COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

2010 ANNUAL REPORT

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 and Technology. 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 fibre 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. Altitude is 200 m above sea level.

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2010 ANNUAL REPORT

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Tamale, GHANA

Savanna Agricultural Research Institute

(SARI)

2010 Annual Report

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TABLE OF CONTENT

Forward

The importance of access to agricultural technologies by our farmers continued to be a subject of much discussion during 2010. The key role that agricultural technologies play in improving productivity for farmers and the great impact that adoption of these technologies can make to livelihoods is recognised at the highest national level. Similarly, the many constraints to productivity and difficulties that affect farmers' access to appropriate technologies have been identified and various suggestions made. As these discussions continue, the challenge of feeding 24.4 million people in Ghana continues to be a cause for concern and severe challenges such as climate change emerge to complicate matters.

With a mandate to provide farmers in the Northern, Upper East and Upper West Regions with appropriate technologies to increase their food and fibre crop production based on a sustainable production system which maintains and/or increases soil fertility, SARI and its partners made good progress during 2010 that we are happy to share with you. These are captured under Scientific Support Group, Northern Region Farming Systems Research Group, Upper West Region Farming Systems Research Group and Upper East Region Farming Systems Research Group.

Nevertheless, work on the Emergency Rice Initiative Project under the auspices of USAID improved farmers' access to quality rice seed and fertilizer and expanded knowledge on best-bet rice technologies. The project reached out to 12,635 farmers in 27 districts in the three northern regions and increased paddy production by 28,663 tons. These farmers gained access to best-bet rice technologies through on-the-job training and videos on rice technologies. Rural radio and TV broadcasts on these technologies were also used to reach other farmers not directly involved in the project. Translation of rice technologies into 7 major languages namely Dagbani, Kusal, Dagaari, Gonja, Kassin, Sissali and Buli was one of the major achievements chalked by the project.

I am glad to report that SARI continued expanding its partnerships and collaborations so as to comprehensively and holistically address farmer constraints in Northern Ghana. SARI worked with partners 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.

Work on the installation of the facility for confined field trial on developing a *Maruca*-resistant cowpea had made significant progress with a favourable regulatory decision by the National Biosafety Committee to permit SARI to conduct the first CFT in 2013.

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

Looking back, 2010 was a good year for SARI and on behalf of the Management Board, I would like to most sincerely thank all SARI partners, donors, staff and Board members for their support and commitment to the fulfillment of the SARI vision and mission.

Dr. Stephen K. Nutsugah

Director

ADMINISTRATION

Management

The Institute is managed by a 7-member Management Board, chaired by the Mr. Alhassan Andani, MD of Stanbic Bank, and a 16-member Internal Management Committee (IMC), chaired by the Acting Director. Membership of the Management Board and IMC are presented below:

Membership of CSIR-SARI Management Board

No.	Name	Designation
1	Mr. AlhassanAndani	MD, Stanbic Bank, Chairman
2	Dr. (Mrs.) Rose Emma Mamaa Entsua-Mensah	Deputy Director-General, R&D
3	Dr. N. Karbo	Cognate Director, CSIR-ARI
4	Dr. S. K. Nutsugah	Director, CSIR-SARI
5	Mr. Mumuni Alhassan	Private Sector
6	Mr. Roy Ayariga	MoFA
7	Alhaji Nashiru Kadri	Private Farmer

Staff Strength

Staff strength as at the end of 2010 stood at 435. However, by the end of the year the number had decreased to 406 comprising of 39 Senior members, 87 senior staff and 280 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 at Manga and Wa have a staff total of 52 and 46 respectively. With Manga having 5 Senior members, 8 senior staff and 39 junior staff while Wa has 5 senior members, 11 senior staff and 30 junior staff.

Table 1. Promotions, appointments and deaths

	Senior Research	Senior Members	Senior Staff	Junior Staff	Total
Promotion	-	-	3	8	11
Appointment	-	-	14	-	14
Consideration	-	-	3	-	3
Retirement	-	-	-	-	15
Death	-	-	-	12	12
Total	-	-	20	20	??

Human Resource Development

The Human Resource Development Committee has received approval for thirteen staff both local and foreign who qualified for training for 2010/11 academic year.

No	Name	Course	Finish	*Place
1	Salifu Abdul-Wahab	PhD	2012	Univ. of Florida, USA
2	William Atakora	MSc	2012	KNUST, Kumasi
3	Abubakari Mumuni	BSc	2012	IPS, Accra
4	Abihiba Zulai	BSc	2012	IPS, Accra
5	Francisca Abaah	BSc	2012	UEW, Kumasi
6	Yahaya Inusah	MSc	2012	KNUST, Kumasi
7	Kambe John Baptist	HND	2013	Tamale Poly
8	Thomas Coker-Awortwi	EMBA	2011	KNUST, Kumasi
9	Ibrahim Hashim	BSc	2012	UCC
10	Joseph Adjabeng Dankwa	PhD	2014	Univ of Ghana, Legon
11	Mahama George Yakubu	MSc	2011	Kansas State Univ, USA
12	Tahiru Fulera	MSc	2012	Univ of Bonn, Germany
13	Alidu Issah	MSc	2010	Tuskegee Univ, USA

Table 3. Staff back from training

Name	Grade	Programme
Kwabena Acherimu	Asst Res Scientist	MSc
Abubakri Mutari	Asst Res Scientist	MSc
Mohammed Haruna	Asst Res Scientist	MSc
Alhassan Sayibu	STO	BSc
Peter Asungre	STO	BSc
Paul Berko	Chief Acct Asst	BSc

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

National Service

Nine 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	1
Domongo Agric College	2
UCC	1
University for Development Studies	5
Total	**9**

Membership of CSIR-SARI Internal Management Committee

No.	Name	Designation
1	Dr. Stephen K. Nutsugah	Director (Chairman)
2	Dr. Stephen K. Asante	Deputy Director
3	Dr. James M. Kombiok	Head, Northern Region Farming Systems Research Group
4	Dr. Roger A. L. Kanton	Head, Upper East Region Farming Systems Research Group
5	Dr. Jesse B. Naab	Head, Upper West Region Farming Systems Research Group
6	Dr. Ibrahim D. K. Atokple	Head, Scientific Support Group
7	Dr. Benjamin D. K. Ahiabor	Representative, Research Staff Association
8	Mr. Mohammed Dawuni	Representative, Senior Staff Association
9	Mr. Mahama Tibow	Representative, Local Union
10	Mr. Thomas K. Coker-Awortwi	Head, Accounts
11	Mr. P. D. K. Opoku	Internal Audit
12	Mr. Joseph S. Bapule	Representative, Commercialization and Information Division
13	Mr. Robert K. Owusu	Scientific Secretary, Recorder
14	Mr. Robert C. A. Adongo	Workshop Manager
15	Mr. Richard Y. Alhassan	Farm Manager
16	Mr. M. Adul-Razak	Head, Administration

Staff Distribution Among Divisions

Division	Senior Members	Senior Staff	Junior Staff	Total
Northern Region Farming Systems Research Group	7	9	50	66
Upper East Region Farming Systems Research Group	5	8	39	52
Upper West Region Farming Systems Research Group	5	11	30	46
Scientific Support Group	17	31	59	107
Commercialization and Information Division • Documentation • Library	3	5 1	3 1	11 2
Accounts	1	9	6	16

Administration Division • Personnel • Transport/Workshop • Farm Management • Estate • Security	1	13	92	106
Total	**39**	**88**	**281**	**406**

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
M. Abdul-Razak	BA MBA	Political Science Strategic Management	Administrative Officer
Accounts			
T. K. Coker-Awortwi	BEd (Accounts Option)	Accounting	Assistant Accountant
*Paul Berko	ICA (Inter), BSc	Accounting	Chief Accounting Assistant
R. S. A. Adongo	RSA III	Accounting	Senior Accounting Assistant
N. K. Abass	HND	Accounting	Senior Accounting Assistant
A. K. Alhassan	BSc Accounting & Finance	Accounting	Principal Accounting Assistant
Bawa Ford	HND	Accounting	Principal Accounting Assistant
S. F. Farouk	HND	Accounting	Principal Accounting Assistant

Issah Issifu	Dpl Com	Accounting	Senior Accounting Assistant
Sebastian Tigbee	RSA III	Accounting	Senior Accounting Assistant
Mahama A. Rufai	HND	Accounting	Principal Accounting Assistant
ZulaiAbihiba	DBS	Accounting	Senior Storekeeper
Kofi Konadu	HND	Accounting	Senior Accounting Assistant
Farm Management			
R.Y. Alhassan	Dpl	Horticulture	Chief Technical Officer
Workshop			
R. C. A. Adongo	MVT	Part I & II	Principal Works Superintendent
I. K. Acquah	Certificate	NVTI	Principal Works Superintendent
A. Y. Ndinyah	MVT	Part I & II	Principal Works Superintendent
Patrick Apullah	City and Guilds	Carpentry and Joinery Art	Senior Works Superintendent
A. Owusu	MVT	Part I & II	Works Superintendent

Upper East Farming Systems Research Group

Name	**Qualification**	**Area of Specialisation**	**Rank**
R. A. L. Kanton	MSc PhD	Agronomy	Senior Research Scientist
E. Y. Ansoba	Certificate	Agriculture	Technical Officer
*F. Kusi	MSc	Entomology	Assistant Research Scientist
*SalifuWahab	BSc	Agric Economics	Assistant Research Scientist
Peter A. Asungre	BSc	Agric Engineering	Technical Officer
Zakaria Muntaru	Diploma	General Agriculture	Technical Officer

Northern Region Farming Systems Research Group

Name	Qualification	Area of Specialisation	Designation
Wilson Dogbe	MSc PhD	Agronomy Soil Microbiology	Senior Research Scientist
J. M. Kombiok	BSc MSc PhD	Agriculture Agronomy Agronomy	Senior Research Scientist
Mumuni Abudulai	BSc MSc PhD	Agriculture Agricultural Entomology Agricultural Entomology	Senior Research Scientist
**Osman K. Gyasi	BSc MSc PhD	Agriculture Agricultural Economics Agricultural Economics	Research Scientist
Baba Inusah	MSc	Irrigation Agronomy	Research Scientist
A. N. Wiredu	BSc MSc	Agriculture Agricultural Economics	Research Scientist
M. Mawunya	BSc	Agriculture	Assist Research Scientist
D. Y. Opare-Atakora	BSc	Agriculture	Assist Research Scientist
Sulemana Daana Alhassan	Diploma	General Agriculture	Technical Officer
E. O. Krofa	Diploma	General Agriculture	Technical Officer
Mahama Alidu	HND	Horticulture	Principal Technical Officer
IddrisuSumani	Diploma	General Agriculture	Chief Technical Officer

Upper West Farming Systems Research Group

Name	Qualification	Area of Specialisation	Rank
J. B. Naab	BSc PhD	Soil Science Soil Physics	Research Scientist
S. Saaka Buah	BSc MSc PhD	Agriculture Agronomy Soil Fertility & Plant Nutrition	Research Scientist
S. S. Seini	BSc MPhil	Agriculture Agricultural Entomology	Research Scientist
George Mahama	BSc	Agriculture	Ass Res Scientist
Asieku Yahaya	BEd	Agricultural Science	Ass Res Scientist
Nyour Anslem	HND	Agriculture Engineering	Technical Officer
Alhassan Nuhu Jimbaani	HND	Agriculture Engineering	Technical Officer

Scientific Support Group

Name	Qualification	Area of Specialisation	Designation
S. K. Asante	BSc MSc PhD	Agriculture Plant Protection Agricultural Entomology	Principal Research Scientist
I. D. K. Atokple	BSc Dip Ed MSc PhD	Agriculture Education 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	Senior Research Scientist
N. N. Denwar	BSc	Agriculture	Research Scientist

	MPhil	Plant Breeding	
B. D. K. Ahiabor	BSc MSc PhD	Agriculture Plant Physiologist Mycorrhizology	Research Scientist
A. A. Abunyewa	BSc Dip Ed Mphil PhD	Agriculture Education Soil Chemistry Soil Chemistry	Senior Research Scientist
N. Tabi Amponsah	BSc MSc	Agriculture Nematology	Research Scientist
J. Adjebeng-Danquah	BSc MSc	Agriculture Plant Breeding	Research Scientist
FuleraTahiru	BSc	Agriculture	Asst Research Scientist
George Oduro	Certificate	General Agriculture	Principal Tech Officer
N. A. Issahaku	Certificate HND	General Agriculture Agriculture	Senior Tech. Officer
H. Mohammed	HND BSc	General Agriculture	Principal Tech. Officer
A. L. Abdulai	BSc MSc	Agriculture Agrometeorology	Research Scientist
Ester Wahaga	BA	Sociology	Ass Res Scientist
A. S. Alhassan	Diploma	General Agriculture	Principal Tech. Officer
A. Mohammed	Certificate	General Agriculture	Senior Tech. Officer
F. A. Adua	HND	Horticulture	Principal Tech Officer
M. M. Askia	BSc MPhil	Chemistry	Asst. Research Scientist
K. Acheremu	BSc	Agriculture	Asst. Research Scientist
A. A. Issah	BSc	Agriculture	Asst. Research Scientist
Abukari Saibu	Diploma	Agriculture	Senior Tech. Officer
Abubakari Mutari	BSc	Agriculture	Asst Research Scientist

B. D. Alhassan	BSc Technology	Agriculture	Principal Technical Officer
E. Atsu	Diploma	Farm Mechanization	Chief Technical Officer
William Atakora	BSc	Agriculture	Technologist

Business Development and Information Unit

Name	Qualifi-cation	Area of Specialisation	Rank
J. S. Bapule	BA MA	Economics/ Sociology Development Economics	Senior Commercial Manager
R. K. Owusu	BSc MSc	Agricultural Mechanisation Postharvest & Food Preservation Engineering	Scientific Secretary
Musah Iddi	Technician III Certificate	Radio, Television & Electronics Radio, Television & Electronics	Principal Superintendent
Mumuni Abukari	HND	Marketing	Marketing Asst
Warihanatu Baako (Miss)	HND	Marketing	Marketing Asst

COMMERCIALISATION

Introduction

SARI has through her collaborative research activities developed crop varieties to suit the ecology and the demands of farmers in her mandate area. These varieties are high-yielding, drought-tolerant, disease-resistant and satisfy different maturity periods – that is, short, medium and long – term. A number of SARI's crop varieties are also very good for use as industrial raw material. Very little marketing activities were undertaken to promote these technologies. It was when the new CSIR Act (CSIR Act 521, 1996) was passed that attempts were made to promote the institutes and their technologies through a process known as research commercialization.

The principal focus of the institute's Commercialization and Information Division (CID) is to market the institute and her technologies. In this regard the under-listed functions have been defined for the division.

i) Identify technologies and services that can be commercialized
ii) Determine the cost of technologies and services
iii) Promote available technologies and services
iv) Sensitize the institute on technologies and services that can be commercialized
v) Negotiate for the sale of technologies and services on behalf of the institutes

The team executing the institute's commercialization mandate is made up of the following officers:

i)	Mr. J. K. Bidzakin	-	Ag. Head, CID
ii)	Mr. Robert Owusu	-	Scientific Secretary
iii)	Mr. Abukari Mumuni	-	Snr. Marketing Assistant
iv)	Miss Baako Warihana	-	Snr. Marketing Assistant
v)	Mr. Alhassan B. Yamyoliya	-	Marketing Assistant

Technologies Identified For Commercialization

- Improved Crop Varieties
- Crop an Soil Management Practices
- Soil Fertility Management
- Insect Pest Control
- Soil and Plant Analysis
- Agrometeorological data generation

Income Generating Activities

Through the promotional and marketing activities of the division the institute derives her income from the following sources:

- Soil and plant analysis
- Agromet data generation
- Contract Work (NAFCO)
- Tractor services/farm management
- Combine harvester services
- Guest House services
- Photocopying and documentation services
- Workshop – vehicle hiring services
- Rice processing services
- Conference services

Table of income generated in 2010 and reported on in 2011

Source of Revenue	Gross Income	Expenses	Net Income
Guest House Services	2,506.00	2,331.00	175
Soil Analysis	4,386.00	4,408.02	-22.02
Tractor Services	24,948.60	5,610.47	19,338.13
Farm Produce	257	-	257
Conference Hall	91,016.63	1,343.00	89,673.63
Rice Processing	18,434.40	14,160.40	4,274.00
Combine Harvester	17,196.00	3,442.90	13,753.10
Documentation	4,106.54	11,270.65	-7,164.11
Agromet Data	5,769.00	-	5,769.00
Project Support	8,706.18	-	8,706.18
Workshop	120	-	120
TOTAL	**177,446.35**	**42,566.44**	**134,879.91**

Significant Achievements Of The Division

a) **Contract With NAFCO**
The institute won a contract with National Food Buffer Stock Company of Ministry of Food and Agriculture. We milled 2000 bags of paddy rice.

b) Contract with AMSIG Resources

We also signed a contract with AMSIG, a local NGO to use our parboiling facility at the rice processing center.

Generally, the Division was able to achieve 35% increase in IGF over 2009 IGF. The performance was good and we hoped to improve on the level by 30%.

DOCUMENTATION AND LIBRARY

Robert Kwasi Owusu, 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.

Coordination of Industrial Attachment

Among the institutions that paid educational visit to the institute were students from the Faculties of Agriculture, University of Cape Coast and KNUST, Kumasi. In addition to that students from the Damongo Agric College and tamale Polytechnic came for industrial attachments ranging from eight (8) to ten (10) weeks.

Preparation and submission of Reports

The first, second and third quarterly reports were prepared and submitted to head office in time. The fourth quarter report was submitted in February 2011. The Annual Report for 2008 was submitted to CSIR-INSTI for printing whilst editing of the 2009 begun.

Updating of brochures

The following brochures were updated to include further information regarding release of new improved crop varieties:

- SARI Overview
- Cowpea Production Guide
- Rice Production Guide

The SARI website was updated to include new reports. This website for local consumption only contains the following information:

- Annual Reports from 1997 to 2010
- In-House Review reports from 2000 to 2010
- Proceedings of the Workshop on Improving Farming Systems in the Interior Savanna Zone of Ghana. 1993 and 1996
- Links Yahoo Mail, Hotmail, Google, AGORA, etc
- Staff Publications

Since the server broke down the site has not been available to staff. There is the need to purchase an internet server to host SARI Website on the LAN to enable staff, both new and old, search for locally produced research information at the comfort from their offices.

REPORT ON THE LIBRARY

Introduction

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 exceeds 5000 volumes. The Library used to subscribe to about 16 journals, but subscription ceased in 1997 when support from GTZ ended. Now the Library subscribe only two daily newspaper and one weekly newspaper. It also depends largely on book donation.

Electronic Resources

The library currently offer literature search from the following sources:

- AGORA (Access to **Online** Research in Agriculture): username and password available
- OARE (Online Access to Research in Environment)
- HINARI (Health InterNetwork Access to Research Initiative): username and password available
- ScienceDirect
- CD-ROMS (FAO, INASP, AGROMISA & CTA etc.)

Other services rendered are

- Lending of books (to staff only)
- Reference service: box files have been created for each scientist to sore journal publications in for reference purposes
- Question and Answer Services: This enable Scientists to get full text literature that are not available at the electronic resources mentioned above
- Comb binding
- Thermal binding
- Lamination
- Design of complementary cards, wedding cards, etc.

PUBLICATIONS

Buah, S.S.J and L.N. Abatania (2010). Tillage and fertilizer effects on maize production in northern Guinea Savanna of Ghana. *Agriculture and Food Science Journal of Ghana*.8:653-666.

Buah, S. S. J., A. B. Huudu, B. D. K. Ahiabor, S. Yakubu and M. Abu-Juam (2010). Farmer Assessment, conservation and utilization of endangered sorghum landraces in the Upper West region of Ghana. *West African Journal of Applied Ecology*, vol. 17:11-25.

Buah, S.S.J., L.N. Abatania and G.K.S. Aflakpui (2010) Quality protein maize response to nitrogen rate and plant density in the Guinea Savanna zone of Ghana. *West African Journal of Applied Ecology*, vol. 16: 9-21.

Ahiabor, B. D. K., Fosu M. and Tibo I. (2010). Effect of pre-crop type on growth and yield of maize on two soils in the Guinea Savanna zone of Ghana. *West African Journal of Applied Ecology*, Vol. 17:55-63

Wiredu, A. N., K. O. Gyasi, and Aliou Diagne. 2010. Impact of improved varieties on inequality of income among rice-producing households in northern Ghana. Book of abstracts, Africa Rice Congress.

Wiredu, A. N., K. O. Gyasi, K. A. Marfo, S. Asuming-Brempong, J. Haleegoah, A. Asuming-Boakye, B. Nsiah-Frimpong and Aliou Diagne. 2010. Impact of Improved Varieties on the Yield of Rice Producing Households in Ghana. Submitted to Journal of Applied Economics.

Asuming-Brempong S. **,** K. O. Gyasi, K. A. Marfo, **Wiredu, A. N**., J. Haleegoah, A. Asuming-Boakye, B. Nsiah-Frimpong and Aliou Diagne. 2010. The Adoption Of NERICAs Among Ghanaian Rice Farmers: What Does the Evidence Say? Submitted to Ghana Journal of Agricultural Science.

Workshops/Conferences Attended in 2010 (list is below)

LIST OF RESEARCH SCIENTISTS AND CONFERENCES/WORKSHOPS ATTENDED IN 2010

No.	Name	Date of conference/Workshop	Country	Conferences/Workshops Attended
1	Dr. M. Fosu	6th – 12th June, 2010 6th – 7th Oct. 2010 30th Oct. – 2nd Nov. 2010	Tsukuba, Japan Brazil Nairobi, Kenya	"Lowland Rice Development in Africa" Africa-Brazil Agricultural Innovation Market Place AGRA Mid-Term Review
2	Dr. S. S. J. Buah	22nd – 26th March,2010 29th March – 2nd April, 2010 9th October – 15th November, 2010	Bamako, Mali Ibadan, Nigeria Senegal, Mali, Nigeria & Ghana	Rice Congress 2010 Regional Planning Meeting of the Drought Tolerant Maize for Africa (DTMA) Monitoring and Evaluation of USAID Emergency Rice Initiative Project activities
3	Dr. J. M. Kombiok	31st March – 2nd April, 2010 28th Sept. 1st Oct. 2010	Ibadan, Nigeria Abidjan, Cote D'Ivoire	DTMA Annual Planning Meeting For Africa 3rd ECOWAS Business Forum
4	Dr. J. B. Naab	8th – 12th March, 2010 28th – 30th Oct. 2010 22nd – 24th Nov. 2010	Niamey Colombia Senegal	Annual Meeting of CODEWA Project Agricultural Model Inter-Comparison and Improvement Project (AgMIP) Farming System Modeling Workshop
5	Francis Kusi	21st – 24th Sept. 2010	Dakar, Senegal	"West Africa Cowpea Consortium"
6	Joseph Adjebeng-Danquah	19th – 22nd April, 2009	Lilongwe, Malawi	Generation Challenge Programme (GCP)
7	Alexander Nimo Wiredu Alexander Nimo Wiredu	22nd – 26th March,2010 31st March – 2nd April, 2010 26th – 31st July, 2010	Bamako, Mali Ibadan, Nigeria Adisabab, Ethiopia	Rice Congress DTMA Annual Planning Meeting For Africa Strengthening the Availability and Access to Rice Statistics for Sub-Saharan Africa
8	Dr. S. K. Nutsugah	22nd – 26th March,2010 6th -12th June, 2010	Bamako, Mali Tsukuba, Japan	Rice Congress "Lowland Rice Development in Africa"
9	Dr. B. D. K. Ahiabor	3rd – 7th May, 2010	Lome, Togo	Development of Fertilizer Recommendations for Cassava using the Cassava trials outputs and for

Manual

Atokple, I.D.K, , R.A.L Kanton, S.S. Buah, **A.S. Karikari**, A.N. Wiredu, W. Dogbe, M. Abdul-Razak and S.K. Nutsugah (2010). Training Manual on Integrated Rice Management Techniques: CSIR- Savannah Agricultural Research Institute.

Advisory service

Buah, S.S.J. and J.M. Kombiok (2010). Documentation of the Community of Research and Practice in Regenerative and Conservation Agriculture in Ghana. Prepared for CARE International. pp 77.

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 2010.

MAIZE IMPROVEMENT PROGRAMME

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

Dr. M. S. Abdulai, Mr. Haruna Alidu and Miss Gloria Adu Boakyewa

Executive Summary

Three main activities were implemented under this project in the 2010 farming season. They included:

- Evaluation of genotypes for tolerance to *Striga hermonthica* on–station to identify superior stable yielding varieties.
- Evaluation of extra early, early and late/intermediate maturity groups of hybrids and OPV's tolerant to drought to identify superior stable yielding varieties.
- Production of breeder seeds of some released varieties.

To achieve the objectives set for these activities several trials were designed and planted in Nyankpala, Yendi and Damongo in the Guinea savanna zone, and Wa and Manga in the Sudan savanna zone, of Ghana. Germplasm used was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. The experimental design used was the randomized complete block design and lattice design with four replications per location. Multiple trait selection method was used based on all important traits conferring superiority in a line. Combined analyses of the data across locations were done to increase the efficiency of selection.

Over 300 genotypes were evaluated and the following genotypes were identified as superior in terms of grain production and their inherent ability to tolerate drought (abiotic) and *Striga* (biotic) stress conditions: EEWH-13, EEWH-17, EEWH-9, EEWH-19 EEWH-21, EEWH-11, EEWH-7, EEWH-4, EEYH-17, EEYH-15, EEYH-14, EEYH-24, EEYH-16 and EEYH-8 (extra-early white and yellow DT hybrids); 2004 TZEE-W Pop STR C4, TZEE-W POP STR C4, 2008 TZEE-W STR, TZEE-W Pop STR QPM C0, TZEE-W Pop STR C5 and 2004 TZEE-Y Pop STR C4 (extra-early maturing white and yellow OPVs); TZE-Y DT C2 STR, 2009 TZE-Y DT STR, DTE-W STR Syn C1 TZE Comp3 DT C2 F2 and TZE-W DT C2 STR (early maturing DT OPVs); EYH-18, EYH-6, EWH-6, EYH-9, EYH-16, EWH-5 and EWH-8 (early maturing DT hybrids); TZL COMP4 C3 DT, (White DT STR Syn/TZL COMP1-W) F2, S14DKD Medium DT, TZL COMP3 C3 DT, IWD C3 SYN F2 and (White DT STR Syn/IWD C3 SYN) F2 (Intermediate/late maturing DT OPVs); M1001-10, M1001-7, M1001-11, M1001-2, M1001-1, M1001-3, M1001-12, M1002-17, M1002-1, M1002-10, M1002-5, M1002-16 and M1002-3 (Late-maturing white and yellow OPVs); M1026-9, M1026-8, M0926-8, M0926-6, M0926-7, M1026-11, M0826-1, M0926-2, M1026-2 and M1026-1 (Three-way and top-crosses DT Hybrids); Oba Super-4, Oba Super-II, LY0906-8, LY0902-12 and LY0902-18 (hybrid yellow maize); M1009-13, M1009-1, M1009-6, M1009-7 and M1009-9 (Intermediate/late Striga resistant OPVs); 2008 DTMA-Y STR, Syn DTE STR –Y, EV DT-Y 2008 STR, 2004 TZE-Y Pop DT STR C4, 2009 TZE-W DT STR and POOL 18SR/ACR94TZECOMP5-Y/ACR94TZECOMP5-Y (early maturing *Striga* resistant OPVs); 0502-5STR, 0602-1STR and 0804-7STR (single cross and three- way cross STR hybrids).

Introduction

Maize ranks first among cereals and second among grains in importance Worldwide. In Ghana, it has become a staple food crop that has gradually replaced sorghum and millet due to its high yield potential. The crop is cultivated by 1.75 million (64%) of the 2.74 million households operating farms in Ghana covering a total area of about 713,000 hectares with production levels averaging 1.5 metric tons (mt) per hectare (FASDEP, 2002). It is produced in all the five major agro-ecological zones in Ghana, and is the most important cereal grain in terms of total production and utilization. In the Guinea and Sudan Savanna Zones of Ghana, maize is widely cultivated and forms an important part of the daily nutrition of the people of the area. The area has the potential of leading in maize production.

Maize grown in Ghana (like the rest of South Saharan Africa) is mainly rain-fed and characterized by rainfall patterns which are highly variable both in amount and distribution. Drought therefore has an overwhelming importance to maize production in Ghana, affecting people's livelihoods, food security and economic development. It has become a major constraint to agric productivity in SSA including Ghana as a result of climate change. The potential of the Guinea and Sudan Savanna zones of Ghana leading in maize production has been menaced by frequent drought, nitrogen stress and the prevalence of striga. Effective and sustainable approaches to curb current impacts of drought, striga and the looming threats of climate change are of uttermost importance. There is therefore the need to develop maize varieties that are tolerant to drought and *striga* stresses to maintain stable yields, promote food security, increase farmers' income and contribute to poverty alleviation.

Objectives:

- To provide the National Maize Programme a wide range of germplasm from which to select varieties with superior characteristics.
- To develop appropriate maturity maize varieties with high yield potential that are tolerance to stresses (drought, *striga* infestation and low nitrogen deficiency), test and release superior varieties to farmers within a very short time.
- To produce breeder seed of drought tolerant commercial maize varieties and new varieties.

Expected Beneficiaries: At least 4 each of Late/intermediate and extra early/early Yellow and white QPM hybrids and composite maize varieties that are tolerant to drought stress identified and released to about 400,000 farmers in the Guinea and Sudan savanna zones of Ghana.

Materials and Methods

The genetic materials used in this project were obtained from IITA, Ibadan and local sources. The materials comprised of hybrids and Open Pollinated Varieties (OPVs) of maize, developed for grain yield and adaptation to abiotic (drought) and biotic (*Striga*) stress factors.

The experimental design was Randomized Complete Block Design and lattice design with three replications across locations. Each plot consisted of two rows of each entry. The rows were 5.0 m long and spaced 0.75 m apart. Three seeds were sown per hill at an intra-row spacing of 0.5 m 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 materials were arranged in both variety and hybrid trials and planted in Nyankpala, Yendi and Damongo in the Guinea savanna zone and Wa and Manga in the Sudan savanna zone, of Ghana. Trials were established in the main cropping seasons of these zones.

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. The data were analyzed using statistical system analyses (SAS, 1996) after conversions of grain yield in kilograms per plot to grain yield in tonnes per hectare (GYLD) at 15% grain moisture. The data were 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

Extra – early white DT hybrid trial

Twenty-five genotypes were evaluated in Wa, Manga and Nyankpala in these trials. There were significant differences ($p < 0.01$) among locations for grain yield, days to flowering, anthesis- silking interval and number of ears harvested per plot. Within locations however, there were no significant differences ($p < 0.01$) among genotypes for these traits. There was also no genotype by environment interaction effects for all the traits measured. The mean grain yield at Nyankpala was significantly higher than those at Wa and Manga The mean grain yield across locations was 3.44 t/ha. The grain yields of genotypes EEWH-1, EEWH-3, EEWH-12 and EEWH-24 were location specific whilst the grain yields of genotypes EEWH-7, EEWH-11, EEWH-13 EEWH-17 and EEWH-19 were stable across locations. Genotypes EEWH-13, EEWH-17, EEWH-9, EEWH-19 EEWH-21, EEWH-11, EEWH-7 and EEWH-4 were identified as outstanding in performance in terms of traits measured across locations. They have therefore been selected for further work.

RUVT extra-early maturing white and yellow grain varieties

Eighteen genotypes were evaluated in Nyankpala, Manga, Yendi and Wa. There were significant differences ($p < 0.01$) among the genotypes and among locations for grain yield, days to flowering, ears harvested and anthesis-silking interval ($p < 0.05$). There was no genotype by environment interaction effects for all the traits measured. The mean grain yield of Yendi was significantly higher than those of Nyankpala, Manga and Wa. Genotype 2004 TZEE-W Pop STR C4 produced the highest mean grain yield of 4.21 t/ha across locations and the highest mean grain yields of 5.13, 4.33 and 4.16 t/ha in Yendi, Wa and Manga, respectively. Since there was no significant genotype by location interaction effects, the mean grain yields of genotypes were used to select the best broadly adapted genotypes.

Genotypes 2004 TZEE-W Pop STR C4, TZEE-W POP STR C4, 2008 TZEE-W STR, TZEE-W Pop STR QPM C0, TZEE-W Pop STR C5 and 2004 TZEE-Y Pop STR C4 were selected based on their stable performance across locations

Intermediate/late maturing drought tolerant variety trial

Twenty-eight genotypes were evaluated in Nyankpala and Damongo. There were significant differences ($p < 0.01$) among the genotypes and among locations for grain yield, days to flowering and ears harvested. However there was no significant genotype by environment interaction effects for these traits. Mean grain yield and ears harvested per plot in Damongo was significantly higher than mean grain yield and ears harvested per plot in Nyankpala. Performance of genotypes in Damongo was generally better than in Nyankpala. Genotype TZL COMP4 C3 DT recorded the highest grain yield of 5.60 t/ha across locations. Genotypes TZL COMP4 C3 DT, (White DT STR Syn/TZL COMP1-W) F2, S14DKD Medium DT, TZL COMP3 C3 DT, IWD C3 SYN F2 and (White DT STR Syn/IWD C3 SYN) F2 were selected as superior to the rest based on the stability of their grain yield across the locations. They all out-yielded the local check, Okomasa, by 3.85% to 15.18% across locations. For each location grain yield of genotypes were ranked and the best five selected since there was no significant genotype by environment interaction effects.

EVT-LSR-W (Late-maturing, white-grain varieties)

Eighteen genotypes were evaluated in Nyankpala, Damongo and Yendi (Table 1). There were no significant differences among genotypes for grain yield, anthesis-silking interval and ears harvested per plot within locations. Across locations, genotypes were significantly different ($p < 0.01$) in grain yield, days to flowering and ears harvested per plot. There was no significant genotype by environment interaction effects for grain yield, ears harvested and anthesis- silking interval. The mean grain yield for Damongo (5.04 t/ha) was significantly higher than the mean grain yields for Nyankpala (4.20 t/ha) and Yendi (4.25 t/ha). However the mean grain yields of Nyankpala and Yendi were not significantly different. The mean grain yield across locations was (4.50 t/ha) with genotype M1001-10 recording the highest mean grain yield of (5.22 t/ha) across locations. The mean grain yield and anthesis-silking interval of genotypes are presented in Table 1.

Since there were no significant genotype by environment interaction effects, the genotypes were ranked and based on their ranked sum values across locations, the following genotypes were selected, M1001-10, M1001-7, M1001-11, M1001-2, M1001-1, M1001-3 and M1001-12. Their performance was very stable across the locations. For the individual locations, the best five in each location was selected.

Table 1: Mean grain yield (t/ha) and anthesis-silking interval of the eighteen genotypes evaluated in Nyankpala, Damongo and Yendi

Genotype	**Grain Yield**				**Anthesis-Silking Interval**			
	N'la	**Yendi**	**D'go**	**Across**	**N'la**	**Yendi**	**D'go**	**Across**
M1001-1	4.5	4.8	5.2	4.8	1.7	2.1	1.8	1.8
M1001-2	4.8	5.0	4.8	4.9	1.2	2.3	1.7	1.7
M1001-3	4.9	4.2	5.4	4.8	1.8	1.7	1.8	1.8
M1001-4	4.1	3.7	5.1	4.3	1.6	1.9	1.9	1.8
M1001-5	4.3	4.8	4.5	4.5	1.8	1.9	1.7	1.8
M1001-6	4.2	4.5	4.9	4.5	2.3	2.7	1.1	2.1
M1001-7	5.0	4.2	5.4	4.9	1.7	2.3	2.1	2.1
M1001-8	4.4	4.0	4.3	4.3	1.7	2.0	2.0	1.9
M1001-9	4.5	4.3	4.0	4.3	1.6	2.2	1.4	1.7
M1001-10	5.0	5.1	5.6	5.2	2.1	2.4	1.7	2.1
M1001-11	4.4	4.5	5.8	4.9	2.2	1.9	2.3	2.1
M1001-12	3.9	4.3	6.0	4.7	2.1	0.8	1.5	1.5
M1001-13	4.4	4.0	5.1	4.5	1.9	2.1	1.5	1.8
M1001-14	3.8	3.1	4.8	3.9	1.7	1.1	1.6	1.4
M1001-15	4.1	3.9	5.1	4.4	1.9	2.0	2.0	2.0
M1001-16	3.2	3.5	4.9	3.9	2.1	2.2	1.7	2.0
M1001-17	3.2	4.4	4.8	4.1	1.8	1.8	1.3	1.6
M1001-18	2.8	4.3	5.1	4.1	2.1	2.1	2.0	2.1
Mean	**4.2**	**4.3**	**5.0**	**4.5**	**1.9**	**2.0**	**1.7**	**1.9**
SE	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
CV	**25.6**	**17.8**	**17.2**	**22.5**	**20.2**	**37.1**	**30.3**	**30.6**

Evaluation of genotypes for tolerance/resistance to *Striga hermonthica*

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. 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* can reduced maize yields by about 100% in heavily infested fields forcing farmers to abandon their fields. Several control measures 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 this program. To achieve the objectives the performance of 18 intermediate/late and 16 hybrids, were evaluated under *striga* infested (inf) and non-infested (noninf**)** plots at Nyankpala in 2010.

Intermediate/late *Striga* Resistant Open - pollinated Variety trial

Results of the combined ANOVA showed significant genotypic mean squares ($p < 0.01$) for grain yield, days to 50% anthesis, days to 50% silking and number of ears harvested per plot under both *Striga* infested and non-infested environments. There was no significant genotype by environment interaction for all traits under both conditions. Grain yield ranged from 0.61 to 1.86 t/ha under *Striga* infestation and from 0.74 to 2.79 t/ha under non-infested environment. Mean yield reduction due to *Striga* infestation was 39.78%.

Genotype M1009-13 was the highest grain yielding genotype under the *striga* infested environment. Despite the high grain yield, it also had high values for STRCO1 and STRCO2. The high STRCO1 and STRCO2 values imply that this genotype supported large number of *Striga* plants and yet produced high grain yield, suggesting that it was tolerant/resistant to *Striga*. Genotypes M1009-13, M1009-1, M1009-6, M1009-7 and M1009-9 were found to possess superior traits, suggesting that they were tolerant/resistant to *Striga* and have therefore been selected.

Single cross and three- way cross STR hybrids trial

Sixteen hybrids were evaluated under *striga* infested (inf) and non-infested (noninf**)** plots at Nyankpala in this trial. The combined analysis of variance across environments indicated significant genotypic mean squares for grain yield, days to 50% anthesis and number of ears harvested per plot under both the striga infested and the *Striga*-free conditions. However, there were no genotype-by-environment effects for all traits under both environments.

Mean grain yield of the genotypes under *Striga* infestation ranged from 0.19 to 1.34 t/ha; and 0.81 to 1.57 under noninfested conditions. Average grain yield of genotypes under *Striga* infestation was 39.26% of that under noninfestation. All other genotypes except genotype 8338-1 out-yielded the local check by at least 12%. Genotypes 0502-5STR, 0602-1STR and 0804-7STR had high values for grain yield and ears harvested per plot and were considered superior in performance in terms of these traits. In addition, 0502-5STR, 0602-1STR and 0804-7STR also had low values for STRCO1, STRCO2, and STRA1 and STRA2 (Table 2).

Table 2: Grain yield (t/ha) and other agronomic traits of 16 Single cross and three- way cross STR hybrid Varieties evaluated under artificial Striga infestation (Inf) and Non-infested (Noninf) environments at Nyankpala

Pedigree	Grain yield (t/ha)		Days to flowering		Ears harvested per plot		STRCO1	STRCO2	STRA1	STRA2
	Inf	Uninf	Inf	Uninf	Inf	Uninf	Inf	Inf	Inf	Inf
0501-1STR	1.1	1.5	61.2	59.9	18.2	19.9	9.1	11.8	1.7	1.8
0501-2STR	1.2	1.8	61.9	59.7	19.1	19.2	4.7	7.8	1.8	1.9
0601-6STR	0.8	1.7	60.8	60.2	19.8	18.4	11.9	14.9	2.3	2.2
0502-5STR	1.3	1.6	62.2	60.6	17.3	18.1	0.0	5.6	1.3	1.7
0602-1STR	1.3	1.6	62.5	61.3	17.9	17.5	7.0	9.5	1.2	1.4
0804-3STR	0.9	1.0	62.5	61.0	19.3	19.1	1.7	3.3	2.9	3.3
0804-6STR	1.0	1.3	62.8	61.0	18.2	20.2	10.7	10.9	2.2	2.4
0804-7STR	1.3	2.1	61.2	59.2	17.5	19.3	3.1	4.1	2.4	2.5
0702-2STR	0.7	1.3	61.5	59.7	13.7	15.5	4.7	6.8	2.4	2.7
0902-14STR	1.0	1.5	58.9	57.7	15.1	17.5	7.7	10.2	3.1	2.9
0902-15STR	0.5	1.0	63.0	60.9	9.3	17.5	2.1	4.8	2.4	2.4
0902-18STR	0.6	1.3	64.3	60.5	14.7	16.5	14.1	14.8	2.8	2.7
9022-13	0.3	1.1	64.0	62.5	7.4	12.1	19.6	19.2	3.3	3.7
8338-1	0.2	0.8	65.1	60.7	3.7	10.2	14.0	15.8	5.4	7.4
Oba Super 1	0.5	0.9	63.8	62.5	10.1	13.8	12.6	14.9	2.6	3.2

Check (Obatanpa)	0.3	1.2	62.4	60.8	7.7	13.5	18.6	19.8	4.6	6.3
Mean	0.8	1.4	62.4	60.5	14.3	16.8	8.8	10.9	2.6	3.0
SE	0.1	0.1	0.3	0.2	0.8	0.5	1.5	1.4	0.2	0.3
CV	29.4	20.4	1.7	2.1	18.2	14.4	10.9	9.0	29.3	23.7

The low STRCO1 and STRCO2 values imply that the three genotypes supported less number of *Striga* plants suggesting that they were resistant to *Striga*. Genotype 8338-1 had the lowest values for grain yield and ears harvested per plot but the highest values for days to 50% anthesis and STRA1 and STRA2. The low ears harvested per plot and high *Striga* damage might have contributed to the low yield of 8338-1 and indicates that it was *Striga* susceptible. Genotypes 0601-6STR, 0902-18STR and Oba Super 1 had low scores for STRA1 and STRA2. Since these genotypes also supported relatively large number of *Striga* plants (Table 2), it may be concluded that they possessed *Striga* tolerant genes. Base on their performance in terms grain yield, ears harvested per plot, STRCO1, STRCO2, STRA1 and STRA2, genotypes 0502-5STR, 0602-1STR and 0804-7STR were seen to be superior and have therefore been selected.

Demonstration and breeder seed production

Maize being a cross pollinated crop, released varieties usually gets contaminated within a couple of years after their release. To maintain the genetic purity of the released varieties, there is the need for the production and maintenance of breeder seeds. This thus calls for the annual production of breeder seeds of released maize varieties. The program combined the production of breeder seed with demonstrations on station in Nyankpala.
The objective of the demonstration was to plant the most superior genotypes to showcase their agronomic performance to attract farmers and seed growers to enhance their adoption. Four such genotypes (DT SR-W C0 F2, DT SYN-1-W, IWD STR C1 and ACR 97 TZL Comp1-W) were planted for demonstration during the 2010 cropping season. Two field days were organized to showcase these genotypes.

The following quantities of breeder seeds of the under listed varieties/genotypes in Table 3 were produced.

Table 3: Produced quantities of breeder seed of the under listed varietie/ genotypes.

Variety /genotype	**Quantity (kg)**
Obatanpa	40
Dorke SR	40
Okomasa	50
Dodzi	50
ACR 97 TZL COMP 1-W	70
IWD STR C1	40
DT SYN – 1 – W	100
DT SR-W C0 F2	120

To ensure high genetic purity, time isolation and sib mating were adopted in the seed production. An effective population size of 300 – 500 ears and plant density of 40,000 plants/ha was used. An intensive selection and control of off-types was adopted. Border rows were discarded at harvest since the probability of their being contaminated was very high. Only seed of disease-free plants were harvested to represent each varieties/genotype.

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ROOT AND TUBER CROPS IMPROVEMENT.

Evaluation of eighteen cassava genotypes for their performance under dry conditions of Northern Ghana.

Kwabena Acheremu and Joseph Adjebeng-Danquah

Executive Summary

Northern Region is noted for its inherent long dry spell and great variability in the distribution and amount of precipitation spread over six (6) months. Eighteen (18) genotypes introduced from IITA, CIAT and landraces were evaluated for physiological traits that contributed to tolerance to drought conditions in Northern Region of Ghana. Measurements were taken at monthly interval for the growth parameters. Preliminary results of the tolerant genotypes showed significant differences ($p<0.05$) based on leaf retention, plant height, canopy spread, stem diameter, dry matter and root yield. The genotype 96/0409 recorded the highest root yield of 12.5t/ha, followed by the genotype CTSIA 45(12.1t/ha). The genotype CTSIA 48 recorded the highest number of leaves (160), which is not significantly different from that of CTSIA 8 recording 142 leaves. Genotype CTSIA 8 recorded the highest (1.134m) canopy width, plant height (1.13cm), number of tubers (18.3) and top weight (3.17 kg). The root yield of the genotype CTSIA 8 (10.0t/ha) is not significantly different from that of the highest (12.5t/ha) root yield.

Introduction:

Cassava (*Manihot esculenta,* Crantz) is incorporated into many household diets in northern Ghana, used mainly as flour from dried chips. It is grown by resource-poor farmers, mainly women, often on marginal lands for food security and income generation. It also has the potential to produce starch for industrial purposes as well as feed for livestock production at a relatively cheaper cost than maize (Nweke *et al.,* 1994). It has become an important crop because it is relatively inexpensive to cultivate and survives the five to six months of sometimes-absolute dry weather before harvest during the next wet season. The parts of Ghana noted for their inherent long dry spell experience great variability in the distribution and amount of precipitation spread over six (6) months. This short period of rainfall is interspersed with periods of intermittent drought which is then followed by a long dry season contributing to low productivity of most crops. About 82 to 96% yield decline has been reported in cassava under severe moisture stress (Aina *et al.,* 2007). Drought adversely affects the lives of 2.6 billion people that are engaged in agriculture worldwide. Yield losses due to water deficits however, vary depending on timing, intensity and duration of the deficit, coupled with other location-specific environmental stress factors such as high solar radiation and temperature (Serraj *et al.,* 2005). Drought tolerant cassava varieties have been found to give up to 40% higher yield than drought susceptible ones (Alves and Setter, 2004).

Tolerance to drought is a complex trait and efficiency of phenotypic evaluation for drought improvement is considerably affected by the environment (G x E). The ability to produce significant roots under difficult or marginal conditions is related to various physiological traits (Lenis *et al.,* 2006). In response to mild drought, cassava reduces transpiration substantially by closing its stomata, as do other species that act to retain water during drought episodes (El Sharkawy *et al.,* 1984; Tardieu and Simonneau, 1998; Alves and Setter, 2000). In addition, leaf area growth is decreased in response to water stress and is rapidly reversed following the release from stress. When water is available, cassava maintains a high stomata conductance and can keep internal CO_2 concentration high; but when water becomes limiting, it closes its stomata in response to even small decreases in soil water potential. Although the combined effects of reducing leaf surface area and stomata closure can improve crop water use efficiency, it also leads to reduction in potential photosynthesis and in turn, total biomass and root yield. Leaf longevity is one of the main traits associated with high yields in cassava (El-Sharkawy *et al.* 1992). Furthermore, increased leaf retention during water deficit increases total biomass production and most of this increased biomass accumulates in the roots, leading to increased root yield (Lenis *et al.,* 2006). By retaining functional leaves with high water use efficiency and at the same time reducing the production of new leaves under drought conditions, the photosynthate will tend to accumulate in the roots thus increasing harvest index. This work aims to identify physiological traits particularly leaf retention as it relates to improved performance of cassava under dry conditions with the aim of using these traits as a selection criteria in cassava breeding programme.

Materials and methods

The experiment was based on 18 cassava genotypes arranged in a randomized complete block design with three replications. The work was carried out at the Savanna Agricultural Research Institute research fields at Nyankpala. The land was ploughed and harrowed after which mounding was done. Cassava stakes measuring 25-30cm were planted using a standard spacing of 1m x 1m giving a total population density of 10,000 plants/ha. Each plot consisted of four rows by four genotypes per row. Data were recorded on the four central plants at two weeks intervals for growth parameters until final root harvest at 12 months after planting. Data taken include number of leaves as an indicator of leaf retention, plant height, canopy spread, stem diameter, tuber yield and harvest index which was calculated as the ratio of tuber yield to total biomass. .

Results and Discussion

Scientific findings

Results of the selected tolerant genotypes were studied based on measurements of growth parameters taken at three months after plant establishment and monthly thereafter until 10 months when the rains begun in May. The results indicate variation in the rate of leaf production for most of the genotypes (Fig 1). In general lower number of leaves was produced between November and February when the conditions were dry (Fig 2). However variations were observed among the genotypes for the rate of leaf production. Genotypes CTSIA 48, CTSIA 1 and CTSIA 110 produced a relatively higher amount of leaves than the other genotypes, including the local check *Biabasse*.

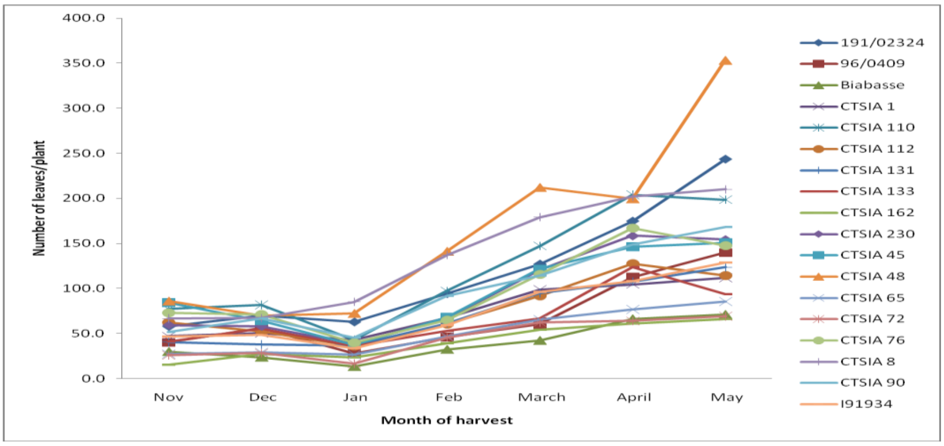

Fig1. Rate of leaf production of eighteen cassava genotypes at different months

The reduction in leaf production during period of water shortage and subsequent resurgence in leaf production following the onset of the rains confirms earlier studies (El-Sharkawy 2007). In a study involving four contrasting cassava genotypes exposed to mid-season stress, crop recovery was observed with the aid of rainfall and supplementary irrigation. Analysis of growth and yield parameters also indicated significant differences ($P<0.05$) among the genotypes (Table 1). The genotype 96/0409 recorded the highest root yield of 12.5t/ha, followed closely by the genotype *CTSIA* 45 (12.1t/ha). The biggest stem diameter (1.77cm) was also recorded by 96/0409. The genotype *CTSIA* 48 recorded the highest mean number of leaves (160), which was not significantly different from that of *CTSIA* 8 which recorded 142 leaves. Genotype *CTSIA* 8 however recorded the highest (1.134m) canopy width, plant height (1.13cm), number of tubers (18.3) and top weight (3.17 kg). Although the genotype 96/0409 recorded the highest root yield, the yield difference was not statistically significant from that of the local genotype *Biabasse*. The highest root yield produced by 96/0409 in absolute value, is an indication of the ability of the genotype to recover quickly from the water stress period to produced dry matter and then translated into root yield. The highest result of the genotype *CTSIA* 8 in the plant height, canopy width, biomass and number of tubers did not translate into higher root yield, although the value recorded was not statistically significant from the highest value recorded by 96/0409. Though increased leaf retention during water deficit has been associated with increased root yield (Lenis *et al.*, 2006), the improved leaf retention potential of the exotic genotypes did not translate into tuber yield.

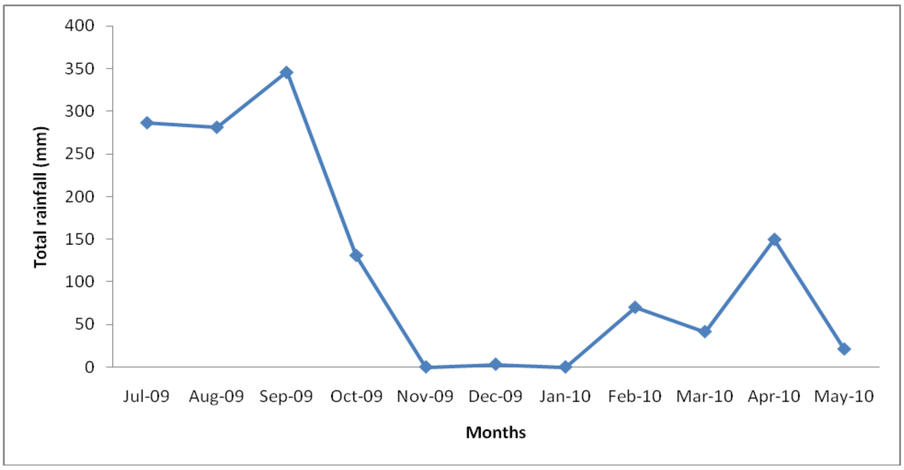

Fig 2 Rainfall pattern during the period of experiment

Technology Developed

Two genotypes 96/0409 and Ctsia 8 have been identified based on their yield performance.

Technology transferred

This work is at the clonal evaluation stage on-station to select best performing lines based on attributes important to the cassava growing areas of the Northern Region.

Table 1 Growth and yield components of 18 cassava genotypes

Genotypes	CW	PH	NOL	NoT	ToWt. (kg)	StDm (cm)	Ryld (t/ha)	HI
CTSIA 48	0.83	0.86	160.0	18	3	1.69	11.3	0.603
CTSIA 110	1.08	0.94	126.6	14.7	3.2	1.4	8.8	0.517
CTSIA 72	0.62	0.70	44.7	13	1.5	1.05	2.2	0.627
CTSIA 112	0.99	0.91	80.1	22	2.7	1.45	11.3	0.647
CTSIA 230	0.99	0.97	95.3	13.3	2.5	1.33	7.5	0.54
CTSIA 76	1.05	1.16	101.9	15.3	2.8	1.43	6.3	0.493
CTSIA 162	0.54	0.86	42.1	14	1.2	1.1	7.1	0.707
CTSIA 8	1.13	1.22	142.1	18.3	3.2	1.52	10	0.583
96/0409	0.81	0.92	66.1	11.3	3.2	1.77	12.5	0.637
CTSIA 90	1.02	0.99	101.6	16	3	1.37	9.2	0.547
CTSIA 1	0.69	0.89	79.2	12.3	2	1.14	5.4	0.503
191/02324	0.93	0.84	116.7	9.7	3	1.5	7.9	0.483
CTSIA 131	0.94	1.15	75.3	10	2.7	1.48	7.1	0.557
CTSIA 65	0.76	1.20	51.8	11.3	1.8	1.3	4.2	0.48
CTSIA 45	0.95	0.96	99.8	23	2.7	1.41	12.1	0.653
I91934	0.63	0.60	74.5	13	1.8	1.22	9.6	0.68
CTSIA 133	0.84	1.10	67.7	11.7	1.7	1.37	5.8	0.573
*Biabass*e	0.61	0.67	39.7	13.3	1.8	1.23	10.0	0.69
Mean	0.86	0.94	86.95	14.46	2.43	1.37	8.24	0.58
LSD (0.05)	0.28	0.31	72.0	9.6	1.5	0.36	4.9	0.11
CV(%)	19.68	19.33	47.6	40	37.3	15.7	35.2	11.6

Key words: *CW=canopy width, PH=plant height, StDm=stem diameter, NoL=number of leaves, NoT=number of tuber,ToWt=top weight, Ryld=root yield. HI=harvest index.*

Conclusion

None of the exotic genotypes gave statistically higher yield than the local farmer preferred variety, *Biabasse.* However their relatively better growth and leaf retention properties offer an opportunity for introgression of such genes into the locally adapted genotypes for improved performance under dry conditions. The genotypes 96/0409, *CTSIA* 45, *CTSIA* 112, *CTSIA* 48 and *CTSIA* 8 were statistically similar in root tuber yields, but different in absolute values. However, *CTSIA* 8 recorded the best performance in terms of yield parameters measured, although these attributes did not translate into the highest final yield. Based on the physiological attribute and final root yield, the genotypes 96/0409 and *CTSIA* 8 are selected for further breeding work. The findings of the research have unravelled important information on some physiological traits underlying cassava productivity and tolerance to prolonged water shortage. This information can be used to develop novel cassava varieties for both favourable and stressful environments.

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Evaluation and selection of high and stable yielding beta-carotene rich varieties of sweet potato for Northern Ghana.

Kwabena Acheremu and Joseph Adjebeng-Danquah

Executive Summary: Sweetpotato varieties with yellow or orange flesh have high beta carotene content and taste like sweet carrots. Nineteen varieties, including orange flesh sweetpotato varieties were, evaluated under our local condition for their performance in terms of yield. “Ogyefo” recorded the highest plant establishment of 72.22% and the lowest was “Santompona” with a value of 37.96%. “Apomuden” recorded the highest (34) number of commercial roots sizes after that of the local check of 38. In terms of overall yield, “Apomuden” emerged the highest with a value of 12.84t/ha over that of the local check of 8.22t/ha. The lowest yield records of zero were produced by “Gweri” and “Carrot-C”

Introduction:
Sweet potato (*Ipomoea batata)* belongs to the family convolvulaceae. The tubers, harvested 100-180 days after planting stem cuttings, are tuberous roots. It has a high dry matter content (25-33%) and contains starch, dextrins and sugars (Messiaen, 1992). Sweet potato is the tropical tuber crop that can give the highest production of enegy per unit area in a given time and at all seasons of the year. Varieties with yellow or orange flesh have a high (up to 0.18 %) β-carotene content and taste of sweet carrots. Sweet potato has the lowest requirements for organic matter among the root and tuber crops (Messiaen, 1992). This work is aimed at identifying varieties with high and stable yields of sweet potato for northern Ghana. It is also aimed at assessing the suitability of varietal characteristics to the food and income needs of farmers.

Materials Methods:
Twenty lines were received from CSIR-Crops Research Institute, Kumasi, including local checks and β-carotene rich varieties, and were planted on the experimental field in Nyankpala, in 3 replications using randomised complete block design. The parameters evaluated were number of plants harvested (SHI), number of commercial (NOCR) and non commercial (NONCR) roots per plant harvested, and the amount of biomass (VW) produced in the expense of root development, as well as total root yield per hectare (RYTha).

Results and Discussion:

Scientific findings

The results show significant differences ($p \leq 0.05$) in yield and yield components among the 20 sweet potato varieties evaluated (Table 2). "Ogyefo" recorded the highest plant establishment of 72.22%, and closely followed by "Gweri" and the local check (NRV-CHK) with a survival rate of 68.52% respectively. The variety that recorded the lowest plant establishment was "Santompona" with a value of 37.96%. Among the introduced varieties, "Apomuden" recorded the highest number (34) of commercial roots, which is lower than that of the local check variety (NRV-CHK) of 38. Some varieties like "Gweri", "Carrot-C" and "Wagabolige" however did not produce roots with a record of zero. In terms of the total root yield produced per hectare (RYTha), "Apomuden" recorded the highest with a yield value of 12.84t/ha over the local check variety (8.22t/ha.).

Technology developed

High performing varieties ("Apomuden" and "Kemb 37") have been selected based on their yield performance.

Technology transferred

The best performing varieties were identified in a participatory evaluation together with 10 farmers selected from Tingoli, Cheyohi and Kpalsogu communities of the Tolon/Kumbugu District.

Conclusion:

"Ukerewe" and "Wagabolige" recorded the highest vine yields of 14.83 t/ha and 14.53 t/ha, respectively, in expense of the economic yield. "Apomuden" recorded the best yields both in roots and the vines for planting material among the introduced carotene rich materials, giving similar performance as the local check variety. It could be selected as the best yielding, β-carotene rich and disease resistant variety identified for farmers in potato growing areas in Northern Ghana.

Table 2. Average yield parameters of 20 sweetpotato varieties.

Variety	SHI	NONC	CRWt	VWt	HI	RYTha
Gweri	68.52	0	0	9.5	0	0
199062.1	66.67	25	2	**4.7**	40.4	3.98
Apomuden	51.85	24.33	**10.17**	10.33	**53.65**	**12.84**
Carrot-C	50.93	0	0	7.03	0	0
Faara	56.48	13.33	1.33	11.5	15.06	2.31
Naspot-1	58.33	15	0.53	12.23	9.61	1.44
Hi starch	50.93	11.67	1.83	8.17	23.3	2.8
Junkwa orange	51.85	27	1.5	13.67	18.15	3.45

Kemb 37	61.11	31.67	5.33	9.33	42.18	7.77
Moh-C	61.11	20.67	3	11.5	23.57	4.36
Santompona	37.96	9	3.67	11.5	26.39	4.92
NRV-CHK	68.52	21	**6**	6.33	**53.2**	**8.22**
Ogyefo	72.22	15.33	3.7	10	30.29	5.15
Okumkom	57.41	26.33	5.5	7	48.74	7.58
Otoo	59.26	16	1.13	6.67	22.12	2.23
Wagabolige	55.56	1.67	0	**14.53**	1.45	0.19
Sauti	65.74	20.33	1.67	9.67	20.38	2.8
Semsa 74-228	65.74	25.33	5.03	6.83	48.05	7.23
Tanzania	67.59	23.67	1.33	10.33	19.99	2.84
Ukerewe	57.41	18	0.5	**14.83**	7.95	1.44
LSD	*10.8*	*11.14*	*2.06*	*5.3*	*10.32*	*2.47*
CV(%)	*11*	*39*	*45.9*	*32.8*	*24.8*	*36.5*

Key words: *SHI=number of plants harvested, NOCR=number of commercial roots, CRWt=commercial root weight, VW=vine weight, RYTha=root yield per hectare, HI=harvest index.*

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Improved production of "Pona" seed yam using the minisett technology.

Kwabena Acheremu and Joseph Adjebeng-Danquah

***Executive Summary*:** Seed yam production using the minisett techniques is widely known to contribute to the supply of planting materials. Two community-based farmer groups were selected to produce "Pona" seed yam using the minisett technique. From a total of 27,840 minisett cuttings obtained, 4176 sprouts were recorded representing 15% sprout at 7 WAP of setts. The percentage sprout rose to 22% at 17WAP. Out of 25,600 minisett cuttings planted on Tingoli field, 2931 sprouts were recorded 5WAP, representing 11.4% sprouted setts. The number of sprouted setts rose to about 7316 stands 15WAP, representing 28.6%.

Introduction:

White yam (*Dioscorea rotundata* Poir) is the major and important yam species grown in Ghana (Tetteh and Saakwa, 1994). The generation of

plantable seed yam in production is a major problem. The reason for the low output of seed yam is the inherent low multiplication ratio of yam crop.
Seed yam production using the minisett techniques is widely known to contribute to the supply of planting materials. The technology was designed to reduce seed yam cost. By the yam minisett technique, 20-25 setts can be obtained from an average sized yam tuber. The adoption of the technique has considerably contributed to the increased supply of planting materials in Ghana. Although Pona variety responds relatively poor to the minisett technology, it is the most preferred cultivar among the yam species by both farmers and consumers because of its early maturity, high market value and excellent organoleptic qualities. In view of its value, funds were sourced to produce Pona seed yam for farmers by the participatory approach method. The aim of this project is to encourage yam farmers into seed yam production of the most preferred cultivars using the minisett technique.

Materials and methods:
Two community-based farmer groups in Cheyohi and Tingoli were selected to produce up to sixty thousand (60,000) setts of seed yam using the minisett technique. Six thousand (6,000) farmers' seed-yam and 2,000 ware-yam setts were purchased before the beginning of the season and stored. At the time of preparing the cuttings into minisett, seed yam setts were cut into 5 pieces and ware yam setts also cut into 20. In total 25,600 setts were obtained for Tingoli and 27,840 for Cheyohi communities.

The setts were planted to a one hectare fields acquired in each of the two communities, ploughed and harrowed. Ridges were made at 1m apart, and the setts planted at 30 cm apart. The setts were cut to about 25g in weight and treated in a solution of Topsin-M (fungicide) and wood ash (against bacteria). Cuttings were air-dried and then planted at 30 cm apart on the ridges. Cheyohi field was planted on the 10^{th}, 11th and 12^{th} of July, whilst that of Tingoli was on the 25^{th} of July 2010. The field was shared into subplots (25m ridge-long by 17-18 ridges - 0.045 ha area), with a total of 1360 to 1440 setts planted in each subplot, among the farmers to manage. There was an initial post-emergence weedicide (atrazine) application to control the first weeds that will compete with the emerging sprouts 3days after planting.

Results and discussions:
Findings:
In Cheyohi, the rate of sprouts at specific dates of count after planting ranged from 9.2 to 31.4% at the final count for plant stand taken in the various subplots demarcated after planting the whole field (Table 1.).

Table 1. Field Distribution Plan and yield parameters for Cheyohi

Plot No.	**Name of Farmer**	**No. Of rows**	**No. Of Cuttings planted**	**Number Sprouted**			
				7 WAP	**11WAP**	**17WAP**	***%SP***
1	Tahidu Nindow	17	1360	183	259	267	***19.6***
2	Sayibu Nindow	17	1360	314	391	390	***28.7***
3	Peter Y. Alhassan	17	1360	159	240	244	***17.9***
4	Alhassan Salifu	**18**	**1440**	190	266	269	***18.7***
5	Fuseini Alhassan	17	1360	174	262	267	***19.6***
6	Dawuda Nindow	17	1360	189	241	**233**	***17.1***
7	Fuseini Issahaku	**18**	**1440**	215	309	**299**	***20.8***
8	Adam Alhassan(Baako)	**18**	**1440**	369	458	**452**	**31.4**
9	Alhassan Tahidu	17	1360	196	398	**329**	***24.2***
10	Yakubu Nindow	**18**	**1440**	236	350	396	***27.5***
11	Dawuda Alhassan	**18**	**1440**	256	353	357	***24.8***
12	Alhassan Imoro	17	1360	273	397	421	***31.0***
13	**Mohammed Yakubu**	**18**	**1440**	243	377	402	***27.9***
14	Sayibu Salifu	17	1360	177	316	322	***23.7***
15	Iddi Ibrahim	**18**	**1440**	162	282	300	***20.8***
16	Abukari Nabillah	17	1360	152	275	287	***21.1***
17	Musah Salifu	17	1360	165	262	267	***19.6***
18	Baba Sulemana	**18**	**1440**	196	295	319	***22.2***
19	Alhassan Nabila	17	1360	57	141	143	***10.5***
20	Abu Mutawakilu	17	1360	118	232	125	***9.2***

From a total of 27,840 minisett cuttings obtained, 4176 sprouts were recorded representing 15% sprout at 7 WAP of setts. The percentage sprout rose to 22% at 17WAP. Out of 25,600 minisett cuttings planted on Tingoli field (Table 2), 2931 sprouts were recorded 5WAP, representing 11.4% sprouted setts. The number of sprouted setts rose to about 7316 stands 15WAP, representing 28.6%.

The fields were harvested on the 6th and 7th December 2010 for Cheyohi and Tingoli respectively, and the yields are shown in the tables 3 and 4 below. The number of tubers per farmer's plot was not taken; hence, weight per tuber could not be estimated.

Table 2. Field Distribution Plan for Tingoli

Plot No.	**Name of Farmer**	**No. of rows**	**No. of cuttings planted**	**Number Sprouted**			
				5WAP	**8WAP**	**15WAP**	***%SP***
1	Nantogmah Zakaria	16	1280	125	296	379	***30.9***
2	Fuseini Issah	16	1280	129	306	367	***28.7***

3	Kojo Fatawu	16	1280	130	307	379	***30.9***
4	Kojo Zakaria	16	1280	113	290	330	***25.8***
5	Alhassan Abdulai	16	1280	186	372	433	***33.8***
6	Danaa Mohammed	16	1280	191	370	438	***34.2***
7	Mustapha Kpahinbang	16	1280	132	316	368	***28.8***
8	Sayibu Mohammed	16	1280	144	276	302	***23.6***
9	**Iddrisu Abu**	16	1280	99	193	324	***25.3***
10	Abibu Tahidu	16	1280	121	272	319	***24.9***
11	Sulemana Alhassan	16	1280	134	320	**274**	***21.4***
12	Alhassan Napari (Kamonaa)	16	1280	109	339	**303**	***23.7***
13	Issahaku Inusah	16	1280	105	259	308	***24.1***
14	Danaa Abdulai	16	1280	135	293	357	***27.9***
15	Issahaku Issah	16	1280	161	299	372	***29.1***
16	Moro Azindow	16	1280	171	310	372	***29.1***
17	Afa Abdala	16	1280	179	305	377	***29.5***
18	Abdulai Ziblim	16	1280	167	377	415	***32.4***
19	Alhassan Mohammmed	16	1280	204	481	**461**	***36.0***
20	Tahidu Zakaria	16	1280	196	384	438	***34.2***

Table 3. Harvest data for Cheyohi

Plot No.	Name of Farmer	Plant stand @ harvest	Yield in (kg.)
1	Tahidu Nindow	220	64.3
2	Sayibu Nindow	355	67.1
3	Peter Y. Alhassan	224	62.0
4	Alhassan Salifu	219	39.7
5	Fuseini Alhassan	250	60.4
6	Dawuda Nindow	237	40.9
7	Fuseini Issahaku	277	55.6
8	Adam Alhassan(Baako)	434	93.0
9	Alhassan Tahidu	298	57.0
10	Yakubu Nindow	315	83.0
11	Dawuda Alhassan	323	76.5
12	Alhassan Imoro	417	141.4
13	Mohammed Yakubu	380	111.9

14	Sayibu Salifu	265	58.6
15	Iddi Ibrahim	207	37.7
16	Abukari Nabillah	231	38.4
17	Musah Salifu	223	34.1
18	Baba Sulemana	**242**	**23.6**
19	Alhassan Nabila	86	10.1
20	Abu Mutawakilu	176	26.04

Technology developed:
Large scale production of "Pona" seed-yam using yam minisett techniques through farmer participatory approach was demonstrated to encourage pona seed-yam production.

Technology transferred
Twenty (20) farmer groups from Cheyohi and Tingoli in the Tolon/Kumbugu district were assisted to produce "Pona" seed yam using the yam minisett technology to demonstrate the possibility of increased seed-yam production for the recalcitrant yam varieties.

Conclusion
The yield response of the Pona variety to minisett seed-yam technology was low. These could partly be attributed to poor management by the farmers. Out of these harvested produce, 60% of the yield were given to the each farmers as payment their labour input into the seed yam production.

Table 4. Harvest data for Tingoli

Plot No.	Name of Farmer	Plant stand @ harvest	Yield in (kg.)
1	Nantogmah Zakaria	347	61.20
2	Fuseini Issah	305	51.80
3	Kojo Fatawu	356	58.90
4	Kojo Zakaria	335	34.70
5	Alhassan Abdulai	409	55.90
6	Danaa Mohammed	409	63.90
7	Mustapha Kpahinbang	336	44.90
8	Sayibu Mohammed	260	35.10
9	**Iddrisu Abu**	252	24.10
10	Abibu Tahidu	311	46.80
11	Sulemana Alhassan	326	46.50
12	Alhassan Napari (Kamonaa)	376	52.00
13	Issahaku Inusah	299	54.20
14	Danaa Abdulai	328	49.50
15	Issahaku Issah	288	37.80
16	Moro Azindow	327	53.40
17	Afa Abdala	262	40.30

18	Abdulai Ziblim	349	85.50
19	Alhassan Mohammmed	436	86.50
20	Tahidu Zakaria	345	40.10

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Determining Mineral Fertilizer Requirements for Yam on Benchmark Soils in Northern and Upper West Regions of Ghana

Dr. Benjamin Ahiabor, S. S. Buah, A.M. Mohammed, J. Adjebeng-Danquah, M. Fosu

Executive Summary

This project seeks to determine the growth, yield and nutrition response of yam to NPK fertilizers on benchmark soils in the Northern and Upper West Regions of Ghana that will lead to the development of recommended rates for yam. The effect of these fertilizers on storability and culinary qualities of yam is also being investigated. Twelve (12) farmers in the two target regions were selected and the total seed-yam required for project implementation on-farm was purchased and stored in a barn. Soils sampled from the Northern Region have been characterized and analysed for their physical and chemical properties. Soils from Cheshegu, Kpachi and Kpalsawgu have been identified as Kumayili series (Haplic Lixisol), Nyankpala series (Plinthosol) and Wenchi (deep) series (Petric Plinthosol). According to World Reference Base (WRB) classification, Jakpaful, Demonayili and Kpagturi soils are respectively a Plinthosol, Plinthosol and Petric Plinthosol. The soils are generally not rich in N, P and K and are either moderately or slightly acidic. Per cent organic matter content was generally average in almost all the soils. However, the Kpachi soil has high levels of available P (29.34 mg P/kg).

Introduction

Yam (*Dioscorea rotundata)* is a major staple in West Africa and apart from being popular in household diets of the people of northern Ghana, it is also an important cash crop. In spite of the enormous importance attributed to yam, the crop has been the least considered on the scale of preference for fertilizer application aimed at yield improvements by farmers in northern Ghana. In Ghana yam yield is estimated at 5.5 t/ha (unpublished data, MoFA, 1990) but it is recognized that yields of 10 t/ha are achievable.

The need for this project is pressing because fertile virgin lands which are traditionally used for yam cultivation have become almost non-existent. This, coupled with absence of recommended fertilizer rates for yam on impoverished soils of northern Ghana, has led to a drastic decline in the yields of yam. Indeed farmers are reluctant to apply soil amendments especially inorganic fertilizers because they believe these factors have detrimental effects on cooking and storage qualities of harvested tubers (ICRA, 1996). Despite this perception, the critical fertilizer nutrient levels at which the shelf life is reduced has not been researched into. More so, soils of these parts of Ghana are inherently poor in plant nutrients, especially nitrogen and phosphorus. Consequently, the yield of yam has since been dwindling annually on these soils.

In this project therefore, the effects of varying levels of NPK fertilizer nutrients on growth, tuber yield, nutritional responses, culinary qualities and shelf-life of yam were assessed. An innovative aspect of this project is the involvement of farmers in the development of the technology which can help speed up its adoption

Materials and methods

Site and Farmer Selection

Communities in two yam-growing districts each in Northern and Upper West Regions were selected. These were Tolon-Kumbungu District (Cheshegu, Kpachi, Kpalsawgu) and Nanumba North District (Demonayili, Kpagturi, Jakpaful) in the Northern Region and Wa Municipality (Kpongu 1, Kpongu 2, Kpongu 3) and Sissala West District (Sorbelle, Silbelle 1, Silbelle 2) in the Uper West Region. Three yam farmers were selected in each of the 4 target districts in the two regions. The coordinates of the respective sites were taken as shown in Table 1.

Soil sampling and characterization

These activities were carried out in all the four target districts with the assistance of staff of Soil Genesis, Survey and Classification Division of CSIR-Soil Research Institute, Kumasi. The soils from the two regions were air-dried and sieved (0.25 cm mesh) but only those from the Northern Region were analysed for their chemical and physical properties.

Seed- yam acquisition

All the seed-yam required were procured very early in the year 2010 from individual farmers in the Tolon-Kumbungu District. These seeds were stored in a concrete barn at SARI’s experimental field. The barn was sprayed against insects and rodents prior to the packing of the seeds into it. Inside the barn, the seeds were spread on locally-woven straw mats (called *zana* mats) on wooden shelves. Unfortunately, by the planting time quite a lot of the seeds got bad and those that did not lost viability

Land preparation and planting

After ploughing, mounds were raised at 1 m intervals in plots of 4 m x 4 m dimension and the seeds of the yam variety *Laribako* was planted giving a total of sixteen mounds per plot. Each plot was separated from the other by a 0.5 m alley. Table 2 shows the respective durations after which the plants were harvested at the various locations:

Table 1: GPS coordinates of the sites where Laribako was grown and fertilized in the Northern and Upper West Regions in 2010.

District	**Trial Site**	**Gps Coordinates**	**Name of Farmer**
Tolon-Kumbungu	Town-centre*	09°24'11.9"N 000°59'01.4"W	
	Kpachi	09°25'57.0"N 000°58'21.0"W	Hudu Wumbei
	Kpalsawgu	09°23'51.0"N 001°00'52.4"W	Mohammed Wunibiyele
	Cheshegu	09°27'18.9"N 000°57'23.2"W	Ibrahim Shaibu
Nanumba North	Town Centre*	08°51'28.3"N 000°03'23.0"E	
	Demonayili	08°36'48.7"N 000°00’22.9"E	Yakubu Mutaru
	Kpagturi	08°51'35.7"N 000°01'40.3"E	Mahammadu Mahama
	Jakpaful	08°52'45.6"N 000°04'36.3"E	Abdulai Mahama
Wa Municipal	Town Centre*	10°04'25.5"N 002°30'25.7"W	
	Kpongu	09°58'46.8"N 002°30'38.4"W	Yakubu Abu
	Kpongu	09°59'11.3"N 002°30'30.8"W	Abudu Kassim
	Kpongu	09°59'11.3"N 002°31'55.6"W	Hamari Olo-naa
Sissala West	Sorbelle (Town Centre*)	10°52'49.7"N 002°03'55.3"W	
	Sorbelle	10°54'00.2"N 002°05'00.7"W	Yakubu Adama
	Silbelle(Town Centre*)	10°53'15.6"N 002°02'54.4"W	
	Silbelle	10°53'44.6"N 002°02'06.8"W	Alhasa Bakilu
	Silbelle	10°55'25.9"N 002°02'08.1"	Nuhu Issifu**

*These are not trial sites but usually some central location in the main town/village closest to where the trial was located.

Table 2. Dates of planting and harvesting of Laribako grown in the Northern and Upper West Regions of Ghana in 2010.

District	Site	Farmer	Date of Planting	Date of Harvest	Days After Planting
Tolon-Kumbungu	Cheshegu	Ibrahim Shaibu	23 April	30 Nov.	221
	Kpachi	Hudu Wumbei	30 April	1 Dec.	214
	Kpalsawgu	Mahammed Wunibiyele	5 May	16 Dec.	225
Nanumba North	Jakpaful	Abdulai Mahama	22 April	8 Nov.	200
	Demonayili	Yakubu Mutaru	19 April	9 Nov	204
	Kpagturi	Mahamadu Mahama	24 April	8 Nov	198
Wa Municipal	Kpongu	Yakubu Abu	25 May	1 Dec	190
	Kpongu	Abudu Kassim	5 May	1 Dec	216
	Kpongu	Hamari Olo-naa	2 May	2 Dec	214
Sissala West	Sorbelle	Yakubu Adama	2 June	3 Dec	184
	Silbelle	Alhassan Bakilu	31 May	3 Dec	186

Replication
Three farmers per district were the replicates except in Sissala West where onlytwo farmers planted the trial.

Fertilizer treatments
The following fertilizer (N, P, K) levels constituted the treatments in a factorial design:
(i) N (0, 40, 80, 120 kg/ha),
(ii) P (0, 40, 80 Kg P_2O_5/ha),
(iii) K (0, 40, 80, 120 kg K_2O/ha).

The combinations resulted in a total of forty-eight treatments per farmer. The fertilizers were applied in two splits with the basal application done two months after planting on average and the top dressing carried out about one-and-half months after the basal dose.

Weeding

This was carried out by the farmers themselves as and when necessary. At Cheshegu, for example, the farmer did as many as four weedings as the main weed was Comelina.

Harvesting

Tubers were harvested from four inner mounds out of sixteen mounds per plot (treatment) and their fresh weights taken on a field balance whereas the vines were transported to the laboratory where they were oven-dried at 80^oC for 48 h and the dry recorded. Dry weights of the tubers were determined by chopping weighed subsamples of the fresh tubers into small pieces before oven-drying at 80^oC for 96 h. The per cent moisture content was then calculated and the value was used to compute the dry weights of the harvested fresh tubers. At the time of harvest, all the leaves had dropped from the vines hence no leaves were harvested for analysis.

Sensory (Palatability) test

Tubers harvested from three trials in the Nanumba North District were used for sensory test on 23rd November, 2010 at the Kpachi community in the Tolon-Kumbungu District. Women were engaged to boil the yam according to their normal local practice. The taste evaluation was done by twelve groups of women and six groups of men with each group consisting of five people. After tasting the boiled yam, the members of a particular group conferred among themselves and ranked the taste as very good (3), good (2), or poor (1). The data is yet to be analyzed.

Rotting test

One tuber each was selected at random from treatments T0 (0 kg N, 0 kg P_2O_5, 0 kg K_2O per ha), T3 (0 kg N, 0 kg P_2O_5, 120 kg K_2O per ha), T8 (0 kg N, 80 kg P_2O_5, 0 kg K_2O per ha), T11 (0 kg N, 80 kg P_2O_5, 120 kg K_2O per ha), T36 (120 kg N, 0 kg P_2O_5, 0 kg K_2O per ha), T39 (120 kg N, 0 kg P_2O_5, 120 kg K_2O per ha), T44 (120 kg N, 80 kg P_2O_5, 0 kg K_2O per ha) and T47 (120 kg N, 80 kg P_2O_5, 120 kg K_2O per ha) from the Kpachi, Cheshegu and Kpalsawgu trials for this test. The tubers were put in the concrete yam barn at the SARI's experimental field at Akukayili where their weights were being taken weekly in order to monitor any deterioration in the tubers. The weekly ambient temperature was also recorded.

Results and Discussion

Scientific findings

Tuber yield and average tuber size, vine dry biomass and the average per cent moisture content are shown in Tables 3a and 3b, and Tables 4a and 4b, respectively. Differences observed in these parameters as a result of imposition of the different fertilizer combinations, were not statistically significant. As such, only the treatments with the first five highest values are shown in the tables mentioned above. The highest tuber yields in the Nanumba North district and Wa Municipality were obtained without including K in the fertilizer nutrient combinations whereas all the nutrients were important in raising yam tuber yield in the Tolon-Kumbungu and the Sissala West Districts with even N being required in its highest amount (Tables 3a and 3b). Generally, both the mean highest tuber yield and largest tuber size were obtained in the Nanumba North district (Tables 3a and 4a) with the tubers weighing almost twice as much as those from the other districts.

Table 3a. Effect of fertilizer rate on tuber yield (kg/ha) of yam grown in some four districts in The Northern and Upper West Regions of Ghana

Treatment ($N-P_2O_5-K_2O$)	Nanumba North	Treatment ($N-P_2O_5-K_2O$)	TolonKumbungu
40-80-0	2592	120-40-40	1885
40-40-80	2468	80-80-120	1690
120-0-80	2396	0-80-80	1565
120-0-120	2333	80-40-40	1526
80-40-80	2332	120-40-120	1485
MEAN	**1998**		**1169**
LSD $_{(0.05)}$	**NS**		**NS**

Table 3b. Effect of fertilizer rate on tuber yield (kg/ha) of yam grown in some four districts in The Northern and Upper West Regions of Ghana

Treatment ($N-P_2O_5-K_2O$)	Sissala East	Treatment ($N-P_2O_5-K_2O$)	Wa Municipal
120-40-80	2375	80-40-0	1158
120-40-120	2225	80-80-40	1081
80-80-120	2026	40-80-80	1073
80-80-40	1920	120-80-0	1033
40-40-0	1877	120-40-120	1020
	1260		**741**
LSD $_{(0.05)}$	**NS**		**NS**

The results of the palatability test showed that generally the presence of a very high dose of N improved the taste of yam and this became more pronounced when K is excluded in the treatment. Women ranked yam treated with 120N-0P-0K as the tastiest whilst men ranked yam treated with 120N-80P-0K as the tastiest.

Table 4a. Effect of fertilizer rate on average tuber size (g) of yam grown in some four districts in the Northern and Upper West Regions of Ghana

Treatment ($N-P_2O_5-K_2O$)	Nanumba North	Treatment ($N-P_2O_5-K_2O$)	Tolon-K
0-40-40	384	80-0-120	124
40-0-40	221	120-40-0	116
120-0-0	209	0-40-80	114
0-80-80	178	0-80-40	109
120-40-120	177	0-80-80	96
MEAN	**127**		**68**

Table 4b. Effect of fertilizer rate on average tuber size (g) of yam grown in some four districts in the Northern and Upper West Regions of Ghana

Treatment ($N-P_2O_5-K_2O$)	Sissala East	Treatment ($N-P_2O_5-K_2O$)	Wa Municipal
120-40-80	119	80-40-80	174
120-40-120	111	80-40-0	116
80-80-40	100	40-80-40	92
0-80-120	96	0-40-120	82
40-0-40	91.2	40-80-80	76
	65		**57**

Conclusions/Recommendations

Since the project is still in the implementation state, it is not possible to draw any meaningful conclusions yet. However, it seems the different N, P, K fertilizer combinations applied to the yam did not have any differential effects on the parameters measured. This may be attributed to the late application (two months after planting) of both the basal N and K. It is therefore recommended that this period be reduced to about four weeks after planting in any future work

References

ICRA. 1996. Production and marketing of yams in the forest/savanna transition zone of Ghana. Working Document Series 53. International Centre for Development Oriented Research in Agriculture, Wageningen, The Netherlands.

Farmer Field Fora Implementation under the Root and Tuber Improvement and Marketing Programme

Dr. S. K. Asante

Executive summary

The Farmer Field Fora (FFF) implementation which began in 2007 is still on-going (CSIR-SARI Annual Report 2007). The objective of the FFF implementation is to bring researchers, extension agents and farmers together to identify constraints to root and tuber crop production, conduct experiments to develop technologies to address the constraints and implement or disseminate these technologies together. The FFFs ensure that the priorities of farmers, processors, consumers and marketers are ascertained in a systematic manner. So far 40 FFFs have been conducted on cassava, yam and sweet potato in 2008, 2009 and 2010. During the year under review, 20 FFFs were conducted in 10 districts. Before the activities started, Participatory Rural Appraisal (PRA) was conducted to: interact with the farmers; know their farming practices; challenges; select the thematic area for the training, select Fora participants, select site or land for the Fora and develop learning guide. Based on the constraints or challenges identified with the farmers, the 20 FFFs were established in the following districts: Nkwanta south, Nkwanta north, West Gonja, East Gonja, Nanumba North, Nanumba south, Kassena-Nankana East, Kassena-Nankana West, Kpandai and Saboba. A total of 1,369 farmers, traders and processors were involved in the training.

After the land preparation for the yam cultivation, the farmers realized that their practice results in considerably low plant population. Whereas three hundred (300) mounds were obtained in the integrated crop management (ICM), plot, the farmers practice plot gave a range of 144 – 231 mounds from the same land area. Also, percentage sprouting was higher on the ICM plot than that of the Farmer practice plot. In addtion, pest infestation was higher on FP than ICM plot. At harvest, the farmers observed that the number of tubers obtained from the ICM plot was more, weighed higher and also pests and diseases free than that of the FP due to closer mounding, application of fertilizer and insecticide. Therefore, the farmers concluded that the yield from ICM plot would give them more money than their normal practice. Hence, they pledged to adopt ICM practices such as closer mounding, seed treatment, application of fertilizer and farm sanitation in their farms during the next cropping season.

Background

The Farmer Field Fora (FFF) implementation which began in 2007 is still on-going (CSIR-SARI Annual Report, 2007). So far 40 FFFs have been conducted on cassava, yam and sweetpotato in 2008, 2009 and 2010. The objective of the FFF implementation is to bring researchers, extension agents and farmers together to identify constraints to root and tuber crop production, conduct experiments to develop technologies to address the constraints and implement or disseminate these technologies together. The FFFs ensure that the priorities of farmers, processors, consumers and marketers are ascertained in a systematic manner. The topics to be address by FFFs are identified by the farmers through Participatory Rural Appraisal (PRA) and they are proactively encouraged to take charge of the experiments and trials.

Materials and Methods

Season-long Farmer Field Fora (January to December 2010)

Curriculum was developed for each of the selected Root and Tuber crops to begin Farmer Field Fora (FFF) in 10 districts in Zone 1. Before the programme started, Participatory Rural Appraisal (PRA) was conducted to: interact with the farmers; know their farming practices; challenges; select the thematic area for the study, participants, site or land for the fora and develop learning guide. Based on the constraints or challenges identified with the farmers, twenty (20) Farmer Field Fora (FFFs) were established as follows: Nkwanta south (Cassava), Nkwanta north (Yam), West Gonja (Cassava), Nanumba North (Yam), Nanumba south (Yam), Kassena-Nankana East (Sweet potato), Kassena-Nankana West (sweet potato), Kpandai (Yam) and Saboba (Yam) (see Tables 1,2,3,4,5 and 6). A total of 800 farmers, traders and processors were involved in the training.

Results and Discussions

Participatory Rural Appraisal (Pra)

The Farmer Field Fora which is a season-long activity was preceded by a participatory rural appraisal (PRA) which was conducted in 20 communities in the selected 10 districts to:

- Interact with the famers to know their farming practices, challenges or constraints
- Select the thematic area, participants and site for the Fora
- Develop a Learning Guide

Some of the constraints mentioned by farmers in Zone 1;

Cassava

- Inability to keep proper farm records mainly due to illiteracy
- High mortality of stored planting materials
- Inability to identified improved varieties
- Inability to separate healthy planting materials from unhealthy ones
- Lack of knowledge and skills in handling and proper use of agrochemicals
- Lack of skills in plant spacing to ensure optimum plant density

- Destruction of planting materials by bush fire and animals (cattle, goats and sheep)
- Harvesting is tedious and drudgery
- Lack of technology for storage of fresh cassava
- Lack of market for cassava produce and products
- High cost of labour for land preparation, planting, and weed management

Table 1. Communities and crops on which the PRA was conducted

District	**Community**	**Date**	**No. of participants**		**Crop**
			M	**F**	
	Nabori	20 -5-10	37	21	Cassava
West Gonja	Mempeasem	20-7-10	26	26	Cassava
	Yakubupe	27-5-10	32	12	Cassava
East Gonja	Kakoshie	28-6-10	28	14	Cassava
	Gbungbaliga	18-5-10	29	14	Yam
Nanumba south	Wulensi C-Line	7-7-10	31	20	Yam
	Bakpaba	6-6-10	53	36	Yam
Nanumba north	Kpagturi	26-6-10	41	29	Yam
Kpandai	Onyumba	22-5-10	115	88	Yam
	Ekumdi-Overbank	28-7-10	62	23	Yam
Saboba	Gbadagbam	20-5-10	27	19	Yam
	Chapong	05-7-10	30	27	Yam
Nkwanta north	Jato-Krom	21-5-10	47	10	Yam
	Jumbo	04-7-10	29	13	Yam
Nkwanta south	Pusupu	09-7-10	42	29	Cassava
	Agua-Fie	06-7-10	38	24	Cassava
Kassena-Nankana East	Nyangua	07-7-10	37	27	Sweetpotato
	Upper Telania	09-7-10	54	36	Sweetpotato
Kassena-Nankana West	Nyangnia	14-7-10	45	28	Sweetpotato
	Bembisi	21-7-10	49	21	Sweetpotato
Total			**852**	**517**	

Yam

- Inability to keep proper farm records mainly due to illiteracy
- Inadequate planting materials
- Lack of improved varieties
- Lack of skills in spacing mounds to ensure optimum plant density
- Lack of knowledge and skills in handling and proper use of agrochemicals
- Lack of technical knowledge on fertilizer and manure application
- Lack of knowledge on identification and control of pests and diseases
- Limited knowledge and skills in post-harvest handling and storage
- Limited knowledge in processing of yam
- Lack of means of transport to cart harvested yam to markets
- High cost of labour for land preparation (ploughing and mounding) and weed management

Sweet potato

- Inability to keep proper farm records mainly due to illiteracy
- Unavailability of planting materials of improved varieties
- Difficulty in conserving/storing planting materials
- Low soil fertility and lack of technical knowledge on application of fertilizer and manure
- Lack of knowledge on identification and control of pests and diseases
- Limited knowledge on processing and storage of fresh potato
- Lack of skills in spacing to ensure optimum plant density
- Lack of market and low prices of produce

Yam (*Dioscorea rotundata*)

After the land preparation, the farmers realized that their practice results in considerably low plant population. Whereas three hundred (300) mounds were obtained in the ICM plot, the farmers practice gave a range of 150 – 231 mounds. Also, percentage sprouting was higher on the ICM plot than the Farmer practice plot. Due to seed treatment before planting
At the end of the study, the farmers observed that the number of tubers obtained from the ICM plot was more and also weighed higher than that of the FP. Fertilizer (inorganic and organic) treated plots yielded higher than the farmer practice (untreated) plot (Tables 7, 8 & 9). Also pest infestation was higher on FP than ICM (Table 10). Therefore, the farmers concluded that the yield from ICM plot would give them more money than their normal practice. Hence, they pledged to adopt ICM practices such as closer mounding, seed treatment, application of fertilizer and farm sanitation in their farms during the next cropping season.

Table 2. Number of FFFs Established per district and thematic areas

District	**No. of FFF per district**	**Crop**	**Thematic area**
West Gonja	2	Cassava	Improved cultivation practices
East Gonja	2	Cassava	Integrated pests and diseases management
Nanumba south	2	Yam	Integrated soil fertility management
Nanumba north	2	Yam	Integrated pests and diseases management
Kpandai	1	Yam	Integrated pests and diseases management
	1	Cassava	Improved crop varieties
Saboba	2	Yam	Integrated soil fertility management
Kassena-Nankana East	2	Sweet potato	Improved cultivation practices
Kassena-Nankana West	2	Sweet potato	Improved cultivation practices
Nkwanta north	2	Yam	Integrated soil fertility management
Nkwanta south	2	Cassava	Improved cultivation practices

Table 3. Location and number of FFF sessions conducted

District	**Location**	**Date of planting**	**Thematic area**	**Sessions conducted**	**No. of participants**	
					M	F
West Gonja	Nabori	25 -6-10	Cultivation practices	8	28	12
	Mempeasem	23-07-10	Cultivation practices	5	22	18
East Gonja	Yakubupe	22-06-10	IPDM	7	26	14
	Kakoshie	20-07-10	IPDM	5	31	9
Nanumba south	Gbungbaliga	20-05-10	ISFM	10	34	6
	Wulensi C-line	09-07-10	ISFM	10	27	13
Nanumba north	Bakapba	30-06-10	IPDM	10	28	12
	Kpagturi	07-07-10	IPDM	10	22	18

Kpandai	Onyumbo	24-06-10	IPDM	10	24	16
	Ekumdi Overbank	09-09-10	Varieties	5	30	10
Saboba	Gbadagbam	07-07-10	ISFM	8	26	14
	Chakpong	09-07-10	ISFM	6	19	21
Nkwanta north	Jato-Krom	07-06-10	ISFM	8	25	15
	Jumbo	08-07-10	ISFM	6	30	10
Nkwanta south	Pusupu	20-07-10	Cultivation	8	22	18
	Agua-Fie	22-07-10	Cultivation	8	23	17
Kassena-Nankana East	Nyangua	21-07-10	Cultivation	8	26	14
	Upper Telania	24-07-10	Cultivation	8	26	14
Kassena-Nankana West	Nyangnia	22-07-10	Cultivation	8	20	20
	Bembisi	27-07-10	Cultivation	8	20	20
Total					**509**	**291**

Table 4. Learning plots for Yam FFFs

No.	Plots	Description
1	Farmer Practice (FP)	Haphazard and widely spaced mounding on 24m x 18m land area which gave 150-240 mounds. Some staked and others non-staked
2	Integrated Crop Management (ICM)	Mounding was done on 24m x 18m land area with 1.2m x 1.2m spacing which gave 300 mounds. All staked. **Seed Treatment** Seeds for the ICM plot were treated with Fungicide/Insecticide mixture before planting as follows; *Fungicide*: Manzocarb, Rodomil (4 match boxes/15 litres of water) *Insecticide*: Deltametrin (10ml in 15 litres of water)
3	Participatory Action Research (PAR)	Mounding was done on 24m x 18m land area with 1.2m x 1.2m spacing. Seeds were treated as stated in ICM . *Saboba district*: 1 match box (approx. 10gm) of NPK placed at one side of the mound as against ring application *Nkwanta north district*: (i) Staking against non-staking (ii) Timely weed control against farmer's practice (iii) Bat slurry against NPK and control *Nanumba north*: Yam intercropped with millet against sole yam *Nanumba south*: Manure against NPK

Table 5. Learning Plots for Cassava FFF

No.	Plots	Description
1	Farmer Practice (FP)	**Nkwanta south:** Three (3) local varieties (Anlo bankye, Adekpor) planted haphazardly on the flat **West Gonja:** Local variety planted haphazardly on mounds
2	Integrated Crop Management (ICM)	**Nkwanta south:** Tek bankye, Bankye Hemaa, Fil-indiakong planted at 1m apart on flat land **West Gonja:** Nyerikobga planted at 1m apart on mounds
3	Participatory Action Research (PAR)	**Nkwanta south:** Improved and local varieties planted on flat and mounds **West Gonja:**

Table 6. Learning plots for Sweet potato FF

No.	Plots	Description
1	Farmer Practice (FP)	Farmers ridge was about 45cm high, 45cm wide and 10m long; Vine length 15cmplanted 2 rows on the bed at 15cm apart. Soil fertility management: One head pan (12kg) of farm yard manure per bed was applied before planting. Variety used: Tek-Santum
2	Integrated Crop Management (ICM)	Beds were ridged at 1m apart (i.e. from middle of one bed to the middle of the adjacent bed) and 10m long; Vine length was 30cm, and planting was done at one row in the middle of the ridge with 30cm between stands/vines. **Soil fertility management:** (i) One head pan (12kg) of farm yard manure per bed was applied before planting. Variety used: Tek-Santum (i) Inorganic fertilizer (NPK) 30-45-60kg/ha (one tea spoon about 6g) was applied two weeks after planting
3	Participatory Action Research (PAR)	(i) Comparing the performance of bed type (ii) Comparing the performance of 3 improved varieties viz. CRO-Otoo, Faara and Tek-Santum with a local variety.

Table 7. Yield of yam under different treatments at Gbadagbam in Saboba district

Treatment	Plot size	Total no. of mounds per plot	Total no. of yam tubers harvested	Total weight of yam (kg)
FP (No. treatment)	24m x 18m	281	280	256.8
ICM (Inorganic fertilizer)	24m x 18m	300	321	321.5
PAR (Manure)	24m x 18m	300	285	329.0

Table 8. Yield of yam under different treatments at Chakpung in Saboba district

Treatment	Plot size	Total no. of mounds per plot	Total no. of yam tubers harvested	Total weight of yam (kg)
FP (No. treatment)	24m x 18m	231	154	71.6
ICM (Inorganic fertilizer)	24m x 18m	300	245	121.6
PAR (Manure)	24m x 18m	300	241	74.0

Table 9. Yield of yam under different treatments at Gbungbaliga in Nanumba south district

Treatment	Plot size	Total no. of mounds per plot	No. of mounds harvested	Total no. of tubers harvested	Total weight of tubers (kg)
FP	24m x 18m	186	164	309	535.0
ICM	24m x 18m	300	241	401	656.8

Table 10. Number of yam tubers infested by pests and diseases at Onyumbo in Kpandai district

Treatment	Mealybugs	Millipedes	Termites	Tuber beetle	Nematodes	No. of rotten tubers
FP (No. treatment)	12	22	4	0	0	3
ICM (Neem seed)	0	15	2	0	0	0

Biological control of the larger grain borer, *Prostephanus truncatus* (Horn) in northern Ghana

S. K. Asante

Executive summary

Work on the biological control of the larger grain borer (LGB), *Prostephanus truncatus* Horn which was started at CSIR-SARI in 2001 is still in progress. *Prostephanus truncatus* which is the most damaging pest of stored dried cassava chips and maize in storage is being controlled by an exotic predatory beetle, *Terestrus nigrescens* Lewis, an environmentally friendly antagonist. The main objective is to reduce postharvest losses in dried cassava chips to economically acceptable level by managing the LGB populations using this predatory beetle. So far (i.e., from 2001 to 2010), 433,339 predators have been produced in the laboratory and released in 148 locations in 10 districts in northern, Volta and Brong-Ahafo regions of Ghana. During the year under review, 90,000 predators were reared and released in 33 locations in five districts of northern region.

Background

The larger grain borer (LGB), *Prostephanus truncatus* (Coleoptera: Bostrichidae), is the most damaging pest of dried cassava chips in storage. As part of an effort to improve cassava production and storage under the Root and Tuber Improvement Programme (RTIP), work on the biological control of this economically important pest which was started at CSIR-SARI in 2001 is still in progress (Annual Reports 2007, 2008 and 2009).

Materials and methods

Work on the biological control of the larger grain borer (LGB) started in 2001 in the northern region when samples of the predator were obtained from the Plant Protection and Regulatory Services Division (PPRSD) of the Ministry of Food and Agriculture (MOFA) at Pokuase. The main activities involved in the study include; (i) laboratory mass production of the predator

(ii) baseline survey (iii) releases into areas of high pest incidence (iv) monitoring of establishment and spread and (v) impact assessment. The steps for mass rearing of LGB predator (*T. nigrescens*) are described in Annual Report 2009.

Results and Discussions

From August 2001 to December 2010, 433,339 predators have been produced in the laboratory and released in 148 locations in 10 districts in northern, Volta and Brong-Ahafo regions. The districts are West Gonja, East Gonja, Yendi, Nanumba north, Nanumba south, Zabzugu-Tatale,Tolon-Kumbungu, Central Gonja, Nkwanta north and Kintampo. Baseline survey of 145 farmers and traders was conducted in these locations before the predators were released to enable us to compare the situation before and after release. During the period under review, 90,000 predators were reared in the laboratory and released in 33 locations in five districts (see Table 1).

Table 1. The larger grain borer predators reared and released in northern Ghana in 2010

Date	Metro/Municipal /District	Community	Number Released
09 – 02 - 2010	Kpandai	Mbowura II	4000
		Mbowura I	8000
		Kpandae Market area	4000
13 – 07 - 2010	West Gonja	Mempeasem	10000
		Kawankura	2000
		Tailorpe	2000
		Kojope	2000
		Janepe	2000
		Fufulso	2000
10 – 08 - 2010	East Gonja	Nyikata	6000
		Kayereso	4000
		Katanga	4000
09 – 09 - 2010	Kpandai	Tenglenton	2000
		Ekumede Overbank	2000
		Konjade	2000
		Kachilendi	2000
		Tekarini	2000
		Knyinkpan	2000
08 – 12 - 2010	Tamale Metro	Wamale	2000
		Zuo	2000
		Pagazaa	2000
		Zorborgu	2000
		Zakaliyili	2000
		Tugu	4000

		Tugu Yipala	2000
08 – 12 - 2010	Yendi Municipal	Botingli	2000
		Kpalkori	2000
		Jimli	4000
		Kpligine	2000
		Salinkpang	2000
		Sang	2000
		Puriya	2000
		D C Kuraa	2000
Total	**5**	**33**	**90,000**

On-farm evaluation of improved yam (*Dioscorea rotundata*) genotypes from IITA breeding programme

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Executive Summary

A trial was conducted at Mbowura, Kpandai district in Northern Region of Ghana during the 2010 cropping season to evaluate 10 improved yam genotypes from the IITA breeding programme for higher yield, pests and diseases resistance. The experimental design was randomised complete block design (RCBD) with three replications. Mounding and planting of the trial were done on the 11th and 12th May 2010. The total land area planted was 0.18 ha and there were 60 mounds per each genotype. Data collected include; percentage germination/establishment, pests and diseases attack/damage, tuer yield and food quality assessment. Percentage sprouting and establishment ranged from 67-100 (Mean: 87.2) with Laribako having the lowest establishment. A few stands were attacked by anthracnose and virus diseases. The pests found attacking the yam tubers were millipede, mealybug and nematode. Millipede infestation was high (16-56.9%) and was found on all the genotypes. All the improved genotypes yielded higher than the local checks (Puna and Laribako). The most promising genotypes in terms of yield were; 96/02610, 95/19158 and 95/01942. However, results from food quality assessment showed that farmers preferred genotypes 95/01942, 95/1894 and 95/19156 after Laribako and Puna.

Background and Justification

Yam, (*Dioscorea* spp.), are among the oldest recorded food crops believed to have originated in the tropical areas of three separate continents, Africa, Southeast Asia and South America (Burkill, 1960). The six most economically important *Dioscorea* species grown as staple foods in Africa are: *Dioscorea rotundata* (white guinea yam), *D. alata* (water yam), *D.*

cayenensis (yellow yam), *D. esculenta* (Chinese yam), *D. dumetorum* and *D. bulbifera* (aerial yam). estimated at 30.2 million metric tonnes in 1997 (FAO, 1998). In Ghana, the most cultivated yams are cultivars of *D. rotundata* (white yam) and *D. alata* (water yam). Yam is processed into various types of food such as fufu, boiled, roasted or grilled yam; mashed yam and chips in Ghana. Compared to other food crops such as cassava and plantain, yam tubers have better storability. Hence, farmers and retailers store them either in the ground or on racks in farm stores and gradually release onto the market, particularly during the lean season (i.e. between March and June). Yam therefore, contributes to food security in Ghana in addition to generating income for farmers from local trade and revenue for export.

Due to the important role yam plays in meeting the food needs of the rapidly increasing human population and also ensuring food security in general, there is the need to give attention to its genetic improvement. Over the years, farmers in northern Ghana have not had access to, improved and high yielding yam varieties despite its high market potential. Therefore, they continue to cultivate their local varieties which are low yielding due to their inherent genetic traits, reduced soil fertility and the biotic stress imposed by viruses, fungi, nematodes and insects. These constraints adversely affect yam production and reduce profits considerably.

In recent times, efforts to make genetic improvement a viable option for enhancing yam production have been vigorously pursued by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, who has the world mandate for yam improvement. Through such efforts, CSIR-SARI received ten (10) improved clones of white yam (*D. rotundata*) from the IITA in 2002 to be evaluated under the Regional Collaborative Trials in different agro-ecologies. Promising varieties which will be adapted to the various locations will be put together and tested on farmers' fields for evaluation and acceptability. Such on-farm trials are very essential because they give the farmer the opportunity to participate in the varietal selection and varieties selected this way will have a higher rate of adoption. Scientists at the Root and Tuber Section of SARI have evaluated these yam clones on-station at Nyankpala (Tolon-Kumbungu district, Northern Region) for the past seven years (i.e. from 2002 -2008) and some have proven to possess superior tuber yield and resistance to diseases and pests. The overall objective of the project is to evaluate and select with farmers and consumers yam clones from the IITA breeding programme that are adaptable to the food and farming systems in Guinea Savanna Zone of Ghana.

Methodology

Ten (10) yam genotypes (viz. 95/019156; 95/18949; 95/18922; 95/01942; 96/02025; 96/02610; 95/19158; 95/18544; 96/00595; 95/19177) were evaluated on-farm at Mbowura in Kpandai district of Northern Region alongside two best local varieties (Laribako and Puna) as “checks”. Farmer participatory evaluation and selection approach were adopted to obtain yam varieties that are high yielding, resistant/tolerant to pests and diseases and stable in performance. The experimental design was Randomised Complete Block (RCBD) and there were three replications for each genotype. Each plot consisted of twenty mounds about 0.4 m high and a base diameter of 1.4m. (i.e. the mounds were 1.4m apart). Land preparation (ploughing, mounding) and planting of trials were done between 1st and 12th of May 2010. The total land area planted was 0.18 ha and there were 20 mounds mounds per each genotype per replicate.

The vines were staked with wooden sticks of about 1.5m high on 31st July. Weed control was done first by using herbicide at 4 weeks after planting (i.e. before the seeds sprouted and formed leaves) and this was followed by hand weeding using hoe at 8, 12 and 16 weeks after planting. Harvesting was done on 17th December 2010. Thirty (30) farmers were involved in the evaluation of these yam genotypes. Data were collected on establishment, pests and diseases, yield, assessment of food quality based on: colour of peeled slices, appearance of cooked slices, texture, flavor and taste. The data were subjected to statistical analysis (ANOVA) to select the best genotypes.

Results

Germination and plant establishment were good since sprouting percentage ranged from 67 to 100 (Table 1). Assessment for pests and diseases conducted on 21 August 2010 indicated that a few stands were attacked by Anthracnose and virus diseases. Also, millipedes, mealybugs and nematodes were found to attack the tubers when assessment was done immediately after harvesting (Table 2). Moreover, assessment of yield indicated that all the improved genotypes tended to have higher yields higher than the local checks (Puna and Laribako) although the differences were not statistically significant (Table 3). The most promising genotypes in terms of yield were; 96/02610, 95/19158 and 95/01942. However, when the food quality of the different genotypes was assessed based on: colour of peeled slices, appearance of cooked slices, texture, flavour, taste, Farmers’ preference for the genotypes was as follows; Laribako, Puna, 95/01942, 95/1894, 95/19156, 96/00594, 95/19177, 96/02610, 95/19158, 96/02025, 95/18544, and 95/18922. The genotype (95/0142) which was the third highest yielding genotype was also selected by the farmers and consumers as the third most preferred genotype after Laribako and Puna when the food quality test was conducted.

Table 1. Percentage establishment of yam genotypes at Mbowura, Kpandai district

No.	Genotype Code	% Establishment
1	**95/019156**	**98.3**
2	95/18949	81.7
3	95/18922	78.3
4	95/01942	86.7
5	**96/02025**	**91.7**
6	**96/02610**	**100**
7	**95/19158**	**93.3**
8	**95/18544**	**100**
9	**Laribako**	**66.7***
10	**96/00594**	**98.3**
11	Puna	83.3*
12	**95/19177**	**68.3**
Mean		**87.2**

***Local checks**

Table 2. Percentage of yam stands infested or infected by pests and diseases at Mbowura in Kpandai district

No.	Genotypes	Millipede	Mealybug	Nematode	Anthracnose	Virus
1	96/02610	52.4	6.8	5.0	5.3	10.4
2	95/19158	52.8	9.4	1.7	1.8	14.4
3	95/01942	46.8	13.8	2.1	5.1	13.0
4	95/18922	45.1	**34.4**	0	3.5	5.3
5	95/18949	33.3	2.2	0	6.7	5.5
6	96/00594	43.7	9.0	0	5.0	**23.5**
7	95/019156	16.7	6.7	0	3.3	18.3
8	95/18544	51.7	7.7	6.7	6.7	15.0
9	96/02025	40.9	**23.8**	1.8	3.3	9.2
10	95/19177	56.9	9.7	**10.4**	1.7	13.6
11	Puna	47.0	16.9	1.9	1.9	**26.8**
12	Laribako	**65.2**	16.4	0	**7.8**	**30.3**

Table 3. Yield of improved yam genotypes planted at Mbowura in Kpandai district

No.	**Genotypes**	**Mean no. of tubers per mound**[1]		**Yield per mound (kg)**	**Mean wt. of tuber (kg)**	**Yield per 39.2m^2 (kg)**	**Yield (t/ ha)**
1	**96/02610**	**1.6**	**(1-5)**	**2.3**	**1.52**	**45.5**	**11.6**
2	**95/19158**	**1.7**	**(1-5)**	**2.0**	**1.11**	**40.7**	**10.4**
3	**95/01942**	**1.7**	**(1-4)**	**1.9**	**1.10**	**38.6**	**9.9**
4	95/18922	1.6	(1-4)	1.9	1.15	37.2	**9.5**
5	96/00594	1.6	(1-4)	1.9	1.21	37.0	**9.5**
6	95/18949	1.7	(1-4)	1.8	1.10	36.3	**9.3**
7	95/019156	2.2	(1-5)	1.8	0.84	35.9	**9.2**
8	95/18544	1.7	(1-4)	1.8	1.09	35.7	**9.1**
9	96/02025	1.9	(1-4)	1.8	0.94	35.0	**8.9**
10	95/19177	1.7	(1-4)	1.7	1.01	34.3	**8.8**
11	Puna	1.2	(1-4)	1.6	1.02	31.3	**8.0**
12	Laribako	1.9	(1-5)	1.8	0.66	23.5	**6.0**
	P-Value						**>0.5**

SOIL FERTILITY IMPROVEMENT

Calibrating the QUEFTS model for cassava fertilization in West Africa: The case of Ghana

Dr. B. D. K. Ahiabor and Guillaume K. S. Ezui (IFDC, Togo)

Executive Summary

After the first phase of this study consisting of calibrating the QUEFTS model for the fertilization of cassava by building a database during on-station fertilizer trials on cassava for two consecutive years, the second phase is focused on the validation of the QUEFTS model obtained from the calibration. This phase is being implemented especially on-farm and it involves validating N, P, & K fertilizer rates recommended by the QUEFTS model for cassava. Generally, cassava root yield was extremely low at all locations. Apart from the values recorded on-station all the other yield values obtained on-farm were not up to 10% of the targeted yields even though Afisiafi yielded close to 1 t/ha of root at Gbalahi. Above-ground growth of the varieties was also abysmally poor at all locations. The poor growth and yield responses of the varieties could largely be attributed to the late planting of the crops and the delayed application of the basal fertilizer N and K. Generally, root yield in Afisiafi was more than the rest of the varieties followed by Tek Bankye.

Introduction

Cassava constitutes an important calorie source in human and animal nutrition. It thrives under environmental conditions where most other crops do not succeed (GRET *et al*., 2002). In Sub-Saharan Africa, it is cultivated by several farmers, especially on impoverished soils. Almost all the parts of the cassava crop are taken off the field: animals and human feed on the leaves, while the stems serve in propagation through cuttings or as fuel-wood and the roots have multiple uses (*gari*, flour, *fufu*, *Attiéké*, tapioca, starches, etc.). The peels are used in feeding animals among other uses. This contributes to the impoverishment of the soil in essential nutrients, of which potassium is absorbed in large quantities by the plant (Howeler, 1985).

The lack of fertilizer application in cassava production and the non-existence of recommendations for soil types, contribute to worsen the situation making cassava production not very competitive for the market. It is therefore important to determine site specific fertilizer rates for cassava in order to promote its production while preserving the soil from degradation, consequently from mining the nutrients. The usage of the model QUEFTS (**QU**antitative **E**valuation of the **F**ertility of **T**ropical **S**oils) (Janssen *et al*., 1990), a decision support tool developed for the quantitative evaluation of initial fertility of tropical soils will assist to meet this objective. Initial soil fertility is an important factor that characterizes native fertility of every soil (Dobermann and Fairhurst, 2000). In quantifying the initial soil fertility level and the nutrient needs for an objectively targeted yield, the QUEFTS model is a powerful tool formulating N, P and K recommendations. Originally developed to determine fertilizer rates in maize production, QUEFTS is adaptable to other crops (Janssen *et al*., 1990).

The initial objective of this study was to calibrate the model QUEFTS for the determination of fertilizer rates for cassava. This calibration was done giving way to the subsequent objective of validating the growth and yield responses of four cassava varieties to N, P, and K fertilizer rates on-farm recommended by the calibrated QUEFTS model

Materials and Methodology

Soil sampling

Soil samples were taken at random from each trial site from the 0-20 cm and 20-40 cm layers for the determination of their physical and chemical properties. Profile pits have been dug at the trial sites for detailed characterization of the soil type which is yet to be done by staff of the Soil Genesis and Survey Division of the Soil Research Institute, Kumasi. This will be done in due course in order to have the results incorporated in the final report.

Procurement of planting materials

The varieties Afisiafi and Tek Bankye were purchased from the Roots and Tuber Improvement and Marketing Programme (RTIMP) at Damongo in the Northern Region of Ghana. The varieties Eskamaye and Nyerikobga were obtained from the Roots and Tuber Breeding Section of SARI (they were released by SARI). The yield potentials (fresh root) of Eskamaye and Nyerikobga are between 15.8-22.7 and 16.7-28.6 t/ha, respectively.

Land Preparation

The sites marked for the trials were ploughed with a tractor and mounds were raised with the hand-hoe and one cassava stick was planted per mound directly on top of the mound. The other details on the management of the trials are indicated in Table 2 below.

Treatments

Table 1. Targeted Root Yields & Fertilizer Treatment Combinations

Targeted Root Yield (t/ha)	Treatments	Rates (kg/ha)		
		N	P_2O_5	K_2O
-	T0	0	0	0
6.0	T1	48.75	0	95.0
6.5	T2	68.00	27.50	128.8
7.0	T3	82.25	27.48	154.5
7.5	T4	98.25	54.96	183.0

Table 2. Trial Information

Trial Location	Cassava variety	Planting Date	Basal fertilizer application	Top dressing	No. of Farmers
Gbalahi	Eskamaye & Nyerikobga	4/7/10	29/8/10	29/9/10	10*
Tingoli	Eskamaye & Nyerikobga	4/7/10	2/9/10	28/9/10	5
Savelugu.	Afisiafi & Tek Bankye	15/6/10	2/8/10	8/9/10	5
Akukayili (SARI Field)	Afisiafi & Tek Bankye	17/6/10	19/8/10 (Tek Bankye) 20/8/10 (Afisiafi)	3/10/10	Researcher-managed

*Each farmer planted two varieties.

Weeding

Weeding was done by the respective farmers as and when necessary using the hand-hoe.

Monitoring

At least two monitoring trips were made to the trial sites during the growth of the plants apart from the one conducted together with Mr. Guillaume Ezui on December 20-21, 2010

Trial harvest

Before the time of harvest, animals belonging to both Fulani herdsmen and the local people as well as wild fires (bush fires) destroyed a few of the trials. Those trials that survived are indicated below (Table 3). Even in some of the surviving trials (like the on-station one) we could not get leaves to harvest even though the stems were available to harvest.

Mode of harvesting

Four stands were harvested from the sixteen stands in each plot by cutting the stand at the base with a cutlass. The soil around the roots was then loosened with a hand-hoe and the roots gently pulled out. Any broken or detached roots were retrieved from the soil and added to the bulk

Table 3. Trials that survived and were harvested.

Trial Location	Type	No. of farmers	Name of farmer	Cassava variety	Date of harvest
Gbalahi	On-farm	5	Yakubu Alidu	Afisiafi & Eskamaye	26th & 28th Jan, 2011
			Seidu Alhassan	Afisiafi & Eskamaye	
			Abukari Mahamadu	Afisiafi only	
			Alhassan Mahamadu	Afisiafi & Nyerikobga	
			Yusif Napuro	Afisiafi & Eskamaye	
Tingoli	On-farm	3	Abass Tahiru	Eskamaye & Nyerikobga	3rd Feb, 2011
			Fuseini Issah	Eskamaye & Nyerikobga	
			Fuseini Fatau	Eskamaye & Nyerikobga	
Savelugu.	On-farm	2	Baba Alhassan	Afisiafi & Tek Bankye	17th Jan, 2011
			Abdulai Alhassan	Afisiafi & Tek Bankye	
Akukayili (SARI Field)	On-station	Researcher-managed		Afisiafi & Tek Bankye	8th Jan, 2011

These were then loaded into fertilizer sacks and weighed on a field balance and the weights recorded immediately. Sub-samples were then taken from the bulk roots from each stand and taken to the laboratory for dry weight determinations by drying in oven at 80^{o}C for 96 hours.

The cut stems were bulked and weighed on the field after which sub-samples were taken to the laboratory for dry weight determinations the same way as for the roots. Where leaves were present, they were picked from the stem and branches into sacks before the stands were cut at the base as described above. These leaves were also sent to the laboratory for drying in an oven at 80^{o}C for 48 hours. These data are, however, yet to be collated and analyzed.

Results and discussion

Scientific findings

Generally, cassava root yield was extremely low at all the locations. Apart from the values recorded on-station, all the other yield values obtained on-farm were not even up to 10% of the targeted yields (6.0-7.5 t/ha) even though Afisiafi yielded close to 1 t/ha of root at Gbalahi at Alhassan Mahamudu's field. Above-ground growth of the varieties was also abysmally poor at all the locations. The poor growth and yield responses of the varieties could largely be attributed to the late planting of the crops, delayed application of the basal fertilizer N and K (Tables 1&2) and early harvesting. Generally, root yield in Afisiafi was more than the rest of the varieties, followed by Tek Bankye. Percent moisture contents of the roots of Afisiafi, Tek Bankye, Eskamaye and Nyerikobga are 68%, 61%, 67% and 72%, respectively while those of stems are respectively 70%, 65%, 72% and 75%.

Conclusions/Recommendations

Cattle of Fulani herdsmen were a real threat to the success of the trials. Since the trials were planted late, other plants/crops around them on the field were harvested earlier leaving the trials alone thereby exposing them to invasion by such animals. It is therefore recommended that during the second year validation trials will be established latest by the middle of May.

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Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa:

a. Evaluation of different legume varieties for their response to inoculation and fertilizer application in northern Ghana (named Variety trials)
b. Determination of appropriate input requirements for the target grain legumes in northern Ghana (named Input trials)

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Executive Summary
Two types of experiments were conducted either on-station at Nyankpala or on-farm in Chereponi and Karaga Districts of the Northern Region to determine the response of cowpeas, groundnuts and soybeans to P and K fertilizers and also to determine the response of soybean to rhizobium inoculation with and without P. Simultaneously, these technologies were disseminated to farmers in demonstrations plots on their farms in six selected districts in the three regions of northern Ghana but only the agronomic data are reported on in this report. Inoculation with rhizobium appreciably promoted nodulation in soybean in on-station or on-farm trials. However, not all the soybean varieties used responded positively (in terms of grain yield) to the application of the rhizobium inoculants. Application of P enhanced grain yield in soybean with or without inoculation. Phosphorus also enhanced cowpea grain yield but depressed that of groundnut. Application of potassium fertilizer (KCl) did not have any positive effects on grain yield of both cowpea and groundnut.

Introduction
Nitrogen is the nutrient element most limiting to plant growth in northern Ghana. It is, therefore, not surprising that each improvement in grain crop production technology has been associated with increasing the availability of nitrogen to crops. Nitrogen deficiency results from its continual depletion from the soil pool by processes such as volatilization, leaching and, perhaps most importantly, removal of nitrogen-containing harvest products and crop residues from the land. The nitrogen reserve of agricultural soils must,

therefore, be replenished regularly in order to maintain an adequate level for crop production. This replacement of soil nitrogen is generally accomplished by the addition of inorganic fertilizers or by biological nitrogen fixation (BNF).

While there is a wide range of organisms and microbial-plant associations that are capable of fixing atmospheric N_2, the symbiotic relationship between rhizobia and legumes is responsible for contributing the largest amounts of fixed nitrogen to agriculture. Grain legumes contribute more than 20 million tons of fixed N to agriculture each year (Herridge *et al.* 2008). Thus, the significance of BNF as the major mechanism for the recycling of nitrogen from the atmosphere to available forms in the biosphere cannot be overemphasized.

Enhancing BNF and scaling-up of legume integration in smallholder farming systems will be achieved in this project in the short-term (0-4 years) by introducing high quality rhizobial inoculants and selecting legume genotypes with enhanced potential for BNF and targeting these legume/rhizobium combinations within different agro-ecologies, with best agronomic practices. This will lead to a major expansion of the area under legumes that fix substantial amounts of nitrogen that will also help to improve soil fertility for other crops.

The objectives of the project are (i) to identify and field-test multi-purpose legumes providing food, animal feed, structural materials and high quality crop residues for enhanced N_2-fixation and integrate improved varieties into farming systems and (ii) to deliver legumes, inoculant technologies and associated N_2-fixation technologies to farmers throughout northern Ghana

Materials And Methodology

Establishment of trials

Experimental areas

The trials were located in Chereponi and Karaga Districts in the Northern Region. In the Chereponi District, the variety trials involving soybean, groundnut and cowpea were located at Ugando while the input trials involving the same legumes were sited at Andonyamanu. In the Karaga District, however, both the variety and input trials for soybean and cowpea were located at Nyebsobga whereas those for groundnut were established at Sung. Similar trials (researcher-managed) were established on-station at SARI’s experimental field at Nyankpala in the Tolon-Kumbungu District of the Northern Region.

Failed trials

Establishment of soybean and groundnut varietal trials was not successful at Ugando in the Chereponi District because germination of soybean was extremely poor due to water-logging and groundnut plants were eaten by animals from the nearby community. Soybean varietal and input trials at Nyebsobga (Karaga District) were successfully established but failed due to poor maintenance as a result of the farmer's lackadaisical attitude towards the trials.

Crop varieties grown

(a) Soybean

Four varieties, namely Jenguma, Anidaso, TGX 1448-2E and TGX 1835-10E were used as the test crops for the variety evaluation test whereas only one variety (Jenguma) was used for the input trial.

(b) Cowpea

Six varieties (Songotra, Marfo-tuya, Padi-tuya, Zayura, Omondao and IT98K-573-1-1) were tested in the variety trial. Of these only the first four are released varieties. Only Songotura was used in the input trial

(c) Groundnut

Three groundnut varieties (Chinese, SAMNUT 22 and SAMNUT 23) were tested in the variety trial. Chinese was used in the input trial. SAMNUT 22 and SAMNUT 23 were released varieties obtained from the TL II systems in Nigeria.

Plot layout

The plot size for both the variety and input trials for all the crops was 4.5 m x 3.0 m and the planting distance was 75 cm x 10 cm for soybean and 75 cm x 20 cm for both cowpea and groundnut. For each of the crops, the variety trial was planted on the flat whereas the input trial was on ridges. Weedy fallow plots were also established and each treatment was replicated three times. A one-meter wide alley was left between adjacent plots within each replicate whereas adjacent replicates were two meters apart.

Plant density

For soybean three seeds were planted per hill on the flat for the varietay trial and on ridges for the input trial without thinning. For both cowpea and groundnut, three seeds were planted per hill on both the flat and ridges but later thinned to two per hill two weeks after planting.

Inoculation with rhizobium

Before planting, the soybean seed was either inoculated, or not, with rhizobium inoculant *Legumefix* using the slurry method. This involves suspending 5 g of inoculants in 30 ml of 20% sucrose solution which was poured onto 1 kg of seed and mixed gently but thoroughly. The seed was then spread on a sheet and air-dried for at least one hour to ensure adequate coating of the inoculant on the surface of the seed.

Fertilizer application

About two weeks after planting (i.e. just after thinning), only Chinese, Jenguma and Songotra were fertilized with 40 kg N/ha (Urea), 30 kg P/ha (TSP) and 30 kg K/ha (KCl) in different combinations, or not, in both types of trials. The fertilizers were banded 10 cm away from the planting line in a 2-cm deep trench and covered after application.

Reference crops

Maize (Dodzi; 70-75-day maturity) was used as a reference crop in both the variety and input trials for cowpea and groundnut to allow for the quantification of the atmospheric nitrogen fixed by the soybean crop using the Total Nitrogen Difference Method. For soybean, sorghum (Kapaala; 95-110-day maturity) was included in addition to the maize in the variety trial.

Weeding

Weeding was done with the hand-hoe as and when necessary. Because of the late but persistent heavy rains which caused vigorous growth of weeds, weeding was done more than twice in all the trial sites except at Nyebsobga and Sung in the Karaga District where a pre-emergence herbicide Alligator 400EC (with Pendimethaline as the active ingredient) in combination with a contact herbicide Sarosate (with Glyphosate as the active ingredient) was applied before planting.

Spraying

Cowpea and soybean were sprayed with the insecticide Kombat 2.5EC (active ingredient: Lambda Cyhalothrin) as and when necessary according to the severity of incidence of the insect pests.

Sampling for nodulation & biomass

For soybean, two hills (3 plants/hill) were sampled from each of the two second outermost rows (i.e. a total of 12 plants) at 69 and 96 days after planting (DAP). A cutlass was used to loosen the soil around each and the plants pulled out gently. Any detached nodules were picked up with the hand. The nodules on all the 12 plants were removed with the hand and counted and weighed after which the roots were cut off and washed thoroughly on a sieve under a jet of tap water. Fresh weights of the shoots of all the twelve plants harvested per plot were taken after which a sub-sample (1 hill = 3 plants) was taken and its fresh weight also taken. The heights of these three plants were also measured. The dry weights of the three shoots, nodules (from the 12 plants) and roots (from the 12 plants) were determined by drying them in the oven at 80^oC for 24 hours.

In the case of cowpea and groundnut, two plants (i.e. one hill) were sampled from each of the two outermost rows per plot following the same procedure used for soybean. The nodules on all the four plants were removed with the hand and counted and weighed after which the roots were cut off and washed thoroughly on a sieve under a jet of tap water. Fresh weights of the shoots of all the four plants harvested per plot were taken after which a sub-sample (1 hill = 2 plants) was taken and its fresh weight also taken. The dry weights of the two shoots (vines), nodules (from the four plants) and roots (from the four plants) were determined after drying them in an oven at 80^oC for 24 hours.

During the sampling of the legumes, their respective cereal reference crops were also harvested. One plant of each cereal was uprooted from each of the second outermost rows per plot. The roots were cut off and washed thoroughly on a sieve under a jet of tap water after which the fresh weights of both the shoots and the roots were measured. Their dry weights were determined after drying them in an oven at 80^oC for 24 hours.

Harvest

When all the legumes were fully matured, plants from the two innermost rows were harvested for the determination of grain yield and shoot biomass yield. Only these parameters are reported in this report.

Results and Discussion

Soybean grain yield was relatively lower in inoculated treatments except for TGX1448-2E whereas its stover yield increased with inoculation for Jenguma and Anidaso (Table 1). On the contrary, when Jenguma was given a combination of N, P and K, grain and stover yields were remarkable. With TGX 1835-10E, however, both grain and stover production were not favoured by rhizobium inoculation (Table 1). The nodule number of this variety was also lower especially at 69 days after planting (Table 1). Generally, nodulation (nodule number and nodule dry weight) was appreciably increased by rhizobium inoculation. Grain yield and nodulation of Jenguma in the on-station trial did not respond to rhizobium inoculation until P was applied and these responses were at the expense of stover production (Table 2). Application of N, however, enhanced grain and stover production but depressed nodulation in on-station trial at Nyankpala (Table 2) and on-farm trial at Chereponi (Table 3)

The performance of the various cowpea varieties was location-dependent with IT98K-573-1-1out-yielding all at Nyankpala except when Songotra was fertilized (Table 4). Songotra and Omondao out-yielded the other varieties on-farm at Ugando and Nyebsobga, respectively when no fertilizer was applied. Application of fertilizer to Songotra on-farm increased its grain yield above the other varieties (Table 4). K generally depressed grain yield and stover production of Songotra on-farm but P is beneficial for grain yield of Songotra (Table 5).

Groundnut performed comparatively very poorly at Nyebsobga (Tables 6) and both K and P generally depressed grain yield of Chinese (Table 7). The two Nigerian varieties far out-yielded the local Chinese variety in terms of grain yield and haulm biomass even when Chinese was fertilized, especially at Nyebsobga (Table 6).

Major Findings

Inoculation with rhizobium inoculant is generally beneficial to soybean but varieties defer in their response to the rhizobia. P application was beneficial to cowpea growth but unfavourable to groundnut.

Technology developed

The seemingly positive effects of rhizobium inoculation on some varieties of soybean need to be confirmed by further investigation

Conclusions/Recommendations

Inoculating soybean with rhizobium holds good promise for soybean production and productivity in the Northern Region and for the soybean industry as a whole. The effectiveness of the rhizobium inoculants can be enhanced by the application of P to the soybean crop. Contrary to popular perception that P is beneficial to the growth of legumes, application of this fertilizer to Songotra in this work rather depressed the yield of the crop although further work needs to be done to authenticate this. Based on the excellent performance of the introduced foreign groundnut varieties (SAMNUT 22 and SAMNUT 23) in terms of grain yield and haulm biomass production as compared to the local variety (Chinese), It is recommend that these two varieties be brought to Ghana for further evaluation and eventual release.

Table 1. Grain yield (kg/ha), stover yield (kg/ha) and nodulation responses of different varieties of soybean to Rhizobium inoculation and fertilizer application on-station at Nyankpala

Treatment	**Grain yield**	**Stover yield**	**Nodule no./hill** 69 DAP	96 DAP	**Nodule dry wt. (mg/hill)** 69 DAP	96 DAP
Jenguma –Ino	1928	3181	60	38	547	397
Jenguma + Ino	1839	4433	**149**	**121**	**1267**	**843**
Anidaso - Ino	1722	4726	91	38	777	477
Anidaso + Ino	1503	5750	**134**	**104**	**1327**	**953**
TGX 1448-2E - Ino	1538	5694	108	47	543	633
TGX 1448-2E	1635	4295	**168**	44	**713**	517

+ Ino						
TGX 1835-10E - Ino	1300	1645	163	8	1003	93
TGX 1835-10E + Ino	1067	1394	145	5	**1300**	**200**
Jenguma+ /P/K/N	2439	9273	90	39	517	427
SED	461	1174.5	40	31	152.8	292.5
LSD (5%)	977.4	2489.8	85	67	323.9	620

Table 2. Grain yield (kg/ha), stover yield (kg/ha) and nodulation responses of Jenguma to Rhizobium inoculation and different fertilizer applications on-station at Nyankpala in 2010.

Treatment	**Grain yield**	**Stover yield**	**Nodule no./hill**	**Nodule dry wt. (mg/hill)**
Jenguma - Ino	2174	6409	15	170
Jenguma+ Ino	2067	5276	25	160
Jenguma+P -Ino	2856	6736	21	213
Jenguma+P + Ino	3055	6125	82	777
Jenguma+P/K - Ino	2534	8268	17	197
Jenguma+P/K + Ino	2798	6718	75	710
Jenguma+P/K/N	3068	9789	13	310
Sed	278.3	1520.2	28	203.3
LSD (5%)	606.3	3312.2	62	442.9

Table 3. Grain yield (kg/ha), stover yield (kg/ha) and nodulation responses of Jenguma to Rhizobium inoculation and fertilizer application on-farm at Andonyamanu (Chereponi District).

Treatment	Grain yield	Stover yield	Nodule no./hill	Nodule dry wt. (mg/hill)
Jenguma - Ino	567	1259	42	143
Jenguma+ Ino	625	1037	48	293
Jenguma+P -Ino	746	1185	106	550
Jenguma+P + Ino	493	2222	43	453
Jenguma+P/K - Ino	1055	2741	86	520
Jenguma+P/K + Ino	941	2593	106	770
Jenguma+P/K/N	1103	2741	48	220
Sed	153.5	617.2	41.1	112.2

LSD (5%)	334.5	1344.8	89.6	244.5

Table 4. Grain and stover (vine) yields (kg/ha) of different cowpea varieties grown at Nyankpala (Tolon-Kumbungu District), Ugando (Chereponi District) and Nyebsobga (Karaga District).

Treatment	Nyankpala		Ugando		Nyebsobga	
	Grain yield	**Stover yield**	**Grain yield**	**Stover yield**	**Grain yield**	**Stover yield**
Songotra	994	4469	**1959**	1672	474	2647
Marfo-tuya	1013	5190	1123	1436	631	3687
Padi-tuya	918	5581	1708	**1841**	343	**5867**
Omondao	1345	6314	552	1317	**804**	3792
IT98K -573-1-1	**1489**	5940	1259	1221	543	3740
Zayura	690	**6625**	1085	**1768**	549	3889
Songotra/ P/K/N	**2051**	**8430**	**2433**	1582	**889**	**4155**
Sed	333.8	1579.7	529.4	693.5	151.9	1008.8
LSD (5%)	727.4	3441.8	1153.4	1510.9	330.9	2198

Table 5. Effect of fertilizer application on grain and stover (vine) yields of cowpea (Songotura) grown at Nyankpala (T-Kumbungu District), Andonyamanu (Chereponi District) and Nyebsobga (Karaga District).

Treatment	Nyankpala		Andonyamanu		Nyebsobga	
	Grain yield	**Stover yield**	**Grain yield**	**Stover yield**	**Grain yield**	**Stover yield**
Songotra	988	6049	1870	**3554**	606	3683
Songotra+P	1652	**6117**	**2055**	2592	**834**	3453
Songotra+P/K	1414	4783	1759	2987	583	2764
Songotra+P/ K/N	**1948**	5916	1568	3398	644	**4259**
Sed	272.9	1089.3	316.3	847.1	141.4	975.8
LSD (5%)	667.7	2665.4	773.9	2072.8	346	2387.6

Table 6. Grain and stover (haulm) yields (kg/ha) of different groundnut varieties grown at Nyankpala (Tolon-Kumbungu District), and Nyebsobga (Karaga District)

Treatment	Nyankpala Grain yield	Nyankpala Stover yield	Nyebsobga Grain yield	Nyebsobga Stover yield
Chinese	386	1671	18.5	286
SAMNUT 22	**699**	**3324**	183.9	**849**
SAMNUT 23	456	2293	**209.2**	604
Chinese/P/K/N	421	2204	29.1	338
Sed	158.9	112.4	54.9	2.286
LSD (5%)	388.8	275.1	134.3	5.593

Table 7. Effect of fertilizer application on grain and stover (haulm) yields (kg/ha) of groundnut (Chinese) grown at Nyankpala, Andonyamanu and Nyebsobga in 2010

Treatment	**Nyankpala**		**Andonyamanu**		**Nyebsobga**	
	Grain yield	**Stover yield**	**Grain yield**	**Stover yield**	**Grain yield**	**Stover yield**
Chinese	**220**	1316	**145**	1429	**42.3**	362
Chinese+P	188	1387	72	1407	16.9	131
Chinese+P/K	175	1280	131	1531	24.8	397
Chinese+P/K/N	192	1653	138	1696	52.1	449
Sed	31.5	141.7	45.5	305.4	10.08	89.1
LSD (5%)	77.1	346.6	111.3	747.2	24.67	218

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

Mathias Fosu, B.D.K. Ahiabor, Francis Kusi, S.S. Buah, J.M. Kombiok, A. N. Wiredu, John K. Bidzakin, A. Mutari, F.M. Tetteh

Introduction

Project rationale/Background

Northern Ghana is considered as the Breadbasket of Ghana. It produces nearly 20% of the country's maize output but yield of maize remains low at 1.1 t/ha on average. Soybean is a recent cash crop introduction with a high potential to increase the income of smallholder farmers. Within the maize-based cropping system, groundnut and cowpea are important companion and alternate crops. The low yields of these crops are attributable to lack of access to high quality seeds, fertilizers, credit and market. The rational of this project is to contribute to agricultural production and reduce poverty through up-scaling integrated soil fertility management (ISFM), strengthening extension agents and farmers, developing fertilizer recommendations and monitoring the impact of ISFM adoption on livelihoods of farmers.

Materials and Methods

Sixteen ISFM Technologies were packaged into 5 Demonstration and installed in 150 communities in northern Ghana. Demonstration (Demo) 1 showed the effect of different rates of fertilizer and cowpea rotation on yield of maize. Demo 2 showed the response of hybrid and OPV maize to different levels of fertilizer. Demo 3 compared the performance of Obatanpa and two drought tolerant maize (DTMA) varieties. Demo 4 showed the effect of organic and inorganic fertilizers and their mixtures on maize yield and Demo 5 showed the effect of rhizobium inoculation and P application on soybean yield. The demonstrations were installed with MoFA and managed by FBOs. FBOs and agro-dealers were profiled, offloaded unto the farms platform and trained. Farmer-based Organizations were trained in governance, managing farming as a business, and credit management. AEAs were trained in Farmer school facilitation and extension communication. Radio and TV programs were used to reach farmers with extension messages. Adaptive research was carried out in the two agroecologies (Guinea and Sudan savannas) on selected benchmark soils and the data was model using DSSAT to determine site specific fertilizer recommendations for northern Ghana.

Scientific findings

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

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

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

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

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

Technology Developed

Integrated Soil fertility management technologies were transferred in 150 communities in 35 districts in northern Ghana. About 18,000 farmers were reached through demonstrations, FFS and Field days.

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

Conclusions/Recommendations

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

Effect of tillage type and soil amendment on soybean yield in northern Ghana

Mathias Fosu and B.D.K. Ahiabor

Introduction

Project rationale/Background

Soybean requires fertile soil for optimum production. Its response to organic and phosphate fertilizer has not been well documented in northern Ghana. In addition, the effect of conservation tillage and other forms of tillage practiced in Ghana needs to be investigated as information on this is scarce in the literature. The objective of the study was to assess the effect of tillage and ISFM options on soybean yield.

Materials and Methods

A split-plot experiment with two factors- fertilizer and tillage replicated 4 times was installed at Nyankpala. The levels of fertilizer were: no fertilizer, NPK 0-60-30, manure 5t/ha and manure + fertilizer at half rates. The levels of tillage were zero, manual, bullock and tractor. Each tillage plot was divided into 4 sub-plots for the different fertilizer levels. The test crop was soybean. The weeds on the zero tillage plots were killed with Roundup (Glyphosate) at 2L/ha. After the preparation of all plots and planting, the entire field was sprayed with pre-emergence herbicide Alligator (a.i. Pendimethaline) at 3L/ha. .

Results and Discussions: Scientific findings

The manual tillage was the best in terms of soybean grain yield (1.6 t/ha) followed by zero tillage (1.4 t/ha). Tractor tillage gave the lowest yield of 1.1t/ha. The mixture of organic and mineral fertilizer gave the highest grain yield of soybean (1.7 t/ha) followed by sole manure application (1.4 t/ha). Soybean yield without any soil amendment was 0.94 t/ha while application of PK to soybean gave a yield of 1.3t/ha.

Conclusions/Recommendations

Best soybean yield is obtained when manual and zero tillage are practiced. Mixture of mineral and organic fertilizer gave higher yield of soybean. Conservation agriculture practice will increase soybean yield in the Guinea savanna.

POSTHARVEST

The effects of nutrition, variety and harvesting stage on the shelf life of tomato

Abubakari Mutari, Baba Inusah and Robert Kwasi Owusu

Executive summary

The production and supply of tomatoes in Ghana rest greatly on the Upper east region. In recent times however, farmers are making marginal profits and sometimes heavy losses as tomato buyers in Ghana prefer that of Burkina Faso as a result of shelf life considerations. The buyers argue that tomatoes from the Upper east has a shorter shelf life (4 days) while that of Burkina Faso can last for a week (Yilma 2006). In both cases, the tomatoes are vine-ripened before they are harvested and transported to the southern part of the country. The Ghanaian traders attribute this short shelf life problem though without scientifically proven evidence, to poor nutrient and water management on the part of the Ghanaian farmers.

Introduction

The shelf life of a perishable commodity like tomato can be affected by pre-harvest factors such as nutrition and harvesting practices. Also, different varieties by their genetic robustness have different shelf life capabilities. Against this backdrop, this experiment was conducted under drip irrigation at the IFDC Technology Park with the objectives of assessing the impact of nutrition on the shelf life of tomato. Also, the effects of variety and stage of harvesting on tomato shelf life were assessed

Materials

Pre-installed drip irrigation facility

Experimental design

The experiment was a 2 x 2 x 3 factorial conducted in a Randomised Complete Block Design in three replications.

Treatment

Tomato seeds – Petomech (PM or V1) and Castlerock (CR or V2)
Harvesting stages – mature green, turning and red ripe.
Fertilizer – organic (OF) and inorganic (IF)

Methodology

The seeds were nursed on the 6th of May 2010 in sterile soil-less medium in seed trays and the seedlings transplanted on the fourth week after sowing. The beds, measuring 0.8m by 23m were overlaid with pre-installed drip irrigation system. Prior to this, the dripper lines were folded and the beds covered with plain polythene sheets for three days to sterilise the soil. The dripper lines were then laid along the length of the beds and spaced 0.60m apart while the drippers were predetermined at a spacing of 0.30m from each other. Two beds were used for the preliminary investigation. Each bed contained plots measuring 0.80m x 7m, replicated three times with a 1m separation between them. The seedlings were transplanted on the 14th of June 2010 spaced 0.60m along the dripper lines giving a total of 12 plants per plot. Height of six plants in each plot were measured at 14, 30 and 45 days aftertransplanting. The fruits in each replicate were selectively harvested at a specified stage – mature green (MG), turning (T) and red ripe (RR). They were then kept in a room at ambient temperature to determine their shelf life.

Results

Table 1 show the plant height of the treatment. There was no significant diference in the heights of the two treatments

Table1. Plant height

Treatment	**Variety**	**Mean Plant height (cm)**
Organic	Petomech	57.81
	Castle rock	57.74
Inorganic	Petomech	59.47
	Castle rock	54.63
LSD (0.05)		**5.734**

Table 2. Fruit count

Treatment	**Variety**	**Harvesting stage**	**Fruit count**
Organic	Petomech	MG	11
		T	12
		RR	12
	Castlerock	MG	15
		T	14
		RR	7
Inorganic	Petomech	MG	12
		T	12
		RR	12
	Castlerock	MG	11
		T	11
		RR	9
LSD (0.05)			**4.331**

MG – mature green, T – turning, RR – red ripe

Table 3. Yield and yield loss

Treatment	Variety	Harvesting stage	Total yield kg/ha	Marketable yield/ha	Loss/kg	%Loss
Organic	Petomech	MG	422	320	102	**24.17**
		T	508	274	234	**46.06**
		RR	387	183	204	**52.71**
	Castlerock	MG	379	257	122	**32.19**
		T	454	228	226	**49.78**
		RR	439	259	180	**41.00**
Inorganic	Petomech	MG	435	250	185	**42.53**
		T	378	262	116	**30.69**
		RR	370	230	140	**37.84**
	Castlerock	MG	436	200	236	**54.13**
		T	323	240		
					83	**25.70**
		RR	466	240	226	**48.50**
LSD (0.05)			**157.0**	**88.8**	**119.9**	**17.06**

Discussions

From the analysis of variance, it was observed that plant height (Table 1) was not statistically significant ($P > 0.05$). The two varieties were both determinate and therefore apical growth at a point (1 -2m) stopped and could account for the comparative heights between the two varieties.

Fruit count (Table 2) were not significant ($P > 0.05$) among the treatments as well as yield and yield losses

Conclusion and recommendation

From the experiment, it could be observed that plant height was not affected by nutrient application. Also, fruit count, yield and yield loss were not affected by nutrient, variety or stage of harvesting. It is recommended the experiment be repeated confirm these preliminary results.

Integrated Soil Fertility Management for Vegetable Production in Northern Ghana: Varietal Evaluation of Tomato Under Rain-fed Conditions in Northern Ghana

Abubakari Mutari, Alexander Nimo Wiredu, Dr. Benjamin Ahiabor, Dr. Wilson Dogbe, Richard Yaw Agyare and Ayuba Jalilatu

Executive Summary

As per the agreement reached between the donor (IFDC) and the implementing agency (SARI), a trial was conducted to evaluate the performance of a newly-bred rainy season tomato by the IFDC team in Nigeria with the commonly cultivated varieties in Ghana. This trial was to

measure the adaptability to local conditions in terms of productivity and tolerance to pests and diseases of the new variety.

Introduction

One of the activities of the Integrated Soil Fertility Management (ISFM) for vegetable production in northern Ghana is a rainy season evaluation of the heat tolerant tomato variety from the IFDC team in Nigeria. The purpose of this sub-project was to evaluate the performance of the newly identified rainy season tomato against commonly cultivated varieties (pectomech and Tropimech). In that light, the project was categorized into three stages, sensitization/training of farmers, on-station evaluation of the new variety and field visits/days.

Materials and Methodology

The materials used for the study included the tomato varieties – ICRISIND**,** Pectomech and Tropimech, compound fertilizer NPK 15-15-15 and, insecticide. The experiment was conducted on- station at the Savanna Agricultural Research Institute. Seeds were nursed on 6th June, 2011 and transplanted on 10th July, 2011. Randomized Complete Block Design was used with four replicates. Data were taken on plant height at anthesis (cm): days to 50% flowering, number of fruits per plant, fruit size (mm), weight per fruit (g), fruit yield (t/ha), soluble solids (percent brix), titrable acidity and shelf life.

Results and Discussions

Statistical differences were observed among the varieties for days to 50% flowering, number of fruits per plant, fruit size and fruit yield (Table 1). The new variety recorded earlier days to flowering, more fruits per plant and more weight (tons/ha). However the new variety recorded the lowest value for fruit size. Plant height, weight per fruit, percent brix, titrable acidity and shelf life did not show any statistical differences among the varieties.

Conclusions and recommendations

Though significant differences were observed for days to flowering, number of fruits per plant, fruit size and weight, the experiment needs to be repeated to be able to compare the results of the two studies and make a final inference.

Table 1. Agronomic characteristic of tomato varieties

Variety	Plant height (cm)	Days to 50% flowering	Number of fruits per plant	Fruit size (mm)	Fresh weight/ fruit (g)	Weight (tons/ ha)	Soluble solids (% brix)	Titrable acidity	Shelf life
ICRISIND	62.40	24.50	21.00	42.77	72.20	47.30	3.65	0.54	9.25
Petomech	57.80	30.75	7.25	44.85	67.90	15.90	3.63	0.40	7.75
Tropimech	65.30	28.75	7.50	50.01	83.30	20.00	3.95	0.43	7.00
Sed	3.25	1.47	0.76	1.480	9.75	3.29	0.531	0.075	0.89
CV%	7.40	7.40	9.00	4.6	18.50	16.80	20.1	23.30	15.70
Grand mean	61.80	28.00	11.92	45.88	74.50	27.70	3.74	0.45	8.00
Level of Significance	Ns	*	**	*	ns	**	Ns	ns	ns

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 field substations at Damongo, Yendi and Salaga. The team's work focuses on characterizing and describing the farming systems of the region, identifying and prioritizing constraints to increase sustainable agricultural production and generating suitable interventions to address the prioritized problems of the farmers through adaptive on-farm as well as on-station research. Besides, the team also has oversight responsibility of coordinating Research, Extension and Farmer Linkage Committee (RELC) activities in the NR. This report highlights activities of the year under review.

COTTON IMPROVEMENT PROGRAM

Mashark S. Abdulai

Executive Summary

Cotton has become a very important cash crop following new discoveries that can lead to environmentally producing and making profits. These new methods include Bt cotton genotypes that cuts down on the chemicals used thereby increasing profits. Ghana is endowed with land and growing conditions that can be exploited for high production but these have not been done probably due to alternatives. These alternatives are likely to dwindle with time so it is suggested that cotton production be taken seriously. This can be achieved by developing new varieties instead of depending on old seed from Burkina Faso in particular. As a first step germplasm has been collected and evaluated for characters desired by the consumers. For 2010 season S1, S5 and S6 were the most superior. Seed of Sarcot 1 and Sarcot 5 were multiplied to revamp the seed industry. Breeder seed of the thirty-six genotypes evaluated was also produced. Many more genotypes and hybridization using the genotypes will begin in 2011.

Introduction

Project rationale/Background

According to FAO statistics (2000), cotton production in Africa has tripled since 1961 whereas the world production only doubled within the same period. In 2002, South Saharan Africa produced 1.4 million metric tonnes of cotton fiber (7% of the world production). Out of this, West and Central Africa produced 1.1 million MT. However, Ghana's share in the export trade is very small (6,000 mt in 2002) although the cultivation of the crop began by the introduction of two species of *Gossypium hirsutum* during the 17^{th} century by the Basel Missionaries (Koli, 1973). Cotton grows best in Northern, Upper West and Upper East Regions of Ghana which stretches from Longitude 1^{o}E to 3^{o}W and Latitude 8.5^{o}N to 11^{o}N. Among the numerous constraints to sustainable cotton production in Ghana is absence of improved cotton seed. The industry imports seed from Burkina Faso, Cote d'Ivoire and Togo. These planting materials are usually expensive and unreliable but the source of purchase cannot be held liable for the poor performance of the seed.

Successes are possible in developing varieties for cotton growers in Ghana if the stakeholders in the industry identify the positions they fit in the value chain of the industry. The position of research in this value chain fits well in cultivar development and capacity building. On the part of research, these have been going on as part of the mandate of the Savanna Agricultural Research Institute.

The objective of this research is to evaluate and identify genotypes suitable for growing in Ghana and/or for introgressing into other genotypes to develop superior genotypes.

Materials and Methodology

There are several breeding techniques available to develop new lines in cotton but in our case the conventional breeding method has been followed. It started with the collection of germplasm, these were then characterized, evaluated and the best genotypes selected for consideration for release. The cotton program intensified these activities by collecting germplasm from West Africa, Syria, USA and from within the country from 1992 to 1997. In 1996, mass selection breeding methodology was used to purify the germplasm and then characterized morphologically. Thirty-six genotypes were selected for the trial in 2010 season.

The experiment fields were tractor ploughed and harrowed. The design used for the trial was a randomized complete block design with three replications. Five to six seeds were sown per hill on the flat for each treatment and thinned to two per stand 2 weeks after emergence. The final population after thinning was 74000 plants ha^{-1}. Six rows of 5 m and 90 cm between rows were used. The intra-row spacing was 30 cm. Data was recorded from the inner rows.

Compound fertilizer (NPK) was applied at a rate of 50 -30-30 kg ha^{-1} but the N was applied in split doses; 30kg ha^{-1} at 2 weeks after emergence and 20 kg ha^{-1} at 6 weeks after emergence. Diuron 80 WP, a pre-emergence herbicide was applied using a CP 15 knapsack sprayer at a rate of 0.8 kg/ha to all fields on the day of planting. Supplemental hand weeding at 6 and 11 weeks after emergence was carried out to control weeds. Insect pests were managed by the application of K-D plus insecticide at a rate of 2l/ha using a ULV sprayer. The data were analyzed using Statistical Analytical System (SAS) for windows.

Results and Discussions

Planting was done late in July due to poor rainfall. The mean squares for seed cotton produced, plant height, number of bolls per hectare and per cent opened bolls are presented in Table 1. There were significant differences among the genotypes/accessions for the characters observed except for plant height. Even though the season was very bad during the early stages of the season the seed cotton produced per hectare was very high. The mean values per accession are presented in Table 2. The most superior accessions in terms of seed cotton yield were S1, S5 and S6. The seed cotton produced per hectare for these accessions was above 1,600 kg. The correlation coefficients among the characters showed that there were highly significant (P>0.01) correlation between seed cotton yield and number of bolls. There were no significant correlations between seed cotton yield and percent opened bolls, and seed cotton yield and plant height. For this study it is suggested that number of bolls significantly influenced the seed cotton yield and not the per cent opened bolls.

Twenty best accessions will be selected and evaluated in a multi-location trial in the mandate area. This will assist in selecting genotypes for specific locations. The program will embark on collection of germplasm to be included in what it has.

Table 1a: Mean squares of seed cotton, plant height, bolls and percentage of open bolls

Source	df	Seed cotton	Plant height	Bolls no	% open bolls
Replication	1	500000.00	33.35	23473936.90	0.04
Accession	35	126082.70**	17.73ns	13033509.70**	81.76*
Error	35	46384.48	13.63	3174113.30	46.10
CV %		16.46	5.20	10.63	8.70
Mean		1309.00	71.04	16759.26	78.12

Table 2: Mean seed cotton, plant height, bolls and percentage of open bolls

Accession	Seed cotton ($kgha^{-1}$)	Plant height (cm)	Number of bolls/ha	Opened bolls (%)
S1	1888.89	72.50	18611.11	78.99
S5	1833.33	72.00	20000.00	89.69
S6	1694.44	70.00	15555.56	78.46
CV3	1638.89	70.50	21111.11	81.39
CV26	1583.33	74.00	15000.00	79.66
CV15	1527.78	73.00	18888.89	76.14
G26	1527.78	69.00	15555.56	81.79
G33	1527.78	70.00	15555.56	81.79
STAM42	1527.78	69.50	15833.33	78.78
G34	1500.00	77.00	16111.11	79.29
S10	1416.67	70.50	21111.11	84.17
UC7	1416.67	76.50	21666.67	79.37
G15	1388.89	70.50	20277.78	82.69
G16	1388.89	71.00	17222.22	68.23
NTA93-2	1333.33	69.00	15833.33	72.64
S15	1333.33	71.00	19444.44	76.48
NTA90-5	1305.56	69.50	17222.22	86.97
NTA93-15	1305.56	69.00	15555.56	78.97
S13	1305.56	69.50	17500.00	66.97
CV4	1277.78	70.50	15555.56	75.13
NTA886	1277.78	71.50	17222.22	80.83
S12	1222.22	71.50	16388.89	71.26
UC9	1222.22	72.50	16111.11	75.71
CT25	1166.67	71.50	15555.56	68.46
CV7	1166.67	69.00	12777.78	83.46
FK290	1166.67	76.50	16388.89	81.26
G28	1166.67	65.50	21111.11	60.83
S8	1111.11	79.00	15833.33	80.40
G5	1055.56	68.00	16666.67	76.34
CV10	1027.78	73.00	17222.22	72.50
STAMF	1027.78	69.50	17777.78	88.26
UC4	1027.78	72.00	16666.67	79.91
CG	1000.00	71.00	11666.67	71.36
CB	944.44	64.00	12222.22	90.83
ISA205	916.67	70.50	13888.89	76.62
G11	888.89	68.00	12222.22	76.67
$LSD_{0.05}$	437.23	7.50	3616.80	13.78

UPLAND AGRONOMY

J. M. Kombiok, Haruna Abdulai and Ahmed Dawuni,

Introduction

Upland Agronomy programme is one of the several units of the Northern Region Farming Systems Research Group (NR-FSRG). This unit is mainly responsible for carrying out adaptive trials (with farmers) of all the crops except cotton, rice and the root and tubers 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 mandate crops.

For the year 2010, the unit was able to execute four major activities. These were three (3) on-station and one (1) on-farm experiments. The details of these experiments are stated below:

Planting Methods and Fertilizer Levels Studies on the Performance of Sesame in the Northern Region of Ghana

J. M. Kombiok, Haruna Abdulai and Ahmed Dawuni

Abstract

Sesame has several uses including its leaves, seed and oil, with the seed cake used in the livestock industry as feed but the production of the crop is left in the hands of subsistent farmers who plant the crop in haphazard manner with no fertilizer application and no weed control measure adopted. Two field experiments were established in 2010 in Nyankpala: The first one was to assess the yield of sesame as affected by the various combinations of N and P. This was made up of 4 levels of N (0, 30, 60 and 90 kg/ha) and 3 levels of P (0, 30 and 60 kg/ha). The second experiment was also conducted to determine the appropriate spacing for the production of the crop. The spacing tested included 60 x 5 cm (drilling), 60 x 20 cm, Broadcasting, 60 x 10 cm and 60 x 15 cm. Each of the experiments was laid in a Randomized Complete Block Design (RCBD) with the appropriate number of treatments in each case and replicated three times. The results of the fertilizer experiment revealed that the application of the combination of N and P (N_3P_1) at 90 kgN/ha and 30 kgP/ha gave the highest yield. This yield was similar to those obtained from N_0P_1, N_3P_1 and N_0P_2 treatments. On the spacing, it was observed that using any of the above listed spacing will give similar yields of Sesame. However, for ease of cultural practices and best crop management practices such as weeding and fertilizer application after planting, it is better to use any of the spacing except broadcasting. The broadcasting treatment makes such practices more difficult, laborious and time consuming. The application of P is therefore necessary to achieve high yields of Sesame and broadcasting should be avoided for ease of cultural practices on the field.

Introduction

There are several local names of sesame that include Sim-sim in arabic and Benniseed as popularly called in West Africa. It is said to originate from the summer rainfall areas of Tropical Africa and spread to the Middle East, India and China. The world production amounted to about 2.2 million tonnes in 1990 mainly from China, India, Sudan and Burma but the main exporting countries are Sudan, Mexico and China.

In Ghana yields of some local varieties range from 300-500 kg/ha but can go up to 3,000 kg/ha on fertile soils and under good cultural practices and general crop management. However, it has been observed that the break-even yield is around 2,000 kg/ha. The yield components of the crop include number of pods/plant, pod length, number of seeds/pod and seed weight.

When the crop is planted on fertile soils, no fertilizers are applied but in nutrient deficient soils such as the soils in the northern Savanna zone of Ghana, the application of fertilizers are necessary. On very poor soils, yields of the crop can be reduced significantly. It has however been known that Nitrogen (N) and Phosphorus (P) application to the crop can significantly improve soil fertility and subsequently raise yields substantially.

Sesame has several uses including its leaves, seed and oil, with the seed cake used in the livestock industry as feed. In Ghana, improved varieties are scarce and local varieties planted are not on any large scale. The production of the crop is therefore left in the hands of subsistent farmers who plant the crop in haphazard manner with no fertilizer application and no weed control measure adopted.

It is in this direction that Association of Church Development Projects (ACDEP) has since 2009 initiated collaboration with the Savanna Agricultural Research Institute (SARI) in the areas of fertilizer (fertilizer levels) and plant population studies (Method of planting) on the crop to improve sesame yields.

Planting Method experiment

Methodology on Planting Method

For the second time the experiment was conducted on the research farm of the Savanna Agricultural Research Institute (SARI) at Nyankpala during the 2010 rainy season. It was planted on 18/08/10 with a net plot size of 7.5 m^2

The experiment was laid in a Randomized Complete Block Design (RCBD) with five treatments replicated three times. The treatments were different spacing as:

(i) 60 x5 cm (drilling) (ii) 60 x 20 cm (iii) Broadcasting (iv) 60 x 10 cm (v) 60 x 15 cm.

Data were taken on a number of paarameters but the report here will cover only the grain yield. Yield Data were analysed using General Linear Model programme (Statistix). The analysis of Variance procedure for Randomised Complete Block Design (RCBD) was used to determine whether differences existed among treatments.

Results/Discussion

Even though the grain yield was highest when Sesame was drilled at a spacing of 60 x 5 cm and lowest when the crop was established by broadcasting, there were no significant differences among the treatments (Table 1).

Table 1: Grain yield of sesame as affected by different spacing at Nyankpala

Treatment (spacing-cm)	Grain yield of Sesame (kg/ha)
60 x 5	2,435.50
60 x 20	1,745.32
Broadcasting	1,579.50
60 x 10	1,752.40
60 x 15	2,030.75
LSD $_{(0.05)}$	989.82

The results obtained in two years suggests that using any of the above listed treatments will give similar yields of Sesame. However, for ease of cultural practices and best crop management practices such as weeding and fertilizer application after planting, it is better to use any of the spacing except broadcasting. The broadcasting treatment makes such practices more difficult, laborious and time consuming.

Also, for the fact that it is difficult to obtain uniform plant stand (population), the empty spaces observed in the broadcasting method in the trial, will normally promote weed infestation. Similar to this treatment is the 60 x 20 cm spacing which results in larger intra-row spacing. Relatively longer distance between one plant and the other, also allows vigorous weed growth and spread. In that situation, farmers may have to spend more money to control the weeds on their farms.

Fertilizer Experiment

Methodology on fertilizer levels

The second experiment was on different levels of fertilizers which was also conducted at the same site at SARI, Nyankpala. It was also planted on the same day (18/08/10) as the first. The experiment was laid in a Randomized Complete Block Design (RCBD) with 12 treatments replicated three times. The treatments were different levels of Nitrogen and Phosphorus (N and P). These were 4 levels of N and 3 levels of P as:

(i) N_0 – no N (ii) N_1 – 30kg/ha (iii) N_2 – 60kg/ha (iv) N_3 – 90kg/ha
(v) P_0 – no P (vi) P_1 – 30 kg/ha (vii) P_2 – 60kg/ha.

Yield data were recorded and analyzed using a statistical program (SAS) and differences separated using least significant difference (LSD) at 5 % level of probability.

Results and Discussion

The results of the fertilizer experiment are shown in Table 2. The results show that the effect on the yield were grouped into three categories as N_3P_1 (90-30), N_3P_2 (90-60), N_0P_2 (0-60) and N_0P_1 (0-30) being the highest with no significant differences among treatments.

The treatments in the second category which had the second highest yield were N_1P_1 (30-30), N_2P_1 (60-30) and N_2P_2 (60-60). Even though there were also no significant differences among this group of treatments, the individual yields were all significantly lower than the highest yield from N_3P_1 (90-30).

Table 2: Effect of N and P levels on the yield of sesame in Nyankpala

Treatment (Levels of N and P)	Grain yield (kg/ha)
N_0P_0 (0,0)	1,206.93
N_0P_1 (0,30)	2,156.00
N_0P_2 (0,60)	2,230.70
N_1P_0 (30,0)	1,203.10
N_1P_1 (30,30)	2,069.30
N_1P_2 (30,60)	1,635.60
N_2P_0 (60,0)	1,540.90
N_2P_1 (60,30)	1,947.30
N_2P_2 (60,60)	1,667.70
N_3P_0 (90,0)	1,469.80
N_3P_1 (90,30)	2,643.10
N_3P_2 (90,60)	2,432.00
$LSD_{(0.05)}$	510.60

The rest of the treatments made up of N_1P_2 (30-60), N_2P_0 (60-0), N_3P_0 (90-0), N_1P_0 (30-0) also gave similar sesame yields but were all significantly lower than all the yields obtained in the first category.

It was observed that the lowest sesame yield was obtained when no fertilizer was applied but increased sharply when only P was applied at the first (N_0P_1) and second (N_0P_2) levels of P even without the application of N. This suggests that the application of P may be more important for higher yields of sesame as the residual quantities of soil N in this particular site than the application of N.

The availability and uptake of N by crop plants is however known to be facilitated by the presence and availability of P in the soil. This could have been accounted for the increase in yield when P was applied to the crop.

Even though there have been increases in sesame yields with increasing levels of N and sometimes increases in P up to the extent that the highest sesame yield was recorded at the highest levels of N and the first level of P (N_3P_1), the differences in yield due to the various N and P treatments such as N_0P_1, N_3P_2, N_0P_1 and N_0P_2 were not significantly different.

Conclusions

In conclusion, the application of P is necessary to achieve high yields of Sesame. Farmers should therefore be encouraged to apply P to the crop. However from the results, the application of the combination of N and P (N_3P_1) at 90 kgN/ha and 30 kgP/ha gave the highest yield. This yield was similar to those obtained from N_0P_1, N3P_1 and N_0P_2 treatments. It is therefore recommended that in order to obtain the most economic level of N and P to achieve high yields for enhance profitability in the production of Sesame, economic analysis should be carried out.

The Productivity of Maize as Affected by Newly Formulated Fertilizers in the Northern Savanna Zone of Ghana

J. M. Kombiok, Iddrisu Sumani, Haruna Abdula and Ahmed Dawuni,

Abstract

Low grain yields of cereals in Northern Ghana have been attributed to poor soils. YARA Company Ltd has been championing the introduction of various fertilizers with balanced nutrients to raise the soil fertility status for the production of both cereals and legumes for farmers to increase their yields in the region. Newly formulated fertilizers were compared with the existing ones at four sites (Yendi, Nyankpala, Damongo and Walewale). A total 8 treatments made up of *Unik15 @ 2bags + Ammonium Sulphate @ 1bag, Unik15 @2bags + Sulfan @ 1bag, Actyva @1bag + Actyva @ 2bag, Actyva @1bag + Actyva @1bag + Actyva @1bag, Actyva @1bag + Actyva + @1bag + Winner @ 2bags, Rock Phosphate @ 1bag + Actyva @2bag + Actyva @1bag, No fertilizer application (Zero)and Actyva @ 2bags + Actyva @1bag.* The test crop at each site was maize (Obatanmpa). At each site, the experiment was laid in Randomized Complete Block Design (RCBD) with 8 treatments (plots) replicated three times. Generally, the results show that for high maize yields, Actyva should be applied at planting, two weeks after planting and as a top-dresser five weeks after the basal application each at 1 bag/acre. Similar maize grain yields were obtained after the application of Unik 15 and either top-dressed with Sulfan or Sulphate of Ammonia. There was no significant difference in maize yield between top-dressing with sulphate of Ammonia and sulfan indicating that any of them could be used to achieve the same results. The application of

Rock Phosphate before planting will be beneficial if only the Phosphorus content of the soil is low.

Introduction

Soils in the northern Savanna zone of Ghana are generally poor in nutrients. This is however blamed on the annual bush burning which exposes the soil to both water and wind erosion during the rainy and dry seasons respectively. As a result, the farmers in the northern part of Ghana are unable to obtain reasonable yields of most of the crops without fertilizer application especially the cereals (maize and sorghum), which are considered to be the staple food crops. Low soil fertility has been one of the agricultural constraints raised by farmers in every district of the Northern region of Ghana each year.

In the past when population was low, soil fertility was replenished through the bush fallow sytem. This however, can no longer be practised as arable lands are limited due to increased population in the area. It is in this direction that YARA Company Ltd has been championing the introduction of various balanced nutrition fertilizers for both cereals and legumes for farmers to increase productivity of the major crops in these areas.

For the fact that these are newly formulated products and have never been used in this part of the country, it became necessary to test the fertilizers within the Northern Savanna environment using maize as the test crop. The yield of maize was used to compare the effectiveness of Unik 15 and sulfan as basal and top-dressing fertilizers, respectively.

Materials and Methods

The experiment involving maize (Obatanpa) was conducted at four sites representing different Agro-ecologies of the Northern Region of Ghana. These sites are Nyankpala, Walewale, Damongo and Yendi. At each site, the experiment was laid in Randomized Complete Block Design (RCBD) with 8 treatments (plots) replicated three times giving a total of 24 plots per site.

The treatments were as follows:

1. *Unik15 @ 2bags + Ammonium Sulphate @ 1bag*
2. *Unik15 @2bags + Sulfan @ 1bag*
3. *Actyva @1bag + Actyva @ 2bag*
4. *Actyva @1bag + Actyva @1bag + Actyva @1bag*
5. *Actyva @1bag + Actyva + @1bag + Winner @ 2bags*
6. *Rock Phosphate @ 1bag + Actyva @2bag + Actyva @1bag*
7. *No fertilizer application (Zero)*
8. *Actyva @ 2bags + Actyva @1bag*

The time of application of the basal fertilizers differed among the various treatments. The basal application of some of the fertilizers such as Actyva was done at planting and at two weeks after planting. However the Rock phosphate was applied and worked into the soil before planting the maize. Top dressing was also done at least five weeks after the basal application of fertilizers. This was done by opening up holes as deep as 5 cm near the plants and putting the fertilizers and covering the holes with soil.

Weeds were removed from each of the plots three times making sure weed did not compete with crops for the nutrients from the fertilizers applied. Manual weeding was done two and four weeks after germination, and just before tasseling.

Harvesting was done at physiological maturity and sun-dried before dehusking. Each cob was shelled and sun-dried further before taking the weight per net plot after which it was converted into yield per hectare basis.

Data collected included plant height at harvest, 100 grain weight and grain yield (per hectare). Data were analysed using General Linear Model programme (Statistix). The analysis of variance procedure for RCBD was used to determine whether differences existed among treatments.

Results and discussion

Maize height at harvest

There were significant differences in maize height as affected by the application of the various fertilizers at Damongo (Table 1). Maize height due to no fertilizer application was observed to be the lowest in height and the highest was recorded when actyva was applied three times. The height of maize when Actyva was applied three times (***Treatment 4)*** was not significantly different from when Actyva was applied twice and top-dressed with Winner ***(Treatment 5),*** when Unik15 was applied and top-dressed with Ammonium sulphate ***(Treatment 1)*** and when Unik15 was applied and top-dressed with sulphan **(Treatment 2).**

At Nyankpala, the trend was not very different as the lowest plant height was recorded at no fertilizer application plots. All other treatment plots at the site gave similar plants heights (Table 1). The Walewale and Yendi sites were also similar in maize plant height as the lowest value was always recorded at no fertilizer plots and the highest when Actyva was applied as basal fertilizer and ether top-dressed with actyva or Sulphate of Ammonia (Table 1). Generally, it was observed that at each site that the trend in the height of maize was similar suggesting that the fertilizers have similar influence on the height of the maize. However, it was found that the plants were taller at Damongo than the rest of the sites and could be due to environmental effects and the frequency of the rains at the site.

Table 1: Maize height (cm) at Harvest from four sites in Northern Region of Ghana

Treat * No	Treatment Name	#D'go	N'la	Wale	Yendi
1	Unik15 @2bags + Sulphate of Ammonia @ 1 bag/acre	182.7	185.0	148.2	144.0
2	Unik15 @2bags + Sulfan @ 1bag	186.0	191.0	147.6	146.7
3	Actyva @1bag + Actyva @ 2bag	171.0	185.3	145.3	147.0
4	Actyva @1bag + Actyva @1bag + Actyva @1bag	231.7	185.7	162.5	165.7
5	Actyva @1bag + Actyva @1bag + Winner @ 2bags	230.0	194.0	168.8	174.0
6	RP @ 1bag + Actyva @2bag + Actyva @1bag	180.7	191.3	185.6	145.0
7	Zero + Zero Zero	145.3	168.0	132.2	127.7
8	Actyva @2bags + Actyva @1bag	178.3	185.3	145.2	150.3
	LSD 5 %	13.89	10.8	15.2	20.62

** Each of the treatments is in bags of 50 kg of the fertilizer/acre*
#D'go = Damongo; N'la = Nyankpala; Wale = Walewale

Maize Grain yield

The grain yields of maize as affected by the various basal and top dressing fertilizers are presented in Table 2. Generally with the exception of the no fertilizer treatment, maize grain yield at Damongo was the highest for all the treatments compared to the rest of the sites. This suggests that apart from the effect of fertilizers, other factors favouring high yields such as regular and consistent rainfall could be responsible for this situation. The results further indicate that even though the grain yields from the no fertilizer plots are the lowest at each site, the yield at Walewale was the highest with over 2 tonnes/ha. This is not surprising because the trial was established in an abandoned house which could be high in nutrients as results of the refuse dumps.

At all the sites, the lowest grain yields among the treatments were recorded when no fertilizers were applied to maize but with Nyankpala and Walewale again giving grain yields more than 2 tonnes/ha, further confirming that the soils at the sites might have higher nutrients than the rest of the sites. The application of 1 bag of Actyva three times; at planting, two weeks after planting and top-dressing at five weeks after the basal application gave highest maize yields at all four sites (Table 2). This suggests that Actyva might have enough balanced nutrients to supply to the maize crop at each of the stages applied for high yields.

Table 2: Maize grain yield (t/ha) as affected by the various fertilizers applied

Treat No	Treatment Name	D'go*	N'la	Wale	Yendi	Best yields
1	Unik15 @2bags + AS @ 1bag	4.38	2.78	2.94	2.15	DWNY#
2	Unik15 @2bags + Sulfan @ 1bag	4.43	2.90	2.93	2.18	DNYW
3	Actyva @1bag + Actyva @ 2bag	4.89	2.67	2.76	2.24	DWNY
4	Actyva @1bag + Actyva @1bag + Actyva @1bag	5.82	3.55	3.27	2.29	DNWY
5	Actyva @1bag + Actyva @1bag + Winner @ 2bags	4.47	3.40	3.02	2.61	DNWY
6	Rock Phosphate @ 1bag + Actyva @2bag + Actyva @1bag	4.71	2.80	2.54	2.19	DNWY
7	Zero + Zero + Zero	1.31	2.14	2.17	1.46	WNYD
8	Actyva @2bags + Actyva @1bag	4.59	2.99	2.39	2.24	DNWY
	LSD 5 %	0.63	0.99	1.74	0.55	

**D'go – Damongo; N'la – Nyankpala; Wale - Walewale*
#D-Damongo, W-Walewale, N-Nyankpala and Y-Yendi

The application of Unik 15 as basal fertilizer and top-dressing with Sulfan gave higher maize yields than applying Unik 15 and top-dressing with Sulphate of Ammonia, although the yield difference was not significant. This means that top-dressing with Sulfan or Sulphate of Ammonia after the application of Unik 15 will result in similar grain yield of maize if other factors affecting crop yield are held constant.

Maize grain yield obtained from the application of Rock Phosphate was rated third after the application of Actyva three times ***(Treatment 4)*** and the application of 1 bag/acre Actyva and top-dressing with 2 bags/acre ***(Treatment 3)*** at Damongo. At the rest of the sites however, the grain yields of maize from the Rock Phosphate treatments were among the lowest after the plots with no fertilizers. The non-significance in the yield of maize due to the application of Rock Phosphate could be due to the adequate availability of the mineral in these soils.

Conclusions

From the results of the first year of the trial at Damongo, Walwale, Yendi and Nyankpala, one can draw preliminary conclusions that, for the best maize (Obantampa) yields, Actyva should be applied at planting, two weeks after planting and as a top-dresser five weeks after the basal application each at 1 bag/acre.

Similar maize grain yields would be obtained after the application of Unik 15 and either top-dressed with Sulfan or Sulphate of Ammonia since there was no significant difference in yield between the two treatments. The application of Rock Phosphate before planting will be beneficial if only the Phosphorus content of the soil is low.

The application of different fertilizers alone may not affect the height of the maize crop at harvest if the environmental and weather factors are not favourable. However, enough nutrients are needed for the crop to maintain its potential height. It is recommended that the trials be repeated at each site to be able to confirm the results of 2010 since the results of only one year may not be adequate enough for any meaningful conclusion.

Participatory On-Farm Testing of Drought Tolerant Maize Lines in the Northern Region of Ghana (Mother and Baby Trials)

J. M. Kombiok, S. S. Buah, R. A. L. Kanton, N. N. Denwar, A. Wiredu, Haruna Abdula and Ahmed Dawuni

Abstract

The response to the call by farmers for new crop varieties is a joint effort of Scientists from the National Research Systems (NARS) of individual countries in collaboration with International Agricultural Research Centres such as IITA. Varietal releases are made to replace the existing ones used by farmers most often at their request. The recent search for new varieties is geared towards striga/drought resistant varieties. Even though the process of breeding is on-going, there are some promising drought/*Striga* tolerant maize lines each year. These are always advanced for further testing with farmers within the Savanna ecological zone to validate the results obtained from the on-station trials for the past years. The mother and baby trials methodology was used in the Tolon/Kumbungu and West Mamprusi Districts of the Northern Region to test DTMA lines. This was made up of 5 lines (mainly intermediate maturing ones), 2 of which are the farmers' variety and Obatampa (released) involving only 10 farmers as there was limited seed. The mothers were researcher managed which was made up of 5 varieties laid in Randomized Complete Block Design replicated 3 times while the babies were farmer managed trials. The results so far indicate that the highest grain yield at both sites was obtained from the **DT-SR-W-COF2** and the lowest from the farmers' varieties. Even though the various farmers' varieties were found to be of improved type, they were not pure but mixed with other varieties. Results of the farmers' assessment of the lines indicated

that farmers at Nyankpala preferred **IWD- C2- SYN-F2** and **DT-SR-W-COF2** to the other intermediate maturing lines. However in Walewale, the farmers preferred **DT-SR-W-COF2** and Obatampa**.** The interest by farmers in the materials at this stage suggests that these would be adopted if they are released as new varieties.

Introduction

The process of releasing new maize varieties for adoption by farmers starts with the development of new maize lines by International Agricultural Research Centres such as IITA. The lines are made available to the National Research Systems (NARS) of individual countries for adaptation and extension to farmers.

Due to the break down of the genetic potential of the old crop varieties coupled with the ever decreasing amount and erratic nature of the rainfall in the savanna region, it has become necessary to develop varieties to cope with this situation. These new releases which may be early maturing or drought resistant are therefore made to replace the existing ones used by farmers. However, before these lines are officially released as varieties, they are tested widely with farmers (on-farm) to ensure that they are not rejected.

SARI in collaboration with IITA has put in place a breeding programme for stresses including drought and *Striga* tolerance. Although the process of breeding is on-going, there are always some promising drought/*Striga* tolerant maize lines each year. These lines could be always advanced for further testing with farmers within the Savanna ecological zone to validate the results obtained from the on-station trials for the past years.

It is expected that the results of the participatory on-farm evaluation including farmer assessment of the lines will generally serve as guide for the breeders to fine-tune or re-strategize their breeding programs. In addition to this, the participatory on-farm testing of the lines would also facilitate the adoption of these varieties by farmers when they are suitable to their needs. For the past two years now, the objectives of the on-farm testing were:

- For farmers' to validate the draught/*striga* tolerant maize lines
- Introduce farmers to drought/striga tolerant maize lines
- Generate data to support the release of maize varieties

Materials and Methods

Northern Region of Ghana

There were two mother trials. Each of the intermediate maize lines were planted at Nyankpala and Walewale in the Northern Region of Ghana. A set of one intermediate maturing lines was established with farmers in the Tolon/Kumbungu District (Kpachi) and the second set was established in the West Mamprusi District (Walewale). The intermediate varieties in these trials were 7 made up of DT SR W COF2, DT SYN-1-W, IWD C2 SYN F2, TZL COMP 1 W(6)/ DT-1-W (07C5409), TZL COMP 3C3 DT 08C/3747, IWD C3 SYN F2 and (IWD C3 SYN/DT SYN-W 07C0508).

Obatampa and the various farmers' varieties were used as checks for the mother trials at both sites. With one mother trial at each location, the quantities of seed available could do for 10 farmers, 5 each at Kpachi and Walewale.

***Mother trial*:** Two mother trials (comprising only intermediate maturing lines) were planted on farmers' fields at each site in the Tolon/Kumbungu and Walewale Districts. With the collaboration of the extension staff of Ministry of Food and Agriculture (MoFA), interested maize farmers who participated in these trials in 2009 were contacted. The rest of the farmers who made up the number in these areas were also identified and selected by their colleagues. Tolon/Kumbungu and the West Mamprusi districts have persistently recorded high infestation of Striga and have been experiencing dry days in June for some years now. The intermediate mother trial consisted of 7 drought tolerant maize varieties and one local check and farmers' varieties.

The experimental design used was Randomized Complete Block Design (RBCD) with three replications per maturity group at each of the sites. A plot consisted of 5 m long with rows spaced at 0.75 m and intra-row spacing of 40 cm with 2 plants/stand resulting. Data was recorded on the two central rows. Recommended fertilizer rate and cultural practices were followed accordingly.

***Baby trials*:** Baby trials, which are farmer-managed, were also conducted with a total of 10 farmers in both the Tolon/Kumbungu and West Mamprusi Districts. With one Mother of each intermediate maturing varieties, the quantities of seed available could do for only 10 farmers for the intermediate category. The farmers selected participants among themselves to test the varieties from the mother trials. A set of three drought tolerant varieties were tested on each farmer's field alongside Obatampa and the farmers' variety in each case. Each farmer was a replicate of the five treatments, which was planted in parallel plots for comparison. Each variety was planted to an area of 400 m^2 (i.e., 20 x 20 m) for each farmer.

Results

Intermediate maturing lines

Mother trials in Nyankpala and Walewale (Intermediate maturing lines)

(i) Days to 50 % silking

The number of days to silking for all the intermediate maturing test lines including the check were not significantly different at both the Nyankpala and Walewale sites (Table 1). The longest days to silking was recorded by TZL COMP 1 W (6)/ DT-1-W (07C5409) at both sites while the line with the shortest days to silking was DT SR W COF2

Table 1: Days to 50% silking of intermediate maturing varieties of maize in Nyankpala and Walewale

Maize lines	Wale	Nyankpala	Mean across
DT SR W COF2	58	56	57
DT SYN-1-W	56	60	58
IWD C2 SYN F2	63	65	64
TZL COMP 1 W(6)/ DT-1-W (07C5409)	66	68	67
TZL COMP 3C3 DT 08C/3747	60	62	61
(IWD C3 SYN/DT SYN-W 07C0508)	58	60	57
IWD C3 SYN F2	62	60	61
Obatampa	58	62	60
Farmers variety	61	62	61.5
LSD(0.05)	NS	NS	
CV (%)	10	12	

Intermediate maturing lines

(i) Grain yields

At both the Nyankpala and Walewale sites most of the intermediate maize lines had more than 2t/ha (Table 2). The highest mean grain yield at both sites was obtained from the **IWD C2 SYN F2** and the lowest from **(IWD C3 SYN/DT SYN-W 07C0508).** The grain yields of all the intermediate were observed to be in two distinct groups. Those which had yields more than 2 t/ha were DT SR W COF2, DT SYN-1-W, IWD C2 SYN F2, TZL COMP 1 W(6)/ DT-1-W (07C5409), IWD C3 SYN F2 and Obatampa (check).

The second group which recorded grain yields less than 2 t/ha included the TZL COMP 3C3 DT 08C/3747 and (IWD C3 SYN/DT SYN-W 07C0508). For the second year, DT SR W COF2 and IWD C2 SYN F2 have performed better than the local check (Obatampa). These two lines could be proposed for further work and possible release as new varieties.

There were however no significant differences observed among the first group. Also the grain yields of the lines in the second group were also not significantly different. However, there were significant differences in grain yields of some of the lines between the two groups of the intermediate lines.

Table2: Grain yields (t/ha) of intermediate maturing maize lines evaluated in Mother trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	Wale	Nyankpala	Mean across
DT SR W COF2	2.10	2.09	2.09
DT SYN-1-W	2.08	2.06	2.07
IWD C2 SYN F2	2.18	2.15	2.67
TZL COMP 1 W(6)/ DT-1-W (07C5409),	2.17	2.00	2.08
TZL COMP 3C3 DT 08C/3747	1.90	1.40	1.65
(IWD C3 SYN/DT SYN-W 07C0508)	1.34	1.32	1.33
IWD C3 SYN F2	2.19	2.15	2.17
Obatampa	2.05	2.01	2.03
LSD(0.05)	0.62	0.84	
CV (%)	14	16	

Baby Trials
Generally, the results from the baby trials show that days to silking for the intermediate were similar to that obtained from the mother trials. However, the grain yields for all the lines in the baby trials were comparatively lower than those obtained from the mother trials. This could be due to poor crop management on the part of the individual farmers or differences in weather conditions since the mother trials were not planted at the same time with the baby trials.

Intermediate maturing lines
Days to silking
It was observed that in the baby trials for intermediate maturing varieties, the days to silking were similar to what were obtained from the mother trials (Table 3). The longest days to silking at both the Walewale and Nyankpala sites was recorded by **IWD C2 SYN F2** and the shortest days to silking from the **DT-SR-W-COF2** maize line. However, the days to silking at both sites were not significantly different among the maize lines including the farmers' varieties.

Intermediate maturing lines
Grain yields
At both the Nyankpala and Walewale sites all the intermediate maize lines including the farmers' varieties had less than 2t/ha (Table 4). The highest grain yield at both sites was obtained from the **DT-SR-W-COF2** and the lowest from the farmers' varieties. Even though the various farmers' varieties were found to be of improved type, they were not pure but mixed

with other varieties. This could have been responsible for the low yields observed.

Table 3: Days to 50% silking of intermediate maturing maize lines evaluated in baby trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	Walewale	Nyankpala	Mean across
DT-SR-W-COF2	57	59	58
DT-SYN-1-W	62	64	63
IWD- C2- SYN-F2	63	65	64
Obatampa	60	62	61
Farmers variety	61	62	61.5
LSD(0.05)	NS	NS	
CV (%)	10	12	

Table 4: Grain yields (t/ha) of intermediate maturing maize lines evaluated in baby trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	Walewale	Nyankpala	Mean across
DT-SR-W-COF2	1.43	1.25	1.34
DT-SYN-1-W	0.60	0.97	0.79
IWD- C2- SYN-F2	1.18	1.02	1.10
Obatampa	1.35	1.05	1.20
Farmers variety	0.57	0.65	0.61
LSD(0.05)	0.27	0.49	
CV (%)	28	25	

The grain yields of **DT-SR-W-COF2, IWD- C2- SYN-F2** and the local check (Obatampa) were not significantly different but were each significantly higher than the farmers' varieties and **DT-SYN-1-W** at both sites.

Farmer assessment of the test lines

It was easy for farmers to assess at both sites since the number of entries was few as it was only the intermediate lines available. The results of the exercise showed that farmers at Nyankpala preferred **IWD- C2- SYN-F2** and **DT-SR-W-COF2** to the other intermediate maturing lines. However in Walewale, the farmers preferred **DT-SR-W-COF2** and Obatampa**.** Just as last year, the QPM Obatampa which is a released variety was also considered as a check along side the new lines. Crop features and characters considered included plant stand, cob size, grain size, and drought/striga resistance. All the IITA maize lines were considered to be better than the local checks (farmers' varieties).

Conclusions

Generally, most of the improved drought tolerant lines from IITA assessed in this study (mother trials) performed similar to or better than the best available local varieties at the various locations under rain fed conditions. Some of the farmers who have been participating in these trials (mother and baby trials) continue to select some of the lines they preferred. This is being monitored by the field Officers of MoFA and pieces of advice given to them especially in the case of hybrids. The interest by farmers in the materials suggests that these would be adopted by farmers if they are released as new varieties.

Constraint

Limited seeds of the maize lines to be tested from IITA

The influence of Jatropha on the yields of cereals (maize & Sorghum) and Legumes (Cowpea & Soyabean) in intercropping systems in the Savanna zone of Ghana.

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Abstract

Jatropha which was considered as a wild shrub and used for fencing purposes has suddenly become a crop because of the high seed oil content which can be used for both domestic and commercial purposes. Jatropha in other countries are grown in sole cropping systems where the oil is extracted from the seeds for use. However, for the fact that most of the farmers in the sub-region practice intercropping, it became necessary to introduce intercropping systems involving the Jatropha plant and the commonly grown legumes (Soyabean and Cowpea) and cereals (Maize and Sorghum). For Jatropha/cereals intercropping, the treatments were: Sole Jatropha, Sole maize, sole sorghum, Jatropha/ maize and Jatropha/sorghum and the treatments for the Jatropha/Legumes were sole Jatropha, Sole cowpea, sole soyabean, Jatropha/cowpea and Jatropha/Soyabean. The results show that the grain yields of soyabean and cowpea in the intercrop was each higher than in the sole system but the differences between yields were not significantly different. The grain yield of maize even though was higher in the intercropping system than in the sole, the difference was not significant. However, for sorghum, the grain yield in the intercropping system was significantly higher than in the sole situation and this was probably due to flooding in the sole plots. These experiments have to be repeated several years to be able to arrive at a meaningful conclusion.

Introduction

Jatropha is found in almost every community in Northern Ghana as a border crop or as a life fence of gardens and other portions of the house or farms. However, it has never been considered as a crop and as a result it is difficult to determinewhether the plants found in these areas are of the same variety or mixtures of different varieties.

With the inception of the EU-Sponsored Jatropha Project which is community oriented, SARI was among other things mandated to assemble the readily available germplasm of the plant, characterize them for earliness and for high yields and to carry out field trials involving jatropha.

For the fact that most farmers in the sub-region practice intercropping, it became necessary to introduce intercropping systems involving the Jatropha plant and the commonly grown legumes (Soybean and Cowpea) and cereals (Maize and Sorghum).

The objective of the trial was therefore to assess the performance of some legumes (soyabean and cowpea) and cereals (maize and sorghum) in itercropping systems with Jatropha.

Materials and methods

The two sets of trials involving legumes and cereals were conducted at the Savanna Agricultural Research fields, Nyankpala. Each of the trials were 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 2m by 3m
- 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 2m by 3m
- ii. Sole Soyabean
- iii. Sole Cowpea
- iv. Jatropha/ Soybean
- v. Jatropha/Cowpea

Results

a) Jatropha intercropped with legumes

The grain yields of both soybean and cowpea obtained from the trial are in Table 1. It was observed that the grain yield of soyabean in both the intercrop and sole cropping system was each more than 2 tons/ha while for cowpea each was less than 1 ton/ha.

Table 1: Grain yields of soybean and cowpea as affected by intercropping with Jatropha at Nyankpala

Treatment	Yield (t/ha)
Soyabean intercropped with Jatropha	2.63
Sole Soyabean	2.37
LSD $_{(0.05)}$	NS
Cowpea intercropped with Jatropha	0.67
Sole Cowpea	0.52
LSD $_{(0.05)}$	NS

It was also found out that the grain yields of soyabean and cowpea in the intercrop was each higher than in the sole system but the differences were not significant. Comparatively, soyabean yields were higher than the yields of cowpea in both Jatropha/soyabean and Jatropha/cowpea cropping systems. The low yield of cowpea observed in both the sole and the intercropping systems between cowpea and soyabean could be due to genetic differences in the crops. Cowpea and soyabean are two distinct crops with different genetic constitution, different growth habit and yields potentials.

It was visually observed that there was higher insect pests infestation on cowpea in the sole than in the intercrop. This could suggest that the presence of Jatropha might be responsible for repelling the insect pests and which might have resulted into the difference in the low yield of cowpea in the cropping systems.

b). Jatropha intercropped with Cereals

The grain yield of maize even though was higher in the intercropping system than in the sole, the difference was not significant (Table 2). However, for sorghum, the grain yield in the intercropping system was significantly higher than in the sole cropping system. The grain yield of sorghum in both cropping systems was also obviously lower than the grain yields of maize in both situations.

The lower grain yield of sorghum compared to that of maize could be due to the fact that they are different crops with different genetic make up and yield potential. However, the significantly higher sorghum grain yield found in the intercropping system than in the sole crop situation could be due to water logging conditions on the plots. It was observed that during the crop growing season, most of the plots within the sole cropping system had more standing water than in the intercropping systems and this could have affected the sorghum yield negatively.

Table 2: Grain yields of maize and sorghum as affected by intercropping with Jatropha at Nyankpala

Treatments	Yields (t/ha)
Maize intercropped with Jatropha	3.44
Sole Maize	3.15
LSD $_{(0.05)}$	NS
Sorghum intercropped with Jatropha	2.33
Sole Sorghum	1.63
LSD $_{(0.05)}$	0.63

Emergency Initiative to Boost Rice Production

Afua Serwa Karikari, S.K. Nutsugah, IDK Atokple, Wilson Dogbe, SS. Buah, R.A.L. Kanton A.N. Wiredu .

EXECUTIVE SUMMARY

The Emergency Rice Initiative Project (ERIP) to boost rice production in Ghana commenced with the Project Planning Workshop organized by CRS/Ghana and hosted by CSIR-SARI on 26th July, 2008. The objective of the workshop was to leverage the existing capacities and expertise of Partners in Research and Development to address short-term food insecurity by improving rice production among targeted farmers in the Upper East, Upper West and Northern Regions of Ghana. The project actors at the workshop included CRS/Ghana, CSIR-SARI and implementing partners involving the Catholic Archdioceses of Tamale, Wa and Navrongo-Bolgatanga and local NGOs in the project districts. The project was launched on Friday, 30th January 2009 in Accra at the M-Plaza Hotel. The launching was attended by national and international stakeholders and was used to prepare the national workplan with input from the Regional Project Coordination Unit through the Project Manager of Ghana and Nigeria.

The activities carried out during the quarter under review were country coordinating unit review meeting, development of seed management decision tool for extension agents and farmers, training of trainers on best-

bet practices, monitoring of rice fields, mass and media sensitization and educational campaign with radio and video programs, preparation of final technical report and in-country final workshop. Three CCU Project Implementation Team meetings were held on 28th October, 1st December and 21st December 2010 to discuss various project implementation issues. The first was a debriefing meeting with the regional monitoring team from Nigeria, Senegal, Mali and Ghana on the outcome of monitoring of project activities in the project sites. The second was to discuss and plan for the completion workshop while the third was to discuss progress of work, completion workshop, outstanding assignments and reports to be completed by 31st December 2010.

CSIR-SARI facilitated the packaging and distribution of certified seeds to 8,607 farmers across the three project regions; 1,048 farmers in Upper West Region (UWR), 4,203 in Upper East Region (UER) and 3,102 in Northern Region (NR). A total of 3,447 farmers planted in UER, 915 farmers planted in UWR while 2,392 farmers planted in NR. Cumulatively, 9,494 farmers (representing 95.0%) across the three project regions planted the improved seed provided by the project. Thirty (30) demonstrations on ISFM and 12 Nutrient Omission trials were implemented across the three Project regions and used to train FBO's on how to manage the new fertilizers and to demonstrate their efficacy. Yield assessments were carried out to determine the performance of paddy yield across the regions. The paddy yields were generally low and ranged from 1.7-5.0 t/ha for UER, 0.8-2.8 t/ha for NR and 0.8-2.0 t/ha for UWR. In collaboration with CRS/Ghana and Diocesan Partners and MoFA, SARI organized field days for farmers to demonstrate the best-bet practices on the key rice management options. CDs of best-bet practices in all the 7 languages were made available to all the key implanting partners for extension purposes. Translation of videos into the 7 major languages (Dagbani, Kusal, Dagaari, Gonja, Kassin, Sissali and Buli) was a major achievement chalked by the project.

The completion workshop of the ERIP was held in the Conference Room of the CSIR-SARI, Nyankpala near Tamale on Monday, 20th December, 2010. The workshop was attended by national and international stakeholders and was used to discuss the significant achievements, make assessment of the results obtained for improved rice production. The closing proceedings was broadcast on the GTV on 29th December, 2010 with a repeat broadcast the next day.

BACKGROUND

Food, fuel and fertilizer prices have soared up considerably in 2008 and therefore resulted in food security especially in West Africa being at great risk. The AfricaRice Center (ex WARDA), Catholic Relief Services (CRS) and the International Center for Soil Fertility and Agricultural Development Services (IFDC) led a network of national agricultural research organizations, NGOs and local implementing partners in proposing an Emergency Rice Initiative, a two-year initiative to boost rice production in four countries in West Africa – Ghana, Mali, Nigeria and Senegal.

This initiative has targeted 10,000 poor rice farm families in each of the four countries. The objective is to boost total domestic rice production in each of these countries by a total of 30,000 tons of paddy rice with a current market value of about US$21 million. This Initiative aims to improve farmers' access to rice seed and fertilizer and to expand knowledge on best-bet rice technologies. It aims to provide certified rice seed and mineral fertilizer inputs to 40,000 farmers through existing distribution channels such as the private sector, government and non-government agencies (i.e. Catholic Relief Services).

These farmers will also gain access to best-bet rice technologies through on-the-job training and through videos on rice technologies. Rural radio and TV broadcasts on these technologies will also be used to reach other farmers not directly involved in the project.

In this connection, the Ghana component of the project was launched at a workshop on January 30, 2009 in Accra where the contents of the project and implementation strategies were shared with stakeholders during the one-day workshop. The workshop led to three results namely:

1. All relevant stakeholders were informed about the project
2. A national action plan was elaborated
3. A strategy was elaborated to implement the project, defining roles and responsibilities of all project actors.

A pre-launching workshop meeting was held to dialogue with some relevant stakeholders on January 14, 2009 at the Conference Room of the Director-General, CSIR Head Office, Accra to prepare the ground for the launching workshop.

ACHIEVEMENTS

Intermediate Result	Output	Achievements
IR 1.1: Country Coordination Unit is established	Effective M&E mechanisms operational at country level	CCU is functional; meets periodically to revie progress reports. CCU met on 28/10/10, 1/12/1 and 21/10/10 to discuss various project implementation issues
IR 1.2: Partners & target farmers & implementation & M&E mechanisms are identified	Collaborative linkages well developed and functional Target farmers identified, selected and registered	Wellbeing analysis/periodic interaction played pivotal role in achieving output in Upper East, Upper West &Northern Regions Farmer registration was completed with the selection of participating communities

Intermediate Result	Output	Achievements
IR 2.1: Rice seed is multiplied in sufficient quantities for distribution to target farmers in 2010 cropping season	Breeder, Foundation & Certified seeds were purchased & distributed	SARI, MoFA, SEEDPAG, GLDB & CRS/Gha involved in seed packaging and distribution Seed cleaning and certification took place at S Inspection Unit of MoFA
IR 2.2: Farmers have obtained quality seed in sufficient quantities through the use of voucher systems and seed fairs	Demand driven approach for dissemination of improved rice seed introduced	Outcome from farmer registration targets mad possible for seed voucher requirements to be ordered for printing Trained Input dealers on their role in seed fairs

Intermediate Result	Output	Achievements

IR 4.2: Best-bet rice management options identified & distributed to farmers through a variety of methodologies including video	Videos translated into Dagbani, Kusal, Sissali, Dagaari, Gonja, Kassin & Buli	CDs of best-bet practices in 7 languages made available to key stakeholders for extension purposes TOT on best-bet practices was conducted in al three project regions

PROBLEMS AND SOLUTIONS

Problem 1. The flooding affected some farmers' fields in UER and NR

Solution 1. Affected farms have been abandoned

MEETINGS AND VISITS (OBJECTIVES AND RECOMMENDATIONS)

i). CCU Meeting, Nyankpala on 28th October, 2010: Wrap-up meeting with regional monitoring team from Nigeria, Senegal, Mali and Ghana to debrief CCU Members on the outcome of monitoring of project activities in Ghana.

ii). CCU Meeting, Nyankpala on 1st December, 2010: Project Implementation meeting to plan the In-Country Final Workshop on 20th December, 2010.

iii). CCU Meeting, Nyankpala on 21st December, 2010: Project Implementation meeting to review progress of work, completion workshop, outstanding assignments and reports to be completed by 31st December, 2010.

FIELD ENTOMOLOGY

Use of Jatropha Plant to Improve Sustainable Renewable Energy Development and Create Income–generating Activities: An Integrated Approach to Ensure Sustainable Livelihood Conditions and Mitigate Land Degradation Effects in Rural Areas in Ghana

Sub-Component: Pilot Insect Pests Survey of the EU-Jatropha Project

S.K. Nutsugah, J.M. Kombiok, P. Etwire

Introduction

Jatropha curcas is gaining importance commercially as a biodiesel plant and is being advocated for development of Wastelands and dry lands. Thus it is popularly called energy plantation. Currently, Jatropha appears to be one of the most promising feedstocks upon which the energy industry will be built.

Ghana Government has devoted a great deal of attention to bio-fuels, particularly those derived from the multi-purpose perennial crop *Jatropha curcas* L. on the basis of several successful experiences in other Sub-Saharan neighbouring countries (Mali, Burkina Faso, Tanzania and Niger).

Contrary to popular belief that toxicity and insecticidal properties of *J. curcas* are a sufficient deterrent for insects that cause economic damage in plantations, several groups of insects have overcome this barrier, particularly noteworthy is the insect order Heteroptera (Chitra and Dhyani, 2006). In Nicaragua alone there are at least 15 species with the key pest, identified as *Pachycoris klugii* Burmeister (Scutellaridae: Heteroptera), occurring at a density of 1234 to 3455 insects per hectare (Grimm, 1996).

It is against this background that a pilot insect pest survey was conducted for the EU-Jatropha Project to safeguard against any possible pests during the full implementation this year.

Monitoring

The about 2-acre Pilot Eu-jatropha field at the SARI Experimental Field was the site for the monitoring. A weekly visit was made to the field to monitor the plants from the seedling stage through to the fruiting stage. This was to ensure that all the insect visitors and pests at the various stages of the plant growth are recorded.

Findings

Various insects were found visiting the plants. Some were minor. Others like the Scutellarid Bugs: *Calidea dregii* Germar were found to bear economic threshold

Recommendation

Based on the severity of the major pests attack as shown above, it is recommended that a budget be made for a weekly monitoring on-farm for early pest identification and management.

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SOCIO-ECONOMICS

Alexander Nimo Wiredu

Generalities of Socio-economic Activities in 2010

In 2010, the economic section generated relevant information to support the activities of the natural scientists. The information was generated through impact studies and economic evaluation of some technologies. During the period, the section has successfully developed an effective and efficient database management system, an essential tool for the generation of socio-economic information. Focus group discussions, key informant interviews, desk studies and formal household and producer surveys continued to be useful means of data collection.

So far, reports on the actual and potential impacts of the NERICA dissemination project, the Emergency Rice Initiative project as well as the AGRA Soil Health project are available. The section in collaboration with Ministry of Food and Agriculture is developing the national rice data systems dubbed National Rice Survey. This has already provided useful information for the analysis of the competitiveness of the rice industry in Ghana under the DIIVA project. There is also an effort to develop strategies to manage yam glut in the Brong-Ahafo region under WAAPP. Other on-going activities include a baseline study to characterize the vegetable based agricultural production systems in the Northern and Upper East regions and the economic evaluation of drought tolerant maize varieties under the DTMA project.

This report features synthesis of key findings from all completed studies. It also highlights the progress made so far with on-going studies and a look at the way forward. Some new activities proposed for 2011 are also mentioned.

Ex-post Impact of NERICAs Dissemination Project in Ghana

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Executive Summary

This study was a follow up to the baseline study conducted in 2006. The end-line survey was repeated in Ejura-Sekyedumase, Hohoe and Tolon-Kumbungu. The results of the end-line study were compared to the baseline study. The results revealed a huge leap in the rate of exposure to the NERICAs among up to 60 percent of the sampled farmers. The rate of

adoption has also increased to about 36 percent. All the farmers who cultivated NERICAs have access to adequate quantities of seeds and other critical inputs. Adoption of NERICA is affected by access to seeds, land and labour resources. Experience, education and membership of farmer based organisation also contributed significantly to the rate of adoption. Cultivation of NERICA increased yields and income obtained from rice cultivation. This subsequently translates into higher rates of school enrolment by the children of the farmers. There is the need for continued support for the disseminations of NERICAs and an extension of the accompanying technologies as well as coverage.

Introduction

The impact study primarily puts human face to the multi-national NERICA dissemination program. It provided an appreciation of the actual and intended benefits of the project in Ghana. It primarily generated information for the evaluation of the rate of diffusion and adoption of the NERICAs and their impacts on income and access to education among the project beneficiaries in Ghana**.**

Methodology/Approach

The study featured rice producing households in Ejura-Sekyedumase district, Hohoe district and Tolon-Kumbungu district, which are also within the domain of the ARI project. To provide an appreciation of the gains made so far, the baseline results were compared to the end-line results. Following the average treatment effect methodology (Diagne and Demont, 2007), a parametric exposure and adoption models were estimated to assess the determinants of adoption. A local average response function was also estimated for the description of the impacted outcomes on income and access to education among the direct beneficiaries of the project and the indirect beneficiaries.

Results and Discussions

Scientific Findings

The results suggest a huge leap from about 5 percent exposure rate to about 60 percent among the sampled rice farmers (beneficiaries and non-beneficiaries). The rate of NERICA adoption has also moved to 38 percent from about 5 percent. All the farmers who cultivated NERICA had access to adequate quantities of seeds and other agro-chemicals. In addition to access to seeds, adoption of NERICA is also shown to be affected by access to land and labour resources. Other factors that influence the rate of NERICA adoption include the number of years of experience in rice cultivation, the level of education of the farmer and membership of farmer based organization.

Between the baseline period and the end-line period, the farmers also recorded significant changes in their livelihoods. NERICA cultivating farmers have seen yield increases by about 76 percent from 1.38 ton/ha to 2.43 ton/ha. This yield increases translated to higher levels of rice income which moved from about GH¢700 to about GH¢3400. The rate of school enrolment among the children of these farmers is presently over 80 percent from an initial rate of less than 25 percent.

Conclusions/Recommendations
NERICA indeed has high potential for increasing rice production to enhance the livelihoods of resource poor farmers in Ghana. The study has shown that NERICA adoption has positive impact on incomes and school enrolment. There is the need to consolidate these gains made through continued support for dissemination of NERICAs and an extension of the coverage to other regions.

References
Diagne and Demont (2007). Taking a New Look at Empirical Models of Adoption: Average Treatment Effect Estimation of Adoption Rates and their Determinants. Agricultural Economics 37.

Impact of Emergency Rice Initiative project in Ghana

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Executive Summary
The study assessed the impact of the Emergency Rice Initiative Project on the livelihoods of targeted rice producers. The effect of the project was captured through the distribution seed voucher which facilitated the access to quality seeds. Training in good agricultural practices also resulted in positive impact on the income of the rice farmers. Regardless of the treatment status, sampled farmers in the intervention area recorded significant increases in their yields and income from rice. The incomes of farmers who received seed vouchers were doubled. It is therefore recommended that interventions that seek to improve farm level performance should include strategies to ensure consistency in the availability of inputs including quality seeds coupled with regular and appropriate training programs. Sustainability will also be achieved if existing linkages with on-going development programs are maintained and strengthened.

Introduction

The seed voucher system was a key component of the emergency rice initiative (ERI) project. This was intended to facilitate access to and the use of quality seed among the targeted rice producers. The use of high quality seeds was in turn expected to improve farm-level performance and livelihood of the farmers. The impact study assessed the specific effect of quality rice seeds on household income among other things. In addition to the seed vouchers, farmers were generally trained in good agricultural practices.

Methodology/Approach

With a set of highly specialized questionnaires, data from a cross section of 360 systematically selected rice farmers were used for the study. In order to compare the effect of quality seeds on project participants and non-participants, equal samples of rice producers were selected from the two categories. The analysis is differentiated by region in order to capture existing variations. The effect of the project is captured through the receipt of seed voucher, use of improved seeds and then income.

Results and Discussions

Scientific Findings

On the whole 77 percent of the farmers who received seed vouchers collected the approved quantity of quality seeds and are shown as "compliant". This suggests that some farmers rejected the package from the project and are described as "non-compliant". Farmers in Upper West Region had the highest rate of compliance (88 percent), while those in Northern Region had the highest rate of non-compliance (32 percent).

The estimated income of sampled farmers was GH¢11,118 per annum. Rice production activities contributed about 33 percent of the total household income. The contribution of rice to total income was much higher, about 55%, for farmers from the Northern Region. The other sources of household income identified are other cropping activities, livestock rearing and non-agricultural activities, with the latter contributing the least.

Overall, the results show that the use of quality rice seed had a positive effect on the income regardless of the treatment status of the rice producer or the location. Both farmers who received the seed voucher and those who did not received it made some gains from the project. On the whole, the use of quality seeds doubled the income of all the sampled rice producers. The results underscore the fact that even without the seed vouchers, farmers who had knowledge of the availability of the quality seeds got themselves on board.

Conclusions/Recommendations

The seed voucher system under the Emergency Rice Initiative Project enhanced farmers' access to quality seeds both directly and indirectly. The use of quality seeds had a positive impact on household income and obviously translates into other livelihood outcomes.

Given the outcomes, there is the need to consolidate the gains made so far. Strategies to ensure consistency in the availability of quality seeds together with regular and appropriate training programs are encouraged. Sustainability will also be achieved if existing linkages with on-going development programs are maintained and strengthened.

References

Diagne and Demont (2007). Taking a New Look at Empirical Models of Adoption: Average Treatment Effect Estimation of Adoption Rates and their Determinants. Agricultural Economics **37**.

JICA Rice Survey

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Executive Summary

As part of efforts to generate reliable information on the rice production system in Ghana and Africa, JICA contracted CSIR-SARI to implement the Survey in the northern region of Ghana. The approach was well designed to suite the nature of the survey. Overall, more than 98 percent of the interviewed rice producing households are male headed. Apart from farming and rice production, some of the interviewed farmers are involved in off-farm income generating activities. Each rice producer crops about 1.73 acres of rice farm regardless of their location. They apply about 3 bags of seeds to their fields. However the farmers from the project site are more efficient in the use of seeds. Although some delays were encountered in the delivery of the product under this consultancy, it is believe that the work output is excellent.

Introduction

As part of efforts to generate reliable information on the rice production system in Ghana and Africa, JICA implemented a series of surveys in selected countries of sub-Sahara Africa. Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) was contracted to implement the Survey in the northern region of Ghana.

The project was expected to collect information on samples that are representative of rice production in the Northern region. A total of 6 rice valleys were involved in the survey. The valleys also represent implementation zones of LRDP in Northern Region of Ghana.

The survey was to generate reliable information for the assessment of the impact of water harvesting technology and other complementary technologies of the Lowland Rice Development Project (LRDP) which was implemented in the Northern region of Ghana. The information generated was useful for the assessment of the rate of diffusion and adoption of these technologies and the extent to which these have affected farmer livelihood.

The presents report provides a summary of the implementation process of “The Survey” for the “Empirical Analysis of Expanding Rice Production in SSA” conducted in Northern Region of Ghana. It also includes results of key descriptive statistics of the surveyed communities as well as the rice producers.

Methodology/Approach

Our approach was well designed to suite the nature of the survey. A series of desk studies and reconnaissance visits to some rice producing communities were conducted. Questionnaire adaptation and the recruitment and training of enumerators marked the preparatory phase of the survey. In phase 2 was the field work. The third and final phase was characterised by processing and reporting.

Results and Discussions

Scientific Findings

The survey involved 600 rice producing households randomly drawn from 60 rice communities in Northern region of Ghana. The 60 communities were evenly distributed across valleys namely Koblijor, Kulda Yarang, Lower Sillumn, Upper Sillumn, Tolon and Zwari valleys. There was a brief description of the demographic characteristics of the sampled households which provides interesting revelations with minimal variations across the three groups of communities. Overall, more than 98 percent of the interviewed rice producing households are male headed. A typical farmer is about 46 years of age.

Marriage is a highly cherished custom among the people in northern Ghana. It is therefore not a surprise to find less than 5 percent single farmers who have never been married. About 95 percent of the farmers are married whilst 55 percent monogamous and 40 percent polygamous. There are also divorced and widowed farmers among the sample.

Another interesting revelation from the initial analysis is the fact that over 95 percent of the farmers are in good health condition. A very few of the farmers are partly or fully disabled, aged or sick. This provides opportunity for the rice industry in the survey area as regards to the availability of efficient labour force.

Literacy on the other hand is pretty low among the sampled farmers with about 90 percent being illiterate farmers. There is however a handful of basic school, secondary school, college and post college graduate in the sampled communities.

Apart from farming and rice production, some of the interviewed farmers are involved in off-farm income generating activities. More specifically, about 8 percent of the sampled farmers are engaged in self employed income generating activities while about 3 percent are salaried workers.

Some results of rice production indicators among the sampled farmers are also presented. Similarly, minimal variations exist among these indicators across the groups of communities. Each rice producer crops about 1.73 acres of rice farm regardless of their location. They apply about 3 bags of seeds to their fields. However, the farmers from the project site are more efficient in the use of seeds. Although they apply about 2 bags of seeds to their crop fields, they harvest about 18.6 bags which is much higher than the farmers from the non-project site who apply about 4 bags and harvest about 17 bags.

Conclusions/Recommendations

Although some delays were encountered in the delivery of the product under this consultancy, it is believe that the work output is excellent. The rigorous nature of the implementation process is supposed to ensure accuracy and reliability of the database.

Ghana Rice Data Systems

Alexander Nimo Wiredu, John Nortey (Statistician, MoFA)

Executive Summary

The Rice Data Systems project was primarily intended to develop a reliable database on rice production in Ghana and Africa as a whole. The study was designed to generate information to reflect rice production system and existing capacities for rice production and research. The results show that farm holdings range from less than 1 ha to more than 50 ha. Farm sizes between 1 ha and 5 ha constitute the largest proportion (about 38 percent) of the total land area of the sampled farmers. Five rice ecologies were identified, namely, irrigated, upland with supplementary irrigation, strict upland, and upland with ground water and lowland ecologies. With an average yield of about 5 ton per ha, lowland rice production contributes the largest proportion (about 24 percent) of rice produced in Ghana. Improved NARS varieties, the NERICAs as well as the other improved varieties are mostly cultivated by the sampled farmers. The first phase focused on the production system.

Introduction

Rice has in the past decade become a commodity of strategic importance for most African economies including Ghana. For the rice sector in Ghana to attain its potential of improving livelihoods, policies must be well targeted. The success of the Emergency Rice Data Systems project in Ghana is key to the generation of reliable information for evidence based policy formulation. The Rice Data Systems project was primarily intended to develop a reliable database on rice production in Ghana and Africa as a whole.

Methodology/Approach

The study was designed to generate information to reflect regional and national indicators. Three rounds of surveys, involving rice producing farm households, rice producing community (village) and selected researchers (experts), were conducted. Selection of rice producing communities and rice producing farm households followed a multistage sampling strategy involving stratified and random sampling techniques. The main sample frame was rice producing communities in the country. A total of 488 households were interviewed.

Results and Discussions

Scientific findings

The results show that farm holdings range from less than 1 ha to more than 50 ha. Farm sizes between 1 ha and 5 ha constitute the largest proportion, about 38 percent, of the total land area of the sampled farmers. Five rice ecologies were identified, namely, irrigated, upland with supplementary irrigation, strict upland, and upland with ground water and lowland ecologies. With an average yield of about 5 ton per ha, lowland rice production contributes the largest proportion, about 24 percent, of rice produced in Ghana. Improved NARS varieties, the NERICAs as well as the other improved varieties are mostly cultivated by the sampled farmers.

Overall, less than 25 percent of the sampled farmers had access to quality seeds. Apart from seed constraint, access to fertilizer and credit facilities, equipments, extension services, labour and land resources, market and seed, as well as the cost of production constitute the main socioeconomic constraints. Disease and pest conditions constitute the main biotic constraints. The abiotic constraints include post losses, soil conditions, water management and drought. The results show that farmers who manage small land areas experience fewer the constraints relative to those with large land areas.

Conclusions/Recommendations

Despite the numerous challenges encountered during the implementation of the rice data system project in Ghana, some success has been realized. Through the relentless efforts of the implementing agencies and cordial collaborations, the project has been able to generate reliable information on the rice sector in the country.

With this success, experiences with rice data system can be extended to the other cereals. The questionnaires and the implementation strategies can be adapted and modified for that purpose.

Assessing the Impact of the AGRA Soil Health Project in Northern Ghana

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Executive Summary

Monitoring and evaluation and impact assessment is an important component of the AGRA Soil Health Project in northern Ghana. The baseline study conducted as part of this component revealed first and foremost a high level of awareness of organic and inorganic fertilizer types which suggests that the ISFM technology has high potential adoption. The project should be gender sensitive in order to capture a wide range of beneficiaries. The existence of such farmer based organizations in the study/project area provides opportunity for effective technology dissemination. Regarding project indicators, a 50 percent increase in the yields of the sampled farmers will be enough to move their productivity to the national average let alone the yield potentials from research fields. Given that the estimated yields form the study is very low, the project can make much significant impact if yields are rather doubled. This can then translate into other livelihood outcomes such as income and stock of resource endowments.

Introduction

Monitoring and evaluation and impact assessment is an important component of the AGRA Soil Health Project in northern Ghana. As part of the activities under this component is this baseline study, which primarily describes the prevailing conditions in the study area. The study highlighted the characteristics of the farm households, their farming activities and their livelihood outcomes. The results of the study provide information for the development of an effective monitoring and evaluation (M&E) system for the project.

Methodology/Approach

Through a formal household survey, a database of farm household was generated. The data will serves as a decision tool on project indicators and targets. It will also guide the collection of up-to-date information on adoption and diffusion of the ISFM technologies and their impacts on livelihoods and poverty of the targeted farm households. Towards the end of the project, the survey will be repeated as end line study to provide a panel dataset for ex-post assessment of the overall impact of the project.

Results and Discussions

Scientific findings

Apart from agriculture, some of the sampled households were engaged in off farm income generating activities. The heads of the households were largely males and old aged. Most of the heads of the sampled household, about 72 percent, were not educated. The sampled households were endowed with human and land resources which are critical for their agricultural production activities.

Two main kinds of fertilizers, organic and inorganic fertilizers were identified with the sampled farm households. Broadcasting, dibbling, placement and plough back were the common methods of fertilizer application among the sampled households. While dibbling and placement method was only found with the application of inorganic fertilizers, plough back was only associated with organic fertilizer application. On the other hand, broadcasting method was shown to be mostly used for organic fertilizer application.

With the exception yam, the farm households obtained less than 1 MT of any harvested produce from a hectare of their land. The least yields were recorded for rice as well as the legumes crops. In order to attain the regional and national estimates, the yields obtained by the sampled households must increase by at least three folds. Among the list of cereal crops cultivated by the sampled households rice and maize were shown to be the most consumed.

Food security, income levels and household expenditure profile were the main livelihood indicators measured by the study. The results revealed that about 50 percent of the sampled households had access to adequate amount of nutritious food throughout the year. The other half of the sampled households experienced food shortages for at least a month and at most a year. In addition to crop and off-farm income sources, the sampled household obtained income from livestock rearing.

Conclusions/Recommendations

The results of the baseline study suggest that the ISFM technology has high potential impact on the livelihood outcomes of the project participants. This will be possible through strategic packaging of the technology and targeting of the project activities. If properly done final evaluation of the project will reveal positive impact.

References

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Strategies to Manage Yam Glut in Brong-Ahafo Region of Ghana

Alexander Nimo Wiredu, Richard Yeboah (Agric Economist, UDS)
John Nortey (Statistician, MoFA)

Executive Summary

The project primarily seeks to develop strategies to manage yam glut in the Brong-Ahafo Region of Ghana. Rapid surveys implemented in communities and markets in key yam production and marketing districts provided useful means for the identification of major stakeholders of the yam industry in the Brong-Ahafo region. In addition to the production and consumption agents in the industry, commercial agents also constitute a significant part of the industry. Research and the ministry of food and agriculture as well as other agro-base institutions (state, private and NGOs) were identified as technical service providers in the industry. Collection of relevant secondary data and literature review for trend analysis is on-going. One key outcome of the working strategy is the survey design. The survey will be implemented at three different levels, community level, household level and market level.

I. Introduction

The project primarily seeks to develop strategies to manage yam glut in the Brong-Ahafo Region of Ghana. This is to be achieved through an assessment of the structure, functions and dynamics among actors and existing linkages in the yam industry to generate adequate information for the development of an efficient and effective yam value chain the region.

Methodology/Approach

A workshop was to be implemented to enable the identification of stakeholders and development of working strategies. However due to delay in the release of funds, the workshop was substituted with separate meetings with identified stakeholders. Through reconnaissance visits to the directorates of ministry of food and agriculture (MoFA) and other research institutions previously engaged in the assessment of yam market, all the relevant stakeholders were identified. During such visits, relevant data on yam marketing and other literature was sought.

Results and Discussions

Scientific findings

Rapid surveys implemented in communities and markets of key yam producing districts provided useful means for the identification of major stakeholders of the yam industry in the Brong-Ahafo region. In addition to the production and consumption agents in the industry, commercial agents also constitute a significant part of the industry. Research and the ministry of food and agriculture as well as other agro-base institutions (state, private and NGOs) were identified as technical service providers in the industry.

Though on-going, some reconnaissance visits to the district directorates of Ministry of Food and Agriculture have generated relevant secondary data on yam production and prices. One key outcome of the working strategy is the survey design. Data collection is completed for two districts with three more to go. This will be completed as soon as funds are available.

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 Agricultural Economist. The team's work focuses on characterizing and describing the farming systems of the region, identifying and prioritizing constraints to increase sustainable agricultural production and generating suitable interventions to address the prioritized problems of the farmers through adaptive on-farm as well as on-station research. Besides, the team also has oversight responsibility of coordinating Research, Extension and Farmer Linkage Committee (RELC) activities in the UWR. This report highlights activities of the year under review.

AGRONOMY PROGRAMME

Increasing Soybean productivity with Rhizobium inoculation and mineral fertilizer application

S.S. J. Buah and M. Fosu

Executive Summary

Soils in the savanna zone of Ghana are inherently low in plant available nutrients particularly nitrogen (N) and phosphorus (P). With farmers' current production practices, soybean (*Glycine max*) is generally grown under low plant stand without any fertilizer addition, thus leading to lower grain yields. An experiment was conducted in 2010 to assess the agronomic and economic benefits of using rhizobium inoculum and mineral fertilizer on the grain yield of soybean in the savanna zone of Ghana. Preliminary results of this study showed that soybean varieties responses to rhizobium inoculation and mineral fertilizer were similar. Pod shattering was visually more severe in Salintuya 1 than in Anidaso and Jenguma. Soybean fertilized with mineral fertilizer with or without rhizobium had similar yields as those that did not receive fertilizer or rhizobium.

Introduction

Soybean (*Glycine max*) is increasingly gaining prominence as a cash crop due to its importance both in the domestic and export markets, and its products (oil and cake) for both domestic and industrial uses. It requires lower production inputs. In general, farmers in the savanna zone have attributed low crop yields to declining soil productivity, which in turn is linked to shortened bush fallows. The increasing use of inorganic fertilizers has compensated but fertilizers are expensive and not readily available. This leads to a decline in soil nitrogen which frequently results in low crop yields or soil productivity. Farmers in the savanna zone plant soybean with little or no fertilizer input. The high cost and unavailability of fertilizers require that the limited amounts that are available must be used judiciously for maximum benefit. In general, soil fertility can be maintained or increased using an integrated approach such as the use of fallows, biological nitrogen (N_2) fixation (BNF) by legumes, the use of crop residues, the application of mineral fertilizers and the use of household wastes and manure. Research results have shown that alternative technologies such as the use of the right strain of inoculum to enhance nitrogen fixation in grain legumes could address these problems. Mean grain yields on farmers' fields in this zone remain low (< 1.0 t/ha) compared to yields obtained from research fields (1.6 -2.5 t/ha). Lower grain yields associated with farmers' current practice when compared with high management treatment may be attributed to low plant stand, inadequate fertilization and poor weed management. Increased plant population combined with fertilizer application and improved varieties have been used to increase soybean grain yield in field and demonstration trials. Furthermore delay in harvesting some varieties often lead to post harvest shattering losses. It is therefore important that farmers observe the optimum planting distances and harvest on time else they lose the grains through shattering of the pods. Hence there is the need to introduce the non-shattering soybean variety, Jenguma, to the farmers. It has been proven that it is economically attractive to grow soybean at the recommended spacing with fertilizer additions. There was therefore the need to evaluate soybean response to mineral fertilizers and rhizobium inoculation in the savanna zone in order to come out with the most economic fertilizer combination for soybean farmers.

Materials and methods

The experiment was conducted at the SARI Research Farm at Wa to assess the agronomic and economic responsiveness of soybean to mineral fertilizers and rhizobium inoculation. The experiment was conducted in a split-plot arrangement of treatments in a randomized complete block design with three replications. The main plot treatments were three soybean varieties (Jenguma, Anidaso and Salintuya 1). Five (5) fertilizer treatments were applied to the subplots (Table 1.1).

Table 1.1. List of fertilizer treatments tested in 2010

Treatment code	Treatment Description
T1	No fertilizer
T2	Rhizobium inoculation
T3	60 kgP_2O_5+30 kg K_2O/ha
T4	25 kg N+60 kg P_2O_5+30 kg K_2O/ha (Recommended fertilizer rate for soybean)
T5	Rhizobium +60 kg P_2O_5+30 kg K_2O/ha

Improved production package were followed that included growing the 3 improved soybean cultivars using the 5 fertilizer treatments. Jenguma is a non-shattering soybean variety which is quite popular among soybean farmers while Salintuya 1 has become less popular due to its pod shattering characteristics. The non-shattering attributes of Jenguma has stimulated widespread interest in scaling up its production. However, most farmers have complained that the thick pods of Jenguma makes threshing of its pods difficult when compared to Salintuya 1 which rather has relatively higher yield potential. The fertilizers were applied within 10 days after sowing while the seed was inoculated an hour before planting. The experiment was replicated three times.

Results and discussion

Data are for 2010 cropping season only and this necessarily limits the type of conclusions that can be drawn from the results. The previous crop on this piece of land was sorghum that was fertilized with Urea. The soil at this site is slightly acidic (pH=5.46). On average, the three soybean varieties did not differ significantly among each other in agronomic traits like plant height, dry weight, pods per plant and seed size (Table 2). Although Jenguma tended to have higher grain production, its yield was not significantly different from those obtained from Anidaso and Salintuya 1. However, pod shattering was visually more severe in Salintuya 1 than in Anidaso and Jenguma.

Fertilizer treatment did not significantly influence flowering date, plant height, grain yield and its components when compared with no fertilizer treatment (Table 1.2). The application of fertilizer with or without rhizobium inoculation did not lead to significant increase in grain yield. Application of mineral fertilizer to soybean resulted in increased plant dry matter production and pods per plant when compared with plots that were inoculated with rhizobium but this did not translate to greater grain production.

Table 1.2. Mean grain yield and some yield components of soybean as affected by fertilizer and rhizobium inoculation in Wa, Upper West region, 2010.

Treatment	Days to flowering (days)	Plant dry weight for 5 plants (g)	Pods per plant No	100- Seed weight (g)	Grain yield (kg/ha)
Variety					
Jenguma	48	60.0	46	10.2	2453
Salintuya 1	52	47.8	42	10.8	2275
Anidaso	51	63.1	41	9.5	2133
LSD (0.05)	1.0	NS	NS	NS	NS
Fertilizer treatment					
No fertilizer	52	56.7	41	9.6	2178
Rhizobium inoculation	52	46.9	32	10.5	2282
60 kgP_2O_5+30 kg K_2O/ha	52	65.5	42	10.0	2341
Rhizobium +60 kgP_2O_5+30 kg K_2O/ha	53	56.2	45	10.3	2296
25 kg N+60 kgP_2O_5+30 kg K_2O/ha	52	59.5	54	10.4	2341
LSD (0.05)	NS	10.1	7	NS	NS
CV%	1.4	18.3	17.2	10.6	9.6
Mean	52	57	43	10.1	2287

Evaluation of foliar and compound fertilizers effects on rice production

S.S.J. Buah, W.Dogbe and S.K. Nutsugah

Executive summary

In the savanna zone of Ghana, soil fertility depletion is already high and relatively small amount of crop residues and animal manures are produced, hence mineral fertilizers will remain the principal sources for building up nutrients in soils. Moreover with farmers' current production practice, rice (*Oryza sativa* L.) is generally grown under low plant stand with little or no fertilizer addition, thus leading to lower grain yields. An experiment was conducted in 2010 to assess the agronomic and economic benefits of using foliar (Boost xtra), compound and urea fertilizer on rice production in the savanna zone of Ghana. In general, preseason and terminal drought prevented the crop from reaching its full potential. Mean paddy yield ranged from 983 to 1783 kg/ha. On average, paddy yields were lowest with the treatment without fertilizer application while the highest yields were obtained from plots that received 125 kg of NPK (15-15-15) and 125 kg of urea per ha. In general, the application of fertilizers has proved to have good effect on rice production in the region. However, foliar fertilizer alone is not enough for optimum paddy yield because the amount of NPK supplied in the foliar fertilizer is not adequate for optimum grain yields.

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops for both rural and urban dwellers in sub-Saharan Africa (SSA) and its importance in the food basket in West Africa has been increasing steadily during the last few decades. Unfortunately, the sharp rise in consumption has not impacted positively on the local rice production levels since a significant proportion of rice consumed is imported. Improvement in rice productivity potential will therefore play a critical role in feeding the African population that is expected to double during the next two decades. Nutrient inputs from chemical fertilizers are needed to replace nutrients which are exported and lost during cropping, to maintain a positive nutrient balance. However, because of scarcity and high cost, most smallholder farmers in tropical Africa rarely use inorganic fertilizers on food crops including rice. Subsistence farming in sub-Saharan Africa is thus characterized by low external input, low crop yield, food insecurity, nutrient mining and environmental degradation Statistics showed that average rice paddy yield in Ghana in 2009 was 1.9 t/ha. Average yield in researcher-managed on-station and on-farm research is about 6 t/ha. In general, there is a wide gap between potential and actual crop yields among smallholder farmers in developing countries, mainly because of poor extension services, institutional and cultural constraints and the farmers' long history of adaptation to traditional practices, which has limited their ability and willingness to fully adjust their input levels. Therefore, one of the challenges for researchers is to reduce the yield gap between research and production. However, because new technologies require intensive management and information, farmers in developing countries with low literacy rates, poor extension services and inadequate infrastructure have difficulties in adapting to the new technologies.

Materials and methods

The experiment was conducted at the SARI Research Farm at Bamahu near Wa to assess the agronomic and economic responsiveness of rice (*cv.*

Digang) to foliar (Boost xtra), compound and urea fertilizer in the savanna zone of Ghana. The experiment was conducted in a split-plot arrangement of treatments in a randomized complete block design with three replications. The main plot treatments were two foliar fertilizer rates (0 and 1.25l/ha). Seven (7) fertilizer treatments were applied to the subplots (Table 2.1).

Table 2.1. List of treatments in the demonstration trial in Upper West Region, 2010

Treatment code	Basal treatment (kg/ha)	Top dressing (kg/ha)	Foliar application (l/ha)
T1	125kg NPK/ha	125 kg urea/ha	1.25l/ha Boost xtra
T2	250 kg 15-15-15/ha	62.5kg urea/ha	1.25l/ha Boost xtra
T3	125 kg Actyva/ha	125 kg urea/ha	1.25l/ha Boost xtra
T4	250 kg Actyva/ha	62.5kg urea/ha	1.25l/ha Boost xtra
T5	125kg NPK/ha	125 kg USG/ha	1.25l/ha Boost xtra
T6	250 kg NPK/ha	62.5 kg USG/ha	1.25l/ha Boost xtra
T7	No fertilizer	No fertilizer	1.25l/ha Boost xtra
T1	125kg NPK/ha	125 kg urea/ha	Nil
T2	250 kg 15-15-15/ha	62.5kg urea/ha	Nil
T3	125 kg Actyva/ha	125 kg urea/ha	Nil
T4	250 kg Actyva/ha	62.5kg urea/ha	Nil
T5	125kg NPK/ha	125 kg USG/ha	Nil
T6	250kg NPK/ha	62.5 kg USG/ha	Nil
T7	No fertilizer	No fertilizer	Nil

NPK = 15-15-15; Actyva = 23-10-5-3-2-0.3 as N, P, K S, Mg and Zn; USG = Urea super granules

Results and discussions

The weather significantly affected the performance of the demonstrations in 2010. In general, preseason and terminal drought prevented the crop from reaching its full potential. Overall, foliar application tended to increase rice paddy yields, but the difference in mean yield was not statistically significant when compared with no foliar treatment. Mean paddy yield ranged from 983 to 1783 kg/ha (Table 2.2). On average, paddy yields were lowest with the treatment without fertilizer application (T7) while the highest yields were obtained from T1, i.e., plots that received 125 kg of NPK (15-15-15) and 125 kg of urea per ha. The results also showed that the slow N releasing USG is capable of increasing N use efficiency in rice production. In general, the application of fertilizers has proved to have good effect on rice production in the region. However, access to fertilizer is still a problem for most farmers. It seems foliar fertilizer alone may not be enough for optimum paddy yield because the amount of NPK supplied in the foliar fertilizer is not adequate for optimum grain yields. Moreover, the greatest difficulty on supplying N, P, and K in foliar sprays is in the application of adequate amounts without severely burning the leaves and without an unduly large volume of solution or number of spraying operations. To grow more food from less land we need to provide farmers with the innovation and the knowledge to use natural resources more efficiently.

Table 2.2. Fertilizer effect on rice paddy yield at Bamahu near Wa in the Upper West region, 2010

Treatment	Paddy yield without foliar fertilizer (kg/ha)	Paddy yield with foliar fertilizer (kg/ha)	Mean paddy yield (kg/ha)
T1	1883	1683	1783
T2	1467	2083	1775
T3	1633	1833	1733
T4	1533	1750	1733
T5	1783	1583	1683
T6	1733	1733	1642
T7	984	983	983
Mean	1574	1664	1619
CV%			24.2
LSD (0.05)			467

Nutrient Omission Trial (NOT) with Rice

S.S.J. Buah, W. Dogbe and S.K. Nutsugah

Executive summary

Soils in the savanna zone of Ghana are inherently low in plant available nutrients especially N and P. Most farmers generally grow rice (*Oryza sativa* L.) with little or no fertilizer addition, thus leading to lower grain yields. An experiment was conducted in 2010 to determine the most limiting nutrients in rice production and determine rice nutrient requirements in the region. In general, preseason and terminal drought prevented the rice crop from reaching its full potential. Mean paddy yield ranged from 983 to 1783 kg/ha. On average, paddy yields were lowest with the treatment without fertilizer application while the highest yields were obtained from plots that received 125 kg of NPK (15-15-15) and 125 kg of urea per ha. In general, the application of mineral fertilizers has proved to have good effect on rice production in the region. However, foliar fertilizer alone is not enough for optimum paddy yield because the amount of NPK supplied in the foliar fertilizer is not adequate for optimum paddy yields.

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops for both rural and urban dwellers in sub-Saharan Africa (SSA) and its importance in the food basket in West Africa has been increasing steadily during the last few decades. In many smallholder farms in West Africa, little or no agricultural input is added to the soil. This leads to a decline in soil nitrogen and phosphorus which frequently results in low crop yields or soil productivity. In general, there is a wide gap between potential and actual crop yields among smallholder farmers in developing countries, mainly because of poor extension services, institutional and cultural constraints and the farmers' long history of adaptation to traditional practices, which has limited their ability and willingness to fully adjust their input levels. Therefore, one of the challenges for researchers is to reduce the yield gap between research and production. However, because new technologies require intensive management and information, farmers in developing countries with low literacy rates, poor extension services and inadequate infrastructure have difficulties in adapting to the new technologies. The limited amounts of fertilizer available need to be used judiciously for maximum benefit. Since a majority of these farmers have low income, technical packages to increase and sustain agricultural production must be affordable, profitable and applicable to ensure their acceptability.

Materials and methods

The experiment was conducted at the SARI Research Farm at Bamahu near Wa to determine the most limiting nutrients in rice production (cv *Digang)* and rice nutrient requirements in the savanna zone of Ghana. The experimental design was a randomized complete block design with three replications. Five (5) fertilizer treatments were evaluated (Table 3.1).

Results and discussions

In general, drought period early and late in the growing season affected crop performance. Complete NPK fertilizer, on average increased yields by 61% compared with yields from the control treatment (Table 3.2). The application of fertilizer increased plant height. The unfertilized plants were shorter compared with plants that received fertilizer. In general, the application of N and P has proved to have good effect on rice production in the region. These two nutrients are generally reported to be the most limiting nutrient in savanna soils. Traditionally, soil fertility in the savanna zone has been maintained through shifting cultivation where farmers abandoned land to fallow as productivity declined, but increasing population pressure has shortened the fallow periods in many areas. Within this constraint, supply of N to crops in this region through mineral fertilizer is increasingly becoming important.

Table 3.1. Treatments used in the nutrient omission trial at Bamahu, UWR, 2010

Code	Treatment	Fertilizer rate (kg/ha)
T1	No fertilizer	No fertilizer
T2	NP	90N-90P_2O_5-0K_2O
T3	NK	90N-0P_2O_5-90K_2O
T4	PK	0N-90P_2O_5-90K_2O
T5	NPK	90N-90P_2O_5-90K_2O

Table 3.2. Nutrient omission effect on rice paddy yield at Bamahu near Wa, UWR, 2010

Treatment	Paddy yield (kg/ha)	Plant height (cm)	1000 seed weight (g)
No fertilizer	1233	59	21.3
NP	2533	86	25.0
NK	2100	86	24.2
PK	1717	85	23.1
NPK	3200	71	24.2
Mean	2157	77	23.6
CV%	10.2	13.1	5.3
LSD (0.05)	412	19	2.4

The Way Forward

Data were obtained from one season only and could not be used to draw firm conclusions. Nonetheless, the preliminary results provided useful information for fine-tuning management options to maximize rice paddy yields and reduce costs. Further studies were required for an additional season in order to obtain data from at least two seasons in order to draw valid conclusions and make firm recommendations. Therefore the experiment would be repeated in 2011.

Source of funding: Emergency Rice Initiative Project/IFDC

On-farm Testing and Demonstration of Drought Tolerant Maize Varieties and/or Hybrids (DTMA P3C)

Executive Summary

Studies were initiated in 2008 and continued through 2010 in order to enhance maize productivity and improve livelihood opportunities through improved production technologies in drought prone and Striga endemic areas in the Savanna zone of Ghana. Promising high yielding and drought tolerant maize varieties and hybrids were evaluated in farmer participatory

on-farm trials and demonstrations since 2008. The variable weather in 2010 affected plant growth and development and ultimate grain yield at most sites. Genotypic differences among the maize varieties for grain yield were significant at all sites. For the extra-early maturing maize, grain yield was highest for 2000 SYN EE W and TZEE W POP STR QPM C0 but least for the farmer's variety. Abontem had similar grain production as the highest yielding variety. Grain yield was highest for the early maturing varieties EVDT Y 2008 STR and TZE COMP 3 DT C2F2 but least for the farmer's variety. For the medium/intermediate maturing varieties, grain yield of the QPM hybrid, Etubi was lower due to low plant stand as a result of poor seedling establishment. The highest yielding cultivar was M09-25-9. Many of the improved drought tolerant varieties from IITA evaluated in this study performed similarly as or better than the best available local varieties at 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. Across years, 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, probably because the fields were not Striga endemic plots.

Introduction

Maize (*Zea mays*) is an important staple crop in Ghana but drought and Striga infestation are serious constraints to its production, especially in the northern Guinea savanna zone. Over the years, the National maize breeding program in Ghana has been collaborating with the IITA to develop and evaluate improved maize varieties and hybrids suitable for the various agro-ecological systems in Ghana. Thus, 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. In order to increase maize production in Ghana drought and Striga tolerant varieties were introduced to farmers in drought prone areas of the savanna zone of Ghana. 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 consist of varieties from the mother trial.

Materials and methods

The mother and baby trial was adopted for the on-farm testing of the drought tolerant varieties at three locations in the Upper West region

(Kpongu in Wa municipality, Jirapa in the Jirapa district and Silbelle in the Sissala West district. Three sets 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 Jirapa, Kpongu and Silbelle, respectively. The extra-early mother trial consisted of seven (7) 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 Early mother trial consisting of 6 varieties was planted at Kpongu. The intermediate maturing mother trials consisting of 8 elite varieties from IITA, one QPM hybrid (Etubi from CRI and a local check were planted at Silbelle. 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 Recommended cultural practices were followed. The total fertilizer rate was 64-38-38 kg/ha as N, P_2O_5 and K_2O, respectively.

Satellite or baby trials were also conducted on farmers' fields at the three sites using extra-early, early as well as intermediate sets of maize varieties. Five and eight varieties of maize from both early and intermediate sets were respectively, evaluated alongside the farmers' varieties as local checks. 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. 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. Farmers evaluated the varieties at physiological maturity.

Results and discussions

Planting was significantly delayed until July due to prolonged pre-season drought. However, after mid July, we experienced wet conditions and floods have been reported in some parts of the region in August. Wet conditions reduced seedling emergence of the On-farm Mother and Baby trials and this necessitated refilling. The variable weather affected plant growth and development and ultimate grain yield at most sites.

Extra-early maturing maize variety trials

In the mother trial, genotypic differences among the extra-early DT maize for grain yield were significant at Jirapa (Table 4.1). Grain yield was highest for 2000 SYN EE W and TZEE W POP STR QPM C0 but least for the farmer's variety. Abontem had similar grain production as the highest yielding variety. However, differences among the varieties for plant height, days to 50% silking and anthesis were not significant. In addition, 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, probably because the fields were not Striga endemic plots.

Table 4.1. Some agronomic parameters of extra-early maturing maize varieties evaluated in mother trial at Jirapa, Jirapa district, Upper West Region, Ghana, 2010

Variety	Grain yield	Days to 50% anthesis	Days to 50% silking	Plant height
	kg/ha	days	days	cm
2004 TZEE W POP STR C4	2720	51	53	174
99 TZEE Y STR C1	1867	51	53	169
TZEE W POP STR C5	1974	51	53	162
TZEE W POP STR QPM C0	2820	52	54	165
TZEE W POP STR C4	1867	51	53	173
2000 SYN EE W	2854	50	52	160
2008 TZEE W POP STR F2	1840	51	54	165
Abontem	2747	50	52	175
Farmers variety	1307	53	55	171
LSD(0.05)	1019	NS	NS	NS
CV(%)	28	3	3	11

NS= not significant at the 0.05 and 0.01% level of significant

In the baby trials, the extra-early maturing varieties, 2000 SYN EE W and TZEE W POP STR QPM C0 were the top-ranking varieties in grain yield (Table 4.2). The lowest yielding varieties were 99 TZEE Y STR C1 and the farmers' variety. The grain yields of 2004 TZEE W POP STR C4 and Abontem were not significantly different from those of 2000 SYN EE W and TZEE W POP STR QPM C0. Overall, the elite varieties from IITA produced more grain than the farmer's variety in Jirapa. It is worthy of note that the farmers' varieties that were included in these experiments were mostly not extra-early maturing varieties. However, the local checks were the best available variety at each evaluated site, which differed among locations. Furthermore, the variable weather conditions in 2010 affected seedling establishment at most sites hence the optimum plant stand of 66,600 plants/ha was not achieved for most varieties.

Table 4.2. Some agronomic parameters of extra-early maturing maize varieties evaluated in baby trials at Jirapa, Jirapa district, Upper West Region, Ghana, 2010

Variety	Grain yield	Days to 50% anthesis	Days to 50% silking	Plant height
	kg/ha	days	days	cm
2004 TZEE W POP STR C4	1529	50	52	173
99 TZEE Y STR C1	960	46	48	182
TZEE W POP STR C5	1131	50	52	189
TZEE W POP STR QPM C0	1996	51	53	188
TZEE W POP STR C4	1027	50	52	187
2000 SYN EE W	1618	48	50	186
2008 TZEE W POP STR F2	976	51	53	193
Abontem	1547	49	51	174
Farmers variety	753	51	53	190
LSD(0.05)	651	3	3	NS
CV(%)	29	3	3	7

NS= not significant at the 0.05 and 0.01% level of significant

Early maturing maize variety trials

In the mother trial, genotypic differences among the early DT maize for grain yield were significant at Kpongu (Table 4.3). Grain yield was highest for EVDT Y 2008 STR and TZE COMP 3 DT C2F2 but least for the farmer's variety. Differences among the varieties for plant height, days to 50% silking and anthesis were not significant. In addition, no significant differences were detected among the varieties for Striga counts at 10 weeks after planting (10 WAP). Furthermore, the variable weather conditions in 2010 affected seedling establishment hence the optimum plant stand was not achieved for most varieties.

In the baby trials, the early maturing varieties TZE W DT STR C4 and EVDT Y 2008 STR were the top-ranking varieties in grain yield (Table 4.4). The lowest yielding varieties were Aburohemaa and the farmers' variety. The grain yield of EVDT Y 2008 STR was not significantly different from that of TZE Y DT STR C4. Overall, the elite varieties from IITA produced more grain than the farmer's variety. The local checks were the best available variety at each evaluated site, which differed among locations. The data presented for farmers' variety for the baby trial are, therefore, not necessarily from one variety but the mean of several varieties.

Table 4.3. Some agronomic parameters of early maturing maize varieties evaluated in mother trial at Kpongu, Wa municipality, Upper West Region, Ghana, 2010

Variety	Grain yield kg/ha	Days to 50% anthesis days	Days to 50% silking days	Plant height cm
TZE Y DT STR C4	3129	48	51	173
EVDT Y 2008 STR	3360	47	50	172
TZE COMP 3 DT C2F2	3236	46	50	165
TZE W DT STR C4	3111	47	49	173
Aburohemaa	2347	48	54	159
Farmers variety	2009	52	56	183
LSD(0.05)	721	3	NS	NS
CV%	14	5	3	5

NS= not significant at the 0.05 and 0.01% level of significant

Medium/Intermediate maturing maize variety trials

In the mother trial, differences among the varieties for grain yield were significant (Table 4.5). However, 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. All the IITA intermediate maturing varieties had similar yields which were; however, higher than the yield of the farmer's variety. Etubi is a hybrid and is expected to produce more grain than open-pollinated variety of similar maturity rating. However, grain yield of the QPM hybrid, Etubi was lower due to low plant stand as a result of poor seedling establishment. The highest yielding variety was M09-25-9. All the varieties had similar days to 50% anthesis.

Table 4.4. Some agronomic parameters of early maturing maize varieties evaluated in baby trials at Kpongu, Wa municipality, Upper West Region, Ghana, 2010

Variety	Grain yield kg/ha	Days to 50% anthesis days	Days to 50% silking days	Plant height cm
TZE Y DT STR C4	1185	48	51	180
EVDT Y 2008 STR	1268	47	50	195
TZE COMP 3 DT C2F2	1051	46	50	187
TZE W DT STR C4	1594	47	49	166
Aburohemaa	1074	48	54	189
Farmers variety	1034	52	56	183
LSD(0.05)	256	3	NS	NS
CV%	15	5	3	16

NS= not significant at the 0.05 and 0.01% level of significant

Table 4.5. Some agronomic parameters of intermediate maturing maize varieties evaluated in mother trial at Silbelle, Sissala West district, Upper West Region, Ghana, 2010

Variety	Grain yield kg/ha	Days to 50% anthesis days	Days to 50% silking days	Plant height cm
MO9-25-2	2987	58	62	170
MO9-25-8	3218	56	59	178
M09-25-9	3751	57	62	180
MO9-25-13	3289	58	61	168
DT SR W COF2	3286	57	60	165
DT SYN 1 W	3022	58	61	158
IWD C2 SYN F2	3431	57	59	174
Etubi	2862	56	58	183
Farmers variety	2649	57	60	178
LSD(0.05)	539	NS	2	16
CV%	10	3	2	5

NS= not significant at the 0.05 and 0.01% level of significant

In the baby trials for intermediate maturing varieties, although the varieties had similar days to 50% anthesis and plant height, grain yields were significantly different (Table 4.6). Again the highest yielding variety was M09-25-9 and the farmer's variety had the lowest grain yields. The yield of the hybrid, Etubi was lower under farmers' management. The mean grain yield of the farmers' varieties was below the overall mean grain yield of all the genotypes. The local checks were the best available intermediate maturing varieties at each site, which differed among locations.

Table 4.6. Some agronomic parameters of intermediate maturing maize varieties evaluated in baby trial at Silbelle, Sissala West district, Upper West Region, Ghana, 2010

Variety	Grain yield	Days to 50% anthesis	Days to 50% silking	Plant height
	kg/ha	days	days	cm
MO9-25-2	1444	58	62	170
MO9-25-8	1733	56	59	178
M09-25-9	2400	57	62	180
MO9-25-13	1822	58	61	168
DT SR W COF2	1956	57	60	165
DT SYN 1 W	2022	58	61	158
IWD C2 SYN F2	2100	57	59	174
Etubi	1289	56	58	183
Farmers variety	989	57	60	178
LSD(0.05)	720	NS	2	16
CV%	24	3	2	5

NS= not significant at the 0.05 and 0.01% level of significant

Farmer assessment of the varieties

Maize farmers who evaluated the drought tolerant varieties regard them very positively. Several 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 and the voting exercise suggested that 2000 SYN EE W, TZEE W POP STR QPM C0 and Abontem were the most preferred extra-early maturing varieties. Farmers also preferred the extra-early yellow maize variety, Abontem because it could be planted with the early rains and sold or eaten fresh. Among the intermediate varieties, IWD C_2 SYN $F_{2,}$ DT SR W COF2 and DT SYN 1 W were most preferred. 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, farmers perceived that 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. During the field days, participants saw the plants and ears of the maize varieties being offered and received information on their performance in the field. After visiting the trials, farmers could purchase seed of some of the varieties they wanted from the community seed producers. Farmers who participated in the baby trials verified that the varieties performed better than their local varieties even under their circumstances in the baby trials.

Conclusion

The results of both the mother and baby trials for the extra-early, early and intermediate maturing varieties suggested that 2000 SYN EE W, TZEE W POP STR QPM C0 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. It seems a fundamental step towards promoting adoption of a technology would be to develop mechanisms for providing knowledge and inputs

Strengthening Seed Systems for Multiplication and Distribution of the Best Drought Escaping and/or Tolerant Maize Varieties and Hybrids (DTMA P2A)

Executive summary

In 2010, 38.9 t of seed was produced from about 34 ha. This included the three released varieties (Abontem, Aburohemaa and Omankwa). Over the years, economic analysis generally revealed that seed production is a profitable venture in this drought prone area of Ghana. Other farmers who received some support from the project to produce seed in 2009 were able to

produce 5t of seed of the various varieties on their own without additional support from the project. This is particularly important because the farmers were not expected to develop a dependency syndrome but to be financially self-sustaining. Through the project, farmers were trained in seed selection and management techniques and learned principles to assist them in maintaining the characteristics of maize varieties they valued.

Introduction

Maize (*Zea mays*) is an important cereal in terms of production and utilization in Ghana. The crop is well adapted and grows in most of the ecological zones in the country. Maize grain is used for food, for sale and for marketing local brewery and the stover is used for construction, animal feed and domestic fuel. Climatic constraints in the zone include a short monomodal rainy season; high intra-seasonal rainfall variability with risk of periodic drought greatest during critical early stages of crop growth; high evaporative demands that peak at the beginning and end of the rainy period which further increases the risk of drought stress during sowing and grain-filling stages. Thus, farmers in the Upper West region have been yearning for suitable drought tolerant maize varieties. The International Institute of Tropical Agriculture (IITA) in collaboration with national agricultural research systems has developed a number of drought tolerant varieties and/or hybrids which are higher yielding when drought strikes. They have in-built tolerance mechanisms to water shortage and continue producing more than other maize varieties. Also, they may mature early to cope with the erratic and the declining rains of northern Ghana. Average maize grains yields from farmers' fields is often low (<1.5 t/ha) due to poor agronomic practices. However, yields of about 5.0 t/ha can be achieved through the adoption of improved seed and sound agronomic practices.

Quality seed availability is a crucial factor in any efforts to ensure food security in such a semiarid region which is also a striga endemic area. Farmers in many remote areas in the region do not have access to quality seed of drought as well as striga tolerant maize varieties. A number of factors limit the involvement of the small-scale farmers in hybrid seed production in Ghana, but such farmers have the capacity to produce seed of open pollinated varieties (OPV). The quantities of seed maize produced annually by the Seed Producers Association (SEEDPAG) in northern Ghana are woefully inadequate. Current seed production trends reveals that the SEEDPAG alone cannot meet the demands for maize seed, assuming that even 10% (adoption rate) of the total maize estimated area is planted to improved seed alone. Since the seed gap is significant in the zone, the probability of adoption and impacts of improved seed is high.

Objectives:

(i) Promote and sustain availability of drought and Striga tolerant maize seed.
(ii) Establish community groups to manage drought and Striga tolerant seed production and distribution within the communities.
(iii) Train community groups, extension staff in drought tolerant maize seed production techniques.

Materials and methods

During the 2010 cropping season, community seed producers were selected as seed producers depending on their willingness to participate fully in project activities. The research team selected farmers, provided technical advice; distributed seed; monitored seed and inspected seed fields in collaboration with Ghana Seed Inspection Division of MOFA. Seed of two extra-early maturing (80-85 days to maturity) drought tolerant variety, 3 early maturing (90-95 days to maturity) varieties and 3 intermediate/medium maturing (110 days to maturity) varieties were multiplied in the Upper West region of Ghana during the 2010 cropping season (Table 5.1) Six of the varieties have been released for commercial production. Foundation seed and other fertilizers were supplied to farmers on credit and at harvest the cost in kind (with seed) was recovered from the farmers as the farmers are not expected to develop a dependency syndrome but to be financially self-sustaining. To ensure the sustainability of the project and the involvement of more farmers each year, funds from the sale of the seed would be used to purchase other inputs in subsequent seasons.

In order to maintain the purity of the variety and produce good quality seed, the seed production fields were isolated from other maize fields. Isolation of the seed crop was done by either space (distance of at least 300 m between the seed crop and any other maize field) or by time (seed crop was sown at least a month earlier than neighbouring maize fields of similar maturity rating). Thus, we were selective in choosing the communities. The maize varieties were planted using recommended production practices including spacing and fertilizer rates and time of application. Through the project, farmers were trained in seed selection and management techniques and learned principles to assist them in maintaining the characteristics of maize varieties they valued.

Results and discussions

Planting was significantly delayed until mid-July at most sites due to prolonged pre-season drought in the region. The preseason drought affected seedling establishment at most sites hence the optimum plant stand of 66,600 plants/ha was not achieved for most varieties. It was also late to refill as the season was far advance. However, after mid July, we experienced wet conditions and floods were reported in some parts of the region in August. The variable weather affected plant growth and development and ultimate grain yield at most sites. We expect that the involvement of the various communities in seed multiplication and distribution will increase adoption of drought tolerant maize varieties and other agronomic practices for increased income of small scale farmers in the remote and/or drier areas of Ghana

In 2010, 38.9 mt of seed was produced from about 34 ha (Table 5.1). The overall mean grain yield of the varieties was 1.24 t/ha. A kilogram of seed maize sold for GH¢1.00 during the 2010 cropping season. Thus, if we assume a seed price of GH¢1.20 per kg for the 2011 cropping season and a production cost of GH¢670/ha, then we expect a profit ofGH¢812/ha (1 US $ = GH¢1.52). Thus seed production of DT maize appears profitable in this drought prone area of Ghana. Other farmers who received some support from the project to produce seed in last two seasons were able to produce 5 mt of seed of the various varieties on their own without financial support from the project. This is particularly important because the farmers are not expected to develop a dependency syndrome but to be financially self-sustaining.

Table 5.1. Grain yield of maize varieties planted in the community seed production program in UWR, Ghana, 2010.

Variety	Area (ha)	Total grain produced (t)	Quantity of seed processed(t)	Mean grain yield (t/ha)
Aburohemma	5.6	8.50	6.80	1.46
Omankwa	2.6	2.55	2.04	1.00
Abontem (foundn seed)	1.2	1.26	1.08	1.07
DT SYN 1 W	2.0	1.85	1.48	0.93
Sammaz 15	0.3	0.20	0.16	0.67
Obatanpa	0.4	0.80	0.64	2.00
Dodzi	1.0	1.70	1.36	1.67
Abontem (certified seed)	24.0	31.60	25.28	1.32
2004 TZE W POP DT STR C4	2.6	2.55	1.00	1.00
Total	38.1		39.84	

Aburohemma (EVDT-W-99 STR QPM CO)
Omankwa (TZE W Pop DT QPM CO)
Abontem (TZEE Y Pop QPM CO)

Training

All the community seed producers (20) were trained in seed selection and management techniques, and they were also taught principles to help them maintain the characteristics of the varieties they valued. These interventions were available to any farmer who wanted to participate and open invitations and publicity encouraged farmers to participate.

Training sessions started with a discussion of farmers' knowledge about maize reproduction and perceptions of maize improvement. Additional sessions taught basic principles of maize reproduction, principles of seed selection in the field (including hands-on exercises in the field) and principles and techniques for storing seed and grain. The training activities showed that participating farmers often did not understand certain aspects of maize reproduction, but once this knowledge was provided, at least some of them were keen to try new management techniques. Since 2008, we have been able to build the capacity (train) of at least one hundred and fifty (150) farmers and eight (8) extension agents to produce high quality maize seeds. They also received training on seed selection and management techniques and learned principles to assist them in maintaining the characteristics of maize varieties they valued.

Conclusion

Several farmers have improved access to improved drought tolerant maize varieties in the region. Farmers also received training on seed selection and management techniques and learned principles to assist them in maintaining the characteristics of maize varieties they valued.

Alliance for Green Revolution in Africa (AGRA) - Soil Health Project (AGRA SHP OO5) activities in Upper West Region

S.S.J. Buah and M. Fosu

Ongoing Activities

Executive Summary

A project to increase the adoption of integrated soil fertility management options for increased maize production and to reduce poverty and improved food security, incomes and livelihoods of small-scale resource poor farmers in northern Ghana is being funded by Alliance for Green Revolution in Africa (AGRA). The project partners in the Upper West region include Council for Scientific and Industrial Research-Savanna Agricultural Research Institute (CSIR-SARI), Ministry of Food and Agriculture (MOFA), Seed Producers Association of Ghana (SEEDPAG) and a Non-Governmental Organization (NGO) in the region (Upper West Agro-Industry). The project is targeting 120,000 farmers in northern Ghana. In 2010, the project was implemented in 16 communities in all 9 districts in the Upper West region and it targeted 36 Farmer based organizations (FBOs), but only 29 FBOs actually planted the demonstrations.

During the 2010 cropping season, the regional team carried out the following activities: selection, registration and sensitization of FBOs, procurement of inputs (seed and fertilizers), training of agricultural

extension agents (AEAs) and their supervisors in integrated soil fertility management (ISFM), data collection and effective extension communication. During the cropping season, technology dissemination pathways included demonstrations on ISFM, training of trainers, open days/field days, pen for a and seed multiplication of soybean (Jenguma, Salintuya 1 and Anidaso) and drought tolerant maize varieties (Aburohemma and Omankwa)

Overall 36 FBOs were targeted to participate in the project activities in 2010. However, only 29 actually participated in the project activities and therefore planted the demonstrations. This represented 81% of the targeted figure of 36 FBOs. Each FBO handled one demonstration of 0.2 ha in each community. The FBOs were provided with timely and affordable access to quality seed, utilizing existing distribution channels including the private sector, government agencies and NGOs. In 2010, the project improved access for 29 FBOs to certified seed and quality fertilizer while expanding knowledge of ISFM for maize production in the region.

In August 2010, 18 AEAs (3 females + 15 males) from the region received training on how to lay out demonstrations, collect representative soil samples for laboratory analysis, quality data collection and analysis as well as bet-best crop production practices in Tamale. Also 40 extension staff (4 females +35 males) participated in a 2-day training (13-14 December 2010) on effective extension communication in Wa. 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 program.

Introduction

The AGRA Soil Health Projects is being implemented in the three Northern regions comprising Northern, Upper West and Upper East regions. It is a pro-poor project targeting 120,000 maize farmers in Ghana. The project aims at improving farmers' access to improved seed and fertilizer as well as improved maize production technologies. The project was launched in April 2010 in Tamale. In 2010, project activities such as site selection, farmer registration, field activities and monitoring of field work started in the first quarter and continued through out the season. The participating FBOs also had access to best-bet rice technologies through trainings and demonstrations. The project also encouraged farmer to farmer information sharing.

Materials and methods

Five main demonstrations on ISFM were carried out in the Upper West region in 2010 (Table 6.1). Each demonstration was planted on 0.2 ha of land by an FBO. Planting was mostly done during the third week of July in most of the communities due to preseason season drought.

Table 6.1. List of demonstrations planted in the region in 2010

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)	Yaamosahyiri
	Wa West	
	Wa East	Wongtogirah
	Sissala East	Ti-suntaa
	Sissala West	Challu farmers Assoc.
	Nadowli	Jeffisi farmers Group
	Lambussie/Karni	Bommbo ve-ele
		Bapaara Group
Soil fertility in maize with organic and inorganic fertilizers	Wa municipal	Tambileju farmers Assoc.
	Wa West	
	Wa East	Kawulubeyi
	Sissala East	Kong farmers Assoc.
	Sissala West	Mwini Numbu
	Nadowli	Mahama Benjamin
		Yendaw Eugene
Evaluation of different drought tolerant maize cultivars/varieties under fertilized conditions	Wa municipal	Sombo farmers Assoc.
	Wa West	Lantaa maali
	Wa East	Nuntaa
	Sissala East	Kong farmers Assoc.
	Sissala West	Sumani Sulemani
	Nadowli	Ligire
	Jirapa	Ben Bayor
	Lawra	Koli Pour
Evaluation of hybrid and open-pollinated maize varieties under fertilized conditions	Wa municipal,	Wawanayiri
	Wa West	-
	Wa East	Suntaa
	Sissala East	Challu Farmers Assoc.
	Sissala West	Ali Abass Baarta
	Nadowli	Imora Sumpuo
	Lambussie/Karni	Bapaara Group
	Jirapa	Godfred Dorsaah
	Lawra	Tanchara Coop. Farmers

Four sets of demonstrations trials were dispatched to each of the 9 District Agricultural Development Units (DADU). Nonetheless not all districts planted all the four sets of demonstrations. The corresponding number of data field books received for these trials were 2 each from Jirapa, Lawra and Lambussie/Karni districts, 3 from Wa West district and 4 each from Wa East, Wa municipal, Nadowli, Sissala East and Sissala West districts. In addition, 4 demonstrations (1 on soybean and 3 on miaze) were planted by the research team at SARI, Wa station. Overall, 32 demonstrations were planted in the region. However, no reliable and meaningful data were obtained from Lambussie/Karni and Sissala East districts hence data from the two regions are excluded in this report. Additionally, no data were reported for the demonstration on drought tolerant maize varieties in the Wa municipality because the farmer group harvested the maize without the permission of the AEA in charge of the demonstration. This report provides summary results of analyses of data sets of the demonstration trials for seven participating districts where reliable and meaningful data were obtained.

Results and discussions

1. Soil fertility in maize with mineral fertilizer and rotation with a legume

The demonstration was carried out in 9 communities spread across 7 districts but reliable and meaningful data were obtained from only 6 sites. The list of treatments evaluated in this demonstration is presented in Table 6.2.

Table 6.2. 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	½ recommended rate of NPK and SA fertilizer	125	62.5
T3	Recommended rate of NPK and SA fertilizer	250	125
T4	2bags NPK 15-15-15 +1½ bags SA/acre	250	187.5
T5	legume/maize rotation (legume 30 kg/ha P_20_5; Maize: as in T2), first crop= groundnut	0	0

This was the set-up year hence it was not possible to measure rotation effects. Grain yields averaged over 7 sites in the Upper West region are presented in Table 6.3. Grain yields ranged from 852 to 2252 kg/ha. In general, grain yields were lower than expected probably due to late planting as a result of preseason drought in the region in 2010. Fertilizer application increased maize yields significantly across sites. On average, applying half of the current recommended rate of fertilizer (i.e. T2) increased grain yields by 104% when compared with unfertilized treatment. However, there was no significant yield increase beyond this rate. Greatest grain yields were obtained from the demonstration that was carried out at the SARI research farm at Dokpong, Wa. Grain yields were lowest at Wechau in the Wa West district (Table 6 3)

Table 6.3. Mean grain yield of maize as affected by mineral fertilizer at various sites in the Upper West region, 2010.

Treatment code	Grain yield (kg/ha)	Site	Grain yield (kg/ha)
T1	852	Dokpong (SARI)	3212
T2	1735	Kpaglahi (Wa East)	2970
T3	1897	Kampaha (Wa municipal)	2188
T4	2252	Jeffisi (Sissala West)	927
		Dondole (Wa municipal)	875
		Tabiase (Nadowli)	811
		Wechau (Wa West)	805
LSD (0.05)	604	LSD (0.05)	799
CV%	32	CV%	32
Mean	1684	Mean	1684
No. of sites	7		

2. Soil fertility in maize with organic and inorganic fertilizers

The demonstration was carried out 7 communities spread across 6 districts but reliable and meaningful data were obtained from 6 sites. The list of treatments evaluated in this demonstration is presented in Table 6.4.

Table 6.4. 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 6 sites in the region are presented in Table 6.5. Grain yields ranged from 685 to 2495 kg/ha. In general, grain yields were lower than expected probably due to late planting. 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 inorganic fertilizer (sulphate of ammonia) had similar yields as applying inorganic fertilizers only (T2 and T4). The current recommended rate of fertilizer for maize (T2) increased grain yields by 200% when compared to no fertilizer treatment (T1). In addition the combined use of organic and inorganic fertilizers (T3) increased yields by 221% 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). Differences in yields among sites were due to differences in management and attention devoted to the demonstrations. Greatest grain yields were obtained at Tampaala in Wa East district while yields were lowest at Liplime in the Sissala West district (Table 6.5).

Data are for one season only. Grain yields averaged over 6 sites are presented in Table 6.7. Grain yields as affected by fertilizer treatment ranged from 275 to 1871 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 mostly grown by farmers in the various communities. On average fertilizer application increased grain yields by over 500% when compared with no fertilizer application. The greatest yield increase due to fertilizer application was obtained for the farmers' variety. On average, applying current recommended rate of fertilizer to Omankwa, Aburohemma and farmers' variety increased grain yields by 469, 500 and 580%, respectively when compared with unfertilized treatment. However, there was no significant yield difference among the varieties at each level of treatment. Averaging over treatments, grain yields for the various sites ranged from 778 to 1501 kg/ha. Greatest grain yields were obtained at Kouli junction in the Lawra district. Grain yields were lowest at Woggu in the Nadowli district (Table 6.7).

Evaluation of drought tolerant maize varieties under fertilized conditions

The demonstration was carried out in 8 communities spread across 8 districts but reliable and meaningful data were obtained from 6 sites. The list of treatments evaluated in this demonstration is presented in Table 6.6.

Table 6.5. Mean grain yield of maize as affected by organic and inorganic fertilizers at various sites in the Upper West region, 2010.

Treatment code	Grain yield (kg/ha)	Site	Grain yield (kg/ha)
T1	685	Tampaala (Wa East)	3059
T2	2052	Tambileju (Wa municipal)	2435
T3	2198	Kampaha (Wa municipal)	2434
T4	2495	Siiriyiri (Wa West)	1304
		Ombo (Nadowli)	1002
		Liplime (Sissala West)	918
LSD (0.05)	510	LSD (0.05)	625
CV%	22	CV%	22
Mean	1859	Mean	1859
No. of sites	6		

Table 6.6. List of treatments evaluated in drought tolerant maize varieties under fertilized Conditions, UWR, 2010.

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

Table 6.7. Mean grain yield of drought tolerant maize as affected by mineral fertilizer at various sites in the Upper West region, 2010.

Treatment code	Grain yield (kg/ha)	Site	Grain yield (kg/ha)
No fertilizer			
Omankwa	313	Kuoli (Lawra)	1501
Farmers' variety	275	Ulgozu (Jirapa)	1157
Aburohemaa	252	Hambarikole (Wa East)	913
		Wechau (Wa West)	855
		Bullu (Sissala West)	800

Recommended fertilizer rate			
Omankwa	1781	Woggu (Nadowli)	778
Farmers' variety	1871		
Aburohemaa	1512		
LSD (0.05)	458	LSD (0.05)	458
CV%	32		
Mean	1001		
No. of sites	6		

Evaluation of hybrid and open-pollinated maize varieties under fertilized conditions

The demonstration was carried out in 8 communities spread across 8 districts but reliable and meaningful data were obtained from 6 sites. The list of treatments evaluated in this demonstration is presented in Table 6.8.

Table 6.8. 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

Data are for one season only. Grain yields averaged over 6 sites are presented in Table 6.9. Grain yields as affected by fertilizer treatment ranged from 252 to 1991 kg/ha. In general, preseason drought delayed planting until late July. Thus grain yields were lower than expected. Despite the lower yields, the quality protein maize (QPM) hybrid (Etubi) had significantly higher grain yields than the most common maize variety cultivated by farmers in the various communities and the open-pollinated QPM variety Obatanpa On average fertilizer application quadrupled maize yields when compared with no fertilizer application. The greatest yield increase due to fertilizer application was obtained for the hybrid. On average, applying current recommended rate of fertilizer to Obatanpa, farmer variety and hybrid maize increased grain yields by 335, 387 and 564%, respectively when compared with unfertilized treatment. However, there was no significant yield difference between Obatanpa and farmers' variety. Greatest grain yields were obtained at Kunta in the Wa East district. Grain yields were lowest at Dondole in the Wa Municipality (Table 6.9).

Table 6.9. Mean grain yield of hybrid and open-pollinated maize as affected by mineral fertilizer at various sites in the Upper West region, 2010.

Treatment code	Grain yield (kg/ha)	Site	Grain yield (kg/ha)
No fertilizer			
Etubi	300	Kunta (Wa East)	1616
Farmers' variety	252	Ulgozu (Jirapa)	1446
Obatanpa	317	Tanchara (Lawra)	681
		Bullu (Sissala West)	620
		Buu (Nadowli)	566
Recommended fertilizer rate			
Etubi	1991	Dondole (Wa municipal)	537
Farmers' variety	1228		
Obatanpa	1378		
LSD (0.05)	580	LSD (0.05)	580
CV%	34		
Mean	911		
No. of sites	6		

Table 6.10. Mean grain yield of maize (kg/ha) as affected by mineral fertilizer at individual sites in the Upper West region, 2010.

Site	T1	T2	T3	T4	Mean
Dokpong (SARI)	2089	3287	3300	4172	3212
Kpaglahi (Wa East)	849	2798	3986	4245	2970
Kampaha (Wa municipal)	947	2616	2210	2980	2188
Jeffisi (Sissala West)	376	1035	1072	1224	927
Dondole (Wa municipal)	681	847	851	1019	875
Tabiase (Nadowli)	681	697	842	1022	811
Wechau (Wa West)	340	764	1016	1101	805
Mean	852	1735	1897	2252	

Results of individual site analysis

Results for each individual site in each district are presented in Tables 6.10 to 6.13. These summaries would be useful to select treatments specifically adapted to one or a group of testing sites.

Table 6.11. Mean grain yield of maize (kg/ha) as affected by organic and inorganic fertilizers at individual sites in the Upper West region, 2010.

Site	T1	T2	T3	T4	Mean
Tampaala (Wa East)	1278	3134	3573	4249	3059
Tambileju (Wa municipal)	960	2598	2965	3219	2435
Kampaha (Wa municipal)	807	2451	3107	3370	2434
Siiriyiri (Wa West)	510	1738	1272	1696	1304
Ombo (Nadowli)	178	1321	1238	1272	1002
Liplime (Sissala West)	376	1073	1035	1186	918
Mean	685	2052	2198	2495	

Table 6.12. Mean grain yield (kg/ha) of drought tolerant maize as affected by mineral fertilizer at individual sites in the Upper West region, 2010.

Site	T1	T2	T3	T4	T5	T6	Mean
Kuoli (Lawra)	384	2788	128	2686	341	2680	1501
Ulgozu (Jirapa)	323	1988	304	2203	265	1797	1157
Hambarikole (Wa East)	296	1216	377	2341	216	1031	913
Wechau (Wa West)	141	2071	329	1318	141	1129	855
Bullu (Sissala West)	565	1224	282	1318	376	1035	800
Woggu (Nadowli)	170	1398	170	1357	171	1401	778
Mean	313	1781	275	1871	252	1512	

Table 6.13. Mean grain yield (kg/ha) of hybrid and OPV maize as affected by mineral fertilizer at individual sites in the Upper West region, 2010.

Site	T1	T2	T3	T4	T5	T6	Mean
Kunta (Wa East)	649	3380	407	2240	478	2542	1616
Ulgozu (Jirapa)	414	2918	188	2259	452	2447	1446
Tanchara (Lawra)	171	2340	128	511	170	767	681
Bullu (Sissala West)	188	1073	198	941	282	1035	620
Buu (Nadowli)	171	801	263	917	271	974	566
Dondole (Wa municipal)	208	1432	329	501	249	504	537
Mean	300	1991	252	1228	317	1378	

Integrated Management of *Striga hermonthica* in Maize in the UpperWest Region

S.S.J. Buah and N.N. Denwar

Executive summary

Continuing soil degradation is threatening food security and the livelihood of millions of farm households throughout the world. The parasitic weed, *Striga hermonthica* (witch weed) adversely affect the production of the major cereal crops such as maize, sorghum and pearl millet in Upper West region particularly in the Lawra district. Cereal yield reduction due to *Striga* infestation could range from 10 to 100% depending on the level of infestation. On average, the striga tolerant maize variety Aburohemma had greater grain production than the farmers' variety in both intercrop and sole crop situation in the striga endemic plots. Results showed that soybean is capable of reducing striga population on farmers' fields. Hence, a cash crop like soybean should be grown in association or in rotation with the staple cereal crops like maize, sorghum or millet in order to reduce striga seed bank in farmers' fields. Farmers in Striga endemic areas should therefore be encouraged to grow cash crops like soybean in rotation or in association with the staple cereal crops like maize, sorghum or millet in order to reduce striga seed bank in their fields.

Introduction

Soils in the northern savanna zone are deficient in essential plant nutrients like N and P. In addition, low organic matter and N contents of the soils in this zone could be attributed to low vegetation cover and annual bush burning prevalent in many farming communities. Relatively, small amount of crop residues and animal manures are produced in northern Ghana, hence mineral fertilizers remain the principal sources for building up nutrients in soils. In general, soils in the Lawra district are undergoing degradation since traditional farming practices such as shifting cultivation are no longer sustainable and increasing pressure on land due to increasing population and competing uses of land have shortened fallow periods leading to continuous cropping and consequently undesirable effects on soil structure and mineral status. The declining soil fertility problem is further aggravated by the annual indiscriminate bush burning, low nutrient application rates, over grazing among others. The sandy-textured surface horizons of the soil have low organic matter content which limits their moisture-holding capacity and potential for growing annual crops. The parasitic weed, *Striga hermonthica* (witch weed) adversely affect the production of the major cereal crops such as maize, sorghum and pearl millet in the district. Cereal yield reduction due to *Striga* infestation could range from 10 to 100% depending on the level of infestation. The use of varieties tolerant to striga is the most economical way of growing maize in striga endemic areas since the varieties are available. As the mode of resistance of the varieties is horizontal, total striga control is not possible especially when infestation is heavy. The use of intercropping with trap crops such as cotton and soybean fits well in the cropping system of the mandate area. The system also has been shown to be effective in increasing productivity and controlling striga on-station. Rotating a tolerant variety with trap crops has also proved effective in controlling striga. The objectives of the study were to reduce the incidence of striga infestation in selected communities in northern Ghana and also improve crop and soil productivity in the selected communities.

Materials and methods

Permanent plots were established in 2010 for rotating maize and soybean through a 2-yr growing cycle along with continuous sole maize. Another trial had maize-soybean intercropped compared with continuous sole maize, Thus in 2011, maize will be planted on the previous soybean plots. Two maize varieties (Improved striga tolerant early maize – Aburohemma and farmers' variety) and soybean (cv. Jenguma) were grown on adjacent plots during the cropping season (June – October) at Eremon and Zambo in the Lawra district. Recommended production practices for each crop were followed. Planting was done in July.

Results and discussions

Data are for the 2010 cropping season only and since that was the set-up year no rotation effect was measured. The only comparison was made between continuous maize and maize-soybean intercrop. On average, maize grain yields from sole maize plots were significantly higher than yields from the maize-soybean intercrop plots probably due to competition effect. The striga tolerant maize variety Aburohemaa produced 40% more grain than the farmers' variety across the two sites regardless of the cropping system. Mean maize grain yield at Zambo was 890 kg/ha. On average, maize grain yields from continuous sole maize plots were 37% higher than yields obtained from the maize-soybean intercrop plots. As expected, mean grain yields from continuous sole maize plots were 42% higher than yields obtained from the maize-soybean intercrop plots at Eremon.

The number of emerged Striga plants per 10 x 10 m plot is presented in Table 7.1. In both communities, a highest number of emerged Striga plants were recorded on the sole maize plots followed by the maize-soybean plots. The sole soybean plots had the lowest number of emerged Striga plants. This showed that soybean is capable of reducing the Striga population on farmers' fields. Hence, a cash crop like soybean or groundnut should be grown in association or in rotation with the staple food crops like maize, sorghum or millet in order to reduce Striga seed bank in farmers' fields in the Lawra district. Maize-soybean intercrop or maize-soybean rotation would be especially beneficial in low-input agricultural production systems where low crop yields and economics preclude the use of mineral fertilizers.

Table 7.1. Emerged Striga plants as affected by various treatments at selected communities in the Lawra district, 2010.

Treatment	Zambo	Eremon
	Striga count	Striga count
Continuous sole maize	48	56
Maize/soybean intercrop	36	33
Soybean	10	12
LSD (0.05)	5	9
CV(%)	10	20

ENTOMOLOGY PROGRAMME

Development of control strategy for termite infestation in the field

S.S. Seini, J.B. Naab, Saaka Buah, Yahaya Iddrisu,

Executive Summary

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.

Introduction

Project Rationale/Background:

Termites are very destructive to all manner of field crops including cereals such as maize, millet and sorghum. Other field crops attacked include cowpea, groundnuts, bambara groundnuts, soya bean as well as all kinds of vegetables. Termites in the genera *Microtermes* and *Odontotermese* are important pests of groundnuts in the semi-arid regions of India and Africa. Their attack may cause up to 50% reduction in groundnut yield, affect quality and market price (Johnson et al., 1981). Damage and yield losses result from cutting of stems, removal of foliage and invasion of tap root (Johnson et al., 1981). Termites also remove manure and other organic matter from fields (Wood, 1976) which may reduce soil fertility and crop yield. They also cause widespread destruction to grain storage as well as general building infrastructure.

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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 Chlorpyrifos 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 Chlorpyrifos 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.

Results and Discussions

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 60%. Other crops affected to a lesser degree are millet, sorghum, groundnuts, yam and cassava with damage levels of up to 15%.

- Across the survey area two genera of termites were encountered viz: Macrotermes spp which build large spectacular mounds and whose presence is generally obvious, and Odontotermes spp 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 – 45 % 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 –

750kg/ha of maize grain yield. This was lower than that of the treated plots which recorded between 900 – 1400 kg/ha maize grain yield.(P>0.05) From these results yield loss due to termites in maize is estimated to be about 34%.

Technology under development

The use of Jatropha seed products for termite control

Conclusions/Recommendations

Jatropha seed powder has the potential to protect maize against termite damage in the field. This compares favourably with reports of neem being able to offer similar protection.

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Development of control strategies for pests and diseases of harvested groundnuts left on the field and in storage barns

S.S. Seini, J.B. Naab, Saaka Buah, Yahaya Iddrisu,

Executive Summary

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 laboratory bioassays have demonstrated the efficacy of plant extracts on termites and other arthropod pests of groundnut in the field and in storage. 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 storage and field pests.

Introduction

Project Rationale/Background:

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 storage. 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 storage 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.

The main objective of this proposal is to develop effective and sustainable control for groundnut field and storage pests. Specific objectives are:

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 Chlorpyrifos 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 Chlorpyrifos were included as checks. Grain weight losses were evaluated after six months of storage. Each sample initially weighed 1.0kg.

Results and Discussions

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 60% of farm stores inspected.

In the on-station trials, groundnut pod damage due to soil arthropods was generally between 8 – 10 % in the untreated control plots. Treatments with Jatropha and Neem seed powder reduced groundnut pod damage significantly to between 1.0 – 3.0%, a reduction of about 60% ($P < 0.05$).

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 600 – 800kg/ha of fresh pod yield. This was lower than that of the treated plots which recorded between 900 – 1200 kg/ha fresh pod yield ($P>0.05$) From these results yield loss due to soil arthropods in groundnuts is estimated to be about 25%.

Jatropha seed powder therefore has the potential to protect groundnuts against damage from soil arthropods. This compares favourably with reports of neem being able to protect groundnut pods from soil arthropod damage.

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, chlorpyrifos offered good protection for about 5 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 15%; that in the chlorpyrifos lot was 4% and that in the seed extract lots was 8.5%

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.

Technology under development

The use of Jatropha seed products for groundnut pest control

Conclusions/Recommendations

Jatropha seed powder has the potential to protect groundnuts against soil pest damage in the field. This compares favourably with reports of neem being able to offer similar protection.

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UPPER EAST REGION FARMING SYSTEMS RESEARCH GROUP (UER-FSRG)

Kanton, R. A. L, Yirzagla, J, Kusi, F, Sugri, I,

General introduction:
The Upper East Region farming Systems Research Group (UE-FSRG) was established in May 1993 and based at the Manga Agricultural Research Station about 4 km South-East of the Bawku Municipal. Currently the team has a membership of six research scientists, 2 Agronomists, 1 Entomologist, 1 Post-harvest specialist, 1 Soil Scientist currently on study leave, 1 Assistant Agricultural Economist also on study leave. The Team also has 4 Technicians and supported by 3 supervisors. The group also has oversight responsibility for the Co-ordination of Research, Extension and Farmer Linkage Committees (RELC) activities in the Upper East Region. The Team also provided research support both technical and advisory services and also participated in the implementation of the Conservation of Agriculture Project (CAP) activities by CARE International. The Team also co-ordinated Alliance for a Green Revolution in Africa (AGRA) Soil Health Project (SHP) in the region. The Team also collaborated with the Association for Church Development Project (ACDEP) in the conduct of research into sesame.

AGRONOMY PROGRAMME

Executive Summary
Appropriate technological innovations are key to the attainment of house-hold food security and improvement of livelihoods among resource-poor farmers within the Upper East Region of Ghana. Through the development, evaluation and dissemination of proven agronomic practices for enhanced food production and productivity in the Upper East Region. The Agronomy Programme of the Upper East Region-Farming System Research Group (UER-FSRG) made significant contributions to the improvement of soil quality, water use and use efficiency and crop productivity at the farm household level. With the overall objective of identifying production constraints and missed opportunities as well as developing appropriate and cost effective agronomic technologies and innovations that seek to address these constraints. The following research activities were conducted during the 2010 cropping season under the Programme are i). : Effects of sorghum varieties, rates of nitrogen fertilizer, plant spacing and densities on the performance of sorghum in a semi-arid agro-ecology in northern Ghana; Effects of intra-row spacing and rate of nitrogen fertilizer on the performance of sesame (*Sesamum indicum* L.) in a semi-arid agro-ecology

in northern Ghana; On-farm testing of Extra early and early Drought Tolerant Maize for Africa (DTMA) in a semi-arid agro-ecology in northern Ghana; Promotion of Drought Tolerant Maize for Africa (DTMA) maize varieties/hybrids through the Community Seed Maize concept in the Upper East Region of Northern Ghana and Effect of spatial arrangement on the performance of Pearl millet-Cowpea intercrop

Effects of intra-row spacing and rate of nitrogen fertilizer on the performance of sesame (*Sesamum indicum* L.) in a semi-arid agro-ecology in northern Ghana.

R.A.L. Kanton, J. Yirzagla, I. Sugri, P. A. Asungre, S. Lamini and Y. E. Ansoba*

Abstract
A five by four (5 x 4) field experiment was 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. Main effects of nitrogen rates and intra-row spacing significantly ($P \leq 0.001$) affected most of the traits evaluated. The interaction effects of 20 cm and 30cm at 80kg N/ha produced the highest plant populations of 6.9 and 7.1 respectively. Sesame plant height was significantly ($P \leq 0.001$) influenced by N application with plant height increasing with higher N rates, attaining a maximum of 142cm at 60kgN/ha in 2009. Nitrogen rate of 60 kg ha^{-1} produced the best grain yields in both seasons compared to the other rates. Consistently, intra-row spacing of 30 and 40cm produced the highest grain yield in both seasons. 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. Marginal insignificant yield response was observed with increased nitrogen level attaining the peak at 80kgN/ha.
Key word: Sesame, intra-row spacing, nitrogen fertilizer rate, main effect, interaction effect.

Introduction
Sesame (*Sesamum indicum* L.) is one of the oldest spice and oilseed crop in the world and the seeds contain approximately 50% oil and 25% protein (Burden, 2005). The presence of some antioxidants such as 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). It contains no linolenic acids and thus useful for the manufacture of medicine and perfumes. Generally, the average yield of sesame which is estimated at 0.46 ton ha^{-1} is very low (FAO, 2004). The world production is estimated at 3.66 million tonnes with Africa producing only 0.95 million

tonnes per annum (Anon, 2008). The low yield has been attributed to inadequate agricultural inputs such as improved varieties, agro-chemicals and poor agronomic practices(Ashri, 1994, 1998; Weiss, 2000; Uzun and Cagirgam, 2006). Significant seed losses during threshing also contribute to low yield of the crop across the globe.

Studies conducted in Nigeria on the crop by Weiss (1983), Ogunbodede and Ogunremi (1986) and Ogunremi and Ogunbodede (1986) reported that the growth performance of sesame in terms of shoot characteristics such as plant height and type of branching, height to first capsule, number of branches per plant, internode length and number of nodes are largely variety specific. In Ghana, however, there is limited information on the response of sesame to agronomic practices. This study was therefore conducted to determine the growth and yield response of sesame to nitrogen rates and plant spacing.

Materials and Methods

Field trials were conducted at the Manga Agricultural Research Station during the 2009 and 2010 cropping seasons. The 5 x 4 factorial experiment was arrangement in a 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 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. The fields were harrowed and ridged and sesame seeds sown manually using 3 to 4 seeds per hill. Two weeks after sowing, seedlings were thinned to 2 plants per hill followed by the basal application of half the nitrogen with all the P and K, at the rates of using 40 kg P_20_5 and 40 kg K_20, whilst the remaining half in the form of Sulphate of ammonia applied as top-dress at 4 WAS. Side placement method was used for the fertilizer application which was preceded by weeding so as to reduce the effect of weed competition. fertilizer at the various rates of nitrogen under study. Half of the nitrogen fertilizer was applied at 2 weeks after sowing (WAS) with the remaining half in the form of sulphate of ammonia applied as top-dress at 4 WAS. Side placement method was used for the fertilizer application which was preceded by weeding so as to reduce the effect of weed competition.

Five (5) plants were selected at random and tagged from the middle rows in each plot for data collection. The parameters studied were plant height and grain yield. The data were subjected to analysis of variance after which means resulting from significant treatment effects were separated using the least significance test by Steel and Torrie (1980) using All statistical analyses were conducted using the GenStat Statistical program (GenStat Discovery Edition 3, version 7.2.0.220).

Climate and soil characteristics of the study area

The Guinea savannah experiences annual rainfall of 100-110cm (between May to November). Annual rainfall figures (cm) during the 2009 and 2010 cropping seasons were respectively 89.7 and 99. Details of the soil attributes of the study area within the study period as well as a guide to their interpretation are presented in Tables 1 and 2 respectively. Soil chemical analysis of the area within the 0-20cm depth showed that the pH was acidic with a mean of 5.37. Total N and available P content were very low compared with the critical levels for Ghanaian soils.

Table 1: Range (and mean) of various chemical attributes of the soils at sample points in the trial site within the 0-20cm depth for 2009 and 2010 cropping seasons.

Soil variable	Manga
Nitrogen (%)	0.025 – 0.031 (0.029)
Phosphorus (mg/kg)	3.02 – 4.90 (3.57)
Potassium (mg/kg)	10.0 – 25.0 (14.0)
pH	4.9 – 5.6 (5.35)

Results

Response of sesame to N rate and Spacing

Mean plant population at harvest was significantly ($P \leq 0.001$) affected by intra-row spacing effect with the closer intra-row spacing treatments (20cm and 30cm) recording significantly higher plant population density compared to their wider intra-row (40cm and 50cm) counterparts. Even though there was no significant interaction effect on plant population, the interaction effects of 20cm and 30cm at 80kg N/ha produced the highest plant populations of 69,000 and 71,000 respectively in 2009 (Table 2).

Table 2. Mean plant population (10,000/ha) at harvest as affected by N rate (Kg/ha) and intra-row spacing (cm) during the 2009 and 2010 cropping seasons

2009						2010				
N rate	20	30	40	50	Mean	20	30	40	50	Mean
0	2.6	2.5	2.9	2.6	2.7	6.2	4.6	3.6	3.7	4.5
20	4.0	4.1	3.7	4.0	4.0	6.1	4.6	3.6	3.6	4.5
40	5.2	5.8	5.4	4.8	5.3	5.9	5.0	3.6	3.2	4.4

60	6.2	6.2	6.3	5.7	6.1	5.8	4.3	4.3	3.6	4.5
80	6.9	7.1	6.7	6.3	6.8	5.8	4.2	3.9	3.5	4.3
Mean	4.9	5.1	4.4	4.7		6.0	4.6	3.8	3.5	
Sed			0.275					1.4		
LSD			0.56					1.8		

Generally, sesame plant height increased with wider intra-row spacing in both cropping season. Mean plant height was significantly ($P \leq 0.001$) influenced by N application with the height increasing with increase in N rate, attaining a maximum height of 142cm at 60kgN/ha in 2009. Intra-row spacing of 20cm at 60kgN/ha accounted for the tallest plant (142cm) in 2009 whilst the shortest plant (87cm) was recorded by the control (0kgN/ha) at 20cm intra-row spacing in 2010 (Table 3).

Table 3. Mean plant height (cm) of sesame as affected by N rate (Kg/ha) and intra-row spacing (cm) during the 2009 and 2010 cropping seasons

2009						2010				
N rate	20	30	40	50	Mean	20	30	40	50	Mean
0	100	101	126	103	108	90	92	87	105	94
20	140	121	126	129	129	133	113	126	131	126
40	133	128	126	130	129	115	129	116	128	122
60	142	137	131	137	131	117	126	130	120	123
80	131	139	132	140	136	121	115	124	127	122
Mean	129	125	128	128		115	115	117	122	
Sed			5.64					4.3		
LSD			11.4					8.6		

Mean plant population at harvest was significantly ($P \leq 0.001$) affected by intra-row spacing effect with the closer intra-row spacing treatments (20cm and 30cm) recording significantly higher plant population density compared to their wider intra-row (40cm and 50cm) counterparts. The increase in sesame plant height with wider intra-row spacing in both cropping seasons could be ascribed to lesser competition for resources

Table 4. 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.

2009						2010				
N rate	20	30	40	50	Mean	20	30	40	50	Mean
0	100	83	125	80	97	61	64	63	60	62
20	161	168	167	174	168	153	162	167	179	165
40	198	218	222	212	213	197	288	248	206	229
60	199	226	263	235	231	218	314	260	285	269
80	267	273	246	235	255	265	285	243	245	259
Mean	185	194	205	187		179	218	196	195	
Sed			22.14							25.3
LSD			45							50.6

Main effects of nitrogen rates and intra-row spacing significantly (P≤0.001) affected most of the traits evaluated more than the interaction effects. Generally, mean grain yield in 2010 cropping season was higher than that of 2009. In 2009, shorter intra-row spacing produced higher grain yield. The yields in both seasons were significantly (P≤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 60 kg/ha was recorded under N rate of 0 kg N/ha in the same season (Table 4). In both cropping seasons higher N application produced higher grain yield 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).

Discussion

Sesame yields reported in 2010 cropping season were generally higher than those reported in 2009. Seasonal variation in the amount and distribution of rain could be partly responsible for the year differences in the yield. 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. Generally the grain yield of sesame in the current study is comparable to what is usually reported in the literature for Africa. The low yield could be attributed to low yielding dehiscent varieties with low harvest index values as well as significant yield loss during threshing (Ashri, 1994, 1998; Weiss, 2000; Uzun and Cagirgam, 2006). The low yields reported could also be ascribed to the wider inter-row spacing (75cm) adopted in this study compared to closer inter-row spacing as reported by Olowe and Busari (1994). Marginal insignificant yield response was observed with increased nitrogen level attaining a peak at 80kgN/ha. This suggests that sesame is a low N response crop, an observation which is consistent with reports by Olowe (2006) who suggested that sesame is a low N response crop. Earlier reports have also shown that maximum grain yield of sesame was recorded on relatively low to medium levels of 30-60 kg /ha (Subramaniah *et al*.1979; Daulay and Singh, 1982). In Nigeria, a similar study by Olowe and Busari (1994) reported that 60cm x 5cm and 60cm x 10cm were the appropriate plant spacing for sesame in southern Guinea savannah of Nigeria. Earlier reports by Subramaniah et al., (1979) and Daulay and Singh (1982), have indicated that maximum grain yield of sesame was recorded on relatively low to medium levels of 30-60 kgN/ha.

Conclusion and Recommendation

Sesame is gradually becoming an important export crop and Ghana has a substantial role in the global sesame trade. It is therefore time to develop support and action to facilitate the continued expansion of this sector. As a smallholder crop, capable of providing income in areas where the options are quite limited, sesame has a key role in sustaining agriculture in disadvantaged areas. Adequate support must be given to farmers to promote its production A reduction in intra-row spacing from 75cm to 60cm and an increase in the N rate to 120 kg/ha will be appropriate to observe the agronomic performance of sesame under these conditions. Given the contrasting results regarding both N application and intra row spacing there is the need to repeat the trial in order to establish the optimal rate of nitrogen and Spacing as well as plant population for increased and stable sesame yield in the study area.

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On-farm testing of Extra early and early Drought Tolerant Maize for Africa (DTMA) in a semi-arid agro-ecology in northern Ghana.

Roger A. L. Kanton, Saaka S. Buah, Kombiok, J. M, Obeng-Antwi, Alexander Nimo Wiredu, Peter A. Asungre, Emmanuel Y. Ansoba

Abstract

Field trials were conducted at 4 districts, namely: Garu-Tempane, Bawku Municipal, Bawku West and talensi-Nabdam in the Sudan Savanna Agroecology of the Upper East Region during the 2010 cropping season. The mother and baby trial concept was adopted. All cultural practicesare as recommended for maize cultivation in Ghana. A combined analysis of the data across locations and years indicated significant (P<0.001) differences for most of the maize traits analysed hence the data across locations and seasons cannot be combined hence the respective years results are presented. EVDT-W 99 STR QPM CO significantly out-yielded all the maize varieties tested. All the DTMA maize significantly out-yielded the local check 'Akposoe'. From the economics point of view TZEE Y POP STR C4 and TZE WDT STR C4 recorded the highest marginal rates of returns from resource shift respectively. In conclusion the following maize varieties were recommended to the National Variety Releases Committee, which were released for increased maize production and productivity in Ghana. These are: TZE-W Pop STR QPM C0 now called CSIR-Omankwa; EVDT-W 99 STR QPM C0 is now called CSIR-Aburohema and TZEE-Y Pop STR QPM C0 is called CSIR-Abontem.

Key words: Maize, Drought, Tolerant, Variety, Yield, Mother, Baby, Release.

Introduction

Maize (*Zea mays* L.) is one of the most important food cereals in the developing world (CIMMYT, 1990). However, its production is too low to meet growing demands, which necessitates large increases mainly through yield improvement (Crosson & Anderson, 1992). Maize growing environments in sub-Sahara Africa are mainly rain-fed and characterized by rainfall patterns, which are highly variable both in amount and distribution. As a result, 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. Farmers participating in the Annual Planning Sessions under the auspices of the Research Extension Farmer Linkage Committee (RELC) in the three northern regions of Ghana have always identified low soil fertility, insufficient and erratic rainfall as the major constraints to maize production in the area. In order to address the problem of water stress several water harvesting techniques such as tied ridges have been proposed, but the efficiency of these techniques could be further enhanced if biotic interventions such as the use of drought tolerant varieties, which will use the harvested rainwater more efficiently in these arid regions. Research cost can be reduced significantly and adoption rates increased if farmers are allowed to participate in variety evaluation Girma *et al*. (2005).

The release of promising drought tolerant maize hybrids and varieties by the International Institute of tropical Agriculture (IITA) is therefore welcome news. The overall objective of the study was to:

1. test on farmers' field drought tolerant maize varieties;
2. let farmers select at least one best suited maize variety or hybrid that is tolerant to drought;
3. determine the economic benefits of planting drought tolerant maize varieties with farmers' variety and
4. to introduce to at least 50 farmers at least one each of drought tolerant maize variety and hybrid to enhance maize production in northern Ghana.

Materials and methods

Site and farmer selection

Field trials were conducted at 4 districts, namely: Garu-Tempane, Bawku Municipal, Bawku West and Talensi-Nabdam in the Sudan Savanna Agroecology of the Upper East Region during the 2010 cropping season. These are the major maize growing districts in the region. In each ditrist 1 farmer planted the mother trial, whilst in Garu-Tempane, Bawku Municipal and Bawku West 5 farmers planted the baby trial, whilst in Talensi-Nabdam 1 farmer planted the baby trial. In all a total 16 farmers planted the baby trials, 3 farmers planted extra early and 4 farmers planted the early mother trials giving a total of 7 farmers for the two maturity groups mother trials. Thus a grand total of 23 farmers participated in the evaluation of the drought tolerant maize varieties/hybrids. Farmers were selected based upon their previous experience in conducting on-farm adaptive trial with the Savanna Agricultural Research Institute Station at Manga and also their willingness to collaborate in this particular study.

***DTMA maize varieties/hybrids tested*:**

Extra early:

i. **2000 SYN EE-W DT STR C4** ii. **2004 TZEE-W Pop STR C4** iii. **2008 TZEE-Y Pop STR F2**, iv. **99 TZEE-Y Pop STR C4** v. **TZEE-W Pop STR C4** vi. **TZEE-W Pop STR C5** and vii **TZEE-W Pop STR QPM CO**.

Early:

i **EVDT-Y 2006 STR** ii. **TZEE-W DT STR C4** iii. **TZE-Y COMP 3 DT C2F2** and iv **TZE-Y DT STR C4**

Experimental design and replications

The randomised complete block design was adopted for both mother and baby trials. The mother trial had 3 replications whilst for the baby trial each collaborating farmer served as a replicate. The plot size for mother trial was 4.5 m x 5m whilst for the baby trial it was 20 x 10 m. Experimental data were taken on the 4 central rows whilst harvesting was done leaving out the outer 2 rows.

Land preparation and cultural practices

Lands ploughed and ridged using a pair of bullocks and planting was done on ridges, which were spaced at 0.75 m apart. Planting was done at 0.4 m between hills and seed sowed at the rate of 3 to 4 seed per hill and later on thinned to 2 plants per hill as practiced in the country. At Garu-Tempane both the mother and baby trials were planted from the 22 to 24 June 2010, in the Bawku Municipal the mother trial was planted on 16th and the baby trials on the 22nd of June 2010 due to ethnic conflict. At Bawku West the mother trial was planted a little later on the 27th of June 2010. Weeding was done at 2 and 4 weeks after sowing and fertiliser was applied using compound 15-15-15 as basal and sulphate of ammonia (S/A) applied as top-dress at the rate of 60 kg N/ha and 30 kg each of P_20_5 and K_20 at 2 weeks after sowing (WAS) and ammonium sulphate 4 weeks after sowing. Half of the N fertilizer and all the 30 kg of the P_20_5 and K_20 will be applied in the basal application. The ridges were re-shaped using bullocks at exactly 2 months after sowing to avoid root lodging and also to control any unmanaged weeds as adopted by maize farmers in the region. The experimental data taken on growth, development, yield and its components of maize as recommended.. Insect pests and disease were also looked for but none were found to have any economic effect on maize yields. Data was analysed using GenStat 3rd Edition.

Results

Extra Early DTMA Baby Trial

TZEE-W Pop STR C4 recorded the highest number of cobs at harvest, whilst 99 TZEE-Y STR C4 recorded the lowest. Except 99 TZEE-Y STR C4 and 2008 TZEE-W Pop STR F2, all the DTMA varieties/hybrids produced more cobs than the farmers' variety (Table 5). The longest cobs were produced by 99 TZEE-Y STR C4, with 2008 TZEE-W Pop STR F2 and the farmers' varieties producing the shortest cobs. 2008 TZEE-W Pop STR F2, produced the broadest cobs followed closely by TZEE-W Pop STR C4 and TZEE-Y Pop STR QPM C0, whilst, TZEE-W Pop STR C5 produced the smallest cobs. All the DTMA varieties produced heavier kernels as compared to the farmers' variety, which produced the lightest kernels. All the DTMA maize varieties/hybrids produced higher harvest indices compared to the farmers' variety. Maize kernel yields recorded by the baby trials were generally higher as compared to those reported for their mother trial counterparts. TZEE-W Pop STR C4, produced the highest kernel yield followed closely by TZEE-W Pop STR C5 and 2004 TZEE-W Pop STR C4, whilst 2000 SYN EE-W produced the lowest kernel yield (Table 11).

Similarly TZEE-W Pop STR C4 produced the highest straw yield followed closely by TZEE-W Pop STR C5 and TZEE-Y Pop STR QPM C0, whilst 99 TZEE-Y STR C4 produced the least. Thus TZEE-W Pop STR C4, TZEE-W Pop STR C5 and TZEE-Y Pop STR QPM C0 produced consistently superior maize grain and straw yields across locations in the region. If this performance is repeated in 2011, then they could be recommended as candidates to the National Variety Release Committee for consideration for release in Ghana with a view to boost maize production and productivity.

Table 5. Cobs harvested, 100-kernel weight (g), cob dimensions, kernel and straw yield of Extra Early DTMA varieties/hybrids baby trials on-farm in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	100-kernel weight (g)	Harvest index	Grain yield (kg/ha	Straw yield (t/ha)
2000 SYN EE-W	213	11.1	38.4	24.1	0.39	2.4	4.4
2004 TZEE-W Pop STR C4	207	10.6	39.4	23.8	0.41	3.0	4.4
2008 TZEE-W Pop STR F2	194	10.4	41.4	24.7	0.41	2.8	4.5
99 TZEE-Y STR C4	186	11.7	39.0	22.2	0.41	2.9	4.0
TZEE-W Pop STR C4	216	12.2	41.3	24.9	0.39	3.8	6.0
TZEE-W Pop STR C5	212	10.7	37.6	23.9	0.41	3.5	5.3
TZEE-Y Pop STR QPM C0	204	11.0	40.2	23.1	0.40	3.4	5.3
Farmers' variety	191	10.5	38.4	20.5	0.36	2.8	4.2
Mean	203	11.3	39.4	23.4	0.40	3.1	4.8
*s.e.*d.	14.87	1.12	2.54	2.92	0.062	0.94	1.2

Extra Early DTMA varieties/hybrids Mother Trial.

There were significant ($P<0.09$) grain yield, straw yield ($P<0.001$), harvest index ($P<0.001$) across locations, hence the need to analyse the locations separately. Maize grain yields at Garu-Tempane and Bawku West districts were significantly higher than that obtained in the Bawku Municipal.

Garu-Tempane Extra Early DTMA Mother Trial

The farmers' variety and 2008 TZEE-W Pop STR F2 produced the highest number of cobs at harvest with 2000 SYN EE-W producing the lowest cobs at harvest. The farmers' variety, 2008 TZEE-W Pop STR F2, TZEE-W Pop STR C5, TZEE-Y Pop STR QPM C0 and TZEE-W Pop STR C5 produced more cobs than the trial mean (Table 5). TZEE-W Pop STR C4 produced the longest cobs followed closely by 2004 TZEE-W Pop STR C4 with 2008 TZEE-W Pop STR F2 and TZEE-W Pop STR C5 producing the shortest cobs. 2008 TZEE-W Pop STR F2 produced the broadest cobs whilst 2004 TZEE-W Pop STR C4 produced the smallest (Table 12). The farmers' variety produced the boldest cobs followed closely by 2000 SYN EE-W and 2004 TZEE-W Pop STR C4, with TZEE-W Pop STR C4 producing the smallest grains. Most of the improved maize varieties produced kernels bigger than the trial mean. 99 TZEE-Y STR C4 had the highest harvest index followed closely by 2000 SYN EE-W, which were both significantly ($P<0.09$) higher as compared to those obtained by all the other treatments except for TZEE-W Pop STR C4. The farmers' variety recorded the lowest harvest index (Table 12). The Drought Tolerant Maize for Africa maize varieties/hybrids recorded superior harvest indices as compared to the farmers' variety. Maize kernel yield was generally comparable amongst all the treatments tested however; TZEE-W Pop STR C5 produced the highest grain yield whilst 2000 SYN EE-W produced the lowest. TZEE-W Pop STR C5 produced the highest straw yield, followed closely by 2004 TZEE-W Pop STR C2, 2008 TZEE-W Pop STR F2 and TZEE-W Pop STR C4, which were all significantly ($P<0.09$) greater than that produced by 99 TZEE-Y C4. Maize performance in the Garu-Tempane district was far better than those obtained for the rest of the districts in the 2010 cropping season.

Table 5. Cobs harvested, 100-kernel weight (g), cob dimensions, kernel and straw yield of Extra Early DTMA varieties/hybrids evaluated at the Garu-Tempane district in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	100-kernel weight(g)	Harvest index	Grainl yield (kg/ha	Straw yield (t/ha)
2000 SYN EE-W	76.5	12.0	42.5	25.4	0.52	2.5	2.3
2004 TZEE-W Pop STR C4	80.8	13.0	40.7	25.4	0.44	2.8	3.5
2008 TZEE-W Pop STR F2	90.0	11.8	45.2	23.1	0.45	2.8	3.4
99 TZEE-Y STR C4	86.0	12.5	42.0	24.5	0.57	2.2	1.7
TZEE-W Pop STR C4	84.8	13.3	43.7	22.6	0.49	2.8	2.9

TZEE-W Pop STR C5	89.8	11.8	43.7	24.3	0.47	2.9	3.3
TZEE-Y Pop STR QPM C0	88.0	12.5	41.5	24.1	0.47	2.7	3.1
Farmers' variety	90.8	13.0	43.5	26.0	0.41	2.7	3.9
Mean	85.8	12.5	42.8	24.4	0.47	2.7	3.0
s.e.d.	5.57	0.86	1.84	1.41	0.017	0.20	0.26
CV (%)	4.4	6.4	4.8	3.8	1.2	3.2	4.7

Bawku Municipal Extra Early DTMA Mother Trial

Maize performance in the Bawku Municipal in 2010 was generally poor as compared to that of 2009, due to extensive flooding of maize fields during the cropping season**.** TZEE-W pop STR C5 produced the highest cobs at harvest whilst TZEE-Y Pop STR QPM C0 recorded the lowest (Table 6). Almost all the improved maize varieties/hybrids produced cobs greater than the trial mean whilst the farmers' variety produced lesser cobs than the trial mean. 2004 TZEE-Y Pop STR C4 produced the boldest kernels followed closely by 99 TZEE-Y STR C4, whilst TZEE-Y Pop STR QPM C0 produced the smallest kernels. Only this variety and the farmers' variety produced kernels lower than the trial mean. Maize harvest indices were generally great as compared to those recorded in 2009, with 2000 TZEE-W Pop STR C4 and 2008 TZEE-Y Pop STR F2 recording the highest harvest indices, whilst TZEE-Y Pop STR QPM C0 recorded the lowest. Maize kernel yield in 2010 was quite low as compared to the yields recorded in 2009, due to extensive flooding experienced in the Bawku Municipal. However, 2004 TZEE-W Pop STR C4 and TZEE-W Pop STR C5 recorded the highest kernel yield with TZEE-W Pop STR C4 producing the lowest (Table 6). This variety and the farmers' variety produced kernel yields lower than the trial mean. TZEE-Y Pop STR QPM C0 produced the highest straw yield followed by TZEE-W Pop STR C5, whilst 2004 TZEE-W STR C4 and 2008 TZEE-Y Pop STR F2 produced the lowest.

Table 6. Cobs harvested, 100-kernel weight (g), harvest index, kernel and straw yield of Extra Early DTMA varieties/hybrids evaluated at the Bawku Municipal in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	100-kernel weight(g)	Harvest index	Grainl yield (kg/ha	Straw yield (t/ha)
2000 SYN EE-W	76	22.3	0.46	1.4	1.8
2004 TZEE-W Pop STR C4	75.8	23.7	0.48	1.5	1.6
2008 TZEE-W Pop STR F2	75.2	22.0	0.48	1.4	1.6
99 TZEE-Y STR C4	73.2	22.9	0.44	1.4	1.8
TZEE-W Pop STR	76	22.6	0.46	1.2	1.5

C4					
TZEE-W Pop STR C5	81.5	22.8	0.45	1.5	1.9
TZEE-Y Pop STR QPM C0	68.2	20.8	0.43	1.4	2.0
Farmers' variety	73.2	21.7	0.45	1.3	1.7
Mean	74.9	22.3	0.45	1.4	1.7
*s.e.*d,	6.37	1.16	0.028	0.17	0.24
LSD (0.05)	13.25	2.24	0.058	0.35	0.50
CV (%)	3.2	5.6	2.8	2.6	2.7

Bawku West Extra Early DTMA mother Trial

2008 TZEE-W Pop STR F2 and TZEE-W Pop STR C4 produced the highest number of cobs at harvest whilst the farmers' variety and 99 TZEE-Y STR C4 produced the lowest cobs at harvest (Table 7). TZEE-Y Pop STR QPM C0 produced the longest cobs followed closely by the farmers' variety whilst 2004 TZEE-W Pop STR C4 and 99 TZEE-Y STR C4 produced the shortest cobs at harvest. Maize cobs this season were generally smaller as compared to their counterparts in the 2009 season. 2000 SYN EE-W produced the broadest cobs, which were significantly (P<0.01) broader than those produced by 99 TZEE-Y STR C4. TZEE-Y Pop STR QPM C0 produced the boldest kernels followed by 2008 TZEE-W Pop STR F2, were significantly (P<0.08) bigger than those produced by 99 TZEE-Y STR C4. Similarly 2008 ZEE-W Pop STR F2, 2004 TZEE-W Pop STR C4 and 2000 SYN EE-W, also produced significantly (P<0.001) kernels compared to by 99 TZEE-Y STR C4. 2004 TZEE-W Pop STR C4 recorded the highest harvest index, which was significantly higher than that recorded by the farmers' variety. All the improved varieties/hybrids recorded harvest indices greater than the farmers' variety, which recorded a lower harvest index than the trial mean. Maize yield this season was generally low as compared to that obtained in 2009 due to flooding.2008 TZEE-W Pop STR F2 and TZEE-Y Pop STR QPM C0 produced the highest kernel yields, whilst 99 TZEE-Y STR C4 recorded the lowest.

Table 7. Cobs harvested, 100-kernel weight (g), cob dimensions, kernel and straw yield of Extra Early DTMA varieties/hybrids evaluated at the Bawku West district in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	100-kernel weight(g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)
2000 SYN EE-W	85.2	12.3	47.0	28.0	0.49	2.6	2.7
2004 TZEE-W Pop STR C4	73.5	12.8	46.4	28.8	0.52	2.5	2.3
2008 TZEE-W Pop STR F2	85.8	13.3	46.1	29.1	0.49	2.7	2.9

99 TZEE-Y STR C4	69.2	12.8	40.4	23.0	0.51	1.8	1.8
TZEE-W Pop STR C4	81.2	13.3	45.7	27.6	0.51	2.3	2.3
TZEE-W Pop STR C5	87.5	11.5	46.4	27.2	0.49	2.6	2.7
TZEE-Y Pop STR QPM C0	80.5	14.5	45.7	30.4	0.49	2.7	3.1
Farmers' variety	69.2	13.5	45.8	27.4	0.38	2.2	3.7
Mean	79.0	13.0	45.4	27.7	0.48	2.4	2.7
s.e.d.	7.75	1.08	1.66	2.07	0.028	0.34	0.48
CV (%)	3.7	5.5	4.8	7.1	3.3	5.1	6.9

The farmers' variety produced the highest straw yield followed closely by TZEE-Y Pop STR QPM C0, whilst 99 TZEE-Y STR C4 produced the lowest (Table 8). The improved maize varieties/hybrids produced kernel yields that are comparable to straw yields in 2010 compared to 2009, as reflected in the higher harvest indices associated with the improved maize varieties.

Early DTMA Mother Trial:
There was significant (P<0.001) differences across the districts in maize grain yield, with Bawku West district recording the highest followed by Garu-Tempane district, whilst Bawku Municipal and Talensi-Nabdam district recorded the lowest maize yields. EVDT-Y 2006 STR produced the highest yield amongst the varieties evaluated across the locations followed closely by TZE-Y DT STR C4, whist the farmers' variety produced the lowest (Table 8). Mean increase in maize grain yield recorded by the Bawku West district over Garu-Tempane was 22% and 352% over those recorded for Bawku Municipal and Talensi-Nabdam districts. Similarly, the Garu-Tempane recorded a mean increase in kernel yield of 270% compared to the mean grain yield recorded for the Bawku Municipal and Talensi-Nabdam districts. EVDT-Y 2006 STR, recorded the highest kernel yield amongst the varieties tested across the locations, whilst the farmers' variety produced the lowest grain yields.

Table 8. Across locations kernel yield (t/ha) of Early Drought Tolerant Maize varieties in the Upper East Region in northern Ghana in the 2010 cropping season.

District	EVDT-Y 2006 STR	TZE-W DT STR C4	TZE-Y COMP3. DT C2F2	TZE-Y DT STR C4	Farmers' variety	Mean
Bawku West	3.5	3.2	3.1	3.2	3.4	3.3
Garu-Tempane	2.7	2.6	2.8	2.8	2.6	2.7
Bawku Municipal	0.76	0.87	0.75	0.80	0.48	0.73

Talensi-Nabdam	0.90	0.84	0.70	0.71	0.47	0.72
Mean	1.97	1.88	1.79	1.88	1.74	
s.e.d.	0.087					
CV(%)	2.5					

Maize grain yield was significantly (P<0.001) affected by location, with Bawku West recording the highest maize kernel yield of 3.3 t/ha followed by Garu-Tempane district (2.7 t/ha) whilst Bawku Municipal and Talensi-Nabdam recorded the lowest mean kernel yield of 0.72 t/ ha. Maize variety/hybrid or district * maize variety/hybrid effects were not significant.

Early DTMA Baby Trials

TZE-Y DT STR C4 produced the tallest, whilst EVDT-Y 2006 STR produced the shortest plants (Table 9). Similarly TZE-Y DT STR C4 recorded the highest plant population at harvest followed closely by TZE Comp DT C2F2 and the farmers' variety. The longest cobs were also produced by this same variety, whilst EVDT-Y 2006 STR produced the shortest cobs. The heaviest maize kernels were also produced by this same variety followed closely by the farmers' variety and TZE-W DT STR C4 with EVDT-Y 2006 STR producing the lightest kernels. Maize harvest index was generally lower as compared to those recorded for their extra early baby counterparts. Only EVDT-Y 2006 STR recorded the highest harvest index comparable to the mean value obtained for the extra early maize baby trial. However, the early maize varieties produced superior kernel yield as compared to their extra early counterparts, with TZE-Y DT STR C4 producing the highest yield and followed closely by EVDT-Y 2006 STR, whilst the farmers' variety recorded the lowest (Table 9). These yields were about double those produced by their counterparts in the 2009 cropping season.

Table 9. Plant height, maize kernel yield and its components of Early Drought Tolerant Maize varieties/hybrids evaluated in baby trials in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	Plant height (m)	No. of cobs harvested	Cob length (mm)	1000-kernel weight(g)	Harvest index	Kernel yield (kg/ha)
EVDT-Y2006 STR	1.31	550	9.0	16.6	0.41	4.0
TZE-W DT STR C4	1.39	538	10.3	21.1	0.39	3.5
TZE-Y Comp3 DT C2F2	1.39	559	10.7	19.7	0.39	3.1
TZE-Y DT STR C4	1.61	561	11.8	21.8	0.34	4.6

Farmers' variety	1.40	559	10.5	21.6	0.31	3.0
Mean	1.42	553	10.5	20.2	0.34	3.6
s.e.d	10.26	27.75	1.84	1.69	0.074	0.97
CV (%)	7.25	10.40	17.5	8.25	20.3	27.7

Garu-Tempane Early DTMA Mother Trial

TZE-Y DT STR C4 recorded the highest cobs at harvest followed closely by the farmers' variety, with TZE-Y Comp 3 DT C2F2 producing the least (Table 10). The cobs recorded by TZE-Y DT STR C4 were significantly ($P<0.07$) higher than those produced by TZE-Y Comp 3 DT C2F2. EVDT-Y 2006 STR produced the longest cobs whilst TZE-Y Comp3 DT C2F2 produced the shortest cobs. The farmers' variety produced the broadest cobs whilst TZE-Y DT STR C4 recorded the smallest. The farmers' variety produced the heaviest kernels followed close by TZE-Y Comp3 DT C2F2. Maize 100-kernel weight recorded this year was generally greater than those reported for the 2009 season. Similarly maize harvest indices obtained in 2010 were also higher than their counterparts recorded in 2009. However, EVDT-Y 2006 STR and TZE-Y DT STR C4 recorded appreciably higher harvest indices than the other varieties. TZE-W DT STR C4 and the farmers' varieties had the smallest harvest indices. Maize kernel yield was generally higher as compared to those obtained in the Bawku Municipal and Talensi-Nabdam districts. However they were lower than those reported for the Bawku West district. TZE-W DT STR C4 and the farmers' varieties recorded the highest straw yield as compared to the rest of the varieties/hybrids tested, with EVDT-Y 2006 STR producing the lowest straw yield.

Table 10. Maize kernel yield and its components of Early Drought Tolerant Maize varieties/hybrids evaluated in mother trials at the Garu-Tempane in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	1000-kernel weight(g)	Harvest index	Kernel yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	78	15.3	43.0	25.0	0.43	2.7	3.6
TZE-W DT STR C4	79	13.5	42.4	24.7	0.40	2.6	3.9
TZE-Y Comp3 DT C2F2	73	12.5	43.3	26.9	0.42	2.6	3.7
TZE-Y DT STR C4	88	12.7	41.2	25.6	0.43	2.8	3.8
Farmers' variety	84	13.7	45.4	28.6	0.41	2.7	3.9
Mean	81	13.5	43.1	26.2	0.42	2.7	3.8

s.e.d.	4.68	1.29	1.57	1.56	0.023	0.19	0.31
CV (%)	9.2	1.4	1.3	4.1	1.7	4.7	7.6

Bawku Municipal Early DTMA mother trial

TZE-W DT STR C4 produced the highest number of cobs at harvest followed by TZE-Y Comp3 DT C2 F2, whilst the farmers' variety recorded the least. The cobs produced by TZE-W DT STR C4 were significantly (P<0.05) higher compared to those obtained by TZE-Y Comp3 DT C2 F2 (Table 11). Maize cob dimensions this season were far low as compared to those obtained in 2009. EVDT-Y 2006 STR produced the longest cobs, whilst TZE-W DT STR C4 produced the shortest. TZE-W DT STR C4 and the farmers' variety produced the broadest cobs, with TZE-Y Comp 3 DT C2 F2 produced slightly smaller cobs. Maize kernels this season were generally smaller compared to those produced in 2009. TZE-Y DT STR C4 produced the heaviest kernels followed closely by EVDT-Y 2006 STR, whilst TZE-Y Comp3 DT C2F2 produced the smallest kernels. Maize harvest index in Bawku Municipal were amongst the lowest in the region for this season. Maize kernel yields were generally very low compared to their counterparts in 2009. TZE-W DT STR C4 produced the highest kernel yield followed by TZE-Y DT STR C4, with the farmers' variety producing the lowest (Table 11). The Drought Tolerant Maize for Africa varieties/hybrids recorded a mean yield increment of 65% higher than the farmers' variety. However, maize straw yields were appreciably higher than their kernel counterparts with TZE-Y Comp3 DT C2F2 recording the highest straw yield followed closely by TZE-W DT STR C4 and TZE-Y DT STR C4, whilst the farmers' variety produced the least straw yield.

Table 11. Maize grain yield and its components of Early Drought Tolerant Maize varieties evaluated in the Bawku Municipal in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	1000-kernel weight (g)	Harvest index	Kernel yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	64	12.1	39.5	16.5	0.40	0.76	6.3
TZE-W DT STR C4	72	10.8	40.3	18.2	0.41	0.87	6.5
TZE-Y Comp3 DT C2F2	69.2	11.4	38.7	15.7	0.33	0.75	6.3
TZE-Y DT STR C4	66.8	11.9	39.4	19.0	0.38	0.80	6.6
Farmers' variety	44.8	11.6	40.3	17.1	0.34	0.48	6.6
Mean	63.4	11.6	39.6	24.0	0.37	0.73	3.9
s.e.d.	8.21	0.84	0.78	1.41	0.054	0.153	0.41

CV (%)	6.3	18.9	15.0	15.8	19.0	22.8	6.4

Bawku West Early maize mother trial:

The highest number of cobs was produced by EVDT-Y2006 STR followed closely by TZE-Y DT STR C4, whilst the farmers' variety produced the least. Maize cobs in 2010 were generally smaller in dimension compared to their counterparts in the 2009 season. TZE-W DT STR C4 and farmers' variety produced longer cobs compared to those produced by the other varieties (Table 12). Maize 100-kermel weight in 2010 was higher compared to that obtained in 2009. TZE-W DT STR C4 and the farmers' variety produced the heaviest kernels, whilst TZE-Y Comp3 DT C2F2 produced the smallest. TZE-Y Comp3 DT C2F2 and TZE-DT STR C4 produced the highest harvest índices compared to the other varieties tested. Maize kernel yields in 2010 in the Bawku West district were generally higher as compared to those produced in 2009. EVDT-Y 2006 STR produced the highest kernel yield and TZE-Comp3 DT C2F2 the lowest (Table 12). EVDT-Y2006 STR and the Farmers' variety produced the highest straw yield, whilst TZE-Y Comp3 DT C2F2 and TZE-Y DT STR C4 produced the lowest straw yield.

Table 12. Maize kernel yield and its components of Early Drought Tolerant Maize varieties evaluated in the Bawku West district in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	1000-kernel weight(g)	Harvest index	Grain yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	98	13.0	24.9	0.46	3.5	4.2
TZE-W DT STR C4	93	11.3	25.7	0.45	3.2	3.9
TZE-Y Comp3 DT C2F2	94	12.8	20.9	0.48	3.1	3.5
TZE-Y DT STR C4	95	11.5	22.6	0.48	3.2	3.5
Farmers' variety	87	12.8	25.7	0.45	3.4	4.2
Mean	93	12.3	24.0	0.46	3.3	3.9
s.e.d.	6.06	0.63	1.58	0.023	0.25	0.75
L.S.D. (0.05)	NS	1.29	3.43	0.051	0.55	NS
CV (%)	2.1	7.8	3.1	21.6	1.40	6.4

Talensi-Nabdam Early maize mother trial:

Maize cobs at harvest was lowest in the Talensi-Nabdam district, with TZE-W DT STR C4 producing the highest cobs whilst the farmers' variety produced the lowest (Table 13). Maize cob dimension were generally poor with EVDT-Y 2006 STR producing the longest cobs and TZE-W DT STR C4 the shortest cobs. TZE-W DT STR C4 produced the broadest cobs whilst the farmers' variety produced the smallest. TZE-W DT STR C4 produced the heaviest kernels followed close by EVDT-Y 2006 STR and TZE-Y DT STR C4, whilst farmers' variety recorded the lightest kernels. Except for TZE-Y Comp3 DT C2F2, all the drought tolerant maize varieties/hybrids produced kernels weight, which is in consonance with those usually reported for maize. Maize harvest indices recorded for Talensi-Nabdam were generally very low compared to those usually reported for maize. EVDT-Y 2006 STR and the farmers' variety recorded the highest harvest index, which is typical for maize, whilst TZE-Y Comp DT C2F2 recorded the lowest. Maize yield for the Talensi-Nabdam district was one of the lowest recorded in the current study. EVDT-Y 2006 STR produced the highest grain yield followed closely by TZE-W DT STR C4, whilst the farmers' variety produced the lowest yield (Table 13). All the DTMA maize varieties/hybrids produced yields that were about twice that produced by the farmers' variety. Maize straw yield was equally low, with TZE-W DT STR C4 recording the highest straw yield whilst the farmers' variety recorded the lowest.

Table 13. Maize kernel yield and its components of Early Drought Tolerant Maize varieties evaluated in the Talensi-Nabdam district in the Upper East Region in northern Ghana in the 2010 cropping season.

Maize variety/hybrid	No. of cobs harvested	Cob length (cm)	Cob girth (mm)	1000-kernel weight (g)	Harvest index	Kernel yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	37	13.2	42.1	20.3	0.41	0.90	1.3
TZE-W DT STR C4	44	10.2	44.4	21.4	0.34	0.84	1.6
TZE-Y Comp3 DT C2F2	33	11.7	39.0	18.4	0.33	0.70	1.5
TZE-Y DT STR C4	31	11.2	41.8	20.3	0.36	0.71	1.3
Farmers' variety	26	10.7	37.4	17.4	0.41	0.47	0.94
Mean	34	11.4	41.0	19.6	0.37	0.72	1.3
s.e.d.	7.79	1.02	1.75	1.31	0.067	0.156	0.44
CV (%)	14.3	3.6	1.6	4.0	4.3	14.5	19.8

Soliciting farmers' impressions about DTMA extra early and early maize

For the extra early maize varieties/hybrids 2000 SYN EE-W was the most preferred variety/hybrid by both men and women followed by 99 TZEE-Y STR C1 and TZEE-W Pop STR C4. The least preferred variety/hybrid was 2004 TZEE-W Pop STR C4 and 2008 TZEE-W Pop STR F2. It was quite interesting that this year both genders preferred the same varieties equally as compared to that recorded for 2009. Similarly for the early maize varieties/hybrids TZE-W DT STR C4 was the best preferred variety by both men and women followed by TZE-Y DT STR C4 and the farmers' variety was the third most preferred variety. TZEE-Y Pop STR C4 and TZE Comp 3 DT C2F2 were those that were not preferred by either gender. Here again both genders settled on the same maize varieties/hybrids (Table 14). Most of the farmers' preference was ascribed to higher kernel yield, whilst reasons given for rejection of a given variety/hybrid was also attributed to low yield. It is however interesting that the best performers from the analysis were not those selected by the farmers.

Table 14. Soliciting farmers' impressions on the performance of improved drought tolerant maize varieties evaluated during the 2010 cropping season in the Upper East region of northern Ghana.

District	Location	Maize variety	Men (Score)	Women (Score)	Men (Rank)	Women (Rank)
		Extra early maize varieties				
Bawku	Sakpari	99 TZEE-Y STR C1	4	3	2nd	3rd
Municipal		2000 SYN EE-W	12	9	1st	1st
		TZEE-W Pop STR QPM C0	1	4	4th	2nd
		TZEE Pop STR C4	3	2	3rd	4th
		2008 TZEE-W Pop STR F2	1	0	4th	6th
		TZEE-W Pop STR C5	0	2	5th	4th
		2004 TZEE-W Pop STR C4	0	1	5th	5 th
		Farmers variety				
		Early maize varieties				
Bawku Municipal	Demateg	TZE-W DT STR C4	17	19	1st	1st
		TZE-Y DT STR C4	6	4	2nd	2nd
		TZEE Y POP STR C4	1	0	4th	5th
		TZE Comp 3 DT C2 F2	1	0	4th	5th
		EVDT-Y 2006 STR	1	2	4th	4th
		Farmers variety	3	3	3 rd	3rd

Discussion

Maize yield and its components this season were generally lower as compared to those reported for the 2009 season. Particularly poor were the yields reported for the Bawku Municipal and Talensi-Nabdam districts, which recorded mean yields that were about a quarter of those recorded for the Bawku West and Garu-Tempane districts. Bawku West recorded the highest maize yields both by the baby and mother trials in the current season. The low yields reported for the Bawku Municipal and Talensi-Nabdam district might be ascribed to the extensive flooding experienced by these districts as compared to the Bawku West and Garu-Tempane districts. However, the baby trials this year outperformed their mother trial counterparts, which was clearly the reverse in 2009

For the extra early maize varieties/hybrids, TZEE-W Pop STR C4 produced the overall best maize kernel yield followed byTZEE-W Pop STR C5 and TZEE-Y Pop QPM C0, with a yield range between 2.4 to 3.8 t/ha, which is about twice the achievable average maize yield in the region. The low yield recorded by the farmers' variety might be ascribed to the low harvest index and inferior cob dimensions recorded by the farmers' variety. In Garu-Tempane district TZEE-W Pop STR C5 was the overall highest yielder followed by 2004 TZEE-W Pop STR C4 and 2008 TZEE-W Pop STR C4. In the Bawku Municipal 2004 TZEE-W Pop STR C4, was the best performer followed by TZEE-W Pop STR C5, whilst in the Bawku West district 2008 TZEE-W Pop STR F2 was the best performer followed by TZEE-W Pop STR F2 and TZEE-Y Pop STR QPM C0. Thus for the extra early maize varieties/hybrids TZEE-W Pop STR C4 and TZEE-W Pop STR C5 are the best performers across the districts and are thus potential candidate varieties/hybrids, which could be recommended to the National Variety Release Committee for their consideration for release in 2013 should the same varieties/hybrids exhibit the same yield superiority as they did in 2010.

For the early maize varieties/hybrids Bawku West recorded the best yields followed by the Garu-Tempane districts, whilst the lowest yields were recorded for the Talensi-Nabdam and Bawku Municipal. This was obviously due to the massive flooding by the White Volta in these 2 locations where maize yields were generally abysmal with entire crop failures being reported in some communities in these districts. EVDT-Y 2006 STR recorded the highest yield followed closely by TZE-W DT STR C4 and TZE-Y DT STR C4 across the districts. In the Garu-Tempane district TZE-Y DT STR C4 recorded the highest yield followed by EVDT-Y 2006 STR and the farmers' variety. In the Bawku Municipal TZE-W DT STR C4 was the best yielder followed by TZE-Y DT STR C4, whilst in Bawku West EVDT-Y 2006 STR gave the best results and also in the Talensi-Nabdam the same variety/hybrid EVDT-Y 2006 STR produced the best results followed by TZE-W DT STR C4. Thus for the early maize varieties/hybrids TZE-W DT

STR C4 and EVDT-Y 2006 STR are the overall best performers, which if the repeat their superiority in 2012 will be recommended to the National Variety Release Committee for consideration for release in 2013. The highest maize yield produced by these improved drought tolerant maize varieties/hybrids might be attributed to their higher harvest indices compared to the farmers' variety, indicating that the improved drought tolerant maize partitions assimilates more efficiently to generative parts as compared to the vegetative organs, which is a good requirement for higher maize yields. The superior performance of the improved varieties/hybrids as compared to the local varieties might be ascribed to enhanced genetic performance of these varieties/hybrids compared to the local check. Generally maize yields reported in the current study are well within the range reported for hybrid maize on-farm in Sallah *et al*. (2007). These results are in consonance with the assertion that the maize plant is a very that can convert natural resource s for increased yields (Spraque & Dudley, 1988).

Conclusion

The 2010 results are in consonance with those reported in 2009. These results have the potential to increase and sustain maize production and productivity in the Upper East Region, which of late used to be an exclusively millet and sorghum based cropping system. The most consistent performers over the 2-year period are EV DT W99 STR QPM C_O and 2004 TZEE Y Pop STR C_4 and are hereby recommended for release to increase and sustain maize yields in the Upper East Region to ensure food security for farm families.

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Effect of spatial arrangement on the performance of Pearl millet-Cowpea intercrop

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Abstract

Spatial arrangements 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 (1M1C), two rows millet/one row cowpea (2M1C), two rows millet/two rows cowpea (2M2C) and two rows millet/four rows cowpea (2M4C). There were also the sole crop arrangements of millet and cowpea. 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 cultivated in the Guinea and Sudan savannah zones of Ghana, where it is used in the preparation of various traditional foods. In all the agro-ecological zones of Ghana, cowpea is intercropped primarily with cereals (especially maize and sorghum), cassava and sometimes yam. It is generally grown as the minor crop in a system based on cereal or tuber crop (FCDP, 2005). The system is practically relevant to the development of a sustainable cropping system. In this system, the next non-leguminous crop utilizes the nitrogen fixed by the legume and thus reduces the need for added nutrients.

Cowpea 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

Methodology

Location, experimental design and crop management

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 (1M1C); two rows of millet alternating with one row of cowpea (2M1C); two rows of millet alternating with two rows of cowpea (2M2C); two rows of millet alternating with four rows of cowpea (2M4C); 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. Cowpea seeds were planted between the millet rows two weeks after, at two seeds per hill with intra-row spacing of 0.20m. Each plot consisted of 6 rows. 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 at the rate of Fertilizer (NPK) was applied to millet at 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 (shriveled or holed) pods and good 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 maize under intercropping, *Ysm* is the yield of maize 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 (1M1C) and lowest under two rows millet/two rows cowpea (2M2C) as well as sole millet condition. Percent incidence of downy mildew was significantly (P >0.05) high under 2M4C, 2M1C and 2M2C but lowest under 1M1C. There were no significant differences (P >0.05) among the arrangements in terms of initial plant count. One row millet/one row cowpea (1M1C) 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. 2M2C 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(kg	Total tillers
2M1C	71.3	26	144	34	28.7	32.3	0.197	47.7
2M2C	68.7	22.7	131	36	20	34.3	0.137	45
1M1C	58.4	25	142.7	33.3	46.3	34	0.240	62
2M4C	72.4	21.7	143	27	53.5	34	0.163	58
SM	68.7	24.3	141	26.4	73.6	34.3	0.136	66.7
Mean	67.9	23.94	140.34	31.34	44.42	33.73	0.1746	55.88
LSD*(p>0.05)*	22.53	4.429	16.78	1.352	23.71	3.036	0.0158	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 (kg)	LER	ATER	MEAN LERATER
2M1C	20,976	144	66.6	2.44	0.75	1.59
2M2C	21,3333	131	54.6	2.04	0.52	1.27
1M1C	21,509	142.7	65.1	1.48	0.91	1.19
2M4C	21,124	143	68	2.26	0.62	1.44
SM	20,091	141	70		0.75	1.59
Mean	21,006	140.3	64.9			
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 similar 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 2M4C and lowest under 2M2C. Bad (uneconomical) pods –shriveled, bored, etc - were most associated to 2M4C and least associated to 2M2C. Good (economic) pods were mostly recorded under the 2M4C and sole cowpea arrangements. There were no significant differences among the arrangements in terms of stover weight. Two row millet/four row cowpea (2M4C) and sole cowpea were among the spatial arrangements that recorded appreciable pod weight per plot while 2M2C recorded the least. Total number of economic (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 2M4C 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 Wt/plot (Kg)	Stover Wt/plot (Kg)	Grain yield (kg)	Bad pods	Good pods
2M1C	0.53	3.50	0.411	24.3	202
2M2C	0.45	3.83	0.330	17.3	189
1M1C	0.65	3.83	0.466	27	235
2M4C	1.07	3.50	0.736	39.3	418
SC	1.62	3.67	0.686	39.7	423
Mean	0.864	3.66	0.5258	29.52	293.4
Lsd(p>0.05)	0.2283	ns	0.0216	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 (2M1C) 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 2M1C 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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ENTOMOLOGY PROGRAMME

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Executive Summary

Insect pests rank high among the constraint to increased crop production in the Upper East Region (UER). They attack all the crops grown in the existing farming systems and cause losses both in the field and in storage. In an effort to address insect pests' problems in UER, the following research activities were conducted in 2010 by the Entomology Division of the Upper East Region-Farming System Research Group (UER-FSRG): Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation and Integrated management of field and storage pests to extend shelf life of yam. A participatory technology development approach was used by a team comprising of Research, MoFA and Farmer Based Organizations (FBOs) to evaluate different IPM strategies to manage pests and diseases of onion, pepper, tomato and yam. Training programmes based on proven agronomic and protection methods were also organized for the AEAs and the FBOs. The detailed research activities and the major achievements so far are as follows.

Integrated management of field, storage pests and post-harvest handling to extend shelf life of yam.

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Introduction

In West Africa, yams are cultivated in the fairly high rainfall areas with distinct dry and wet seasons. The 'yam zone' extends from the drier part of the forest zone through the Derived savannah zone to the Guinea savannah zone (Tweneboah, 2000). West Africa produces over 90% of the total world production of 20-25 million tons annually (Obeng-Ofori, 1998).

Short shelf life of yam in storage has been identified as one of the major constraints to yam production and storage. This could be attributed to two major factors: predisposing factors during production and storage (i.e. insect pests' infestation, nematode and disease infection). Lack of pre-storage treatment of yam tubers coupled with poorly constructed storage structures also contribute to the short shelf life of yam tubers. Losses as high as 46% has been recorded over a period of just two months in yams stored under ambient conditions (Lyonga, 1984). Morse *et al*, (2000), demonstrated that damage caused by pests during storage is as important as damage inflicted in the field prior to storage to the incidence of fungal disease of yam.

The project therefore aim at determining the optimum integrated pests and diseases management practices and post harvest handling of yam tubers to extend the shelf life of yam in storage in the Northern and Upper West regions.

Objectives:

- To determine the best integrated pests and diseases management practices to produce healthy yam tubers.
- To determine the best post harvest handling and storage practices of yam.
- To determine socio-economically feasible integrated pests and diseases management and post harvest practices that will extend shelf life of yam.
- To Promote the adoption of the economically feasible IPDM strategy

Methodology

The different treatments evaluated include site selection, treatment of yam setts before planting, pests control after crop establishment and treatment of yam tubers prior to storage. With the exception of pests control practices, all other recommended agronomic practices (e.g. spacing, weed control, staking, fertilizer application etc) were observed uniformly. Randomized

Complete Block Design (RCBD) was used in a 4x2 factorial experiment. There were 4 pre-planting treatments of yam setts combined with 2 after sprouting treatments.

Pre-planting Treatments

1. Hot water
2. Wood ash
3. Insecticide + Fungicide solution
4. Neem powder

After Sprouting Treatments

1. Neem Extract spray
2. Insecticide spray

Treatment Combinations

Treatment No.	Treatment combinations
1	Hot water + Neem Seed Extract spray
2	Hot water + Insecticide spray
3	Wood ash + Neem Seed Extract spray
4	Wood ash + Insecticide spray
5	(Insecticide + Fungicide) + Neem Seed Extract spray
6	(Insecticide + Fungicide) + Insecticide spray
7	Neem powder + Neem Seed Extract spray
8	Neem powder + Insecticide spray
9	Control

The storage studies looked at the following treatments: two pre-storage treatments (Wood ash and saturated salt solution) and a control. These were evaluated in three different storage structures (thatch structure, mud structure roofed with thatch and well ventilated wooden structure with

Results and Discussion

Pre-implementation survey

The survey was conducted to assess the level of technology use among the roofing sheets).
yam farmers and it revealed the following:

a) Farmers do not treat yam setts against pests and diseases at planting.
b) Most of the farmers are aware of termites, yam tuber beetles, and mealy bugs as pests of yam.
c) When asked to distinguish the symptoms of termites, yam tuber beetles and nematode attack, most of the farmers could not clearly distinguish them.
d) Farmers rely on heavy rains to control pests on yam leaves
e) Farmers delay harvesting as a means to handle the yam storage problem.

f) Thatch structure is the predominant yam storage structure among the farmers.
g) Staking is mostly done for fields they intend harvesting early in the season.
h) The farmers induce dormancy by regularly removing sprouts as soon as they emerge, this help to extend the shelf life of yam.

The pre-planting treatments (wood ash, warm water, insecticide + fungicide solution and neem powder) were found to decrease sprouting significantly ($P < 0.05$). However the reduced number of sprouts of 1 or 2 out of 16 setts was seen to be acceptable. The Hot water treatment which the farmers were skeptical that it might affect greatly the sprouting percentage of the setts rather caused less than 10 % reduction in sett sprouting.

The vigour score of the plant establishment after sprouting showed the pre-planting plot as more vigorous than the control plots. However, the post-sprouting treatment did not cause significant ($P > 0.05$) difference in the number of feeding holes of yam beetles per tuber when compared to the control. This could be attributed to the short persistent nature of the treatments coupled with the heavy and frequent raining days at the time of treatment application.

Effect of IPM strategies yield and pests and diseases incidence of yam

Treatment	Tuber Yield /ha (tons)	Weight /tuber (Kg)	Sprouts/ plot	Vigour Score	Tuber/ Plot	Feeding points /Tuber	Rotten Tubers
Hot water + Neem	22.10	2.52	14.33	4.33	14.00	2.67	1.33
Hot water + Insecticide	22.92	2.50	14.67	5.00	14.67	2.00	1.00
Wood ash + Neem	23.54	2.46	15.67	4.67	15.33	3.00	0.00
Wood ash + Insecticide	22.92	2.50	15.00	5.00	14.67	2.33	0.67
(Insecticide + Fungicide) + Neem	23.3	2.74	14.33	4.67	13.67	3.00	1.00
(Insecticide + Fungicide) + Insecticide	21.67	2.40	15.00	4.33	14.67	2.67	0.67
Neem powder + Neem	21.88	2.30	16.00	4.33	15.33	2.67	0.33
Neem powder + Insecticide	22.92	2.34	16.00	4.33	15.67	2.00	0.33
Control	20.83	2.30	16.00	3.33	14.67	1.33	0.67

Mean	22.50	2.44	15.22	4.44	14.74	2.41	0.67
S. E. D.	0.78	0.1	0.43	0.44	0.64	0.84	0.638
CV (%)	4.2	3.4	3.5	12.2	5.3	42.9	117.3

Data on the post harvest study for the first year is being compiled for analysis. However, our observation has revealed that the storage structures being evaluated can be improved to control rodents' attack, to improve ventilation in the mud structure roofed with thatch. Method used by the farmers to induced dormancy in stored yam is to be evaluated to see its effect on pest and diseases attack and how to improve upon the practice.

The on-station evaluation of the treatments will continue and the post-sprouting treatments will be reviewed. The research team and MoFA will carry out educational programmes for yam farmers groups based on the findings of pre- implementation survey.

Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation

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Background

Over the years the rainfall pattern has been erratic in distribution and low intensity. This has resulted in decline in total annual rainfall in this part of Ghana. In Upper East region in particular, frequent drought and subsequent crop failure has made rain fed agriculture unreliable and as a source of livelihood. The intensification of vegetable production coupled with the cultivation of vegetables that share the same pests and diseases could be attributed to the proliferation of pests and diseases on irrigated fields in the region (Obeng-Ofori, 1998; Tanzubil, 1991; Tanzubil and Yakubu, 1996).

Attempts by farmers to control these pests and diseases over the years has led to high cost of production and misused of insecticides leading to poisoning of human beings, livestock and the environment. The project therefore aim at determine the optimum integrated pests and diseases management strategies for onion, tomato and pepper production under irrigation in Upper East region.

Objectives:

1. To evaluate different IPM strategies for onion, Tomatoes and pepper production under irrigation.
2. To determine the socio-economically feasible IPM strategy for onion, tomatoes and pepper production under irrigation.

3. Promote the adoption of the economically feasible IPM strategy by Participatory technology development.

Methodology

The type of technology the project is developing and to promote for adoption is IPM strategies consisting of safe and judicious use of chemical insecticides and fungicides to supplement botanicals, use of host plant resistance and cultural practices in a more efficient and environmentally friendly manner. Six nursery treatments and five post-nursery treatments were evaluated for the 3 crops.

Nursery Treatments

1. Seeds treated with Benlate T
2. Seeds dressed with Seed power 44 WS (Imidacloprid + Metalaxyl + Anthraquinone)
3. Seedbed drenched with Neem seed extract
4. Seedbed sterilized with heat
5. Seedbed dressed with Carbofuran (Check)
6. Control

Treatments after transplanting

1. Neem Extract
2. Insecticide + Fungicide
3. Alternating Neem Extract and Insecticide
4. Alternating Systemic and Contact Insecticides + Fungicides
5. Control (take action when there is disease or insect outbreak – Farmer practice)

Results and Discussion

Combine effect of Good nursery management, early transplanting, good land preparation, efficient water management, monitoring (pests and diseases incidence and favourable conditions for pests and diseases) and timely, adequate and safe application of the treatments resulted effective management of pests and diseases of the three vegetables. All the treatments evaluated were found to be effective in managing pests and diseases of onion tomato and pepper when compare to the control. The incidence of onion bulb and basal rots were considerably reduced as a result of good water management. Incidence and effect of Thrips was found to be associated with late transplanting (Between late December and mid January). Likewise, weight per bulb and yield per hectare were found to be higher with early transplanting than late transplanting (2010 and 2011 data).
White fly, a major insect pest of pepper and tomato was effectively managed with the treatments. Monitoring and protecting the plants against white fly and Tomato fruit worm during harvesting is also recommended (using short persistence insecticides and fungicides immediately after harvesting). Poor spray coverage and under dose were the main reasons for high tomato fruit worm damage. The IPM strategies considerably controlled

the incidence of other pests and diseases (at nursery, nursery to permanent field and after seedling establishment)

Table 2. Effect of IPM strategies on yield of onion under irrigation (2011)

Treatment	Bulb Yield /ha (tons)	Bulbs /plot	Weight/bulb
Neem Extract	46.0	77.3	60.0
Insecticide + Fungicide	46.67	73.0	64.7
Alternating Neem and Insecticide	46.33	64.3	72.1
Alternating systemic and contact insecticides + fungicides	47.80	87.0	54.5
Control	47.0	83.7	59.5
Mean	46,76	77.06	62.16
S. E. D.	3.782	6.9	6.10
CV (%)	9.9	11.1	12.2

Table 1. Effect of IPM strategies on yield and incidence of pests and diseases of onion (2010)

Treatment	Bulb Yield /ha (tons)	Bulbs /plot	Weight/ bulb	Bulb rot	Thrips count
Neem Extract	43.00	90.2	47.9	1.25	1.5
Insecticide + Fungicide	40.13	93.8	43.0	1.00	1.5
Alternating Neem and Insecticide	42.63	91.5	46.6	0.50	1.0
Alternating systemic and contact insecticides + fungicides	40.75	92.5	44.4	1	0.75
Control	36.00	93.2	39.5	0.5	4.5
Mean	40.50	92.2	44.3	0,85	1.85
S. E. D.	1.71	6.19	3.33	0.842	0.516
CV (%)	6.0	9.5	10.6	140	39.5

Table 3. Effect of IPM strategies on yield and incidence of pests and diseases of tomato and pepper (2010)

TOMATO						PEPPER
Treatment	Yield / ha (tons)	Weight/ fruit (g)	Fruits/ plot	Bored fruits	Virus infected plants	Yield / ha (tons)
Neem Extract	33.00	37.80	276	16.00	1.00	3.13
Insecticide + Fungicide	31.00	41.00	226	11.30	1.00	2.71
Alternating Neem and Insecticide	30.11	35.10	254	14.00	0.33	2.83
Alternating systemic and contact insecticides + fungicides	34.32	37.00	228	7.00	0.67	2.71
Control	25.9	38.6	210	22.3	4.00	2.32
Mean	31.00	37.90	251	14.1	1.40	2.74
S. E. D.	6.21	3.50	62.2	4.22	0.67	232.8
CV (%)	24.7	11.93	31.8	36.5	58.3	10.4

POST-HARVEST PROGRAMME

The most critical decision after production is the moment to harvest as well as the form and time of utilization. Few days or weeks of delay in harvesting can have detrimental effect on produce quality. The Postharvest Program among others aims at improving postharvest handling, storage and processing to reduce losses and thereby conserve the already scarce food resources. Research targets have been to improve pre-harvest, harvesting and storage operations of small-holder farmers as a means of containing productivity increases, reducing postharvest losses and improving produce quality. Specific emphases were placed on low-cost storage methods, seed preservation and storage, postharvest physiology and handling of some vegetables and consumer taste preference issues.

Analysis of seed size and moisture content relations on the viability of 8 Pearl Millet (*Pennisetum glaucum* (L) R. Brown) Varieties

Issah Sugri

Introduction

A critical constraint in pearl millet production is the irregular seed viability which leads to poor stand establishment and yield performance. Farmers have been found to use high seed rates (8-12 seeds per hill) because they are unsure of the germination capacity of their seeds. In many instances where laboratory tests show optimum viability (>70%), abysmal rates are recorded under field conditions. This study examined the effect of seed size and moisture content relations on the viability of eight pearl millet varieties after one year of storage.

Materials and Methods

Eight millet varieties were used for the study. The seeds were fractionated into three sizes: <2mm, >2mm and 1-3mm sieve grades, and subjected to standard germination test. Germination counts were made on day 3, 5, and 7 after incubation, and up to day 9 for field testing. Days to 3-leaf and 5-leaf stages were determined as when 50% of the seedlings attained the 3 and 5 leaves stages respectively. The incidence of seedling growth abnormalities was recorded using a three-point visual score; where score 1= normal seedlings, score 2= root growth abnormalities, score 3= shoot abnormalities.

Results

Four varieties, *Tongo yellow*, *Arrow millet*, *Bristle millet* and *Bongo short head* were distinct for large seed size characteristics compared to *Salma-1*, *Salma-3*, *Langbensi millet* and *Indiana-05* (Table 1). The former group recorded less than 5% of the proportion of seeds below 2mm grade compared with the latter group which recorded as high as 8 to 30%. Significant differences (P<0.001) existed between the two blocks of varieties for thousand seed weight and bulk density. The bulk densities of *Tongo yellow*, *Arrow millet*, *Bristle millet* and *Bongo short head* were 84.7, 82.2, 81.7 and 81.8 kg/m^3 compared with *Salma-1*, *Salma-3*, *Langbensi millet* and *Indiana-05* with 76.0, 78.1, 80.6 and 74.9 kg/m^3 respectively. Across varieties, seeds of the >2mm grade recorded germination rates above 90% under controlled conditions except *salma-1* which had 84% germination. The 4 varieties, *Arrow millet*, *Bongo short head*, *B*ristle *millet* and *Tongo yellow*, which exhibited large seed characteristics consistently showed higher germination rates compared with their smaller-sized counterparts. Ironically, the former are early maturing varieties which are usually harvested during the humid months of August to September; which should greatly affect their viability. Under field conditions, the germination rates (%) were *Arrow millet* (54.3), *Bongo short head* (51.4), *B*ristle *millet* (55.2), *Tongo yellow* (56.8), *Salma-1* (39.2), *Salma-3* (49.4), *Indiana-05* (49.3) and *Langbensi millet* (50.0) (Table 2). The number of days to 3-and-5-leaf stages as well as incidence of seedling abnormalities showed direct relationships between seed size and initial vigour across varieties. Higher germination potential was associated with low incidence of root and shoot growth abnormalities. Across varieties, the 3 seed grades, >2mm, <2mm and 1-3mm recorded as high as 86.8, 81.8 and 85.9 % normal seedlings respectively which was indicative of a fairly good seed-quality. Large seeds showed lower incidence of root (6.8%) and shoot (3.9%) abnormalities compared with small seeds which recorded higher incidence of root (9.9%) and shoot (4.4%) abnormalities.

Table 1: Seed physical characteristics of eight pearl millet varieties used for the viability test

Variety	<2mm sieve range(%)	>2mm sieve range(%)	Bulk density (kg/m^3)	1000 grain weight(g)	Moisture content (%db)	Seed purity (%)
Arrow millet	2.9	97.3	84.7	13.2	8.9	99.8
Bongo short head	3.9	95.7	82.2	14.9	8.2	99.8
Bristle millet	4.2	95.9	81.7	14.1	10.8	99.8
Indiana-05	10.8	89.4	74.9	11.2	12.3	99.7
Langbensi millet	18.0	82.3	80.6	9.0	10.7	99.6
Salma-1	8.4	91.5	76.0	11.6	12. 5	99.7
Salma-3	30.1	71.2	78.1	7.8	13.9	99.6
Tongo yellow	0.3	99.6	81.8	17.9	10.7	99.9
Mean	8.8	91.5	80.0	12.5	11.0	99.7
$LSD_{(0.05)}$	0.8	1.6	1.5	0.6	0.8	NS
CV (%)	6.5	1.5	1.6	3.7	6.0	

Table 2: Effect of seed size on the viability of eight pearl millet varieties Seed (%)

	Laboratory viability test				Field viability test			
Varieties	Control	<2mm sieve	>2mm sieve	Mean	Control	<2mm sieve	>2mm sieve	Mean
Arrow millet	94.2	96.00	97.1	95.7	55.3	42.0	65.7	54.3
Bongo short head	88.3	87.0	97.0	90.8	53.3	40.5	60.3	51.4
Bristle millet	89.3	87.0	95.7	90.8	57.0	44.3	65.3	55.2
Indiana-05	73.8	77.3	90.8	80.7	51.0	34.0	62.5	49.3
Langbensi millet	90.0	89.2	94.3	91.2	51.0	36.2	62.8	50.0
Salma-1	80.0	77.2	87.7	81.6	34.2	30.2	53.3	39.2
Salma-3	88.2	85.2	94.7	89.3	50.5	40.7	57.2	49.4
Tongo yellow	87.7	84.7	90.7	87.7	58.3	46.2	65.8	56.8
Mean	86.4	85.5	93.5	88.8	51.3	39.3	61.2	50.8
$LSD_{(0.05)}$= 4.69, CV(%)= 4.6					$LSD_{(0.05)}$= NS, CV(%)=11.9			

Conclusion

Given that pearl millet seed production is done largely by peasant farmers, efforts to achieve higher germination should concentrate on prompt harvesting, adequate drying and appropriate storage; since these are within their capacity. The complex interrelationships among seed size, moisture content and good storage need to be understood by farmers. However, the high moisture deficit resulting from the drier conditions which coincides with the period of seed storage provides favourable condition for further drying. Based on role of seed size on viability, an indigenous farmer practice where large millet heads are selected for seed may yield dividend. Though sporadic rainfalls at harvest are a major abiotic stress, early harvesting by 7 days after the hard-dough stage could improve seed viability. Where undue delay in harvesting is anticipated due to farmers' busy schedule, selective harvesting for seed can be adopted. In all cases, adequate drying of seed to around 10.5±1 moisture content should be emphasized.

Review of crop storage practices and estimates of post-harvest losses in the Upper East Region of Ghana.

Issah Sugri

Introduction

Postharvest losses in Ghana according to the Ministry of Food and Agriculture (MoFA) are estimated at 10-20% in cereals and 20-40% in roots, fruits and vegetables. This is unacceptable since economic resources and energy would have been expended. There is usually a glut in supply of most harvested produce and followed shortly by acute scarcity, which results in excessive price fluctuations. Apparently, the traditional methods of storage do not satisfactorily protect the produce from biological, physical and environmental hazards such as pests, disease pathogens, water imbibitions and high temperatures. In general, storage of agricultural produce is necessary because the production of major food crops is seasonal and the produce is highly perishable. Consequently, the food is produced in just one harvest period and must be stored for gradual consumption until the next harvest. This requires some level of processing, preservation and storage in order to maintain quality until the produce is needed.

Objective

To review the current methods of storage and assess the nature and quantities of losses incurred under farmer handling conditions using a field survey and standardized loss assessment methods.

Methods

The region was stratified into three broad zones based on ethnic, cultural diversities and agriculture potentials. Two methodologies comprising a field survey and standard loss assessments were adopted. The survey employed a structured questionnaire and focus group discussions to capture data on demographic and socio-economic factors, cropping systems, crop storage practices, safety of agro-chemicals among others. Specific emphases were placed on pest management options, loss mitigating measures and safety of post-harvest chemicals used. Grain samples (~ 0.5-1kg) were obtained from farmers and local markets from each zone of the region. The gravimetric method ('count and weigh') was used for the standard loss assessment to calculate weight losses.

Results

The gender distribution of respondents was 78.8% male and 20.2% female, and an average of 13 members per household. Majority of the respondents (79.8%) were between 20 to 60 years. Around 75% of respondents had no formal education, 22.1% had basic education, and only 2.9% had tertiary education. Four crops, maize, sorghum, millet and rice provided most of the dietary energy requirements. The average farm size was 2.5 ha per crop with yields below average potentials (Table 3). Where storage was anticipated above 4 months, over 50% of farmers used some kind of protection. Farmers applied chemicals only when infestation was noticed during storage. The common grain protectants were *Actellic* (Pyriphos methyl), *bioresmethrin* (pyrethroid) p*hostoxin*, *gastoxin*, *Gastox* (Aluminium phosphate) and *Wander77 powde*r. Only 16.3% of farmers acquired agro-chemicals from accredited sources, a large majority (80.6%) obtained chemicals from the informal sources. Consequently only 17.3% received training on responsive use of chemicals; such as pre-harvest internal, dosage, protective clothing and chemical disposal. As high as 13.5 and 11.0 % losses were incurred in cowpea and bambara beans compared to 3.5, 4.8, 6.7, 2.2, 1.7 and 3.1 % in maize, sorghum, millet, rice, soybean and groundnut, respectively (Table 4). However, farmers' estimation showed much higher losses (21.4 and 13.12 %) in cowpea and bambara beans and around 5-11% losses in the other cereals. Extreme losses of 23.2, 24.5, 22.3, 21.4 and 25.0 % were incurred in tomato, onion, sweet potato water melon and yam respectively; over 50% of the losses were due to delayed marketing arrangements

Table 3: Average farm size, yield and proportion of produce utilization.

Crop	Farm size (ha)	Yield (kg/ha)	% of farmers cultivating	Proportion of harvested (% response):		
				Consumed	As gift	Marketed
Maize	2.0	9. 6	93.3	65.0	10.3	39.5
Sorghum	2.5	5.9	96.7	70.5	10.7	37.4
Early millet	2.9	6.4	96.2	84.9	10.7	28.4
Late millet	2.8	5.5	57.7	81.0	12.8	36.9
Rice	1.4	7.3	827	27.3	10. 6	77.1
Cowpea	1.3	2.5	81.6	30.6	9.0	72.4
Soybean	1.5	2.5	61.5	14.4	0.0	94.3
Groundnut	1.9	7.8	87.5	20.0	9.9	77.5
Bambara nut	1.1	3.0	56.7	30.4	11.4	65.0
Tomato	1.1	16.6	14.4	12.7	8.8	81.2
Onion	0.7	7.5	35.6	10.2	9.0	90.4
Sweet potato	0.7	15.5	13.5	30.2	7.5	81.5
Water melon	0.7	252	15.4	9.4	7.5	84. 6
Yam	0. 5	450	1.9	77.8	5.0	40.0

Table 4: Postharvest loss estimates under farmer storage in the Upper east region of Ghana

Crop	Farmer Estimation of Losses (%)			Standard Loss Estimates (%)		
	Min.	Mean (±std)	Max.	Min.	Mean (±std)	Max.
Maize	1.0	11.0±7	30	1.5	3.5±2	7.0
Sorghum	1.0	9.9±6	30	1.1	4.8±3	10.0
Early millet	1.0	10.3±5	25	1.1	6.6±4	12.0
Late millet	1.0	9.6±5	20	1.1	6.7±4	11.9
Rice	1.0	8.1±5	20	0.5	2.2±2	5.5
Cowpea	2.0	21.4±2	80	3.3	13.5±7	25.5
Soybean	1.0	5.7±4	12	0.5	1.7±1	5.0
Groundnut	1.0	6.7±4	20	0.5	3.1±2	6.2
Bambara nut	1.5	13.1±1	50	6.0	11.0±2	24.0
Tomato	10.0	23.2±12	50	*	*	*
Onion	10.0	24.5±13	70	*	*	*
Sweet potato	10.0	22.3±1	50	*	*	*
Water melon	10.0	21.4±9	50	*	*	*
Yam	20.0	25.0±7	50	*	*	*

Around 10-15 % losses incurred at sorting and grading were due to surface blemishes, rots and high internal infestation of insects. Quality losses in fruits included off-flavours, external and internal blemishes due to insect infestation, sprouting and mechanical injury.

Conclusion

Though these quantities of losses may seem inconsequential at the individual farmer level their cumulative effect on the national food balance sheet is huge. Subsequent loss assessment must meet minimum standards for each crop; taking into consideration climate data, scale of production, and the form, method and length of storage. Preferably, the losses should be also tracked along the value chain from harvesting to storage and subsequent marketing.

Effect of Season and Stage of Ripeness on Marketable Shelf Life of Tomato

I. Sugri, F. Kusi

Introduction

In Ghana, the stage of ripeness that tomatoes should be harvested to meet best sensory quality, price and prolonged shelf life is still in controversy. The tomatoes are currently harvested at the full-red stage because that is the consumer preference. Taste, flavour and colour of tomatoes harvested at mature-green or turning stages are known to be of inferior quality. This study attempted to identify the appropriate harvest index that would present best sensory quality and still meet other flexibilities such as price and shelf life.

Objective:

To evaluate the effect of three stages of ripeness on the marketable shelf life of tomatoes cultivated in both the dry and wet seasons.

Materials and Methods

Three exotic varieties of tomato, *No Name*, *Pectomech* and *Tropimech*, were cultivated in the dry and wet seasons and harvested at mature-green, half-ripe and full-red stages for the study. All standard agronomic as well as pest and disease management practices were observed. Susceptibility to mechanical injury was determined as the percentage of fruits that were bruised when transported from the point of production to storage. Total weight loss was determined as the percentage of original weight to the final weight during the storage period. The terminal shelf life was expressed as the number of days between harvesting and when over 75% fruits became unwholesome due to rotten odour, fermentation, sour taste or microbial spoilage.

Results and Discussion

All varieties showed large fruit characteristics in the wet season except for dry weight which was higher in dry season (Table 5). The variety *No Name* was distinct for most traits studied in the dry season but showed abysmal performance in the wet season. The average fruit weights of *No Name*, *Pectomech* and *Tropimech* were 60.1, 57.6 and 56 g respectively. Fruits of the wet season were more susceptible (9.9%) to injury than dry season (7.8%). Also, fruits harvested at the full-red stage were more susceptible (12.3%) to mechanical injury compared with the mature-green (7.3%) and half-ripe (8.1%) stages. A progressive daily weight loss of 2.8% with prolonged storage and a strong correlation (r^2=87) between weight loss and reduced shelf life was established. Severe weight loss per day (2.8%) occurred in the dry season compare to the wet season (1.8%). Prolonged shelf life was influenced largely by the season of storage and variety, but the effect of the stage of ripeness was not consistent (Table 6). Apparently longer shelf life of 8.5, 10.4 and 10.3 days for *No Name*, *Pectomech* and *Tropimech* was recorded in the wet season, but reduced to 8.1, 5.1 and 6.2 days respectively in the dry season. The onset of senescence (softening and decay) in the dry season indicates that *Pectomech* and *Tropimech* should preferably be marketed within 3-4 days and up to 5 days for *No Name* (Figure 2).

Table 10: Fruit characteristics of the 3 tomato varieties

Varieties	Fresh Weight (g)	10 Fruit Weight(g)	Dry weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Susceptibility to injury (%)
No Name	60.1	558.7	14.1	9.3	16.2	3.6
Pectomech	57.6	522.3	13.7	8.9	16.1	10.6
Tropimech	56.0	499.8	13.7	8.4	15.7	5.5
LSD $_{(0.05)}$:	2.8	20.8	1.8	0.6	0.5	3.4
CV (%):	14.3	8.3	19.7	14.7	6.3	15.1

Table 11: Effect of season and ripening on shelf life of 3 tomato varieties (days)

Varieties	Mature -green	Half -ripe	Full-ripe	**Mean**	Green-mature	Half-ripe	Full-ripe	**Mean**
No Name	8.5	8.2	7.7	8.1	7.5	8.3	9.5	8.4
Pectomech	5.3	5.3	4.7	5.1	8.8	11.8	10.5	10.4
Tropimech	6.2	6.3	6.2	6.2	10.3	10.7	9.8	10.3
Mean	6.7	6.6	6.2	6.5	8.9	10.3	9.9	9.7

LSD $_{(0.05)}$: Var. =0.79, Season =0.64, ripening =0.79, Var. x season =1.11, Var. x ripening =1.36,
CV (%): 12

However, all varieties will maintain some appreciable quality for up to 7 days in the wet season, though the fruits would be sold at a trade-off price. The tomatoes harvested in wet season were more turgid, susceptible to injury and prone to micro-biological infestations which relates inversely to shelf life. However, a favourable environment for storage (~22-33 ^{o}C, ~65-95 rh%) as well as moderate respiration rate of 239-516 mg CO_2/Kg/h may prevail (Doganlar *et al*., 1998). A reverse environment occurs in the dry season, the fruits are less turgid and perhaps low incidence of pests and diseases but a harsh storage environment (~26-42^{o}C,~34-49rh%) and high respiration rate (1053-1600 mg CO_2/Kg/h) may prevail.

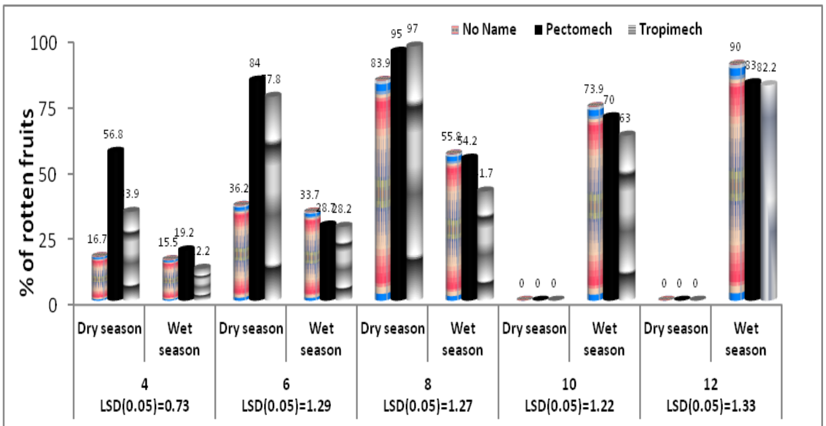

Figure 2: Effect of season of storage on shelf life and quality deterioration (days after storage)

Conclusion

Recommendations on harvest index to prolong shelf life of tomatoes should consider the growth season, handling conditions and particularly temperature at handling. At the mature-green and half-ripe stages, the fruits still have firm texture to withstand the cumbersome handling. However, attaining the full-red colour may be difficult at high temperature as lycopene synthesis is inhibited at temperatures above 30^{o}C. Harvesting at the full-red stage can be recommended where the current difficulties with regards to transport and marketing arrangements are mitigated. If the producers have ample time to harvest twice a week, harvesting at the full-ripe stage has advantages of good yield, competitive pricing and adequate development of the flavournoids. But where harvesting interval is prolonged (eg. weekly interval) all the green-mature, half-and-full-ripe fruits should be picked in order to minimize harvest losses.