the farmers have attained primary education and married. It was also observed that most of the farmers had knowledge about crop establishment methods, field management practices and harvest and post-harvest practices, however, there were some deficiencies in terms of the use.

Significant differences also exist among the male and female farmers in some of the farm practices and technology usage. The traditional, other improved and NARS varieties were the three main rice varieties grown by majority of the sampled farmers with the NARS as the most cultivated variety. Female farmers mostly cultivate the traditional variety. Finally, the sampled farmers have different perception with regard to agricultural characteristics of rice varieties in the Navrongo hub of Ghana. The result has implications for research and development in the rice sector of Ghana.

Future activities/Way forward
Draft report has been prepared and yet to be finalized. Training on data analysis and impact study will be conducted in June, 2014.

FBO development and M&E for Agricultural Value Chain Mentorship Project (AVCMP)

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Executive Summary
The International Fertilizer Development Center (IFDC), Savanna Agricultural Research Institute (SARI) 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 project is being implemented in sixteen districts in the Northern Region/Breadbasket of Ghana focusing on rice, soybeans and maize value chains.
Conduct of socioeconomic studies, identification and priming of farmers to participate in the project, linking farmers to agro inputs and credit as well as improving farmers technical and entrepreneurial skills, are some activities being implemented under the project.

Introduction
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.

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 (productivity component) of the Project which has the objective of improving entrepreneurial and technical skills of FBOs and their member farmers to upscale ISFM technologies for rice, soybean and maize production.

Methodology/Approach

In order to achieve the objective of the project, a combination of approaches was adopted. Interactive and participatory methods were employed in identifying and priming, training as well as linking farmers to services.

Frontier, profitability, Kendall's and probit analysis were used for the socioeconomic studies carried under the project in order to provide some feedback on implementation.

Results and Discussions

Scientific findings

About 16,000 farmers have been identified and primed to participate in the project. The project partnered Wienco Ghana Limited to link 4 FBOs to access certified maize seed, herbicides and inorganic fertilizers. Rural Banks (Borimanga and BESSFA), Financial NGOs (Center for Agricultural and Rural Development), Development Interventions (Savannah Accelerated Development Authority, SADA and Block Farm) and the private sector (Wienco and Yara through Masara N`Arziki Farmer Association) were the main avenues through which some of the project FBOs were able to obtain some production credit.

Different institutions have slightly different criteria for granting credit. With the rural banks, the FBOs had to operate an account with them as well as deposit at least 10% of the amount requested. Masara N`Arziki provided it member associations with credit in kind. CARD supported the FBOs through its cashless value chain crop financing concept where credit and repayment are both in kind. SADA and Block Farm also provided input credit to some of the project FBOs.The project also linked 24 FBOs in 4 districts to tractor service. A total of 183 hectares was ploughed.

A total of 288 farmer leaders from 144 FBOS as well as 20 MoFA staff were trained in value chain approach and strategies for sustaining FBOs. In order to improve record keeping among FBOs working with the project, a days' training workshop was held in each of the project district. The capacities of 177 FBOs (340 farmers) and 45 MoFA staff were built on how to practically keep records in an AVCMP branded notebooks that were given the participating FBOs.

For the socioeconomic studies, results showed a mean technical efficiency estimate of 53 percent and the return to scale was 0.75. Location of farm, participation in the AVCMP and age of farmer were found to be important in explaining technical inefficiency among soybean farmers.

It appears that farmer's interest in agricultural projects can be permanently sustained by providing them with tangible benefits such as production credit and agricultural extension services. The probability of participating in an agricultural project reduces by about 2 percent if a farmer stays in school for an additional year. Farmers who have access to credit are about 15 percent more likely to participate in an agricultural project. A farmer who has access to agricultural extension service is also about 14 times more likely to participate in an agricultural project.

Soybean production was found to be unprofitable in Chereponi District for both male and female farmers but profitable for male farmers in Saboba District. Constraints to soybean production include lack of right over land, selling of produce on credit, among others.

Conclusions/Recommendations

Location of farm, participation in the AVCM Project and age of farmer were found to be important in explaining technical inefficiency among soybean farmers. Farmers in the Chereponi District are less technically efficient as compared to their counterparts in Saboba District. In addition, farmers who are receiving mentorship from the AVCM Project were found to be more technically efficient as compared to other farmers who are not participating in the project. Older soybean farmers were also found to be more technically efficient than younger soybean farmers in the Saboba and Chereponi districts of the Northern Region of Ghana.

Number of years in school, access to production credit and agricultural extension service are factors that significantly determine farmers' participation in agricultural projects in the Saboba and Chereponi districts of northern Ghana.

Results of the profitability analysis indicate that on the average, soybean production in Chereponi District is not profitable even though female farmers are relatively better-off than male farmers. Soybean production is however profitable for male farmers in Saboba District but not female farmers.

Constraints to soybean production include lack of right over land, difficulty in joining or forming a farmer based organization, selling of produce on credit, inadequate access to soybean training and extension, poor storage facilities and low yield. Analysis of the result indicates that constraints to soybean production may not be gender specific but rather location specific.

The findings of this study have important policy implications. There is the need to improve access to extension services on soybean production, with more emphasis on Chereponi District. Extension services could be improved through scaling up of current agricultural interventions, implementation of new agricultural projects, employment of more agricultural extension agents, improvement in logistical support for agricultural extension agents among others. In addition, there is also the need to create an enabling environment for soybean farmers, which will serve as an incentive for them to continue to remain in production until they are well advanced in age.

Government and its development partners can create a conducive environment through improvements in access to inputs, financial services and output markets.There is the need to improve promotion and dissemination of improved soybean technologies such as fertilizers, pesticides and inoculants. Both governmental and non-governmental organizations could increase farmers' awareness of these technologies through the use of radio, drama, video, announcements from pubic vans among others.

There is also the need for government to lead the way in finding solutions to pertinent issues such as land tenure arrangements, agricultural extension staffing, motivation and training, storage facilities among others. These constraints could be addressed in collaboration with the private sector.

Future activities/The way forward

The project intends to enter into partnership with Wienco to support Samford Enterprise to build capacity of FBO working with him in ISFM & FBO management, select farmers/ FBO's around FLC for credit support and deepening of mentorship Support, farmers/FBOs around FLC to aggregate input and cultivation services, link remaining project FBO to access inputs and cultivation services needs, support other FBO to aggregate inputs & services among others.

Adoption Monitoring of Drought Tolerant Maize Varieties in Ghana

Prince Maxwell Etwire, Abdoulaye T., E. Martey, K. Obeng-Antwi, R.A.L Kanton, M. S. Abdulai, S. S. Buah, H. Haruna, A.N. Wiredu

Executive Summary

Maize is food to millions of households in Ghana accounting for more than 50 percent of total cereal production. It is the second most important commodity crop in the country after cocoa. This study was conducted to measure DT maize penetration as well as describes the key factors associated with farmer uptake of DT maize varieties.

About 32 percent of the sample are aware of DT maize varieties. Analysis of the data shows that about 13 percent of the sample has adopted DT maize varieties. However, among the sub sample of those who have been exposed to DT maize varieties, the adoption rate is about 42 percent. About 2 and 3 percent of the sample have adopted Aseda and Etubi respectively. Level of adoption among the exposed sub sample for Aseda and Etubi is about 5 and 10 percent respectively. The level of adoptio of Abontem among the sample is about 5 percent whiles that of Aburohemaa and Omankwa is about 2 percent each. About 15, 8 and 5 percent of the exposed sub sample have adopted Abontem, Aburohemaa and Omankwa respectively. Farmers' awareness of DT maize variety is influenced by agro ecology, access to agricultural extension and purchasing of certified seed from formal sources. Agro ecology, age and purchasing of certified seed from formal sources are the factors that influence farmers' adoption of DT maize varieties.

Introduction

Since 2008, promising high yielding, striga and drought tolerant (DT) maize varieties are being evaluated in participatory on-farm trials and demonstrations under the DTMA Project. 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. This study was therefore conducted in order to measure DT maize penetration as well as describes the key factors associated with farmer uptake of DT maize varieties.

Methodology/Approach

The study was undertaken in the Forest-Savannah Transition and Interior Savannah agro ecologies of Ghana. The study relied mainly on primary data collected through household survey. A multi-stage sampling technique was employed. In all, a total of 600 respondents were interviewed. The study combined both qualitative and quantitative analytic tools. Regression techniques such as bivariate probit, multinomial logit, probit and ordered logit were used for analysis. Descriptive statistics subjected to the Students T Test and Binomial Test were also utilized for analysis.

Results and Discussions

Scientific findings

The mean age of adopters and non-adopters is estimated be 50 and 47 years respectively. The average household size of the respondents was estimated to be 10 people. Adopters and non-adopters require about half an hour (36 minutes) and an hour (54 minutes) to travel one-way to buy maize seed. The number of drought events in the last 10 years reported by adopters is significantly higher than non-adopters. The average maize field of the sample is less than 2 hectares. There is no significant difference between the mean number of cattle owned by maize secured and maize in-secured households. There is however a significant difference with respect to poultry and small ruminants such as sheep and goats. Maize in-secured households have about 4 more fowls and 2 more small ruminants when compared to maize secured households. Male is the dominant sex for both adopters (93%) and non-adopters (94%). Majority of adopters (65%) and about 42 percent of non-adopters have had formal education. Majority of adopters (about 51%) and about 43 percent of non-adopters have enough income to either meet their expenses or make some savings. Majority of adopters (about 53%) and about 48 percent of non-adopters bought their certified maize seed from formal sources. An overwhelming majority of adopters (80%) and about 65% of non-adopters received extension services on improved maize varieties.

About 32 percent of the sample are aware of DT maize varieties. Analysis of the data shows that about 13 percent of the sample has adopted DT maize varieties. However, among the sub sample of those who have been exposed to DT maize varieties, the adoption rate is about 42 percent. About 2 and 3 percent of the sample have adopted Aseda and Etubi respectively. Level of adoption among the exposed sub sample for Aseda and Etubi is about 5 and 10 percent respectively. The level of adoptio of Abontem among the sample is about 5 percent whiles that of Aburohemaa and Omankwa is about 2 percent each. About 15, 8 and 5 percent of the exposed sub sample have adopted Abontem, Aburohemaa and Omankwa respectively. Farmers' awareness of DT maize variety is influenced by agro ecology, access to agricultural extension and purchasing of certified seed from formal sources. Agro ecology, age and purchasing of certified seed from formal sources are the factors that influence farmers' adoption of DT maize varieties.

Conclusions/Recommendations

About 32 percent of the sample are aware of DT maize varieties. Analysis of the data shows that about 13 percent of the sample has adopted DT maize varieties. However, among the sub sample of those who have been exposed to DT maize varieties, the adoption rate is about 42 percent. Farmers' awareness of DT maize variety is influenced by agro ecology, access to agricultural extension and purchasing of certified seed from formal sources. Agro ecology, age and purchasing of certified seed from formal sources are the factors that influence farmers' adoption of DT maize varieties.

Agricultural extension staff as well as development workers should be continuously supported to enable them to continue to provide key extension services to farmers. Support could be financial or technical assistance from Government and donor agencies. There is the need for research, extension and seed companies to intensify the promotion of DT maize seed. There is also the need to strengthen the formal seed system in order to ensure that smallholder farmers have access to affordable and improved DT maize seed at their doorstep.

The Upper East Region should be given priority by both government and donors in terms of distribution of income generating and maize developmental projects so to reduce maize insecurity. Government should also intensify efforts aimed at improving adult literacy. Subsidy on maize seed should be expanded to include all released DT maize seed.

Maize Value Chain in the West Gonja and Mion Districts of Northern Ghana

Prince Maxwell Etwire, Martey E., A. Tahirou

Executive Summary

The object of this study is to describe the maize value chain in the Northern Region of Ghana prior to an implementation of a five year maize sector development project dubbed "Support to Agricultural Research for Development of Strategic Crops in Africa". Two districts namely West Gonja and Mion, were purposively sampled for the study because they constitute the intervention districts of SARD SC in the Guinea Savannah Zone of Ghana. Through snowball and purposive sampling, all actors and facilitator of the maize value chain were interviewed in both districts. Qualitative and quantitative methods were both employed for the analysis.

The main actors of the maize value chain include agro input dealers, farmers, traders, processors and consumers. The chain however benefits from the services of several institutions including research, extension, Non-Governmental Organisations (NGOs), financial institutions (who all sometimes use the media as an outreach tool) as well as transporters. Addressing the constraints facing each stakeholder whiles harnessing the opportunities available, will greatly enhance the efficiency of the maize value chain.

Introduction

The Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) is a 5 year program being implemented by the International Institute for Tropical

Agriculture (IITA) with funding from the African Development Bank (AfDB). The program is being rolled out in some selected countries in Africa with focus on some selected crops. For Ghana, maize is the target crop.Prior to the implementation of the SARD SC in Ghana, a producer and community survey was conducted in order to determine the baseline situations of maize farmers before the intervention of SARD SC. This present study is a follow up to the producer baseline survey with focus on all other actors in the maize value chain except farmers. The objective of the study is to describe the maize value chain in the Northern Region of Ghana.

Methodology/Approach

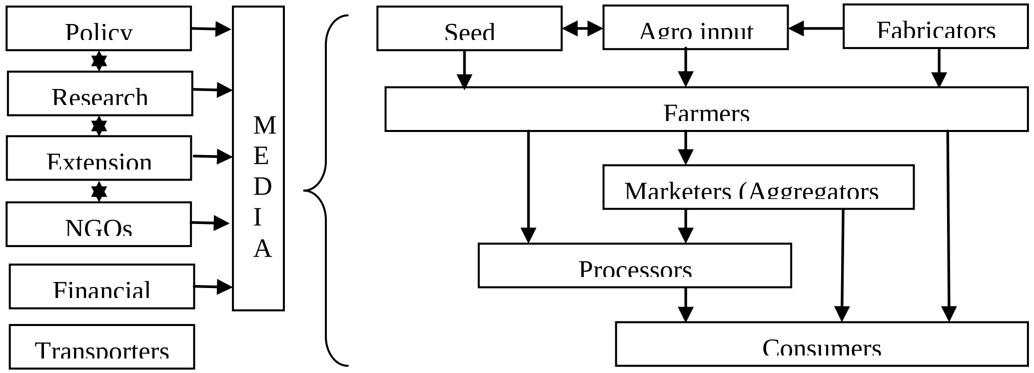
The study relied mainly on primary data collected through questionnaire administration. A separate questionnaire was administered to each category of actors in the maize value chain. The questionnaire focused on key issues such as demographic characteristics of actors, operations, constraints, opportunities among others. Qualitative (flow chart) and quantitative (descriptive statistics) methods were both employed for analysis.

Results and Discussions

Scientific findings

A flow chart of the maize value chain in the Northern Region of Ghana is shown in figure 1. The main actors of the chain include agro input dealers, farmers, traders, processors and consumers. Agro input dealers do get their chemical supplies (fertilizers, pesticides, herbicides etc) from wholesalers, simple farm implements from fabricators and maize seed from both seed companies and registered seed growers. The agro dealers in turn sell their products to farmers and do also supply see2d companies with other inputs. Some maize farmers buy their seed and simple farm implements directly from seed companies/growers and fabricators respectively.After production, maize is mostly procured by marketers (aggregators and retailers) who in turn sell to consumers or processors. Some farmers sell directly to processors and consumers at their communities. The maize value chain however benefits from the services of several institutions including research, extension, NGOs, financial institutions (who all sometimes use the media an outreach tool) as well as transporters. Detailed discussion of each category of actor is presented below.

Figure 1: Maize value chain in the Northern Region of Ghana



Conclusions/Recommendations

The main actors of the maize value chain include agro input dealers, farmers, traders, processors and consumers. The chain however benefits from the services of several institutions including research, extension, NGOs, financial institutions (who all sometimes use the media an outreach tool) as well as transporters.Agro dealers are mainly responsible for the supply of agro inputs to the maize sub sector. They play an important role in increasing the productivity of farmers as well as serving as a market for seed, fertilizer, herbicides, simple farm implements among other agro chemicals. They mostly sell their wares on 'table tops'. Whereas demand is seasonal, supplies are unreliable. Fabricators are involved in turning scrap metals into simple farm implements. Significant addition of value to maize is done by processors. The processors sampled were all middle aged women who were involved in the business before establishing their own. Processing is on a small scale. Maize marketing in the study area is dominated by aggregators and retailers. Trading is done in periodic markets or along the road side or at the community.

There are several institutions providing services to the maize value chain in the Northern Region of Ghana. Whiles producers are the immediate beneficiaries of research and extension, other actors along the chain do receive capacity building services from research and extension. Tricycles are the principal means of transportation of maize and maize products with money lenders and microfinance institutions being the main financiers of the maize value chain. The use of radio is one of the means through which services providers reach out to various actors in the maize value chain.

There are certain characteristics or issues that are common to all actors along the maize value chain. None of the actors belonged to a platform where they meet and interacted hence there appears to be weak linkages among actors. Inadequate access to credit is a major constraint affecting all actors. Inadequate modern storage facilities and poor road network especially in the rainy season is hampering the activities of actors along the chain.

There is therefore the need establish an innovative platform in each project district. The platform will ensure frequent interaction among the stakeholders in the maize value chain. The platform could serve as an avenue for building the entrepreneurial and technical skills of various actors in the chain in order to strengthen linkages.

There is also the need to improve access to credit in the chain through innovative value chain financing such as the cashless credit system where a financial institution facilitates the transactions between actors in the chain without the use of cash.

Further, there is the need to build modern storage facilities that can serve the needs of all actors along the maize value chain. The warehouse receipt system could be implemented at the producer level. Improvement in the road infrastructure will not only be a boost to the maize industry but to the agriculture sector in general.

Capacity Building of SME Seed Company Personnel in WCA on Marketing and Selling Directly to Smallholders and Business Management

Prince Maxwell Etwire, Abdoulaye T., Fulton J., Makan F., E. Martery

Executive Summary
A training workshop was therefore held at the Ahmadu Bello University in Zaria, for 50 seed companies in Nigeria on March 27, 2013. The capacities of 25 agro input dealers (seed sellers) and 5 seed companies in Ghana were also built at the Christian Council Guest House on May 29, 2013. On July 31, 2013, the capacities of 45 seed companies and stakeholders in Mali were also built. Generally, the training programs were 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 businesses for improved performance. The project team therefore intents to engage in periodic monitoring, in order to help seed companies and seed sellers to implement their Marketing Action Plans as well as improve upon their business management.

Introduction
The importance of seed to any crop based production system cannot be overemphasized. It is the fundamental unit of production since it is the source of life. The quality of seed of any preferred variety is the basis for agricultural productivity improvements. Access to quality improved seed by farmers is key to improving productivity of maize in West and Central Africa (WCA). This will require the existence of a vibrant private seed sector who will deliver the seed to farmers at an effective cost.

There are very few private seed companies selling maize in WCA and most of them continue to rely on government and NGO purchases for their business. For sustainable growth, these seed companies need to develop tools to allow them to sell directly to the millions of smallholder farmers in WCA that need improved maize seeds. In addition, the maize seed sector in WCA is still very small compared to East and Southern Africa. This difference in size makes most training offered not well adapted to the needs of seed companies in WCA. There is a need to develop and deliver courses that are tailored to the conditions and situation of the small companies of WCA to enhance their efficiency.

A cursory look at the seed companies and seed deliverers in Ghana, Mali and Nigeria shows that most of them are weak and inadequately animated. This therefore necessitated the need for training and in some cases retraining of these seed companies and seed sellers on marketing and selling directly to smallholder farmers as well as business management.
The objectives of the trainings were to:

1. Develop skills and tools for seed companies and seed deliverers on simple direct marketing techniques (Marketing Action Plans)
2. Build capacity of seed companies and seed sellers on business management

Methodology/Approach
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 power point presentation, demonstrations, use of worksheets, group discussion and role play and plenary discussion.

Results and Discussions
Scientific findings
A training workshop was held at the Ahmadu Bello University in Zaria for 50 seed companies in Nigeria on March 27, 2013. The capacities of 25 agro input dealers (seed sellers) and 5 seed companies in Ghana were built at the Christian Council Guest House on May 29, 2013. On July 31, 2013, the capacities of 45 seed companies and stakeholders in Mali were also built.

Conclusions/Recommendations
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 business for improved performance. Seed companies and agro input dealers need to be supported and encouraged to deliver quality seed to smallholder farmers. The project team therefore intents to engage in regular monitoring and follow ups, in order to mentor seed companies and seed seller to implement their marketing action plans and to improve upon their business management.

M&E and Diagnostics of the Seed System in Ghana

Prince Maxwell Etwire, Atokple I.D.K., S.S Buah, A. Abdulai, P. Asungre, S. Karikari, E. Etwire, E. Martey, A.N. Wiredu

Executive Summary
The value of seed in a farming system cannot be overemphasised. The formal and informal seed systems are the two major components of the seed supply system in Ghana. The characteristics of the formal seed supply system are well documented and known globally to be a vertically organised production and distribution of tested and improved seed varieties. The characteristics of the informal seed system are perhaps not well known leading to an unregulated and unsupervised system. For the main staple crops, adoption of improved and certified seed varieties by farmers is significant in improving seed supply and production. Meanwhile, the share of the informal seed supply is estimated to be ninety percent of the total seed supply system in most staple crops of Ghana. Despite investments in the formal seed system to breed quality varieties for farmers, the utilisation of improved seeds for staple crops by farmers is low.

Introduction

The seed system in the Ghana is made up of two main parallel components known as the formal seed system and the farmers' seed system or broadly as the informal seed system. The formal seed system in the northern savannah zone of Ghana is described as a well-documented vertically organised production and distribution of improved and tested seed varieties (Louwaars and De Boef, 2012). Meanwhile, the share of the informal seed system is ninety percent of the total seed system for most staple crops (MoFA, 2011). Additionally, the informal seed system is not characterised, regulated, supervised system and it is dominated by small scale farmer. The objective of the project is to identify a cost-effective seed delivery system in order to enhance adoption of certified seed by farmers.

Methodology/Approach

The survey relied on randomised sampling procedures at the district, community and farmer level. Actors in the seed system were identified through snowball sampling. A total of 201 farmers, 14 community seed growers, 14 registered seed growers, 14 agro input dealers, 5 seed companies, 3 staff of the seed inspection division of MoFA, 3 staff of the Grains and Legumes Development Board and 3 scientists from CSIR-SARI were sampled through questionnaire administration or key informant interviews.

Descriptive statistics and flow charts will be used to characterize the informal seed system. Identified challenges and opportunities will be subjected to farmers' ranking and analysed with Kendall's coefficient of concordance in other to determine the level of agreement. Regression technique will be employed to determine the importance of farmer's perception and preference on adoption of improved seed of staple crops. Simple excel sheet and SPSS will be used for data entry, cleaning and sorting and interpretation.

Results and Discussions

Data collection is complete. The data will be entered in a statistical software after which results will be generated for reporting.

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Multi-stakeholder Platform (MSP) Processes for Rice-based Systems in the Upper East and Northern Regions of Ghana

Prince Maxwell Etwire, Dogbe W., E. Martey, J. Yirzagla

Executive Summary

In line with AfricaRice's rice sector development concept, two rice sector development hubs have been identified in northern Ghana namely the Navrongo hub in the Upper East Region and the Savelugu hub in the Northern Region. The criteria for selecting MSP locations was based on secondary data including population, socioeconomic, agricultural, and rice production data, as well as technical reports from MoFA and CSIR-SARI.

Introduction

The rice value chain comprises a wide range of actors. These include various stakeholders such as input suppliers, farmers/producers, processors, millers, traders, consumers, local authorities, administrative (extension) partners, and other private and public-sector organizations, such as development and non-governmental organization (NGO) partners who provide support services.

MSP facilitates the organization and prioritization of different actors' interests and activities by providing an opportunity for individuals and groups to come together and openly discuss their respective needs.

Methodology/Approach

The establishment of a MSP is a dynamic iterative process involving mentoring and coaching through regular technical backstopping visits.

Results and Discussions

Scientific findings

Monthly MSP meetings have been facilitated, executives have been elected, registration processes has completed and activities are being implemented to help MSPs achieve their short term goals.

Future activities/The way forward

The team will continue with monthly meetings and capacity building of MSPs to be self-sustaining. SARI will also facilitate seed production and farm demonstrations at the level of MSP.

UPPER EAST REGION FARMING SYSTEMS RESEARCH GROUP (UER-FSRG)

AGRONOMY PROGRAMME

Evaluation of Pearl millet varieties and hybrids for adaptation to the semi-arid agro-ecology of northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Peter, A. Asungre and Emmanuel Y. Ansoba
Estimated Duration: 2 Years
Sponsors: Own Resources
Location: Manga

Background Information/Justification/Introduction
Millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important cereal crops in the Upper East Region in northern Ghana. The importance of the crop is most pronounced in the Upper East Region where it serves as a hunger-breaker breaker immediately after the long dry season. Most farm-families would have exhausted their scanty harvest and even have difficulties in purchasing seed for the cropping season. Pearl millet is the only cereal that reliably provides grain and fodder under dryland conditions on shallow and sandy soils with low fertility and low water holding capacity. While pearl millet farmers have managed to feed their families under harsh conditions for centuries population growth is outstripping their capacity to meet new demand with ancient practices and landraces. The only cereal crop that can be sowed and harvested within 3 months in the region is pearl millet. Regrettably there has not been any improved pearl millet crop varieties since Ghana's independence from our colonial masters. The most important characteristic of millet is their unique ability to tolerate and survive under adverse conditions of continuous or intermittent drought as compared to most other cereals like maize and sorghum (LCR, 1997. The only pearl millet variety that was bred during the colonial era and released was Manga Nara, which is currently been cultivated extensively in the Upper East Region. This situation has come about because pearl millet unlike its other cereal counterparts has never been regarded as an important crop in Ghana. The Council for Scientific and Industrial Research (CSIR) Savanna Agricultural research Institute (SARI) engaged a millet breeder in the later part of the 1990s, who bred for early maturing, insect pests and diseases resistant pearl millet varieties, which are being evaluated for subsequent release for mass production in Ghana. Adoption of improved pearl millet varieties tends to be slow in some regions due a complex of factors such as seed availability, variety performance or household preferences (Ndjeunga and Bantilan, 2005). The ability of pearl millet to reliably produce on marginal lands and under low rainfall makes it attractive choice for sandy, low fertility and acidic soils (Menezes *et al*. 1997). There are 2 schools of thought in plant breeding one is of the view that selecting for broad adaptation has greater gains and stability whilst the other believes that developing crops such as pearl millet that are grown as landraces and also are produced in marginal areas site-specific breeding is of the essence (Ceccreli, 1996 and Omanya *et al*. 2007).

Brief Objectives (one or two lines)
The objective of the current study is to test the performance of pearl millet varieties and hybrids for their response to agro-ecological conditions of the Upper East Region of Ghana.

Expected Beneficiaries
Pearl millet farmers and consumers and marketers of millet products and Ghana at large.

Materials and Methods
Field trial was established at the Manga Agricultural Research Station near Bawku in the Sudan savanna agro-ecological zone of Ghana. The soil was a sandy loam with below average plant nutrients as presented in Table 1. The study evaluated 9 pearl millet varieties/hybrids comprising of 3 bio fortified hybrids, 4 improved millet varieties from the CSIR-SARI Pearl Millet breeding P and a local landrace called Manga Nara. The experiment was established in a randomized complete block design with 4 replicates. Plot dimensions were 4.5m x 5m long on ridges made by bullocks with a spacing of 0.75m apart and the spacing between hills was 0.30m. Cow dung was applied to the field just before disc harrowing with a tractor. The land was prepared by tractor and the ridges were made by bullock. Pearl millet seeds were sowed using 3 to 4 seeds per hill and thinned to 2 plants per hill at exactly 2 weeks after sowing (WAS). 1 weeding was done 2 weeks after sowing prior to the first fertilizer application. The second fertilizer application was done 2 weeks after the first fertilizer was applied. The fertiliser was applied at the rate of 80 kg N/ha and 40 kg /ha each of P_20_5 and K_20 immediately after thinning using NPK 15-15-15 and top-dressing done on 27th July using ammonium sulphate. Half the N (40 kg N/ha) and all the P_20_5 and K_20 was applied in the form of compound fertiliser. R**e**-shaping was done on 30th July 2012 to prevent root lodging using bullocks as recommended for cereals in Ghana. All recommended data for pearl millet production was taken. The millet was harvested in October 2013 and the data was subjected to standard statistical analysis and means separated using the standard error of 2 means.

Major Findings
Grain yield of pearl millet was significantly (P<0.001) influenced by variety, with Arrow producing the highest grain yield and followed closely by Soxsat and Bristle millet whilst, TABI-B9 produced the lowest grain yield. Arrow; Soxsat and Bristle produced significantly (P<0.001) greater grain yield than those produced by TABI-B9; Bongo Short Head; Farmers variety and ICTP (Table 1). Similarly, Tongo Yellow significantly out-yielded TABI-B9; Farmers variety Bongo Short Head and ICTP. Arrow; Soxsat; Britle millet and Tongo Yellow produced grain yields that were far in excess of that obtained by the trial mean. These grain yields are comparable and in some instances superior to those reported in the literature for pearl millet. All the improved millet varieties with the exception of TABI-B9 and Bongo Short Head out-yielded the Farmers variety. Soxsat produced the highest straw yield followed closely by TABI-B9 whilst, Tongo Yellow produced the lowest. Soxsat produced significantly (P<0.001) higher straw yield than the rest of the treatments with the exception of TABI-B9. The Farmers variety produced the lowest straw yield among the varieties. TABI-B9 and Bristle millet produced significantly (P<0.001) greater straw yield compared to Bongo Short Head; GB 8735 and the Farmer variety. Rainwater use efficiency (RUE), which is a measure of how efficient the genotype uses rain water was significantly (P<0.001) affected genotype with Arrow recording the highest RUE followed closely by Soxsat and Bristle millet whilst TABI-

B9 recorded the lowest RUE followed by Bongo Short Head. Rainwater use efficiencies recorded by Arrow; Soxsat and Bristle millet were significantly ($P<0.001$) greater than those recorded by TABI-B9; Bongo Short Head; Farmer variety and ICTP (Table 1).

Table 1.Effect of millet variety on grain yield and its components of millet in a semi-arid agro-ecology at Manga Station in the 2013 cropping season.

Millet variety	Panicle length (cm)	Panicle (mm)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainfall use efficiency (kg ha^{-1} mm^{-1})
Arrow	26.92	40.5	0.11	2131	8.8	3.3
Bongo short head	13.45	62.9	0.21	1188	7.2	1.8
Bristled millet	31.80	42.4	0.09	2022	10.5	3.1
GB 8735	24.42	49.9	0.08	1519	7.7	2.4
ICTP 8203	26.70	42.5	0.08	1344	8.7	2.1
Soxsat	32.45	54.1	0.07	2069	13.2	3.2
TABI-B9	31.65	37.6	0.06	972	11.2	1.5
Tongo Yellow	20.72	50.0	0.10	1896	8.7	2.9
Farmers variety	17.27	53.3	0.08	1296	7.4	2.0
Mean	23.93	48.1	0.08	1604	9.3	2.5
s.e.d.	1.45	21.84	0.012	256	0.97	0.40
C.V. (%)	12.5	90.8	27.9	22.6	14.8	22.6

Conclusion/Recommendations

In 2012 the varieties that produced superior gran and straw yields were: ICTP 8203; Soxsat; Bristle millet; Bongo Short Head; Arrow and Tongo Yellow, whilst in 2013 the best performers were Arrow; Soxsat; Bristle and Tongo Yellow.Thevarieties that are consistent in both grain and straw yields are Arrow; Soxsat; Bristle and Tongo Yellow. These varieties would therefore be recommended to the National Variety Release and Technical Committee for consideration for release

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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: Peter, A. Asungre and Emmanuel Y. Ansoba
Estimated Duration: 3 years
Sponsors: WAAPP 2A
Location: Manga

Background Information/Justification/Introduction
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). Increasing population has placed too much pressure on the limited land resources thereby leading to continuous cropping particularly of cereals after cereals (Anane-Sakyi *et al*. 2005). Though farmers use various improved maize varieties with high yield potential, grain yield has been observed to be very low, rarely exceeding 1 t ha^{-1} in farmers' fields (Abunyewa and Mercer-Quarshie. 2004). Sarfo *et al*. (1998) concluded that for most crops, the best type, rate and time of application are not known and that this constitutes a constraint to the use of fertiliser. 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). Best fertiliser application for savanna soils is a combination of organic and inorganic fertilisers (Dennis *et al*. 1994). Application of of organic manure and/or compost has been proven to improve soil organic matter content (Adani *et al*., 2007; Sounare *et al*., 2003) and the available water content of soils by 58-86% (Celik *et al*., 2004). Increase in wheat yield from 1190 kg ha^{-1} in the control to 1520 kg ha^{-1} due to the application of Municipal solid waste compost, because of availability of water in the rooting zone attributable to reduction in evaporation (Agassi *et al*., 2004).

Brief Objectives: The objective of the current study is to determine the most optimal source of organic and inorganic sources of fertilizer for increased and stable maize productivity.

Expected Beneficiaries: Maize farmers and consumers and marketers of millet products and Ghana at large.

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 field was a flat land and the soil is Plinthic Lixisol (FAO-UNESCO, 1988) classification and developed from granite. The soil is deep to moderate deep and well drained. The mean physical and chemical properties of the surface soil taken at a depth of 0-15 cm before sowing have been presented in 2013. 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, *strigahermonthica* resistant and has quality protein. Maize was hand sowed by dibbling on 11th July 2012, 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). The various sources of organic fertilisers were applied at the rate of 5 t/ha before sowing. Basal chemical fertilisers was applied at the rate of 60 kg N; 60 kg P_2O_5/ha as triple super phosphate (TSP) and 60 kg K_2O/ha as Muriate of Potash (MOP). Half of the nitrogen fertiliser, 30kg N/ha all of the P and K were applied at 2 weeks after sowing, dibbling at 3 to 5 cm from the maize plants and placing the fertiliser into holes and closing as the foot as recommended. Top-dressing with S/A at the rate of 40 kg N/ha for all treatments at 2 weeks after the first fertiliser application as recommended for maize cultivation in Ghana. The first weed control was by through the use a herbicide at recommended rate on the 12th July 2012 and the second weed control was done by hand on 13th August 2012. The ridges were re-shaped to control any remnant weeds and also control root lodging at mid-season. Data on maize growth, development, yield and yield components were taken throughout the season. Maize was harvested at on 17th July 2012 and sun dried to about 14% moisture content. No major insect pests and disease was observed during the season. The data was subsequently subjected to standard statistical analysis using GenStat release 14, statistical package and where there were significant differences at the $P<0.05$ confidences level means were separated using the least significant difference procedure.

Major Findings

Generally, maize harvest index values are generally low as compared to those obtained in 2012. The highest harvest index was recorded when maize was fertilized with 21:10:10:2S and followed closely by maize fertilized with Sheep dropping; Poultry manure and Fertisoil, whilst the lowest was obtained for Town waste and Compost. Maize grain yield was significantly ($P<0.001$) influenced by treatment effect, with maize fertilised with Poultry manure producing the highest grain yield followed closely by maize fertilized with 21:10:10:2S (Table 2). The lowest grain yield was produced by maize fertilised with Town waste. Maize grain yield under Town waste; Compost; Urea and 15:15:15 were less than that recorded for the trial mean. Generally, the chemical fertiliser treatment plots recorded a mean grain yield increment of 15%

over their organic counterparts. However, maize fertilised with poultry manure produce the highest grain yield under the organic sources whilst 21:10:10:2S produced the highest grain yield under the chemical fertilizer treatments. Maize straw yield followed a similar, trend like maize grain, except that maize treated with Actyva recording the highest straw yield followed by Poultry. Poultry dropping recorded the highest straw yield amongst the organic sources followed by sheep dropping. General, the chemical sources of fertiliser produced higher straw yields as compared to their organic counterparts with the exception of Urea. Rainfall use efficiency (RUE), which is a measure of rainwater capture, use and use efficiency was significantly ($P<0.001$) affected by treatment effect and varied considerably amongst treatments with Poultry manure recording the highest RUE followed closely by 21:10:10: 2S whilst, the Town waste recorded the least RUE (Table 2). Generally rainfall use efficiency increased with the chemical sources of fertiliser as compared to their organic sources. The inorganic sources of fertiliser recorded a mean increase in RUE of 16% over their organic counterparts.

Table 2.Effect of sources of fertilisers on maize growth and development in a dry agro-ecology in northern Ghana, in 2013.

Source of fertilizer	No. of ears at harvest	100-grain weight (g)	H.I.	Grain yield (kg/ha)	Straw yield (kg/ha)	Rainfall use efficiency (kg mm^{-1} ha^{-1})
Cow dung	41	26.59	0.36	3013	5267	4.7
Goat dropping	38	27.42	0.35	2480	4633	3.8
Sheep dropping	41	31.33	0.37	3457	6100	5.4
Poultry manure	46	30.87	0.37	4173	7033	6.5
Compost	40	27.71	0.33	2337	5267	3.6
Town waste	41	25.29	0.32	1970	4067	3.1
Fertisoil	43	28.04	0.37	2843	4967	4.4
15:15:15	40	27.45	0.36	3010	5233	4.7
21:10:10:2S	44	28.10	0.38	4137	6500	6.4
23:10:5:3S:2Mg:0.3Zn	43	27.33	0.34	3707	7133	5.8
Urea	37	25.92	0.36	2473	4533	3.8
Mean	41	27.82	0.36	3055	5464	4.7
s.e.d.	2.79	2.47	0.029	434	766	0.67
C.V. (%)	9.60	12.50	11.5	20.1	19.8	20.1

Conclusion/Recommendations

The preliminary results indicated that the chemical sources produced superior maize plants as compared to their organic counterparts. 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 chemical fertilizer, whilst Poultry manure; Sheep dropping and Cow dung were the best sources among the organic fertilizers used in 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: Peter, A. Asungre and Emmanuel Y. Ansoba
Estimated Duration: 5 years
Sponsor: WAAPP 2A
Location: Manga

Background Information/Justification/Introduction
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. Loss of soil organic matter, and nutrients, low water infiltration and water holding capacity of soils are among the factors that have resulted in poor soil productivity (FAO-RAF, 2000). Increasing population has placed too much pressure on the limited land resources thereby leading to continuous cropping particularly of cereals after cereals (Anane-Sakyi *et al*. 2005). Though farmers use various improved maize varieties with high yield potential, grain yield has been observed to be very low, rarely exceeding 1 t ha-1 in farmers' fields (Abunyewa and Mercer-Quarshie. 2004). 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). Best fertiliser application for savanna soils is a combination of organic and inorganic fertilisers (Dennis *et al*. 1994). Application of organic manure and /or compost has been proven to improve soil organic matter content (Adani *et al*., 2007; Sounare *et al*., 2003) and the available water content of soils by 58-86% (Celik *et al*., 2004). Increase in wheat yield from 1190 kg ha^{-1} in the control to 1520 kg ha^{-1} due to the application of Municipal solid waste compost, because of availability of water in the rooting zone attributable to reduction in evaporation (Agassi *et al*., 2004). With appropriate tillage and rotation maize roots can also absorb water from the subsoil at 40 to 50 cm depth (Ghuman and Lal, 1991).

Brief Objective: The objective of the current study is 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 farmers and consumers and marketers of millet products and Ghana at large.

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 (2011-2012) of the experimental site was mm, it is mono-modal, starting in June and ending in October. The field was a flat land and the soil is Plinthic Lixisol (FAO-UNESCO, 1988) classification and developed from granite. The soil is deep to moderate deep and well drained. Soil organic carbon was determined by Walker-Black wet oxidation, available Potassium (K) ammonium Acetate (Toth and Prince, 1949), Available Phosphorus (P) by Bray and Kurz, 1945. Particle size distribution by Bouyoucos (Hydrometer) Method and Total Nitrogen by Kjeldals' method. 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). Basal inorganic fertilisers was applied by hill placement method at 2 weeks after sowing at the rate of 60 kg N, 60 kg, 60 kg P_2O_5/ha as triple super phosphate (TSP) and 60 kg K_2O/ha as Muriate of Potash (MOP) at sowing. Top-dressing with S/A at the rate of 40 kg N/ha for all treatments at 2 weeks after the first fertiliser application as recommended for maize cultivation in Ghana. Two manual weeding at 2 and 6 weeks after planting and ridges were re-shaped to control any remnant weeds and also control root lodging at mid-season. Data on insect pests and diseases would also be taken during the course of the season. Rainfall use efficiency (RUE) was calculated as grain yield produced per increment of precipitation (Tanaka *et al*., 2007) using the accumulated rainfall from 1st July to 31th October for the season. 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.

Major Findings

Generally, maize growth, development, yield, yield components were superior when maize followed a grain legume as compared to maize after maize (Table 3). Number of maize cobs were not significantly ($P<0.05$) influenced by treatment effect. However, maize after cowpea recorded the highest cobs at harvest followed by maize after pigeon pea and groundnuts with maize following maize the least cobs at harvest. 100-grain weight of maize was significantly ($P<0.05$) affected by treatment. Maize after groundnuts produced the boldest grain whilst maize after green gram produced the smallest grains (Table 3). Maize grains produced by maize after groundnut were significantly ($P<0.05$) bigger than those produced by maize after green gram and maize. Maize grain produced by maize after groundnut; mucuna; cowpea and soybean were greater than those produced by the trial mean. Maize harvest index, which is a measure of partitioning efficiency of dry matter from vegetative to generative organs was not significantly ($P<0.05$) affected by treatment. However, maize after pigeon pea groundnut recorded the highest harvest index followed closely by maize after soybean whilst maize after greengram recorded the lowest (Table 3). Maize following maize equally recorded the lowest harvest index after maize after greengram. 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 9). Maize after a grain legume produced significantly (P<0.01) greater grain yield compared to maize following maize (Table 3). 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 3). Rainfall use efficiency (RUE), which is a measure of rainwater capture, use and use efficiency was significantly (P<0.01) affected by treatment. Maize after groundnut recorded the highest RUE followed closely by maize after cowpea and pigeon pea, whilst maize after maize recorded the lowest RUE (Table 3). Maize preceded by all the grain legumes recorded significantly (P<0.01) higher RUE than that recorded by maize after maize.

Table 3. 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 2013 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/Recommendations

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. This study would have to be repeated several years as it is a long-term study so as to enable us attain conclusive results for recommendation to maize farmers in northern Ghana.

Determination of optimal rate of nitrogen for 3 extra-early; early and medium maize maturity groups in northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Asamoah Larbi, Saaka S. Buah; James M. Kombiok; Ansoba, E; Asungre, A. P. and Lamini, S
Estimated Duration: 2 years
Sponsor: USAID Feed the Future
Location: Manga and Garu

Background Information/Justification/Introduction
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 and unreliable rainfall both in amount and distribution have 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, and nutrients, low water infiltration and water holding capacity of soils are among the factors that have resulted in poor soil productivity (FAO-RAF, 2000). Increasing population have placed too much pressure on the limited land resources thereby leading to continuous cropping particularly of cereals after cereals (Anane-Sakyi *et al*. 2005). IFDC (1998) reported that the annual rate of nutrient depletion from soils of Ghana between 1993 and 1995 in kilogrammes of $N+P_20_5+K_20$ per hectare was 51-100 with average annual rate of nutrients required to achieve optimum levels of production being greater than 80.Though farmers use various improved maize varieties with high yield potential, grain yield has been observed to be very low, rarely exceeding 1 t ha^{-1} in farmers' fields (Abunyewa and Mercer-Quarshie. 2004). 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). IFDC (1998) reported that the annual rate of nutrient depletion from soils in Ghana between 1993 and 1995 in kilgrammes of $N+P_20_5+K_20$ per hectare was 51-100, with average annual rate of nutrients required to achieve optimum levels of production being greater than 80.

Brief Objectives: To determine the optimal and most economic rate of nitrogen fertilizer to boost maize productivity and production in Ghana.

Expected Beneficiaries: Maize farmers and consumers and marketers of millet products and Ghana at large.

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

(2011-2012) of the experimental site was mm, it is mono-modal, starting in June and ending in October. The field was a flat land and the soil is Plinthic Lixisol (FAO-UNESCO, 1988) classification and developed from granite. The soil is deep to moderate deep and well drained. Soil organic carbon was determined by Walker-Black wet oxidation, available Potassium (K) ammonium Acetate (Toth and Prince, 1949), Available Phosphorus (P) by Bray and Kurz, 1945. Particle size distribution by Bouyoucos (Hydrometer) Method and Total Nitrogen by Kjeldals' method. The mean physical and chemical properties of the surface soil taken from 0-15 cm before sowing is presented in Table 16 for the on-station trial and for the on-farm trial in Table 2.. The experimental factors studied were extra early varieties and different rates of nitrogen, The extra early maize varieties are: 99 TZEE Y STR; TZEE W Pop STR QPM C0; 2000 SYN EE STR; 2004 TZEE W Pop STR C4 and for the farmers' variety the newly released CSIR-Abontem was used. The Nitrogen fertiliser rates used are: 0N; 40 kg N/ha; 80 kg N/ha; 120 kg N/ha and 160 kg N/ha. The experimental design was a factorial established in a randomised block with 4 replications. The plot dimensions used are 4.5 m x 5m. The trial field was harrowed by a tractor on the 19th of July 2012, and bullocks were used to ridge the field 2 days after harrowing. Maize was sowed on the 7thof July 2012 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). Basal inorganic fertilisers was applied by hill placement method at 2 WAS. Straight fertilisers were used in the study. Urea was the source of basal nitrogen whilst triple super phosphate and Muriate of potash were the sources of phosphorus and potassium respectively. Half of the compound fertiliser was applied at 2 WAS immediately after thinning to recommended plant population whilst the entire triple super phosphate (TSP) in the form of 60 kg P_2O_5/ha and also the whole amount of the Muriate of Potash (MOP) in the form of 60 kg K_2O/ha as were applied together with the basal nitrogen. For top-dressing of the remaining half of nitrogen ammonium sulphate popularly called sulphate of ammonia (S/A) was used. Two manual weeding at 2 and 6 WAS were carried out and ridges were re-shaped to control any remnant weeds and also control root lodging at mid-season approximately 2 months after sowing. Agronomic data on maize growth, development, yield and its components as recommended in Ghana were taken during the cause of the trial. Maize was harvested at physiological maturity on the 23rd of October 2012. The maize plants were cut from above ground level and cobs removed from the stems, weighed. The cobs were then dehusked and also weighed and then dried to permanent weight and the hand shelled and yields taken for analysis. Maize samples were taken for 100-grain weight measurements. Data on insect pests and diseases would also be taken during the course of the season. The agronomic data were then subjected to standard statistical analysis and where mean values were found to be statistically significant, means were separated using the least significant difference at the ($P<0.05$) level..

Major Findings

Extra-early maize

There was a significant ($P<0.001$) maize variety by nitrogen influence on maize grain yield. The highest maize yield was obtained when 120 kg Nitrogen was applied to maize variety 2004 TZEE-W Pop STR C4 followed closely by the same variety when 80 kg N ha^{-1} was applied. However, the lowest grain yield was obtained the CSIR-Abontem when no N was applied. Generally, mean maize grain yield increased with increase in rate of N applied, but beyond 120 kg N ha^{-1} maize grain yields declined for all the varieties tested in the study. Similarly, mean maize grain yields were highest with 2004 TZEE-W Pop STR C4 followed by and were lowest for 99 TZEE-Y STR. Grain yield of maize when 120 kg N ha-1 was applied to maize variety 2004 TZEE-W Pop STR C4 was significantly ($P<0.001$) greater than all the treatments except when 80 kg N and 160 kg N ha^{-1} were applied to the same variety. Application of 80 kg N ha^{-1}, produced comparable grain yields to when 120 kg N ha^{-1} was applied and even greater that when 160 kg N ha^{-1} was applied (Table 4). This indicates that application of N in excess of 80 kg N ha^{-1} is not economically justifiable in maize production in this study.

Table 4.Interaction effect of maize variety and rate of nitrogen on maize grain yield (kg/ha) at the Manga Agricultural Research Station in the 2013 cropping season.

Maize variety	Rate of Nitrogen (kg/ha)					
	0N	40N	80N	120N	160N	Mean
2000 SYN EE-W STR	702	1900	2203	2245	1730	1756
2004 TZEE-W Pop STR C4	810	2275	2930	3052	2680	2349
TZEE-W Pop STR QPM C0	890	2164	2248	2620	2057	1996
99 TZEE-Y STR	902	972	1117	1468	1443	1180
CSIR-Abontem	647	2443	2582	2560	2434	2133
Mean	790	1951	2216	2389	2069	
Lsd (1%)	788					
C.V. (%)	25.7					

Early maize

There was no significant ($P<0.05$) genotype effect nitrogen use efficiency, however, the CSIR-Omankwa recorded the highest NUE whilst the farmer's variety recorded the least. There no significant ($P<0.05$) genotypic effect on maize grain yield, however, the CSIR-Omankwa produced the highest grain yield, followed by the CSIR-Aburohema, whilst the farmers' variety produced the lowest grain yield. The improved drought tolerant maize varieties produced a mean grain yield increment of 12% over that produced by the farmers' variety. Generally, maize grain yield increased with increase in rate of N applied, with the highest N rates of 120 and 160 kg N ha^{-1} recording the highest grain yields, which are significantly ($P<0.001$) higher than those produced when no N was applied and also when 40 kg N was applied. Straw yield was not significantly ($P<0.05$) affected by maize genotype effect, however, CSIR-Aburohema produced the highest straw yield whilst, TZE-W DT STR C4 produced the least. There were significant ($P<0.001$) differences across the N treatments, with the highest N rates of 120 and 160 kg N ha^{-1} producing significantly ($P<0.001$) higher straw yields than the rest of the treatments (Table 5).

Medium maize

Rain water use efficiency (RUE) was significantly ($P<0.001$) affected genotype and rate of nitrogen. Obatampa used rainwater more efficiently than any of the genotypes, which was significantly ($P<0.001$) higher than the farmers' variety and Sanzal Sima. The farmers' variety was the least efficient genotype with regards to water use efficiency. Rainwater use efficiency was significantly ($P<0.001$) affected by nitrogen (Table 6).

Table 5. 100-grain weight; harvest index; rainwater use efficiency; nutrient use efficiency grain and straw yields of early maize varieties as affected by maize variety and nitrogen interaction in a semi-arid agro-ecology in 2013.

Variety	100-grain weight (g)	H.I.	RUE (kg/mm)	NUE (kg/kgN)	Grain yield (kg/ha)	Straw yield (kg/ha)
TZE Comp3 DT C2F2	20.35	0.38	2.0	20.5	1307	1920
TZE-W DT STR C4	19.18	0.39	1.9	17.6	1283	1680
CSIR-Aburohemaa	20.25	0.34	2.0	19.0	1321	2047
CSIR-Omankwa	22.40	0.42	2.4	22.2	1555	1953
Farmers variety	15.32	0.33	1.5	14..9	959	1547
Mean	19.62	0.37	2.0	18.8	1285	1829
LSD(0.01)	3.83	0.095	1.15	4.45	NS	NS
N level (kg/ha)						
0	15.64	0.16	0.47	-	327	1340
40	20.65	0.45	2.1	33.9	1354	1587
80	20.14	0.43	2.2	17.5	1396	1693
120	20.79	0.43	2.6	14.1	1687	2207
160	20.89	0.40	2.6	10.0	1683	2320
Mean	19.78	0.37	1.99	18.9	1289	1829
LSD (0.01)	1.77	0.053	0.44	4.5	291	343
CV%	15.0	22.6	35.3	30.0	35.7	29.7

There was a systematic increase in rainwater use efficiency with increase in rate of nitrogen. Nitrogen levels of 120 and 160 kg N ha^{-1}, recorded significantly (P<0.001) greater rainwater use efficiencies compared to those obtained when no nitrogen was applied or when 40 kg N ha^{-1} was applied. Similarly, there was no significant interaction between genotype and rate of nitrogen on nitrogen use efficiency (NUE) however, maize genotype and rate of nitrogen significantly (P<0.001) affected NUE. Obatampa recorded the highest NUE followed closely by TZE Comp 3 DT C2F2, whilst the farmers variety recording the lowest. Obatampa recorded significantly (P<0.001) greater NUE compared to those recorded for the farmers' variety and Sanzal Sima. Generally nitrogen use efficiency decreased with increase in nitrogen applied. There were significant (P<0.001) differences among the rates of nitrogen applied, with the lower N rate of 40 kg N ha^{-1}, recording significantly (P<0.001) the highest NUE, whilst the highest N rate of 160 kg N ha^{-1} recording the least. There was no significant (P<0.001) genotype by rate of nitrogen or genotype effect on maize grain yield except rate of nitrogen. However, Obatampa recorded the highest NUE whilst TZE-W DT STR C4 recorded the least (Table 6).

Conclusion/Recommendations

For the two years that this study has been conducted the results are consistent, indicating that the application of nitrogen significantly improved maize growth, development, yield and its components as against the no-application of inorganic fertilizer.

Table 6. Days to 50% anthesis, silking, anthesis silking interval, SPAD reading, rainfall and nitrogen use efficiencies as affected by maize variety and nitrogen interaction in a semi-arid agro-ecology in 2013.

Variety	100-grain weight (g)	H.I.	RUE (kg/mm)	NUE (kg/kg N)	Grain yield (kg/ha)	Straw yield (kg/ha)
TZE Comp3 DT C2F2	118	33.0	2.0	20.5	1799	2757
Sanzal Sima	110	33.2	1.9	17.6	1794	3363
TZE-W DT STR C4	121	30.7	2.0	19.0	1755	3087
Obatampa	132	32.8	2.4	22.2	2142	3450
Farmers variety	105	30.7	1.5	14..9	1852	2430
Mean	117	32.3	2.0	18.8	1868	3017
LSD(0.01)	12.5	6.7	0.44	4.45	NS	643
N level (kg/ha)						
0	84	18.4	0.47	-	379	1340
40	102	30.6	2.1	33.9	1739	1587
80	99	35.2	2.2	17.5	2388	1693
120	101	38.8	2.6	14.1	2410	2207
160	98	38.7	2.6	10.0	2425	2320
Mean	97	32.3	1.99	18.9	1868	1829
LSD (0.01)	7.66	3.26	0.44	4.5	298	343
CV%	12.5	15.9	35.3	30.0	25.2	29.7

H.I. = Harvest index RUE= Rainfall use efficiency, NUE = Nitrogen use efficiency

This is to be expected in the Sudan savanna agro-ecology, which is perceived to the region with the poorest soils in the country. This situation is further exacerbated by the continuous cropping of cereal after cereal with the application of very limited manures and inorganic fertilisers leading to consistently declining crop yield over the years. In order to sustain livelihoods in this zone, there is therefore the need to add modest level of fertilizer so as to increase and maintain crop productivity and production in the zone. The application of 40 to 8o kg N ha-1, is crucial towards realising food self-sufficiency in the Upper East Region, which has been tagged a net food deficit Region in the country.

Sorghum Adaptation trial in northern Ghana.

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Saaka S. Buah; Peter, A. Asungre and Emmanuel Y. Ansoba
Estimated Duration: 2 years
Sponsors: IITA/ICRISAT/USAID Africa Rising Feed The Future Project
Location: Manga and Bonia

Background Information/Justification/Introduction

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. It is against this background that this on-station testing of promising sorghum hybrids and varieties are being proposed for evaluation initially on-station and later with farmers on-farm with a view to coming out with the most adapted varieties for release for mass production to manage the food insecurity been experienced by the Upper East Region over the years.

Brief Objectives: To test and to adapt sorghum varieties to the conditions of northern Ghana.
Expected Beneficiaries: Sorghum farmers and consumers and marketers of millet products in Ghana.

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 (2011-2012) of the experimental site was mm, it is mono-modal, starting in June and ending in October. Soil samples were taken for the determination of soil chemical and physical properties. The experimental treatments are as follows: Fada; Jakube; Pablo; Serwa; Soumalemba and the farmer variety (Kadaga). The experimental design was a randomised complete block with 4 replicates. Plot size for each treatment will be 4.5 m x 5m. Sorghum 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). First weeding was done at exactly two weeks after sowing. Basal inorganic fertilisers was applied immediately after the first weeding by hill placement method at 2 weeks after sowing at the rate of 60 kg N, 60 kg, 60 kg P_2O_5/ha as triple super phosphate (TSP) and 60 kg K_2O/ha as Muriate of Potash (MOP) at sowing. Top-dressing with S/A at the rate of 40 kg N/ha for all treatments at 2 weeks after the first fertiliser application as recommended for maize cultivation in Ghana. Ridges were re-shaped at mid-season to control any remnant weeds and also control root lodging at mid-season. SPAD-502 readings were taken at flowering on the 22nd of October. Data on insect pests and diseases would also be taken during the course of the season. Rainfall use efficiency (RUE) was calculated as grain yield produced per increment of precipitation (Tanaka *et al*., 2007) using the accumulated rainfall from 1st July to 31th October for the season. Sorghum was harvested on the 4th of November 2013 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.

Major Findings

Bonia

Jakumbe and Serwa gave grain that were significantly (P<.0.001) bigger than those produced by the other genotypes. Similarly, Fada and Kadaga produced grain that were significantly bigger than those produced by Serwa. Harvest index of sorghum was significantly (P<0.001) affected by genotype with Jakumbe and Pablo recording the highest harvest indices and Kadaga the smallest. Jakumbe; Pablo and Soumalemba produced significantly greater harvest indices compared to Kadaga. Grain yield of sorghum was significantly (P<0.001) affected by genotype. Pablo produced the highest grain yield whilst the farmers' variety produced the lowest. Pablo produced significantly (P<0.001) higher grain yield as compared to those produced by Serwa and Kadaga (Table 7). Similarly, the other improved sorghum genotypes produced superior grain yield as compared to the farmer variety. Straw yield of sorghum was also significantly (P<0.001) affected by genotype. Serwa produced the highest straw yield and the farmer variety the smallest. Serwa; Fada and Pablo produced significantly (P<0.001) greater straw yield compared to those produced by Kadaga and Jakumbe. Rainwater use efficiency, which is a measure of how efficient a genotype uses rainwater was significantly (P<0.001) affected by sorghum genotype. Pablo recorded the highest rainwater use efficiency whereas the farmer variety recorded the lowest. Pablo was significantly more efficient in rainwater use as compared to Serwa and Kadaga. The other improved varieties were also more efficient in rainwater use than Kadaga. A field day was organized at flowering, to solicit farmers' impressions of the panicles of the sorghum genotypes. The panicles produced by Fada and Serwa were the most appreciated by who participated at the field day, whilst those of their own variety, Kadaga was the least appreciated by the farmers. However, for agronomic desirability, Jakumbe was the most preferred followed by Kadaga, whilst, Fada was the least preferred (Table 7).

Table 7. 1000-grain weight, harvest index, grain and straw yields of hybrid sorghum as affected by sorghum varieties at Bonia in 2013.

Sorghum hybrid	1000-grain wright (g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainwater use efficiency (kg $ha^{-1}mm^{-1}$)	Panicle appreci ation	Grain desirability
Fada	16.64	0.22	729	12.8	1.13	3.6	1.7
Jakumbe	23.23	0.15	778	7.8	1.21	3.3	2.9
Pablo	21.38	0.28	1035	11.3	1.61	3.3	2.4
Serwa	13.04	0.25	601	14.0	0.93	3.6	2.1
Soumalemba	-	0.15	-	-	-	-	-
Kadaga	19.41	0.21	160	7.3	0.25	2.9	2.8
Mean	15.62	0.21	551	8.9	0.85	2.78	1.97
LSD (1%)	2.15	0.068	343	2.7	0.53	0.48	0.718
C.V. (%)	9.1	21.5	41.4	20.6	41.4	11.3	24.2

Manga

Grain yield was significantly (P<0.01) affected by genotype. Pablo produced the highest grain yield whilst Jakumbe produced the lowest. Pablo produced grain yield that was significantly (P<0.01) higher than those obtained by Jakumbe; Serwa and the farmer variety. The remaining sorghum genotype also produced superior grain yield as compared to Jakumbe. Straw yield was also significantly (P<0.001) affected by genotype. Serwa produced the highest straw yield followed Fada, whereas the farmer variety produced the lowest. Serwa produced significantly higher straw yield compared to the rest of the genotypes with the exception of Fada. Rainwater use efficiency was significantly (P<0.01) influenced by genotype (Table 8). Pablo was the most efficient in water use efficiency whilst Jakumbe was the least efficient in water capture and use. The water use efficiency of Pablo was significantly (P<0.01) greater that those recorded for Jakumbe and the Farmer variety. Serwa and Soumalemba panicles were the most preferred by farmers who participated in the field, whereas Jakumbe was the least preferred. Soumalemba had the best preferred grain followed closely by Pablo and Serwa, whilst Jakumbe was the least preferred (Table 8).

Table 8.1000-grain weight, harvest index, grain and straw yields of hybrid sorghum as affected by sorghum varieties at Manga in 2013.

Sorghum hybrid	1000-grain wright (g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainwater use efficiency RUE (kg mm^{-1} ha^{-1})	Panicle appreciation	Grain desirability
Fada	18.60	0.22	866	12.8	1.34	3.8	3.5
Jakumbe	18.00	0.15	262	7.8	0.41	1.8	1.5
Pablo	22.50	0.28	1337	11.3	2.07	3.8	3.8
Serwa	16.60	0.25	726	14.0	1.13	4.0	3.8
Soumalemba	23.40	0.15	872	-	1.35	4	4.0
Farmers variety	18.40	0.21	737	7.3	0.99	3.5	3.0
Mean	19.60	0.21	783	8.9	1.21	3.46	3.3
LSD (1%)	1.31	0.068	502	2.7	0. 78	0.82	0.90
C.V. (%)	9.5	21.5	42.5	20.6	42.5	15.80	18.30

Conclusion/Recommendations

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.

Researcher-Managed Sorghum Varieties Trial at Manga and Bonia

Principal Investigator: Roger A. L. Kanton
Collaborating Scientists: Saaka S. Buah; Peter, A. Asungre and Emmanuel Y. Ansoba
Estimated Duration: 2 years
Sponsor: IITA/ICRISAT/ USAID Africa Rising Feed The Future Project
Location: Manga and Bonia

Background Information/Justification/Introduction

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. It is against this background that this on-station testing of promising sorghum hybrids and varieties are being proposed for evaluation initially on-station and later with farmers on-farm with a view to coming out with the most adapted varieties for release for mass production to manage the food insecurity been experienced by the Upper East Region over the years.

Brief Objectives: To test and adapt exotic sorghum hybrids and varieties to the conditions of Ghana

Expected Beneficiaries: Sorghum farmers and consumers and marketers of millet products and Ghana at large.

Materials and Methods

A field trials was carried out at the Manga Agricultural Research Station in the Binduri District of the Upper east Region to evaluate the performance of nine hybrid sorghum genotypes for adaptation to the Upper East agro-ecology. At Manga the field to, which the genotypes were planted had been planted to maize for the past three years. Nine hybrid sorghum genotypes were evaluated. These comprised: Caufa; FambDiakumbe; Grinka Yerewolo; GPADiakumbe; Mona; Mwaagu; Nielene; Pablo; Serwa; and 12ADiakumbe. The experimental design was an Alpha design, V = 10; k = 2 and r = 4. The plot dimensions were 4 ridges at 0.75m apart with a length of 5m long giving a plant stand of 17 hills per ridge. The field was harrowed using a Massey Ferguson tractor on the 5th of July 2013. The field was later ridged using a pair of bullocks, laid-out and sown on 11th of July 2013. Approximately three seeds per hill were planted at 0.30m apart and later thinned to two plants on 17th of July 2013. Basal fertilizer application in the form of compound fertilizer 15:15:15 was applied at the rate of 30 kg N; 30 kg P_20_5 and 30 kg K_20 per ha. The rains were late and when they finally arrived they were followed by a prolonged dry spell, which resulted in delayed implementation of these some agronomic practices on schedule. First weed control was by the use of hand hoe on the 9th of August 2013 and the second weed control was carried out on the 27th of August 2013. Sorghum was top-dressed using sulphate of ammonia at the rate of 30 kg N per ha^{-1} on 4th September 2013. Re-shaped of the ridges to avoid root lodging and also to cover the sulphate of ammonia from being washed away with bullocks on 10th of September 2013. Data was taken from the middle 2 rows. The data taken include: seedling vigour, plant stand after thinning, days to 50% heading, days to 50% flowering, SPAD -502 meter reading, plant height (cm), panicle length (cm), stem diameter (mm), panicle appreciate, grain desirability, agronomic score, farmer preference, number of hills harvested, 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 grain weight (g). Sorghum was harvested from the middle rows with a net area of 7.5m^2. Derived variables such as harvest index and rainwater use efficiency of sorghum were computed from primary data.

Major Findings

100-grain weight of sorghum was also significantly ($P<0.001$) affected by genotype, with Mona and Pablo producing the heaviest and Nielene the lightest grain weight. The grain produced by Mona; Pablo and FambDiakumbe were significantly ($P<0.001$) bigger than those produced by Nielene; 12ADiakumbe; GPADiakumbe; Serwa and the farmers variety. Sorghum harvest index was significantly ($P<0001$) influenced by genotype, and followed a similar, trend like 100-grain weight. Pablo recorded the highest followed closely by Mona and Nielene, whilst 12ADiakumbe and GPADiakumbe recording the lowest harvest indices (Table 9). Sorghum grain yield was affected significantly ($P<0.01$) by genotype, with Pablo producing the highest and 12ADiakumbe the lowest grain yield. All the improved varieties with the exception of 12ADiakumbe; GPADiakumbe and Grinko Yerewolo produced higher grain yields compared to the farmers' variety. Panlo; FambDiakumbe; Mona and Nielene produced mean grain yield of 185; 110; 101 and 99% over the farmers' variety. There was significant ($P<0.05$) genotype effect on sorghum straw yield. However, GPADiakumbe produced the highest followed closely by Pablo, whilst Grinko Yerewolo produced the lowest straw yield. Rainwater use efficiency was significantly ($P<0.01$) influenced by genotype, with Pablo recording the highest rainwater use efficiency, which was significantly ($P<0.01$) greater than those recorded by 12ADiakumbe; GPADiakumbe; Grinko Yerewolo and the farmers' variety. The rainwater use efficiency recorded by 12ADiakumbe; GPADiakumbe; Grinko Yerewolo and the farmers' variety were generally lower s compared to the trial mean. Grinko Yerewolo and the farmers' varieties were the most preferred by farmers whilst 12ADiakumbe was the least preferred. Nielene; followed by Pablo and the farmers' varieties received the highest average desirability scores compared to the rest of the genotypes. Nielene; Pablo and Serwa received consistently greater average appreciation and average desirability scores compared to the other genotypes (Table 9).

Conclusion/Recommendations

The current results are preliminary and the study will have to be repeated in the 2014 cropping season so as to enable us confirm or reject them. Pablo; FambDiakumbe; Mona and Nielene are quite promising in terms of both grain and straw yields. There is a severe lack of improved sorghum in Ghana and there is a huge demand by sorghum farmers for improved sorghum varieties that high yielding and also resistant to diseases and pests with some reasonable levels of drought tolerance. Grinko Yerewolo, was very much preferred by farmers as depicted in its high score for both Average appreciation and desirability. There will be the need to monitor its performance in 2014. The best performance would be recommended to the CSIR-SARI Sorghum Improvement Programme for consideration with a view to incorporate their desirable traits into local germplasm for increased and stable sorghum production and productivity in Ghana.

Table 9.100-grain weight, harvest index, grain and straw yields of hybrid sorghum as affected by sorghum genotypes at the Manga Station in 2013.

Sorghum hybrid	100-grain weight (g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainwater use efficiency (kg mm^{-1} ha^{-1}) (RUE)	Average appreciation	Average desirability
Caufa	2.1	0.13	898	5.8	1.39	3.3	3.3
12ADiakumbe	1.9	0.05	300	5.8	0.47	2.3	2.1
FambDiakumbe	2.2	0.15	1212	7.2	1.88	3.1	3
GPADiakumbe	1.9	0.05	454	8.7	0.70	3	2.9
Grinko Yerewolo	1.9	0.10	533	4.9	0.83	4	3.3
Mona	2.3	0.16	1164	6.1	1.80	3.4	3.1
Nielene	1.6	0.15	1152	6.7	1.79	3.9	3.9
Pablo	2.3	0.17	1648	8.3	2.56	3.9	3.8
Serwa	1.9	0.12	954	6.5	1.48	3.7	3.7
Farmers variety	2.0	0.08	578	6.7	0.90	4	3.8
Mean	2.0	0.01	889	6.7	1.38	3.4	3.3
LSD (1%)	0.25	0.046	650	4.4	1.01	1.2	1.2
C.V. (%)	8.6	27.40	50.4	45.3	50.4	23.7	25.4

On-farm evaluation of extra-early, 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: John K. Bidzakin, Saaka S. Buah; James M. Kombiok; Ansoba, E; Asungre, A. P. and Lamini, S
Estimated Duration: 2 years
Sponsors: IITA/DTMA Project
Locations: Binduri and Garu-Tempane Districts

Background Information/Justification/Introduction

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).

Brief Objectives: To determine the economic benefits of planting drought-tolerant maize compared with farmers' varieties; and (iv) Introduce at least one drought-tolerant maize variety or hybrid to at least 50 farmers to enhance maize production in northern Ghana.

Expected Beneficiaries: Maize farmers and consumers and marketers of millet products and Ghana at large.

Materials and Methods

In 2013, field trials were conducted at Garu-Tempane, Bainduri and Bawku West 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 (Mother trial) while 2 or 3 entries were planted by 5 other farmers in each of the 2 districts (Baby trial). The maize varieties and hybrids tested were: TZEE-W Pop STR C5 x TZEE I21; TZEE-W Pop STR QPM C0; TZEE I29 x TZEE I49; TZEE-W pop STR C4; CSIR-Abontem and Farmers variety for the extra-early; TZE Comp 3 DT C2F2; TZE-W DT STR C4; Waak-Dataa; CSIR-Aburohemaa and CSIR-Omankwa and for the medium maturity group, IWD C3 SYN F2; TZL Comp 1-W C6 DT SYN 1-W; DT SR-W C2F2; DT SYN F2 and the Farmers variety. However, due to lack of seed the baby trials could not be implemented. The randomised complete block design was adopted, with 4 replications. Plot dimensions used were 4.5 m x 5m. 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. Sowing was done on the 6th of July 2012 on ridges made with bullocks. Maize was sown at the rate of 3 to 4 seeds per hill at a spacing of 0.4 m between hills and later thinned to 2 plants per hill as practiced in the country. First weeding was done on the 16th of July 2013 and second weeding on 15th of August 2013. Compound fertilizer NPK (15-15-15) was applied on the 19th of July and topdressing was done on the 29th of July 2013. The compound fertiliser was applied in the form of 15:15:15 at the rate of 40 kg N; P_20_5 andK_20 per ha; whilst in the topdressing sulphate of ammonia (S/A) was used at the rate of 40 kg N per ha. The ridges were reshaped with bullocks two months after sowing to avoid root lodging and for weed control. Standard agronomic data on maize growth, development, yield and its components were taken. Other derived variables such as harvest index (H.I.), rainfall use efficiency (RUE) were calculated. The incidence of insect pests and diseases was too low to have any economic effect on maize yields. The data was then subjected to statistical analysis using GenStat Release 13, and means were separated using standard errors.

Major Findings

Extra-early maize

Generally, maize grain yields recorded for the extra-early baby trials as usual were consistently lower than their mother trial counterparts. Grain yield of maize was significantly (P<0.05) affected by variety and hybrid (Table 10). With TZEE-W Pop STR QPM C0 producing the highest grain yield and followed closely by TZEE-W Pop STR C5 x TZEEI 21, whilst the TZEEI 21 x TZEEI 49 produced the lowest grain yield. Straw yield of maize was not significantly (P<0.05) affected by maize genotype. However, the CSIR-Abontem produced the highest straw yield followed by TZEE-W STR QPM C0, whilst TZEEI 21 x TZEEI 49 produced the lowest straw yield (Table 10).

Table 10. Yield and its components of extra-early drought tolerant maize varieties and hybrids tested on-farm at Garu-Tempane District in northern Ghana in the 2013.

Maize variety/hybrid	Cob aspect	1000-kernel weight (g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainfall use efficiency (kg mm^{-1} ha^{-1})
TZEE-W Pop STR C5 x TZEEI 29	2.0	23.02	0.60	3093	2100	4.8
TZEE-W Pop STR QPM C0	2.0	23.28	0.55	2827	2150	4.4
TZEE 129 x TZEE 149	1.8	23.89	0.59	2693	2000	4.2
TZEE-W Pop STR C4	1.8	23.97	0.61	2947	1850	4.6
CSIR-Abontem	2.8	26.14	0.32	1747	3417	2.7
Farmers' variety	2.5	21.70	0.53	2213	1950	3.4
Mean	2.1	23.67	0.53	2587	2244	4.0
s.e.d.	0.48	1.98	0.051	591	341	0.92
C.V. (%)	31.7	11.8	13.6	32.3	21.5	32.3

Early maize

Maize height was significantly (P<0.09) affected by genotype. CSIR-Aburohema produced the tallest maize plants, that were significantly (P<0.09) taller than those produced by TZE Comp 3 DT C2F2 and Waak-Data. 100-grain weight of maize was not significantly (P<0.05) affected by genotype, however, Waak-Data produced the biggest grain and TZE Comp 3 DT C2F2, the smallest (Table 11). Maize harvest index was similarly, significantly (P<0.09) affected by genotype, with TZE-W DT STR C4; Waak-Data and CSIR-Aburohema recording the highest harvest indices and CSIR-Omankwa the lowest. Generally, maize grain yield recorded under this study were higher than those usually reported for the Region. Grain yield was not significantly (P<0.05) affected by genotype. CSIR-Omankwa produced the highest grain yield followed closely by TZE-W DT STR C4 and TZE Comp 3 DT C2F2. Straw yield of maize was significantly (P<0.06) affected by genotype. CSIR-Omankwa produced the highest straw yield and CSIR-Aburohema the smallest. Rainwater capture, use and use efficiency was generally, impressive for all the genotypes. Waak-Data recorded the highest rainwater use efficiency and CSIR-Aburohema the lowest (Table 11).

Table 11. Yield and its components of extra-early drought tolerant maize varieties and hybrids evaluated on-farm at Bawku West District in northern Ghana in the 2013.

Maize variety/hybrid	Stay green	100-kernel weight (g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)	Rainfall use efficiency (kg mm^{-1} ha^{-1})
TZEE-W Pop STR C5 x TZEEI 29	4.0	21.75	0.38	2053	3317	3.2
TZEE-W Pop STR QPM C0	3.5	24.00	0.45	2853	3617	4.4
TZEE 129 x TZEE 149	3.3	23.50	0.46	2507	3050	3.9
TZEE-W Pop STR C4	3.0	22.25	0.38	2116	3467	3.3
CSIR-Abontem	3.8	22.00	0.44	2533	3200	3.9
Farmers' variety	4.0	22.25	0.46	2702	3217	4.2
Mean	3.6	22.62	0.43	2461	3311	3.8
s.e.d.	0.35	1.76	0.058	406	960	0.63
C.V. (%)	13.80	11.00	19.00	23.30	19.20	23.30

Medium maize

Maize harvest indices obtained in this study were generally large as compared to those usually reported for maize. Harvest index of maize was significantly (P<0.05) influenced by genotype. Farmer variety recorded the highest harvest index followed closely by IWD C3 Syn F2 and TZU TSR W SGY Syn the smallest. Grain was significantly (P<0.05) affected by maize genotype. IWD C3 Syn F2 produced the highest yield and TZU TSR W SGY Syn the lowest grain yield (Table 11). IWD C3 Syn F2 produced significantly (P<0.05) higher grain yield than TZU TSR W SGY Syn and TZU SR-W Syn. Sanzal-Sima also produced significantly (P<0.05) higher grain yield than TZU TSR W SGY Syn. Straw yield of maize was not significantly (P<0.05) affected by genotype. However, IWD C3 Syn F2 and DT STR-W Syn produced the highest and Farmer variety the lowest straw yield. Rainwater use efficiency was significantly (P<0.05) affected by genotype, with IWD C3 Syn F2 recording the highest rainwater use efficiency and TZU TSR W SGY Syn the lowest (Table 10). DT SR-W Syn and Sanzal-Sima also recorded appreciably higher rainwater use efficiencies as compared to the rest of the genotypes (Table 12).

Conclusion/Recommendations

These on-farm tests have demonstrated the potential of improved drought-tolerant maize varieties and hybrids for increasing and sustaining maize production and productivity in the Upper East Region, which until recently featured only millet and sorghum-based cropping systems. It is anticipated these varieties will help farmers to overcome the perennial initial, mid or terminal drought that is characteristic of the region, which often result in complete maize crop failure. These varieties can also increase the incomes of farmers in the area, given that their estimated rates of returns to investment are quite high. From these two years results, the following varieties would be recommended to the National Variety Release and technical Committee for consideration for release in 2014 to increase maize production and productivity in Ghana. For the extra-early maturity group: TZEE-W Pop STR C5 x TZEEI 29; TZEE-W

Pop STR QPM and TZEE-W Pop STR C4, for the early maturity group: TZE Comp 3 DT C2F2 and TZE-W DT STR C4 and for the medium maturity group: IWD C3 Syn F2 and DT STR-W Syn 2.

Table 12. Cob aspect, 100-grain weight, harvest index, grain and straw yields and rainwater use efficiency of early drought tolerant maize varieties and hybrids evaluated on-farm at the Garu-Tempane District in northern Ghana in 2013.

Maize variety	50% silk	Plant height (cm)	Harvest index	Grain yield (kg/ha)	Straw yield (kg/ha)
TZE Comp 3 DT C2F2	57	112	0.26	1665	1949
TZE-W DT STR C4	59	108	0.30	1629	2096
Waak-Dataa	57	106	0.39	2367	1726
CSIR-Aburohemaa	60	122	0.35	2523	2101
CSIR-Omankwa	59	111	0.38	2721	2227
Mean	54	112	0.34	2181	2020
s.e.d.	1.99	10.95	0.042	355	508
C.V. (%)	4.38	24.11	15.43	19.06	27.39

Compatibility of Millet and Legume Under Relay Cropping Condition

Principal Investigator: Yirzagla Julius
Collaborating Scientists: N. N. Denwarb, W. Dogbe, R.A.L. Kanton, I. Y. B. Inusah, D. B. Akakpo, I. Mohammed

Executive Summary

Double-cropping millet and legumes is a popular cropping system in the Upper East region (UER) of Ghana.For improved production efficiency, suitable millet-legume combinations with short life cycles that permit extension of the growing season to facilitate double-cropping need to be explored. The objective of this study was therefore to use performance data to identify millet-legume combinations compatible for relay cropping within the UER. Three millet cultivars (Bongo Short head, Arrow Millet and Bristled Millet) were factorially relayed by three legumes namely cowpea, groundnut and soybean. In both cropping seasons, cowpea accounted for the highest grain yield among the legumes and is most likely to provide the most compatible combination with the millet cultivars. Bongo short head (BSH) out-yielded the other millet cultivars and relaying with cowpea is likely to offer the most promising combination for relay cropping within the UER.

Introduction

Double-cropping cereal and legume is a popular cropping system in the Upper East region (UER) of Ghana. Relay cropping or inter-seeding legume into standing maize is a concept that has been explored in the Midwest as a means of extending the growing season to facilitate double-cropping (Duncan et al., 1990; Moomaw & Powell, 1990 and Reinbott et al., 1987). Cereal-legume combinations with short life cycles provide excellent opportunity for double cropping in UER where diminishing soil moisture creates terminal drought stress and thus reduces profit potential, especially for the legumes.

The objective of the current study was therefore to use performance data to identify millet-legume combinations compatible for relay cropping within the UER. Specifically, the study was to examine the grain yield and yield components of three millet cultivars and three legumes (soybean, groundnut and cowpea) under the relay cropping conditions.

Materials and Methods

The experiment was conducted during the 2011 and 2012 cropping seasons (May/June to September/October) on Manga experimental station, near Bawku (11°01N, 0°16'W, 249m above sea level). Seeds of the millet cultivars, Arrow millet (AM), Bongo Short Head (BSH) and Bristled millet (BM) as well as the legumes (groundnut, cowpea and soybean) were obtained from the Savanna Agricultural Research Institute (SARI), Nyankpala. The millet and legume components were planted in a randomized complete block design (RCBD) with three replications. Factorial inter-seeding of the legumes in the standing millet was done one week to the harvest of each millet cultivar. The following treatments (millet-legume combinations) were used in the study: AM/ G: Arrow millet followed by groundnut; AM/CO: Arrow millet followed by cowpea; AM/SOY: Arrow millet followed by soybean; SH/G Bongo Short Head followed by g'nut; BSH/CO: Bongo Short Head followed by cowpea; BSH/SOY:Bongo Short Head followed by soybean; BM/G: Bristled Millet followed by groundnut; BM/CO: Bristled Millet followed by cowpea; BM/SOY: Bristled Millet followed by soybean

Data collection and analysis

Data was collected of millet on Stand count at establishment, Stand count at mid-season, Stand count at harvest, Days to 50% flowering (DFF), spike length, spike girth, Stover weight, incidence of Downy Mildew (DM) at establishment, and at maturity, 100 grain weight (100GW) and Grain yield. Data collected of legumes included Days to 50% flowering (DFF), stover weight and Grain yield. Statistical analyses were conducted

Results and Discussion

The 1000-grain weight of pearl millet was generally low with Bristle millet recording the heaviest 1000-grain weight followed by Bongo Shorthead with Arrow millet producing the least. In terms of straw yield, Bongo Shorthead produced the highest straw yield in both cropping seasons followed by Bristled millet, whilst Arrow millet produced the lowest (Table 1). Grain yield values were statistically different in both seasons with BSH maintaining consistently higher values above the mean yields of 2.333t/ha and 2.58 t/ha in 2011 and 2012 respectively (Table 1). Grain yields of Arrow Millet were below these mean figures in both cropping seasons.

Table 1: 1000GW, Straw yield and Grain yield of millet under relay condition during 2011 and 2012 cropping seasons

TREATMENT	2011			2012		
	1000GW (g)	Straw Yield (t/ha)	Grain Yield(t/ha)	100GW (g)	Straw Yield (t/ha)	Grain Yield(t/ha)
AM/ G	9.0	15.8	1.797	8.8	14.3	2.64
AM/CO	8.5	25.3	2.130	8.5	24.5	1.36
AM/SOY	9.5	24.5	2.080	8.0	25.8	2.12
BSH/G	9.5	28.9	2.567	9.5	29.1	4.27
BSH/CO	8.8	25.2	2.447	9.5	31.5	3.82
BSH/SOY	9.2	27.5	2.660	9.5	30.8	4.18
BM/G	11.5	21.7	2.373	10.0	22.1	1.49
BM/CO	10.0	25.3	2.590	11.5	26.1	1.51
BM/SO	12.5	21.9	2.350	11.9	23.5	1.81
MEAN	**9.8**	**24.0**	**2.333**	**9.7**	**25.3**	**2.58**
Lsd (p<0.05)	**0.46**	**0.85**	**0.5172**	**0.71**	**1.02**	**1.267**
CV (%)	**14.2**	**11.1**	**8.0**	**13**	**15.3**	**28.5**

Responses of legume grain yield and other agronomic traits to relay cropping systems
In terms of stover and grain yields cowpea clearly maintained consistent yield superiority over the other legumes with cowpea stover yield values ranging from 14.5t/ha (in 2012 under AM/CO) to 17.2t/ha (in 2011 under BSH/CO), followed by soybean with stover yield range of 8.5t/ha (in 2012 under BM/SOY) to 12.9t/ha (in 2011 under BM/SOY). Groundnut produced the least stover ranging from 7.7t/ha (in 2012 under BSH/G) to 9.7t/ha (in 2011under BM/G). Legume grain yield trend was similar to that of stover yield as cowpea out-yielded the other legumes with a range from 3.13t/ha (in 2011 under AM/CO) to 4.82t/ha (in 2012 under BSH/CO) followed by soybean whose grain yield ranged from 1.80t/ha (in 2011 under AM/SOY) to 3.12t/ha (in 2012 under AM/SOY). Groundnut produced the least grain yield, ranging from 1.27t/ha (in 2012 under BSH/G) to 2.64t/ha (in the same year under AM/ G).

The fact that Bongo Shorthead was more significantly ($P<0.05$) affected by the downy mildew incidence and also recorded the highest number of chaffy heads and still accounted for the greatest straw and grain yields suggests that with adequate control measures against the incidence of downy mildew and chaffy heads, Bongo Shorthead could be a preferred cultivar for the relay cropping system. The higher grain and straw yields could be attributed to their relatively higher plant population and better resource utilization. The low incidence of downy mildew and number of Chaffy heads in Bristled millet could be attributed to its inherent ability to resist the disease. Thus plant breeding efforts geared towards conferring resistance in Bongo Shorthead from Bristled millet could further enhance the suitability of the former cultivar in the cropping system.

Bongo Shorthead was the earliest to attain 50% flower initiation in 2012 season, flowering significantly earlier than the rest of the cultivars and was also among the earliest to flower in both cropping seasons. The cultivar thus has desirable agronomic attributes in terms of maturity period as the short maturity enables it to fit into the short cropping season and erratic rainfall patterns typical of the Guinea and Sudan savanna zones of Ghana (Padi, 2007). The early maturing cultivar could complete its life cycle before the severity of the terminal drought which otherwise would have suppressed grain and straw yield considerably.

Conclusions/Recommendations

Under normal rainfall pattern, BSH-cowpea combinations have the greatest prospect of accounting for superiority in grain yield. This could be attributed to their earliness to flower initiation. It is most likely that cowpea will equally provide compatible combination with any of the other millet cultivars under moderately high probability of unfavourable weather (rainfall) conditions and hence has good prospects of promoting double cropping within the farming system in the UER.

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Contribution of plant spacing and N fertilizer application to growth and Yield of Sesame (*Sesamum indicum* L.)

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Executive Summary

Field trials on sesame were conducted at the Manga Agricultural Research Station during the 2009 and 2010 cropping seasons to determine the optimal rate of nitrogen fertilizer and intra-row spacing for sesame production. Consistently, intra-row spacing of 30 and 40cm produced the best results in both seasons in terms of grain yield. Marginal insignificant yield response was observed with increased nitrogen level attaining the peak at 80kgN/ha. Main effects of nitrogen rates and intra-row spacing significantly ($P \leq 0.001$) affected most of the traits evaluated more than the interaction effects. Plant spacing of 75cm x 30cm at N application of 80kgN/ha recorded the highest grain yield (273kg/ha) in 2009 while 75cm x 30cm at 0kgN/ha (control) recorded the least grain yield (60kg/ha) in 2010. Sesame plant height was significantly ($P \leq 0.001$) influenced by N application with plant height increasing with increase in N rate, attaining a maximum height of 142cm at 60kgN/ha.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest spice and oilseed crop in the world. Its seeds contain approximately 50% oil and 25% protein (Burden, 2005). The presence of some antioxidants (sesamum, sesamolin and sesamol) makes the oil to be one of the most stable vegetable oils in the world. The oil contains mainly unsaturated fatty acids (oleic and linoleic of about 40% each) and 14% saturated acids. Sesame seed contains 17-19% protein and 16-18% carbohydrate (Ustimenko-Bakumovsky, 1983).

Materials and Methods

Field trials were conducted at the Manga Agricultural Research Station during the 2009 and 2010 cropping seasons. Using the randomized complete block design (RCBD) with 4 replications, the 2 factors studied (rate of nitrogen and intra-row spacing) were factorially combined in a plot dimension of 6 ridges each measuring 0.75 m apart and 5 m long. Seeds of the sesame were brought from Burkina Faso by the Association of Church Development Projects (ACDEP) based in Tamale. The factors studied were different intra-row spacing (20cm, 30cm, 40cm, and 50cm each by a constant inter-row spacing of 75cm) and levels of nitrogen (0kg, 20kg, 40kg, 60kg, and 80kg) on the performance of Sesame. A fixed inter-row spacing of 75cm was maintained since that was the predominant practice of the farmers within the study area. Two weeks after sowing, seedlings were thinned to 2 plants per hill followed by the basal application of fertilizer. At the various rates of nutrients under study, full rate of P-fertilizer as single superphosphate, K-fertilizer as muriate of potash and half rate of N-fertilizer as sulphate of ammonia were applied. The remaining half of N-fertilizer was applied as a top-dress in the form of Sulphate of ammonia at exactly 4 WAS. Each fertilizer application was preceded by weeding so as to reduce the effect of weed competition.

On plot basis, 5 plants were selected at random and tagged from the middle rows for the purpose of agronomic data collection. The parameters were stand count, plant height, number of capsules per plant, mean capsule weight, grain yield and biomass yield. The data were subjected to analysis of variance using the GenStat Statistical program (GenStat Discovery Edition 3, version 7.2.0.220), after which means resulting from significant treatment effects were separated using the least significance test by Steel and Torrie (1980).

Results and Discussion

Main effects of nitrogen rates and intra-row spacing significantly ($P \leq 0.001$) affected most of the growth and yield parameters evaluated more than the interaction effects. Generally, mean grain yield in 2010 cropping season was higher than that of 2009. In 2009, grain yield increased with decreasing intra-row spacing possibly due to the crowding effect of plants grown under narrow to medium sized rows (intra-row spacing of 20-40cm). The yields in both seasons were significantly ($P \leq 0.001$) affected by N, with 60 kg N/ha accounting for the highest mean yield of 269kg/ha (in 2010) while the lowest yield of 60kg/ha was recorded under N rate of 0 kg N/ha in the same season (Table 1). In both cropping seasons grain yield increased with increase in N application with the highest mean yield occurring at N rate 60 kg N/ha and 30cm spacing. In 2009, the interaction effect of 75cm x 30cm spacing and 80kgN/ha N rate recorded the highest grain yield (273kg/ha) while 75cm x 50cm at 0kgN/ha (control) recorded the least grain yield of (80kg/ha).

Table 1: Mean grain yield (kg/ha) of sesame as affected by N rate (kg/ha) and intra-row spacing (cm) during the 2009 and 2010 cropping seasons

N application rate (kg/ha)	Grain yield (kg/ha)	
	2009	2010
0	97	62
20	168	165
40	213	229
60	231	269
80	255	259
Lsd (5%)	**42**	**50**
CV %	**40.8**	**41**
Intra spacing (cm)		
20	185	179
30	195	218
40	205	196
50	187	195
Lsd (5%)	**45**	**50.6**
CV %	**30**	**28**

Sesame yields reported in 2010 cropping season were generally higher than those reported on in 2009. Nitrogen at the rate of 60 kg/ha produced the best yields in both seasons compared to the other rates, whereas 30 and 40 cm intra-row spacing consistently produced the best results. Sesame yields in Africa are usually within the range of 200 to 300 kg/ha. Nitrogen fertilizer application significantly affected the performance of most of the parameters recorded in the present study. The low yields reported in the present study could be ascribed to the wider inter-row spacing (75cm) adopted compared to closer inter-row spacing as reported in the literature. Also sesame grain yield increased significantly with increase in the rate of nitrogen fertilization up to 40kg/ha, implying that sesame yields could be boosted through an increase in nitrogen feriliser application. Marginal yield response was observed with increased nitrogen level attaining the peak at 80kgN/ha. This observation is consistent with reports by Olowe (2007) who suggested that sesame is a low N response crop. Earlier reports have shown that maximum grain yield of sesame was recorded on relatively low to medium levels of 30-60 kg /ha by Subramaniah *et al*. (1979) and Daulay and Singh (1982). Ashely (1993) reported optimum population for sesame to be at about 170 – 200, 000 plants /ha. However the findings of both 2009 and 2010 studies do not support the above assertion as there were no significant yield responses by sesame to the varied intra-row spacing used in these studies. The interaction effect of 75cm x 30cm spacing and 80kgN/ha N rate recording the highest grain yield (273kg/ha) and 75cm x 50cm at 0kgN/ha (control) recording the least grain yield of (80kg/ha) in 2009 is similar to study by Olowe and Busari (1994) in Nigeria, who reported that 60cm x 5cm and 60cm x 10cm were the appropriate plant spacing for sesame in southern Guinea savannah of Nigeria. In both cropping seasons, insignificant yield responses were observed with increasing levels of nitrogen attaining a peak at 80kgN/ha. This observation is consistent with reports by Olowe (2007) who suggested that sesame is a low N responsive crop. Earlier reports by Subramaniah et al. (1979) and Daulay and Singh (1982), on the contrary, have indicated that maximum grain yield of sesame was recorded on relatively low to medium levels of 30-60 kgN/ha.

Conclusion

In 2009, N rate of 40 kg/ha, 60 kg/ha and 80 kg/ha produced yields that were among the best whereas in 2010 N rate of 60 kg/ha gave superior results compared to the other rates. Similarly in 2009 intra row spacing of 40 cm gave the best yields whereas in 2010, 30 cm spacing recorded the best.

Recommendation and way forward

Given the contrasting results regarding both N application and intra row spacing there is the need to carry out another trial in order to establish the optimal rate of nitrogen and Spacing. These results will therefore serve as very useful research information for further work on sesame improvement in the country which could leverage the current high levels of poverty in the country.

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Effect of spatial arrangement on the performance of Pearl millet-Cowpea intercrop

Yirzagla, J.

Executive summary

Spatial arrangement of crops is critical in determining the growth and yield of intercrops. The productivity of four spatial arrangements of millet (*Pennisetum glaucum*, [L], Br) and cowpea (*Vigna unguiculata* [L.] Walp) in intercrop was studied from June to October 2010 in the Sudan savannah zone of Upper East Region of Ghana. The intercrop row arrangements were: one-row millet : one row cowpea (1M:1C), two-row millet : one row cowpea (2M:1C), two-row millet : two-row cowpea (2M:2C) and two-row millet : four-row cowpea (2M:4C). There were also the sole crop arrangements of millet and cowpea that formed the basis for comparison with the other arrangements. Even though yields of the intercrop components were lower than their sole crop counterparts, the intercrop components were more productive than the sole crop components as evidenced by the Land Equivalent Ratios (LERs) which ranged from 1.48 to 2.44. The results of the study showed that one row of millet to one row of cowpea (with millet planted 2 weeks before cowpea) proved superior to the other spatial arrangements.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is a major component of the traditional cropping systems within the Upper East Region of Ghana where it is widely grown in mixtures with other crops in various combinations. The dominant intercropping systems for cowpea in the semi-arid tropics is the additive series in which sorghum, millet or maize is planted at the typical population density for sole cropping, and the cowpea is planted between rows of the cereal after the cereal is well established. It is generally grown as the minor crop in a system based on cereal or tuber crop (FCDP, 2005).

The major yield limiting factors of cowpea cropping systems are low population, low yield potential of local cultivars, insect pests and diseases, shading by the cereals and drought stress and low soil fertility. Opportunities for improved management practices that could be exploited to overcome some of these constraints include appropriate sowing date, row geometry, pest incidences, and variety improvement. To overcome the problems of insect pests and diseases as well as shading by the cereals, it is appropriate to develop improved cropping systems using improved cowpea varieties and different crop combinations. There is limited information on the effect of different cereals on the yield and yield components of cowpea in strip cropping system. The objective of this trial was to assess the productivity of cowpea-millet intercrop under different spatial arrangements

Materials and Methods

The trial was conducted in SARI Research Station at Manga, Bawku (11°01N, 0°16'W) in the Sudan savannah zone of Ghana. Six spatial arrangements of millet/cowpea were used as treatments namely, one row of millet alternating with one row of cowpea (1M:1C); two rows of millet alternating with one row of cowpea (2M:1C); two rows of millet alternating with two rows of cowpea (2M:2C); two rows of millet alternating with four rows of cowpea (2M:4C); sole millet; sole cowpea.

The randomized complete block design was used with three replications. Millet seeds were hand-sown in June 2010 in rows 0.75m apart and intra-row spacing of 0.30m at four seeds per hill. Each plot consisted of 6 rows. Cowpea seeds were planted between the millet rows two weeks after, at two seeds per hill with intra-row spacing of 0.20m.. Sowing was done in holes created by manual dibbling with the aid of wooden pegs along planting lines. Within 2 weeks, the millet plants received inorganic fertilizer (NPK) at the rate of 60 kg N/ha, 30 kg P_2O_5 /ha and 30 kg K_2O/ha in split applications of 75% between 10 and 14 days after sowing (DAS), and 25% between 54 and 57 DAS. Cowpea genotypes in both sole and intercropping experiments were not fertilized. The cowpea plants in each experiment were sprayed twice, first at 32–35 DAS, and the second spraying was done 20 days after, to control flower thrips (*Megalurothrips sjostedti*) and a complex of pod sucking insects. The insecticide used was lambda cyhalothrin (Product Karate) at the rate of 20g active ingredient per hectare. Weeds were controlled by hand hoeing whenever it was necessary. Each genotype was harvested promptly when pods were dry.

Growth and yield measurements

The following data were taken on cowpea from 2 central rows**:** Grain yield, stover weight, pod weight per plot, bad (unmarketable shriveled or holed) pods and good (marketable) pods. For millet, Panicle length, grain yield, number of effective tillers per plant, percent incidence of downy mildew, percent incidence of chaffy heads and plant count were taken from 2 central rows.

Estimation of intercrop productivity and competitiveness

The biological productivity of the intercrops per unit of ground area was assessed as a ratio of intercrop to sole crop using the Land Equivalent Ratio (LER) as follows:

$$LER = \left(\frac{Yim}{Ysm}\right) + \left(\frac{Yic}{Ysc}\right)$$

Where *Yim* is the yield of millet under intercropping, *Ysm* is the yield of millet under sole cropping, *Yic* is the yield of cowpea under intercropping, and *Ysc* is the yield of the cowpea under sole cropping (Mead and Willey, 1980).

Results and Discussion

Crop Yields and Land Equivalent Ratios

The Grain yields and other agronomic traits of millet are presented in Table 1. Millet grain yield was highest under one-row millet: one-row cowpea (1M:1C) and lowest under two-row millet : two-row cowpea (2M:2C) as well as sole millet condition. Percent incidence of downy mildew (DM%) was significantly (P >0.05) high under 2M:4C, 2M:1C and 2M:2C but lowest under 1M:1C. There were no significant differences (P >0.05) among the arrangements in terms of initial plant count. One-row millet: one-row cowpea (1M:1C) was among the arrangements that recorded appreciable effective tillers with sole millet recording the least. Total number of effective tillers of millet might have affected millet yields. Even though sole millet recorded the highest number of total tillers, it had the least number of effective tillers as well as highest percentage of chaffy tillers. 2M:2C had the lowest total tillers.

Table 1:Agronomic Response of Pearl Millet as Affected by Spatial Arrangement

Treatment	DM %	P'cle L (cm)	Plt Ht (cm)	Effective Tillers (%)	Chaffy Tillers(%)	Plt count	Grain yield(t/ha)	Total tillers
2M1C	71.3	26	144	34	28.7	32.3	1.97	47.7
2M2C	68.7	22.7	131	36	20	34.3	1.37	45
1M1C	58.4	25	142.7	33.3	46.3	34	2.40	62
2M4C	72.4	21.7	143	27	53.5	34	1.63	58
SM	68.7	24.3	141	26.4	73.6	34.3	1.36	66.7
Mean	67.9	23.94	140.34	31.34	44.42	33.73	1.746	55.88
LSD*(p>0.05)*	22.53	4.429	16.78	1.352	23.71	3.036	1.58	20.27
CV	17.4	3.9	2.7	8.8	19.3	1.2	6.8	4.1

Table 2: Productivity of Pearl Millet as Affected by Spatial Arrangement

Treatment	Plant count /Ha	Plt Ht (cm)	Grain yield (t/ha)	LER	ATER	MEAN LERATER
2M1C	20,976	144	6.66	2.44	0.75	1.59
2M2C	21,3333	131	5.46	2.04	0.52	1.27
1M1C	21,509	142.7	6.51	1.48	0.91	1.19
2M4C	21,124	143	6.8	2.26	0.62	1.44
SM	20,091	141	7.0		0.75	1.59
Mean	21,006	140.3	6.49			
LSD*(p>0.05)*	ns	ns	ns			
CV(%)	2.8	2.2	20.7			

Land Equivalent Ratios (LERs) and the means of the LER and Area-Time Equivalent Ratios (LERATER) used to assess the productivity of the spatial arrangements in Table 2 showed that the intercrops were more productive than the sole crops. LER values showed that intercrop advantage (productivity) ranged from 48% under 1M1C to 144% under 2M1C. The differences in the reproductive yields of the different spatial arrangements are consistent with observation by Azam-Ali *et al.*,(1990). The differences in performance among the intercrop treatments could be accounted for by the differences in plant count. The system is therefore practically relevant to the development of a sustainable cropping system. The agronomic response of cowpea to the spatial arrangements is presented in Table 3. Cowpea grain yield was highest under 2M:4C and lowest under 2M:2C. Bad pods were most associated to 2M:4C and least associated to 2M:2C. Good pods were mostly recorded under the 2M:4C and sole cowpea arrangements. There were no significant differences among the arrangements in terms of stover weight. Two-row millet : four row cowpea (2M:4C) and sole cowpea were among the spatial arrangements that recorded appreciable pod weight per plot while 2M:2C recorded the least. Total number of good pods and pod weight per plot of cowpea might have affected the grain yields of cowpea. Sole cowpea which recorded the highest number of good pods also had the highest number of bad pods. Even though 2M:4C recorded significant numbers of bad pods, it accounted for the highest cowpea grain yield, and was also among the highest in terms of good pods and cowpea pod weight per plot.

Table 3:Agronomic Response of Cowpea as Affected by Spatial Arrangement

Treatment	Pod (t/ha)	Stover wt (t/ha)	Grain yield (t/ha)	Bad pods	Good pods
2M1C	5.3	35.0	4.11	24.3	202
2M2C	4.5	38.3	3.30	17.3	189
1M1C	6.5	38.3	4.66	27	235
2M4C	10.7	35.0	7.36	39.3	418
SC	16.2	36.7	6.86	39.7	423
Mean	8.64	36.6	5.258	29.52	293.4
Lsd(p>0.05)	2.283	ns	0.216	8.69	130.0
CV(%)	1.8	8.8	6.5	10.7	5.9

Studies have shown that nutrient absorption in most crops (including millet and cowpea) is small during their early development, while at the time of full bloom the amount absorbed ranged between 60 to 100 percent (Mittleider and Nelson, 1970). Thus considering the differences in spatial arrangements among the intercrops, it was likely that the millet and cowpea planted at different times (cowpea planted 2 weeks after millet) might have received lesser root competition from each other.

Increase in the productivity of the intercrop may be ascribed to both spatial and temporal advantage. By mixing such crops that have different resource requirements, i.e. light, water and space, it was likely that their demand for resources were at different times. Such complementarity for resource need by the crops is consistent with the findings of Willey (1979). Comparison of the different cropping patterns indicated that the two row millet alternating with one row cowpea (2M:1C) showed the best intercrop advantage. This may have resulted from the efficient use of the available resources. Since millet and cowpea were planted at different times in this cropping pattern, the two crops might have been subjected to less competition from each other. Therefore, to achieve higher intercrop advantage in two crop system such as described in this study, the best option will be an arrangement of one row millet alternating with one row cowpea.

Conclusion

Though farmers generally regard legume yield under cereal-legume cropping system as bonus harvest, the study shows that strip intercropping especially 2M:1C is more productive than the sole cropping. The higher intercrop advantage indicated that the system was more efficient in terms of resource use than the sole crops.

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Evaluation of Pearl millet improved local genotypes for adaptation to the semi-arid agro-ecology of northern Ghana.

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Duration: 4 years
Sponsors: IGF and WAAPP 2A
Location: Upper East Region

Background Information/Justification/Introduction:
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] as a cereal crop has been neglected, and especially in Ghana for some time because it has been tagged as the poor man's crop. Pearl millet is among the most important staple cereals in northern Ghana.Howeverthe lack of improved varieties and proper intensification systems has led to a decline in pearl millet yields over the years. Research efforts at breeding stable, high yielding and disease resistant/tolerant varieties as well as appropriate agronomic packages that go with them, is crucial if current production levels (less than 1 t/ha) are to be increased to meet the ever increasing demand for food in the region. The evidence of climate change effect is fast hitting hard on the country and particularly northern Ghana. Rainfall amounts on annual basis continue to fluctuate with souring temperatures. 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. Pearl millet will soon become a regionally important alternative feed grain, forage crop and as a cover crop or mulch, for fuel, fencing, and roofing material, apart from its use as a food crop, in subtropical areas of Africa. The Savanna Agricultural research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) engaged a millet breeder in the later part of the 1990s, who bred for early maturing, insects pests and diseases resistant pearl millet varieties, which are being evaluated for subsequent release for mass production in Ghana. Intensifying the adoption and use of these improved pearl millet varieties developed by the CSIR-SARI by progressive farmers and community seed producers for increase yields and productivity and well-being of the rural poor is therefore critical for food security in northern Ghana.

Brief Objective: To release and intensifying the adoption and use of improved pearl millet varieties developed by the CSIR-SARI in the Upper East Region of Ghana.

Expected Beneficiaries: Food and commercial farmers and input dealers of Upper East region and other interest groups as well as neighbouring countries.

Materials and Methods:
The millet breeding team at CSIR-SARI, Manga initially requested for germplasm from ICRISAT-Niger and Mali for screening work. The germplasm received did not meet the immediate needs (earliness) of the farmers since all of them were either medium or late maturing materials. There was therefore a collection mission in July-August 1996 that did some collection of local landraces being used by the farmers but which were plagued with disease and low yield problems. These collections were screened out of which four were

selected and subjected to recurrent selection from 2002 to 2007. A simple crossing technique was used to combine the good traits of local Manga Nara and SOSAT-C88 from ICRISAT which resulted in a line called SOXSAT. A fairly stable, uniform and relatively higher yielding materials were then used for Preliminary Yield Trials (PYT) for two years and then moved to Advance Yield Trials (AYT) both on-station and on-farm since 2010 using the Participatory Varietal Selection (PVS) approach.

The design of the trials was a Randomized Complete Block with 4 replications. The plot 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 44,445 plants/ha. Split application of fertilizer was done at a rate of 40 kg N/ha and 30 kg P2O5 and 30 kg K per hectare. Multi-location variety trials were conducted across Upper East region to evaluate the performance of the new and promising genotypes. Trials were established at Bawku and Garu representing the Eastern zone, Gambibigo and Yikene, representing the central zone, and Kandiga and Punyoro representing the western zone of the Upper East region.

All 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.

Major Findings

The work was rewarded with 5 improved genotypes which have been tested for adaptation to the Sudan savanna agro-ecology of northern Ghana. The improved genotypes are; Arrow, Bongo Short Head (BSH), Bristle millet, Soxsat, and Tongo Yellow (TY). Both on-station and on-farm results indicate that the improved genotypes are superior to the local check (Manga Nara) in traits like grain yield and downy mildew incidences but not earliness.

Days to fifty percent flowering, grain and stover yields, 1000 seed weight, threshing percentage and harvest index were not significant for all varieties during the year under review (Table 1).

Table 4: Performance of improved genotypes as influenced by yield components

Variety	DM Incid	DFF	Grain yield/ha (kg)	Stover yield/ha (t)	1000 seed wt (g)	Threshing %	Harvest Index
Arrow		48	1,893	12.13	12.86	64.6	0.121
Bristled		48	1,651	16.04	12.38	60.2	0.087
BSH		46	1,930	15.50	13.06	65.5	0.101
Soxsat		51	1,688	15.83	11.20	61.4	0.079
TY		44	1,940	13.71	13.72	65.6	0.114
Farmer		40	1,499	11.88	15.89	67.1	0.114
Mean		*46*	*1,767*	*14.18*	*13.19*	*64.1*	*0.103*
Lsd (0.05)		*5***	*NS*	*2.53***	*2.19***	*NS*	*0.020***
CV%		*10.30*	*23.50*	*17.50*	*16.30*	*11.30*	*19.30*

However SOXSAT tended to be the latest to flower with an average of 51 days and the farmer varieties being the earliest with 40 days to flowering. Arrow head and farmer varieties seemed to be good convertors of dry matter into useful grain since they gave the highest harvest index values of 0.115 and 0.103 respectively. The 2012 grain yield results were rather higher than the 2013 cropping season. This could be attributed to bad season with erratic rains for Manga. It must however be noted that the yields obtained in 2013 are still significantly higher than those realised by millet farmers in the region.

Downy mildew incidences at 30 days after sowing were virtually zero for all the varieties.(Fig.1). The incidence at maturity also indicated very low percentages with SOXSAT still recording zero per cent incidences while the farmer variety was the worst affected with incidences that were significantly higher (5.98%) than Tongo Yellow (1.92%), SOXSAT (0%) and Bristled head (1.68%). In 2012 SOXSAT recorded zero per cent Downy mildew incidence thus making it a stable material for Downy mildew resistance work with Bristled head which also showed very low levels of incidences

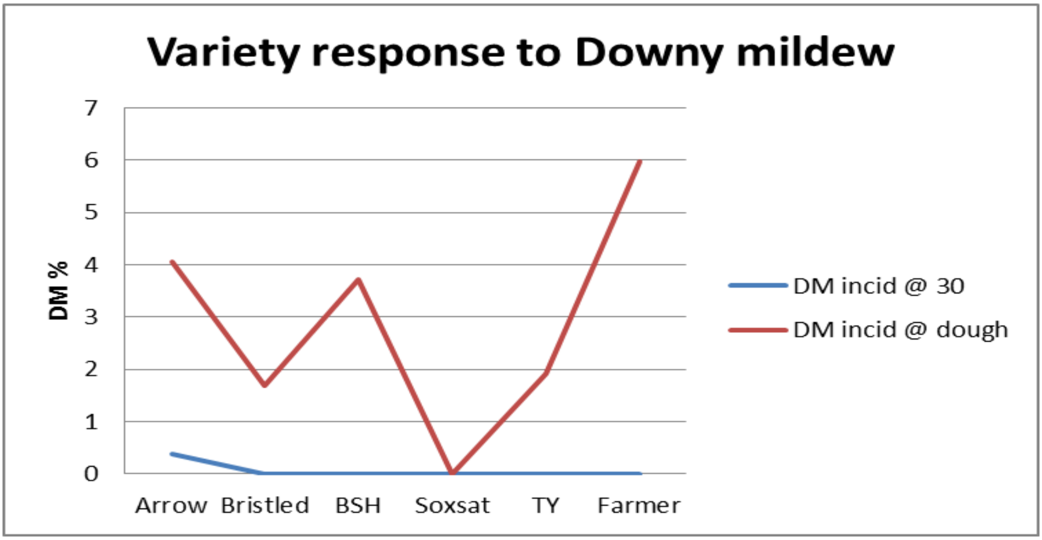


Figure 4: Downy mildew expression by genotype

Conclusion/Recommendations

Farmers have seen the good performance of the genotypes and are ready to adopt and use them. These improved genotypes need to be release by the National Variety release and Registration Committee (NVRRC) so that the anxious farmers can get the improved seeds for the 2015 cropping season.

Evaluation of Pearl millet hybrids for adaptation to the semi-arid agro-ecology of northern Ghana.

Principal Investigator: Peter A. Asungre
Collaborating Scientists: IDK Atokple, SK Nutsugah, Roger A. L. Kanton
Estimated Duration: 3 years
Sponsors: CSIR-SARI, Sugars project
Location: Northern and Upper East Regions of Ghana

Background Information/Justification/Introduction:
Pearl millet or early millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important cereal crops in the Upper East Region in northern Ghana. The importance of the crop is most pronounced in the Upper East Region 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 land conditions on shallow, acidic and sandy soils with low fertility and low water holding capacity (Menezes *et al*. 1997). It is the only cereal crop that can be sowed and harvested within 3 months in the region, yet there has not been any improved pearl millet crop varieties since Ghana's independence from our colonial masters, except Manga Nara. This situation has come about because pearl millet, unlike its other cereal counterparts, has not been regarded as an important crop in Ghana. Adoption of improved pearl millet varieties tends to be slow in some countries due a complex of factors such as seed availability, variety performance or household preferences (Ndjeunga and Bantilan, 2005). The introduction of five promising pearl millet hybrids is therefore welcome news to the anxious peasant farmers of the Upper East Region, who over the years have always ranked the lack of early maturing and insect pest and disease resistant or tolerant crops as the most important constraint rated after only low soil fertility.

Brief Objectives
To test the performance of hybrid pearl millet for their response to agro-ecological conditions of Northern of Ghana.

Expected Beneficiaries
Vulnerable and resource poor Pearl millet farmers in Northern Ghana, Community based Farmer organisations (CBFOs), Food processors, Seed growers

Materials and Methods
Field trials were conducted at the Manga Agricultural Station near Bawku in the Upper East Region to evaluate the performance of 5 hybrids of pearl millet against the only available OPV (local check) [*Pennisetum glaucum* (L.) R. Br.] for adaptation to the Sudan savanna agro-ecology of northern Ghana. The hybrids are: NBH 4599, NBH 4903, GB 8735, ICTP 8203 and TABI-B9. The design of the trials was a Randomized Complete Block with 4 replications. The plot 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 44,445 plants/ha. Split application of fertilizer was done at a rate of 40 kg N/ha and 30 kg P2O5 and 30 kg K per hectare. All standard agronomic practices and data as recommended for pearl millet production in Ghana were strictly adhered to.

Major Findings

All material except GB 8735 showed resistance to downy mildew disease which was significant (Table 2). Also TABI-B9 and ICTP 8203 had smaller seed size. NBH 4903 and ICTP 8203 were similar but different from the others while mean grain yields did not show significant variation. The highest and lowest yields were from BSH (1773 kg/ha) and TABI-B9 (727 kg/ha) respectively which were lower than the 2012 figures of 2.1 t/ha and 2.6 t/ha for NBH 4599 and NBH 4903 respectively. It was clear that these two hybrids were consistent in grain yield and hence could adopt to the ecology.

Table 5: Performance of hybrid millet under the ecology of northern Ghana.

	DM	DFF	Grain yield/ha (kg)	HI	Panicle girth (cm)	Panicle length (cm)	Plant height (cm)	1000 seed wt (g)	Threshing %age
NBH 4599	4.0	45.75	1709	0.128	10.23	23.9	172.4	10.5	71.7
NBH 4903	2.0	48.0	1555	0.098	9.60	25.85	195.2	9.05	66.2
TABI-B9	4.0	53.25	727	0.048	6.38	34.00	247.8	7.75	44.8
GB 8735	11.0	41.75	1468	0.122	8.98	22.23	194.8	10.99	71.0
ICTP 8203	2.0	45.75	1297	0.092	7.08	31.98	204.9	7.92	63.0
BSH	2.75	42.0	1773	0.126	11.15	12.03	199.1	11.97	75.0
Mean	4.29	46.08	1421	0.102	8.90	25.00	202.4	9.70	65.3
Lsd (0.05)	3.42	1.99	515	0.026	0.636	4.22	18.90	1.42	7.47
CV%	52.9	2.90	24.1	16.6	4.7	11.2	6.20	9.7	7.60
P(0.05)	<.001	<.001	0.007	<.001	<.001	<.001	<.001	<.001	<.001

Conclusion/Recommendations:

These preliminary results have clearly shown the impressive performance of the hybrids. Thesewould be tested in the 2014 rainy season and if they are consistent in their superior grain yield they would be recommended to the National Variety Release and Technical Committee for release to pearl millet farmers in order to increase both yield and areas of cultivation of the crop.

References:

Menezes, R. S.-C, Gascho, G. J., Hanna, W. W., Cabrera, M. L. and Hook, J. E. (1997) Subsoil nitrate uptake by grain pearl millet.*Agronomy Journal* **89**: 18`9-194.

Ndjeunga, J. and Bantilan, M. S. C. (2005) Toward understanding household preference for consumption characteristics of pearl millet varieties. A case study from Western Niger.*Agriculture Economic*32:151-165.

Local Germplasm Characterisation on-station

Principal Investigator: Peter A. Asungre
Collaborating Scientists:IDK Atokple, EY Ansoba and S Lamini,
Estimated Duration: **Five Years**

Sponsors: WAAPP 2A
Location: SARI, Manga

Background Information/Justification/Introduction
Pearl millet is predominantly grown along the northern fringes of Ghana and is seen as the 'poor man's crop' by most people. The climatic changes in Ghana are well pronounced in the northern parts where the crop is well adapted. Pearl millet is well adapted to the short rainy season that characterizes northern Ghana and the diversity that these landraces exhibit serve as a good source for genetic improvement work in the crop. In recent past there have been attempts by some farmers to shift toward the production of other cereals especially maize. This is because pearl millet has not been given the needed support by both Research and Government and thus all efforts put into the crop, in the past, have not yielded the needed results thus making farmers wanting to trade their millet fields for short season maize varieties. Collecting missions carried out by CSIR-SARI in the Upper East Region some 10-15 years ago assembled 43 accessions and were sent to Plant Genetic Resources and Research Institute of Ghana (PGRRI).

Currently very insignificant database is available for the Ghanaian pearl millet germplasm. This poses a challenge to conservationists and breeders in identifying and exploiting their inherent potentials. It is therefore important that a comprehensive database for pearl millet from the three regions in Northern Ghana, showing their genetic variability, was developed, fine-tuned and made easily accessible to more scientists. The full genetic potential of the local landraces is not known hence the need to gather these across the production regions (Upper East, Upper West and Northern Regions) for characterisation. A total of 126 collections were made in 2011 and prepared for initial characterisation.

Brief Objectives: Collection and documentation of pearl millet in areas identified as geographical gaps in collections of Ghana

Expected Beneficiaries: **Breeders and users of germplasm**

Materials and Methods
All the 126 accessions were planted out in a one-row plot (0.75 & 0.30 meters inter and intra-row spacing respectively) at the Manga Research Station during the 2012 and 2013 cropping season The descriptors were chosen following international standards requested from ICRISAT Niger. All data points covering seedling to grain were captured in order to eliminate duplicates as well as capture all unique traits associated with each collection.

Major Findings
A total of 126 Pearl millet germplasm was collected. The initial characterisation resulted in the collections put into three maturity groups as early (24), medium (54) and late (45). Further characterisation work (molecular and agronomic) was done in 3013 which resulted in 30 of the accessions selected as core collection representing 24.39% of the entire collections. The core collection is composed of 7, 13 and 10 each of early, medium and late maturity groups respectively as shown in Table 3.

Table 3: Selected core Pearl millet accessions collected from Northern Ghana

Region	Maturity group			Total
	Early	Medium	Late	
Upper East	SARMIL 085, SARMIL 092, SARMIL 097, SARMIL 102, SARMIL 104, SARMIL 113	SARMIL 091, SARMIL 095, SARMIL 110, SARMIL 121, SARMIL 124	SARMIL 084	12 (27.27%)
Upper West	0	SARMIL 002, SARMIL 005, SARMIL 009, SARMIL 016	SARMIL 024, SARMIL 026	6 (23.08%)
Northern	SARMIL 077	SARMIL 044, SARMIL 053, SARMIL 070, SARMIL 082	SARMIL 036, SARMIL 050, SARMIL 054, SARMIL 060, SARMIL 064, SARMIL 069, SARMIL 074	12 (22.64%)
Total	7 (29.17%)	13 (24.07%)	10 (22.22%)	30 (24.39%)

Conclusion/Recommendations

The initial work done would have to continue especially with the morphological data. This will help to tag certain traits specific to some accessions.

Participatory Adaptation of Sorghum Varieties in UER of Ghana

Principal Investigator: Peter Anabire Asungre
Collaborating Scientists: IDK Atokple, RAL Kanton, SS. Buah, EY Ansoba S Lamini and A. Larbi
Estimated Duration: Three Years
Sponsors: Africa-RISING
Location: Upper East Region

Background Information/Justification/Introduction

Sorghum has many uses within the socio-cultural setting as well as the farming environment of the Upper East region. The sorghum variety, Kapaala, released by CSIR-SARI, has been with farmers for some time. Feedback form farmers show that the variety has been susceptibility to grain mold, poor seed germination and poor storage resulting from the compact nature of the head. In response to this the sorghum breeder came up with improved lines that have open head types for on-farm testing. The objective was to present these improved lines to farmers for selection, adoption and incorporation into their cropping systems for increased and stable yields of sorghum in the Upper East Region using the open head Kapaala as the starting point.

Objective: To introduce open-head Kapaala lines to farmers in the Upper East Region

Expected Beneficiaries: **Crop farmers and seed producers**

Materials and Methods

Eight improved Sorghum – Open Kapaala derivatives, KAPAALA, and FARMER VAEIRTY (CHECK)), were tested in three Africa Rising intervention sites of Samboligo (Bongo District), Bonia and Nyangua (Kassena-Nankana district) located in the Sudano-Sahelain belt of the Upper East region of northern Ghana. Samboligo and Bonia were ploughed, harrowed with tractor and ridged using bullocks while the Nyangua field was only ploughed and harrowed and the layout and planting done on the flat.

Randomised complete block design, with four replications with a plot size of 3.0m (4 rows) x 5m = 18m^2 at Samboligo, and Bonia and three replications with plot 3.0m x 4m at Nyangua (12m^2) was used. Inter and Intra row spacing of 0.75m and 0.30m were adopted. NPK fertiliser was applied at the rate of 40-30-30 Kg ha^{-1}. 30 kg ha^{-1} N and all P & K was applied at 2 weeks after sowing (WAS) using 15: 15:15 and the remaining 10 kg ha^{-1} N six weeks after sowing (WAS) using Ammonium Sulphate (S/A). Agronomic data was collected on plot basis and Genstat statistical package used to analyse the results. Farmer assessment (Participatory Varietal Selection – PVS) was done at mid-season and at physiological maturity stage of the crop.

j. Major Findings

It was generally observed that, grain yield/ha (kg) of all the varieties were higher in Samboligo and was followed by Bonia and Nyangua respectively. None of the derivatives significantly out-yielded Kapaala (Table 4) in terms of mean grain yield/ha (kg) at Bonia and Samboligo even though, in absolute figures, they were superior at Samboligo. On the average, the derivatives were better convertors than the local check. Amongst the derivatives, SARSORG – SBG 2011 – 5 and SARSORG – SRG 2011 – 6 were the best performers in Bonia and Samboligo even though with varied level of significance compared with the others and significantly superior to the local check. For grain yield among the varieties (Table 4), SARSORG-SRG-2011-6 recorded the highest yield (1297 kg) followed by SARSORG-MRG 2011-3 (1193 Kg) with the local check recording the lowest yield (197 kg) per hectare. SARSORG – TRG 2011 – 1 and SARSORG-SRG-2011-6 were highly different for grain yield, 1000 seed weight, plant height and harvest index but not stover yield and DFF.

Table 4: Variety and location effect on selected parameters in two communities in 2013

Variety	Grain yield/ha (kg)	Fresh Stover yield/ha (kg)	1000 seed weight (g)	Days to 50% Flowering	Plant Height (cm)	Harvest Index
SARSORG-TRG 2011-1	814.00	7,667.00	25.29	66.38	181.60	0.0880
SARSORG- TBG 2011-2	1,149.00	9,117.00	27.03	67.12	170.10	0.0994
SARSORG-MRG 2011-3	1,193.00	9,217.00	23.37	67.25	176.10	0.1096
SARSORG-MBG 2011-4	1,057.00	8,900.00	23.83	66.50	179.30	0.0964
SARSORG-SBG 2011-5	998.00	6,542.00	21.91	66.62	143.70	0.1247
SARSORG-SRG 2011-6	1,297.00	9,042.00	22.88	66.62	168.50	0.1176
SENSORG-2009-1	889.00	9,375.00	18.31	68.12	154.80	0.0865
SENSORG-2009-2	437.00	9,125.00	18.80	69.12	145.40	0.0441
KAPAALA	875.00	8,658.00	24.28	69.25	167.70	0.0860
LOCAL CHECK	197.00	4,500.00	22.28	68.12	233.00	0.0421
Lsd	*409.30*	*1,799.20*	*2.07*	*1.86*	*12.24*	*0.0275*
P=0.05	**	**	**	*	**	**
Community						
Bonia	566.00	7,842.00	18.44	66.75	155.50	0.0640
Samboligo	1,215.00	8,587.00	27.15	68.28	188.50	0.1149
Lsd	*183.1*	*804.6*	*0.924*	*0.83*	*5.48*	*0.0120*
P=0.05	**	*ns*	**	**	**	**
Mean	*891*	*8214*	*22.8*	*67.51*	*172*	*0.0895*
CV%	*45.9*	*21.9*	*9.1*	*2.7*	*7.1*	*30.7000*

Conclusion/Recommendations

It is early yet to conclude on the work so far but it is clear from the results that the Kapaala derivatives are doing comparatively well, by all standards, compared with the SENSORG materials. The local check lacked many of the qualities that would be required by farmers. SENSORG – 2009 – 1 seem to have potentials for both fodder and grain yields, hence promises to be a dual purpose material.

Diagnostic study of Pearl millet cropping systems in the Upper East Region of Ghana: Farmers' practices, constraints and opportunities for intensification

Principal Investigator: Peter Anabire Asungre
Collaborating Scientists: Salim Lamini, Emmanuel Ansoba, Asamoah Larbi, and Tom Van Mourick,
Estimated Duration: **One year**
Sponsors: **Africa-RISING**
Location: **Upper East Region**

Background Information/Justification/Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important cereal crops in the Upper East Region of Northern Ghana. The crop serves as a hunger-breaker or stop gap for many households in the Upper East Region following the long dry season when most households would have exhausted their harvest. The crop is reported to be the only cereal that provides high grain and fodder yield under marginal soils. It also has the ability to reliably produce on marginal lands with low rainfall and poor soil fertility conditions thereby making it an attractive choice for sandy, poor and acidic soils (Menezes *et al*. 1997) characteristic of Northern Ghana. However, very little documentation exists on the main intercropping patterns that are practiced by most farmers in the crop ecology. The objective of the study therefore was to describe and understand pearl millet cropping systems as practiced by farmer in the Upper East region of Ghana and to identify major constraints and opportunities for intensification and the role of crop-livestock interaction.

Objective: To diagnose the Pearl millet cropping systems of the Upper East region for possible intensification

Expected Beneficiaries: Researchers and NGOs

Materials and Methods

Contact was established with the 5 Africa RISING selected communities of Nyangua, Bonia, Gia, Tekuru and Samboligo in Upper East region for Participatory approach to the data needed. Data was gathered through interview sessions which were done in two parts: focus group discussion and individual interviews with selected farmers. The focus group discussion was done by a team from ICRISAT and SARI whiles the individual interviews were done by SARI team only, using proposed protocol developed by ICRISAT Mali. The results of the focus group and individual interviews are synthesized into tables for reporting.

Major Findings

Millet and sorghum play a very important role in many ceremonies in the Upper East Region hence cannot be ignored in any household. Millet and sorghum are used extensively in various intercrop patterns without actually looking at what the inherent benefits to be derived. Due to the erratic nature of rainfall, many farmers would always include early or late millet in their cropping system as mitigation to crop failure. This was revealed as food security strategy since most of farmers food stock is often depleted very early and hence harvesting the early millet crop in July-August helps to bridge the hunger gap.

Conclusions/recommendations

Samboligo community is seen as a potential early millet intervention site since the crop has maintained its position as one of the top 3 important cereals grown over the last ten years. Improved and quality seed as a factor for yield increases is not well appreciated by most farmers; hence no conscious effort is made at acquiring and using them.Opportunities therefore exist for pearl millet intensification and technology/variety adoption in these communities and possibly beyond.

Table 5 Main cereal cropping systems at the various communities as captured during focus group discussions

Crop1	Crop2
Maize	Sorghum
Millet (late & early)	Cowpea
Early Millet	Sorghum
Early Millet	Late Millet
Maize	Late Millet
Groundnut	Sorghum
Groundnut	Late millet
Maize	Groundnut

CSIR - SAVANNA AGRICULTURAL RESEARCH INSTITUTE

Highlights of Research in the UER

By Francis Kusi

Presented at CSIR-SARI In-House Review of Research Programmes and Projects April 9-11, 2014

ENTOMOLOGY PROGRAME

Introduction

The Entomology programme of UER-FSRG based at Manga focused on the following major activities:

- Deployment of the cowpea aphid resistance gene for cowpea improvement in Ghana Evaluation of planting date, cultivar and insecticide spraying regime for control of insect pests of cowpea in Northern Ghana
- Increasing access to Frafra Potato Germplasm Diversity by Farmers and Breeders in Ghana

Deployment of the cowpea aphid Resistance gene for cowpea Improvement in Ghana

Francis Kusi

Introduction

The objectives for the project during the reporting period include genotyping of BC4F1 and BC4F2 populations between SARC1-57-2 and Zaayura and multiplication of progenies having the aphid resistance gene in homozygous state. Genotyping of the SARC1-57-2 and Zaayura using the SNPs platform to identify markers closer to the aphid resistance gene than CP171/172 and for back ground selection of the BC4 population. Four BC1 populations were also to be developed between SARC1-57-2 and each of IT99K-573-1-1, IT99K-573-3-2-1, Nhyira and Asetenapa. The four genotypes were identified as susceptible *Aphid craccivora* which the current project seeks to improve using SARC 1-57-2 in marker-assisted backcrossing. The project target for the year 2013 was to have improved Zaayura which is resistant to cowpea aphid evaluated on-farm in multi-location and developing BC2 populations between SARC1-57-2 and of IT99K-573-1-1, IT99K-573-3-2-1, Nhyira and Asetenapa. Although the improved Zaayura is in hand the evaluation on-farm in multi-location could only be done during the 2014 cropping season. The development of the BC2s could also not be done due to the harmattan. Molecular laboratory was also established at SARI by Kirkhouse Trust and this has facilitated the Kirkhouse project activities at SARI immensely.

Developing backcross progenies between SARC1-57-2 and Zaayura

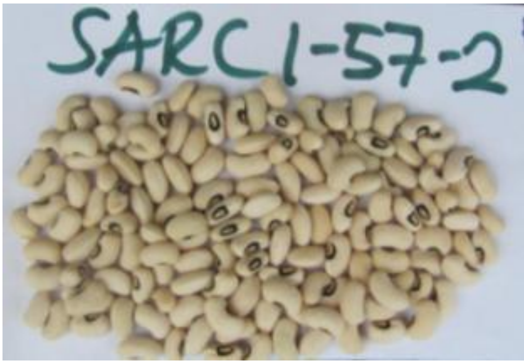
The BC4F1 population of SARC1-57-2 and Zaayura (Fig. 1 and 2) were genotyped to select heterozygote individuals (Fig. 3 and 4). The selected heterozygote individuals were tagged and maintained on the field to self (BC4F2). The BC4F2 population was subsequently planted and genotyped to select the individuals having the gene in homozygote state which were also screened further with aphids. The individuals having the aphid resistance gene in homozygote state (Improved Zaayura) were also selected based on the feature of the recurrent parent (vegetative, podding and seed). The improved Zaayura will be multiplied and tested on farm in multi-location trial to gather data to support its release.

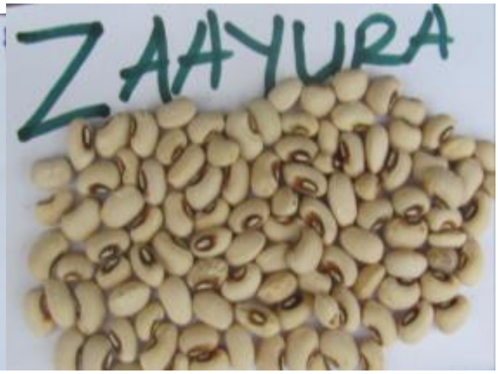
Identification of markers closer to the aphid resistance gene and background selection using SNPs platform

The procedure described above to select the improved Zaayura is based mainly on conventional approach to complement the molecular technique used to develop the population up to BC4F1. The limitation of the conventional approach not withstanding became necessary due to limited time left for me to meet project timeline. However, it is also important to progress in line with the objective of Kirkhouse Trust to improve cowpea production using modern breeding tools (marker-assisted backcrossing). A search has began to identify markers, using the SNPs platform, that can be used to carry out background selection after the marker – assisted backcrossing at the BC4F1 stage. Whiles doing this, effort will also be made to identify markers closer to the aphid resistance gene than the CP171/172. The following protocol has therefore been agreed on by the Kirkhouse and UCR team:

- The first step will be to send UCR the parental material (SARC1-57-2 and Zaayura) in zip-lock bags containing desiccant packs
- The procedure is spitted into the process of finding the improved marker and doing the background selection
- 100-150 seeds of BC4F1s are to be tested rigorously for aphids resistance (no prior 171/172 genotyping) collecting leaf before infesting them
- We assume that about half of the plants will manifest the resistance
- These 50-70 or so individuals will then be the material which will be SNP'ed to identify a better marker(s)
- Once this information is to hand, then the few closely linked SNPs identified, along with the genome-wide set derived from the parental screen, can be applied to a further 100 of the BC4F1s for the purpose of background selection
- The final selection(s) (in the BC4F2) will be tested with aphids just to be sure that they are still resistant, and then fix the aphid resistance in the BC4F3
- Above protocol requires the use of material that has not been genotyped using CP171/172. The reason for this is that the plants that have been genotyped using CP171/172 will contain material from the resistant plant that SNP genotyping can get rid of if there are resistant plants that don’t have linkage drag due to the marker not being within or right next to the resistance gene

Leave samples of the parents have been sent to UCR in USA and BC4F1 population is being screened with aphids, leave samples of the population under screening have also been taken to be sent for genotyping when the results of the genotyping of the parents are ready.





FIG, 1 **FIG.2**

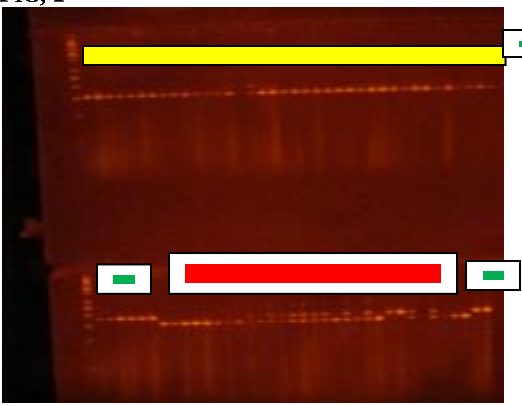
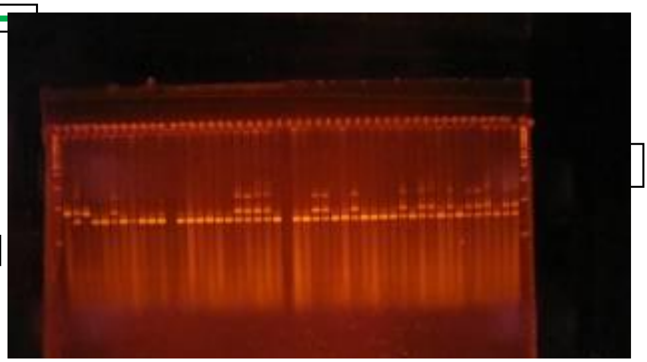



FIG.3 **FIG. 4**

Band of susceptible (Yellow) and Resistance (Green) parents as well as the BC population (Red)

Developing backcross progenies between SARC1-57-2 and each of IT99K-573-1-1, IT99K-573-3-2-1, Nhyira and Asetenapa

Four BC1F1 populations were developed during the reporting period between SARC1-57-2 and each of IT99K-573-1-1, IT99K-573-3-2-1, Nhyira and Asetenapa (Fig. 5, 6, 7, 8 and 9). The objective of the current project is to improve the field resistance of the four genotypes to cowpea aphid. The target for 2013 was to develop at least BC2 populations of each of the four genotypes. Although this could have been achieved, we had to avoid the harmattan season which has negative effect on cowpea growth and flowering when planted in open field. The genotypes, IT99K-573-1-1 and IT99K-573-3-2-1 are resistant to Striga. The two are striga resistance and might carry the same striga resistance, the seeds of the two have different hilum colours as shown in Fig. 6 and 7, brown and black eyes and this will help meet the demand of both the black and brown eyes cowpea in the market. Nhyira and Asetenapa are among the commercially important cowpea varieties (high yielding and white seed coat colour) in Ghana.

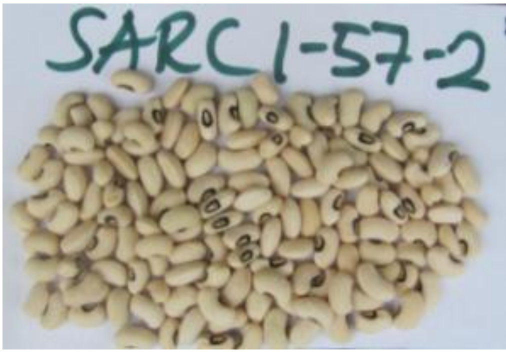


FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 10

Seed Multiplication and exchange of breeding materials

Seeds of SARC1-57-2 (fig.1) and Sanzi (fig. 10) were multiplied during the reporting period under irrigation. About 100 g of each line can be supplied to the PIs of other KT-funded projects who are interested in these lines to multiply. The aphid resistant parent in Ghana (SARC1-57-2) has been sent to the PIs of Kirkhouse projects in Burkina Faso, Nigeria and Cameroon during the reporting period.

Evaluation of lines from Burkina Faso

SARI received 8 lines from Burkina Faso which were screened phenotypically with aphid from Ghana and genotyped with CP171/172 (Fig. 11). Four lines from Ghana were included in the screening as checks.

KVX-295-2-124-99: Genetically classified as susceptible but because it is relatively bigger plant it shows tolerance phenotypically

B301: Genetically classified as susceptible but it has relatively very deep green leave colour, it hardly produce symptoms of aphid damage

IT97K-499-35 and 524B: Genetically classified as resistance but it shows susceptible phenotypically

Most of the lines do not have white seed coats

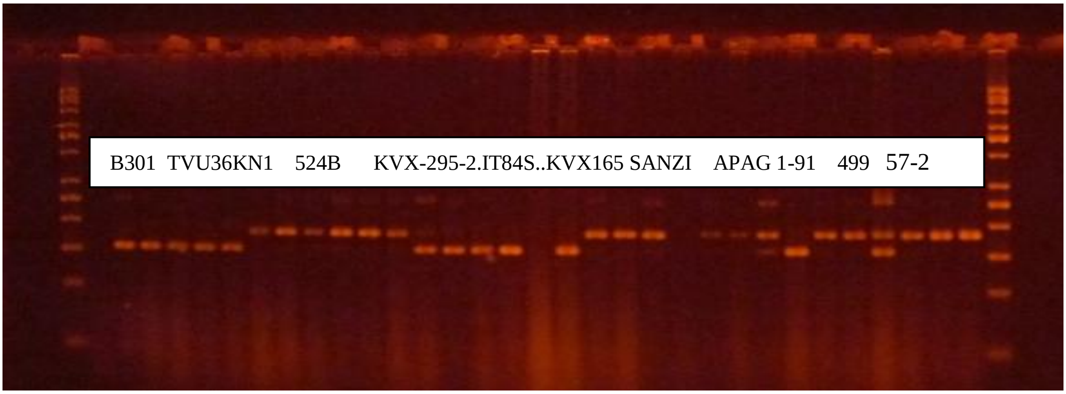


FIG.11

Establishment of molecular laboratory at SARI

The Director and the management of SARI are grateful to the Kirkhouse Trust for establishing a molecular laboratory at SARI. The laboratory has not only enhanced the implementation of Kirkhouse project at SARI, but has also improved the image of SARI as a research institution. Below are Picture taken from the laboratory at SARI

Conclusions

Although the start of the 2013 activities was delayed by the establishment of the laboratory, most of the project time lines would have been achieved but for the harmattan season that prevented the planting to generate the BC2. To ensure that the laboratory is effectively utilised, seventy-eight cowpea lines have been collected from different sources including the breeding lines from SARI for study to identify important traits. The sources of these lines are IITA, INERA and SARI. Some of them are known to be resistant to drought, dual purpose (grain and biomass yield), high yielding. Others are from populations developed to target resistance to Thrips, Striga and bigger seed size. Among the donors of these populations include Sanzi, IT97k-499-35 and others.

Evaluation of Planting Date, Cultivar and Insecticide Spraying Regime for Control of Insect Pests of Cowpea in Northern Ghana

Introduction

Francis Kusi

Cowpea, *Vigna unguiculata* (L) Walp, is a major staple crop in Ghana. The leaves, green pods, green peas and the dry grain are eaten as food and the haulms are fed to livestock. The grain contains 23-28% protein and constitutes the cheapest source of dietary protein for majority of people in Africa who lack the necessary financial resources to acquire animal protein (Tarawali et al., 1997). Sale of the grain also provides income to farmers and traders in Ghana. As a leguminous crop, cowpea also fixes atmospheric nitrogen into the soil which is of major benefit in African farming where most of the lands are exhausted and farmers lack adequate capital to purchase chemical fertilizers. Moreover, cowpea is shade-tolerant and therefore compatible as an intercrop in the mixed cropping systems widely practiced by small holder farmers (Singh and Sharma, 1996).

Despite its importance, cowpea yields on farmers' field are low averaging less than 500 kg ha^{-1}. The major cause of the low yields is due to problem of insect pests that attack the crop throughout its growth, although the most important insect pests are those that attack the crop from flowering (Jackai et al. 1985). Insecticide application is the recommended practice for control of insect pests on cowpea. However, most farmers in Ghana are resource-poor and require pest management strategies that are cost-effective and sustainable. The use of insecticides must be minimized because of high cost and harmful effects on the environment.
The purpose of this study was to develop an integrated management system for cowpea insect pests using host plant resistance in elite cultivars, appropriate planting date and reduced insecticide spraying regimes.

Specific objectives

1. Evaluate cowpea cultivars for their resistance to major insect pests of cowpea
2. Determine appropriate planting dates as a cultural tool for pest management in cowpea
3. Determine the minimum insecticide protection required for increased cowpea yield.

Procedures

Two experiments were established at two locations in the Upper East Region of Ghana. The locations were Googo and Sabulungu in Bawku West and Bongo districts respectively. In Experiment 1, the treatments consist of four planting dates, 6 cowpea cultivars and spray regime The experimental design was a split-split-plot in a randomized complete block design with three treatment replications. Insecticide spraying regime was used as main plots, planting date as sub-plots and cowpea cultivars as sub-sub-plots. The six cowpea cultivars used were

IT99 K-573-1-1 and IT99 K-573-3-2-1 obtained from IITA, Bawutawuta, Songotra and Padi Tuya obtained from the breeding program at CSIR-SARI and a farmer variety. Plantings were made mid-July, late-July, mid-August and late-August. The sub-sub-plots consisted of 4 rows 4 m long spaced at 0.60 between rows and 0.20 m between plants in a row. The replicates and main plots were separated by 2 m alleys while the sub and sub-sub plots were spaced 1 m apart.

In Experiment 2, the treatments comprised of six cowpea cultivars as in Experiment 1 and four insecticide spraying regimes. The insecticide spraying regime treatments were: 1) no spray (untreated control), 2) spraying once at 50% flowering, 3) two sprays, one at flower bud initiation and a second at early podding and 4) three sprays, one each at flower bud initiation, 50% flowering and 50% podding. The experimental design was a split-plot in a randomized complete block design with insecticide spraying regime as the main plots and cowpea cultivars as sub-plots. The treatments were replicated four times. The sub-plots consisted of 4 rows 4 m long spaced at 0.60 between rows and 0.20 m between plants in a row. The replicates and main plots were separated by 2 m alleys while the sub-plots were spaced 1 m apart.

Data collection

Data collected includes days to 50% flowering and maturity, insect pests sampling from the two middle rows of each plot and these include Populations of thrips, *Maruca vitrata* and pod sucking bugs (PSBs) . the populations of Thrips and Maruca were estimated at the beginning of flowering until 50% podding by picking 20 flowers from the two outer rows in alcohol to the laboratory to count the insects. Populations of pod-sucking bugs (PSBs) were estimated by counting nymphs and adults in the two middle rows of each plot. Pods damage by PSBs and *Maruca* were estimated from pods per plot after harvest. Data were also taken on yield parameters.

The cowpea Cultivars

Cultivar	Source
V1 = IT 99K-573-1-1	IITA
V2 = IT99K-573-3-2-1	IITA
V3 = Songotra	CSIR-SARI
V4 = Padi Tuya	CSIR-SARI
V5 = Bawutawuta	CSIR-SARI
V6 = Farm Variety	Farmer at Nyorego – Bawku

Key findings

The study has shown that, good yield could be obtained from any of the improved cowpea cultivars if the crop is sprayed at least twice which must be done at the flower bud initiation and full podding stage. Spraying at these critical stages adequately reduced the populations of flower Thrips, Maruca and PSBs to a level that could not cause economic injury to the plants. Planting of the improved cultivar without spraying should also not be encouraged because it could lead to close to total loss of yield. The study has also identified cultivars 1, 2, and 3 as important cultivars for Upper East Region (UER). This is due to their resistance to Striga. The three cultivars are therefore seen as very important because UER is a hot spot for Striga. The consistent low yield recorded against V4 and V6 could be attributed to the devastating effect of the Striga on the crop performance and yield. Although V5 is also susceptible to striga, the effect of striga on V4 and V6 seems higher than on V5. The relatively low incidence of maruca and PSB on D4 could also be attributed to poor pod formation due to heavy Thrips infestation which might have resulted in most of the flowers being aborted before pod formation. Generally planting of cowpea between mid July (D1) and early August (D2) was found to be suitable for Upper East Region. All the cowpea cultivars planted between mid July (D1) and early August (D2) had already matured before the onset of the terminal drought which usually occurs in late September or early October in the region.

Recommendations

The recommendations from the first year's results (2012) were confirmed in 2013 cropping season and these include the following.

1. Timely planting of cowpea between mid July and early August is recommended for cowpea farmers in Upper East Region.
2. Judicious and timely application of insecticide at flowering and full podding is enough to provide adequate control of key pests of cowpea at flowering and podding.
3. IT99K-573-1-1 and IT99K-573-3-2-1 have been identified as new sources of *Strigagesnerioides* resistance in addition to Songotra in Northern Ghana
4. The field resistance of Padi Tuya and Bawutawuta to *Striga* should be improved

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Increasing access to Frafra Potato Germplasm Diversity by Farmers and Breeders in Ghana

Francis Kusi

Introduction

The frafra potato project; Increasing access to Frafra Potato Germplasm Diversityby Farmers and Breeders in Ghana, seeks to out-scale integrated crop and pests management strategies to frafra potato growers. Increase frafra potato production by introducing elite varieties to farmers, to collect and document germplasm of frafra potato and multiplication and evaluation of frafra potato varieties with farmer participation. The activities carried out under the project during the reporting year include reconnaissance survey, collection and multiplication of frafra potato germplasm, demonstrations to out-scale proven technologies for frafra potato production. Other activities include frafrapotatomorphologicalcharacterization, demonstration of planting frafra potato by stem cutting, farmer field school, field days and post harvest handling evaluation.

The reconnaissance survey was carried out in frafra potato producing areas in Upper East region. The survey captured data on demographic information, type of variety, source of sett for planting, reasons for selecting a variety, current challenges of FP production, possible training needs, and modules to improve utilization of frafra potato. Information was also generated on current forms of utilization, cooking methods, consumer preference traits and postharvest processing methods. A total of 61 germplasm of frafra potato were collected, multiplied and characterised at Manga station during the reporting year. These were collected from Plant Genetic Resource Research Institute (PGRRI) Bunso, farmers in Upper East and Upper West regions.

Four 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. Evaluation of post harvest handling and storage is currently on-going. The multiplied germplasm from PGRRI and the preferred lines from the two regions will be put into participatory evaluation trials in the communities to afford the farmers opportunity to have access to the elite ones. The demonstration of the proven technologies will also be out-scaled to 20 communities. A total of 1025 farmers were reach out by the project during the reporting year, a target number of farmer to be reached out in 2014 is 3000. This will be achieved through demonstrations, farmer field school, field days and participatory field and post harvest trials in the communities.

Specific Objective(s)

1. Provide training and extension services on integrated crop and pests management strategies to frafra potato growers
2. Increase frafra potato production by deploying elite varieties to farmers
3. Collection and documentation of frafra potato in areas identified as geographical gaps in collection
4. Development of database of frafra potato germplasm
5. Multiplication and evaluation of frafra potato varieties with farmer participation

Key Activities Undertaken

1. Reconnaissance Survey was carried out in frafra potato (FP) producing areas in Upper East region. the survey captured data on demographic information, type of variety, source of sett for planting, reasons for selecting a variety, current challenges of FP production, possible training needs, and modules to improve utilization of FP. Information was also generated on current forms of utilization, cooking methods, consumer preference traits and postharvest processing methods.
2. GermPlasm collection and Multiplication: Collections were made from PGRRI, farmers in Upper East and Upper West regions. The collections were multiplied at Manga station of CSIR-SARI
3. On-Farm Demonstration to out-scale proven Technologies for frafra potato production to farmers.
4. Frafra Potato Morphological Characterization
5. Demonstration of planting frafra potato by stem cutting. A technology to be 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.
6. Farmer field school (FFS): the germplasm multiplication site and the demonstration sites were used to run FFS to train the farmers.
7. Field day
8. Post harvest handling evaluation: Post harvest evaluation is currently on-going at Manga station which is looking at different crop residues as storage materials and partial evaporative cooler.

Achievement- Results/Outputs

1. A manuscript was prepared from the reconnaissance survey which has been published in Journal of Plant Sciences
2. The germplasm multiplication field served as learning centre for the Frafra potato farmers groups (FBOs) in Upper East region.The farmers were involved in evaluating the germplasm for their field performance against pests and diseases, growth and development as well as yield and other qualities. The preferred lines by the respective FBOs will be further evaluated together with their own lines in their respective communities in 2014 cropping season and beyond. The germplasm were made up of 61 lines, I6 lines were collections from PGRRI and the remaining were collected from Upper East and Upper West regions.
3. Four demonstration plots were established in four major Frafra potato growing communities in upper East region. The communities are Ninkongo, Tes-Natinga, Kpatia and Tankpalsi-Avusum. Each of the four demonstrations served as learning centre for at least 25 frafra potato farmers at each demonstration site. Spacing, single row planting, weed management, pest management and fertilizer application constituted the package demonstrated to the farmers.
4. Characterisation of the 61 frafra potato germplasm collected from farmers in Upper East and Upper West Regions as well as from PGRRI, Bunso was carried started. Descriptor such as leaf pigments, leaf shapes and size, internodes pigments, flower colour and size as well as tuber size, shape and colour just to mention a few were used to characterised the germplasm.

5. Farmer Field School: The farmers were trained intransplanting by stem cutting, integratedsoil fertility management, pests and diseases identification and management strategies, introduction to different accessions of Frafra potato and harvesting

Success stories

Our interaction with the farmers revealed that most of them have stop using their local varieties of maize, rice, soybeans and many other crops due to introduction of improved varieties. However, they cannot say so about Frafra potato, they are still planting the local varieties handed down to them by their parents and grandparent. The farmers therefore saw the objective of the project to increase their access to Frafra Potato germplasm diversity as timely. They therefore expressed their willingness to collaborate with CSIR-SARI and MoFA to ensure successful implementation of the project in their respective communities.

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 the 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.

Way Forward/Recommendations

Evaluation of post harvest handling and storage is currently on-going. The multiplied germplasm from PGRRI and the preferred lines from the two regions will be put into participatory evaluation trials in the communities to afford the farmers opportunity to have access to the elite ones. The demonstration of the proven technologies will also be out-scaled to 20 communities. A total of 1025 farmers were reach out by the project during the reporting year, a target number of farmer to be reached out in 2014 is 3000. This will be achieved through demonstrations, farmer field school, field days and participatory field and post harvest trials in the communities.

POSTHARVEST PROGRAMME

Containing productivity increases of maize in Ghana through large-scale storage methods

Principal Investigator: Issah Sugri
Collaborating Scientists: Francis Kusi, Osei-Agyeman Yeboah, John K Bidzakin, Cephas Naanwaab, Stephen K Nutsugah, James M Kombiok
Estimated duration: 2 years
Sponsor: USDA
Location: UER

Executive summary
Stored maize can be damaged by insect pests if they are not properly conditioned and protected. This study seeks to improve the livelihoods of farm families by deploying improved storage methods to reduce postharvest losses in smallholder on-farm storage. Participatory evaluation of some storage methods and grain protectants was conducted at 4 communities in the Upper East Region of Ghana. For each treatment, 50kg of maize was stored in jute sacs (JS), polypropylene sacs (PS), hermitic triple-layer sacs (HTS) and hermitic polytanks (HPT). Two grain protectants, Actellic Super 5EC and phostoxin fumigation were applied at recommended rates. Destructive grain sampling (100g) was done every 2 months for determination of grain physical characteristics and loss assessment. Scoring for grain quality was done using a 5-point objective scale. Significant differences (P<0.001) existed in loss of bulk density, insect count and grain quality score across treatments at 12 months after storage (MAS). Overall difference was due to the method of storage, influence of the 2 grain protectants was not consistent. Marginal loss of bulk density (9.6 to 14.8%) was noticed in grain stored in HTS and HPT compared to PS and JS (15-17%). Low postharvest losses (2.2-5.8%) was incurred in grain stored in HTS and HPT compared to PS and JS which showed up to 7.2-31.5% losses. Minimal loss of marketable quality (Score of 1.2C to 1.8F) was noticed in grains stored in HTS and HPT at 12 MAS. Although the initial cost of the HPT is high, they are more efficiency and can be re-used for several years. The use of any grain protectant may be avoided for storage up to 6 months. Due to wide variation in varieties and pre-harvest farm operations among farmers, storage beyond 8 months in JS or PS will require grain protection and close monitoring. Knowledge of farmers and warehouse managers about the factors influencing grain infestation is critical and should be integral in overall strategies to reduce on-farm storage losses. There is need to bridge the knowledge gap in communities in aspects of early detection and appropriate use of grain protectants.

Introduction
Stored-product arthropods can cause serious postharvest losses, estimated from up to 9% in developed countries to 20% or more in developing countries (Obeng-Ofori, 2008). Conservative estimates are that close to one-third of the world's food crops is damaged by insects during growth and storage. A host of insect pests are a constraint in maize storage including: Red flour beetle (*Tribolium castaneum*), larger grain borer (*Prostephanus*

truncatus), lesser grain borer (R*hyzopertha dominica*), maize weevil, *Sitophilus zeamais*, granary weevil *(S. granarius)* and *Sitotroga cerealella*) (Obeng-Ofori 2008, Eziah *et al*., 2013). Under many circumstances, the most rapid and economic method of controlling insects is the use of insecticides. However, most of the contact insecticides used in stored product insect pest management are lipophilic and accumulate in areas of high fat content such as the germ and bran of cereals (Obeng-Ofori 2008, Eziah *et al*., 2013). These toxic residues tend to persist in the treated products which may be detrimental to the consumer, affect non-target insect pests as well as lead to insecticide resistance. Indiscriminate use of common grain protectants such as Actellic (Pirimiphos methyl), bioresmethrin (pyrethroid) phostoxin and Gastox (Aluminium phosphate) is widespread among small-holder farmers (Sugri *et al*., 2010). Most farmers acquire agro-chemicals from non-accredited input dealers without any training on appropriate use. Although the potential of insecticidal dust, plant powders, oils and extracts have been studied few farmers resort to these options due to lack of rapid knockdown effect; particularly where infestation already exist. There is the need to integrate production and postharvest practices to reduce consumer risk to agro-pesticides. Integration of good pre-harvest operations, pest management and appropriate storage techniques to minimize pest damage is therefore very essential. The specific objective is to evaluate, deploy and disseminate medium to large scale storage methods for bulk and prolong storage of maize.

Materials and methods

Study sites were established at 4 communities: Manga, Tansia, Azum-Sapielga and Tes-Natinga. Selection of communities was based on their level of involvement in maize production and reports of high incidence of postharvest losses. In Tansia and Azum-Sapielga, the experiments were held in community grain warehouses whilst in Manga and Tes-Natinga, the experiments were set out in ordinary sheds. Maize grain was bulked from selected farmers during the harvesting season in November- December 2012. For each package, 50kg of maize was stored in polypropylene sacs (PS), jute sacs (JS), Hermitic Triple-layer sacs (HTS) and hermitic poly-tanks (HPT) with and without grain protectants. Two grain protectants, Actellic Super 5 EC and phostoxin, were applied at recommended rates. Actellic Super 5EC is a food-grade chemical containing 80g Pirimiphos-methyl and 15g Permithrin/L. Phostoxin (Aluminum phosphate) is a food-grade fumigant.

Data collection

Destructive grain sampling of 4 replicates of 100g per treatment was done every 2 months for determination of grain physical characteristics, insect count and loss assessment. Data generated include weight loss, number of bored grains, number of live and dead insects and insect species identification. Scoring for grain quality was done using a 5-point objective scale; where score 1= No insect seen in prolonged search, 2= few insects seen, difficult to find and irregularly distributed, 3= insects are obvious to trained eye and occurring regularly, 4= infestation obvious to untrained eye, large crawling insects in grain mass, 5= Heavy infestation, insects can be seen or heard, crawling on floor/walls. Loss assessment was conducted using the standard volume weight and gravimetric methods.

Results

Several physical characteristics were employed to assess produce quality at storage. These include: number and weight of whole grain, number and weight of damaged grain, number and weight of mouldy grain, number and weight of bored grain, and count of live and dead insects per sample (Table 1). These indices indicate the potential damage that can be incurred at any given time so that critical management decisions such protection or disposal options can be chosen. Overall, the method of storage showed significant ($P \leq 0.001$) influence on all physical characteristics but the influence of grain protectants was not consistent. Significant ($P \leq 0.001$) difference existed between the hermitic polytank (HPT) and hermitic triple-layer sacs (HTS) versus the aerated poly-sacs (PS) and jute sacs (JS). Similar pattern was noticed in postharvest losses with respect to the method of storage and use of grain protectants (Table 2). Low losses (2.2-5.8%) were incurred in all treatments held in the HTS and HPT compared to those stored in JS and PS which showed up to 7.2-21.1% losses at 12 MAS. Consistently higher losses were noticed in Manga and Tes-Natinga compared to Tansia and Azum-Sapielga. The species identified were larger grain borer (*Prostephanus truncatus*), lesser grain borer (R*hyzopertha dominica*), maize weevil *(Sitophilus zeamais),* granary weevil *(S. granarius)* and *Tribolium spp*. Only nominal insect count (dead and live) was conducted. Initial pest infestation was minimal, but the number of bored grains across treatments shows a latent pest infestation; high infestation levels could show up when favourable conditions exist.

Table 1: Influence of different storage and grain protection methods on grain physical characteristics in relation to insect damage (12 MAS)

Method of storage	Method of protection	Whole grain		Damaged grain		Bored grains		Insect count	
		Number per sample	Weight per sample (g)	Number per sample	Weight per sample (g)	Number per sample	Weight per sample (g)	Dead insects in sample	Live insects in sample
	Control	279.8^{b}	65.4^{d}	75.0^{b}	13.1^{b}	13.1^{b}	5.9^{b}	2.3^{b}	2.4^{bc}
Poly-sacs	Actellic Super	311.6^{ab}	72.1^{c}	43.9^{d}	8.2^{c}	3.9^{e}	2.1^{d}	1.6^{c}	1.8^{bc}
	Phostoxin	278.7^{b}	70.8^{c}	56.3^{c}	10.3^{bc}	9.9^{c}	4.8^{c}	2.3^{b}	2.6^{b}
Jute sacs	Control	212.6^{c}	58.6^{e}	93.5^{a}	18.6^{a}	17.3^{a}	8.0^{a}	3.4^{a}	3.0^{a}
	Actellic Super	267.3^{b}	74.8^{b}	32.8^{e}	6.2^{c}	4.5^{e}	2.6^{d}	1.7^{c}	2.1^{c}
	Phostoxin	288.2^{b}	71.6^{c}	46.2^{d}	11.5^{bc}	8.2^{d}	5.0^{bc}	1.9^{c}	2.1^{c}
Triple-	Control	366.0^{a}	79.3^{a}	18.6^{f}	2.5^{d}	1.8^{fg}	1.3^{e}	1.4^{d}	1.3^{d}
layer sacs	Actellic Super	322.1^{ab}	76.7^{b}	24.2^{ef}	4.9^{cd}	2.2^{f}	1.3^{e}	1.4^{d}	1.5^{cd}
	Phostoxin	326.0^{ab}	76.6^{b}	22.1^{f}	3.8^{d}	2.2^{f}	1.4^{de}	1.5^{cd}	1.5^{d}
Hermitic	Control	298.7^{b}	80.2^{a}	16.6^{f}	2.2^{d}	1.3^{g}	1.2^{e}	1.4^{d}	1.2^{d}
Poly tanks	Actellic Super	307.5^{b}	80.6^{a}	15.6^{f}	2.8^{d}	1.4^{fg}	1.3^{e}	1.3^{d}	1.3^{d}
	Phostoxin	325.5^{ab}	80.4^{a}	15.0^{f}	1.9^{d}	1.4^{fg}	1.4^{e}	1.3^{d}	1.2^{d}
	CV (%)	3.7	1.6	12.1	10.5	3.3	3.5	3.2	7.2

Data on number and weight of bored grain, and Insect count data was transformed using square root transformation

Table 2: Influence of different storage and grain protection methods on postharvest losses in maize (12 MAS

Method of storage	Method of protection	Location of storage: Manga	Azum-Sapielga	Tansia	Tes-Natinga	Overall Postharvest Losses (%)
	Control	26.10	3.58	3.73	31.50	16.2^{b}
Poly-sacs	Actellic Super	11.09	10.32	8.89	9.01	9.8^{c}
	Phostoxin	8.10	11.21	7.89	21.11	12.1bc
Jute sacs	Control	25.24	7.59	32.80	21.18	21.7a
	Actellic Super	11.87	5.67	4.21	7.08	7.2^{c}
	Phostoxin	10.10	3.49	30.39	9.67	13.4^{b}
Triple-layer sacs	Control	2.58	2.14	5.43	1.79	3.0^{cd}
	Actellic Super	5.79	7.46	6.25	3.68	5.8^{cd}
	Phostoxin	4.74	3.79	6.10	3.59	4.6^{cd}
Hermitic Poly tanks	Control	2.67	2.26	3.15	1.94	2.5^{d}
	Actellic Super	5.86	2.79	2.84	1.39	3.2^{cd}
	Phostoxin	3.46	2.79	0.97	1.70	2.2^{d}
		$P \leq 0.001$, $LSD_{(0.05)}$= 9.11, cv (%)=18.1				

Quality scoring at 12 MAS showed that differences was mainly due to the method of storage, the influence of the grain protectants was marginal and not consistent (Table 3). Across locations, minimal loss of marketable quality (Score of 1.2F to 1.8M) was noticed in grains stored in HTS and HPT. Grain stored in the HTS and HPS ± grain protection recorded high quality scores (1.2 to 1.8), indicating clear grain (C) or few insects (F) which were irregularly distributed and difficult to find by untrained eye (Table 3). Under local grain markets in Ghana, all treatments showing few (F) or medium infestation (M) can be marketed without significant loss of price; but should be consumed immediately. Treatments showing high (H) or very high (VH) infestation are often winnowed and sold immediately in Ghana, albeit at less premium price.

Table 3: Influence of different storage and grain protection methods on grain quality score (12 MAS)

Method of storage	Method of protection	Location of storage: Manga	Azum-Sapielga	Tansia	Tes-Natinga	Overall quality score
	Control	5.0^{a} (VH)	1.3^{de} (C)	1.7^{d} (F)	5.0^{a} (VH)	3.3 (M)^{b}
Poly-sacs	Actellic Super	2.3^{cd} (F)	2.0^{c} (F)	2.0^{d} (F)	3.0^{bc} (M)	2.3(F)^{d}
	Phostoxin	2.0^{d} (F)	2.7^{bc} (M)	2.0^{d} (F)	5.0^{a} (VH)	2.9(M)^{c}
Jute sacs	Control	5.0^{a} (VH)	3.0^{bc} (M)	5.0^{a} (VH)	5.0^{a} (VH)	4.5(VH)^{a}
	Actellic Super	2.3^{cd} (F)	2.3^{cd} (F)	2.0^{d} (F)	3.7^{b} (H)	2.6(M)^{c}
	Phostoxin	3.0b^{c} (M)	1.0^{e} (C)	2.0^{d} (F)	4.0^{b} (H)	2.5(M)^{cd}
PICS sacs	Control	1.0^{e} (C)	1.0^{e} (C)	2.0^{d} (F)	1.0^{e} (C)	1.3(C)^{f}
	Actellic Super	2.0^{d} (F)	1.3^{de} (C)	2.0^{d} (F)	2.0^{d} (D)	1.8(F)^{e}
	Phostoxin	2.0^{d} (F)	2.0^{d} (F)	1.7^{d} (F)	1.0^{e} (C)	1.7(F)^{ef}
Hermitic polytanks	Control	1.0^{e} (C)	1.0^{e} (C)	2.0^{d} (F)	1.0^{e} (C)	1.3(C)^{f}
	Actellic Super	1.3^{de} (C)	1.0^{e} (C)	1.7^{d} (F)	1.0^{e} (C)	1.3(C)^{f}
	Phostoxin	1.3^{de} (C)	1.0^{e} (C)	1.3^{de} (C)	1.0^{e} (C)	1.2(c)^{f}

Where score 1= No insect seen in prolonged storage, 2= few insects seen, difficult to find and irregularly distributed, 3= insects obvious to trained eye and occurring regularly, 4= infestation obvious to untrained eye, large crawling in grain mass, 5= Heavy infestation, insects can be seen or heard, crawling on floor/walls. 2. Letters in parenthesis are quality grade; where C= Clear grain, F= Few insects seen, Medium= Medium infestation, H= heavy infestation, VH= Very heavy infestation. 3. Data values along columns with same letters are not significantly different.

Conclusion

This study reveals the potential hermitic storage methods using triple-layer sacs and polytanks. Although the initial cost of these methods is high, the overall efficiency is high. Grain stored in these packages were still clear (C) or with few insect (F) after 1 year of storage. The hermitic triple-layer sacs have been promoted over the years for cowpea storage, however the critical limitations are high initial cost and the sacs cannot be reused as they are not puncture resistant. The use of hermitic polytanks could serve as alternative for more endowed farmers since the polytanks can be reused for several years; as they are sturdy for handling. A modified polytank can store up to 1 ton of grain, equivalent to storage volumes of most smallholder farming households. The trend of infestation showed that for up to 6 months of storage, use of any grain protectants may be avoided given the low infestation range. Apparently severe dry conditions exist in the first 6 months succeeding harvest, which favour further grain drying. In all cases, the grain must be cleaned and dried to approximately 12-14% moisture. For storage beyond 6 months in JS or PS, the use of grain protection and close monitoring is required; infestation build-up by 8 MAS could be very rapid. Consistently lower infestation was noticed at Tansia and Azum-Sapielga, since these communities have well developed grain warehouses compared to Manga and Tes-Natinga. However, the potential of these warehouses was woefully underutilized due to a myriad of socio-cultural to policy limitations.

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Survey of aflatoxin contamination in maize and groundnut value chains in Upper East and Upper West Regions of Ghana

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Duration: 1 year
Sponsor: IITA/ICRISAT/Africa Rising
Location: Upper East and Upper West Regions

Executive Summary
The study assessed how postharvest operations and time of storage influence aflatoxins prevalence during on-farm storage. The survey was conducted in 6 districts of the Upper East and Upper West Regions of Ghana from October to December 2013, whereas sampling is conducted from October 2013 to September 2014. Maize and groundnut samples were obtained from household stores for aflatoxins analysis at ICRISAT, Mali. Overall, 600 farmers participated in various discussions on aflatoxin management and 240 groundnut and maize samples each (50 to 100 g) were sampled. Majority of respondents 61.5% and 27.4% were aged 20-45 and 45-60 years respectively. Average household size was up to 7±5 individuals, and majority of respondents (74.3%) had no formal education. Up to 78% had heard about aflatoxins although 68.1% did not perceive it as major constraint. Only 23.9% of respondents reportedly ever encountered problems related to eating aflatoxin contaminated foods, a large majority 77.1% either disagreed or were not sure. Many did not perceive aflatoxins as a major food mycotoxin and had no knowledge if aflatoxin contamination had adverse influence on maize and groundnut trade. Only 21.9 have ever received training on aflatoxin management, however a large majority (88.3%) of respondents expressed readiness to adopt aflatoxin management strategies. It is recommended that concurrent management approach consisting of consumer food safety awareness and pre-and-postharvest strategies should be considered. Currently, it appears several piecemeal projects on aflatoxin management are being implemented; these interventions need to be coordinated.

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. The Food and Agriculture Organization estimates that aflatoxins contaminate up to 25% of agricultural crops worldwide. 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. Due to the adverse effects associated with aflatoxins in foodstuffs, many countries have strict regulatory control measures, especially with regard to tolerance levels in food and fodder. The EU maximum tolerable limit for AFB_1 and total aflatoxin (AF) is 2μg/kg and 4μg/kg respectively. Aflatoxin concentration in contaminated maize samples ranged from 24 to 117.5 μg/kg in Benin, from 0.4 to 490.6μg/kg in Ghana, and from 0.7 to 108.8μg/kg in

Togo (James et al., 2007). Integration of host resistant, prompt harvesting, soil amendment, good storage operations and improved small-scale processing methods are critical to reducing aflatoxins levels. This study assesses aflatoxin contamination in maize and groundnut value chain in order to determine consumer risk to aflatoxins in Ghana.

Materials and Methods

The survey was conducted in 6 districts of the Upper East and Upper West Regions of Ghana from October to December 2013. The research tools employed were field surveys, focused group discussions and key informant interviews. A purposeful sampling approach targeting main producing districts, communities and households was adopted. Overall 240 farmers were interviewed and maize and groundnut samples were obtained from each respondent. In addition, 625 farmers participated in various focused group discussions on aflatoxin management. Maize and groundnut samples (50-100g) were obtained from respondents for aflatoxin analysis at ICRISAT Mali. Subsequent sampling was conducted in January, March, June and August 2014.

Results

Table 1 summarizes the demographic structure of households sampled. Majority of respondents 61.5% and 27.4% were aged 20-45 and 45-60 years respectively (Table 1a). In all, 22.6% of respondents were female and 77.4% male farmers (Table 1b). Household structure on average was made up of 7±5 individuals (Table 1c). Majority of respondents (74.3%) had no formal education (Table 1e).Majority of farmers stored maize and groundnut in polypropylene (poly-sacs) and jute sacs (Table 2). The use of Perdue Improved Cowpea Storage (PICS) sacs has recently been introduced, and only few champion farmers utilize them for maize apparently due to high initial cost. Groundnut was mostly stored unshelled for 1-4 months by less endowed farmers and up to 5-8 months by more endowed farmers (2b). Majority (60.9%) store maize for 5-8months, and less than 1% store maize store maize beyond 12 months; indicative that they produce in small quantities for subsistence. Storage volume was 1-3bags for 37.5 % of respondents, 4-10bags by 37.5%, 11-25bags by 8.3% of respondents. Table 4 describes current knowledge and perception about aflatoxin prevalence and effect on consumer health in communities. Overall, 78% have heard about aflatoxins although 68.1% did not perceive it as major constraint. Only 23.9% of respondents reportedly ever encountered problems related to eating aflatoxin contaminated foods, a large majority 77.1% either disagreed or were not sure. Many did not perceive aflatoxins as a major food mycotoxin and had no knowledge if aflatoxins had adverse influence on maize and groundnut trade. Close to 78.1% of respondents have not ever been trained on aflatoxin management. However, a large majority (88.3%) of respondents expressed readiness to adopt aflatoxin management strategies or will adopt resistant plant genotypes.

Table 1: Demographic characteristics of respondents

a. Age group (years)

Up to	Freq.	%
20	1	0.4
20-45	139	61.5
46-60	62	27.4
> 60	24	10.6

b. Gender

	Freq.	%
Male	175	77.4
Female	51	22.6

c. Size of Household		
Up to	Freq.	%
5 members	29	12.8
8 members	50	22.1
12 members	70	31.0
> 12 members	77	34.1

d. Marital status		
	Freq.	%
Single	14	6.2
Widowed	12	5.3
Married	199	88.1
Separated	1	0.4

e. Educational Level		
Up to	Freq.	%
Basic	38	16.8
Secondary	16	7.1
Tertiary	4	1.8
No formal	168	74.3

f. Household income per annum		
Up to	Freq.	%
Ghc 250	51	22.6
Ghc 500	52	23.0
Ghc 1000	69	30.5
> Ghc 1000	54	23.9

Table 2: Postharvest operations in maize and groundnut

Duration of storage (maize)		
Months	Freq.	%
1-4	61	27.1
5-8	137	60.9
9-12	26	11.6
12-24	1	0.4

Duration of storage (groundnut)		
Months	Freq.	%
1-4	65	28.8
5-8	134	59.3
9-12	22	9.7
12-24	5	2.2

Period of pest infestation (maize)		
Months	Freq.	%
1-4	117	51.8
5-8	84	37.2
After 9	11	4.9
No pest incidence	14	6.2

Period of pest infestation (groundnut)		
Months	Freq.	%
1-4	104	46.0
5-8	78	34.5
After 9	9	4.0
No pest incidence	35	15.5

Table 3: Pest infestation and management strategies adopted in maize

Most critical challenges at storage		
	Freq.	%
Insect pests	86	38.2
Rodents	12	4.8
Grain moulds	5	2.2
Combined (insects, rodents, moulds)	121	53.8
No infestation	1	0.2

What IPM strategies are adopted		
	Freq.	%
Only drying	46	20.4
Traditional methods	5	2.2
Phostoxin	36	16.0
Insecticide dust	81	36.0
No protection	47	20.9
Actellic super	10	4.4

Table 4: Knowledge and perception about aflatoxins among respondents in communities

	Strongly disagree		Disagree		Not sure		Agree		Strongly agree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
I have encountered health problems from eating aflatoxin contaminated food	64	28.3	64	28.3	44	19.5	41	18.1	13	5.8
I have heard about aflatoxins in maize and groundnut	25	11	35	15.5	6	4	75	33.2	81	35.8
Aflatoxin is a serious problem in this community/ district	25	11.1	50	22.1	82	35.9	45	9.9	25	11.1
Aflatoxins affect market value of maize and groundnut	22	9.9	60	26.5	64	28	59	26.1	21	9.3
I have been trained on aflatoxin management	129	57.1	48	21.0	5	2.2	30	13.3	14	6.2
I will adopt aflatoxin management strategies or resistant genotypes	3	1.3	-	-	1	0.4	23	10.2	199	88.1

Conclusion

The study characterized current farmer harvesting and storage operations and how these operations influence aflatoxins accumulation in household stores. Results of the laboratory analysis will be essential in providing recommendations particularly relating to the influence of location, method of storage and time of storage on aflatoxin prevalence. However, concurrent management approach consisting of consumer food safety awareness and pre-and-post-harvest strategies will be necessary. There is need to strengthen collaboration among stakeholders in maize and groundnut value chains to achieve considerable results. Currently, it appears several concurrent piecemeal projects on aflatoxin management are being implemented by different actors and/or funding partners.However, there was high willingness (88.1%, Table 8) to adopt aflatoxin management strategies or resistant genotype. Integrated strategies involving clean farm operations, efficient drying methods, use of appropriate storage technologies and provision of improved storage structures may have to be adopted to reduce aflatoxins to safe limits.

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Evaluation of groundnut genotypes for resistance to aflatoxins

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Duration: 1 year
Sponsor: IITA/ICRISAT/Africa Rising
Location: Northern,Upper East and Upper West Regions

Executive Summary
The objective was to conduct participatory evaluation of the performance of 10 groundnut genotypes (consisting of 8 aflatoxin resistant lines from ICRISAT, one improved variety (Nkatie-SARI) and a popular local Chinese variety. Three mother trials and 18 babies were established at Tingoli, Samboligo and Nyagli in Northern, Upper East and Upper West regions respectively. Farmers Field Schools and participatory variety selection (PVS) sessions were organized at all 3 sites. After harvested, seed samples were sent to ICRISAT-Mali for Aflatoxins analysis. The study showed that average days to 50% flowering was 28-30 across the genotypes except Nkatie-SARI which recorded 32-45 days to flowering. Overall susceptibility to early and late leaf spot was marginal among the genotypes. Significant differences ($p<0.05$) existed in percent defoliation with farmer variety and ICGV 93305 being the most susceptible. Nkatie-SARI recorded the highest haulm and grain yield in UW and NR but this was not consistent in Upper East Region. Yield was generally low (0.116 to 1.306 $t.ha^{-1}$) across genotypes; probably due to the late planting in mid-July. There is need to replicate the study in 2014 to obtain consistent yield data which is essential in the release, dissemination and adoption processes.

Introduction
Groundnut (*Arachis hypogeae*) is an important cash crop and component of diet, particularly protein source for many rural households of Ghana. National per capita groundnut consumption is estimated at 0.61 kg/week (Awuah 2000). According to Jolly et al. (2008), 80% of Ghanaians consume groundnut or groundnut products at least once a week, and 32% at least three times a week. Informal small-scale processing of groundnut into paste, oil and cake is widespread particularly among rural women; providing vital source of livelihoods. The nuts

are harvested and sun-dried for 4-6 sunshine days and stored during the drier months of the year. However, aflatoxin contamination in groundnut is still a major food safety concern. The current groundnut varieties are land races which have been recycled for over 3 decades now. Early planting is preferred by farmers though this usually coincides with terminal and prolong drought which is associated with occurrence of aflatoxins. Factors influencing high incidence of aflatoxin contamination of groundnut include drought, poor agricultural practices during planting, harvesting, drying, transportation and storage (Moss, 1998). The extent of contamination varies from geographic location, agronomic practices, and the susceptibility of commodities to fungal invasion. There is the need integrate interventions such as host resistance, good agronomic practices, drying and storage operations to reduce aflatoxins to safe limits. The main objective was to evaluate the performance of 10 groundnut genotypes for aflatoxin resistance.

Materials and methods

Field trials were established at Tingoli, Saboligo and Nyagli in the NR, UER and UWR, respectively. Each farmer was provided with 500g seed of 5 aflatoxin resistant genotypes. Eight of the genotypes were obtained from the breeding programme of ICRISAT-Mali while the remaining two genotypes were standard check from Ghana. The experiment was conducted as 'mother and baby trials'. The "Mother and baby trial design" is an on-farm research paradigm consisting of a central researcher-managed "mother trial" comprising all 10 tested varieties and satellites or "baby trials". The baby trials are farmer-managed trials and are subsets of varieties from the mother trial. In all 18 baby trials, 6 each in NR, UER and UWR were established. Data was generated on canopy spread, days to 50% flowering, haulm weight, pod yield and scoring for leaf spot and percent defoliation. Participatory variety selection was conducted with farmers at all locations.

Results

Tables 1-3 provide a summary of the performances of the 10 genotypes at each location. Overall, good seedling establishment was noticed for all genotypes except Nkatie-SARI which showed extreme poor germination rate. Average days to 50% flowering was 28-30 across most genotypes except Nkatie-SARI which recorded 32-45 days to flower. Nkatie-SARI recorded the highest haulm and grain yield in UW and NR but this was not consistent in Upper East Region (Table 1& 2). Yield was generally low (0.116 to 1.306 $t.ha^{-1}$) across genotypes compared to potential yield of groundnut in Ghana. However, this could be partially attributed to late the late planting of trial in mid-July. Nkatie-SARI showed the highest yield potential (1.063 $t.ha^{-1}$) in Northern region (Table 1) but this was not consistent with UE and UW Regions (Table 2 & 3). Overall susceptibility to early and late leaf spot was marginal among the genotypes (Table 4). Significant difference ($p<0.05$) was noticed in percent defoliation with Farmer variety and ICGV 93305 being the most susceptible (Table 4).For each genotype, grain samples have been forwarded to ICRISAT, Mali for Aflatoxin analysis.

Table 1. Performance of 10 aflatoxin resistance groundnut genotypes in Northern Region

Genotype	Canopy spread			Days to 50% flowering	Haulm weight (t.ha-1)	Pod yield (t.ha^{-1})
	14 DAE	28DAE	42DAE			
ICGV 91317	5.40	14.22	15.28	21.33	0.771	0.363
ICGV 91324	4.53	11.82	12.77	20.67	0.933	0.461
ICGV 93305	4.65	16.02	16.90	20.67	1.167	0.266
ICGV 94379	5.53	17.29	18.10	21.67	0.983	0.453
ICGV 91284	5.52	15.42	16.18	20.67	0.725	0.394
ICGV 91278	5.52	14.27	15.41	20.33	1.533	0.364
ICGV 91315	6.31	14.53	15.41	21.00	0.525	0.364
ICGV 91279	5.21	13.52	14.33	22.00	0.783	0.372
Nkatie-SARI	4.12	9.84	10.75	33.00	2.850	1.063
Far. variety	3.9	10.03	11.49	30.00	0.250	0.550
CV (%)	19.9	8.5	6.5	3.0	19.2	22.0
LSD (*P<0.05*)	3.069	20.0	4.654	1.153	0.725	0.371

Table 2. Performance of 10 aflatoxin resistance groundnut genotypes in Upper West region

Genotype	Stand count (2WAE)	Stand count at harvest	DDF (days)	Mean Canopy spread (cm)	Mean plant height (cm)	Pod load/ plant	Dry haulm wt (t/ha)	Yield (t.ha.$^{-1}$)
ICGV-91317	39.5	34	29	23.5	9	3	0.245	0.138
ICGV-91324	39.3	29.8	29.3	23	10.3	3	0.235	0.116
ICGV-93305	38	30.8	29.5	24	10.2	3.3	0.259	0.134
ICGV-94379	39	33.3	28.2	23.9	11.1	4	0.250	0.187
ICGV-91284	38	34.8	29	23	10	4.5	0.211	0.157
ICGV-91278	36.8	31	29	25.4	11.4	4.8	0.236	0.154
ICGV-91315	31.3	23.8	30.8	21	9.5	4.5	0.244	0.158
ICGV-91279	35.3	29.9	28.8	23.2	11	2.8	0.331	0.157
NKATIE-SARI	16.3	9.5	45	21.5	7.4	5.3	0.415	0.238
Farmer var.	36.8	29.0	30.3	23.4	10.2	4.5	0.263	0.189
LSD	2.42		1.64		2.29	2.73	0.130	0.089
CV	2.3		0.9		1.0	11.8	8.7	19.0

Table 3. Performance of 10 aflatoxin resistance groundnut genotypes in Upper East Region

Genotype	Stand count (2WAE)	Stand count at harvest	DDF (days)	Canopy spread at 60 days(cm)	Dry haulm weight t/ha	Yield (t/ha)
ICGV-91317	59.3	56.7	29	15.5	2.8	1.02
ICGV-91324	51.0	51	29.7	18.8	2.9	0.718
ICGV-93305	55.7	54	29	19	3.5	0.960
ICGV-94379	59.3	58.3	29.3	15.8	3.2	1.222
ICGV-91284	54.3	45.3	29.7	15.4	2.1	1.007
ICGV-91278	50.7	47.7	30.0	15.6	2.5	0.973
ICGV-91315	39.7	34.7	29.3	17.7	2.5	0.550
ICGV-91279	40.7	34.3	29.3	19.1	2.4	0.808
NKATIE-SARI	24	22	32	19.1	3.3	0.422
Farmer var.	61	59.7	29	17.3	2.4	1.304
LSD	8.63	9.158	0.802	5.682	0.904	0.329
CV	3.2	6.5	0.2	17.2	18.4	30.2

Table 4. Leaf spot scores and percent defoliation in 10 groundnut genotypes

Peanut genotype/ Cultivar	Early Leaf Spot	Late Leaf Spot	Defoliation (%)
ICGV 91317	3.73	4.37	38.8
ICGV 91324	3.87	4.03	39.8
ICGV 93305	3.60	4.23	43.1
ICGV 94379	4.13	4.70	37.0
ICGV 91284	3.73	4.00	32.4
ICGV 91278	3.50	4.13	37.2
ICGV 91315	4.40	4.73	40.3
ICGV 91279	3.83	4.07	28.1
Nkatie-SARI	3.07	3.77	30.2
Farmers var.	2.80	3.80	48.7
CV (%)	20.7	18.7	15.5
LSD (*P<0.05*)	0.954	0.836	13.46

Conclusion

The study seeks to increase farmers' access to improved groundnut varieties. Three traits: early maturing, high yielding and resistance to aflatoxins were of essence in this study. The total aflatoxins levels after the laboratory analysis will be critical in recommending the genotypes for further adoption trials and release. The study will be conducted in 2014 to obtain consistent yield data which is essential in the release, dissemination and adoption processes.

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Influence of harvesting dates on yield components of 4 sweet potato cultivars

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Collaborating Scientist: K. Acheremu
Duration: 1 year
Sponsor: Tuskegee Univ.-STOPS
Location: Upper East Region

Executive summary
The study evaluated yield performance of 4 sweet potato cultivars, and further determined which date of harvesting: 60, 80, 100 and 120 DAP, provides optimum yield and commercial grade tubers. The study was conducted at Manga Agric. Station and Nikongo, a community in the Pusiga District. All standard agronomic practices and field labeling were conducted. Overall, the 2 farmer varieties (*Asamarig* and *Cinkanse-Abiga*) showed marginally higher yield at each harvest stage. Yield performance of *Tuskegee-orange* was at par with the local varieties, whiles the *Tuskegee-purple* showed the least yield performance. Overall yield and tuber count was low at 60 DAP but increased by 30-40% by 80 to 100 DAP, and further by 50-60% by 120 DAP. The participatory variety selection sessions showed that the 2 farmer varieties were preferred based on yield performance. These varieties showed good plant establishment and higher yield potential which are critical during drought conditions. Due to perennial gluts in sweet potato at peak harvesting, elongating the harvest from 100 DAP could stretch the harvest period by close to 30 days. The study need to be replicated in 2014 to obtain stable yield performance of the genotypes.

Background
Sweet potato is an important crop in the Upper East Region of Ghana due to its adaptive ability in poor soils. Until recently, a vast majority were low yielding white flesh cultivars which are low in beta-carotene. However, the Root and Tuber Improvement and marketing Programme (RTIMP) made tremendous strides particularly at introducing orange flesh sweet potatoes

(OFSP) and other high yielding cultivars. However, key problems in the sweet potato value chain still include extreme marketable surpluses at the peak harvest season, high postharvest losses and low profit margins to growers. There is the need to integrate interventions to ameliorate these constraints. The study evaluated yield performance of 4 sweet potato cultivars, and determine which date of harvesting: 60, 80, 100 and 120 DAP, provides optimum yield and commercial grade tubers.

Materials and Methods

Two demonstrations were established at Manga Agric. Station and Nikongo, a major sweet potato growing community in the Pusiga District, in 2013 cropping season. Two improved genotypes (*Tuskegee-orange* and *Tuskegee-purple*) obtained from the USA were evaluated alongside with 2 improved yielding cultivars (*Asamarig* and *Cinkanse-Abiga*). Data collected include plant establishment, stand count, vine length, stover yield, tuber yield and number of commercial tubers. Participatory variety selection (PVS) was conducted to identify the preferred varieties based on yield and sensory traits.

Results

Tables 1 provides summary of the establishment and yield performances of the genotypes at the different harvesting times. Overall, good establishment was recorded except *Tuskegee-purple* which showed extreme poor establishment rate. The 2 farmer varieties showed marginally higher yield at each harvest stage. Yield performance of *Tuskegee-orange* was at par with the local varieties, whiles the *Tuskegee-purple* showed the least yield performance. General yield and tuber count was low at 60 DAP but increased by 30-40% by 80 to 100 DAP, and further by 50-60% by 120 DAP. Average yield potential was higher at Nikongo compared to Manga due to differences in soil fertility. Table 2 summarizes farmers' preference ranking as well as reasons influencing their choices. Overall, the 2 farmer varieties *Asamarig* and *Cinkanse-Abiga* were selected mostly based on yield performance. These varieties are high yielding and have the ability to survive drought conditions especially during early plant establishment.

Table 1: Influence of date of harvesting on yield components of 4 sweet potato cultivars

Variety	Stand count	Vine length(m)	Tuber count	Fresh Haulm Yield ($t.ha^{-1}$)	Tuber yield ($t.ha^{-1}$)
			Performance at 60 days		
Tuskegee-orange	20.3	1.24	58.3	2.66	2.84
Tuskegee-purple	10.3	1.01	18.7	0.88	0.52
FV. (Asamarig)	25.7	0.58	55.0	2.83	1.77
$P_{=05}$	0.049	0.026	0.070	0.09	0.19
$LSD_{0.05}$	11.55	0.409	36.56	2.015	2.79
CV (%)	4.5	13.9	17.6	18.5	58.1
			Performance at 80 days		
Tuskegee-orange	21.0	1.47	41.0	6.67	2.926
Tuskegee-purple	9.3	0.86	27.3	4.63	2.11
FV. (Asamarig)	26.3	0.76	42.3	7.52	3.22
$P_{=05}$	0.042	0.193	0.477	0.30	0.07
$LSD_{0.05}$	12.3	0.943	34.5	4.52	0.97

CV (%)	17	2.6	20.6	12	12.5
Performance at 100 days					
Tuskegee-orange	17.7	1.47	43.7	4.22	3.84
Tuskegee-purple	6.7	0.84	12.3	2.07	1.40
FV. (Asamarig)	27.3	0.81	61.3	5.74	6.59
$P_{=05}$	0.008	0.11	0.052	0.001	0.001
$LSD_{0.05}$	9.05	0.736	37.4	9.655	1.055
CV (%)	11.2	9.8	14.5	28.4	18.3
Performance at 120 days					
Tuskegee-orange	31.7	1.01	84.3	7.19	13.74
Tuskegee-purple	27	1.25	71.3	6.00	12.82
FV. (Asamarig)	27.3	3.39	90	5.85	21.15
FV. Cinkanse-Abiga	35.5	2.89	103.3	6.26	27.33
$P_{=05}$	0.011	0.001	0.001	0.037	0.001
$LSD_{0.05}$	4.46	1.159	1.3	0.883	1.165
CV (%)	4.1	1.7	5.379	1.1	3.2

Table 2: Participatory variety selection at 90 and 120 days after planting

Name of variety	Number selecting at		Reasons for preference
	100 DAP	120 DAP	
Tuskegee-orange	-	1	Tuber color and shape
Tuskegee-purple	-	2	Soft bite, not sweet
Asamarig (purupuru)	9	10	Sweet, high yielding, drought tolerant, high price, good establishment
Cinkanse-Abija (Kuffour)	6	7	Early maturity, sweet, high yielding, drought tolerant, high price, good establishment
	15	20	

Conclusion

The study shows that *Tuskegee-orange* has yield potential comparable to existing varieties. The *Tuskegee-purple* showed poor establishment which is essential in sweet potato production. Harvesting at 60 DAP may lead to loss of economic yield, however due to perennial gluts at peak harvest, elongating the harvest from 100 DAP could stretch the harvest period by close to 30 days. The study would be replicated in 2014 to obtain stable yield potential of these genotypes. Consumer preference analysis needs to be conducted alongside the agronomic assessment.

Evaluation of Some Okra, Roselle and Tomato Genotypes for Adoption in the Upper East Region

Principal Investigator:I. Sugri
Collaborating Scientist: M.S. Abdulai, F. Kusi, M. Zakaria
Duration: 2 years
Sponsor: IITA/AVRDC/Africa Rising
Location: Upper East Region

Executive Summary

The objective was to conduct participatory on-farm evaluation of the performance of okro, roselle and tomato genotypes. Two demonstrations were established at Manga Experimental Station and Tekuru one of the Africa Rising communities in the Kasenna East district of the Upper East Region. In all, 19 okro, 15 roselle and 6 tomato genotypes were evaluated. In three of the Africa Rising communities: Saboligo, Tekuru and Bonia, 30 farmers were provided with up to 10-20 g of seed of some extra early maturing of Okro and roselle genotypes to boost up their local germplasm. All standard agronomic practices such as weeding and field labeling were conducted. Four Farmers Field Schools (FFS) and participatory variety selection (PVS) were organized with 256 farmers from 4 major vegetable producing cluster of communities. During PVS sessions, farmers selected their preferred varieties using traits such as seed vigour, plant architecture, yield, multiple harvesting frequency, viscosity, taste, colour, drying quality and marketing potential. Seed of the selected varieties will be multiplied in subsequent cropping seasons to make such genotypes accessible to other farmers. Overall, this study is expected to increase farmers' access to improved tomato, roselle and okro varieties.

Introduction

Vegetables such as okra, onion, garden egg, pepper, tomato, amaranths, roselle and pumpkin are essential component of diet and household income in Ghana. These vegetables are important cash crops to peri-urban farmers particularly in the dry season where commercial production is carried out under irrigation conditions around dug-outs, small dams and along river banks. On arable lands, they may appear as sole crops, intercropped or as boarder crops. 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 fibre. 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, flavonoids, iron and pro-vitamin A.

Technology dissemination

Four Farmers Field Schools (FFS) were organized with 256 farmers from 4 major vegetable producing cluster of communities: Azum-sapielga, Badu, Boku, Tekuru, Bonia, Tampezua, Mognori, Nyorigu, Manga and Nayorko. The participants were taken through good vegetable production practices from nursery and field management to postharvest and marketing operations. Participatory variety selection (PVS) sessions were held with the same 256 farmers at 50% fruiting stage. The PVS assist to identify genotypes and traits which would be suitable for wide adoption in communities, which is essential for future vegetable improvement programmes. Selection was based on preference traits such seed vigour, plant architecture, yield, multiple harvesting frequency, viscosity, taste, colour, drying quality and market potential.

Performance of the Okro Genotypes

Objective:

This study broadly seeks to achieve a more competitive okra value chain, and identify critical traits which are essential in future crop improvement in okra. The specific objectives are to: (1) evaluate the agronomic performance of some okra genotypes for wider adoption in Ghana and; (2) identify traits which are essential to growers and consumers of both local and export markets.

Material and methods

In all, 19 okro genotypes were evaluated using on-station and on-farm demonstrations. These included 13 improved genotypes: Sasilon, P1496946, TZ-SMN-86, ML-OK-37, ML-OK-16, ML-OK-35, ML-OK-10, AAK, NOKH 1002, NOKH 1003, NOKH 1004, NB-55-SRIVAN and Ex-Makutopora, obtained from AVRDC, Mali. The other 6 genotypes were obtained from local markets. Four genotypes Uun, Unn-manna, Shie-manna Kpazeya have names of the Kussasi dialect whiles the two others Pora-nasong and Pora-napong of the Kassina dialect. Planting distance was 30x75cm on 2 replicates of 4x8m plots, but data was collected on 3x4m plots. All agronomic practices were observed but one spraying was done in Manga. Critical data was collected on plant count at 2 weeks after planting, and at harvesting, plant height at 2, 6 and 8, days to flower initiation, 50% flowering and 50% fruiting, fruit count at 60, 80 & 100 DAP. Other plant morphological and fruits characteristics were described.

Results

Overall performance was good in the 2013 cropping season. Trials at Tekuru were planted in late July due to pre-season drought. Table 1 summarizes the plant establishment and yield components of the genotypes. Based on days 50% flowering, 7 genotypes: NOKH 1002, NB-55-Srivan, NOKH 1003, NOKH 1004, AAK, EX-makutopora and FV-Unn-manna were early maturing. These genotypes attained 50% flowering by 40-50 DAP and 50% fruiting by 45-65 DAP. Six genotypes: sasilon, ML-OK-16, ML-OK-37, TZ-SMN-86, Pora-napong and Pora-nasong were of medium maturity; they attained 50% flowering after 50 days of planting. The other genotypes: ML-OK-16 and ML-OK-10, P1496946, FV-Unn and FV-Kpazeya, were late maturing. Overall preference scoring during the PVS sessions is summarized in Table 2. During PVS, farmers were asked to associate with one genotype and assign reasons for their selection. Selection was based on yield, vigour, fruit size, taste, fruit viscosity, drying quality multiple harvest frequency, price and market potential. Overall preference ranking for any particular okro genotype was connected to season of growth. Fruit viscosity was a subjective trait as some prefer much viscous to less viscous types and vice versa. Leaf and fruit pubescence were critical to women as current harvesting is done manually by hand plugging. Glabrous leaf and fruit texture were critical harvest traits. The overall preference ranking (Table 2) showed that Sasilon (16.1%), NOKH 1004 (15.6%), NB-55-Srivan (13.7%) and NOKH 1003 (9.5%) would have wide adoption potential under irrigation and pre-season okra production. In order of preference and performance, NOKH 1004, NB-55-SRIVAN, Sasilon and NOKH 1002 can be considered for further adoption trials. The above average preference ranking for the farmer varieties Kpazeya (8.2%), Unn-manna (7.8%), Unn (7.7%), Pora-nasong (7.8%) and Pora-napong (7.8%) is indicative that these genotypes are still indispensable due to their performance under rain-fed production. They were generally selected due to their high yield and drying qualities.

Conclusion

This study reiterate the need to evaluate and deploy okro genotypes with superior agronomic performance suitable for adoption under both rain-fed and irrigation conditions. Four traits were most critical to growers: high yield (HY), early maturing (EM), multiple harvest frequency (MHF) and drying quality (DQ). Other traits included prolonged tenderness, fruit size, viscosity, price, taste, fruit texture and tolerance to field stress. Few undesirable traits included poor drying quality, late maturity, and leave and fruit pubescence. Under irrigated dry season gardens, EM HY and MHF would be most critical. Late maturing genotypes with poor DQ were generally less preferred. Considering the value and utility of dried okro in Ghana, early maturing genotypes which are amendable to drying and/or access to simple farm level drying facilities would be indispensable to achieving a competitive okro value chain.

Table 1: Some Yield components of 19 okro genotypes

Genotype	Max. plant height at harvest (cm)	Days to 50% flowering	Days to 50% fruiting	Fruit Count (DAP)			Fruit weight /plot (kg)	Yield $T.ha^{-1}$
				60 days	90 days	120 days		
Sasilon	40.0	61	65.5	18	33	65	29.55	1.65
TZ-SMN-86	40.5	61	67	2	18	101	4.17	2.32
P1496946	21.0	87	95	0	4	28.5	0.66	0.37
AAK	31.0	51.5	56.5	52.5	71.5	110	2.96	1.64
Ex-Makutopora	58.0	59	66	25	58	50	0.23	0.13
NB-55-Srivan	43.5	48	51	43.5	58	111	3.43	1.91
ML-OK-10	18.0						0.14	0.08
ML-OK-16	36.5	71	82.5	0	10	33	0.75	0.42
ML-OK-35	15.5						0.14	0.08
ML-OK-37	32.5	62	69	9	25	35	0.97	0.54
NOKH 1002	37.0	48.5	55.5	39	54.5	127	5.41	3.00
NOKH1003	42.0	47.5	51	106	153	311	9.72	5.4
NOKH 1004	35.5	50	55	120	189	370	17.72	9.85
FV (Unn)	80.0	79	85	0	4	137	2.84	1.58
FV (Unn manna)	37.5	56	64	13.6	105	225	10.58	5.88
FV (Kpazeya)	21.0	71	82	0	38	208	2.96	1.64
FV (Pora-napong)	40.0	62	79	3.5	6.5	24	0.23	0.22
FV (Pora-nasong)	46.0	67	78	2	10	7	0.19	0.10
FV (Shie-manna)	45.0	83	95	0	6	5.5	0.1	0.06
P0.05	0.063	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD0.05	26.43	7.9	11.86	9.05	12.47	12.39	0.805	0.447
CV (%)	32.5	0.9	0.4	3.7	4	0.9	1.3	1.3

Table 2: Factors influencing farmers' preference for a specific okro genotypes

Most preferred genotypes	Overall preference		Reasons (traits) for selection	Off-traits
	Freq	%		
Sasilon	41	16.1	HY, EM, large fruits, prolonged tenderness, viscous, good tastes	Poor DQ
TZ-SMN-86	3	1.2	HY, EM, less spines, good taste	Poor DQ
Ex-Makutopora	4	1.6	HY, EM, less spines	Poor DQ
NB-55-Srivan	35	13.7	HY, EM,MHF, long fruits, viscous	Poor DQ
ML-OK-16	4	1.2	HY, EM, long fruit, viscous	Poor DQ
NOKH 1002	5	2	HY, EM, long fruits, less spines	Poor DQ
NOKH1003	24	9.5	HY, EM, MHF, Long fruits, less spines	Poor DQ
NOKH 1004	40	15.6	HY, EM, MHF, long fruits, good taste	Poor DQ
FV (Unn)	19	7.5	HY, MHF, good DQ, high price of dried okra, drought resistant, good taste	Late maturing, pubescence
FV (Unn manna)	20	7.8	HY, MHF, good DQ, high price of dried okra	Late maturing, pubescence
FV (Kpazeya)	21	8.2	HY, MHF, good DQ, high price of dried okra	Late maturing, pubescence
FV (Pora-Napong)	20	7.8	HY, MHF, high price, prolong tenderness, less viscous	Late maturing
FV (Pora-Nasong)	20	7.8	HY, MHF, high price, prolong tenderness, less viscous	Late maturing
Total	256	100		

Poor drying quality: The cultivar respond slowly to drying or easily become mouldy when dried, HY= High yielding, EM=Early maturity, MHF= Multiple harvesting frequency, DQ= Dry Quality

Performance of the Roselle Genotypes

Principal Investigator:I. Sugri
Collaborating Scientist: M.S. Abdulai, F. Kusi, M. Zakaria
Duration: 2 years
Sponsor: IITA/AVRDC/Africa Rising
Location: Upper East region

Objective: To evaluate some roselle genotypes for yield and consumer preference as well as upgrade farmers current roselle germplasm

Materials and Methods
In all, 15 roselle genotypes were evaluated under on-station and on-farm demonstrations. Eight genotypes: *Morongoru*, *Samandah*, *Llafia*, *Marcha de Bozola*, *Dah Rouge*, *Martin*, *Local* and *Navorongo* were obtained from AVRDC, Mali. Seven other genotypes: *Bissem, Bariga, Bit, Nyankpala, Kanzaga* and *Veo*, were obtained from local markets. Two demonstrations were established at the Manga Experimental Field and Tekuru in the Kassena East district. Planting

distance was 20X75cm on 3 replicates of 6x9m plots, but data was collected on 4 inner rows. All agronomic practices were observed but no spraying was done. Critical data was collected on plant count at 2 weeks after planting, and harvesting, plant height at 2 , 6 and 12 WAP, days to50% flowering and 50% fruiting. Other plant morphological and fruits characteristics were described.

Results

General seed germination and seedling establishment was good across genotypes and locations. *Martin, Bit* and *Marcha de Bozola* showed quite poor seed viability. Trials at Tekuru were planted in late July. Table 3 summarizes the plant establishment and yield components of the genotypes. Four Farmer Field Schools and participatory variety selection (PVS) were organized. The participants were taken through nursery and field management to postharvest and marketing operations. Results of the PVS are summarized in Table 4. The most important traits were: leaf reproduction, chalice juice color, leaves forms and color, leaves' soup sourness and softness when boiled, etc. Light-red and brown colored genotypes are used for preparation of *Bissam*, a local snack beverage. Four genotypes, Martin, *Samandah*, *Morongoro*, and *Kanzaga* were consistently selected at 3 sessions. *Martin* and *Bia* were the most preferred genotypes across locations. At Tekuru, farmers rather preferred their local land races: *Kanzaga*, *Veo* and *Bissam* to the other genotypes.

Table 3: Some Yield components at harvest of the 15 roselle genotypes in Upper East Region

Genotype	Stand count	Plant height (cm)			Days to 50% flowering	Days to 50% fruiting	Stover weight	Fruit count	Fruit weight	Seed weight
		2wks	8wks	12wks			(kg)		(kg)	(g)
Morongoru	120	9	170	180	101	106	7.8	902	2.6	432
Samandah	100	4	97	145	125	130	5.6	390	2.2	91
Ilafia	100	6	94	157	94	102	4.0			160
Marcha de Bozola	45	6	125	148	116	126	6.6	735	2.2	331
Local	56	5	72	95	130	135	4.6	554	2.8	143
Dah Rouge	40	5	159	185	115	123	5.7	437	0.7	60
Martin	14	7	82	95	97	103	4.3	272	3	192
Navorongo	115	7	160	164	101	116	7.3	1094	2.9	403
Bissem	110	7	118	142	97	104	4.7	411	1.7	82
Bariga	120	6	117	142	92	113	3.0	370	0.5	85
Bit	42	8	150	170	98	106	4.1	784	2.2	356
Bia	114	8	150	180	105	112	5.2	770	2.1	339
Nyankpala	120	6	74	95	123	128	1.4	91	0.6	194
Kanzaga	120	6	110	165	98	120	2.5	197	0.2	49
Veo	120	5	95	112	78	86	2.6	662	1.2	293

Table 4: Participatory Variety Selection of Roselle genotypes

Most preferred Genotype	Session I	Session II	Session III	Session IV	Preference traits
	Nyorigu andAzum-Sapielga	Mognori, Tampezua	Tekuru, Bado and Bonia	Boku and Nayorko	
Morongoru	5 (7.7)	4 (6.2)	3 (5.6)	5 (8.8)	green leaf, boil-hard, does not shade leaves early, less ingredients required
Samandah	5 (7.7	10 (15.4)		12 (21.1)	green leaves and *Bissam* preparation
Ilafia				5 (8.8)	green and leafy
Marcha de Bozola					
Local		6 (9.2)		9 (15.9)	green leaves and *Bissam* preparation
Dah Rouge	3 (4.6)	7 (10.8)		2 (3.5)	Leafy, Bissam beverage
Martin	11 (16.9)	8 (12.3)	7 (13)	25 (43.9)	green, boil-soft, leafy, calyx, sell fast, less ingredients required
Navorongo					
Bissem	3 (4.6)	6 (9.2)	4 (7.4)		Leaf, for Bissam beverage,
Bariga	3 (4.6)				Multiple harvesting, boil hard, less sour
Bit	9 (13.9)	7 (10.8			Taste good, less sour, fast to boil
Bia	10 (15.4)	11 (16.9)			Good taste, boil soft
Nyankpala	10 (15.4)				Leafy, calyx
Kanzaga	3 (4.6)	7 (10.8)	10 (18.5)		Multiple harvest, taste good, less ingredients required,
Veo	3 (4.6)		30 (55.6)		Fibre, leafy, early maturing,
Total	65	65	54	57	

Values in parenthesis are percentages

Conclusion:
From the PVS processes, all the roselle genotypes would have good consumer acceptance, albeit at different locations. Each cluster of farmers participating in the PVS appeared to vary in preference for the different genotypes. This relates to taste preference which vary among different consumers and often times across locations. Seed of the genotypes will be accessible to farmers in subsequent seasons.

Performance of the Tomato Genotypes

Principal Investigator:I. Sugri
Collaborating Scientist: M.S. Abdulai, F. Kusi, M. Zakaria
Duration: 2 years
Sponsor: IITA/AVRDC/Africa Rising

Location: Upper East region

Objective

Currently the existing tomato varieties are of two types: 1) the indigenous varieties which perform well under rain-fed conditions and 2) exotic varieties which perform well under irrigation. Most varieties in the former have low dry matter content which make them less suitable for industrial processing. This study seek to identify tomato genotypes for yield stability under both rain-fed and irrigation conditions. The main objective was to conduct participatory evaluation of the performance of 6 tomato genotypes to identify yield stability under both rain-fed and irrigation conditions.

Materials and Methods

Study was conducted in the year 2012 and repeated in 2013 at the Manga Agriculture Station. Six genotypes: *Duluti, LBR 7, LBR 16, LBR 17, Tengeru* and *Kénéyé*, were evaluated under rain-fed conditions. Seeds were nursed and transplanted to a permanent field at a distance of 30x75cm on 3 replicates of 6x9m plots. Critical data was collected on plant count at 2, 8 and 12 WAP, plant height at 4, 8 and 12 WAP , days to 50% fruiting, fruit count at 70, 80, 90 & 100 DAP, fruit size, incidence of physiological disorder and diseases. Other plant morphological and fruits characteristics were described.

Results

In 2012, although the tomato seeds were nursed quite late, general field performance was good due to prolonged rainfall. Days to 50% fruiting were Duluti (77.5), Kénéyé (72), LBR 16 (82), LBR 17 (78.5), LBR 7 (77.5) and Tengeru (79.5) (Table 5). The best performing genotypes were LBR 17, LBR 7, Duluti and Kénéyé. The genotype Kénéyé, is an extra-early maturing (52 days to 50% flowering) but quite susceptible to bacteria spot at all stages of growth. At any harvest, Kénéyé produced the highest yield (54.2t.ha^{-1}), fruits/plant (7) and fruits/plot (54.2), but fruits were rather of small to medium sizes (16.9g) (Table 6). Three other genotypes, LBR 17, Duluti and LBR 7 showed good yield performance of 30.5, 25.7 and 22.5 t.ha^{-1} respectively. Tengeru and LBR 16 showed the least yield performance of 138 and 147 kg/ha respectively.

Table 5: Plant establishment and growth characteristics of 6 tomato genotypes (2012)

Genotype	Plant count		Plant height (cm)			Days to	
	Initial	At harvest	2 weeks	6 weeks	12 weeks	50% flowering	50% fruiting
Duluti	16.5	11.5	9	29.5	44.5	69	77.5
Kénéyé	42.5	27	9	33.5	47.5	52	72
LBR 16	35.5	19.2	8.5	29.5	43.5	73	82
LBR 17	35.5	17.5	7.5	31	42.5	68	78.5
LBR 7	23.0	9. 5	9	31	45.5	68	77.5
Tengeru	42.5	17.5	8.5	32.5	48.5	69	79.5

Date of planting= 17-07-12, date of transplanting= 12-08-12, plot size= 3mx4m

Table 6: Harvest and postharvest characteristics of 6 tomato genotypes (2012)

Genotype	Number of fruit harvested	Weight of fruit harvested (g)	Average yield (t.ha^{-1})	Fruit count at harvest	Number of whole fruits	Number of rotting fruits	Weight of rotting fruits (g)
Duluti	8.5	308	25.7	14.2	251	4	138
Kénéyé	38	650	54.2	54.2	504	15.3	149
LBR 16	4.2	176	14.7	12.5	110	1.8	67
LBR 17	10.2	366	30.5	18.5	116	6.3	249
LBR 7	5.5	306	22.5	10.8	134	3.3	172
Tengeru	3.5	166	13.8	8	105	1.5	60
P=0.05	0.001	0.026	0.026	0.057	0.001	0.001	0.325
CV(%)	24.6	32	32	48.8	33.5	4.33	55.7
LSD(0.05)	8.8	283.1	23.59	31.9	173.6	3.8	18.7

Date of planting= 17-07-12, date of transplanting= 12-08-12, plot size= 3mx4m

In 2013, initial plant establishment was poor due to erratic rainfall. The genotypes were similar in terms of morphological, maximum height and maturity period. Number of days to 50% flowering were*Duluti* (64.7.5), *Kénéyé* (64.7), *LBR 16* (61.7), *LBR 7* (62.7), *LBR 17* (56.3) and *Tengeru* (61.7) (Table 7). In both 2012 and 2013 cropping seasons, *LBR 17* showed the highest yield potential, whiles *Tengeru* showed the least yield performance of 19.5 t.ha^{-1}. The best performing genotypes were *LBR 17*, *LBR 7*, *LBR 16* and *Kénéyé*. Overall yield potential (t.ha^{-1}) were*Duluti* (14.6), *Kénéyé* (68.1), *LBR 16* (91.03), *LBR 7* (82.7), *LBR 17* (149.6) and *Tengeru* (19.5). The genotype *Kénéyé*, is an extra-early maturing (52 days to 50% flowering) but quite susceptible to bacteria spot at all stages of growth. At any harvest, *Kénéyé* produced the highest fruits per plant and fruits per plot, but fruits were rather of small to medium sizes (16 to 20 g) (Table 8).

Table 7: Plant establishment and growth characteristics of 6 tomato genotypes

Genotypes	Plant count		Plant height (cm)			Days to 50% flowering	Days to 50% fruiting
	30 DAE	80 DAE	30 DAE	60 DAE	90 DAE		
Duluti	51.7	49.3	19	47.7	58.7	64.7	72.3
Kénéyé	55.3	52.7	21.7	35.7	58.7	64.7	76.3
LBR 16	46.0	41.7	23	34.3	54	61.7	71.3
LBR 17	39.0	36.3	21	41	53	62.7	73.7
LBR 7	65.0	61.3	28.3	45.7	52.3	56.3	74
Tengeru	45.7	41.0	15.7	36.3	53.7	61.7	77.3
P=0.05	0.001	0.001	0.001	0.001	0.026	0.114	0.011
LSD(0.05)	8.45	6.26	2.8	4.7	4.37	6.26	3.04
CV(%)	0.8	1.8	0.9	4.6	2.9	0.9	1.9

DAE= Days after establishment

Table 8: Harvest and yield characteristics of 6 tomato genotypes

Genotypes	Total fruit count	Number of whole fruits	Weight of whole fruits (kg)	Number of rotten fruits	Fruit diameter (cm)	Total fruit weight(kg)	Potential yield $t.ha^{-1}$
Duluti	36.3	27.7	10.5	8.7	23	13.2	14.6
Kénéyé	235.3	180.3	43.2	55	20	61.3	68.1
LBR 16	123	102.3	66.5	52.7	22	81.9	91.1
LBR 17	136.7	90.3	60.8	46.3	24.7	74.4	82.7
LBR 7	206.7	16.2	110.6	44.7	26.3	134.6	149.6
Tengeru	53.3	37.3	14.2	16	21.7	17.6	19.5
P=0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD(0.05)	12.7	10.8	4.4	4.35	2.27	50.3	5.5
CV(%)	4.0	2.8	0.7	8.8	0.8	1.2	1.2

DAE= Days after establishment

Conclusion

Based on yield potential and fruit size, *Duluti*, *LBR 17 LBR 16* and *LBR 7* were promising. Except *LBR 17* which showed superior performance in both seasons, yield stability in the other genotypes has not been consistent. LBR 16 is rather long season (82 days 50% flowering). The genotypes need to be evaluated possibly under irrigation conditions to validate their actual potential and adaptability. However, they all have good potential for production under rain-fed conditions.

AGRICULTURAL ECONOMIST

Needs Assessment of Sweetpotato Production in Northern Ghana: Implications for Research and Extension Efforts

Principal Investigator. J. K. Didzakin
Collaborating Scientists: Mr. Kwabena Acheremu, Dr. Edward Carey (CIP)

Executive Summary
The study was carried out to generate baseline information on production, marketing and utilization of sweetpotato in Northern Ghana. The assessment was carried out using Rapid Rural Appraisal tools, including focus group discussions, key informant interviews, seasonal calendars, problem solving tree, decision making matrix, problem census and prioritization matrix. Northern and Upper East Regions reported higher yields ranging from (3 - 3.6) tons/acre of fresh sweetpotato per acre if fertilizer was applied. Upper West had lower yields of about (1.4 -1.8) tons/acre of fresh sweetpotato (No fertilizer applied). Northern and Upper East Regions also had a benefit-cost ratio of 2.5 compared with that of the Upper West Region of 2.05. Lack of planting material was a major limiting factor to the expansion of sweetpotato production especially in Northern and Upper West Regions. Lack of good market sources was an important limiting factor to production in all regions. 5 varieties were identified in upper east region with 3 and 4 identified in Northern and Upper West Regions, respectively. This was mainly based on flesh and skin colour of the sweetpotato, with orange-fleshed sweetpotato being well-known at each location.

Introduction
With more than 133 million tons (FAOSTAT 1998) in annual production sweet potato ranks the most important crop in fresh weight basis in developing countries after rice, wheat, maize and cassava. In Ghana, annual production is 90,000 tons from an area of 65,000 ha (FAOSTAT, 2006). A recent study by CORAF/IFPRI (2006) indicated that roots and tubers contribute the most to agricultural growth in West and Central Africa and the most to Ghana's agricultural growth as well. Current information available from Ghana's CSIR-CRI shows that roots and tubers account for approximately 40% of Ghana's GDP whilst cereals account for 7%. Ghana is not providing the necessary production support services to the crop to harness its huge potential for food security and poverty reduction (Sam and Dapaah, 2009). A major source of concern in sweet potato production is storage, Marketing and utilization. The tubers are sold within two-four weeks after harvest. The production status per region of Ghana and their relative contribution to national production is shown in table 1 below.

As part of activities to promote the production, marketing and utilization of sweet potato in general and more specifically the orange flesh sweet potato by International Potato Center (CIP) Ghana, a sweet potato community need assessment was carried out to generate relevant information to describe the prevailing sweet potato production, marketing and utilization in northern Ghana. The results of the community analysis was expected to guide **CIP** Ghana to identify entry points and to help in the design of interventions for implementation in the selected districts of the three northern regions and also serve as a data base (reference point/measuring scale) against which progress can be measured.

Table 1: Sweet Potato Production in Ghana (2012)

Region	**Area (Ha)**	**% Contribution**	**Production (Mt)**	**% Contribution**
Central	371	3.9	6,490	4.9
Volta	880	9.1	15,340	11.6
Eastern	1,030	10.7	34,910	26.4
Gt. Accra	38	0.4	640	0.5
Ashanti	37	0.4	620	0.5
Brong Ahafo	145	1.5	2,390	1.8
Northern	414	4.3	6,070	4.6
Upper East	5,550	57.7	46,000	34.9
Upper West	1,157	12.0	19,530	14.8
Total	**9,622**	100.0	**131,990**	100.0

Source: MoFA Field survey, 2012

Materials and Methods

Sweetpotato farmer's needs assessment was carried out using qualitative Rapid Rural Appraisal (RRA) tools developed by Robert Chambers [5], which included focus group discussions (FGDs), key informants interviews, seasonal calendars, problem solving tree, decision making matrix, problem census and prioritization matrix, and personal field observation. This was aimed at gathering information on the production, marketing and processing and utilization.

Besides that some secondary data was obtained through desktop research of literature on existing studies already done on similar subject. Focus group discussions were carried out with randomly selected farmers within the project districts. This was guided by a pre-printed checklist designed to meet the information needs of this assignment. Key informants interviews were conducted, basically engaging in a conversation with key stakeholders in the district such us district MoFA monitoring and evaluation officers and the crops officers.

The proposed sampling strategy used included zoning by region, purposive sampling, randomization, and stratification. Within the Northern sector of Ghana, three regional zones were created to represent the different climatic areas. This included the northern region (Guinea Savanna), the upper east region (Sudan Savanna) and the upper west region (Guinea

Savanna). Two communities were purposively selected within each region, giving us six communities in all. Sites in Upper West and Northern Regions were chosen to coincide with benchmark sites for a multi-partner CGIAR systems research and development program. Farmers were also selected because of their involvement and commitment to sweet potato production. Out of the selected communities, some sweetpotato farmers were randomly selected to take part in the study. The selection of farmers was stratified to give representation to both male and female farmers. In all about 212 farmers took part in the survey.

Results, Analyses and Discussion

The results from the Rapid Rural Appraisal are presented here. This covered all the six communities in the three regions.

Variety Preference

Table 2: Three Dominant Varieties Identified

Variety	Skin colour	Flesh colour
V1	Orange	Orange
V2	White	White
V3	Purple	White

Source: CIP Ghana Field survey, 2012

Table 3: Varietal Preferences Analysis at Dimabi Site

Characteristics	V1	V2	V3	Comments
Taste/consumption				Variety V3 is most preferred for eating
Sweetness				V1 is the sweetest
Yield potential				V1 has the highest yield potential
Prone to Pest/diseases				V3 is more resistant to pest and diseases attack compared to the other varieties
Fibrous				V2 has high fiber content
Market Demand				V3 has high demand
Market value				V3 has high market value
Processing				V2 is easy to process into potato powder for porridge and as sweetener
Dry matter content				V3 is high in DMC
Sum of Scores	16	19	15	
Preference	3rd	2nd	1st	

Source: CIP Ghana Field survey, 2012

Scores Key: 1 2 3

There were three major varieties that were found across all three regions and described in table 2 above. These were ranked from the most important to the least important (1, 2, and 3) with respect to the following attributes; Taste/consumption, Sweetness, Yield potential, Resistance to Pest/ diseases attack, Fibrous, Market Demand, Market value, Dry matter content and ease of processing. The rankings are then summed up and the variety with the least sum of score is the most preferred and the one with the highest sum of scores is the least preferred. These rankings were done in all six communities. The analysis in Dimabi is shown in table 3 above and the summary from all community analysis is provided in table 4 below.

Table 4: Farmer Variety Preference Results Summary

Variety	Skin colour	Flesh colour	Preference					
			NR		UER		UWR	
			Dimabi	Cheyohi	Nikongo	Kpaliga	Touri	Dikpe
V1	Orange	Orange	3rd	2nd	1st	3rd	1st	1st
V2	White	White	2nd	3rd	3rd	2nd	2nd	2nd
V3	Purple	White	1st	1st	2nd	1st	3rd	3rd

From table 4 above, in northern region all the two communities ranked the purple white variety as the most preferred. However Dimabi community ranked white white variety second and the orange orange variety as the least preferred. Cheyohi however ranked orange orange as second and white white as the least preferred.

In the upper east region, Nikongo ranked orange orange variety as the most important, followed by purple white and then white white variety. In Kpaliga purple white was most preferred, followed by white white and then orange orange. For the upper west, the two communities were consistent and ranked orange orange as the most preferred, then white white as the second and then purple white as the least preferred.

Table 5: Seasonal Calendar

MONTH / ACTIVITY / ITEM[5]	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rainfall			*	***	****	****	*****	*****	*****	**		
Drought (shortage of water)	*****	*****	***								**	*****
Floods								*****	*****			
Crop sequence[6]												
• Millet				LP	P	P/W	W	W/H	W	W	H	
• Sorghum				LP	P	P/W	W	W	W	W	H	
• Maize				LP	LP	P	P	W	W	H	H	
• Rice					LP	P	P	W	W	H	H	

[5]The asterisk mark (*) in the table represents an item used (e.g.) stones used by the participants to indicate the degree of change. * not likely, ** bit likely, *** likely, **** very likely, *****most likely,

[6] Land Preparation (LP), Planting (P), Weeding (W), Harvest (H), Selling (S), fertilizer Application (FA), Making Mounds (MM), Obtaining Vines (OV) and Processing (Ps)

• Soya				LP	LP	P	P	W	W	W	H	H
• Potato NR				LP,MM	MM	P,W	W,FA	W,FA	W	H*	H**	H
• Potato UWR					LP,MM	P,W	W,FA	W,FA	H**	H***	H*	
• Sweet Potato UER					LP,MM	P,W	W,FA	W,FA	W	H*	H***	H
Availability of fruits:												
• Shea	*	*	*	*	***	****	*****	*****	**	*	*	*
• Mango	*	**	***	*****	****	***	*	*	***	*	*	*
Availability of vegetables	***	***	****	****	****	*****	*****	*****	*****	****	***	**
Food shortages	*	*	*	**	***	****	*****	*	*	*	*	*
Employment	***	***	***	*	***	****	*****	*****	***	**	**	*
Unemployment	***	***	***	****	***	**	**	*	**	***	***	****
Out-migration	**	**	***	*****	**	*	*	*	*	*	**	***
Non-farm income generating activities												
• Rearing	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
Labour peaks men	***	***	**	**	***	****	*****	*****	*****	*****	****	***
Labour peaks women	**	**	**	****	****	*****	*****	*****	*****	*****	*****	***
Social activities (funerals /weddings)	***	****	*****	*****	***	*	*	*	*	*	**	***
Expenses	**	**	*****	*****	***	***	***	****	**	**	***	**
Income	**	****	*****	***	*	*	**	*	*	***	****	****
Incidence of human diseases	**	***	****	*****	***	**	***	*****	*****	***	**	**

The three regions have similar sweetpotato production calendars this is shown in the seasonal calendar in table 5 above. Land preparation, planting, weeding and harvestings across all regions have similar calendar.

Table 6: Sweetpotato Problem Solving Tree

Problem	Causes	Solutions/Coping Strategies
Lack of planting materials	• *Stealing of preserved planting materials* • *Lack of irrigation facilities to multiply during the dry season*	• *Construction of community gardens to preserve planting materials* • *Buying from neighboring communities* • *Ratooning*
Theft	• *It is sweet and can be eaten raw*	• *Fencing of fields and paying more attention to it*
Weevils and Termites	• *Because of its sweetness it attracts termites and weevils* • *Weeds infestation also induces weevils and termites attack* • *Potato grown on loamy soils are prone to weevils and termites attack*	• *They adopt shifting cultivation to control weevils and termites*
Poor rainfall	• *Planting is mostly late due to lack of planting materials*	• *Early planting when planting materials are available*
Poor market/prices	• *Glut due to harvesting at the same time* • *Easy rot of potatoes (1-2 weeks) after harvest*	• *Provide varieties with long shelve life and different maturity periods*
Storage difficulty	• *Short shelve life (1-2 wks)*	• *Introduce improved varieties*

Table 7: Sweetpotato Farm Budget

Region	Northern	Upper West	Upper East
Parameter			
Av. Farm size in acres	0.75	0.5	3
Yield in tons/acre	3.3	1.6	3.3
Price per ton GH¢	227.27	253.13	227.27
Av. Revenue/acre GH¢	750.00	405.00	750.00
Av. Cost of production/acre GH¢	300.00	200.00	300.00
Gross margin GH¢	450.00	205.00	450.00
Benefit cost ratio (B/C)	2.5	2.025	2.5
Number of Varieties identified	3	4	5

From table 7 above, northern and upper east regions reported higher yields with a mean yield of 3.3 tons of fresh sweetpotato per acre of land cultivated. Upper west has the lowest yield of about 1.6 tons/acre of fresh sweet potato. The reason given for such low yields was non application of fertilizer. It is possible to increase yields from this area when fertilizer is applied.

The gross margins of Northern and Upper East are about 450.00 GHC compared to that of the Upper West Region with 205.00 GHC. Northern and Upper East Regions also have a benefit cost ratio of 2.5 compared with that of the Upper West Region of 2.05. It is economically feasible to increase cost by applying fertilizer and still increase your returns on investment. With regard to average sweet potato farm size per region, Upper East Region has the highest with average of about 5 acres followed by northern region with about 0.75 acres and then Upper West with an average of 0.50 acres.

Constrains to sweet potato production were identified across the three sites to include; lack of planting materials, stealing, weevils and termites attack, poor rainfall pattern, poor market prices, and poor storability of sweet potato. Reasons and coping strategies for this constrains were identified as shown in tale 6 above.

Conclusion and Recommendation

The lack of sweet potato seed was mention as one of the major limiting factors to the expansion of their sweet potato farms especially Northern and Upper West Region. Though Upper East Region acknowledged this, they however mention lack of sufficient farm implements to plough their fields to be their major limiting factor to increase production. All the regions recognize the lack of good market sources as an important limiting factor to production. They unanimously agreed that with the availability of good output market it will motivate them to expand production. Sweet potato production is mainly mono cropping across all the three regions.

About 5 varieties were identified in upper east region with 3 and 4 identified in Northern and Upper West Regions respectively. This was mainly based on flesh and skin colour of sweetpotato.

It is economically feasible to increase cost by applying fertilizer and still increase returns on investment. General there are great potential for the development of sweet potato in these regions of the North if the concerns raised are addressed. The regions soil and climatic conditions support the growth of the sweet potato.

We also want to recommend that a detailed study should be done through household survey using structured questionnaires in order to provide more quantitative estimates on the production, post-harvest losses, processing and utilization of sweet potato in Northern Ghana.

Acknowledgments

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Containing Productivity Increases Of Maize In Ghana Through Large-Scale Storage Methods

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Executive Summary
A baseline survey was conducted in 3 districts of the Upper East of Ghana to assess current postharvest practices and factors influencing long and bulk storage. The research tools employed were field survey, farm visits and key informant interviews. A purposeful sampling approach targeting main maize producing communities and households was adopted. Two communities per district were purposively selected. Twenty farmers were randomly selected from each community making a total of 120 farmers. In all, 42% of respondents were female farmers and 58% male farmers. Household structure on average is made up 7±5 individuals, mean age of household heads was 45-47 years compared to their wives 35 to 38 years. Maize is mostly stored in polypropylene sacs (48%) and jute sacs (33%) on raised platform in household stores. Close to 95.8% of respondents indicated that post-harvest losses during storage are critical challenges to production and household food security. The main causes of loss were insect pest (69.2%), rodents (16.2%) grain moulds (6.7%), weight loss (5.7%) and loss of flavor/nutrition (1.7%). Up to 16.7% of farmers store their maize for 1-4months, 64.2% store maize for 5-8months, and 17.5% store up to 12months. Only 1.7% store maize beyond 12 months; confirming that they produce in small quantities for subsistence. Though some local and synthetic grain protectants were used, post-harvest losses in 1 year of storage were still beyond acceptable limits. Most farmers acquire agro-chemicals from non-accredited input dealers without any training on appropriate use. However, there was high willingness to adopt new efficient methods of crop protection like biological control. The idea of community

storage methods was still not a technology farmers may adopt; due to a myriad of socio-cultural reasons. The results of the baseline study was expected to guide the implementation of the project as well as serve as reference performance indicator for future monitoring and evaluation. Overall, integrated strategies involving clean farm operations, use of appropriate storage technologies and provision of improved storage structures are required to reduce current losses.

Introduction

Maize (*Zea mays* L.) has become an important staple food crop in all parts of Ghana. Currently, maize based cropping systems have become dominant in drier northern savanna areas of Ghana where sorghum and millet were the traditional food security crops. According to SRID (2011), maize is the most cultivated in Ghana, occupying up to 1,023,000ha on arable land compared to rice (197,000ha), millet (179,000ha), sorghum (243,000ha), cassava (889,013ha), yam (204,000ha) and plantain (336,000) (SRID, 2012). Currently, Ghana is net-importer of maize even though it has great potential to be self-sufficient and net-exporter. Per capita consumption of maize is estimated at 44 kg/person/year (FAOSTAT, Feb 2013). Declining yields of maize are now observed due to decreasing soil fertility and high cost of fertilizer. Over the last 2 decades, a myriad of maize varieties, cultivars and hybrids have been released. These genotypes possess traits such as early maturing, drought resistance, diseases and pest resistance, striga resistance, as well as additional nutritional values such as quality protein, yellow and sweet corn. Grains of these genotypes possess diverse textural, physical and compositional characteristics which relate differently to light, moisture and temperature as well as susceptibility to pests and disease pathogens; particularly during prolong storage. This requires commensurate postharvest techniques and strategies to contain harvested surpluses. Also, due to intensification and productivity increase, the need for bulk and prolong storage has become critical. This increase can be attributed to government and donor assisted projects such as providing subsidies on agricultural inputs. Nonetheless, current storage methods are suited for small-holder farmers requiring storage of less than 1 ton. Interventions to introduce large storage units such as community warehousing, community grain banks or metal silos which can contain several tons of grain is still constrained by national agricultural policies as well as low adoption from farmers.

Generally, stored maize can be damaged by insect pests if they are not properly conditioned and protected. This challenge may be exacerbated due to cropping intensification and introduction of hybrid cultivars. Maize is harvested towards the cessation of rainy season and stored during the drier months of the year. Maize is often stored on cob in traditional grain silos or shelled into jute and polypropylene sacs with or without protection for storage. However, pest infestation is a perennial constraint; the conditions favorable for grain storage are as well suitable for insect pest reproduction. On-farm infestation of notorious storage pests such as larger grain borer (*Prostephanus truncatus*),lesser grain borer(R*hyzopertha dominica*), maize weevil *(Sitophylus zeamais),* granary weevil *(S. granaries)* as well as mycotoxins accumulation, are a threat in grain storage. Indiscriminate use of common grain protectants such as Actellic (Pirimiphos methyl), bioresmethrin (pyrethroid) phostoxin and Gastox (Aluminium phosphate) is widespread among small-holder farmers (Sugri et al 2010). Most farmers acquire agro-chemicals from non-accredited input dealer without any training on appropriate use. There is the need to integrate production and postharvest practices to achieve quality food for consumers. Integration of good agronomic operations, pest management and appropriate storage techniques to minimize pest damage is therefore very essential. This project seeks to improve agricultural productivity and farm family livelihoods by deploying improved storage and handling practices to reduce postharvest losses of smallholder farmers in the Upper East Region of Ghana.

Demographic Information

Table 4-8 provide a summary of the demographic structure of the households sampled. In all, 42% of respondents were female farmers and 58% male farmers (Table 4). Household structure on average was made up of 7±5 individuals (Table 5). The mean age of household heads was 45-47 years compared to their wives whose mean age was 35 to 38 years. The results also showed that migration of household members was not common during the rainy season but up to 10% migrate down south when agricultural activities decline. The observations indicate that most of the household heads (99%) were involved in crop production.

Table 4: Gender of Respondents

Gender	Frequency	Percentage
Female	50	42
Male	70	58
Total	120	100

Table 5: Composition and age of households sampled

Description	Variable	Mean	Standard Deviation	Minimum	Maximum
Head	HH size	7	3	2	22
	Age (HHH)	47	14	26	78
(N = 120)	Age (WHH)	38	10	18	70
Partner	HH size	7	3	1	17
(wife)	Age (HHH)	45	14	27	75
(N = 120)	Age (WHH)	35	10	19	65

Table 6: Income status of households

Income(GH₵000)	Freq.	%
1-20	31	26.1
21-40	14	11.8
41-60	26	21.8
61-80	26	21.8
81-100	22	18.5
Total	119	100

Majority of respondents (63%) had no formal education, only 26% had basic education and 10% had post-basic education (Table 7). Livestock rearing is considered as an occupation by very few households (1%). Majority (84.2%) of the respondents were crop farmers, 2.5% were students, a few were engaged in various forms of trade, and only 4% unemployed (Table 8).

Table 7: Educational Status of respondents

Education level	Freq.	%
None	75	63
Primary	15	13
JHS/Middle shool certificate	16	13
SHS/Technical school	12	10
Non-formal	2	1
Total	120	100

Table 8: Primary Occupation of Respondents

	Freq.	%
Student	3.0	2.5
Unemployed	4.0	3.3
Farmer	101.0	84.2
Teacher	1.0	8.0
Nurse	1.0	8.0
Retired	1.0	8.0
Self employed	5.0	4.2
Pastor	1.0	8
Kente weaving	3.0	2.5
Total	120.0	100.0

Cropping systems

Majority (89%) of respondents were engaged in crop production whiles a little minority were involved in animal (7%) and tree (4%) production as main livelihoods (Table 9). Major livelihood crops include maize, sorghum, millet, soybean, cowpea, rice, sweet potato and vegetables (Table 10). Maize is cultivated on up to 4 ha and a maximum land size of 15 ha. The range for cowpea is 2-12 ha, whiles bambara beans, groundnut and sweet potato recorded the least production area of 1, 2 and 2 ha, respectively.

Table 6: Main farming systems in the study area

Farming type	Freq.	%
Crop production	107	89
Tree crop Production	5	4
Livestock marketing	8	7
Total	120	100

Table 7: Main crops and acreage (ha) of production

Crops	Acreage Mean	(ha) Min.	Max.
Maize	4	0	15
Sorghum	1	0	4
Soyabeans	2	0	5
Cowpea	2	0	12
Vegetable	2	0	3
Pearl Millet	2	0	9
Groundnut	1	1	2
Bambarabeans	1	1	1
Sweet Potato	1	1	2
Total land size of HH	8	1	45

Post-harvest operations and losses

In Table 11, 95.8% perceive high levels of post-harvest losses in recent times while 4.2 % of the respondents were adamant. The main causes of damage were insect pests (69.2%), rodents (16.2%) grain moulds (6.7%), weight loss (5.7%) and loss of flavor/nutrition (1.7%). Only 1.7% of the respondents recorded no incidence of post-harvest losses and pest infestation at storage (Table 12).

Table 8: incidence and estimated postharvest losses under farmer storage

Incidence of produce infestation at storage			Quantities of losses incurred (%)		
	Freq.	%		Freq.	%
Yes (incidence)	115	95.8	0 - 8	29	24.2
No (incidence)	5	4.2	10 – 25	67	55.8
			27 - 60	24	20
			TOTAL	120	100

Table 9: description of major causes of postharvest losses

Main causes of losses	Freq.	Percentage (%)
Insects infestation	83	69.2
Rodents	20	16.7
Grain moulds	8	6.7
Weight loss	5	4.2
Quality (taste/ aroma/colour)	2	1.7
No incidence	2	1.7
Total	120	100.0

Maize Storage Methods

Table 13 describes the various storage methods used in the study area. Majority of farmers, 40% and 27.3%, store maize in poly-sacs and jute sacs respectively. The use of poly-sacs has gradually replaced jute sacs due to low cost and readily availability. Though, the use of PICS sacs has recently been introduced, only few champion farmers opt for them apparently due to high initial cost. Up to 16.7% of farmers store their maize for 1-4months, 64.2% store maize for 5-8months, and 17.5 store up to 12months (Table 14). Only 1.7% store maize store maize beyond 12 months confirming that they produce in small quantities for subsistence. Only small quantities 1-3bags are stored by 37.5 % of respondents and up to 37.5% store 4-10bags, only about 8.3% stored more than 25bags of maize (Table 14).

Table 10: Maize storage methods

Maize storage methods	Freq.	%	Ranked	Reasons for selection
Bare floor	15	12.6	3	Easy to store, affordability
Stored in jute sacs	33	27.3	2	Availability, durability,
Stored in poly-sacs	48	40.3	1	Availability, durability, low cost
Stored mud silos	10	8.4	5	Common traditional method, regulate grain use
Stored in maize ban	14	14	4	Regulates use of maize/ reduce wastage
Total	119	100		

Table 11: Duration of maize at storage

Duration of storage			Volume of produce stored		
Storage period	Freq.	%	Bags	Freq.	%
1-4 months	20	16.7	1-3bags	45	37.5
5-8 months	77	64.2	4-10bags	45	37.5
9-12 months	21	17.5	11-25bags	20	16.7
1-2 years	2	1.7	Above 25 bags	10	8.3
Total	120	100	Total	120	100

Pest management strategies adopted farmers

The focus group discussions indicated that farmers' prior knowledge on the type, severity and time of pest infestation in different commodities guided their choice of pest management. Table 15 provides a summary of approximate time of pest infestation and management options for different crops. Close 44.2% of the respondents noticed pest infestation within 1-4 months, 33.3% within 5-months, whiles 12.5% noticed no pest incidence. From the group discussions, over 50% of respondents alluded that, except in cowpea and bambara nuts, pest infestation occurred late at 6 months after storage. Farmers therefore applied postharvest chemicals few months after storage or when some level of infestation was noticed. Where storage was anticipated above 4 months, over 50% of farmers used some kind of protection in cowpea and bambara nuts. The use of biological control was not a familiar term; probably this control measure has not been introduced into the area. Only 1.7% of farmers resorted to the use of botanicals such as *neem*products, pepper, *mahogany* bark, *Jethropha*and other local oils. Majority use insecticidal dust (43.3%) and phostoxin (13.3%) for pest management. It was realized that only 1 respondent use ash to actually prevent pest attack. The common grain protectants were *Actellic* (Pyriphos methyl), *bioresmethrin* (pyrethroid) p*hostoxin*, *Gastox* (Aluminium phosphate), *Wander77 powde*r.

Table 12: Period of pest infestation and common pest management strategies

Months after storage	Freq.	%	Methods of crop protection	Freq.	%
1-4	53	44.2	Only drying	48	40
5-8	40	33.3	Botanicals (neem, mahogany etc)	2	1.7
After 8	12	10	Photoxin tablet	16	13.3
No pest incidence	15	12.5	Insecticidal dust	52	43.3
Total	120	100	No measure taken	1	0.8
			use of ash	1	0.8
			Total	120	100

Summary of results and Conclusions

Majority of the household heads and their wives had no education and their primary occupation was crop production. Household wealth was largely concentrated on Livestock inventory. Farmers cultivate on more than one piece of land which is direct ownership and takes about 58 minutes to walk to the plot. Use of external inputs except labor were very low. Major crops produced in include: maize, millet, peanuts, Bambara nuts, soy beans, rice, and cassava. Major vegetables grown are onion, tomato, pepper and water melon. Though some local and synthetic grain protectants were used, post-harvest loses in 1 year of storage were still beyond acceptable limits. However, there was high willingness to adopt new efficient and effective methods like biological control. The idea of community storage methods was however still not a technology farmers may adopt; due to a myriad of socio cultural reasons. Integrated strategies involving clean farm operations, use of appropriate storage technologies and provision of improved storage structures may have to be adopted to reduce current losses.

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 four research scientists, two Soil Scientists, an Entomologist and an 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 suitableinterventions 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 in the year under review.

AGRONOMY

Response of extra-early, early and medium maturing drought tolerant maize varieties to nitrogen fertilizer in the northern savanna zone.

Principal Investigator: S.S. J. Buah (CSIR-SARI, Wa Station)
Collaborating Scientists: J.M. Kombiok and R.A.L. Kanton, Asamoah Larbi (IITA)
Estimated Duration: 2012-2013
Sponsors: IITA/Africa RISING
Location: Wa and Tumu, Upper West Region

Background Information and Justification

Maize is an important staple food crop in Ghana. However, in most of Ghana, low crop yields are common due to erratic rainfall, low soil nutrient levels, particularly nitrogen (N) and phosphorus (P), use of low yielding local varieties and poor management practices. Maize varieties and/or hybrids that are either tolerant to drought or mature earlier to escape drought have been developed for various agro-ecological systems through collaborative efforts between IITA and NARS in West and Central Africa (WCA) within the frame work of the Drought Tolerant Maize for Africa (DTMA) project. The breeding process is still on-going, but some maize varieties have been jointly released from the programme by CSIR-SARI and CSIR-CRI. Prior to the release, the varieties were tested with farmers within the various agro-ecological systems to validate the results obtained from the on-station trials for the past years. The assessment of these new varieties was done both on station and on-farm with the application of the outdated fertilizer recommendations for maize which is more than four decades old. However, with differences in the maturity periods and the additional attributes they possess to withstand both drought and *Striga*, it became necessary to assess the performance of these new varieties by subjecting them to different fertilizer N levels in the Upper West region (UWR) of Ghana.

Objectives

The objective of the study was to assess agronomic and economic benefits of using different levels of fertilizer N on drought tolerant extra-early, early and medium maturity maize varieties in the northern savanna agro-ecology of Ghana.

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.
Secondary beneficiaries: dependents of the farmers and researchers as well as Non-governmental Organizations (NGOs).

Materials and Methods

Three field studies involving three maturity groups of drought tolerant maize (i.e., extra-early, early and medium) were initiated in 2012. All the three on-station trials were repeated in the 2013 cropping season at the CSIR-SARI experimental field at Wa, but only the trials involving the extra-early and early maturity groups were planted in Tumu in 2013. The experiments were conducted in a split-plot arrangement of treatments in a randomized complete block design with four replications. In all trials, 60 kg P_2O_5/ha as triple superphosphate (46% P_2O_5) and 60 kg K_2O as muriate of potash (60% K_2O) were applied to each plot before sowing. For each trial the main plot treatments were five maize varieties. Five nitrogen levels of 0, 40, 80, 120 and 160 kg/ha from urea were applied to the subplots. Each 6-row subplot measured 5.0 x 4.5 m. The fertilizer N was applied in two equal doses to maximize N efficiency. All fertilizers were applied in a subsurface band about 0.05 m to the side of the maize row. Since farmers do not commonly use fertilizer for maize production in the areas, the no N fertilizer treatment was the control representing the farmers' practice. The maize varieties were chosen on the basis of their superior performance in on-station and on-farm testing trials.

Sowing date of all experiments was in July instead of June due to prolong pre-season drought. Measurements included days to mid-silk and tassel emergence (days), plant height (m) and grain yield (kg/ha). Plant height was recorded for 5 randomly selected plants at maturity by measuring the height from the base of the plant to the where tassel branching begins. Anthesis-silking interval (ASI) was calculated as days to mid silk emergence minus days to mid-tassel. However, 100-kernel weight (g) and leaf chlorophyll concentration were recorded in Wa only. Leaf chlorophyll concentration of the second leaf from the top was assessed at 50% anthesis on 10 plants, using a portable Chlorophyll meter (SPAD-502 Minolta, Tokyo, Japan) and was expressed in arbitrary absorbance (or SPAD) values. All chlorophyll meter readings were taken midway between the stalk and the tip of the leaf. Since chlorophyll content in a leaf is closely correlated with leaf N concentration, the measurement of chlorophyll provides an indirect assessment of leaf N status. Data collected were subjected to analysis of variance (ANOVA) to establish treatment and the interactions effect on grain yield and yield components. Variety and fertilizer treatments were considered as fixed effects and replication were treated as random effects. Main effects and all interactions were considered significant when $P \leq 0.05$. Regression analyses were conducted to determine yield response to N level for the genotypes and simple correlations were used to test association among traits. Nitrogen use efficiency (NUE) was calculated as yield of the N treatment minus yield of the zero kg N/ha (control treatment) divided by the quantity of fertilizer N applied in kg/ha (Cassman *et al*., 1996).

Results/Major Findings

Extra-early maturing maize response to fertilizer N

At both locations (Wa and Tumu), the variety x N rate interactions were not statistically significant for any trait, therefore main effects of variety and N rates are reported and discussed in this report.

In Wa, averaging over fertilizer N levels, differences among varieties were not statistically significant for any trait measured or calculated (Table 1). However, fertilizer N addition significantly affected chlorophyll concentration (SPAD values), NUE, yield and its components (Table 1). At flowering, increasing N levels significantly increased chlorophyll concentration and 160 kg N/ha had the highest value (48.8). The lowest SPAD value was obtained at zero N treatment (33.8). Chlorophyll concentration increased with N rate with significant linear and quadratic responses. In addition, fertilized plants produced numerically more and heavier kernels and therefore had higher grain production. Nonetheless, NUE values decreased with increasing N levels.

Grain yield increased with N rate with significant linear and quadratic responses in Wa ($Y=583.69 +14.94N-0.06N^2$; $R^2=0.64$). Across varieties, mean grain yield increase as a result of 40 kg N/ha applied over the control treatment was 138% in Wa. Doubling N application level to 80 kg/ha resulted in grain yield increase over 40 kg N/ha by 17%. Increasing N application rate to 120 or 160 kg/ha did not result in any significant yield increase over the 40 kg N/ha rate. Grain yield was related to kernel number (r = 0.88) than kernel weight (r = 0.57). Grain yield also was correlated with chlorophyll concentration (r = 0.75) suggesting that maintaining N and chlorophyll concentration of leaves during grain filling may lead to maintenance of leaf photosynthesis resulting in better grain filling. The ASI was significantly negatively correlated with grain yield (r = -0.54).

Table 1. Some agronomic traits of extra-early maize as affected by N levels in Wa, 2013

Variety	DFA	DFS	ASI	SPAD	100-kernel weight	Kernel number	Grain yield	NUE
	Day	Day	Day	No	g	no	kg/ha	kg/kgN
99 TZEE Y STR	48	50	2	46.7	19.6	142	1147	8.4
TZEE W POP STR QPM C0	50	51	1	42.0	23.0	130	1492	13.7
2000 Syn EE W STR	49	52	3	42.6	22.0	139	1199	10.4
2004 TZEE W POP STR C4	49	51	2	42.7	24.6	148	1045	9.8
Abontem	48	51	3	44.4	21.6	131	1278	11.5

Lsd (0.05) ‡	NS	NS	NS	NS	NS	NS	NS	NS
N level (kg/ha)								
0	49	57	4	33.8	18.3	60	514	
40	49	56	2	42.1	21.7	131	1222	17.7
80	48	55	2	45.6	23.4	143	1435	11.5
120	49	55	2	48.1	23.9	164	1398	7.2
160	49	54	2	48.8	23.5	194	1592	6.7
N linear	NS	NS	NS	**	**	**	**	**
N quadratic	NS	NS	NS	**	*	*	**	**
CV%	2.4	2.6	2.4	13.5	17.4	20.7	25.0	36.0

DFA=days to 50% anthesis; DFS=days to 50% silking; ASI=Anthesis-silking interval; NUE=N use efficiency.
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

In Tumu, genotypic differences were observed for days to anthesis and plant height (Table 2). The earliest varieties to flower were 99TZEE Y STR and 2000 SYN EE W STR while the latest to flower was 2004 TZEE POP STR C4. Plant height ranged from 138 cm for 99 TZEE Y STR to 175 cm for TZEE W POP STR QPM C0. Furthermore, fertilizer N addition hastened anthesis, increased plant height as well as grain production in Tumu. However, similar to results obtained in Wa, NUE decreased with N levels. In Tumu, grain yield was linearly related to N rate with the application of the highest N rate (160 kg/ha) resulted in resulted in the highest yield increase of 62% over the 40 kg N/ha rate.

Table 2. Some agronomic traits of extra-early maize as affected by N rate in Tumu, 2013

Variety	DFA	DFS	ASI	Plant height	Grain yield	NUE
	day	day	day	cm	kg/ha	kg grain/kg N
99 TZEE Y STR	50	52	3	138	1150	15.9
TZEE W POP STR QPM C0	53	55	2	175	1492	14.4
2000 Syn EE W STR	50	53	2	146	1642	12.2
2004 TZEE W POP STR C4	54	56	2	147	1662	18.7
Abontem	53	55	2	161	1470	13.7

Lsd (0.05) ‡	1	1	NS	17	NS	NS
N level (kg/ha)						
0	53	55	2	127	987	
40	52	54	2	157	1232	20.8
80	51	54	2	161	1621	16.6
120	51	54	2	163	1773	12.5
160	51	53	2	159	1998	10.2
N linear	**	**	NS	**	**	**
N quadratic	*	NS	NS	**	**	NS
CV%	2.4	2.1	23.4	17.0	26.5	32.4

DFA=days to 50% anthesis; DFS=days to 50% silking; ASI=Anthesis-silking interval; NUE=N use efficiency.
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively

Early maturing maize response to fertilizer N

Similar to results obtained for extra-early maturing maize at both sites, variety and N level showed no significant interaction for any parameter measured or calculated. However, genotypic differences among the maize varieties for grain yield were statistically significant at Wa (Table 3). Mean grain yield ranged from 1270 to 1848 kg/ha. TZE Comp3 DT C2F2 had the highest yield while the farmer variety had the least grain production. On average, added fertilizer N had significant effect on all parameters measured or calculated in Wa. Plant height was higher with fertilizer treatment but was significantly reduced under no fertilizer condition. Similar to results obtained from the extra-early maize experiment, N deprivation increased ASI and delayed silking. In Wa, fertilizer application generally, showed a better trend for higher grain yield and yield components than no fertilizer treatment. In addition, NUE decreased with increasing N levels.

On average, grain yield increased with N level with significant linear and quadratic responses ($Y=731.65+24.27N-0.12N^2$; $R^2=0.73$). Overall, increase in N levels beyond 40 kg/ha did not result in significant increases in grain yield in Wa. Application of the first 40 kg N/ha resulted in the highest mean grain yield increase of 184% when compared to the yield increase obtained from the application of 80 120 and 160 kg N/ha. Similar to results obtained in 2012, grain yield was positively correlated with chlorophyll concentration (r = 0.64). The ASI was significantly negatively correlated with grain yield (r = -0.53). Also, grain yield was negatively correlated (r = -0.46) with days to 50% anthesis. This inverse relationship between days to anthesis and grain yield might be due to the fact that the improved varieties with higher grain production matured earlier than the farmer's variety.

Table 3. Some agronomic traits of early maize as affected by N rates in Wa, 2013

Variety	DFA	DFS	ASI	SPAD	100-seed weight	Kernel number	Grain yield	NUE
	Day	day	Day	No	g	No	kg/ha	kg/kg N
TZE W DT STR C4	52	54	2	41.4	19..2	121	1722	18.8
TZEComp3 DT C2F2	52	54	2	42.2	20.2	124	1848	16.9
Aburohemaa	53	54	1	41.7	20.3	128	1394	12.6
Omankwa	53	55	2	40.4	19.5	129	1443	14.7
Farmer variety	53	55	2	40.8	20.0	126	1270	11.7
Lsd (0.05) ‡	NS	NS	NS	NS	NS	NS	327	NS
N level (kg/ha)								
0	53	56	3	33.9	15.9	45	623	
40	53	55	2	41.2	19.3	118	1770	28.7
80	53	55	2	42.2	20.9	139	1798	14.7
120	52	54	2	44.2	21.9	156	1836	10.0
160	52	54	2	44.4	23.8	168	1650	6.4
N linear	NS	NS	NS	*	**	**	**	**
N quadratic	*	**	*	NS	NS	**	*	*
CV%	2	2	2	20.4	17.3	19.1	29	32

DFA=days to 50% anthesis; DFS=days to 50% silking; ASI=Anthesis-silking interval; NUE=N use efficiency.
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

In Tumu, differences among the varieties were significant for flowering, plant height, grain yields and NUE (Table 4). The farmer variety flowered late and was taller than all the improved varieties in Tumu. Mean grain yield ranged from 1116 to 1900 kg/ha. All the improved varieties had higher grain production than the farmer's variety which had the least grain yield of 116 kg/ha. The variety TZE W DT STR C4 which was later released by SARI as CSIR-Wang-dataa in December 2012 had the highest yield of 1900 kg/ha but this was not significantly different from the yields of the two previously released varieties (Aburohemaa and Omankwa) at both sites. CSIR-Wang-dataa is both drought and *Striga* tolerant.

On average, increasing N rates had significant effect on flowering date, plant height, grain yield as well as NUE in Tumu (Table 4). Plant height was higher with fertilizer treatment but was significantly reduced under no fertilizer condition. Fertilizer application generally, showed a better trend for higher grain yield than no fertilizer treatment. On average, grain yield increased with N level with significant linear and quadratic responses in Tumu ($Y=798.46+22.43N-0.05N^2$; $R^2=0.67$). Overall, increase in N levels beyond 40 kg/ha did not result in significant increases in grain yield. Application of the first 40 kg N/ha resulted in the highest mean grain yield increase when compared to the yield increase obtained from the application of 80 120 and 160 kg N/ha. Similar increases were observed in Wa. Grain yield was negatively correlated (r = -0.62) with days to 50% anthesis.

Table 4. Some agronomic traits of early maize as affected by N rates in Tumu, 2013

Variety	DFA	DFS	ASI	Plant height	Grain yield	NUE
	Day	day	day	cm	kg/ha	kg grain/kg N
TZE W DT STR C4	53	55	2	136	1900	18.1
TZEComp3 DT C2F2	53	56	3	152	1796	17.7
Aburohemaa	52	54	2	150	1822	16.8
Omankwa	52	54	2	155	1896	22.3
Farmer variety	55	57	2	197	1116	13.2
Lsd (0.05) ‡	1	1	NS	16	209	3.8
N level (kg/ha)						
0	53	55	2	142	1007	
40	53	55	2	140	1889	28.8
80	54	56	2	144	2241	18.8
120	52	54	2	156	2310	14.2
160	54	56	2	165	2476	11.4
N linear	**	**	NS	*	**	**
N quadratic	NS	NS	NS	NS	**	*
CV%	1.8	2.0	23.4	18.0	17.2	25.7

DFA=days to 50% anthesis; DFS=days to 50% silking; ASI=Anthesis-silking interval; NUE=N use efficiency

Medium maturing maize response to fertilizer N

The medium maturing maize trial was planted only in Wa in 2013. On average, all the varieties responded similarly to increased N application at Wa as evidenced by the lack of significant variety x N level interactions for any trait. Moreover, differences among the varieties were not significant for any parameter measured or calculated (Table 5). Two newly released drought tolerant varieties, DT SYN-1-W (Sansal-sima) and IWD C3 Syn F2 (Ewul-boyu) had comparable yields as the most commonly cultivated variety (Obatanpa).

Table 5. Some agronomic traits of medium maize as affected by N levels in Wa, 2013

Variety	DFA	DFS	ASI	SPAD reading	100-kernel weight	Kernel number	Grain yield	NUE
	day	Day	day	no	G	No	kg/ha	kg/kg N
DT ST W COF2	54	56	2	39.6	20.1	119	2673	27.6
DT SYN 1-W	58	60	2	39.8	20.3	118	2298	15.7
IWD C3SYN F2	58	61	3	41.3	19.2	124	2800	17.0
Obatanpa	59	61	2	40.5	20.0	136	2380	17.5
Farmer's variety	58	60	2	40.3	20.1	134	2373	20.8
Lsd (0.05) ‡	NS	NS	NS	NS	NS	NS	NS	NS
N level								
0	58	61	3	37.8	13.6	56	1173	
40	58	60	2	39.9	16.8	136	2473	32.5
80	58	60	2	40.3	19.4	148	2727	19.4
120	58	60	3	40.8	22.6	168	2753	13.9
160	58	60	2	42,7	24.6	159	3393	12.1
N linear	NS	NS	NS	*	**	**	**	**
N quadratic	NS	NS	NS	**	NS	**	**	*
CV%	12.1	12.1	20.1	7.1	15.2	14.3	29.2	35.4

DFA=days to 50% anthesis; DFS=days to 50% silking; ASI=Anthesis-silking interval;
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

Consistent with the results obtained for the extra-early and early maturing varieties, variation in N supply affected grain yield and yield components of the medium maturing maize. However, increasing N rates did not affect days to 50% anthesis significantly. Consistently, N deprivation reduced crop growth and development and ultimate crop yield. Significant yield reduction was noted under no fertilizer treatment (Table 5). Averaged across maize varieties, number of kernels per square meter and chlorophyll content at flowering increased with N rate with significant linear and quadratic responses. Kernel size was significantly affected by N rate with significant linear response. In addition, mean grain yield increased with N rate with significant linear and quadratic responses ($Y=1339.05+22.85N-0.07N^2$; $R^2=0.58$). Application of the first 40 kg N/ha resulted in the highest mean grain yield increase when compared to the yield increases obtained from the application of 80 120 and 160 kg N/ha rates. Across varieties, mean increase grain yields as a result of 40 kg N/ha applied over the control treatment was 111%. Doubling N application level to 80 kg/ha resulted in grain yield increase over 40 kg N/ha by 10% only. Grain yield was more positively correlated with kernel number (r = 0.96) than kernel weight (r = 0.64). Grain yield also was correlated with chlorophyll concentration (r = 0.68).

Discussions

At most of the trials, the yield of the farmer variety was as good as the newly released varieties tested. Maize yield in 2013 were slightly lower than those reported in 2012, due to the poor rainfall distribution in 2013, which was characterized by dry spells at most critical stages in crop growth and development. At all locations, fertilizer application generally, showed a better trend for higher grain yield and yield components than no fertilizer treatment. This could be attributed to better utilization of plant growth resources such as water, nutrients and solar radiation in the fertilized treatment thereby resulting in taller plants and early attainment of plant growth stages. Fertilized maize took fewer days to attain 50% anthesis. Leaf chlorophyll concentration, were generally higher at enhanced rates of N but lower at no fertilizer treatments. Chlorophyll concentration reduction and leaf yellowing are good indicators of N remobilization. Generally, N deficiency accelerates senescence as revealed in the present study by the decrease in chlorophyll concentration under no fertilizer N treatment as compared with non-stressed conditions. Leaf N decrease in turn is expected to have a direct effect on canopy photosynthesis, resulting in greater kernel abortion (Pearson and Jacob, 1987) and lower grain number (Uhart and Andrade, 1995). Lack of N probably enhanced kernel abortion and reduced final kernel number. Enhanced leaf chlorophyll concentration could lead to better capture of solar radiation and conversion to dry matter as depicted in the superior grain yields produced under these treatments. In addditon, application of fertilizer N probably facilitated the better partitioning of dry matter to generative organs at the expense of vegetative components.

Overall, NUE values among the varieties were consistent with the amount of grain produced with more efficient varieties having greater values probably due to the fact that these varieties have been bred to tolerate diverse abiotic stresses including drought and low N. Greater N efficiency normally allows a reduction of nutrient to be applied to efficient plants without reducing yield. This implies a larger proportion of fertilizer N recovery in the plants and consequently lower amounts of nutrients loss due to surface runoff or ground water drainage loss. In general, NUE values decreased as a result of increased N supply, regardless of variety. Increased N supply is generally known to reduce NUE in maize (Moll et al., 1982). This suggested that N was most efficiently used when applied at lower rates than at higher rates. The reduction in efficiency with increasing N levels could be attributed to the relatively larger increase in grain production associated with higher N levels. For each maturity group and at each location, maize had highest NUE at 40 kg N/ha and the least value at 160 kg N/ha rate.

Conclusion and recommendations

Over the years, the application of fertilizer N significantly increased maize grain yield and its components when compared with the farmer practice of no fertilizer N application. This is expected in the savanna agro-ecology with low N and P levels. This situation is further exacerbated by the continuous cropping of cereals annually with the application of very limited manures and mineral fertilizers leading to consistently declining crop yield over the years. In order to sustain higher and stable crop yields in this zone, there is the need to add modest level of fertilizers, particularly N so as to increase and maintain crop productivity and production. The application of 40 to 80 kg N/ha is crucial towards realizing food self-sufficiency in northern Ghana. However, since this were on-station trials, it would be imperative to conduct on-farm adaptive trials to confirm these two rates of fertilizer N application (40 to 80 kg N/ha), which hold promise for food production in the region.

Responses of early and late maturing soybean to fertilizer and rhizobium inoculation in the Guinea savanna zone

Principal Investigator: S.S. J. Buah (CSIR-SARI, Wa Station)
Collaborating Scientists: N.N. Denwar, Asamoah Larbi (IITA)
Estimated Duration: 2012-2013
Sponsors: IITA/Africa RISING
Location: Wa, Upper West Region

Background Information and Justification

Soybean is an important cash and oil seed crop, yet grain yields are low on farmers' fields. The low yields are due partly to low soil nutrient and poor management levels. As a grain legume, soybean is able to fix atmospheric nitrogen, thereby improving soil fertility and limiting the application of mineral fertilizers, particularly N. Additionally, soybean could be used as a trap crop against S*triga hermonthica*, an endemic parasitic weed in northern Ghana that causes severe yield losses of cereal crops.

Biological nitrogen fixation (BNF) is a renewable source of nitrogen to replace mineral N fertilizer and it has great potential to compensate for the short falls in availability of mineral fertilizers in African farming system. Soil-P availability during seedling development is an important determinant for plant growth, N_2 fixation, and grain formation of legumes. Phosphorus influences nodule development through its basic functions as an energy source. However, P is generally deficient and limits BNF in highly weathered tropical soils. Application of fertilizer N to soybean remains a complicated issue owing to conflicting results of previous research. Nevertheless, only 25 to 60% of N in soybean dry matter originates from symbiotic N_2 fixation, the remainder comes from soil-N. The use of biofertilizer as N source and the amount of P needed during inoculation is still debatable.

Objectives

The study was initiated to assess the agronomic and economic benefits of using fertilizer N, P and K as well as *Rhizobium* inoculants for soybean production in the Upper West region which lies in the Guinea savanna zone of Ghana.

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, processors in soybean oil and cake industries, poultry farmers, fish feed formulators, nutritionists, policy makers as well as NGOs engaged in promoting soybean production

Materials and Methods

Field studies involving early and medium maturity groups of soybean were initiated at the CSIR-SARI experimental fields in Wa and Bamahu during the 2012 cropping season. The experiments were repeated in the same locations during the 2013 cropping season. The experiments were conducted in a split-plot arrangement of treatments in a randomized complete block design with four replications. For the medium maturing trial, the main plot treatments were five soybean varieties (TGX 1834-5E, TGX 1445-3E, TGX 1448-2E, TGX 1904-6F and Jenguma). Jenguma was released a couple of years ago by CSIR-SARI and it is widely grown by farmers in the region. Five fertilizer treatments (no fertilizer, fertilizer PK only, *Rhizobium* inoculants + fertilizer PK, *Rhizobium* inoculants only, fertilizer N, P and K) were applied to the subplots. The N, P and K rates were 25, 60 and 30 kg/ha as N, P_2O_5 and K_2O, respectively. Nitrogen was applied as urea (46% N). Phosphorus was applied as triple superphosphate (46% P_2O_5) and K as muriate of potash (60% K_2O). The no fertilizer treatment was the control representing the farmers' practice. The response of three early maturing soybean varieties (TGX 1799-8F, TGX 1805-8E and Anidaso) to the same five fertilizer treatments was evaluate at the same locations. The soybean varieties were chosen on the basis of their superior performance in on-station and on-farm trials.

Sowing dates of the experiments at Wa and Bamahu were between 7 and 19^{th} July, 2013. The medium maturing varieties were sown in six rows spaced 0.75 m apart. While the early-maturity varieties were sown in six rows spaced 0.60 m apart. Distance between plants was 5 cm in all experiments with one seedling per stand. Data collected included days to 50% flowering (days), plant height (m) and grain yield (kg/ha). Data collected were subjected to analysis of variance (ANOVA) to establish treatment and the interactions effect on grain yield and yield components. Variety and fertilizer treatments were considered as fixed effects and replication were treated as random effects. Main effects and all interactions were considered significant when $P \leq 0.05$. Simple correlations were used to test association among traits.

Results/Major Findings

At both Wa and Bamahu, interaction between variety and fertilizer treatments were not statistically significant for any train measured or calculated therefore the main effects of variety and fertilizer effects are reported and discussed in this report (Tables 6 through 9).

Early maturing soybean response to fertilizer

The soil in Wa where the trial was conducted is slightly acidic (pH=5.34). Maize was the previous crop on this piece of land and was fertilized with Urea. Differences among the varieties were significant for days to 50% flowering, chlorophyll concentration and stover production but not grain yield (Table 6). The variety TGX 1799-8F which was released as Suong-Pungu in December 2012 was the earliest (47 days) to flower while Anidaso flowered latest (54 days). Both Anidaso and TGX 1805-8F had similar but higher dry matter yield than Suong-Pungu. In contrast, Suong-Pungu had higher chlorophyll content than Anidaso and TGX 1805-8F. Nodule number, nodule weight and grain yield differences among the three varieties were not statistically significant. However, Anidaso tended to have higher grain production although not statistically different from yields of the other two varieties.

Use of inoculants and/or mineral fertilizers did not significantly influence any trait measured or calculated at Wa (Table 6). Nevertheless, the application of fertilizer N, P and K as well as the use of Rhizobium plus fertilizer P and K tended to increase grain yields although yields obtained by these two treatments were not significantly different from those of the other treatments. Similar results were obtained in 2012 at the same location. Moreover, soybean did not respond to inoculation in Wa. Nodule weight and numbers per plant were not significantly different even with inoculation of soybean on this soil.

Table 6. Some agronomic traits of early maturing soybean as affected by fertilizer and Rhizobium inoculation at Wa, UWR, 2013.

Treatment	DFF	SPAD reading	Nodule weight	Nodule number	Grain yield	Stover yield
Variety	days	no	G	no	kg/ha	kg/ha
TGX 1799-8F (Suong-Pungu)	47	42.8	6.6	21	1911	1884
TGX 1805-8F	49	39.2	6.5	16	1902	2640
Anidaso	54	37.4	6.7	23	1956	2880
Lsd (0.05) ‡	2	2.1	NS	NS	NS	454
Fertilizer treatment						
No fertilizer	50	40.5	6.6	20	1926	2356
Rhizobium inoculation	50	38.2	6.7	22	1867	2356
60 kgP_2O_5+30 kg K_2O/ha	50	38.5	6.6	16	1926	2474
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	51	41.5	6.5	19	1970	2637
Rhizobium +60 kg P_2O_5+30 kg K_2O/ha	50	40.4	6.6	25	1926	2519
Lsd (0.05)	NS	NS	NS	NS	NS	NS
CV%	5	7	4	49	16	24

DFF=days to 50% flowering
‡ NS = Not significant at 5 and 1% probability levels.

Nodule number and nodule weigh are for 10 plants/plot.

At Bamahu, differences among the varieties were significant for days to flowering, grain and stover production (Table 7). Similar to results obtained in Wa, Suong-Pungu flowered earlier than Anidaso. Grain yield ranged from 996 kg/ha for Suong-Pungu to 1564 kg/ha for TGX 1805-8E. Anidaso and TGX 1805-8E recorded similar but higher yields than Suong-Pungu which obtained the lowest grain and stover yields at this site.

Fertilizer treatment significantly influenced flowering date and biomass yield but not grain yield and plant height (Table 7). Mean grain yield ranged from 1126 kg/ha for the no fertilizer treatment to 1521 kg/ha for the NPK treatment. Application of Rhizobium inoculants with or without fertilizer P and K did not increase grain yield significantly when compared with no fertilizer treatment. Although differences in yield among the fertilizer treatments were not statistically significant, there was a tendency for the NPK to influence grain yield the most. The synergy between Rhizobium inoculation and PK fertilization was not evident in both Wa and Bamahu in 2013.

Table 7. Some agronomic traits of early maturing soybean as affected by fertilizer and Rhizobium inoculation at Bamahu near Wa, UWR, 2013.

Treatment	DFF	Plant height	Grain yield	Stover yield
Variety	Days	Cm	kg/ha	kg/ha
TGX 1799-8F (Suong-Pungu)	44	49	996	693
TGX 1805-8F	44	59	1564	1493
Anidaso	49	57	1553	1493
Lsd (0.05) ‡	1	NS	379	339
Fertilizer treatment				
No fertilizer	44	56	1126	919
Rhizobium inoculation	46	63	1284	1022
60 kgP_2O_5+30 kg K_2O/ha	46	65	1482	1422
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	45	71	1521	1393
Rhizobium +60 kg P_2O_5+30 kg K_2O/ha	46	78	1442	1378
Lsd (0.05)	1	NS	NS	437
CV%	2	17	32	31

DFF=days to 50% flowering
‡ NS = Not significant at 5 and 1% probability levels.
Nodule number and nodule weigh are for 10 plants/plot.

Medium maturing soybean response to fertilizer

The previous crop on the experimental plots in both Wa and Bamahu was maize and this was fertilized with Urea. In Wa, differences among the medium maturing varieties were significant for days to 50% flowering and grain yield only (Table 8). Grain yield among the varieties ranged from 1849 kg/ha for Songda to 2465 kg/ha for TGX 1834-5E (released as Afayak). Although Afayak had the highest grain production, its yield was not significantly different from those obtained from Jenguma, TGX 1448-2E and TGX 1904-6F. All these varieties on one hand had significantly higher yields than Songda. It should be noted that Jenguma and TGX 1448-2E are the same varieties obtained from two different sources.

Compared with no fertilizer treatment, addition of fertilizer and/or inoculants significantly influenced chlorophyll concentration (SPAD readings), nodule weight, grain and stover production but not flowering date (Table 8). On average, chlorophyll content was higher when fertilizer was applied compared to no fertilizer treatments. The application of fertilizer P and K with or without inoculants increased both stover and grain production significantly relative to the no fertilizer treatment or the treatment with only Rhizobium inoculants in Wa. The least grain yield of 2016 kg/ha was obtained from the no fertilizer treatment, followed by the treatment that received Rhizobium inoculants only (2169 kg/ha). The treatments which received mineral fertilizers had higher but similar yields (Table 8). Applying Rhizobium inoculants alone to soybean did not result in significant yield increase in Wa.

Table 8. Some agronomic traits of medium maturing soybean as affected by fertilizer and Rhizobium inoculation at Wa, UWR, 2013.

Treatment	DFF	SPAD reading	Nodule weight	Nodule number	Grain yield	Stover yield
Variety	days	no	g	No	kg/ha	kg/ha
TGX 1834-5E (Afayak)	51	41.0	9.1	68	2465	2744
TGX 1445-3E (Songda)	56	39.7	8.6	27	1849	2676
TGX 1448-2E	49	41.0	8.7	45	2276	253
TGX 1904-6F	48	40.2	8.4	31	2406	2782
Jenguma	52	40.2	8.1	23	2145	2764
Lsd (0.05) ‡	1	NS	NS	NS	316	NS
Fertilizer treatment						
No fertilizer	51	39.6	8.7	29	1898	1864
Rhizobium inoculation	52	40.3	9.0	55	2169	2444
60 kgP_2O_5+30 kg K_2O/ha	51	40.2	8.6	46	2382	2862
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	51	42.4	8.6	41	2394	2960
Rhizobium +60 kg P_2O_5+30 kg K_2O/ha	51	39.7	8.8	43	2381	2880

Lsd (0.05)	NS	1.3	0.2	NS	316	383
CV%	3	4	3	39	19	19

DFF=days to 50% flowering
‡ NS = Not significant at 5 and 1% probability levels.
Nodule number and nodule weigh are for 10 plants/plot.

The previous crop at Bamahu was maize that was fertilized with compound fertilizer (NPK) and sulphate of ammonia. Differences among the medium maturing varieties were significant for days to 50% flowering, plant height, pod number, grain and stover yields (Table 9). Songda produced more pods per plant (71) and was the latest to flower (58 days) while TGX 1904-6F was the earliest to flower (46 days). On the other hand, the varieties did not differ significantly among each other in nodule weight and nodule numbers. Grain yield among the varieties ranged from 871 kg/ha for Songda to 1520 kg/ha for Afayak. Although Afayak had the highest grain production, its yield was not significantly different from those obtained from Jenguma, TGX 1448-2E and TGX 1904-6F. All these varieties had significantly higher yields than Songda.

Table 9. Some agronomic traits of medium maturing soybean as affected by fertilizer and Rhizobium inoculation at Bamahu near Wa, UWR, 2013.

Treatment	DFF	Plant height	Pod number/plant	Grain yield	Stover yield
Variety	days	cm	No	kg/ha	kg/ha
TGX 1834-5E (Afayak)	48	60	63	1520	1716
TGX 1445-3E (Songda)	53	47	71	871	1005
TGX 1448-2E	47	58	49	1244	1778
TGX 1904-6F	46	59	49	1316	1662
Jenguma	47	60	41	1511	2143
Lsd (0.05) ‡	1	5	12	308	354
Fertilizer treatment					
No fertilizer	48	57	49	1164	1591
Rhizobium inoculation	48	55	49	1244	1564
60 kgP_2O_5+30 kg K_2O/ha	48	57	58	1431	1511
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	47	58	56	1449	1849
Rhizobium +60 kg P_2O_5+30 kg K_2O/ha	48	56	60	1173	1787
Lsd (0.05)	NS	NS	NS	NS	NS
CV%	2	12	29	32	29

DFF=days to 50% flowering

‡ NS = Not significant at 5 and 1% probability levels.
Nodule number and nodule weigh are for 10 plants/plot.

Addition of fertilizer and/or inoculants to soybean at Bamahu did not significantly influence any trait measured or calculated (Table 9). Thus soybean did not respond to Rhizobium inoculants treatment at this site in 2013 although the response was significant in 2012. The treatments with complete NPK and Rhizobium plus PK tended to have higher grain. Similar results were obtained for the early maturing varieties in Wa.

This study aimed at enhancing soybean production among the smallholder farmers in the UWR through the use of Rhizobium inoculation and moderate applications of fertilizer P and K and to sustain soil nutrient level. In Wa, the treatments that received Rhizobium inoculants plus PK tended to have higher grain production, which seems to suggest some synergy between Rhizobium inoculation and PK fertilization. Applying Rhizobium inoculants alone to soybean did not result in significant yield increase at both sites in 2013 probably due to the acidic nature of the soil (pH ranged between 4.85 and 5.34). In addition, the experimental sites had been planted to soybean in the last three years, and indigenous Rhizobium bacteria populations were probably adequate for soybean nodulation. It is widely believed that soybean grown on land where well nodulated soybean has been grown in the last 3-4 years will probably not require inoculation.

Early maturing varieties are required to fit short rainfall regimes, escape terminal drought in areas where the start or cessation of the rainfall season results in shorter duration of the rainy period and results in situations where the crop does not have sufficient moisture to complete the grain filling. In northern Ghana, such situations arise very often leading to significantly reduced yields. Drier areas in northern Ghana will therefore benefit from early maturing varieties. Such early maturing varieties could be used as relay crop especially to early millet in UER. This will enable farmers benefit from both millet and soybean cultivation in one season, particularly in Striga endemic and drought- prone areas. Consequently, Suong-Pungu and TGX 1805-8F will be particularly useful in these areas. The soils collected from these sites are yet to be analyzed and the data will help explain the inconsistent responses observed in the study. More data is required to confirm soybean response to Rhizobium inoculation in the Guinea savanna zone.

Conclusions/Recommendations

The study suggest that applying Rhizobium inoculants alone to soybean may not result in significant yield increase especially if the soil is acidic. Moreover on a land where soybean has been grown for past years, inoculation may not be recommended. The two recently released soybean varieties Afayak and Songda have enhanced capacity to stimulate suicidal germination in Striga seed. Consequently, these two varieties could be used to partner Striga-tolerant maize to effectively minimize the harmful effects of Striga in cereal production. Early maturing varieties may be suitable in drier areas in northern Ghana with shorter cropping seasons. For instance, such early maturing varieties could be used as relay crop to early millet or extra-early drought and striga tolerant maize. This will enable farmers benefit from both millet and maize and soybean cultivation in one season, particularly in Striga endemic and drought- prone areas. The soils collected from these sites are yet to be analyzed and the data will help explain the inconsistent responses observed in the study. More data is required to confirm soybean response to *Rhizobium* inoculation in the Guinea savanna zone.

Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in soybean-maize rotations

Principal Investigator: S.S. J. Buah (CSIR-SARI, Wa Station)
Collaborating Scientists: R.A.L Kanton , Asamoah Larbi (IITA)
Estimated Duration: 2013-2014
Sponsors: IITA/Africa RISING
Location: Goriyiri, Nadowli district, Upper West Region

Background Information and Justification

Soils in the savanna agro-ecological system of Ghana are inherently low in plant available nutrients, particularly N and P. Since the mid 1990s, fertilizer use in Ghana has become necessary if sustainable agricultural production in smallholder farms is to be raised to levels that can sustain the growing population. However, mineral fertilizers are too expensive beyond the reach of the resource poor farmers. In most cases, farmers apply fertilizer quantities lower than the recommended rates and this could lead to reduction in crop yields and profits. Research is therefore is needed to increase judicious use of fertilizer and develop sustainable management practices in response to continually increasing economic and environmental pressures. Grain legumes are good source of food, fodder and cash for the farmer as well as excellent components within the various farming systems because they provide residual N and reduce the needs for mineral N fertilizers by associated non-legumes. Depending on the legume variety, net soil N accrual from the incorporation of grain legume residue can be as much as 140 kg N ha-1 if only seeds are harvested (Giller, 2001). Crop rotation with legumes improves soil physical, chemical and biological conditions (Giller, 2001; Yusuf et al., 2009), thereby enhancing soil nutrient availability. Crop rotation significantly influences N use efficiency and prompts changes in various N sources, affecting availability to the plant. Integrating legumes into the cropping systems of the northern Guinea savanna of Ghana has been considered as an important resource management technology for reduction of energy use, cost and pollution potential of mineral fertilizer usage. However, crop rotation with legumes alone cannot supply all the N requirements of the non-legume component. This is because the current practice of exporting all above ground biomass at harvest largely contribute to negative soil N balance (Sanginga et al., 2002). Supplementary N fertilizer (from either organic or mineral sources or both) would therefore be necessary to obtain higher yield. Little information is available on integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in a 2-yr soybean-maize rotation in the savanna zone of Ghana. Therefore trials were set up in Goriyiri in the UWR to evaluate the response of soybean to organic (fertisoil) and mineral fertilizers as well as *Rhizobium* inoculants in a soybean-maize rotation. Additionally, the response of subsequent maize to these treatments the following year would be evaluated.

Objectives

Specific objective were to:

(i) Evaluate the response of soybean to organic, mineral fertilizers as well as *Rhizobium* inoculants in rotation with maize;

(i) Evaluate the performance of maize when grown in rotation with soybean that received different soil amendments.

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents and farmers.

Secondary beneficiaries: dependents of the farmers and researchers, processors in soybean oil and cake industries, poultry farmers, fish feed formulators, nutritionists, policy makers, seed producers as well as NGOs engaged in promoting soybean and maize production.

Materials and Methods

Integrated Soil Fertility Management (ISFM) trial was conducted at Goriyiri in UWR to evaluate the response of soybean (var. Jenguma) to organic (fertisoil) and mineral fertilizers as well as *Rhizobium* inoculants. The experimental design was randomized complete block design with four replications and seven treatment combinations: (i) no soil amendment, (ii) *Rhizobium* inoculants only, (iii) *Rhizobium* inoculants + fertilizer P and K, (iv) *Rhizobium* inoculants + fertisoil, (v) *Rhizobium* inoculants + PK + fertisoil, (vi) Recommended fertilizer rate) and (vii) continuous maize plot. 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. Planting was delayed until third week of July due to pre-season drought. Plot size for each treatment was 4.5 m x 5m. The 2013 cropping season was the set-up year and therefore only soybean response to the various fertilizer treatments was evaluated. It was therefore not possible to measure rotation effect of maize following soybean that received the different fertilizer treatments in 2013. The rotation is effect will be evaluated in 2014 when maize is planted on all plots. Recommended cultural practices were followed for soybean. Soybean was harvested at physiological maturity, and data collected included yield and its components. All 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 5% level of significance. Farmers were actively involved in the planning, implementation, monitoring, and evaluation processes.

Results/Major Findings

Mean plant height ranged from 33 cm for the treatment that received *Rhizobium* inoculants only to 58 cm for the treatment that received a combination of inoculants, PK and fertisoil (Table 10). The *Rhizobium* inoculants only and the farmer practice of no fertilizer addition affected plant height in a similar manner. Nodule number was numerically highest (99 g) for the inoculants plus fertilizer P and K treatment and least for the no fertilizer treatment. However, all treatments recorded similar nodule weights. Grain yield ranged from 800 kg/ha for both the *Rhizobium* inoculants only and no fertilizer treatments to 1467 kg/ha for the inoculants+PK+fertisoil treatment combination. In general, *Rhizobium* inoculants +PK treatment tended to have higher grain, which seems to suggest some synergy between

Rhizobium inoculation and PK fertilization. Applying *Rhizobium* inoculants alone to soybean did not result in significant yield increase probably due to the poor nature of the soil at the experimental field. Stover production ranged from 1134 to 3300 kg/ha and followed similar trend as grain production. Grain yield was positively correlated with plant height (r=0.60) and biomass production (r=0.82). Judging from the plant growth, the soils at this site looked infertile 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 soybean seed size and grain yields at this site. The soils collected from these sites are yet to be analyzed.

Table 10. Some agronomic traits of soybean as influences by soil amendment at Goriyiri, Nadowli district, UWR in 2013.

Treatment‡	Plant height	Nodule number	Nodule weight	Grain yield	Stover yield
	cm	No	g	kg/ha	kg/ha
No soil amendment (control)	41	84	2.0	800	1134
Rhizobium inoculants only	33	90	2.0	800	1233
Inoculants + PK	48	99	2.2	1067	2600
Inoculants + Fertisoil	51	86	2.4	967	2066
Inoculants + PK + Fertisoil	58	86	2.2	1467	3300
Recommended fertilizer rate	51	92	2.3	1000	2300
Lsd(0.05)	11	11	NS	239	1018
CV%	15	8	25	16	32

‡P and K were applied at the rate of 60 kg P_2O_5/ha and 30 kg K_2O/ha, respectively;
Recommended fertilizer rate 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 2012 season was the set-up year as such rotation effect could not be measured. However, the preliminary results showed that *Rhizobium* inoculants alone to soybean did not result in significant yield increase. More data are required to confirm soybean response to *Rhizobium* inoculation in the Guinea savanna zone and preceding effect of these treatments on subsequent maize yields.

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 (CSIR-SARI, Wa Station)
Collaborating Scientists: Asamoah Larbi (IITA)
Estimated Duration: 2013-2014
Sponsors: IITA/Africa RISING
Location: Goriyiri, Nadowli district, Upper West Region

Background Information and Justification

Crop rotation involving cereals and legumes have 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. Manure as a soil amendment in crop studies has improved 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. Research on integrated soil fertility management influence on grain and fodder yields and soil chemical and physical properties in a 2-yr cowpea-maize rotation in the savanna zone of Ghana. Therefore trials were set up in Goriyiri in the UWR to evaluate the response of cowpea to organic (fertisoil) and mineral fertilizers as well as *Rhizobium* inoculants in a soybean-maize rotation. Additionally, the response of subsequent maize to these treatments the following year would be evaluated.

Objectives

Specific objective were to:

(ii) Evaluate the response of cowpea to organic, mineral fertilizers as well as *Rhizobium* inoculants in rotation with maize;

(ii) 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

Integrated Soil Fertility Management (ISFM) trial was conducted at Goriyiri in UWR to evaluate the response of cowpea (var. Apagbaala) to organic (fertisoil) and mineral fertilizers as well as *Rhizobium* inoculants. The experimental design was randomized complete block design with four replications and seven treatment combinations: (i) no soil amendment, (ii) *Rhizobium* inoculants only, (iii) *Rhizobium* inoculants + fertilizer P and K, (iv) *Rhizobium* inoculants + fertisoil, (v) *Rhizobium* inoculants + PK + fertisoil, (vi) Recommended fertilizer rate) and (vii) continuous maize plot. 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. Planting was delayed until third week of July due to pre-season drought. Plot size was 3.6 x 5 m (6-row plots). The 2013 cropping season was the set-up year and therefore only cowpea response to the various fertilizer treatments was evaluated. It was therefore not possible to measure rotation effect of maize following cowpea that received the different fertilizer treatments in 2013. The rotation is effect will be evaluated in 2014 when maize is planted on all plots. Recommended cultural practices were followed for cowpea. Cowpea was harvested at physiological maturity, and data collected included yield and its components. All 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

5% level of significance. Farmers were actively involved in the planning, implementation, monitoring, and evaluation processes.

Results/Major Findings

Adding fertisoil or fertilizer P and K to inoculated cowpea resulted in numerically higher pod and seed numbers as well as more and heavier nodules when compared with no fertilizer treatments or inoculants only (Table 11). The treatment that received a combination of *Rhizobium* inoculants, PK and fertisoil produced numerically more pods and seeds per pod as well as higher nodule numbers and weight. The *Rhizobium* inoculants only and no fertilizer treatments affected pod and seed numbers as well as grain and stover yields in a similar manner. Nodule number was numerically highest (103 per 10 plants) for the treatment that received recommended fertilizer rate of 25-60-30 kg as N, P_2O_5 and K_2O/ha and least (66) for the no fertilizer and only *Rhizobium* treatments. However, all treatments except the no fertilizer treatment recorded similar nodule weights. Grain yield ranged from 605 kg/ha for no fertilizer treatment to 1531 kg/ha for the treatment that received a combination of inoculants, PK and fertisoil. This treatment had higher yields than the treatment with inoculants and fertisoil only. These results seem to suggest some synergy between *Rhizobium* inoculation and PK fertilization. Applying *Rhizobium* inoculants alone to cowpea did not result in significant yield increase probably due to the acidic nature of the soil. Stover production ranged from 709 to 1708 kg/ha and followed similar trend as grain production. Grain yield was positively correlated with nodule weight (r=0.66), nodule number (r=085), pod number (r=0.84) seed number (r=0.63) as well as biomass production (r=0.98). Plants on the no fertilizer treatment plots looked less vigorous as the soils at this site looked infertile 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 cowpea 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 11. Some agronomic traits of cowpea as influences by soil amendment at Goriyiri, Nadowli district, UWR in 2013.

Treatment‡	Pod number	Seed number	Nodule number	Nodule weight	Grain yield	Stover yield
	no	no	no	g	kg/ha	kg/ha
No soil amendment (control)	3	11	66	0.6	605	709
Rhizobium inoculants only	5	9	67	0.8	625	911
Inoculants + PK	12	12	89	0.9	1077	1250
Inoculants + Fertisoil	13	12	93	1.2	1100	1254
Inoculants + PK + Fertisoil	16	13	100	1.1	1531	1708
Recommended fertilizer rate	12	12	103	1,0	1214	1375
Lsd(0.05)	4	2	18	0.3	253	295
CV%	27	13	13	24	16	17

‡P and K were applied at the rate of 60 kg P_2O_5/ha and 30 kg K_2O/ha, respectively;

Recommended fertilizer rate 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 2012 season was the set up year as such rotation effect could not be measured. However, the preliminary results showed that *Rhizobium* inoculants alone to cowpea did not result in significant yield increase. 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.

Researcher managed sorghum hybrids trials for identification of yield potential

Principal Investigator: S.S. J. Buah,
Collaborating Scientists: R.A.L Kanton, Eva Weltzien-Rattunde (ICRISAT-Mali, Bamako), Asamoah Larbi (IITA)
Estimated Duration: 2013-2014
Sponsors: ICRISAT-Mali/Africa RISING
Location: Wa, Upper West Region

Background Information and Justification

Sorghum (*Sorghum bicolor L.*) is an important staple cereal in northern Ghana. However, grain yields are low probably due to the use of unimproved varieties and poor crop management practices. It is also used largely to brew a local beer called *Pito*. In addition, it is now a suitable raw material in brewing lager beer. Recently the brewing industries in Ghana, especially Guinness Ghana Ltd., have expressed interest in using sorghum as a local substitute for Barley malt in the brewery industry. This has therefore stimulated widespread interest in scaling up sorghum production in the country. The issue of lack of lack of improved sorghum varieties has always been ranked as the most important constraint next only to low soil fertility by several stakeholders at the annual review and planning Sessions of the regional RELC. Research efforts at breeding stable and high yielding varieties and/or hybrids that are resistant/tolerant to major pests and diseases is crucial if current production levels are to be increased to meet the ever increasing demand for sorghum grain. It is against this background that elite sorghum hybrids were evaluated in on-station trials in northern Ghana 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 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. Eleven hybrids were evaluated at Wa. 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 in 2013 adversely affected sorghum growth and development as well as ultimate yield. Genotypic differences were detected for days to half bloom, plant height, grain yield, and kernel size and harvest index (Table 12). Days to half bloom for the sorghum hybrids ranged from 69 to 77 days. Mona, Soumalemba Fadda and Pablo on one hand flowered earlier than the rest of the hybrids. The local variety Kadaga reached half bloom the same time as the hybrids (IPSA1527530, IPSA156721, Yamassa, Sewa, Grinkan Yerewolo, Caufa, Pablo, Fadda and IPSAGolofing) which flowered latest. 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 hybrid was IPSA1527530 (1.66 m) while the tallest was Sewa (3.82 m). On average, 5 hybrids (Sewa, Grinkan Yerewolo, IPSA156731, Fadda and Pablo) and the local variety were taller than 3 m.

Mean grain yield for the sorghum hybrids ranged from 1633 kg/ha for Soumalemba to 2900 kg/ha for IPSAGolofing (Table 12). Generally, Soumalemba, Sewa, Kadaga and IPSA1527530 had similar but lower yields (< 2000 kg/ha) when compared to the other eight hybrids (IPSAGolofing, Yamassa, Fadda, Pablo, Caufa, Grinkan Yerewolo, IPSA156731and Mona) which recorded mean grain yields of more than 2000 kg/ha. Also, these higher yielding hybrids recorded higher harvest indices. Mean grain yields of Fadda, Yamassa and IPSAGolofing were 57, 71 and 78% greater than that of Soumalemba. The same varieties produced 37, 50 and 57%

more grain than the local variety, Kadaga. In general, Pablo and Fadda had similar grain yields. Kernel size (100-kernel weight) ranged from 1.8 g for IPSA1527530 to 2.4 g for three genotypes (Kadaga, Pablo and Grinkan Yerewolo). All hybrids produced heavier seeds than IPSA1527530. Sorghum genotypes that produced bigger seeds also tended to give higher harvest indices, indicating that these sorghum varieties had a better partitioning capacity as they converted dry matter from vegetative to generative parts as reflected in their higher harvest indices. Generally, the higher grain yields achieved by some of the sorghum genotypes could be attributed to a combination of superior heavier grains and harvest indices associated with these genotypes. However, sorghum yields reported in the current study are lower than those reported by (Buah and Mwinkaara, 2009).

Grain yield was positively correlated with harvest index (r=0.94) and not kernel size. No significant differences were detected among the genotypes for biomass production. Grinkan Yerewolo and the local variety were the most preferred by farmers whilst IPSA156731 was the least preferred. Kadaga was preferred for its brown grain that is preferred for brewing the local beer, *Pito*.

Table 12. Some agronomic traits of sorghum hybrids planted in Wa, UWR, 2013

Genotype	Days to 50% flowering	Plant height	Grain yield	100-kernel weight	Harvest index
	day	m	kg/ha	g	
Caufa	75	2.83	2233	2.3	0.41
Fadda	73	3.13	2567	2.2	0.43
Grinkan Yerewolo	75	3.46	2133	2.4	0.40
IPSA156731	77	3.25	2200	2.2	0.40
IPSAGolofing	74	2.55	2900	2.2	0.46
IPSA1527530	77	1.66	1933	1.8	0.36
Kadaga	77	3.10	1867	2.4	0.37
Mona	69	2.97	2233	2.3	0.42
Pablo	73	3.06	2567	2.4	0.44
Sewa	76	3.82	1767	2.3	0.35
Soumalemba	71	2.77	1633	2.2	0.34
Yamassa	76	2.18	2800	2.2	0.45
Lsd(0.05)	4	0.96	764	0.2	0.07
CV%	3.9	23.1	23.7	7.6	12.9

Conclusions/Recommendations

The current results are preliminary and the study will be repeated in the 2014 cropping season so as to provide more data to enable us better explain the genotypic differences. The best performing genotypes would be recommended to the CSIR-SARI Sorghum Improvement Programme for consideration with a view to incorporate their desirable traits into local germplasm for increased and stable sorghum production and productivity in northern Ghana.

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, eight drought tolerant varieties have so far been released in Ghana. In 2012, several extra-early, early and intermediate maturing drought tolerant maize varieties and hybrids which combine Striga and drought tolerance were evaluated in on-farm trials during the cropping season in the Upper West region of Ghana which is a drought prone area.

The activity in 2013 involved on-farm testing of drought tolerant varieties in three districts in the Upper West region of Ghana using the mother and baby methodology. SARI in partnerships with MOFA and farmers conducted on-farm trials at Goriyiri in the Nadowli district, Chinchang in the Sissala East district as well Silbelle and Sorbelle in the Sissala West district with funding from the DTMA project.

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

The mother baby trials 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 consist of varieties from the mother trial.

Mother Trials

Three sets maize mother trials managed by researchers, comprising extra-early (80-85 days to maturity), early maturing (90-95 days to maturity) and intermediate/medium maturing (110 days to maturity) varieties were planted in farmers' fields at Goriyiri, Chinchang, Sorbelle and Silbelle. The extra-early mother trial consisted of eleven (11) elite varieties involving yellow and white source populations obtained from IITA which were compared with a local check (the best available variety in the location). The extra-early mother trial was planted at Silbelle on 17th July 2013 while the early mother trial consisting of 6 varieties was planted at Goriyiri. Sorbelle and Chinchang. The intermediate maturing mother trials consisting of 7 hybrids from IITA, one QPM hybrid (Etubi from CRI) and a local check were planted at Chinchang on 17th July 2013.

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 three replications per site was used for each maturity group of maize. 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. Out of the two hundred and fifty-two (252) participants at two field days organized at Silbelle and Chinchang at physiological maturity, 32 were women. 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

Foe each maturity group 12 baby trials were also conducted on farmers' fields at the four sites using extra-early, early as well as intermediate sets of maize varieties. 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 varieties from both early and intermediate sets were respectively, evaluated alongside the farmers' varieties as local checks. Planting was done between 14^{th} and 27^{th} July 2013. 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 varieties tested were the same as those grown in the mother trial and each variety was tested by four farmers. Each plot measured 20 x 20 m. Farmers evaluated the varieties at physiological maturity. Farmers' preference criteria were based on earliness, cob size, grain colour, disease and drought tolerance and productivity of the variety.

Results/Major Findings

Planting was significantly delayed until 2^{nd} week of July due to prolonged pre-season drought. However, after mid July, we experienced wet conditions which 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. Moreover no meaningful data were obtained at the Goriyiri site as plant stand was so variable. Hence the results from this site are not included in this report.

Mother and baby trials for extra-early maturing varieties

In the mother trial at Silbelle, the extra-early maturing varieties flowered in 43-49 days after planting, producing dry grains in about 85 days (Table 13). 99 TZEE Y STR C1 was the earliest to flower while 5 other genotypes including 2004 TZEE W POP STR C4 and TZEE W POP STR QPM were the latest to flower (Table 13). Differences among the varieties for plant height, aboveground biomass production and grain yield were not statistically significant. However, grain yield tended to be highest for TZEE Y POP STR C5 x TZEEI 82, 2004 TZEE W POP STR C4 and TZEE1 21 x TZEEI 14 x TZEE1 29 which had grain yields above 3 t/ha. 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 13. Extra- early maturing varieties evaluated in a mother trial at Silbelle, Sissala West District, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
2004 TZEE W POP STR C4	49	52	1.90	3378	4978
99 TZEE Y STR C1	43	46	1.70	2398	4267
TZEE W POP STR QPM C0	49	51	1.84	2631	4400
2000 SYN EE W STR	48	51	1.74	2418	3165
TZEE1 76 x TZEEI 79	48	49	1.75	1710	5022
TZEE1 79 x TZEEI 76	46	48	1.80	2524	3333
TZEE1 29 x TZEEI 21	49	52	1.99	2560	2337
TZEE1 29 x TZEEI 49	46	48	1.68	2027	4667
TZEE W POP STR C5 x TZEEI 21	49	51	1.90	2916	3511
TZEE Y POP STR C5 x TZEEI 82	46	49	1.82	3662	3244
TZEE1 21 x TZEEI 14 x TZEE1 29	49	52	1.92	3200	3778
Lsd(0.05)	1.0	1.0	NS	NS	NS
CV(%)	1.0	1.0	9.4	31.2	25.9

NS= not significant at the 0.05 and 0.01% level of significant

Nine varieties were evaluated in the baby trials. The extra-early maturing varieties in the baby trials, on average flowered in 47- 51 days after planting and producing dry grains in about 85 days (Table 14).

Table 14. Extra- early maturing varieties evaluated in baby trials at Silbelle and Sorbelle, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
2004 TZEE W POP STR C4	48	53	1.72	1280	2293
99 TZEE Y STR C1	46	49	1.55	1648	2457
2000 SYN EE W STR	48	51	1.62	1240	2267
TZEE1 76 x TZEEI 79	47	48	1.79	2304	2985
TZEE1 29 x TZEEI 49	47	49	1.45	1440	2690
TZEE W POP STR C5 x TZEEI 21	49	51	1.87	1248	2560
TZEE Y POP STR C5 x TZEEI 82	46	50	1.66	1600	2587
TZEE1 21 x TZEEI 14 x TZEE1 29	49	52	1.78	2144	2287
Farmer variety	51	54	1.87	1189	3247
Lsd(0.05)	4	3	NS	838	808
CV(%)	3.2	2.9	15.7	23.1	12.7

NS= not significant at the 0.05 and 0.01% level of significant

Differences among the varieties for plant height were not statistically significant. However, mean grain yield ranged from 1189 to 2304 kg/ha. The highest yielding hybrid was TZEE1 76 x TZEEI 79 while the farmers' varieties on average, produced the least grain yields. The farmer varieties were taller and more prone to lodging. Most 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 2013 affected seedling establishment hence the optimum plant stand was not achieved for most varieties.

Mother and baby trials for early maturing varieties

In the early maturing mother trials, the varieties flowered in 49-50 days after planting at both Chinchang and Silbelle and producing dry grains in about 90-95 days (Tables 15 and 16). Differences among the varieties for days to flowering were not statistically significant at both locations. The varieties also produced similar amounts of biomass at both locations. Genotypic differences among the early DT maize for grain yield were statistically significant at both locations. Grain yield ranged from 2240 to 4124 kg/ha at Chinchang in the Sissala East district (Table 15). At this location, mean grain yield was highest for Aburohemaa and least for TZE Comp3 DT C2 F2. Grain yield ranged from 2205 to 3947 kg/ha at Silbelle in the Sissala West district (Table 16). Mean grain yield at this location was highest for TZEI 7 x TZEI 26 and least for TZE W DT STR C4 (Wang Dataa). In addition, at both locations, no significant differences were detected among the varieties for Striga counts at 10 weeks after planting (10 WAP). The Striga emergence counts were generally very low.

Table 15. Early maturing varieties evaluated in mother trial at Chinchang, Sissala East District, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
TZE Comp3 DT C2 F2	50	52	1.57	2240	2578
TZE Y POP DT STR C4 X TZE1 17	49	52	1.64	3911	4089
TZE W POP DT STR C4 x TZE1 7	50	52	1.69	3022	3600
TZEI 7 x TZEI 26	49	52	1.68	2951	3289
TZE W DT STR C4 (Wang Dataa)	49	51	1.68	2667	3378
Aburohemaa	50	53	1.75	4124	3956
Lsd(0.05)	NS	1.0	NS	1044	NS
CV(%)	1.3	1.0	4.0	18.2	18.5

NS= not significant at the 0.05 and 0.01% level of significant

Table 16. Early maturing varieties evaluated in mother trial at Silbelle, Sissala West district, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
TZE Comp3 DT C2 F2	49	51	1.79	3591	3733
TZE Y POP DT STR C4 X TZE1 17	49	51	1.57	3129	2845
TZE W POP DT STR C4 x TZE1 7	50	52	1.71	3627	3911
TZEI 7 x TZEI 26	49	52	1.67	3947	3600
TZE W DT STR C4 (Wang Dataa)	49	51	1.73	2205	2355
Aburohemaa	50	52	1.74	3236	3644
Lsd (0.05)	NS	NS	6	923	NS
CV (%)	1.3	1.0	2.0	15.4	18.1

NS= not significant at the 0.05 and 0.01% level of significant

In the early maturing baby trials, the varieties similarly flowered in 50-60 days after planting. (Table 17). No significant differences were noted among the varieties for any parameter measured although TZE W POP DT STR C4 x TZE1 7 tended to have high grain yield.

Table 17. Early maturing varieties evaluated in baby trial at Sissala East and West districts, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
TZE Comp3 DT C2 F2	50	52	1.59	1783	2825
TZE Y POP DT STR C4 X TZE1 17	50	52	1.53	1797	3211
TZE W POP DT STR C4 x TZE1 7	51	53	1.77	2725	4102
TZEI 7 x TZEI 26	50	52	1.26	1724	2816
TZE W DT STR C4 (Wang Dataa)	52	55	1.79	2069	3019
Aburohemaa	50	52	1.20	1635	2547
Farmer variety	52	55	1.89	1865	4000
Lsd(0.05)	NS	2	NS	NS	1146
CV(%)	3.5	3.2	18.4	35.5	19.4

NS= not significant at the 0.05 and 0.01% level of significant

Mother and baby trials for intermediate maturing varieties

Intermediate maturing mother trial was planted at Chinchang. The varieties flowered in 52-57 days after planting and producing dry grains in about 110 days (Table 18). No Significant differences were detected among the varieties for any parameter measured or calculated. However, Obatanpa tended to produce the highest grain yield.

Table 18. Intermediate maturing varieties evaluated in mother trial at Chinchang, Sissala East District, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
TZL Comp4 C3 DT F2	58	60	1.75	3627	4000
DT STR W SYN2	57	59	1.60	3414	3955
IWD C3 SYN/DT SYN 1 W	60	63	1.62	3556	4078
DT STR SYN/IWD C3 SYN F2	58	60	1.78	3093	3556
DT SR W C2F2	58	60	1.61	3235	4311
IWD C2 SYN F2	58	60	1.65	3022	4133
TZL Comp1 W C6/DT SYN 1 W	59	62	1.79	2631	4133
TZU TSR W SGY SYN	58	60	1.79	3200	3911
Obatanpa	57	59	1.84	4089	4355
Lsd(0.05)	NS	NS	NS	NS	NS
CV(%)	3.2	1.6	7.1	23.9	17.8

NS= not significant at the 0.05 and 0.01% level of significant

Similar results were obtained for the baby trials. The intermediate maturing varieties had similar days to 50% anthesis and grain production (Table 19). 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.

Table 19. Intermediate maturing varieties evaluated in baby trials at Sissala East and West Districts, 2013

Variety	Days to mid anthesis	Days to mid silk emergence	Plant height (m)	Grain yield (kg/ha)	Biomass yield (kg/ha)
DT STR W SYN2	57	59	1.86	2070	3066
IWD C3 SYN/DT SYN 1 W	58	60	2.02	3160	4808
DT STR SYN/IWD C3 SYN F2	56	59	1.93	3199	4126
TZL Comp1 W C6/DT SYN 1 W	58	61	1,91	3192	4262
Farmer variety	57	59	1.97	2965	4633
Lsd(0.05)	NS	NS	NS	NS	NS
CV(%)	2.6	2.7	6.7	27.1	24.6

NS= not significant at the 0.05 and 0.01% level of significant

Farmer assessment of the varieties

Maize farmers evaluated the varieties and regarded them very positively. Most of the farmers have a long tradition of cultivating maize. The study showed that farmers valued many characteristics in maize varieties, especially traits related to consumption. Among women, yellow maize is in particular demand. 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, 2004 TZEE W POP STR C4 and TZEE1 21 x TZEEI 14 x TZEE1 29 were the most preferred extra-early maturing varieties. The most preferred early maturing variety was TZEI 7 x TZEI 26 and Aburohemaa. 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, DT STR SYN/IWD C3 SYN F2 and Obatanpa 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).

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. However, 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. Furthermore the early maturing yellow maize TZE Y DT STR C4 and its white version, TZE Y DT STR C4 as well as a medium variety DT SYN 1 W were among five new maize genotypes that were released onto the Ghanaian agricultural sector for cultivation and consumption in December 2012. They were given names in different local languages that signified their drought or Striga tolerance. The genotype DT SYN 1 W was named Sanzal-sima, TZE – Y DT STR C4 (Bihilifa) and TZE – W DT STR C4 (Wang Dataa)

Conclusions/Recommendations

In this study, mean yields from researcher-managed trials as well as some of the varieties 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 often perform better if accompanied by recommended cultural practices. The results of both the mother and baby trials for the extra-early, early and intermediate maturing varieties suggested that some IITA varieties were relatively stable in grain yield performance. Extra-early and early maturing yellow maize is preferred for its earliness and yellow endosperm. Additionally, many of the improved drought tolerant varieties 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 varieties are also known to show good performance when Striga infestation and drought conditions occur simultaneously. Thus, the DT maize varieties 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 varieties.

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
Location: Jirapa and Lawra districts.

Background Information and Justification

Unpredictable and erratic climatic patterns resulting from climate change will affect agricultural production and food security all over the world. This will have an impact on farmer livelihoods and food availability especially those living in developing countries, who will face shortages of water and food and greater risks to health and life because of climate change. With fewer social, technological and financial resources for adapting to changing conditions, developing countries are the most vulnerable to the impacts of climate change. Although smallholder farmers in African already use a broad variety of mechanisms to cope with variable weather conditions and adapt to climate change, improved strategies for increasing resilience and coping with risks are still needed. Sustainable management practices of soils, land, water and nutrients could allow farmers to become more resilient to climate change by increasing food production, conserving soil and water, enhancing food security and restoring productive natural resources. 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. Since 2012, member countries (Mali, Ghana, Niger, Burkina Faso and Senegal) have developed country specific workplans for participatory action research at the CCAFS benchmark sites. National workshops involving local key stakeholders were later held in each country to refine and validate the workplans developed during the regional inception workshop. The activities planned in these 2012 workplans and implemented during the first year included: baseline studies, 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

Objectives 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.

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
Activities implemented in 2013 included the following

- Community Participatory Technology Development (PTD) workshops to identify and prioritize climate change adaptation and mitigation practices in 2 communities – in Doggoh in the Jirapa district and Bompari in the Lawra district.
- Follow-up to plan and design adaptation and mitigation options according to farming systems and land use for implementation.
- Test basket of technologies selected by communities for implementation at field scale with households
- Organized farmers' field day to visit trials and share their perceptions with researchers.
- Identified adapted tree species for wood production and fruit tree of choice and assist the communities in establishing and evaluating them.
- Organized workshops to empower local level institutions with information, knowledge and capability to address longer term issues such as climate change
- Organized training sessions for community leaders on participatory development planning
- Construction of tree seedling nurseries at Doggoh and Bompari to be used to train farmers on seedling production for easy access to tree seedlings in each community in order to mitigate the effect of climate change.

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. A total of 103 people (70 males +33 females) attended the workshops in the two project communities. 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.

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 require no inoculation or little mineral fertilizers to produce high grain yields, an emphasis on sustainable agricultural practices. After discussions, the community agreed to implement the following trials:

- Maize- cowpea Rotation *(*11 farmers – 8 farmers at Doggoh and 3 farmers at Bompari planted the trial).
- Tie-ridges and fertilizer effect on crop production (10 farmers – 5 farmers each at Doggoh and Bompari planted the trial).
- Integration of organic and mineral fertilizers for crop production (7 farmers – 3 farmers at Doggoh and 4 at Bompari planted the trial).
- Integrating Jatropha in the existing cropping system (4 farmers – 2 farmers each at Doggoh and Bompari planted the trial).
- Organic amendment and water harvesting effect on crop production (8 farmers – 4 farmers each at Doggoh and Bompari planted the trial)
- No-tillage effect on soybean production (3 farmers only at Doggoh planted the trial
- No-tillage effect on maize production (3 farmers only at Bompari planted the trial).
- Earth bunding and fertilizer effect on crop production (4 farmers only at Bompari planted the trial).
- Evaluation of drought tolerant maize varieties under fertilized conditions (4 farmers – 2 farmers each at Doggoh and Bompari planted the trial)

On-farm trials

- Addition of fertilizer significantly increased maize yields by 133-425% when compared with no fertilizer application
- Maize after cowpea with fertilizer increased grain yields
- Bunding complemented with fertilizer 68-38-38 kg/ha as N, P_2O_5 and K_2O increased maize yield more than three fold (345%) when compared with bunded field without fertilizer.
- No-tillage with fertilizer increased maize yields by 65% when compared with conventional tillage. Even without fertilizer addition, no-tillage maize was 76% higher.

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. Under these 2 objectives, the following milestones were achieved:

In 2013, AGRHYMET conducted two workshops on identifying and evaluating climate risk management strategies" and "Tailoring climate information to the needs of farmers in northern Ghana. Information gathered during the first workshop on 18th and 19th June 2013 with farmers included their perceptions on the impact of climatic factors on agricultural activities, the different indigenous techniques and strategies used to reduce the negative effects of these factors, the information needs in climate and/or weather to mitigate or avoid adverse effects, and opportunities for better use of this weather information.

The objective of the second workshop in November 2013 was to assess how close the predictions in the weather forecast were to the observed trends during the season and how farmers coped with the weather situation. Farmers agreed that the predictions were to a large extent close to what was actually observed during the season and that the information helped them to re-adjust their production practices especially as they were warned of a drought spell in June and early August.

The activity enabled AGRHYMET and GMA to explain seasonal forecasting to farmers in Jirapa and Lawra districts and this built common ground between scientific forecasting and traditional knowledge. Farmers now understand and use seasonal forecasts to improve crop strategies. In addition, farmers were able to explain to meteorologists what seasonal climate information they most needed, in turn improving the usefulness of the forecast.

Other milestones that were achieved under capacity building, communication and knowledge dissemination included the following:

i. One student was identified and enrolled at the Kwame Nkrumah University of Science and Technology and he is pursuing the M.Phil degree programme in Agricultural Economics.
ii. Two community members (1 male & 1 female) from the villages of Doggoh and Bompari, were trained in participatory video filming in 2012.
iii. A climate change adaptation committee, made up of representatives from different stakeholders or partners, was formed to supervise the implementation of activities.
iv. The Ghana country team was trained by IUCN on the tools for PM&E of the project. This was followed by testing of the tools in the community and the sharing of the findings with stakeholders in a District workshop.
v. Five local committees on gender, agroforestry, integrated soil fertility management, bushfires and overall management were formed by the community to implement various aspects of the project.

A farmer platform was held at Lawra during a durbar to climax the annual farming festival (Kobine festival) of the chiefs and people of the Lawra Traditional area on 10th October 2013. This provided a forum for the CCAFS team and farmers to dialogue on CSA. 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 increased the visibility of the project and also gave non-participating farmers the opportunity to learn more about the effect of climate change as well as how to adapt or mitigate these effects.

Mainstreaming gender into CCAFS activities

Climate change does not discriminate, but the fragile group of persons, particularly women, suffer 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 bonding for soil and water conservation and they have adapted these practices for rice and maize production on fields that are pruned 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 appraprasan utilization) and village savings and loans groups.

In the two project communities, access to land is controlled by men 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. The project has been trying to address this issue by working with chiefs and elders to ensure that women's rights to fertile lands are recognized and enforced.

In addition, 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 are not 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.

Project Outputs

- Three (3) appropriate 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
- Two (2) anti-bushfire squads trained
- 146 farmers trained in compost preparation and use
- 234 farmers trained on land reclamation and soil fertility management practices
- At 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 appraprasan 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.

Conclusion and Recommendations

- There is the need to train selected community members in nursery practices and the establishment of a community nursery for sustained implementation of this activity. Fencing materials for the two nursery garden has been purchased for the community.
- Five local committees on gender, integrated soil fertility management, agroforestry, bush fires, and a general one comprising representatives from the first four committees, were formed by the Doggoh community to help in implementation of the project. Similar committees will be formed in Bompari. However, it is important to strengthen the capacity of these committees by training them in group dynamics to make them more functional.
- There is also the need to train the anti-bush fire committees in bush fire management and control. Initial contact has been made with the District National Fire Service office to provide this training when funds are available.
- Building partnerships is crucial for climate smart agriculture. A committee comprising various partners was formed to help in implementation of the project. It is important to sustain the interest of the local committees and partners by incentivizing them for greater commitment.
- Early planning and a calendar of activities for the year will help partners plan for other activities.
- 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.
- CSA is mainly reflected in systems being managed through an ecosystem approach at the landscape level, as well as in integrated systems. We need to pay attention to the role of crop-livestock integration in CSA as the crops will provide feed for the animals and the animals intend provide manure to fertilize the crop.

Boosting maize cropping system productivity in northern Ghana through widespread adoption of integrated soil fertility management

Principal Investigator: Mathias Fosu
Collaborating Scientists: S.S. J. Buah, F. Kusi, B.D.K. Ahiabor, E. Martey
Estimated Duration: 2010--2015
Sponsors: *Alliance for a Green Revolution in Africa (AGRA)*
Location: Eight districts (Wa West, Wa East, Wa Municipal, Nadowli, Jirapa, Lawra, Sissala West and Sissala East)

Background Information and Justification
Crop 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 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. 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 is targeting 120,000 farmers in northern Ghana.

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 2010. However, during the 2013 cropping season, the project was implemented in 15 communities in eight districts in the Upper West region and it targeted 28

Farmer based organizations (FBOs) who planted 31 demonstrations in the eight districts. In 2013, 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.

Forty-two (42) FBOs executive members were also trained on organizational strengthening and enterprise development, best practices in crop production and fertilizer use. In addition, 23 Agri-input dealers in the region were trained on safe handling as well as safe and efficient use of agro-chemicals such as fertilizers and pesticide. In general, technology dissemination pathways included demonstrations on ISFM, training of trainers, Farmer Field Schools, exchange visits, field days, posters, community outreach programs (radio broadcast) and feed back (review and planning meetings with farmers). The project also encouraged farmer to farmer information sharing. Participating FBOs were provided with timely and affordable access to quality seed of non-shattering soybean and drought tolerant and quality protein maize, utilizing existing distribution channels including the private sector, government agencies and NGOs. In 2013, participating FBOs also had access to best-bet maize technologies through trainings and demonstrations while expanding knowledge of ISFM for maize production in the region.

Establishment of Demonstrations on ISFM

Five main demonstrations on ISFM were carried out in the UWR in 2013. Overall, a total of 31 ISFM demonstrations were established in eight districts (Wa West, Wa East, Wa Municipal, Nadowli, Jirapa, Lawra, Sissala West and Sissala East) by 28 FBOs (Table 20). Each demonstration was planted on 0.4 ha of land by each FBO. Planting was delayed until the 2rd week of July in most of the communities due to preseason season drought. Four sets of demonstrations trials were dispatched to each of the 7 District Agricultural Development Units (DADU). In addition, three demonstrations (1 on soybean and 2 on maize) were planted by the research team at SARI, Wa station. Nonetheless, no reliable and meaningful data were obtained from Woggu and Matanga sites in the Nadowli and Lawra districts, respectively. Therefore data from the two locations are excluded in this report. This report provides summary results of analyses of data sets of the demonstration trials for eight participating districts (including those planted at SARI) where reliable and meaningful data were obtained.

Maize was planted in rows spaced 0.80 m apart but with intra row spacing of 0.40m. The Agricultural extension agents that assisted the FBOs to plant the maize in multiple locations were encouraged to use recommended cultural practices including optimum plant spacing. Analysis of variance was computed for important agronomic traits combined across sites in the region. Mean grain yields were used to calculate percent increase of each treatment over the standard or usual farmers' practice in each demonstration. Furthermore, the Least Significant Difference (LSD) provided at the bottom of the tables can be used to compare the difference between each treatment with the standard (control treatment).

Table 20. List of demonstrations planted in the region in 2013

Title of Demonstration	Districts where demonstration was carried out	Name of FBO
Soil fertility in maize with mineral fertilizer and rotation with cowpea or soybean	Wa municipal (including 2 by SARI in Wa municipal)	
	Wa West (Wechiau)	Wontogirah
	Jirapa (Nyenvaari)	Suntaa Nontaa farmers
	Wa East (Kpaglaghi)	Suntaa farmers Assoc.
	Sissala East (Chinchan)	Chinchan farmers
	Sissala West (Jeffisi)	Jeffisi farmers Group
	Nadowli (Tabiase)	Lambunuma
	Lawra (Magtanga)	Dogbelanta Yirdem
Soil fertility in maize with organic and inorganic fertilizers	Lawra (Breworce)	Kolebpour
	Wa West (Dorimon)	Nuntaa farmers
	Wa East (Manwe)	Angamwini
	Sissala East (Chinchan)	Chinchan farmers
	Sissala West (Liplime)	Benin Association
	Nadowli (Ombo)	Ombo-Yirkori farmers
	Jirapa (Nyenvaari)	Suntaa Nontaa farmers
Evaluation of different drought tolerant maize cultivars/varieties under fertilized conditions	Wa West (Dariyiri)	Nuoriyen farmers
	Wa East (Loggu)	Sungoli farmers
	Sissala East (Tumu)	Inusah Dramani
	Sissala West (Bullu)	Kanuleirun farmers
	Nadowli (Woggu)	Tieta-do farmers
	Jirapa (Da-wuri)	Nyotaa-eri
	Lawra (Lawra)	Songtaa
Evaluation of hybrid and open-pollinated maize varieties under fertilized conditions	Wa West (Piisie)	Mwinisungbu
	Wa East (Loggu)	Karasung
	Sissala East (Chinchan)	Bani Suntuo
	Sissala West (Bullu)	Baatala
	Nadowli (Kaleo)	Booduori
	Jirapa (Da-wuri)	Nyotaa-eri
	Lawra (Magtanga)	Dogbelanta Yirdem
Increasing Soybean productivity with rhizobium inoculation and mineral fertilizer application,	Wa (conducted by SARI)	

Results of across site analysis

1. Soil fertility in maize with mineral fertilizer and rotation with a legume

The demonstration was carried out in 9 communities spread across 8 districts but reliable and meaningful data were obtained from 8 sites only. Data from Lawra were excluded in the analyses. The list of treatments evaluated in this demonstration is presented in Table 21.

Table 21. List of treatments evaluated in the Soil fertility in maize with mineral fertilizer and rotation with a legume

Treatment code	Treatment description	NPK (kg/ha)	Sulphate of ammonia (kg/ha)
T1	No fertilizer	0	0
T2	legume (legume 30 kg/ha P_20_5;	0	0
T3	Recommended rate of NPK and SA fertilizer	250	125
T4	2bags NPK 15-15-15 +1½ bags SA/acre	250	188
T5	Maize planted after a legume with ½ recommended rate of NPK and SA fertilizer	125	63

The experiment is in the 3rd year and therefore rotation effects were measured in 2012 and 2013. Grain yields averaged over 8 sites are presented in Table 22. Grain yields ranged from 945 to 4111 kg/ha. Fertilizer application increased maize yields significantly across sites. On average, maize following legume with half the recommended rate of fertilizer applied to maize resulted in a 273% (2575kg/ha more grain) increase in grain production when compared with no fertilizer treatment. Similarly, the application of the recommended rate of fertilizer to maize increased grain yield by 278%. The highest yield increase of 335% was observed when the quantity of sulphate of ammonia fertilizer used in top dressing was increased from 125 kg/ha to 188 kg/ha. However, rotating maize with a legume with half the recommended rate of fertilizer had similar yields as continuous maize with the recommended rate of fertilizer. Differences among treatments were not significant for biomass yield.

Table 22. Mean grain and aboveground biomass yield of maize as affected by mineral fertilizer at various sites in the Upper West region, 2013.

Treatment code	Grain yield (kg/ha)	Biomass yield (kg/ha)
No fertilizer	945	255
250 kg/ha NPK + 125 kg/ha SA	3659	3497
250 kg/ha NPK + 188 kg/ha SA	4111	3118
Maize-legume rotation with 125 kg/ha NPK + 63 kg/ha SA	3523	2907
Lsd (0.05)	1330	NS
CV%	35.8	33.3

2. Soil fertility in maize with organic and mineral fertilizers

The demonstration was carried out 7 communities spread across 7 districts. The list of treatments evaluated in this demonstration is presented in Table 23.

Table 23. List of treatments evaluated in the Soil fertility in Maize with organic and inorganic fertilizers

Treatment code	Treatment description	NPK (kg/ha)	Sulphate of ammonia (kg/ha)
T1	No fertilizer	0	0
T2	Recommended rate of NPK and SA fertilizer	250	125
T3	Full rate of organic fertilizer (fertisoil) and SA fertilizer	3 t (fertisoil)	125
T4	2bags NPK 15-15-15 + 2 bags SA/acre	250	250

Grain yields averaged over the 7 sites are presented in Table 24. Grain yields ranged from 707 kg/ha for the no fertilizer treatment to 3066 kg/ha for the highest fertilizer treatment (T4). Application of both organic and inorganic fertilizers increased maize yields significantly across sites. On average, applying a combination of organic fertilizer (3t/ha of fertisoil) and mineral fertilizer (sulphate of ammonia) had similar yields as applying mineral fertilizers at the recommended rate or at a higher rate (T2 and T4). The current recommended rate of fertilizer for maize (64-38-8 kg/ha as N P_2O and K_2O or 250 kg/ha NPK + 125 kg/ha SA) increased grain yields by 317% when compared to no fertilizer treatment (T1). In addition the combined use of organic and inorganic fertilizers (T3) increased yields by 277% when compared with the no fertilizer treatment. Topdressing with a higher rate of nitrogen from sulphate of ammonia (T4) did not increase maize yields significantly when compared with the recommended rate (T2). However, this rate increased yields by 334% when compared with no fertilizer treatment. Differences among treatments were significant for biomass yield with fertilized plots producing higher biomass. Differences in yields among sites were due to differences in management and attention devoted to the demonstrations.

Table 24. Mean grain yield of maize as affected by organic and mineral fertilizers at various sites in the Upper West region, 2013.

Treatment code	Grain yield (kg/ha)	Biomass yield (kg/ha)
No fertilizer	707	1056
250 kg/ha NPK + 125 kg/ha SA	2947	2526
3 t of fertisoil + 125 kg/ha SA	2668	1956
250 kg/ha NPK + 250 kg/ha SA	3066	2850
Lsd (0.05)	782	1050
CV%	29.5	34.6

3. Evaluation of drought tolerant maize varieties under fertilized conditions

The demonstration was carried out in 7 communities spread across 7 districts but reliable and meaningful data were obtained from 6 sites. Those from Woggu in the Nadowli district were excluded in the analyses. The list of treatments evaluated in this demonstration is presented in Table 25.

Table 25. List of treatments evaluated in drought tolerant maize varieties under fertilized Conditions, UWR, 2013.

Treatment code	Treatment description
T1	Omankwa (DT maize) with no fertilizer
T2	Omankwa with recommended rate of NPK and SA fertilizer
T3	Farmer variety with no fertilizer
T4	Farmer variety with recommended rate of NPK and SA fertilizer
T5	Aburohemma (DT maize) with no fertilizer
T6	Aburohemma with recommended rate of NPK and SA fertilizer

Grain yields averaged over 6 sites are presented in Table 26. Grain yields as affected by fertilizer treatment ranged from 963 to 2779 kg/ha. In general, preseason drought delayed planting until late July. Thus grain yields were lower than expected. The early maturing drought tolerant varieties had similar yields as the most common variety grown by farmers in the various communities. On average fertilizer application increased grain yields by over 100% when compared with no fertilizer application. The highest yield increase due to fertilizer application was obtained for Omankwa. On average, applying current recommended rate of fertilizer to farmers' variety, Aburohemma and Omankwa increased grain yields by 103, 111 and 140%, respectively when compared with unfertilized treatment. However, there was no significant yield difference among the varieties at each level of treatment. Averaging over treatments, biomass yield followed a similar trend as grain yield.

Table 26. Mean grain yield of drought tolerant maize as affected by mineral fertilizer at various sites in the Upper West region, 2013.

Treatment code	Grain yield (kg/ha)	Biomass yield (kg/ha)
Omankwa + No fertilizer	963	740
Farmers' variety+ No fertilizer	1367	1785
Aburohemaa+ No fertilizer	1240	1000
Omankwa + recommended rate of fertilizer	2307	2073
Farmers' variety+ recommended rate of fertilizer	2779	2913
Aburohemaa+ recommended rate of fertilizer	2615	2603
Lsd (0.05)	829	1168
CV%	37.1	42.1

4. Evaluation of hybrid and open-pollinated maize varieties under fertilized conditions

The demonstration was carried out in 7 communities spread across 7 districts but reliable and meaningful data were obtained from 6 sites. The list of treatments evaluated in this demonstration is presented in Table 27.

Table 27. List of treatments evaluated in hybrid and open-pollinated maize varieties under fertilized conditions

Treatment code	Treatment description
T1	Hybrid maize (Etubi) with no fertilizer
T2	Hybrid maize with recommended rate of NPK and SA fertilizer
T3	Farmer variety with no fertilizer
T4	Farmer variety with recommended rate of NPK and SA fertilizer
T5	Open pollinated variety (Obatanpa) with no fertilizer
T6	Obatanpa with recommended rate of NPK and SA fertilizer

Grain yields averaged over 6 sites are presented in Table 28. Grain yields as affected by fertilizer treatment ranged from 1125 to 3053 kg/ha. In general, preseason drought delayed planting until late July. The farmer variety, Obatanpa and the hybrid maize had similar grain yields at each fertility level. On average fertilizer application doubled yields of the hybrid and the farmer variety when compared with no fertilizer application. The greatest yield increase due to fertilizer application was obtained for the farmer variety. On average, applying current recommended rate of fertilizer to Obatanpa, Etubi and farmer variety increased grain yields by 87, 158 and 177%, respectively when compared with unfertilized treatment. On average, biomass yields were similar among the treatments.

Table 28. Mean grain yield of hybrid and open-pollinated maize as affected by mineral fertilizer at various sites in the Upper West region, 2013.

Treatment code	Grain yield (kg/ha)	Biomass yield (kg/ha)
Etubi + No fertilizer	1125	1347
Farmers' variety+ No fertilizer	1104	2693
Obatanpa+ No fertilizer	1467	2760
Etubi + recommended rate of fertilizer	2904	3047
Farmers' variety+ recommended rate of fertilizer	3053	3250
Obatanpa + recommended rate of fertilizer	2748	2977
Lsd (0.05)	973	NS
CV%	34.5	42.1

5. Increasing Soybean productivity with rhizobium inoculation and mineral fertilizer application

Overall Objective - To increase adoption of ISFM technology options for increased soybean production to reduce poverty and improve food security, income and livelihoods of small-scale resource poor farmers in Northern Ghana

Experimental Design: RCBD, 4 replications.

Treatments

T1 – Soybean with no Fertilizer

T2 – Soybean + *Rhizobium* inoculation

T3 – Soybean + 60 kgP_2O_5+30 kg K_2O/ha

T4 – Soybean + 25 kg N+60 kgP_2O_5+30 kg K_2O/ha
T5- Soybean + *Rhizobium* +60 kgP_2O_5+30 kg K_2O/ha
Plot size: 4.5 x 5.0 m (6-row plots).

Results and discussion

Compared with no fertilizer treatment, addition of fertilizer significantly influenced chlorophyll concentration (SPAD readings), nodule weight, grain and stover production but not flowering date, plant height, pod and nodule numbers (Table 29). On average, chlorophyll content was higher when fertilizer was applied compared to no fertilizer treatments. The application of P and K fertilizers with or without inoculants increased grain yield significantly relative to the no fertilizer treatment or the treatment with only Rhizobium inoculants. The lowest grain yield of 2016 kg/ha was obtained from the no fertilizer treatment, followed by the treatment that received *Rhizobium* inoculants only (2169 kg/ha). The treatments which received mineral fertilizers had higher but similar yields (Table 29). Applying *Rhizobium* inoculants alone to soybean did not result in significant yield increase probably due to the acidic nature of the soil (pH=4.85). In addition, the experimental sites had been planted to soybean in the last three years, and indigenous *Rhizobium* bacteria populations were probably adequate for soybean nodulation. It is widely believed that soybean grown on land where well nodulated soybean has been grown in recent years will probably not require inoculation. The soils collected from these sites are yet to be analyzed and the data will help explain the inconsistent responses observed in the study. More data is required to confirm soybean response to Rhizobium inoculation in the Guinea savanna zone.

Table 29. Some agronomic traits of early maturing soybean as affected by fertilizer and Rhizobium inoculation at Wa, UWR, 2013.

Treatment	DFF	SPAD reading	Nodule weight	Nodule number	Grain yield	Stover yield
Fertilizer treatment						
No fertilizer	51	39.6	7.8	29	1898	1864
Rhizobium inoculation	52	40.3	9.0	55	2169	2444
60 kgP_2O_5+30 kg K_2O/ha	51	40.2	8.6	46	2382	2862
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	51	42.4	8.6	41	2394	2960
Rhizobium +60 kg P_2O_5+30 kg K_2O/ha	51	39.7	8.8	43	2381	2880
Lsd (0.05)	NS	1.3	0.2	NS	316	383
CV%	3	4	3	39	19	19

DFF=days to 50% flowering
‡ NS = Not significant at 5 and 1% probability levels.
Nodule number and nodule weigh are for 10 plants/plot.

Establishment of Farmer Field Schools

Farmer Field Schools were organized in each of the 7 project districts in the regions

Field Days Organized

Field Days were organized in all districts for participating and non-participating farmers with Government officials and District Chief Executives and other stakeholders in attendance. Three grand field days were held on 25th October in Wechiau in the Wa West district, 28th October 2013 at Silbelle near Tumu and on Bullu in the Sissala west district. The Silbelle field day was organized at the farmer learning center. A total of 204 farmers (155 males + 49 females attended the three field days.

Organized Exchange visits between Farmer-based Organizations (FBOs)

Intra-district exchange visits were organized within all the districts to engender competition and exchange learning. Inter district exchange visits were also organized between farmers in Sissala West and Sissala East districts.

Project Monitoring

Monthly monitoring visits were conducted by project team comprising SARI and MoFA staff to ensure compliance with project plans, Challenges and suggested solutions were gathered (Table 30).

Table 30. Problems and Solutions

No	Problem	Solution
1	Frequent turnover of supervisors and agricultural extension agents in some districts affected project implementation	The regional team had to sensitize new staff taking over from those leaving the region or leaving MOFA during the season
2	Preseason drought delayed land preparation and planting of maize in some cases where land was already prepared. This discouraged some farmers who failed to plant their maize much earlier	It was late to replace farmers who opted.
3	Meaningful and reliable data collection was a problem for the demonstrations as some of the extension staff only joined the project midway after the training was carried out on management of the demonstrations and data collection	SARI technicians tried to fill in to collect data in Wa municipal where a research technician is available.
4	Some farmers were misled by extension staff that the project will supply them with herbicides for weed control. This affected timely weed control	The regional team had to intensify education and sensitization of farmers on the package available to them
5	Other maize projects with free input or credit facilities being executed in the various districts by government and Non-government Organizations (PLAN Ghana and ADRA), MOFA maize block farm, Northern Rural Growth Project were threat to the successful implementation of AGRA SHP activities in the region	Extension staff should facilitate and coordinate linkages of AGRA SHP farmers to such projects credit facilities at the district level

Technology dissemination pathways

Dissemination pathways to be used for up-scaling ISFM technologies in the region included

- Demonstrations
- Training of trainers,
- Farmer Field Schools,
- Exchange visits,
- Field days,
- Posters,
- Community outreach programs (radio broadcast) and feed back (review and planning meetings with farmers).

Regional Review and planning meeting

Regional Planning meetings involving District Directors of Ministry of Food and Agriculture, NGOs, and other stakeholders were held in May 2013 to plan for ISFM Demonstrations

Capacity building activities

Training of Agi-input dealers

Training of Agri-input dealers in order to sensitize them and farmers on safe handling as well as safe and efficient use of agro-chemicals such as fertilizers and pesticide carried out in Wa on 13^{th} and14^{th} June 2013. A total of 23 agro-input dealers (22 males +1 female) were trained. We purposefully targeted agro-input dealers who have not received such training before.

Training topics covered

- Packaging and handling of certified seed
- Safe and efficient use of agro-chemicals
- Fertilizers (grade and formulations)
- Handling and transportation of agro-chemicals
- Introduction to ISFM
- Storage procedures for seed and agro-chemicals

Training of Farmer-based Organizations

FBOs were trained in organizational strengthening and enterprise development, best practices in crop production and fertilizer use. The objective was to make them functional and effective. The training was carried out in Wa on 11^{th} and 12^{th} June 2013. Training topics included FBO governance, farming as a business, credit management. A total of 42 FBO representatives (37 males 5 females) were trained. Training cantered on the 5 Modules in the AGRA SHP005 FBO training manual

- Module 1: Group formation and development
- Module 2: Financial management
- Module 3: Business management
- Module 4: Credit management
- Module 5: Contracting

Training of field staff

Training of SARI and MoFA field staff on establishment and management of Integrated Soil Fertility Management (ISFM) demonstrations, extension communication, facilitation of Farmer

Field School, compost preparation and storage was carried out in Wa from 29th - 30th May 2013. A total of 20 field staff (18 males +2 females) were trained (14 from MoFA, 3 from SARI, 1 from NGOs + 2 casual hands). We mostly targeted field staff who did not attend such trainings in previous years.

Training areas included:

- Review of problems associated with quality and meaningful data collection in previous years
- Discussion of results of 2012 demos
- How to establish demos
- Data collection (agronomic, economic, soil etc)
- FFS facilitation
- Extension communication
- Compost preparation and use

Radio broadcasts on AGRA Soil Health Project and ISFM

Radio scripts were prepared and broadcasts in conjunction with MoFA on two local FM stations (Radio Progress in Wa and RADFORD radio in Tumu) during the cropping season. The programs centered on AGRA Soil Health Project and ISFM Technologies.

Review workshop

Review workshop was held on 7th and 8th March in Bolgatanga with MoFA, NGOs, FBOs and other stakeholders to evaluate project performance in each region during the 2012 season.

Results/Major Findings in 2013

- 31 demonstrations installed and managed by 28 FBOs established in 7 districts in the region
- 7 Farmer field schools (FFS) established;
- Three (3) grand field days organized with the participation of 204 farmers (155 males + 49 females)
- Four (4) exchange visits carried out with 300 farmers involved
- Six (6) radio broadcast were done on AGRA SHP and ISFM in Wa and Tumu
- Forty-three (43) FBOs trained
- 60 copies of FBO Training manuals distributed
- 300 farmers trained in ISFM in Farmer Field Schools
- About 350 farmers were directly involved in the demonstrations and 800 farmers were linked to the demonstrations through their households
- Participatory approaches were successfully introduced and used in implementation of project activities
- Twenty (20) AEAs trained - capacities of 20 AEAs increased in ISFM and FFS facilitation. Success of Demonstrations increased
- Capacities of 104 AEAs increased in extension methods
- Capacities of 107 AEAs increased in composting; 14 FBOs producing compost for use during the season

Conclusions/Recommendations

The experience gained in the implementation of this project in the region reveals that it may not be useful spreading project activities thinly to cover all districts as the first season has revealed that some districts lack the capacity to handle the demonstration mostly due to low staff strength that turns to overburden the few extension agents available in the district. The composite soil samples collected should be analysed as soon as possible in order to give an insight into the initial health of the soils used for the demonstrations. Economic analysis should be carried out by the socio-economic team on the grain yield data collected so far. There is the need to compile and combined data across sites and regions for statistical analyses so as to write scientific papers for publication in peer reviewed journals.

Acknowledgement

These trials were organized with funding from AGRA Soil Health Project. We are grateful to collaborators for running these demonstration trials and their invaluable contributions to this report. I am very grateful to be given the opportunity by the Project Manager, Dr. Mathias Fosu to coordinate the activities of the project in Upper West region. I truly enjoyed the team work with other project members including the regional coordinators of the project.

Commissioned Project on Strengthening Seed System Research and Development in West and Central Africa

Principal Investigator: I.D.K Atokple (CSIR-SARI)
Collaborating Scientists: S.S.J. Buah, Peter Asungre, Prince M. Etwire, Alhassan Lansah Abdulai, Afia Serwa Karikari
Estimated Duration: 2011-2013
Sponsors: AusAID/CSIRO-CORAF/WECARD
Location: Wa municipal, Sissala East and West as well as Lawra districts in UWR

Background Information and Justification

In the northern Guinea savanna of Ghana, low crop yields are common due to erratic rainfall, low soil nutrient levels, use of unimproved varieties and poor management practices. Maize is an important component of poultry and livestock feed and to a lesser extent, a substitute in the brewing industry. It is also is a major source of calories and cash income in Ghana, yet grain yield levels are low. Currently, the national average maize yield is estimated at 1.6 tons per hectare. Most maize in West and Central Africa is produced under low nitrogen (N) conditions because of low N status of tropical soils, low N use efficiency in drought-prone environments, high price ratios between fertilizer and grain, limited availability of fertilizer and low purchasing power of farmers. Maize and sorghum are either grown alone, in mixtures or rotation with legumes such as soybean, cowpea and groundnuts. In general, grain yields of cereals and legumes even of the improved varieties in the Guinea savanna zone of Ghana are far below the on-station yields probably due to management problems such as low plant populations, inappropriate planting time, inadequate control of weeds, pest and diseases and control of *Striga* as well as untimely application of adequate quantities of fertilizers.

Recent surveys carried out in northern Ghana revealed that declining soil fertility, erratic rainfall, preseason and terminal drought, pest and disease problems as well as unavailability of improved seed of crop varieties are the main agricultural production problems in the region. As low soil N is a major factor limiting cereal production, rotations with N-fixing legumes such as soybean, cowpea and groundnuts could supply some part of the nitrogen required for cereal crop growth and may minimize the depletion of soil of organic matter and the build-up of weeds, diseases, and insects. Other solutions for maintaining soil organic matter include crop residues and animal manure. Integration of grain legumes with maize or sorghum can provide additional protein in the diet which contributes to improved human nutrition. Although some improved varieties of various cereal and legume crops have recently been released, agronomic packages to optimize yield under different agro-ecologies in the Guinea savannah are not available. These studies were therefore conducted to address this problem.

As part of the Australian Government's Food Security and Rural Development Initiative to improve food security and agricultural production in West and Central Africa, the Australian Agency of International Development (AusAID) is supporting a multi-stakeholder agricultural research project through the AusAID/CSIRO-CORAF/WECARD partnership to improve agricultural research, technology dissemination and adoption to significantly increase productivity in the sub-region. The project is being implemented in Mali and Burkina Faso in the semi-arid zone as well as Ghana and Cameroon in the Sub-Humid zone. The implementation strategy of the CORAF/WECARD operational plan is aimed at making a significant contribution to agricultural growth and economic development in the sub-region. Therefore, the CSIR-SARI in collaboration with Ministry of Food and Agriculture (MoFA) initiated some *sub-projects in northern Ghana starting in 2012 as part of the CORAF project initiative.* This annual report covers experiments implemented by CSIR-SARI, Wa Station in 2013 and covers the period July to December, 2013.

Objectives

The objective of the sub-project was to evaluate the performance of high yielding varieties of maize, sorghum and cowpea with farmers in their own environment with the aim of finding adoptable varieties which are appropriate to their needs

Expected Beneficiaries

Direct beneficiaries: researchers, agricultural extension agents, seed producers and farmers.
Secondary beneficiaries: dependents of the farmers and researchers, brewery industry and NGOs.

Materials and Methods

Prior to the establishment of the on-farm trials, consultative meetings were held with the extension staff of MoFA in each of (Lawra, Sissala East and West) as well Wa municipality to agree on sites for the trials. Informal discussions were held in the communities and subsequently, volunteer farmers were selected in agreement with members of the communities to participate in the on-farm trials. The criteria used in the selection included: access to land, willingness to spare a portion of the farm for pure stand crop production, field location within the community and willingness to share experience with other farmers. Generally, the dominant means of livelihood in the communities is farming. Cereals (especially maize and sorghum) and grain legumes (mostly cowpea and groundnut) are the major crops grown in all the project communities.

The mother-baby on-farm testing approach has been widely adopted as a strategy for testing and promoting the release of improved varieties and/or technologies. It is a new approach consisting of a central researcher-managed “mother’ trial comprising all tested technologies and satellites or “baby’ trials, which are farmers managed and are a subset of technologies from the mother trial.

This approach was adopted for the on-farm testing of high yielding varieties of maize, sorghum, and cowpea confirmed in participatory on-farm trials in communities in three administrative districts in the Upper West region. One set mother trial managed by researchers, comprising three improved varieties of maize, sorghum and cowpea were planted in farmers’ fields under two fertility regimes during the 2013 growing seasons (June – October) at Chinchang, Silbelle, Kpongu and Lawra. The three improved varieties obtained from SARI were planted alongside a local check. The local checks for all crops were the best available varieties in the location, which however, differed among locations. The improved varieties for each crop were chosen on the basis of their superior performance in on-station and on-farm testing trials. A randomized complete block design (RBCD) with three replications per site was used for each crop in the mother trials. Recommended cultural practices were followed. The treatment design was a 2 x 4 factorial involving four varieties of each crop grown under two fertility levels. The fertility levels for maize and sorghum were recommended fertilizer rate (250 kg NPK + 125 kg Sulphate of ammonia) and a higher fertilizer rate (250 kg NPK + 250 kg Sulphate of ammonia). Plot size for maize and sorghum was 5 m x 4.5 m with rows spaced 75 cm apart. Each of three cowpea varieties was grown with or without 30 kg P_2O_5 /ha phosphorus fertilizer. Plot size for cowpea was 5 m x 3.6 m with rows spaced 60 cm apart. Intra-row spacing for sorghum and cowpea was 20 cm in all experiments with one seedling per stand, whereas distance between plants was 40 cm in maize trials with two seedlings per stand.

Satellite or baby trials were also conducted on farmers' fields at the four sites. Farmers’ fields near to mother sites were selected for each baby trial. For each crop, farmers evaluated one variety under the two fertility levels alongside their local varieties which were the best available variety at each evaluated site. However, the local checks differed among locations and farmers. Farmers managed all plots similarly. The varieties tested were essentially the same as those grown in the mother trial and each variety was tested by four farmers at each site. Each plot in the baby trials measured 20 m x 20m. Farmers evaluated the treatments at physiological maturity.

Sowing date of all experiments was from 13-19th July 2013. Weeds were controlled manually using a hand held hoe. For each crop, the grain was harvested at physiological maturity. Other measurements included days to flowering (days), plant height (m) and aboveground dry matter yield (biomass). For the mother trial, grain and aboveground dry matter yields were determined by harvesting the centre two rows of each subplot while an area of 5 m x 5 m or 10 m x 10 m was used for grain yield determination in the baby trials. Data collected were subjected to analysis of variance (ANOVA) to establish treatment and the interactions effect on grain yield and yield components. Main effects and all interactions were considered significant when $P \leq 0.05$.

Results/Major Findings in 2013

The farmers who evaluated the crop varieties were representative of maize, sorghum and cowpea producers in the respective locations. Most have a long tradition of cultivating these crops. In general, soils in northern Guinea savanna agro-ecology are inherently low in soil organic matter and available P. The soils are moderately acidic to strongly acidic suggesting that some fields in the region are more fragile due to degradation. This often reduces crop yield potential. In 2013, the variable weather affected seedling establishment, plant growth and development and ultimate grain yield at all locations. Prolonged pre-season drought delayed planting until mid-to-late July. However, there was excessive rainfall in August and September that coincided with the grain-filling period of the crops. The subsequent water-logging/flooding of fields coupled with high cloud cover may have significantly reduced grain yields of all crops. Despite the bad weather, mean grain yield from the maize mother trials were higher than the average grain yield of maize (1.7 t/ha) reported for the northern Guinea savanna of Ghana (SRID, MoFA). This higher yield may be due to the use of improved maize seed and recommended quantities of fertilizer. Moreover, the agricultural extension staff ensured that the farmers carried out timely crop management practices on the mother trials as these were researcher-managed.

Maize trials

Meaningful data were obtained from one mother trial and 12 baby trials at Chinchang near Tumu and 12 baby trials only at Kpongu. No data were obtained from Lawra because of prolonged preseason drought in this drier area. In both Chinchang and Kpongu, the interaction of variety x fertilizer rate was not statistically significant for any trait in both the mother and baby trials, therefore main effects of variety and fertilizer levels are reported and discussed in this report (Tables 31 through 33).

In the mother trial at Chinchang, the three improved maize varieties flowered (Table 31) earlier but they also produced lower dry matter compared with the farmer variety (local check). The farmer variety was the tallest and late maturing but this did not translate into higher grain production as expected probably because less biomass was partitioned to the grains. Differences among the varieties in terms of grain production were statistically significant with Aburohemaa producing the highest yield of 4187 kg/ha. The farmer variety had the least grain production.

On average, increasing fertilizer level beyond the recommended rate for maize did not result in significant increase in grain production for any variety. Similar results were obtained for the same treatments in 2012.

Table 31. Some agronomic traits of maize as affected by fertilizer levels in a mother trial at Chinchang near Tumu, Sissala West district, 2013.

Variety	DFA	DFS	Plant height	Grain yield
	day	Day	m	kg/ha
Aburohemaa	49	51	1.72	4187
Omankwa	49	51	1.64	3375
Abontem	49	51	1.77	3792
Farmer variety	55	59	1.97	2792
Lsd (0.05) ‡	1	1	0.17	945
Fertilizer rate (kg/ha)				
250 kg NPK + 125 SA	51	53	1.78	4948
250 kg NPK + 250 SA	51	53	1.76	5479
Lsd (0.05)	NS	NS	NS	NS
CV%	1.0	1.0	7.7	21.6

DFA=days to 50% anthesis; DFS=days to 50% silking; Harvest index = (Grain dry weight/total plant dry weight).
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

It is worthy of note that 12 baby trials were planted at Chinchang but only none were planted at Kpongu. No meaningful data were obtained at Lawra. In the baby trials at both Chinchang and Kpongu genotypic differences in terms of grain yields were statistically significant (Tables 32 and 33). Omankwa obtained the highest grain yield at Chinchang. Moreover it tended to produce more grain at Kpongu. The farmer varieties were taller and late maturing and probably accumulated more dry matter but this did not translate into higher grain production as expected probably because less biomass was partitioned to the grains as indicated by the low harvest index value at Chinchang (Table 32). Furthermore, because the farmer variety was taller, they were more prone to lodging than the improved varieties. Also increasing fertilizer rate beyond the recommended rate did not significantly influence grain yield of the maize varieties at Kpongu but this resulted in about 31% yield increase at Chinchang.

Table 32. Some agronomic traits of maize as affected by fertilizer levels in 12 baby trials at Chinchang near Tumu, Sissala East district, 2013.

Variety	DFA	DFS	Plant height	Grain yield	Harvest index
	day	Day	M	kg/ha	
Aburohemaa	50	51	1.85	3143	0.41
Omankwa	55	52	1.97	3896	0.51
Abontem	49	51	1.82	2920	0.46
Farmer variety	53	56	2.30	3034	0.31
Lsd (0.05) ‡	4	1	0.14	350	0.04

Fertilizer rate (kg/ha)					
250 kg NPK + 125 SA	50	53	1.97	2814	O.42
250 kg NPK + 250 SA	53	53	1.99	3683	0.45
Lsd (0.05)	NS	NS	NS	221	0.02
CV%	10.2	2.4	8.9	14.8	12.1

DFA=days to 50% anthesis; DFS=days to 50% silking; Harvest index = (Grain dry weight/total plant dry weight).
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

Table 33. Some agronomic traits of maize as affected by fertilizer levels in nine baby trials at Kpongu near Wa, Wa municipality, 2013.

Variety	DFA	DFS	Plant height	Grain yield
	Day	Day	m	kg/ha
Aburohemaa	49	54	1.97	1593
Omankwa	51	54	2.02	1954
Abontem	49	54	1.90	1527
Farmer variety	54	59	2.31	1832
Lsd (0.05) ‡	1	2	0.27	365
Fertilizer rate (kg/ha)				
250 kg NPK + 125 SA	50	55	1.97	1621
250 kg NPK + 250 SA	50	55	1.99	1831
Lsd (0.05)	NS	NS	NS	NS
CV%	2.5	2.5	11.6	19.1

DFA=days to 50% anthesis; DFS=days to 50% silking; Harvest index = (Grain dry weight/total plant dry weight).
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively.

Sorghum trials

Meaningful data were obtained from only 6 baby trials at Chinchang. No data were obtained from Kpongu and Lawra because farmers failed to plant these experiments. Over the years the collaborating farmers have not been keen in growing the improved varieties of sorghum being introduced because of heavy bird damage due to the sugary nature of the grains coupled with grain quality problems associated with these varieties. Farmers need to be sensitized further as Kapaala and Dorado are suitable for breeding larger beer and therefore have an assured market because the brewery is interested in buying the grain of these varieties. Nonetheless, in this trial, the interaction of variety x fertilizer rate interactions were not statistically significant for any trait, therefore main effects of variety and fertilizer levels are reported (Table 34). The farmer variety which was essentially Kadaga recycled over several seasons was the tallest (>2.5 m) and took a longer time to flower. Dorado and Kapaala had higher but similar yields and they also produced significantly more grain than the farmer variety. The farmer variety tended to have a lower harvest index and more panicles which were however lighter in weight. It appears panicle weight had a greater influenced on grain yield than panicle number. On average, grain yield was increased by about 39 % (543 kg/ha more grain) when the fertilizer rate was increased beyond the recommended rate.

Table 34. Some agronomic traits of sorghum as affected by fertilizer levels in baby trials at Chinchang near Tumu, Sissala East district, 2013.

Variety	DFF	Plant height	Grain yield	Biomass	Harvest index
	day	m	kg/ha	kg/ha	
Dorado	64	1.31	1773	2597	0.40
Kapaala	67	1.81	1780	1748	0.50
Farmer variety	78	2.63	1395	2156	0.39
Lsd (0.05) ‡	1	0.40	301	220	0.06
Fertilizer rate (kg/ha)					
250 kg NPK + 125 SA	69	1.89	1378	2016	0.41
250 kg NPK + 250 SA	69	1.94	1921	2318	0.45
Lsd (0.05)	NS	NS	233	170	0.01
CV%	1.0	16.9	17.2	9.1	13.3

DFF=days to 50% flowering;
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively

Cowpea trials

Meaningful data were obtained from one mother trial and twelve baby trials at Chinchang. There were no significant differences among the treatments at Kpongu, therefore the data are not shown. At Chinchang, the interaction of variety x fertilizer rate interactions were not statistically significant for any trait in the mother and baby trials, therefore main effects of variety and fertilizer levels are reported (Tables 35 and 36).

Average grain yields at all the locations were generally lower than expected. In the mother trial at Chinchang, Sogotra was the tallest while the farmer variety was the shortest (Table 35). In addition, Sogotra had heavier pods that the rest of the varieties. The farmer variety produced numerically, least number of pods. Songotra produced the highest grain yield but the yields of the other two improved varieties were similar to that of the farmer variety. Grain yield was more associated with pod weight (r=0.67) and pod number (r = 0.66). Fertilizer P addition did not significantly influence grain production of any variety (Table 35).

In the baby trials at Chinchang, all the improved varieties produced more grain than the farmer variety (Table 36). However, Apagbaala produced about 58% more grain than the farmer variety. Moreover Songotra and Padituya were taller than Apagbaala and the farmer variety. Padituya and Songotra produced numerically more pods which were nonetheless heavier than those of the farmer variety. and which were also heavier resulted in significant increase (451%) in grain production at this location. Fertilizer P addition resulted in significant increase

(41%) in grain production at this location. Grain yield was associated with pod weight (r=0.79) and pod number (r = 0.64).

Table 35. Some agronomic traits of cowpea as affected by fertilizer P in Mother trial at Chinchang near Tumu, Sissala West district, 2013.

Variety	DFF	Plant height	Pods/ha	Pod weight	Grain yield
	Days	cm	no	kg/ha	kg/ha
Apagbaala	42	50.8	7557	1141	644
Padituya	41	64.0	7556	1133	686
Songotra	42	66.8	9481	1659	941
Farmer variety	40	49.5	6444	1237	570
Lsd (0.05) ‡	1	1.2	431	282	198
Fertilizer P rate (kg/ha)					
0 P	41	57.0	7630	1256	644
30 P	41	58.6	7889	1320	778
Lsd (0.05)	NS	0.8	NS	NS	
CV%	1.2	1.6	4.5	17.6	22.5

DFF=days to 50% flowering;
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively

Table 36. Some agronomic traits of cowpea as affected by fertilizer P in baby trials at Chinchang near Tumu, Sissala West district, 2013.

Variety	DFF	Plant height	Pods/ha	Pod weight	Grain yield
	Days	cm	no	kg/ha	kg/ha
Apagbaala	43	50.5	6700	1440	1010
Padituya	40	64.7	6850	1665	900
Songotra	42	65.3	7933	1647	953
Farmer variety	40	51.4	5983	1235	641
Lsd (0.05) ‡	1	1.7	286	248	143
Fertilizer P rate (kg/ha)					
0 P	41	57.5	6617	1292	727
30 P	41	58.4	7117	1702	1025
Lsd (0.05)	NS	0.5	181	157	90
CV%	1.2	3.3	4.7	19.0	19.3

DFF=days to 50% flowering;
‡*, **, and NS = significant at 5 and 1% probability levels and not significant, respectively

Innovation platform

An innovation platform was also formed in Sissala east district in 2013 to link various actors along the maize, sorghum and cowpea value chains. The actors included tractor owners, Agro-input dealers, producers, retailers and processors. The main purpose of the innovation system linkages is knowledge sharing through interactions, which would lead to learning resulting in development and deployment of new products and processes which ultimately contribute to social and economic change. Important for the innovation system is how patterns of relationships, habits and practices of actors either nurture or hinder knowledge flows, sharing and process of learning (learning by doing or by interacting) amongst them. 'Social capital', that is, the ability to form relationships of cooperation, is a key ingredient of effective innovation systems.

Field day

A field day was held on 24th October 2013 at Chinchang in the Sissala West district in collaboration with the extension service of MoFA in order to facilitate the dissemination of the various technologies to farmers. The field day also allowed non-participating farmers to assess the new varieties and/or technologies using their own criteria. In attendance were 96 farmers (69 males + 27 females) from four communities (Silbelle, Sorbelle, Chinchang and Tumu) who evaluated the various crop varieties and regarded them very positively. This event was covered by the community radio station in Tumu (RADFORD Radio). Several of the farmers who attended the field day have a long tradition of cultivating the various crops. During the field days, participants saw the improved varieties of the various crops being offered and received information on their performance in the field. Farmers valued many characteristics in the new crop varieties, especially traits related to consumption. All the improved varieties were considered to be better than the local checks (farmers' varieties). The field day drew much attention and participation from farmers and the voting exercise suggested that farmers were happy with the response of cowpea and groundnut to fertilizer P. Farmers who participated in the baby trials of cowpea and groundnut testified that cowpea and groundnut pants that received fertilizer P performed better than those that did not receive the fertilizer even under their circumstances. They therefore expressed interest in applying fertilizer P to their legumes and wondered where they could purchase P fertilizers, more especially when the two most popular P fertilizers in Ghana (triple superphosphate, TSP and single superphosphate, SSP) are both not covered by the current Government subsidy on fertilizers. Generally, farmers perceived that limited availability of fertilizers coupled with poor access to quality seed are the most binding constraints to adopting appropriate nutrient management for crop production in northern Ghana.

Conclusion and recommendation

The experiments were initiated in 2012. Consequently crop responses to fertilizer application were measured in two seasons. The results of both the mother and baby trials suggested that many of the improved varieties evaluated in this study performed similarly as or better than the best available local varieties in the various locations under rainfed conditions. This was not surprising as there are no true "farmers' local varieties" in all the control plots. All the varieties provided by the farmers were either second-generation varieties previously bought from seed companies or supplied by other development organizations over the past years. Thus the term "farmer varieties" should be used with caution since there is widespread use of improved varieties in Ghana due to the activities of the national agricultural research and extension systems. Maize was the two major cereal crop in the selected communities because its production is largely motivated by market considerations to generate income to farmers.

The project allowed farmers to gain access to the diversity of crop varieties. The variation in P supply affected both growth and development of cowpea plants and low P stress mostly reduced crop growth and grain yield significantly. Consequently the application of fertilizer P would increase cowpea grain yield and sustain soil fertility in the Guinea savanna zone. The practice will ensure food security, reduce nutrient mining and environmental degradation. The objectives of the experiment have not been fully met yet. Moreover, the soils collected from these sites are yet to be analyzed and the data will help further explain the responses observed in the study. It is therefore recommended that the studies should continue for one or two more seasons. This will allow for collection of more data to reliably document the following:

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 unimproved varieties and poor management practices. Research has shown that adoption of improved varieties by small holder farmers is low. Reasons attributed to these among others, are that iimproved 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, PVS exercise was initiated using the Mother and Baby trial approach in the Polee community in the Wa West district, UWR. This was repeated in 2013. 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 trials. The farmers were trained and 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. In addition, MoFA staff and FBOs representatives were trained in the PVS methodology as well as Participatory Learning Action Research (PLAR) procedure before the start of the season. 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.

Results/Major Findings in 2013

In 2012, farmers in Polee cultivated about 30 ha of rice and 34 ha in the 2012 cropping season using improved varieties from 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. A total of 21 farmers (13M + 8F) selected Exbaika 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 application 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

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. There has been a spill-over effect where non-project farmers purchased seed of the improved varieties, particularly Gbewaa rice and planted on their own in 2013. In 2014 Mother and Baby trials will be repeated to increase the reliability of results and to confirm previous results. More communities in the other three project districts in the region will be involved in the process.

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ENTOMOLOGY

Development of control strategy for termite infestation in the field

Principal Investigator: S.S. Seini
Collaborating Scientists: J.B. Naab, Saaka Buah, Yahaya Iddrisu
Estimated Duration: Three (3) years
Sponsors: CIDA
Location: On-station

Background information and Justification

Many farmers in the Upper West Region of Ghana have reported termite damage to their field crops. The importance and seriousness of the attack came to the fore when termite attack ranked highly as a priority problem to farmers in the region during recent RELC planning sessions.

Many laboratory bioassays have demonstrated the efficacy of plant extracts on termites Extracts such as those of neem have been found to be effective against termites on cassava-maize intercrops (Umeh et al., 2001). Since plant extracts are less hazardous, it is appropriate to harness the insecticidal activity for the control of termites in field crops. The current proposal therefore seeks to survey damage and estimate crop losses due to termites in the Upper West Region of Ghana and develop effective termite control measures in the region.

Objectives

The main objective of this proposal is to develop effective and sustainable control for termite in field crops. Specific objectives are:

a) To estimate the levels of incidence, abundance, severity and diversity of termite species in the project area.
b) To document range of crops mostly destroyed
c) To estimate losses due to termites in affected crops
d) To evaluate neem and Jatropha for termite control in field crops.

Expected Beneficiaries

The results of this study is expexted to benefit all manner of crop farmers especially rural resource-poor farmers.

Materials and Methodology

Survey of farmers' fields

Farm surveys were conducted in each of nine districts of the Upper West Region at a time crops were well-established in the field. Special emphasis was placed on termite hot-spots, reports of which were obtained in collaboration with Agricultural Extension Agents (AEAs) of Ministry of Food and Agriculture in the region. The incidence of termites was assessed by noting the presence or absence of termites in any farm visited. Information was recorded about the range of crops mostly attacked. Crop losses were evaluated by counting the number of plant stands destroyed by termites and calculated as a percentage of total plant stands. Samples of termite were collected from all farms in which they were present, for subsequent identification.

On-station termite control trials
The study was conducted on-station trials at SARI research fields at Boli, Yibile, Dinansu and Kpongu in the Upper West Region of Ghana, where termites have been regularly reported to destroy crops. The trials involved two crops, maize and groundnuts.

For the groundnut trial, experimental lay out was randomized complete design and treatments replicated six times. Each plot consisted of six rows 5m long with spacing of 0.4m between rows and 0.1m between plants in a row. The groundnut variety Chinese was used. Treatments consisted of neem seed extract applied at 10% (w/v) concentration at pegging stage of the crop. Untreated control and plots treated with lambda cyhalothrin were included as checks. Crop losses were evaluated by counting the number of plant stands destroyed by termites and calculated as a percentage of total plant stands.

For the maize trial, experimental lay out was randomized complete design and treatments replicated six times. Each plot consisted of six rows 5m long with spacing of 0.75m between rows and 0.4m between plants in a row with 2 plants /hill. The maize variety Obatampa was used. Treatments consisted of neem seed extract applied at 10% (w/v) concentration at planting. Untreated control and plots treated with lambda cyhalothrin included as checks. Crop losses were evaluated by counting the number of plant stands destroyed by termites and calculated as a percentage of total plant stands.

Results / Major Findings

a. Scientific findings

- A survey of crop fields during the season indicated that termites are present in all districts of the Upper West Region. The major crop affected is maize in which damage levels range between 5 and 65%. Other crops affected to a lesser degree are millet, sorghum, groundnuts, yam and cassava with damage levels of up to 13%.

- Across the survey area two genera of termites were encountered viz: *Macrotermes bellicocus* which build large spectacular mounds and whose presence is generally obvious, and *Odontotermes badius* which occur in the ground and build smaller mounds.

- In the on-station trials, maize stalk damage due to cut down by termites was generally between 20 – 50 % in the untreated control plots. Treatments with Jatropha and Neem seed powder reduced maize stalk damage significantly to between 2.0 – 25%, a reduction of about 50% ($P < 0.05$).

- Comparing the maize yield in all treated plots there was no significant difference between the neem and Jatropha treated plots ($P>0.05$). The control plots in general recorded between 600 – 800kg/ha of maize grain yield. This was lower than that of the treated plots which recorded between 900 – 1500 kg/ha maize grain yield.(P>0.05) From these results yield loss due to termites in maize is estimated to be about 34%.

Conclusions/Recommendations

Jatropha seed powder has consistently shown the potential to protect maize against termite damage in the field. This compares favourably to similar protection offered by neem.

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Development of control strategies for pests and diseases of harvested groundnuts left on the field and in storage barns

Principal Investigator: S.S. Seini
Collaborating Scientists: J.B. Naab, Saaka Buah, Yahaya Iddrisu
Estimated Duration: Three (3) years
Sponsors: CIDA
Location: On-station

Background and Justification

Groundnut is a major food and cash crop in Ghana, especially in northern Ghana which accounts for 92% of national groundnut production (SRID, 2004). However, average yields of 840 kg/ha obtained on farmers' fields in Ghana are low compared to 2500 kg/ha reported in developed countries such as the United States (FAO, 2002). Relatively low groundnut yield in Ghana and other parts of West Africa is attributed largely to the deleterious effects of soil arthropod pests, soil and foliar disease, nematodes and weed interference (Kishore, 2005; Umeh, 2001). Yield loss from termites ranges from 21 to 50% in West Africa (Johnson et al., 1981; Umeh et al., 1999). Infestation by these pests predisposes pods to attack by disease causing organisms such as the carcinogenic fungus *Aspergillus flavus* (Link) (Lynch et al., 1990; Waliyar et al., 1994)

Many farmers in the Upper West Region of Ghana have reported sighting unfamiliar field insect pests which infest harvested pods. These reports were made more serious when during recent RELC district planning sessions, all districts reported that apart from these field pests, some other pests also attack groundnuts in storage. The pests suck out valuable oil from kennel leading to shriveling of grain. The kennels are rendered bitter making them unsuitable for consumption.

Many laboratory bioassays have demonstrated the efficacy of plant extracts on termites and other arthropod pests of groundnut in the field and in storages (Umeh et al., 2001 and field pests.

The current proposal therefore seeks to survey farm stores to estimate losses in groundnut yield due to field pests in the Upper West Region of Ghana and develop effective control measures for them.

Objectives

The main objective of this proposal is to develop effective and sustainable control for groundnut field and storage pests. Specific objectives are:

a) To estimate the incidence, abundance, severity and diversity of groundnut field pests in the project area.
b) To estimate losses in groundnut yield due to field pests
c) To estimate losses in stored groundnuts due to storage pests
d) To evaluate neem and Jatropha for control of groundnut field and storage pests.

Expected Beneficiaries

The results of this study is expected to benefit all groundnut farmers in Northern Ghana, especially rural resource-poor farmers.

Materials and Methodology:

Survey of farmers' fields

A survey of groundnut storage structures were conducted in each of nine districts of the Upper West Region. Special emphasis was placed on groundnut storage pest hot-spots, reports of which were obtained in collaboration with Agricultural Extension Agents (AEAs) of Ministry of Food and Agriculture in the region. Three farm stores were visited in each district of the region. The incidence of groundnut storage pests were assessed by noting the presence or absence of storage pests in any store visited. Losses in groundnut weight and quality were assessed. Insect samples were collected for identification.

On-station groundnut pest control trials

The study was conducted on-station at SARI research fields at Boli, Yibile, Dinansu and Kpongu in the Upper West Region of Ghana, where groundnut field pests have been regularly reported to destroy crops. Experimental lay out was randomized complete design and treatments replicated six times. Each plot consisted of six rows 5m long with spacing of 0.4m between rows and 0.1m between plants in a row. The groundnut variety Chinese was used. Treatments consisted of neem and Jatropha seed extracts applied at 10% (w/v) concentration at planting or pegging stage of the crop. Untreated control and plots treated with lambda cyhalothrin were included as checks. Crop losses were be evaluated by counting the number of groundnut pods damaged by field pests and calculated as a percentage of total pod yields.

Groundnut storage studies
Storage studies were conducted to investigate the ability of neem and Jatropha seed extracts to protect stored groundnut from insect pest attack. Groundnut variety Chinese was used. Treatments consisted of neem and Jatropha seed extracts applied at 10% (w/v) concentration. Untreated control and groundnut samples treated with lambda cyhalothrin were included as checks. Grain weight losses were evaluated after six months of storage. Each sample initially weighed 1.0kg.

Results / Major Findings
a. Scientific Findings

- During survey of groundnut farm stores the groundnut pod borer, *Caryedon serratus* was found to attack unshelled groundnuts causing an estimated 20% loss in grain weight in the most seriously infested stores. *Caryedon serratus* was present in 55% of farm stores inspected.

- In the on-station trials, groundnut pod damage due to soil arthropods was generally between 6 – 12 % in the untreated control plots. Treatments with Jatropha and Neem seed powder reduced groundnut pod damage significantly to between 1.0 – 3.5%, a reduction of about 65% ($P < 0.05$).

- Comparing the fresh pod yield in all treated plots there was no significant difference between the neem and Jatropha treated plots ($P>0.05$). The control plots in general recorded between 650 – 850kg/ha of fresh pod yield. This was lower than that of the treated plots which recorded between 920 – 1250 kg/ha fresh pod yield ($P>0.05$) From these results yield loss due to soil arthropods in groundnuts is estimated to be about 28%.

- In the storage trials Jatropha and Neem seed extracts were able to protect stored groundnut pods from insect damage for about 3 months which is half of the storage period. The check protectant, lambda cyhalothrin offered good protection for about 3 months. At the end of the experimental period of six months, the control lots suffered more damage to groundnut pods than the treated lots ($P>0.05$). The estimated weight loss in groundnuts in the control was 16%; that in the chlorpyrifos lot was 4.5% and that in the seed extract lots was 8.2%.

- Jatropha seed extract has the ability, just as in neem to protect stored groundnuts against storage pests. It can be postulated that two treatments with Jatropha seed extract at 2 to 3 month intervals can offer enough protection for a storage period of six months.

Conclusions/Recommendations
Jatropha seed powder has the potential to protect groundnuts against soil pest damage in the field. This compares favourably with similar protection offered by neem.

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