COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

2011 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 **"Conduct research into food and fiber crop farming in Northern Ghana (Northern, Upper East and Upper West Regions) for the purpose of introducing improved technologies to enhance agricultural productivity"**. 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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2011 ANNUAL REPORT

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

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CSIR-INSTI
P. O. Box M.32
Accra

Editorial Committee

Dr. S. S J Buah (Chairman)
Dr. I. D. K. Atokple
Dr. J. M. Kombiok
Dr. M. Abudulai
Dr. M. Fosu
Mr. R. K. Owusu (Secretary)

Typeset

Mr. Robert K. Owusu

Publisher and Distributor

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P. O. Box TL 52
Tamale

Tel: +233 3720 91215

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FORWARD

The Savanna Agricultural Research Institute continued to live up to its mandate of conducting research into food and fiber crop farming in Northern Ghana for the purpose of introducing improved technologies to enhance agricultural productivity. Within the year all the research programmes made strides in that direction.

We are particularly happy to share with you activities undertaken and achievement chalked so far in most of the programmes. With climate change we are currently experiencing, the quantity and distribution of rainfall which cannot be determined based on the long term weather data available. Plant Breeders are now braced for it, and are gearing towards developing crop varieties from early or extra-early to drought tolerant to enable our numerous farmers get something to feed their households in very bad years. Moreover, as a result of continuous farming, pests and diseases have built up and are becoming resistant to pesticide. Hence efforts are being made to get crop varieties that are tolerant to stresses like pests and diseases, low soil nitrogen, and more importantly the parasitic weed – *Striga*. A number of improved crop lines have gone for one or two years evaluation on-farm. It is hoped that by the end of next year some of these lines would be released as crop varieties by the National Varietal Release Committee.

Work on the biological control of the larger grain borer (LGB), *Prostephanust runcatus* which was started in 2001 is still in progress. The LGB 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*, an environmentally friendly antagonist. So far, 548,339 predators have been produced in the laboratory and released in 187 locations in 13 districts in Northern, Volta and Brong-Ahafo Regions. During the year under review, 115,000 predators were reared and released in 39 locations in 9 districts in Northern Region. Preliminary evaluation carried out by our Entomology team has revealed that the pest has virtually vanished in the most endemic communities. The release would continue until the LGB no longer poses a threat to stored produce.

I would like to thank the staff for their hard work and commitment. I encourage all to work even harder to make sure that SARI succeeds in its vision of being a lead research and development institution by making agricultural research responsive to farmer needs and national development. My thanks go to all donors, especially AGRA, DANIDA, USAID, EMBRAPA and others that have supported us during the course of the year.. Our appreciation also goes to the MoFa and numerous press houses who helped us disseminate our technologies.

We hope that you will enjoy reading this report with much pleasure. Never hesitate to consult us for any of the technologies we have developed.

Dr. Stephen K. Nutsugah
Director

ADMINISTRATION

Management

The Institute is managed by a 7-member Management Board, 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. MumuniAlhassan	Private Sector
6	Mr. Roy Ayariga	MoFA
7	AlhajiNashiruKadri	Private Farmer

Staff Strength

Staff strength as at the beginning of 2011 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 located in Manga and Wa also 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.

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	Ph.D	2012	Univ. of Florida. USA
2	William Atakora	MSc.	2012	KNUST-Kumasi
3	Abubakari Mumuni	B.Sc	2012	IPS-Accra
4	Abihiba Zulai	B.Sc.	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	B. Sc.	2012	UCC
10	Joseph AdjabengDankwa	Ph. D	2014	Univ. of Ghana-Legon
11	Mahama George Yakubu	M Sc	2011	Kansas State Univ. USA
12	Tahiru Fulera	M.Sc	2012	Univ. of Bonn-Germany
13	Alidu Issah	MSc	2010	Tuskegee Univ. USA

Staff back from training

Name	Grade	Programme
Kwabena Acherimu	Asst. Res. Scientist	MSc.
Abubakri Mutari	//	//
Mohammed Haruna	//	//
Alhassan Sayibu	STO	BSc.
Peter Asungre	//	//

Paul Berko	Chief Acc. Asst.	//

Membership of Committees

Staff continued to serve on various committees listed below:

- Publication/Editorial
- Human Resource Development
- Expenditure Control
- Guest House
- Housing Allocation & Maintenance
- 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

Ten graduates from tertiary institutions in the country undertook their national service at the Institute. The details are presented in 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	John Bidzakin	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, Administrative Division

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	1	13	92	106

• Estate • Security				
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	**Qualifications**	**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 Agric. Entomology Agric. Entomology	Senior Research Scientist
Osman K. Gyasi	BSc MSc PhD	Agriculture Agric. Economics Agric. Economics	Research Scientist
Baba Inusah	MSc	Irrigation Agronomy	Research Scientist
A. N. Wiredu	BSc MSc	Agriculture Agric. 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	Principal Technical Officer
Asieku Yahaya	BEd	Agricultural Science	Technical Officer
Nyour Anslem	HND	Agriculture Engineering	Technical Officer
Alhassan Nuhu Jimbaani	HND	Agriculture Engineering	Technical Officer

Scientific Support Group

Name	**Qualifications**	**Area of Specialisation**	**Designation**
S. K. Asante	BSc MSc PhD	Agriculture Plant Protection Agric. Entomology	Principal Research Scientist
I. D. K.	BSc	Agriculture	Senior Research

Atokple	Dip Ed MSc PhD	Education Plant Breeding Plant Breeding	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 MPhil	Agriculture Plant Breeding	Research Scientist
B. D. K. Ahiabor	BSc MSc PhD	Agriculture Plant Physiologist Mycorrhizology	Research Scientist
A. A. Abunyewa	BSc Mphil PhD	Agriculture Soil Chemistry Soil Chemistry	Senior Research Scientist
N. TabiAmponsah	BSc MSc	Agriculture Nematology	Research Scientist
Adjebeng-Danquah J.	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	BSc	General Agriculture	Principal Tech. Officer
A. L. Abdulai	BSc MSc	Agriculture Agrometeorology	Research Scientist
Ester Wahaga	BA	Sociology	Research 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	**Qualification**	**Area of Specialisation**	**Rank**
J. S. Bapule	BA MA	Econs/ Sociology Development Economics	Senior Commercial Manager
R. K. Owusu	BSc MSc	Agric. Mechanisation Postharvest & Food Preservation Engineering	Senior Scientific Secretary
Musah Iddi	Technician III Certificate	Radio, Television & Electronics	Principal Superintendent
Mumuni Abukari	HND	Marketing	Marketing Asst
Warihanatu Baako (Miss)	HND	Marketing	Marketing Asst

COMMERCIALISATION AND INFORMATION

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 of 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 (C.I.D) 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	-	Snr Scientific Secretary
iii)	Mr. Abukari Mumuni	-	Snr. Marketing Assistant
iv)	Miss Baako Warihana	-	Snr. Marketing Assistant
v)	Mr. Alhassan B. Yamyoliya	-	Marketing Assistant
vi)	Mr. Musah Iddi		ICT Specialist

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 2011 and reported in 2012

Revenue Source	**Gross Income**	**Expenses**	**Net Income**
Guest House Services	9,610.00	6,566.50	3,043.50
Soil Analysis	16,329.00	4,429.00	11,900.00
Tractor Services	15,326.01	7,785.22	7,540.79
Documentation	4,028.35	2,743.00	1,285.35
Conference Hall	63,758.98	0.00	63,758.98
Rice Processing	136,712.41	55,415.20	81,297.21
Combine Harvester	6,190.56	2,778.41	3,412.15
Farm Produce	19,925.00	0.00	19,925.00
Transport	5,537.04	12,367.10	-6,830.06
Facility user fees	3,314.00	0.00	3,314.00
Project Support	9,747.00	0.00	9,747.00
Total	290,478.35	**92,084.43**	**198,393.92**

Challenges

The year was without challenges, some of which include:

Limited Capacity of Combine Harvester

As mentioned earlier, the Combine Harvester service is an area where substantial amount could be realized. Before the onset of the harvesting season, the Division received about 2000 acres applications from farmers, unfortunately; only about 240 acres applications could be served. The Institute could have harvested more acres if there were two Combine Harvesters. The existing one has been in operation for seven years and is now old.

Soil Analytical Laboratory

Most equipment in the soil chemistry laboratory are broken down, making it impossible to meet deadlines or even execute jobs that come. This affected the cash inflow of the unit.

We had difficulties clearing laboratory equipments that were purchase by the institute.

The rice processing center

The rice mill has small storage capacity which is not sufficient to meet the demand. We do not also have a drying platform to dry parboiled rice.

Significant Achievements of the Division

Contract with NAFCO

The institute continued with its contract with national food buffer stock company (NAFCO) of ministry of food and agriculture (MoFA). We milled about 22500 bags of NAFCO parboiled paddy rice.

Contract with AMSIG

The contract with AMSIG a local NGO to use our parboiling facility at the rice processing center continued for 2011.

Operations of two haulage trucks

We were able to put to use our two benz trucks of 10 and 30 tons. The vehicles help a lot in the execution of the NAFCO contract.

DOCUMENTATION AND LIBRARY

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

DOCUMENTATION

Introduction

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

Preparation and submission of Reports

Within the year under review, the first, second and third quarterly reports were prepared and submitted to head office on time. The fourth quarter report of 2010 was also submitted in early 2011. Editing of 2009 Annual Report was completed and submitted for printproduction whilst editing of the 2010 report commenced.

Experimental Field Visit

The weekly field visit started on 30th August and ended on 11th October, 2011. With a visit to two programmes each week all the programmes were visited, starting with Cassava Improvement and ending with Rice Improvement. Attendance was very encouraging as all Research Scientists and Technical Officers attended.

LIBRARY AND INFORMATION

The institute’s library was established in 1980. Its main objective is to develop a strong information service to support the institute's research programmes and to meet the needs of the scientific community. The Library's collections are mainly on Agriculture with special collections on Farming Systems Research. The book collections currently 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 are available at the library

- 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.)
- TEEAL

Within the year 530 were catalogued, classified and shelved according to the class number. These materials have been entered into a database. On Question and Answer service (QAS), the library provided answers to 29 clients, mainly Research Scientists and Technicians, and some students and farmers. In all the Library recorded over 220 clients, who were mostly students from UDS.

Book Donation

Within the year the Library receive over 60 volumes of book through donations on various topics. some of them were:

- Vegetable cultivation
- Linking local learners: Negotiating new development relationship between village, district and nation
- Sweet potato cultivation
- Integrated Pest Management in vegetable production: A guide to extension workers in West Africa.
- Learn how to grow yams .

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.

Challenges

- Failure of some Scientists to submit copies of their publications
- Inability of the library to acquire/buys new books and have to depend on donation.
- Failure of some staff to return borrowed books.

STAFF PUBLICATIONS

Kombiok, J.M., S. S. J. Buah, I. K. Dzomeku and H. Abdulai (2011). Sources of pod yield losses in groundnut in the northern Savanna zone of Ghana. *West African Journal of Applied Ecology*

Abu. H.B and **S.S.J Buah**. (2011). Characterization of Bambara Groundnut Landraces and their evaluation by farmers in the Upper West region of Ghana. *Journal of Developments in Sustainable Agriculture* 6:64-74

Buah, S. S. J., S. K. Nutsugah1, R. A. L. Kanton1, I. D. K. Atokple1, W. Dogbe1, Afia S.Karikari1, A. N. Wiredu1, A. Amankwah, C. Osei, Olupomi Ajayi and Kabirou Ndiaye, 2011. Enhancing farmers' access to technology for increased rice productivity in Ghana. African Journal of Agricultural Research Vol**. 6**(19), pp. 4455-4466,

Sugri I, SK Nutsugah, J Yirzagla. 2011. Effect of some physical characteristics on viability of pearl millet (*Pennisetum glaucum* (L.) R. Brown). Research Journal of Seed Science **4**(4): 181-191.

Mutari, A. and Rees, D. (2011). The effects of postharvest handling and storage temperature on the quality and shelf of tomato. *African Journal of Food Science* Vol. **5**(7), pp. 446

Mutari, A. (2011). Handling and 1–MCP application on the quality and shelf life of tomato. A Monograph published by LAP Lambert academic publishing. GmbH and Co. KG. Dudweiler Lanstr 99, 66123, Saarbruchen, Germany. ISBN 978-3-8454-7158-7.

Israel K. Dzomeku**, Mumuni Abudulai** and Muntari Abukari 2011. Influence of weeding regime and neem seed extracts on the population of insect pests and yield of cabbage in the guinera savanna zone of Ghana. *Agriculture & Biology Journal of North America* **2**: 921- 928.

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Denwar, N. N, C.E. Simpson, J.L. Starr, T. A. Wheeler, J. L. Ayers, M. R. Baring, S. K. Nutsugah, P. Sankara and M. D. Burow. 2011. Evaluation of Interspecific Lines and Breeding Populations of *Arachis hypogaea* L. for Yield and Resistance to Leaf spot Diseases in Ghana and Texas. *Paper presented at American Peanut Research and Education Society (APRES) Conference, Atlanta, Georgia.*

Acheremu, K., Adjebeng-Danquah, J., Asante, S.K and Parkes, E.Y. 2011. Evaluation of eighteen cassava genotypes for their performance under dry conditions of Northern Ghana. *Abstract: proceedings of WAAPP-Root and Tuber Conference*. 12th-16th September 2011.

Ahiabor, **B. D. K.,** S. S. Buah, A. M. Mohammed, J. Adjebeng-Danquah and M. Fosu (2011). Determining Mineral Fertilizer Requirements for Yam on Benchmark Soils in Northern and Upper West Regions of Ghana. *Book of Abstracts/Conference Programme of the West Africa Root and Tuber Crops Conference*, p. 96. Sept 12-16, 2011, Mensic Grand Hotel, Accra, Ghana.

B.D.K. Ahiabor, M. Fosu, E. Atsu, I. Tibo and I. Sumaila (2011): *Integrated Soil Fertility Management for Increased Maize Production in the Degraded Farmlands of the Guinea Savanna Zone of Ghana Using Devil-Bean (Crotalaria retusa) and Fertilizer Nitrogen*. **In:** Innovations as Key to the Green Revolution in Africa – Vol.1, Exploring the Scientific Facts (Eds. A. Bationo, B. Waswa, J.M. Okeyo, F. Maina and J. Kihara), Pp. 183-189.

Kusi F., Obeng-Ofori D., Asante S. K., Padi F. K. (2012). Deployment of the cowpea aphid (*Aphis craccivora*) resistance gene for cowpea improvement in Ghana. Kirkhouse Trust sponsored West Africa Annual cowpea Consortium meeting, 16th – 19th October 2012, Niamey, Niger.

Kusi F., Nutsugah S. K, Asante S. K., Owusu R. K., Nimo-Wiredu A., Buah S. S. and Adjebeng-Danquah J. (2011). Integrated Pests Management strategies of field and post harvest practices to extend shelf life of yam. *Book of Abstracts/Conference Programme of the West Africa Root and Tuber Crops Conference*, Sept 12-16, 2011, Mensic Grand Hotel, Accra, Ghana.

BOOKS/STUDENT THESES

Denwar, N. N. 2011. Evaluation of interspecific lines and breeding populations of A*rachis hypogaea* L. for yield and resistance to leafspot diseases in Ghana and Texas. PH.D Dissertation. Texas Tech University, Department of Plant and Soil Science, Lubbock, TX 79409.

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 2011.

MAIZE IMPROVEMENT

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

Haruna Alidu, M.S. Abdulai, James Kombiok, S.S. Buah, R.A.L. Kanton and Gloria Adu Boakyewaa

Executive Summary

Three maturity groups of maize – extra-early, early and intermediate/late – composed of hybrids and OPVs tolerant to drought were evaluated under this project in the 2011 farming season to identify superior stable yielding varieties. To achieve this, 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 three replications per location. Multiple traits 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.

Introduction

In Ghana, maize production has increased and continues to increase across the entire country over the years due to its high potential grain yield. It is grown mainly for its energy-rich grains and its production has continued to gain wider acceptability over other traditional cereal crops in sub-Saharan Africa, especially in the savanna of West and Central Africa (WCA). It has a wide range of uses than any other cereal. Maize high yield potential, wide adaptability, relative ease of cultivation, processing, storage and transportation has increased the potential of the crop for combating food security challenges posed by population increase in WCA (BYERLEE and EICHER, 1971).

The Guinea and Sudan savanna zones of Ghana have the potential of leading in maize production in Ghana. Unfortunately these areas are challenged by plant growth stresses such as low nitrogen deficiency, drought and striga infestation. Of these stresses, drought and striga infestation have an overwhelming importance to maize production in these ecological zones, affecting people's livelihoods, food security and economic development.
A good strategy to counteract drought stress is the use of elite germplasm that has high yield potential with considerable tolerance to drought. The development, deployment and cultivation of drought tolerant maize varieties are a relevant intervention to reduce vulnerability, food insecurity and the damage to our local markets accompanying food aid. The Multi-location testing of drought tolerant and striga resistant/tolerant varieties and hybrids in regional trials through the Drought Tolerant Maize for Africa (DTMA) Project seeks to identify such elite germplasm with high yield potential and tolerance to these stresses. Evaluating varieties across several locations for a few years makes it possible to identify and release such tolerant genotypes to famers within a short period of time.

Objectives

- To provide the National Maize Programme a wide range of germplasm from which to identify and select superior stable yielding drought tolerant maize genotypes:
    - **i.** For developing experimental varieties, hybrids and synthetics.
    - **ii.** For population Improvement by introgressing drought and or striga tolerance into locally adapted germplasm.
- Release superior drought tolerant varieties to farmers within a very short time for cultivation in the guinea and the sudan savanna zones of Ghana

Materials and Methods

They genetic materials used in this project were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. The materials comprised of hybrids (single crosses, three way crosses and top crosses) and Open Pollinated Varieties (OPVs) of maize, developed for grain yield and tolerance to drought or a combination of drought and striga stress factors. They can be classified into three main maturity groups: extra-early, early and intermediate/late maturing. For this reason, they were planted at different geographical locations in Ghana (Lat.4^0 44´- 11^0 11´ N, Long. 1^0 11´ E - 3^0 11´ W).

The experimental design was Randomized Complete Block Design and lattice design with three replications across locations. 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. Trails were established in the main cropping seasons of these zones. The experimental fields were ploughed, harrowed and ridged before planting. Each plot consisted of two rows of each entry. The rows were 5.0 m long and were spaced 0.75 m apart. Three seeds were sown per hill at an intra-row spacing of 50 cm or 40 cm and the seedlings thinned to two plants per hill at 3 weeks after planting (WAP) to obtain the target population of 53,333 plants ha^{-1}.

Weeds on the trial fields were controlled both chemically (by the use of Pre and post-emergence herbicides) and manually by the use of the hoe. NPK 20-20-5 fertilizer was applied at the rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer at two weeks after planting and top-dressed with additional N at 30 kg N ha^{-1} at four weeks after planting.

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

Results and Discussions

Extra-Early White DT Hybrids

The grain yields of genotypes EEWH-9, EEWH-16, EEWH-19 and EEWH-20 were location specific whilst the grain yields of genotypes EEWH-13, EEWH-11, EEWH-8, EEWH-18, EEWH-16 and EEWH-21 were stable across locations. Base on the mean grain yields across locations, genotypes EEWH-13, EEWH-19, EEWH-11, EEWH-8, EEWH-18, EEWH-16 and EEWH-21 have been identified as drought tolerant genotypes and selected for further testing.

Extra-Early Yellow DT Hybrid Trial:

There was no significant genotype by location interaction effects; hence tolerance of genotypes to drought in Manga and the stability of grain yields of genotypes across locations were used to select the genotypes with superior performance for further testing. Genotypes selected were EEYH-8, EEYH-11, EEYH-16, EEYH-17, EEYH-21, EEYH-23, EEYH-26 and EEYH-15.

Early white DT hybrid trial

Out of 31 DT hybrids included in the trial, 29 produced 50% to 138% more grain yields compared to TZE COMP3 DT C1 F2 (RE). The performance of genotypes EWH-17, EWH-30, EWH-14, EYH-11, EWH-7, SC529, SC535 and SC403 were stable across locations. They all out-yielded the check across locations and in the individual locations. They have been selected for further test.

Early yellow DT hybrid trial

There were no significant genotype by location effects, hence genotypes were ranked based on their general performance across the locations and the following genotypes, EYH-24, EYH-6, EYH-9, EYH-15, EYH-16 and EYH-28 identified as the best performers. Their grain yields were above 4 t/ha across locations.

Early DT variety trial

Varieties TZE-W DT STR C4, TZE-Y DT STR C4, 2009 DTE-W STR Syn, 2009 DTE-Y STR Syn, DTE-W STR Syn C1, DTE-Y STR Syn C1, DT-W STR Synthetic, 2009 TZE-W DT STR and TZE Comp 3 DT C2F2 performed very well across locations producing over 4 t/ha grain yields across locations and above 5 t/ha grain yields at Damongo, Nyankpala and Wa. TZE-W DT STR C4 and TZE-Y DT STR C4 have been proposed for release to farmers.

Hybrid Maize Yellow

The top best performing 5 genotypes in terms of grain yield across locations were A0905-28, LY0614-8, Oba Super-II, A0905-35 and LY0906-8. They have been selected for further observation.

Hybrid Maize White

Genotype (L0904-27) produced significantly higher grain yield than the local check, Mamaba, across locations. The mean grain yield of this genotype over Mamaba was 44%. It has been selected for further evaluation.

Top-cross DT and DTSTR Hybrids Trial

Genotypes M1026-10, M0926-7, M0926-8, M1026-3, M1126-5 and M1126-6 were identified to be very promising and have been selected for further study.

Challenges and Recommendations

The Maize Program of CSIR – SARI is poise to shift from its current technology adapting status to generation of crosses and development of hybrids for increased maize productivity. Unfortunately funds allocated to the DTMA Project are always too meagre to support any meaningful breeding work. There is therefore the need for financial support outside the DTMA Project for the Maize Program to successfully carry out its planned breeding activities.

The other challenge is the uncoordinated planting of maize on the research fields. This makes it difficult for the Maize Section to secure an isolated land either by space or time for the production of breeder seed. The Maize Section is therefore appealing to scientists who intend using maize in their research work on the research fields to consult with the section for a coordinated use of the lands. This will make it possible for the maize section to secure an isolated land either by space or time for the production of breeder seed.

The way forward

Multi-location trials
The phase III of the DTMA Project will commence in April 2012 for another four years. Multi- location trials will be conducted across selected locations in the Guinea and Sudan savanna zones in Regional trials to evaluate the performance of genotypes of the different maturity groups for tolerance to drought stress.

Hybrid maize development

Fifty inbred lines each of extra-early, early and intermediate/late maturing groups to be received from IITA and the Ghana maize programme would be planted at Nyankpala during the cropping season. About ten promising lines from each maturity group would be selected from the 50 lines to generate single-cross hybrids. Crosses from each of the 3 maturity groups plus 4 checks would be evaluated separately in a lattice design. About 8-10 promising lines with good general combining ability from the evaluation will be selected and used to form a synthetic variety. Superior single cross hybrids would be crossed to superior drought tolerant inbred lines to form three-way cross hybrids. In addition, top-cross hybrids would be developed by crossing drought tolerant lines to superior IITA and Ghana drought tolerant populations.

Establishment of demonstration fields:
Demonstration fields of five superior drought and striga tolerant/resistant varieties (DT SR-W CO F2, DT SYN -1-W, IWD STR C1, TZE-W DT STR C4 and TZE-Y DT STR C4) identified in the 2nd phase of the project would be established at Nyankpala for inspection by the Variety Release Committee. Field inspections would be at the seedling, vegetative and reproductive stages.

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

Haruna Alidu, M.S. Abdulai and Gloria Adu Boakyewaa

Executive Summary

Two types of *Striga* Trials involving late/intermediate maturing *Striga* tolerant/resistant OPVs and single-cross and three-way cross STR hybrids were evaluated in Nyankpala in 2011. Genotypes M1109-14, M1109-8, M1109-1, M1109-3 and M1109-6 were identified as high yielding and tolerant to Striga *hermonthica* from the late/intermediate maturing *Striga* tolerant/resistant OPVs trial whilst 0804-3STR, 1001-3STR, 0501-1STR, 0902-18STR and 0601-6STR were identified as high yielding and tolerant to Striga *hermonthica* from the single-cross and three-way cross STR hybrids trial.

Introduction

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

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

Several control measures such as hand pulling, crop rotation, trap and catch cropping, high rates of fertilizer application, fallow, seed treatment and host plant resistance/tolerance have been developed to combat the Striga menace. Of these, host plant resistance or tolerance is considered the most affordable and environmentally friendly for the resource-poor farmers of the Guinea and Sudan Savanna Zones of Ghana. This is the preferred method adopted by the maize program. To achieve this objective the performance of 18 intermediate/late and 18 single-cross and three-way cross STR hybrid, were evaluated under striga infested (inf) and non-infested (noninf**)** plots at Nyankpala in 2011 with the objectives of:

i. Identifying and selecting high yielding *Striga hermonthica* tolerant maize genotypes for population Improvement
ii. Releasing superior *Striga hermonthica* tolerant maize varieties to farmers within a very short time for cultivation in the Guinea and the Sudan savanna zones of Ghana

Materials And Methods

The genetic materials used in this project were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. Two types of *Striga* trials involving late/intermediate maturing *Striga* resistant open pollinated maize varieties and single-cross and three-way cross STR hybrids were evaluated in Nyankpala in 2011. The experimental fields were ploughed, harrowed and ridged before planting. Each plot consisted of two rows of each entry. The rows were 5.0 m long and were spaced 0.75 m apart. Three seeds were sown per hill at an intra-row spacing of 40 cm and the seedlings thinned to two plants per hill at 3 weeks after planting (WAP) to obtain the target population of 53,333 plants ha^{-1}. The experimental design was Randomized Complete Block Design with three replications. Each plot consisted of two rows each 5.0-m long. The row-to-row spacing was 75 cm.

For the artificial infestation, the *Striga* infestation method developed by IITA maize program that ensures uniform *Striga* infestation with no escapes (Kim 1991; Kim and Winslow 1991) was used. The infested plots were artificially infested with *Striga hermonthica* seeds collected from maize and sorghum fields at the end of the previous cropping season. Infestation was carried out by digging small holes at 40-cm intervals along a ridge and infesting with a sand mixture containing 5000 germinable *Striga* seeds.
In general, a maximum of 60-kg N/ha^{-1} was applied as NPK in a split application at planting and at about three weeks after planting. Fertilizer rates for trials conducted under artificial *Striga* infestation was adjusted based on observed *Striga* symptoms during the early growth stages. Apart

from striga seed infestation, all other management practices for both striga infested and non- infested plots were the same.

Data was collected from the two rows of each plot on plant stand (PLST), plant height (PHT), days to 50% pollen shed (DTA) and silking (DTA), grain yield (GYLD), root lodging(RL) , stalk lodging(SL), husk cover (HUSK), plants harvested (PHARV), ears harvested (EHARV) and moisture (Moist) at the time of harvesting, *Striga* damage rating at 8 and 10 WAP and *Striga* emergence count at 8 and 10 WAP. The data was analyzed using PC-SAS.

Results and Discussions

Scientific Findings

Late/Intermediate Maturing Striga Tolerant/Resistant OPV Trial

Under *Striga* infestation, M1109-14, M1109-8, M1109-1, M1109-3 and M1109-6 were the top five yielding genotypes in terms of grain yield, and *Striga* damage. Interestingly, these top ranking varieties except for M1109-3 were also among the highest yielding genotypes under non-infested conditions. They have been selected for further testing.

Single-cross and Three-way cross STR Hybrid Trial

The most promising hybrids under *Striga* infested conditions were 0804-3STR, 1001-3STR, 0501-1STR, 0902-18STR and 0601-6STR. Yield averages of these hybrids ranged from 2.7 t/ha for 0601-6STR to 3.9 t/ha for 0804-3STR and were 150% to 290% over the local check (Mamaba). Except for hybrid 0501-1STR, all the other hybrids produced over 5 t/ha under the non-infested condition.

Challenges

Lack of ethylene gas which is normally injected into the soil to stimulate suicidal germination of existing *Striga* seeds in the field before artificial infestation. This does not allow for the *Striga* infested blocks to be placed back-to-back in strips with the non-infested blocks across the field. This arrangement reduces the movement of *Striga* seeds into the non-infested plots and also provides an opportunity to make comparative observations of the *Striga* infested and non-infested plots at the same time.

The way forward

The trials will be repeated next year to validate the performance of the selected genotypes for recommendation for on-farm trials.

SORGHUM IMPROVEMENT

Promoting Sorghum and Millet Production.

IDK Atokple, SS Buah, RAL Kanton, AN Wiredu, SA Karikari

Executive Summary

The incidence of climate change has resulted in recurrent droughts and floods with dire consequences on lives and livelihoods. In fact, huge production losses have already been reported in sub-Saharan Africa (SSA). In addition, as a result the declining soil fertility and diseases and pest conditions, farmers have become more vulnerable. Vulnerability is much higher among rural farm households who have meager resources.

In Ghana, millet and sorghum have been identified to be very important cereal crops in the bid to adapt to the changing climate and the fight against food insecurity and poverty. The two crops are major ingredients for the preparation of traditional food such as porridge and tuo with over 60 percent of these cereals consumed after harvest. The production of millet and sorghum therefore form integral parts of the livelihood activities of most of the farm households in the three regions. In 2010, the crops together occupied a total of 424,415.00 ha of land accounting for about 57 percent of total cereal production in the three northern regions. Similarly, about 61 percent of the volume of cereal produced in the three northern regions consists millet and sorghum.

Despite the importance of millet and sorghum in the cereal economy of Ghana, the crops are gradually being replaced by maize and rice. By implication, these crops are gradually being relegated. Most interventions have heavily focused on rice and maize with little or no emphasis on millet and sorghum. However, the importance of the two crops cannot be easily overlooked as they still remain important ingredient for the preparation of local dishes and local beer. Sorghum in particular, is a key ingredient for the brewery industry in Ghana.

In this regard, some efforts in the past have focused on the development of improved varieties of these crops. The most recent of these interventions sought to promote millet and sorghum production in Ghana and some selected countries in the West African Sub-region. The goal of the project was therefore to promote millet and sorghum production in Ghana in response to critical food shortages resulting from severe climatic changes. In this regard, the capacities of resource-poor farm households, especially women in northern Ghana, would be built. The project specifically sought to

introduce improved practices in millet and sorghum production through the establishment of farmer field schools and field demonstrations. The project also built the capacities of farmers, extension agents and researchers through training in integrated millet and sorghum production and farmer field school approach. Capacity building also featured the renovation of seed facilities, basic seed production among others.

Six key outputs of the project included capacity building, technology options, communication, monitoring and evaluation, and coordination.

The project covered 18 communities in 9 districts of the three regions. A total of 117 (9 females and 108 males) including researchers extension workers, seed producers and input dealers were directly trained under the project. In all the regions, the project conducted participatory evaluation of 2 new improved varieties of sorghum and two improved varieties of millet alongside local checks at different locations per region. Each site was managed by a group of 20-40 farmers under the supervision of an agricultural extension agent. At each site, the popular variety within the locality was used as a check. Within the communities where the variety testing and demonstrations were established, farmer field schools were also established. This provided the opportunity to train farmers throughout the season. In all, 390 farmers (214 males and 176 females) from the 18 communities participated in the farmer fields schools in the three regions. At the same time the general populace (communities) had the opportunity to observe the outcomes of the demonstration. The results showed that the approach significantly reduced the effect of striga infection on both millet and sorghum. Yields on the recommendation plots were significantly higher than those from the farmer practice. In fact, farmers within all the project communities pointed out that the demonstrations attracted a lot of passers-by.

The activities of PROMISO 2 in Ghana were largely gender balanced owing to the gender sensitivity of the in-country project team. The team also adopted an affirmative action such that about 50 percent of the project beneficiaries were females. All project beneficiaries were excited about the demonstrations and trainings they obtained. Most of them remarked that the activities of the project gave them the opportunity to learn simple but new techniques. For the farmers, it was easy for them to decide which of the practices were good for their situation. Some farmers have already made contacts and have been assisted to identify sources of seeds of the new varieties. According to one farmer if they had known of at least one of the approaches earlier, namely, use of quality seed, optimal plant population, fertilizer application and intercropping with legumes, poverty and food insecurity would have been out of their community. Further knowledge about the fact that existing brewery industries in the country were potential buyers of their grains was good news and provided adequate motivation for them to adopt the new practices.

At the level of the project staff, the training and the materials (handouts) provided additional means for them to undertake their work more effectively. Capacity building also in terms of the equipment and machines they received will also go a long way to improve their overall work output. Another success story was the ability of the project to replicate the same activities at different locations with the ingenuity of the in-country coordination team.

Though the farmers requested for the continuation of these activities for greater impact, the PROMISO 2 project had come to an end. As we appeal to the donors for extension, we will endeavour to tailor the on-going projects on sorghum and millet to take advantages of the gains of PROMISO 2 for up-scaling.

Introduction

The incidence of climate change has resulted in recurrent droughts and floods with dire consequences on lives and livelihoods. In fact, huge production losses have already been reported in sub-Saharan Africa (SSA) (Hodson *et al*. 2002). In addition, declining soil fertility, diseases, and pest conditions, have made farmers more vulnerable. Vulnerability is much higher among rural farm households who have meager resources.

In Ghana, millet and sorghum have been identified to be very important cereal crops in the bid to adapt to the changing climate and the fight against food insecurity and poverty. The two crops are major ingredients for the preparation of traditional food such as porridge and tuo. In fact over 60 percent of these cereals are consumed after harvest (Wiredu *et al*., 2010). Data from the Ministry of Food and Agriculture reveal that the three northern regions dominate in the production of millet and sorghum in the country. In fact millet production is restricted to only the three northern regions. Some amount of sorghum is produced in the Brong-Ahafo Region and the Volta Region (SRID/MoFA, 2011).

The production of millet and sorghum therefore form important parts of the livelihood activities of most of the farm households in the three regions. In 2010, the crops together occupied a total of 424,415.00 hectares of land accounting for about 57 percent of total cereal production in the three northern regions. Similarly, about 61 percent of the volume of cereal produced in the three northern regions was from millet and sorghum. Yields obtained in 2010 were 1.24 mt/ha and 1.28 mt/ha for millet and sorghum respectively (Table 1).

Table 1: Status of national millet and sorghum production in 2010

	Millet	Sorghum
Area (ha)	176,600 (23.74)	252,555 (33.31)
Production (mt)	218,951.70 (24.73)	324,422.25 (36.35)
Yield (mt/ha)	1.24	1.28

Source: Computations from SRID/MoFA agricultural production data, 2011
Figures in parenthesis are relative shares in total cereal area/production.

Between 2001 and 2010, the yields of millet and sorghum have almost doubled. Although the first half of the decade showed stagnation in growth, there was a sharp rise after a sudden decline in 2007. The occurrence of drought followed almost immediately by floods in 2007 contributed to the sudden drop in yield. However, due to government intervention through the fertilizer subsidy program, yield quickly began to rise at a very rapid rate (Figure 1).

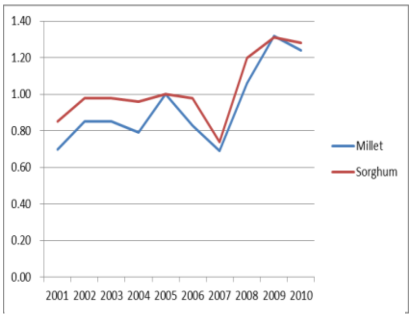

Fig. 1: Trend in millet and sorghum yields 2001-2010

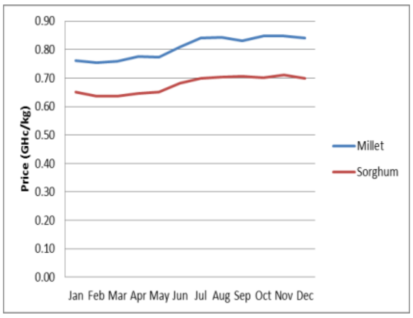

Fig. 2: Price trend of millet and sorghum in 2009

The prices of millet are generally higher than sorghum (Figure 2). On the average, a kilogram of millet sells at Gh¢0.81 while sorghum is sold at Gh¢0.68 per kilogram. Throughout the year, the prices of the two crops on the domestic market follow the same cyclical patterns with minimal variations. The price of millet for instance rises from about Gh¢0.75 per kilogram at the beginning of the year to about Gh¢0.85 per kilogram at the end of the year. Similarly, the price of sorghum also rises from about Gh¢0.64 per kilogram at the beginning of the year to about Gh¢0.71 per kilogram at the end of the year. The pricing pattern also coincides with the lean and peak seasons of production. After harvest, in November-December, the prices quickly assume a downward trend in January and March. After which the prices begin to rise till the peak of the lean season in July and August (Figure 2).

Despite the importance of millet and sorghum in the cereal economy of Ghana, the crops are gradually being replaced by maize and rice. For the periods between 2001 and 2010, the shares of the area under millet and sorghum have declined steadily, while those of maize and rice keep rising. The same trend is also observed with the share of the two crops in the total volume of cereals production in the country. By implication, these crops are gradually being relegated. Most interventions have heavily focused on rice and maize with little or no emphasis on millet and sorghum.

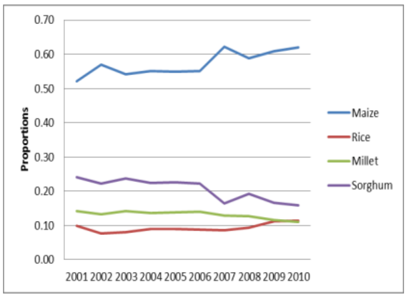

Fig. 3: Trends in the shares of millet and sorghum in cereal area, 2001-2010

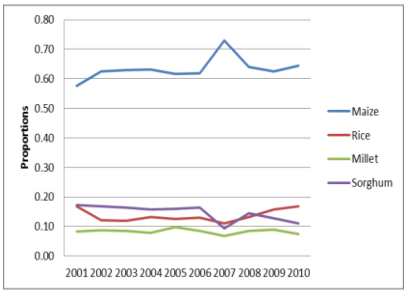

Fig 4: Trends in the shares of millet and sorghum in cereal production, 2001-2010

However, the importance of the two crops cannot be easily overlooked as they still remain important ingredient for the preparation of local dishes and local beer. Sorghum in particular, is a key ingredient for the brewery industry in Ghana. In this regard, some efforts in the past have focused on the development of improved varieties of these crops. The most recent of these interventions seeks to promote millet and sorghum (PROMISO 2) production in the Ghana and some selected countries in the West Africa Sub-region. The project is expected to make meaningful contribution to the global and continental efforts to adapt vulnerable livelihoods and also to consolidate gains made in the past.

Objectives

Global objective

The goal of the intervention is to promote millet and sorghum (PROMISO) in Ghana. The project seeks to increase the production of sorghum and pearl millet in response to critical food shortages resulting from severe climatic changes. In this regard, the capacities of resource-poor farm households, especially women in Ghana will be built.

Specific objectives

The project specifically sought to promote improved practices in millet and sorghum production through the establishment of farmer field schools and field demonstrations. The project also built the capacities of farmers, extension agents and researchers through training in integrated millet and sorghum production and farmer field school approach. Capacity building also featured the renovation of seed facilities, basic seed production among others.

Outputs/Results

PROMISO 2 had 6 key outputs that were to serve as measures of success. These included capacity building, technology options, communication, monitoring and evaluation, and coordination.

R1: Capacity building

Beneficiaries of the project in Ghana have participated in 6 training activities, both local and international. Four persons each from the country participated in training in integrated agricultural research for development (IAR4D) and monitoring and evaluation (M&E) at Bamako, Mali. Locally, there were trainings in community based farmer-field school approach, integrated millet and sorghum production, production of video documentaries and hybrid sorghum production (Table 2). In all a total of 117 persons were directly trained under the project including 9 females and 108 males.

R2:Technological options on Regional Basis (4 cases)

In the Upper West and Upper East regions, the project conducted participatory evaluation of 2 new improved varieties of sorghum and two improved varieties of millet alongside local checks at 6 different locations per region. Each site was managed by a group of 20-40 farmers under the supervision of an agricultural extension agent. At each site, the popular variety within the locality was used as a check (Tables 3a, 3b).

Table 2: Details of training activities conducted under the project

Dates (2011)	Themes of trainings	Number (#) Participants Men	Women	Duration of the training (days)	Name of trainer
March 21st to 23rd	Training in IAR4D	4	0	3	Dr. Sidi Sanyang (CORAF)
March 24th to 25th	Training in M&E	4	0	2	Dr. JV Maama (CORAF)
April 27th to 29th	Training in community-based farmer-field school approach	3	37	3	Dr. Tom van Mourik (ICRISAT)
June 29th to 30th	Training in sorghum and millet production	3	38	2	Dr. IDK Atokple, Dr. SS Buah, Dr. RAL Katon, Miss AS Karikari and AN Wiredu
April 11th to 22nd	Training of media persons to air programs on millet and sorghum production	2	6	12	Paul van Mele, Marcella Vrolijks and Josephine Rodgers
Sept 28th to 29th	Hybrid Sorghum Production Training Workshop	1	19	2	Dr. IDK Atokple, Dr. Marshak Abdulai, (SARI) Mr. Christopher Akai (MoFA)

Table 3a : Variety testing in Upper West Region

Period of planting	Title of the test	Number (#) Varieties	Total area (ha)	Number of producers involved Men	Women
July – October 2011	Influence of variety and management level on sorghum production in the Sissala East District in the Upper West	3 (Kapaala, Dorado and Farmer's variety	0.4	20	15

	Region of Ghana				
July – October 2011	Influence of variety and management level on sorghum production in the Wa East District in the Upper West Region of Ghana	3	0.4	15	10
July – October 2011	Influence of variety and management level on sorghum production in the Lawra District in the Upper West Region of Ghana	3	0.4	30	15
July – October 2011	Influence of variety and management level on pearl millet production in the Lawra District in the Upper West Region of Ghana	3	0.4	25	10
July – October 2011	Influence of variety and management level on pearl millet production in the Wa Municipality in the Upper West Region of Ghana	3	0.4	15	5

Table 3b: Variety testing in Upper West Region

Period of planting in 2011	Title of the test	Number (#) varieties	Total area (ha)	Number of producers involved	
				Men	Women
28 June to 2o Sept	1.1 On-farm testing of improved Pearl millet varieties at Sugudi in the Bawku Municipal.	4	0.165	5	8
P2 29/06/ to 25/09/	1.2 On-farm testing of improved Pearl millet varieties at Sugudi in the Bawku Municipal.	4	0..109	7	6
P3	1.3 On-farm testing of improved Pearl millet varieties at Gambibgo in the Bolga Municipal.	4	0.4	15	15
P4	1.4 On-farm testing of improved Pearl millet varieties at Yikene in the Bolga Municipal.	4	0.4	8	24
P5	1.5 On-farm testing of improved Pearl millet varieties at Abinpundi in the Kassena-Nankana East District.	4	0.4	11	14
P6	1.6 On-farm testing of improved Pearl millet varieties at Punyoro in the Kassena-Nankana East District.	4	0.4	25	10

In addition to the variety testing there were also 2 demonstration sites per region. These sites showcased the integrated management of S*triga hermonthica* in sorghum and millet. At each site the demonstrations were also managed by a group of 20-40 farmers under the supervision of an agricultural extension agent (Tables 4a, 4b).

Table 4a: Demonstration Tests in Upper West Region

Period of installation	**Title of the demonstration test**	**Number (#) Technologies**	**Area (ha)**	**Number of farmers Men**	**Women**
July – Oct 2011	Integrated management of *striga hermonthica* in sorghum in the Wa East District in the Upper West Region	6 (3 varieties x 2 management levels - farmer's usual practice vrs Integrated Striga management	0.4	25	10
July – Oct 2011	Integrated management of *Striga hermonthica* in sorghum in the Lawra District in the Upper West Region	6	0.4	20	15

Table 4b. Demonstration Tests in Upper East Region

Period of installation	**Title of the demonstration test**	**Number (#) Technologies**	**Area (ha)**	**Number of farmers Men**	**Women**
P1	1.1 Intergrated *Striga hermonthica* management in sorghum at Sugudi in Bawku	4	0.40	7	6
P2	1.2 Intergrated *Striga hermonthica* management in sorghum at Tempelim in Bawku.	4	0.40	9	8
P3	1.3 Intergrated *Striga hermonthica* management in sorghum at Gambibgo in Bolga.	4	0.40	6	24

P4	1.4 Intergrated *Striga hermonthica* management in sorghum at Yikene in Bolga.	4	0.40	4	26
P5	1.5 Intergrated *Striga hermonthica* management in sorghum Abinpundi in the Kassena-Nankana East.	4	0.40	10	14
P6	1.6 Intergrated *Striga hermonthica* management in sorghum at Punyoro in Kassena-Nankana East.	4	0.40	30	10

Seed production

The same type of table can be used for breeder, foundation and certified seeds

Table 5a: Breeder and Foundation Seeds of Sorghum Produced

Name of variety or lines	Area under cultivation (ha)	Seed produced by variety (kg)	Number (#) of producers Men	Women	Total area (acre)	Total seed produced (kg)
Kapaala	2 acres	130 (450)*			2	580
Dorado	2 acres	120 (330)			2	450
Kadaga	1 acre	50 (100)			1	150
Tongo Yellow (Millet)	0.5 acre	45			0.5	45
Bongo Short Head	0.5 acre	60			0.5	60

*Figures in parentheses represent foundation seeds

Table 5b. Foundation seeds of Pearl millet (early) produced in Upper East Region

Name of the variety or lines	**Area under cultivation (ha)**	**Seed produced by variety**	**Number (#) of producers Men**	**Women**	**Total area (ha)**	**Total seed produced (kg)**
V1 Arrow	S1	121	N/A	N/A	1	121
V2 Bristle millet	S2	137	N/A	N/A	0.5	137
V3 Bongo Short Head	S3	156	N/A	N/A	1	156
V4 Tongo Yellow	S4	106	N/A	N/A	1	106
V5 Soxsat	S5	47	N/A	N/A	0.5	47

Table 5c. Foundation seeds of Pearl millet (late) produced in Upper East Region

Name of the variety or lines	Area under cultivation (ha)	Seed produced by variety	Number (#) of producers		Total area (ha)	Total seed produced (kg)
			Men	Women		
V1 Salma 1	S1	50.9	N/A	N/A	0.25	50.9
V2 Salma 3	S2	154.6	N/A	N/A	1	154.6
V3 Langbensi	S3	66	N/A	N/A	0.25	66

Within the communities where the variety testing and demonstrations were established, farmer field schools were also established. This provided the opportunity to train farmers throughout the growth period of the sorghum and pearl millet. In all, 390 farmers (214 males and 176 females) from 18 communities participated in the farmer fields schools in the three regions Table 6.

Table 6a: Farmers' fields schools

Period	Title of the farmer's fields schools	Number (#) Technologies	Number of villages	Number of producers Men	Women
July – October 2011	Influence of variety and management level on sorghum production in the Wa East District in the Upper West Region of Ghana	6 (3 varieties x 2 management levels)	6	105	55
July – October 2011	Integrated management of *Striga hermonthica* in sorghum in the Lawra District in the Upper West Region	6	4	109	121

R3 : Communication

Table 6b: Example 2 (to be adjusted according to country's realities)

Means of communication	**Title of the communication activities**	**Number of copies**	**Language**	**Target population**
Manuals				
1	Grain Sorghum Production Guide	Yet to be printed	English	Researchers, lecturers, technicians and extension agents
2	Pearl millet Production Guide	Yet to be printed	English	Researchers, lecturers, technicians and extension agents
Technical leaflets				
1	Effect of agro-chemical poisoning	Yet to be printed	English	Researchers, lecturers, technicians, extension agents and farmers

2	Production guide for sorghum (Sorghum bicolor (L.) Monech) varieties Kapaala and Dorado	Yet to be printed	English	Researchers, lecturers, technicians, extension agents and farmers
3	Farm Records	Yet to be printed	English	Researchers, lecturers, technicians and extension agents
4	Farm planning and budgeting	Yet to be printed	English	Researchers, lecturers, technicians and extension agents
Production Modules	Sorghum and Millet Production Modules	Five pieces in one	English	Farmers, Traditional rulers, Extension workers, Policy makers and NGOs
Documentary films		1	English	Researchers Extension workers, Policy makers and NGOs
Field days September 2011	Field day of integrated management of striga at Bulenga (Wa East District) and Naapaal (Lawra District) in Upper West Region Influence of variety and management level on sorghum production at Loggu (the Wa East District) in the Upper West Region of Ghana			Farmers, extension agents, technicians, civil servants and researchers, Policy makers and NGOs

R4: Monitoring and Evaluation

Field activities began in June and ended in November (6 months) during which monitoring was conducted at the district and regional levels. Two monitoring exercises were conducted per month for each of the 18 communities by the agricultural extension agents and their supervisors at the district level. By computation there were 216 monitoring visits to the demonstrations and trials across the 9 districts of the 3 regions. At the regional levels, there was 1 monitoring visit in every month for each of the 18 communities.

R5: Coordination

There were quarterly planning meetings among the project implementation team. In some cases emergency meetings were also arranged. An implementation team was also constituted to support the country coordinator and also to ensure effective management of the project at all the locations. These included 3 in-country regional coordinators for Northern, Upper West and Upper East regions, 1 M&E officer, 27 agricultural extension agents (including supervisors) 3 technicians and 2 media experts.

Table 7: Recruitment of Human Resources(all in April 20110

Speciality	Duration of the contract	Responsibilities
1. In country regional coordinatiors	April 2011-Dec 2011	Oversee activities at the regional level
Regional Planning committees established	April 2011-Dec 2011	Oversee activities at the regional level
2. M&E officer	April 2011-Dec 2011	Manage M&E system
3. Agricultural extension agents	April 2011-Dec 2011	Oversee activities at district level
4. Technicians	April 2011-Dec 2011	Support regional coordinators
5. Media experts	April 2011-Dec 2011	Produce documentary and assist with the visibility of the project

The project also procured some machinery and equipment to enhance the processes. These included a vehicle, motorcycles, lap top computers, video projector and screen as well as cameras. The items were intended to build the capacities of project partners in the medium term. An old storage structure in the premise of SARI was renovated. Some storage containers were also procured and distributed to the project sub-partners (Table 8 and Table 9).

Table 8: Machinery and equipment

Types	Number	Location	Responsible
Vehicle	1	Tamale, Ghana	National Coordinator, SARI
Motors cycles	13	All project districts	Technicians and AEAs
Plastic Storage containers	Big (30) small (40)	All three Regions	National and Regional Coordinators, SARI
Lap top computers	5	Tamale	National and Regional Coordinators, SARI
Printers	4	All three Regions	National and Regional Coordinators
Video projector/screen	1	Tamale	Coordinators
Cameras	13	All project districts	Technicians and AEAs
Wellington boots	40 pairs	All project districts	Scientists, technicians and AEAs.
Measuring tapes (100m)	14	All project districts	Scientists, technicians and AEAs.
Planting lines	14	All project districts	Scientists, technicians and AEAs.
Weighing Scales	14	All project districts	Scientists, technicians and AEAs.

Table 9: Rehabilitation of infrastructures

Types	Number	Location	Responsible
Warehouse	1	SARI, Nyankpala	National Coordinator
Storage room	1	Nyankpala	National Coordinator
Motorized threshing machine	1	Nyankpala	National Coordinator

R6: Visibility of support from the EU and IFAD

Banners used for the inception workshops

1. Labelling of all project equipment and facilities
2. Sign post for demonstrations and trials
3. Media coverage during inception workshop
4. Media coverage during field days
5. Background of presentations slides

4. Activities

The project is about 83.3 percent complete in that 10 out of the 12 line activities that were proposed have been fully completed. A proposed seminar for the variety release could not be organized due to the delay in rains and the establishment of the trials. Secondly, the proposed translation of the fact sheets could not be achieved. Given the time for the preparation of the fact sheets it was practically impossible to translate the fact sheets.

Table 10: Achievement sheet

No	Planed activities	Indicators/milestones	Observations
1	Organize project inception workshop	Number of participants	Completed
2	Organize planning workshops	Number of participants	Completed
3	Organize farmer field days	At least 1 field day in each region	Completed
4	Organize seminars for variety release	At least two seminars organized	Not organised
5	Produce training manuals on millet and sorghum production for technicians, AEAs and NGOs	At least two types of training manuals produce and 50 copies of each distributed	Completed
6	Produce fact sheets on sorghum and millet production for farmers	At least 5 fact sheets produce and over 100 copies of each distributed	Completed
7	Translate fact sheets into 7 local languages and distribute copies to farmers	At least 1 fact sheets translated into 7 languages and over 100 copies of each distributed	Not complete

8	Train technicians, AEAs and NGO reps in millet ans sorghum production	1 training program on millet and sorghum production with over 30 participants	Completed
9	Train technicians, AEAs and NGO reps in the establishment of farmer field schools	1 training program on millet and sorghum production with over 30 participants	Completed
10	Train farmers in millet and sorghum production	over 200 farmers trained in millet and sorghum production	Completed
11	Train selected radio presenters and resource them to air programs on millet and sorghum production	At least 1 radio presenter trained and resourced	Completed
12	1 farmer field school established in each of the 3 regions	At least 18 farmer field schools established	Completed

Best Practices

The strategy adopted by the country team ensures effective coverage of project activities. Through the farmer field school approach field demonstrations and varietal evaluations were conducted. By this approach, a core group of farmers who were members of the FFS group were given detailed training in integrated millet/sorghum production. At the same time the general populace (communities) had the opportunity to observe the outcomes of the demonstration. In fact, farmers within all the project communities pointed out that the demonstrations attracted a lot of passers-by.

The outcome of the integrated striga management demonstrations was very good for future studies with short life span as PROMISO 2. Instead of the rotational system where a cereal crop replaces a legume crop, in this project, the two were intercropped. The results showed that the approach drastically reduced the effect striga infection on both millet and sorghum. Yields on the recommendation plot were significantly higher than those from the farmer practice.

Aspects of gender and environmental protection

The activities of PROMISO 2 in Ghana were largely gender balanced owing to the gender sensitivity of the in-country project team. At least 1 of the key members on the team was a woman and a gender advocate. The team also adopted an affirmative action such that 50 percent of the project beneficiaries were females. Conscious efforts were made to invite female participants during the trainings and workshops.

The project activities were to a large extent consistent with laid down environmental rules and regulation in Ghana. First of all, the sites selected for the demonstrations and trials were all existing farm lands and therefore did not degrade virgin lands. All the agro-chemicals that were used were approved by the Environmental Protection Agency (EPA) of Ghana. Moreover, the farm operations were all environmentally friendly.

Conclusions/Recommendations

All project beneficiaries were excited about the demonstrations and trainings they obtained. Most of them remarked that the activities of the project gave them the opportunity to learn simple but new techniques. For the farmers, it was easy for them to decide which of the practices were good for their situation. They requested for a continuation of the activities to further impress upon them and others about the benefits of the new practices that were introduced. In fact some farmers have already made contacts and have been assisted to identify sources of seeds of the new varieties.

At the level of the project staff, the training and the materials (handouts) provided additional means for them to undertake their work more effectively. Capacity building also in terms of the equipment and machines they received will also go a long way to improve their overall work output.

Technically, strategy adopted for the demonstration, trials and farmer field schools allowed the project to cover a wide range of beneficiaries, directly and indirectly. While the direct beneficiaries had the opportunity for intensive training, the indirect beneficiaries obtained useful information during field days and field visits. The approach ensured effective coverage with minimal financial implication.

For the project team, one of the key success stories was the participation of women at all levels of the project. As a traditional area there is usually the tendencies of women being side lined but the project was able to break such cultural barrier. Another success story was the ability of the project to replicate the same activities at different locations with the ingenuity of the in-country coordination team.

According to one farmer if they had known of at least one of the approaches, namely, use of quality seed, optimal plant population, fertilizer application and intercropping with legumes, earlier, poverty and food insecurity would be out of their society. Further knowledge about the fact that existing brewery industries in the country were potential buyers of their grains was good news and provided adequate motivation for them to adopt the new practices.

ROOT AND TUBER CROPS IMPROVEMENT

Yam Diversity Survey in Northern Ghana

K. Acheremu, J. Adjebeng-Danquah, J. K. Badzakin, E. B. Chamba, A. Saibu and A.S. Alhassan

Executive Summary: A survey was carried out to assess yam diversity cultivated across the northern yam belt of Ghana. Structured questionnaire were designed to collect passport data on all cultivated varieties of the yam species in randomly selected representative communities in seven (7) districts across the region. The communities were **"Mandari"** in Bole District, **"Tuna"** in the Sawla/Kalba/Tuna District, **"Sori No.3"** in the West Gonja District, **"Tunaa-yili"** in the Tolon/Kumbungu District, **"Zabzugu"** in the Zabzugu/Tatale District, **"Salaga"** in the East Gonja District and **"Demong"** in the Saboba District. A total of 204 different yam varieties were listed from the 7 communities, out of which 145 varieties were *D. rotundata*, 53 were *D. alata*, 4 were *D. bulbifera* and 1 each of *D. cayenensis* and *dumetorum* species. Sample tubers are to be collected and characterised for documentation and conservation, and also group the varieties that appear across the other localities of yam farming communities in Northern Region.

Introduction:

Yam has an extensive genetic diversity which can be exploited for crop improvement. Extensive variability has been observed in morphological features such as tuber size, shape and colour, stem and leaf structures. Variability in some of the morphological features came about as a result of ecological adaptation and the selective pressure imposed on the crop by farmers. These factors have for long influenced the yield and quality of the crop as a food item.

Yam germplasm as any other crop germplasm is the only repository of genetic diversity that can be relied on in times of danger of being narrowed by the current wave of genetic erosion that is sweeping across our genetic resources. The genetic erosion as we know is caused by the diminishing farm lands and the pressure of advanced technology on our farming systems and practices. The task of collecting and characterizing yam germplasm has therefore become necessary if we want to maintain the extensive variability that has been accumulated in the yam species over centuries. It was against this background that a survey was carried out to assess yam diversity across the northern yam belt of Ghana. This exercise is aimed at increasing farmers' and breeders' access to conserved yam diversity in Ghana.

Materials and methods

Seven (7) yam farming communities were randomly selected and visited across the northern yam belt for the yam diversity survey to collect information on the various cultivars available around the catchment area. A questionnaire was designed to interview 30 farmers in each community. The communities visited include "Mandari" in Bole District; "Tuna" in the Sawla-Tuna-Kalba District, "Sori No.3" in the West Gonja District, "Tunaa-yili" in the Tolon/Kumbungu District, "Saboba" in the Saboba District, "Zabzugu" in the Zabzugu/Tatale District and "Salaga" in the East Gonja District. A structured questionnaire requiring information on the cultivation practices, yield and culinary characteristics, and farmers' preferences on the listed cultivars were administered in a focused group discussion for each community. The distribution and extent of yam cultivated in the various communities were summarised in quadrants as follows:

- Quadrant I or QI refers to Many households; large areas (++)
- Quadrant II or QII refers to Many households; small areas (+ -)
- Quadrant III or QIII refers to Few households; large areas (- +)
- Quadrant IV or QIV refers to Few households; small areas (--)

One (1) acre and above is classified as large area of land under our groupings, and many farm household is referred to more than 30% of households in the farm community.

Results and Discussion

Scientific findings

The number of tubers listed was 204 different yam varieties from the 7 communities, out of which 145 varieties were *D. rotundata*, 53 were *D. alata*, 4 were *D. bulbifera* and 1 each of *D. cayenensis* and *D. dumetorum* species. Yam species such as *D. cayenensis; D. bulbifera, and D. dumetorun* are not cultivated in "Mandare", "Sori No.3", "Zabzugu", and "Demong" communities. However, Sori No.3 community listed the highest number of yam varieties (51), out of which 24 were *D. rotundata* and 27 were *D. alata* species. Out of the total of 51 varieties (Table 11), 11 varieties are cultivated by many households on large scale (++), 16 varieties are cultivated by many households but on small land areas (+-). Six (6) varieties are cultivated by few households on large land areas (-+), while 18 varieties fall in the quadrant of few households and on small land areas (--). Sixteen (16) varieties of the 24 rotundata varieties are the early maturing and are harvested twice (double) in one planting season.

The community with the lowest number of yam varieties listed was Tuna (21), out of which 15 varieties were *D. rotundata*, 3 varieties of *D. alata* (Jugbe, Seidu-bile, Koruha-nonibi), 1 variety of *D. cayenensis* (Kangba), 1 variety of *D. dumetorum* (Sakah) and 1 variety of the *D. bulbifera* (Firima) species. From the 21 varieties of yam listed, 6 are cultivated by many households on large acreages of land (++), 13 varieties are cultivated by many farm households but on small areas of land (+-). Only 2 and 1 varieties each were listed as cultivated by few households on large areas (-+) and few households on small land areas (--), respectively. With the exception of the varieties of the *D. rotundata* specie, which are harvested two times in a planting season, the varieties of the *D. bulbifera*, *D. dumetorum*, *D. cayenensis* and *D. alata* species are late maturing and hence harvested once at the end of the planting season.

Table 11 Summary of the survey results of yam in Northern Ghana

Village	Total no. of var	No. of DHV var.	No. of SHV var.	No. of var. in QI	No. of var. in QII	No. of var. in QIII	No. of var. in QIV	NIV (Introd var.)	Rate of loss
Mandare	24	18	6	5	7	7	5	0	0
Tuna	21	8	13	6	12	2	1	0	0
Sori no.3	51	17	34	11	16	6	18	0	0
Tunaa-yili	24	14	10	6	13	3	2	0	0
Zabzugu	26	23	3	10	7	3	6	0	0
Salaga	34	21	13	14	11	3	6	0	0
Saboba	24	13	11	13	11	0	0	0	0
Total	*204*	*114*	*90*	*65*	*77*	*24*	*38*	*0*	*0*

Key words: *DHV=double harvest variety, SHV= single harvest variety, NIV= newly introduced variety, QI, QII, QIII, QIV=quadrants 1,2,3,4.*

Technology Developed

A technical list of yam cultivars is produced and will serve as a guide for the collection of all yam varieties available in the yam growing belt of the Northern Region.

Conclusion

A list of all cultivated yam varieties has been obtained from randomly selected communities across Northern Ghana representative of the yam growing areas. Most of the varieties cut across the yam farming communities. A follow up and collection of the germplasm and characterisation is necessary for proper documentation.

On-farm evaluation of improved yam (*Dioscorea rotundata*) genotypes from the International Institute of Tropical Agriculture (IITA) breeding programme

S. K. Asante, J. Adjebeng-Danquah, Kwabena Acheremu, A. N. Wiredu, S. Alhassan, A. S. Alhassan

Executive Summary

Trial was conducted at Lantinkpa, East Gonja district of northern region of Ghana during the 2011 cropping season to evaluate 10 yam genotypes obtained from the International Institute of Tropical Agriculture (IITA) breeding program for high yield, consumer acceptance, pests and diseases resistance/tolerant. The ten yam genotypes which were evaluated in 2010 at Mbowura, Kpandai district include; 95/019156; 95/18949;95/18922; 95/01942; 96/02025; 96/02610; 95/19158; 95/18544; 96/00594; 95/19177. Experimental design used was Random Complete Block design (RCBD) with 3 replicates per genotype. Mounding and planting of the trials were carried out on 20-22 May 2011. There were 60 mounds per each genotype. Each subplot consisted of 20 mounds planted at 1.2m x 1.2m. Four local checks (Puna, Laribako, Asana and Dente) were used. The vines were staked with wooden sticks about 1.5m high two months after planting. Weed control was done first by using herbicide (Glyphosate) four weeks after planting (i.e. before the seeds sprout and form leaves) and this was followed by hand weeding using hoe at 8, 12 and 16 weeks after planting. Data collected include; percentage germination/establishment, pests and diseases attack/damage, tuber yield and food quality assessment. Plant establishment was high ranging from 83 to 100%. The common diseases found attacking the yam leaves and tubers are Anthracnose, and tuber rot. Pests found attacking the yam include; millipedes, mealybugs, nematodes, yam leaf beetle and scale insect. Yield assessment indicated that the improved genotypes yield significantly ($P>0.05$) higher than the local checks. All the genotypes have been found to store longer than Puna and Laribako. The most promising (Top 5) genotypes in terms of yield are; 96/00594, 95/19158, 95/18544, 95/18949, 96/02610. However, farmers selected the following as their preferred genotypes; 95/18949, 95/01942, 95/19177, 96/02025 and 95/19156.

Methodology

The trial which was conducted at Mbowura in Kpandai district during the 2010 cropping season was repeated at Lantinkpa in East Gonja district of northern region in May 2011. The main objective of this project is to evaluate and select with farmers and consumers, yam genotypes from the IITA breeding programme that will adapt to the food and farming systems in Guinea Savanna Zone of Ghana (high yield, consumer acceptance, pests and diseases resistance/tolerant).

The ten yam genotypes evaluated include; 95/019156; 95/18949;95/18922; 95/01942; 96/02025; 96/02610; 95/19158; 95/18544; 96/00594; 95/19177. Experimental design used was Random Complete Block design (RCBD) with 3 replicates per genotype. Mounding and planting of the trial was carried out between 20-22 May 2011. There were 60 mounds per each genotype. Each subplot consisted of 20 mounds planted at 1.2m x 1.2m. Four local checks (Puna, Laribako, Asana and Dente) were used. The vines were staked with wooden sticks about 1.5m high two months after planting. Weed control was done first by using herbicide (Glyphosate) four weeks after planting (i.e. before the seeds sprout and form leaves) and this was followed by hand weeding using hoe at 8, 12 and 16 weeks after planting. Data collected include; percentage germination/establishment, pests and diseases attack/damage, tuber yield and food quality assessment.

Results

Plant establishment of most of the improved genotypes was high ranging from 83.3 to 100% (mean: 98.2%) whereas that of the local checks ranged from 88.3 to 96.7 % (Mean: 90.4). The common diseases found attacking the yam leaves and tubers were Anthracnose and tuber rot. Pests found attacking the yam include; millipedes, mealybugs, nematodes, yam leaf beetle and scale insect (Table 1). Yield assessment carried out indicated that the improved genotypes gave significantly ($P>0.05$) higher yields than the local checks (Table 2).

All the genotypes have been found to store longer than Puna and Laribako. However, when the food quality of the different genotypes was assessed based on the following characteristics; boiling, pounding (elasticity, expansion, lumps), taste, texture, farmer's preferences or selection for the genotypes were ; 95/18949, 95/01942, 95/19177, 96/02025 and 95/19156 (Table 14).

Table 12: Percentage of yam tubers/stands infested/infected by pests and diseases at Lantinkpa during the 2011 cropping season

Genotype	Scale insect	Mealy bug	Tuber beetle	Leaf beetle	Nematode	Millipede	Bacteria/ fungal diseases
95/19156	0	0.7	0	18.3	7.0	0	2.3
95/18949	0	0	0	6.7	4.0	1.0	0
95/18922	0	1.3	0	15.0	13.3	0	0
95/01942	3.3	0	0	6.7	5.3	2.3	0
96/02025	13.3	1.7	0	3.3	0	6.0	4.0
96/02610	22.0	0	1.3	10.0	3.0	1.7	0
95/19158	0	1.7	0	8.3	5.0	6.7	0
95/18544	0.7	0.7	0	15.0	5.3	1.0	0
Laribako	0	0	0	15.0	19.0	2.7	0
96/00594	0	0	0.7	13.3	11.7	3.6	0
Puna	0	0	3.7	8.3	8.3	8.0	1.0
95/19177	0	0	0	10.0	10.0	3.3	3.3
Dente	26.0	0	0	3.3	19.3	5.0	0.7
Asana	0	4.0	0	20.0	13.7	13.7	0

Table 13. Yield of improved yam genotypes planted at Lantinkpa in East Gonja district during the 2011 cropping season

No.	Genotypes	Mean no. of tubers per mound[1]	Yield per mound (kg)	Mean wt. of tuber (kg)	Yield (t/ ha)
1	95/19156	2.32	1.78	0.77	12.4
2	95/18949	1.72	2.36	1.37	16.4
3	95/18922	1.90	1.93	1.02	13.4
4	95/01942	1.76	2.10	1.19	14.6
5	96/02025	2.02	2.10	1.03	14.6
6	96/02610	1.80	2.31	1.28	16.0
7	95/19158	2.23	2.53	1.13	17.6
8	95/18544	2.57	2.43	0.95	16.9
9	Laribako	2.42	1.57	0.65	10.9
10	96/00594	2.05	2.64	1.29	18.3
11	Puna	1.54	1.60	1.04	11.1
12	95/19177	1.82	2.28	1.25	15.8
13	Dente	1.44	1.42	0.99	9.9
14	Asana	1.11	1.94	1.77	13.5
	CV (%)				15.8
	LSD (5%)				3.83

Table 14. Cooking characteristics of improved yam genotypes based on Farmer's selection

Characteristics	Preferred/Selected Genotypes	Existing cultivars
Consistency:		
(i) Very viscous	96/02025, 95/19156	Puna, Laribako
(ii) Slightly viscous	95/19177, 95/01942	Dente
Boiling	95/19177, 95/19158, 96/02025, 96/02610	Dente, Puna, Laribako
Pounding	95/18949, 95/18922, 95/01942, 95/18544, 96/00594, 95/19177	Asana, Dente, Puna, Laribako
Elasticity	95/19156, 96/02025, 96/02610	Dente, Puna, Laribako
Expansion	96/02025	Dente, Puna, Laribako
Lumps	95/18922, 95/01942	Asana
Taste:		
(i) Very sweet	None	Puna, Laribako
(ii) Slightly sweet	95/19156 ,95/18949, 95/18922, 95/01942, 96/02025, 95/19158,	Dente, Asana
(iii) Bitter	95/158, 95/18544, 96/02610	
Texture:		
(i) Hard	96/00594, 96/02610, 95/19156	
(ii) Soft	95/19177, 95/18544, 95/19158, 96/02025	Dente, Puna, Laribako
Colour:		
(i) Yellow	96/02610	-
(ii) Brown	96/00594, 95/19158, 95/18922	-
(iii) Cream	95/19156, 95/18949	Puna
(iv) White	96/02025, 95/01942	Dente, Asana, Laribako

Stability analysis of traits linked to improved performance of cassava in stress environment of Northern Ghana.

K. Acheremu, J. Adjebeng-Danquah, A. Saibu and A. Sumaila

Executive Summary: Eighteen (18) cassava genotypes were evaluated for three successive years (environments) for their stability using GGxE biplot analysis. Analysis of variance, mean, phenotypic correlation co-efficient and who wins where or which is best for what, of the individual genotypes were estimated to evaluate the stable performance of the genotypes. The mean squares due to genotypes, and genotype- environment interaction were significant for all the characters studied suggesting a lot of variability among the genotypes, and the genotypes interacted significantly with environments. Among all the genotypes, BB (local check) showed stable performance for tuber number per plant and tuber yield under all environments. The genotypes I91934, CTSIA 48 and CTSIA 112 were recorded root tuber yields not significantly different from the local check. The correlation shows positive relationship between root tuber yield and HI (0.48), mean tuber weight (0.59), stem diameter (0.36), and number of roots per plant (0.49). This indicates that these traits can be targeted when selecting genotypes for improved 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 5-6 months of sometimes-absolute dry weather before harvest during the next wet season. The Northern parts of Ghana noted for its short period of rainfall and interspersed with periods of intermittent drought leading low productivity of most crops. 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 irradiance and temperature (Serraj *et al.,* 2005). About 82 to 96% yield decline has been reported in cassava under severe moisture stress (Aina *et al.,* 2007). 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 improved performance under difficult or marginal conditions is related to various physiological traits (Lenis *et al.*, 2006). From the results of Yan *et al*. (2007), it is important to properly examine the stability of these exotic cassava lines for unique traits and for information that would enable the ranking of genotypes. This allows identification of core physiological traits that are related to cassava performance under water stress conditions without losing valuable information about genotypes. It is, therefore, important to improve our understanding of the growth parameters of cassava and determine if it could be used when developing genotypes under similar environments to facilitate a more meaningful cultivar evaluation and recommendation. Genotype by environment interactions (G x E) affects cassava yield performance (Egesi *et al.*, 2007). This requires extensive study of cassava attributes in varying environments over years before realistic recommendations can be made. This study examined the effect of environment stability performance of some exotic cassava lines and to identify physiological traits that are related to yield in Northern Ghana.

Materials and methods

Eighteen (17) cassava genotypes received from CIAT and IITA raised from drought tolerant parents crosses, with a local check, biabasse, were evaluated since 2009 season for 3 years, in a randomized complete block design with three replications. The work was carried out on the Savannah Agricultural Research Institute research fields at Nyankpala. The land was ploughed and harrowed after which 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 ration of tuber yield to total biomass. Analysis of variance was performed using SAS PROC GLM (SAS, 2002).

The GGE biplots were constructed using the first two principal components (PC1 and PC2) that were derived from subjecting environment centred root tuber yield means for each harvest (averaged over years) to singular value decomposition. This provided information on the traits that contributed to drought tolerance and yield, investigation of stability of cultivars in the various harvests.

Results and Discussion

Scientific findings

Phenotypic correlation coefficients among yield and agronomic traits over three harvests

The correlation table (Table 15) shows positive relationship between root tuber yield and HI (0.48), mean tuber weight (0.59), stem diameter (0.36) and number of roots per plant (0.49). This indicates that these traits can be targeted when selecting genotypes for improved yield. The growth parameters such as Av.PHcm, Av.CWcm, Av.StD and Av.NoL were positively correlated with one another and can therefore be used to indirectly select for each other. However, they were not strongly correlated with yield. This implies that, in stress environments, there is competition between allocations of assimilates to the roots and the top part of the plant.

Table 15. Phenotypic correlation coefficients among yield and agronomic traits of 18 cassava genotypes over three harvests seasons (2009-2011).

	NoT _plt	*Tub yld*	*mtw*	*HI*	*AV. PLHcm*	*AV. CWcm*	*AV. StDcm*	*AV. NoL*
NoT_plt	1	0.49	-0.18	0.06	0.11	0.16	0.33	0.22
TUByld		1	0.59	0.48	0.03	0.27	0.36	0.29
Mtw(g)			1	0.37	-0.02	0.18	0.33	0.33
HI				1	-0.45	-0.21	-0.21	-0.15
AV.PLHcm					1	0.56	0.61	0.26
AV.CWcm						1	0.61	0.59
AV.StDcm							1	0.68
AV.NoL								1

NoT_plt-number of tubers/plant, Tubyld = tuber yield (t/ha), mtw = mean tuber weight (g), HI = harvest index, AV. PLHcm =average plant height (cm), AV. CWcm = average canopy width (cm), AV. StDcm = average stem diameter (cm), AV. NoL = average number of leaves

Field performance of the 18 cassava genotypes.

Combined analysis across the three (3) harvests for the eighteen genotypes revealed significant differences ($p \leq 0.05$) among the agronomic traits measured. The genotype BB recorded the highest root yield of 14.53t/ha, but with the lowest average number of leaves, canopy width, and plant height recorded. Similar trend was obtained by the genotype I91934 recording statistically not different root tuber yield of 13.19t/ha. Genotype CTSIA 230 which recorded the highest plant height, and canopy width was among the low yielding genotypes. This suggests that genotype CTSIA 230 invested most of its dry matter production into top growth in the expense of root growth. Genotype CTSIA 48 though retaining a considerably high number of leaves also produced root tubers yield (12.53t/ha) which is not significantly different ($p<0.05$) from the highest performing genotypes (13.19 and 14.53t/ha).

Whereas traits such as leaf retention under moisture stress condition can lead to improved yield (Lenis *et al.*,2005), the genotypes that suspend top growth during stress and resume growth during favourable conditions stand a better chance of improved yield.

Suitability of different cassava genotypes for different harvest times over three harvests

The GGxE biplot for root tuber yield of the 18 cassava cultivars evaluated across 3 harvests periods from 2009 to 2011 seasons is shown in Figures 1 and 2. According to Yan (2001) and Yan *et al.* (2000; 2005; 2010), in the polygon view (Fig. 2), the vertex cultivar in each sector represents the highest yielding cultivar in the location that falls within that particular sector. Based on this information, genotype CTSIA 1 was the highest yielding cultivar in harvest3 (HVST3) and the lowest yielding cultivar was genotype CTSIA 162. Genotypes CTSIA 8 and 96/0409 were the vertex cultivars at harvest2 (HVST2). Genotype 91/02324 was the winning cultivar at harvest1 (HVST1). The vertex genotype BB was the highest yielding cultivar among all the vertexes, but do not fall into any of the harvests, indicating that genotype BB was the outstanding cultivar in all the 3 harvests.

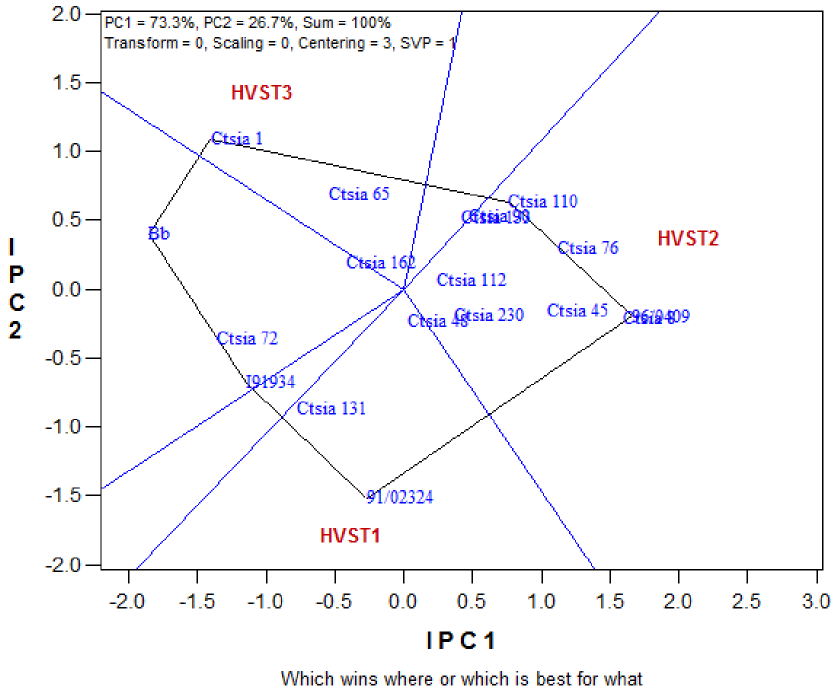

Figure 5. Suitability of different genotypes for different harvest times

Technology Developed

Based on the combined analysis carried out for the 3 seasons' harvests, genotypes I91934, CTSIA 48, CTSIA 112, CTSIA 45, 96/0409 and 91/02324 have been identified based on their yield performance over the period.

Technology transferred

This work is at the clonal evaluation stage evaluated on-station, to select best performing varieties based on attributes important to the cassava growing areas of the northern region.

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 I91934, CTSIA 48, CTSIA 112, CTSIA 45, 96/0409 and 91/02324 were statistically similar in root tuber yields, but different in absolute values. Based on the physiological attributes and final root yield, these genotypes are selected for further breeding work. The findings of the research have unravelled important information on the some physiological traits underlying cassava productivity and tolerance to prolonged water stress. This information can be used to develop novel cassava varieties for both favourable and stressful environments.

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

K. Acheremu, J. Adjebeng-Danquah and A. Saibu

Executive Summary*:* Sweetpotato varieties with yellow or orange flesh have a high beta carotene and taste of sweet carrots. 12 varieties, including orange flesh sweetpotato varieties were evaluated for their performance in terms of yield. Apomuden recorded the highest number of tuber roots with an average of 75.3 tubers, resulting in the highest (17.43 kg) total tuber root yield. Kemb-37 with a significantly similar number of tuber roots (63.7) tubers, recorded a total root weight of 10.43 kg, which is significantly different from that of Apomuden. Carrot-C did not produce tuber roots. Similarly, Apomuden recorded the highest marketable tubers number of 32.0, followed by Santompona with a value of 23.0 tuber roots. Cemsa 74-228 recorded the highest %DM of 42.5%, statistically similar to that of Santompona and Ogyefo with the values of 39.99% and 39.27% respectively. "Apomuden" however recorded the lowest %DM of 22.18%. The HI was highest in Junkwa Orange (78.9) and was followed by Apomuden with a value of 77.0.

Introduction:

The sweet potato, *Ipomoea batata,* belongs to the family convolvulaceae. The tubers, harvested 100-180 days after planting stem cuttings, are tuberous roots. It has high dry matter (DM) 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 kilojoules /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 OM among the root and tuber crops (Messiaen, 1992). The importance of sweet potato is increasing in African farming because it is easy to plant, mature early and has enormous industrial and economic potentials. The leaves are consumed as vegetables (Otoo, *et al.*, 2001). In Ghana sweet potato is grown by peasant and small-holder farmers scattered in upper East and Central-regions.

In northern Ghana sweetpotato is widely consumed, and cultivated by small-scale farmers with varied preferences that include yield and other qualitative parameters such as root taste, texture, aroma of the storage root. Beta-carotene plays a major role in eliminating vitamin-A deficiency (Otoo, *et al.*, 2001). Sweetpotato varieties high in beta-carotene are therefore important in eliminating vitamin-A deficiency. This work is aimed at identifying sweet potato varieties with high beta-carotene and stable yields for the guinea savannah. It is also aimed at assessing the suitability of varietal characteristics to the food and income needs of farmers.

Materials Methods:

Eleven (11) introduced varieties from CRI, Kumasi, including β-carotene varieties and a local check material, were planted on the experimental field in Nyankpala during the 2011 rainy season, in plots of 20 m^2 per treatment, with a plant population of 68 per plot in 3 replications, arranged in a randomised complete block design. A net plot of 10 m^2 was used for the evaluation. The parameters evaluated were number of plants harvested (PltSt), plant vigour, number of root tubers harvested per plot (RtTubN), number of commercial roots per plot (MrktTub), the dry matter percentage (%DM) of root tubers and the total biomass (TopWt) produced in the expense of tuber root development (HI), as well as total root yield per plot (*RW*).

Results and Discussion:

Scientific findings

Results show significant differences ($p \leq 0.05$) in yield and yield components among the 12 sweet potato varieties evaluated (Table 16). Apomuden recorded the highest number of tuber roots with an average of 75.3 tubers per 10 m^2 net plot area, followed by Kemb-37 with an average tuber number of 63.7. However, the tuber numbers recorded by Apomuden

Table 16. Summary of Yield and yield Components of Sweetpotato genotypes

VARIETY	***PltSt***	***RtTubN***	***MrktTub***	***MktRtWt(kg)***	***TopWt.(kg)***	***Wvil***	***RW(kg)***	***%DM***	***HI***
Mohc	**21.67**	31.7	12	3.77	***10.6***	**2.33**	6.03	36.88	35.6
Cemsa-74-228	16.67	36.3	19.7	***7.9***	4.57	4	9.8	**42.5**	67.5
Apomuden	13.67	**75.3**	**32**	**14.1**	4.8	**2.33**	**17.43**	22.18	***77***
Okerewe	18.67	21.7	0.7	0.1	**13.97**	4	2	36.75	13.3
SantPona	20.33	41.3	***23***	11	8.5	4	***13.67***	39.27	63
Tanzania	19.33	47.3	13	2.63	***10.6***	3.67	5.9	38.78	35.7
Nas red vine	18.33	62.3	18.3	5.63	3.67	3.33	8.47	34.2	69
Kemb 37	19.33	***63.7***	20.7	5.63	5.43	3	10.43	38.22	66
Carrot C	**23.33**	0	0	0	7.93	0	0.97	36.75	11.8
JunkOrang	12.67	50.3	20.7	6.8	2.7	4.33	10.17	38.75	**78.9**
Ogyefo	19	28.7	9.3	3.1	8.87	4	5.23	***39.99***	35.3
Otoo	20.33	29.7	14.7	4.3	6.3	3	6.67	36.79	52.5
G. Mean	18.61	40.7	15.3	5.41	7.33	3.17	8.06	36.75	50.5
Lsd	4.738	26.46	10.84	5.117	3.193	1.103	6.32	1.837	12.43
cv %	15	38.4	41.8	55.8	25.7	20.6	46.3	2.9	14.5

Key words: *PltSt=number of plants harvested, RtTubN= total root tuber number MrktTub=number of commercial roots, MktRtWt=commercial root weight, Wvil=Weevil Damage per plot, TopWt. =vine weight, RW. (Kg)=root weight per plot, %DM= Dry matter percentage, HI=harvest index.*

and Kemb-37 were not statistically different from the tuber number recorded by Nasamu Red Vines (62.3), a local check. Carrot-C recorded no tuber roots. Similarly, Apomuden recorded the highest number of marketable tuber roots sizes of 32.0, followed by Santompona with 23.0 marketable root sizes, thereby recording the highest corresponding marketable tuber root weights of 14.10 kg and 11.00 kg, respectively. However, the results of the two were not significantly different.

The highest vine weight was recorded by Okerewe (13.97 kg), significantly higher than those of Mohc (10.60 kg) and Tanzania (10.60 kg). Junkwa Orange recorded the lowest vine weight (2.70 kg). Dry matter percentage (%DM) was highest in Cemsa-37-228, recording 42.5, followed by Ogyefo with %DM of 39.99. The %DM of these two varieties is significantly similar to that of Santompona (39.27%). Apomuden recorded the lowest (22.18) dry matter percentage. The highest HI was recorded by Junkwa Orange (78.9), followed by Apomuden with a value of 77.0. The lowest HI was by Carrot-C recording 11.8.

Out of the 34 cuttings planted for each variety, average of 23.3 stands was harvested for Carrot-C. However, no tuber roots were recorded. Similarly, Okerewe recorded the lowest number of marketable tuber roots, but recorded the highest vine weight (13.97 kg). Apomuden recorded the highest number of tuber roots (75.3) resulting in the highest in both total tuberous root yield and yield of marketable tuber roots sizes. However, the dry matter yield was the lowest in Apomuden. Santompona was statistically similar to Apomuden in terms of the total root tuber yield and number of marketable tuber roots, but significantly different in the number of root tubers and weight of marketable tuber roots sizes.
Cemsa74-228 recorded the highest dry matter content in the roots, although the yield values were the lowest. Similarly, Okerewe recorded the lowest number and weight of marketable root tubers, although it recorded the highest biomass of 13.67 kg.

Technology developed
High performing varieties ("Apomuden" and "Santompona") have been identified based on their yield and some yield components. The varieties Apomuden , Santompona, Kemb-37, Junkwa Orange and Cemsa 74-228 have been selected.

Technology transferred
The best performing varieties were identified and will be advanced to the next stage of the breeding programme.

Conclusion:
"Apomuden" recorded the best yields, giving higher performance together with Santompona and Kemb-37 than the local check variety. Apomuden has emerged the best yielding, β-carotene rich and disease resistant variety for farmers in potato growing areas in Northern Ghana because of its nutritional value.

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GROUNDNUT IMPROVEMENT

Developing high yielding, foliar disease tolerant groundnuts for the Guinea Savanna zone of Ghana

Richard Oteng-Frimpong and Nicholas N. Denwar

Executive summary

Peanut is an important cash crop in the livelihoods of most farm families in northern Ghana. However its production is constrained by a number of factors resulting in yields less than a ton per hectare (< 1 t/ha). It therefore becomes important for research to find solutions to these constraints with the aim of improving production per unit area. One way of improving the available germplasm is through introductions and to this end 50 advanced breeding lines were obtained from ICRISAT-Mali and grown as an observational nursery in randomized complete blocks. The objective was to multiply them to obtain enough seeds for multi-location trial in the coming season while at the same time observing their yielding capabilities. Results showed that most of these lines have the capacity to yield over a ton per ha. The seeds obtained will be used for multi-location testing and the best performing lines would be advanced for further testing with the aim of developing them into a new variety.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important crop for small-scale farmers in Ghana. Although the crop is produced in all agro-ecologies of the country, the bulk of production occurs within the northern sector, which spans the Guinea and Sudan savannah ecologies (Tsigbey *et al*., 2003) lying within latitude 8^o – 11^o N of the equator. The ability of the crop to fix atmospheric nitrogen makes it an important part of the cropping systems, usually in rotation with cereals or tuber crops (Tsigbey *et al*., 2003).

In Ghana, the major constraints to groundnut production include disease incidence, soil pests, drought, and soils of low inherent fertility. Lack of field dormancy in the early maturing varieties also reduces yield as delays in harvesting result in significant yield losses through sprouting of matured kernels (Asibuo *et al*., 2008). According to Waliyar *et al*., (2000), the major diseases include early leaf spot and late leaf spot, although rosette, rust and *Aspergillus flavus* incidence may be severe depending on year and location. The effects of drought are particularly important in the northeast corner of the country where varieties that mature after 110 days are particularly unsuitable.

To profitably grow groundnut, it is important to adopt measures that will mitigate the effects of these yield reducing factors. Such measures among others include the availability and access to improved groundnut germplasm. One way of improving the available germplasm is through introduction of foreign materials. Such material needs to be adapted to our local environment and farming systems. They also provide a source for new genes of desirable traits to be introgressed into local adapted varieties through crosses.

The objectives of this work were to;

- Observe and multiply seeds of 50 advanced breeding lines obtained from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT-Mali) on station.
- Produce breeder seed of four released varieties of groundnut.

Materials and methods

ICRISAT-Mali supplied 50 advanced breeding lines. In all a maximum of 100 seeds per line were obtained. This required that they be multiplied for effective multi-location evaluation later. However to get some preliminary information as to their yielding ability, they were grown in randomised complete blocks with three replications with the released variety Nkatiesari as a local check on station at Nyankpala (9°25′, 0°58′ W). The seeds were sown on ridges at a spacing of 20 cm intra row and 75 cm inter row (20 cm X 75 cm). 30 seeds were sown on each plot however attack by birds reduced this number at the time of maturity. All recommended agronomic practices for groundnut were followed. Hand weeding was done twice and Triple super phosphate was applied at a rate of 25 kg per hectare.

Breeder seeds were also produced on at least one acre of land. Due to the time of planting (early August), tractor made ridges were used as a means of facilitating harvesting when the rain stops. The spacing was 75 cm inter row and 20 cm intra row.

Results and Discussion

A number of limiting factors came into play during the growing season. Key among them was the time of planting (first week of August). Initial seed establishment was hampered greatly from the activities of birds as they removed the seeds from the soil before they emerged. This reduced significantly the number of surviving plants at harvest. The growth period also met some drought spells and a terminal drought at the final stages of growth resulted in low yields and poor pod filling especially for the lines maturing late (>120 days).

Results of the analysed data showed a general low yielding pattern among the lines. This could be due to the poor plant establishment recorded on the field. However the released variety, Nkatiesari, used as a local check yielded better than all the lines used (though below its potential of 2.0 t/ha). Some of the lines look promising as they yielded above 1.0 t/ha despite all the limitations observed during the growth period. There were no significant differences in the pod yield among most of the lines tested. However among the aflatoxin tolerant lines, there were highly significant differences ($p < 0.001$) in pod yield. Multiplication and observation will continue during the dry season under irrigation. This will provide enough seeds for multi-location trial during the major growing season of 2012. The Table below show the yield of lines that were tested.

Table 17: Yield of foliar disease tolerant lines tested at Nyankpala

LINES	*Pod Weight* (kg/ha)	*Kernel Weight* (kg/ha)
ICG (FDRS) 4	411	225
ICG 7878	473	250
ICGV 00064	1284	699
ICGV 00068	415	158
ICGV 01276	970	608
ICGV 99029	340	164
ICGV-IS 08837	875	544
Nkatiesari	805	482
GRAND MEAN	697	391
LSD (P = 0.5)	ns	ns
CV %	10.5	13
s.e.	73.4	50.9

Table 18: Yield of aflatoxin tolerant lines tested at Nyankpala

LINES	*Pod Weight* (kg/ha)	*Kernel Weight* (kg/ha)
ICG 6222	331	158
ICGV 03315	656	291
ICGV 03323	804	381
ICGV 03397	333	211
ICGV 91177	627	390
ICGV 91283	113	87
ICGV 91317	512	321
ICGV 91324	570	349
ICGV 91328	499	297
ICGV 91341	445	238
ICGV 92302	406	381
ICGV 93305	758	397

ICGV 94379	539	187
Nkatiesari	1200	669
Grand Mean	557	311
LSD (p = 0.5)	331.7	209.4
CV %	7.2	5.1
s.e	40.2	15.7

Table 19: Yield of drought tolerant lines tested at Nyankpala

LINES	*Pod Weight* (kg/ha)	*Kernel Weight* (kg/ha)
ICGV 00308	940	587
ICGV 00350	819	426
ICGV 00362	617	348
ICGV 00369	487	296
ICGV 02271	887	504
ICGV 02313	407	222
ICGV 03056	1192	537
ICGV 07356	886	512
ICGV 86124	756	460
ICGV 91114	570	351
ICGV 97188	827	502
ICGV 99240	1482	768
ICGV 99241	1152	689
ICGV 99247	980	512
ICGV 99249	901	413
Nkatiesari	1091	560
Grand Mean	875	480
LSD (p = 0.5)	ns	ns
CV %	4.6	7.6
s.e.	40	36.5

Table 20: Yield of early maturing lines tested at Nyankpala

LINES	*Pod Weight* (kg/ha)	*Kernel Weight* (kg/ha)
Fluer 11	1100	219
ICGV 02022	1020	550
ICGV 02144	858	448
ICGV 03157	1175	504
ICGV 03166	940	606
ICGV 03169	949	382
ICGV 03179	912	322
ICGV 03181	793	518
ICGV 03184	508	332
ICGV 03187	875	531

ICGV 03194	1028	609
ICGV 03196	1324	638
ICGV 03206	698	454
ICGV 03207	1023	402
ICIAR 19BT	1115	775
Nkatiesari	1614	592
Grand Mean	996	493
LSD	ns	ns
CV (%)	6	11.5
s.e.	59.3	56.6

Table 5: Yield (pod weight) of breeder seeds produced at Nyankpala

Variety	Quantity (Kg)
Nkatiesari	170.2
Manipintar	93.8
Kpanieli	32.4
Chinese	16.4
Sumnut 22	71
Sumnut 23	61

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Field Evaluation of F_6 hybrid lines of groundnut for resistance to early and late leaf spot diseases.

N. N. Denwar and Z.O. Wohor

Executive Summary

Early leaf spot (caused by *Cercospora arachidicola* S. Hori) and late leaf spot [caused by *Cercosporidium personatum* (Berk. and Curtis) Deighton] diseases are two of the most limiting biotic stresses in peanut (*Arachis hypogaea* L.) production known worldwide, causing yield losses of up to 50%. In West Africa, the level can be as high as 70%. Although these diseases can be controlled using fungicides their application can increase production costs by about 10%. The most effective way to minimise losses due to fungi attack is by host plant resistance. The objective of this experiment was to evaluate F_7 hybrids from crosses made between interspecific lines and selected cultivated groundnut cultivars for their tolerance/resistance to early and late leaf spot diseases. The results indicated many hybrid lines possessed high levels of resistance to the leaf spot diseases as well as pod yield, thereby suggesting that leaf spot resistance can be improved in cultivated groundnut through introgression of alleles from wild groundnut species using the synthetic amphidiploid TxAG-6 as a bridge between the wild diploid and the tetraploid cultivated groundnut.

Introduction

Leaf spot diseases are a major limitation to groundnut production worldwide. Yield losses due to early and late leaf spot diseases are estimated to be in the region of 50-70%. Even though these diseases can be effectively controlled using fungicides, their application increases production costs significantly. In Ghana much of groundnut production is by small scale peasant farmers who do not have the requisite resources to protect their groundnut fields with fungicides, which may not be readily available. The most effective way to minimize losses to these fungi is by host-plant resistance. Wild species of groundnut possess resistance alleles that can be introgressed into cultivated groundnuts to increase the level of resistance. Investigations found the existence of high levels of resistance to leaf spots in wild species of groundnuts but attempts to utilize these sources have been met with limited success as introgressing wild alleles into *A. hypogaea* is difficult because of genomic (A and B genomes) and ploidy (diploid and tetraploid) barriers. However, with the development of a synthetic amphidiploid, TxAG-6, (Simpson, 1991), new frontiers for peanut improvement have emerged making it possible to introgress alleles from wild species into commercial cultivars with considerable success.But until the development of a fertile synthetic amphidiploid, TxAG-6, it was difficult to introgress these alleles due to differences between the diploid wild species and the tetraploid cultivated groundnut. In this study several F_5 lines developed through crosses among interspecific lines derived from TxAG-6 and Florunner and adapted cultivars were tested for resistance to early and late leaf spot diseases. The objective of the study was to evaluate F_6 breeding populations of groundnuts for resistance to early and late leaf spot diseases under field conditions.

Materials and Methods

Early and late leaf spot rating.

The evaluation of the F_6 generation was carried out in Nyankpala in 2011. The design was a randomized complete block with 3 replications. Each plot consisted of 2 rows at a planting distance of 60 cm between rows and 30 cm between plants, 5 m long. Fertilizer was applied at the rate of 30 kg K_2O and 60 kg P_2O_5 per hectare. Weeds were controlled by hand hoeing at 2 and 6 weeks after planting. Additional weedings were done where necessary. Leaf spot scores were taken monthly after emergence and the final scores taken prior to harvesting. Scores for early and late leaf spot diseases were obtained by visual observation using the Florida scale.
The local checks were two adapted and resistant cultivars (Nkatiesari and Kpaniele) and a susceptible cultivar (Chinese).

Results

Scientific findings: The results suggest, as in previous trials, that many hybrid lines possessed high levels of resistance to leaf spot diseases as well as pod yield.

Technology Developed: Hybrid lines with high levels of pod yield and resistance to leaf spot diseases.

Conclusions/Recommendations: Leaf spot resistance can be improved in cultivated groundnut through introgression of alleles from wild groundnut species through the use of the synthetic amphidiploid TxAG-6 as a bridge between the wild diploid and the tetraploid cultivated groundnut.

Future activities/the way forward: Promising lines would be multiplied and tested on farmers' fields in subsequent years.

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SOYBEAN IMPROVEMENT

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

Nicholas N Denwar and Zackariah Wohor.

Executive Summary

Soybean plays an important role in the farming systems of northern Ghana. The crop has high levels of protein, oil and some essential amino acids needed for human growth and development. As a legume it fixes biological nitrogen which complements the low level of chemical fertilizer application. Again, the haulm is used to feed small ruminants during the dry season when natural pastures are burnt by the annual bushfires. *Striga hermonthica* is a parasitic weed that is prevalent in the area and can cause yield losses in cereal crops in excess of 80%. Over the past few years our breeding efforts have focused on developing varieties with enhanced capacities to control Striga with the aim to increasing maize productivity through the use of soybean trap-crop in complementation with Striga and drought tolerant maize lines. Efforts were also directed towards reduction of the maturity period of commercial varieties available to farmers in order to fit the crop in the dwindling rainfall regime, particularly in the Sudan ecological zone. In 2011, on-farm tests with selected promising lines were conducted throughout northern Ghana with the aim of determining their performance and acceptability to farmers. Two medium (110-120 days) maturing lines bred with enhanced abilities to control Striga and two early (85-90 days) maturing lines were tested on farmers' fields to validate their performances. Yields were in the range of 1000 to 1400 kg/ha. It was concluded that these lines be proposed to the National Variety Release and Technical Committee for consideration for release to farmers in 2012.

Introduction

The three regions of northern Ghana constitute about 40% of the total land mass of the country with a population close to 4 million people, 70% of whom live below the poverty line. Agriculture is the dominant economic activity in the area, employing about 80% of the population. However, agricultural productivity in the area is low, attributable to the over-dependency on rainfed subsistence agriculture and low external inputs application to the largely degraded and infertile soils. As a result, widespread hunger, malnutrition and food insecurity are prevalent leading to high rates of infant mortality and economic decline.

Soybean is an important source of high quality and relatively inexpensive protein and oil, containing about 40% protein and 20% oil. Soybean has superior amino acid profile in that it contains such essential amino acids as lysine and tryptophan. The crop, being a legume, has considerable capacity to fix biological nitrogen and that stands it in good stead as an integral part of subsistence agriculture. The menace of the parasitic weed *Striga hermonthica* reduces maize yields as Striga resistant maize varieties are non-existent. However, the yields of current soybean varieties are just above break-even levels while the capacity to stimulate suicidal germination in *S. hermonthica* seeds is low. The importance of soybean as a food and cash crop in rural communities is growing, occupying the third place after groundnut and cowpea. With the proliferation of soybean processing plants in Ghana of late its potential as a poverty alleviation and wealth creation crop cannot be over-emphasized.

The main goals of the program are to develop varieties that are suited to the agro-ecological conditions as well as the major farming systems in the interior Savannah zone of Ghana, transfer appropriate technologies to farmers for the realization of food security of farm-families and thereby create wealth in the country.

Materials and Methodology

The trials comprised 12 early and 15 medium/late maturing lines tested across 3 locations.
Design: RCBD with 4 replications
Plot size: 4 rows, 5 m long
Spacing: 75 cm x 5 cm (medium /late); 60 cm x 5 cm for early lines.
Planting Method: seeds drilled by hand and seedlings thinned to 20/metre length
Fertilizer application: 25-60-30 kg N, P_2O_5 and K_2O per hectare
Average Population: 266,000 plants/ha
Locations: Nyankpala, Yendi and Damongo.
Planting time: Mid-June to mid-July depending on rainfall

Results and Discussion

Scientific findings

Two sets of early and medium/late maturity lines (70 entries) were introduced from IITA/Ibadan for preliminary evaluation and to broaden the gene pool. This was in addition to already existing advanced breeding lines of early and medium maturing lines (36 lines). Four early maturing lines with appreciable yields were identified as parents for crossing. On-farm tests also indicated that two medium maturing lines with enhanced capacity for causing suicidal germination of *Striga hermonthica* as well as two early maturing lines were acceptable to farmers and could be released.

Technology Developed: Lines with high grain yields and earliness were selected from among the advanced yield trials. Also, the benefits of rotation of soybean lines with identified capacity to control *Striga hermonthica* in the field.

Technology transferred – On-farm trials and demonstrations were conducted to introduce two early maturing soybean lines and two other lines with high capacity to control *S. Hermonthica* to farmers in the three regions of northern Ghana. In Northern Region, West Mamprusi, Yendi, West Gonja, Savelugu and Tolon Districts were covered. Over 50 farmers were introduced to these technologies.

Conclusions/Recommendations: Based on the results of the on-farm tests two early maturing lines and two medium maturing ones with enhanced capacity to stimulate suicidal germination in S. Hermonthica would be proposed to the National Variety Release and Technical Committee for consideration for release in 2012.

Future activities/The way forward: The programme would continue variety development using parental lines so selected in a crossing programme in the coming years.

Strategies for cost-effective management of *Striga hermonthica* in maize-based production systems in northern Ghana.

Nicholas N Denwar, James M Kombiok and Samuel S Buah

Executive Summary

Northern Ghana is endemic to the parasitic weed *S. Hermonthica*. Under severe infestation cereal (maize, sorghum and millet) yields could be reduced by over 80% making it a threat to food security in the region. Realising the importance of this weed to agricultural productivity the Ministry of Food and Agriculture (MoFA) under the Food and Agriculture Budgetary Support of the Ministry of Finance and Economic Planning, gave

support for research to develop cost-effective ways of managing the parasite on farmers' fields. After 3 years of successfully testing soybean lines with enhanced capacities to cause suicidal germination in *S .hermonthica* on farmers' fields, two lines were selected based on grain yield and resistance to pod shattering for consideration for release. Yields were in the range of 1000 to 1400 kg/ha.

Introduction

The devastating effect of *Striga hernonthica* on cereals such as maize, millet and sorghum is well documented (Ogborn, 1987). *Striga* can be controlled by cultural practices such as hand-pulling, biological means and by the use of herbicides (Akobundu, 1988). However, the most widely used method by peasant farmers in West Africa is hand-pulling. This has been described as the most effective method of *Striga* control (Doggett, 1987). The limitation of this method is that it is time consuming and labour intensive. *Striga* plants hand-pulled or weeded by hand-hoe at a time the seeds are developed on the plant might help to disperse more of the weed seeds thereby increasing infestation.

Designing alternative methods to minimize the infestation of the weed, exploiting the peculiar relationship of *Striga* to its host has been advocated (Sauerborn, 1992). The use of cotton as a trap-crop in the cropping systems in northern Ghana has been found to reduce *Striga* seed bank and improved maize and sorghum yields substantially (Kombiok and Clottey, 1999). However, cotton being a commercial crop is not widely grown by most peasant farmers where there is high infestation of *Striga hermonthica.*

In recent times, some lines of soybean have been identified to possess superior qualities as trap-crop in the laboratory compared to the released varieties (SARI, 1998). Replacing cotton with any of these lines of soybean as trap-crop and using *Striga*-tolerant maize varieties will go a long way to reduce *Striga* infestation and increase maize yields which always follow legumes in rotation as practiced by farmers in northern Ghana.

The objectives of this study were:

- To evaluate the trap-cropping ability of the soybean lines in controlling *Striga hermonthica* on-farm, and
- promote the growing of *Striga*-tolerant maize varieties in *Striga* endemic locations in northern Ghana.

Materials and Methods

With the collaboration of some staff of MoFA**,** ten (10) farmers each from the Tolon/Kumbungu and West Mamprusi Districts whose farms were infested with *Striga hermonthica* were identified and selected for the trial.

On each of the farmers' fields, 10 x 10 m of land was demarcated three times. The first plot was planted to the farmers' maize crop, the second plot to the soybean (TGX 1445-3E) and the last plot was planted a Striga tolerant maize variety called Aburohemaa (EV DTW 99 STR QPM CO).

Treatments:
The treatments were:
1. Soybean (TGX 1445-3E)
2. Striga tolerant-maize (Aburohemaa/ EV DTW 99 STR QPM CO)
3. Farmer's maize variety

The soybean was planted in rows at 80 by 10 cm and the maize at 80 by 40 m with two plants per stand. These were maintained and rotated each cropping season. Data collected included *Striga* count per plot every two weeks till harvest and grain yield of both maize and soybean per plot and each converted to per hectare basis.

Scientific findings: Our on-farm results indicate that rotating soybean lines with high ability as trap-crop against *S. Hermonthica* for two years can significantly increase maize yields over continuous maize that do not have *Striga* tolerance in their genetic background.

Technology Developed: Two-year rotation of soybean lines that are efficacious for controlling Striga and Striga-tolerant maize varieties in the field. Two lines (TGX 1445-3E and TGX 1834-5E), which were successfully tested on farmers' fields for 2 years, were found to significantly increase subsequent maize yields.

Technology transferred: Farmers were educated on the benefits of rotating Striga-tolerant maize varieties with soybean lines with high capacity to control Striga in the field. Farmers were also trained to recognize Striga in the field and to destroy the plants before they set seed as this will tremendously increase the seed bank for the succeeding cereal crop. One Striga plant, if allowed to form seeds could add up to 200,000 seeds to the seed bank in the soil within one year.

Conclusions/Recommendations:
Future activities/the way forward: Two lines (TGX 1445-3E and TGX 1834-5E), which were successfully tested on farmers' fields for 2 years and found to significantly increase subsequent maize yields would be proposed to the National Variety Release and Technical Committee (NVRTC) for consideration for release in 2012.

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COWPEA IMPROVEMENT

Breeding for high yielding improved cowpea varieties with resistance to *thrips*, pod sucking bugs and *Striga gesnerioides* in Northern Ghana”

Haruna Mohammed , I.D.K. Atokple, Mumuni Abudulai, James Kombiok, Benjamin Ahiabor, Alexander N Wiredu, Yaw Owusu.

Executive Summary

The cowpea improvement programme aims to identify or develop improved high yielding genotypes of cowpea with stable resistance to the major biotic and abiotic stress factors and to conduct research to establish partnership to upscale the promotion, dissemination and diffusion of already developed technologies in northern Ghana. In 2011, two major projects were implemented. These included *“Breeding for high yielding improved cowpea varieties with resistance to thrips, pod sucking bugs and Striga gesnerioides in Northern Ghana* and *"Increasing utilization of cowpea genetic resources by breeding programmes and farmers in Ghana”*. Insect pests and inadequate supply of improved seed limits cowpea production in Ghana. Research was therefore conducted to develop and disseminate improved high yielding cowpea varieties with stable resistance to thrips, pod-sucking bugs and to *Striga gesnerioides* with high Nitrogen fixing capacity and to promote, disseminated and improve on farmers’ accessibility to new released cowpea varieties through demonstrations and on-farm participatory community seed production scheme. Results from the *striga* and *aphids* resistance crosses tested on-farm in two locations indicated that about 20% yield reduction was attributed to the combine effect of *striga* and *aphids*. During the year under review, the short and prompt end of rainfall adversely affected cowpea yields; however, it provided ideal conditions for effective screening of most germplasm for their reaction to drought. Findings from the research are discussed below.

Introduction

Project rational/Background:

Cowpea (*Vigna unguiculata* (L) Walp) is the second most important legume crop in northern Ghana after groundnut and serve as a cheap source of protein and income but yields are low, averaging 0.8MT/ha on farmers fields. Biotic and abiotic stresses (low soil fertility, drought, insect pests and disease infestations and post-harvest losses etc.) account for low yields in farmers’ fields in Ghana. The root parasitic weed, *Striga gesnerioides* (Willd) Vatke causes extensive grain yield reduction in legume crops especially cowpea in northern Ghana. Grain yield losses of up to 80% are estimated on susceptible cultivars (Singh and Emechebe, 1990). There is a positive correlation between the menace of *Striga* infestation and low soil fertility (Muleba *et al*, 1997). Host plant resistance is the most practical and economic strategy to control this weed. One of the objectives of the project is to incorporate *Striga* resistant genes into the genetic background of recommended cowpea cultivars.

Flower *thrips* caused by *Megalurothrips sjostedti* is perhaps the most important insect pest on cowpea in Ghana and is found in almost everywhere that cowpea is cultivated. They cause considerable damage in areas where there has not been any chemical intervention though losses are yet to be quantified. Studies elsewhere indicate that total crop loss could result from severe infestation from this insect. The adult *thrips* which are minute insects feed in the flower buds and flowers. Severely infested plants do not produce any flowers and when populations are very high, open flowers are distorted and discolored. The flowers then fall early with the result that pods are not formed leading to reduction in the number of pods per plant and subsequently seed yield. It has been estimated that 50-100% yield loss can occur during severe infestation (Adidgbo *et al*, 2007).

Soil infertility remains the major constraint to sustainable agricultural production in northern Ghana. Farmers in this region apply mostly chemical fertilizers to improve the soils which are costly and often unavailable. The Ghana government in 2008 spent about GH¢20m on subsidizing fertilizer under the fertilizer subsidy program (FSP) but farmers still apply less than the rate required per hectare due to their low income status. Policy makers and farmers would therefore welcome any strategy that seeks to turn around the general soil fertility constraint in the north into a resource for sustainable agriculture.

The major objective of the project was therefore to develop through genetic enhancement, improved early cowpea varieties with resistance to *thrips*, *Striga gesnerioides* and high nitrogen fixing ability to improve on the fertility status of northern soils for sustainable crop production.

Materials and Methods

Since the project has just commenced (August, 2011), research activities were concentrated on collection and evaluation of germplasm with relevant traits that will assist accelerate the attainment of the project's set objectives and production of breeder seed of existing varieties. In general, steps followed in the improvement work were as follows.

Germplasm collection and introduction:
Cowpea lines with traits relevant to the attainment of project objectives were collected locally across the country and in international research institutes such as IITA. Fifty-six (56) cowpea lines consisting of both local and exotic materials were assembled. Collection was focused on cowpea lines with the following characteristics:

- Resistance to *Thrips*, pod-sucking bugs and *S. gesnerioides*
- Drought tolerance
- High nitrogen fixing ability

To enhance the release of adapted cowpea varieties, 75 cowpea lines with various characteristics including resistance to drought, *striga* and *aphids* were introduced into the program. They included local collections and introductions from Senegal. Sixteen of the lines were F_6 progenies of crosses between improved existing cowpea varieties and drought resistant/tolerant lines.

Initial evaluation of germplasm:
The collected or introduced germplasm was planted in nurseries (two row plots) in unreplicated trials during the raining season and under irrigation at *Bontanga* to facilitate the identification and advancement of promising lines at the main station in Nyankpala.

Hybridization and evaluation of progenies:
Reciprocal crosses and backcrosses were done in plastic pots on lines with the above traits to produce first filial generations (F_1) in the screen house at CSIR-SARI. The pedigree method of selection was used to develop the desired homogeneous lines. $F_{5:6}$ generation of *striga* and *aphids*' resistance crosses was evaluated on-farm under natural s*triga* and *aphid* infestation ("hot spot") with farmer participation. The trial was conducted in three locations. Two of the trials were on naturally infested *striga gesnerioides* plots with full protection from insects so that any significant reduction in the performance of the lines could be due mainly to the effect of striga and the third trial was on *striga-free* plot with no insect pests protection at the vegetative stage to assess the effect of *aphids* on the performance of the lines.

Breeder seed production and variety maintenance:
Breeder seed production is the starting point of any seed industry. Hence breeder seed of two released varieties (*Songotra* and *Padi-tuya*) were produced under irrigation at Tono (ICOUR) in the Upper East region to maintain genetic purity, viability and increase our seed stock to provide improved seed for increase cowpea production.

Results and Discussion

Preliminary Evaluation:

Introduced germplasm were subjected to preliminary screening on-station at Nyankpala and 39 lines were identified to have good agronomic traits and were selected for further screening. Among the local collections was a landrace “Sanzei”, previously identified to be resistant to *thrips* will serve as a donor parent in developing more varieties with *thrips* resistance.

Genetic improvement (Hybridization):

Results from the *striga* and *aphids* resistance crosses showed that about 20% yield reduction was attributed to the combine effect of *striga* and *aphids*. The trial will be repeated on-farm to generate adequate data for the release protocol.

Breeder seed production and variety maintenance:

Breeder seed of *Songotra* and *Padi-tuya* were produced to supply foundation seed growers and to maintain the genetic purity of these varieties. Quantity of each variety produced is shown in Table 1 below.

Table 22. Breeder seed production of two cowpea varieties.

Variety	**Year Released**	**Institute**	**Characteristics**	**Quantity produced (kg)**
Padi-tuya	2008	CSIR-SARI	Moderately resistant to *Striga*	60
Songotra	2008	CSIR-SARI	Highly resistant to *Striga*	280

Increasing utilization of cowpea genetic resources by breeding programmes and farmers in Ghana

M. Haruna, I.D.K. Atokple, Mumuni Abudulai, James Kombiok

Introduction

Project rational/Background:

Ghana is the fifth largest producer of cowpea in Africa. Cowpea yields in Ghana are the fourth highest in the world, after Peru, Cameroon and Uganda. Ghana’s cowpea production in growth is also the fastest in Africa. Annual rates of growth, for cowpea in term of area, yield and production for the period from 1985-7 to 2005-7 were -0.1%, 39.6% and 39.8% respectively. Cowpea is mainly grown in the Savanna zone (Derived savanna, Southern Guinea savanna and Northern Guinea savanna) of northern Ghana which constitutes about 41% of Ghana's landmass. Despite this impressive production record, farm yields on per area bases are low due to biotic and abiotic stresses. This is notwithstanding the development by SARI of varieties with high yield potential.

A crop production system starts with the basic input-seed, which must be of good quality as a planting material. The related agricultural inputs such as fertilizers, pesticides, irrigation etc. merely help to draw out the yield potential contained in the seed by providing a conducive environment or ambience.

Poor plant stands resulting from the use of unimproved and poor quality seed due partly to inaccessibility of improved cowpea seeds by farmers is the major reason for this low productivity. To change this trend, it is important to develop a strategy that will facilitate farmer adoption of technologies developed by research institutes.

The objective of the project was therefore to introduce to farmers new varieties of cowpea and demonstrate the importance and benefits of improved techniques in cowpea cultivation and also assist and train selected farming communities to produce their own seed requirements of improved varieties released by research institutions to increase farmer's accessibility to these varieties. Specifically, the project seeks to;

- Introduce and create awareness of new cowpea varieties released by research institutions to farmers by establishing demonstration farms of improved varieties.
- Increase the accessibility of farmers to improved cowpea varieties for improved production through the community seed production scheme.
- Improve on the farmer-farmer transfer of technology in cowpea production.

Materials and Methods

Two improved cowpea varieties (*Songotra and Padi-tuya*) released by CSIR-SARI in 2008 were used for both the demonstration and the community seed production. These varieties have unique characteristics of being high yielding, with the preferred seed coat colour and resistant to *Striga gesnerioides.* Four districts in the northern region were selected for project implementation. These districts were; Tolon/Kumbungu, Savelugu/Nanton, Mamprusi East and Mamprusi West. In each district, a location was identified for both the demonstration and the community seed production.

The criterion for selecting the location was the level of cowpea production in the area. In each implementing district, hundred farmers comprising sixty (60) male and forty (40) female farmers were identified by the Agriculture Extension Agent (AEA) in charge. These farmers participated in all activities from the beginning till the end of the project. It is envisaged that participatory farmers will assist in transferring the technology gained to more farmers. Two acres of land was acquired, ploughed and harrowed at all locations. One acre ($4000m^2$) was used for the demonstration and the other acre for the seed multiplication.

Treatments for the demonstrations were; two cowpea varieties and farmers practice versus the recommended practice of cowpea production. The communities involved were also exposed to various storage methods especially hermetic ones such as the triple bagging technique that was developed and introduced by the Purdue University in collaboration with SARI scientists.

i. Size of each demonstration plot: $1000m^2$ (total of $4000m^2$)
ii. Size of each community farm : 1acre (total of 4 acres)
iii. Varieties produced: Padi-tuya and Songotra
iv. Locations : Gubgomo, Bininaayilli, Guabulgu and Langbensi

Planting was done at spacing of 60 cm x 20cm and fertilizer was applied at rate of 25-60-30 of urea, triple single supper phosphate (P_2O_5) and muriate of potash (K_2O). Karate 2.5 E.C at rate of 60mls per 15litres knapsack sprayer to effectively control insect pests at the vegetative, pre-flowering, flowering and pod development stages.

Results and Discussion

Cowpea demonstration:

There was significant difference ($p \leq 0.05$) between maturity period and grain yield. Songotra was five days earlier than Padi-tuya and also recorded the highest yield of 778kg/ha which was greater than the average yield of the two varieties (Table 23). Yields were generally low due to the erratic rainfall witness this year. However, this also indicates that, songotra was a better variety under drought conditions.

Recommended practice gave yields greater than the farmer practice but was late in maturity compared to the farmer practice (Table 24). This could be due to the fertilization resulting in vigorous growth and extension of the vegetative growth period. There was significant ($p \leq 0.05$) interactive effect between variety and practice for grain yield (Table 25). Songotra under the recommended practice recorded the greatest grain yield (992 kg/ha) at all locations, indicating that, for farmers to get the best yield in cowpea production, they should cultivate Songotra with the recommended practice of spacing, planting in rows, apply fertilizer especially phosphorus , control insect pests and harvest at appropriate maturity period.

Table 23. Performance of two improved cowpea varieties on Days to maturity and grain yield (kg/ha)

Variety	Days to maturity	Grain yield (kg/ha)
Padi-tuya	66	380
Songotra	61	778
Mean	64	579
LSD (0.05)	2.6	129.3
CV (%)	3.0	78.7

Table 24. Performance of agronomic practice on Days to maturity and grain yield (kg/ha)

Practice	*Days to maturity*	*Grain yield (kg/ha)*
Recommended	68	730
Farmer	60	430
Mean	64	580
LSD (0.05)	1.9	27.3
CV (%)	3.0	78.7

Table 25. Interaction between variety and practice on maturity and yield

	Practice			
	Days to maturity		Grain yield	
Variety	Recommended	Farmer	Recommended	Farmer
Padi-tuya	71	65	468	293
Songotra	65	58	992	565
Mean	68	62	730	429
SE	1.26		263	
CV (%)	3.42		78.7	

The project recorded a remarkable increase in accessibility of farmers to these released improved cowpea varieties which contributed to 20% increase in cowpea production in districts where the project was implemented.

Farmers, private seed companies and SeedPAG were the primary beneficiaries and secondary beneficiaries were the market women and cowpea consumers. About 30,000 smallholder cowpea farmers had access to improved seed for increase production.

Community seed production:
The project assisted three cowpea farming villages to produce seed of songotra and Padi-tuya varieties. Five hundred and fifty kilograms (550kg) seed of both varieties was produced. This quantity was enough to cultivate thirty hectares (30ha) of cowpea foundation seed next cropping season. The produce forms the planting material for all cowpea farmers in the community. This will help promote, disseminate and diffuse these newly released varieties and also improve on farmers' accessibility to these varieties. This concept is sustainable in that incomes generated from the sale of seeds to the community are ploughed back for subsequent seed production. This hopefully, will expand in subsequent years to engage more farmers to increase their production of cowpea by the use of improved varieties.

Breeder seed production:
Breeders in research institutes are mandated to produce breeder seed of released varieties to supply foundation seed growers. Seven hundred and sixty (760) kilograms breeder seed of four released varieties was produced over the period and shall be given to foundation seed growers. It is anticipated that this quantity can cultivate about hundred acres (100acres) of foundation seed.

Conclusion
Resources (human and material) and the necessary logistics exist for the attainment of project objections. Genetic makeup of selected genotypes will be enhanced through hybridization to incorporate traits relevant to the attainment of project objectives. The only threat to the project is environmental conditions. High night temperatures and erratic rainfall, major products of climate change in our part of the world may affect the performance of high performing genotypes.

Way Forward
The AGRA-Cowpea project will continue with screening more genotypes for resistance to *striga, thrips,* pod sucking bugs and high nitrogen fixing ability. Five set of trials consisting 82 cowpea genotypes with various characteristics have been received from IITA to enrich the programme with more diverse materials for local selection and adaptation. They will be screened and promising genotypes will be identified and selected. Genetic

makeup of selected genotypes will be enhanced through hybridization to incorporate traits relevant to the attainment of project objectives.

Genetic analysis (mode of inheritance) will be performed on crosses to ascertain the possibility of developing a single variety that will combine all four attributes (high yielding and resistance to Striga, pod sucking bugs and thrips). Scale up the acreages under breeder seed production of all recommended cowpea varieties to meet seed requirements of foundation seed growers.

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Determining the Population Dynamics of *Maruca vitatra* on Cowpea in Northern Ghana

Dr. IDK Atokple, Dr. M. Abudulai and Issah Ramat

Executive Summary

The trial was carried out to help determine the appropriate screening technique for Maruca in terms of adequate selection pressure either by natural infestation or augmented by artificial infestation. The experiment which started on 28 July 2011 involved six cowpea lines with four planting dates at weekly intervals. For all the cowpea lines tested, Maruca infestation increased over time during the season and therefore the late planted crops were affected most. The results showed that correlation between the intensity of Maruca infestation and grain yield were significantly negative. There is the need for further tests or monitoring of the pest dynamics most importantly with the introduction of the pre-cereal cowpea production system in northern Ghana.

Introduction

The knowledge of generation time and the population dynamics of an insect species are crucial in resistance screening trial in a breeding program. Some insects have a very low potential for population size increase, whereas others have explosive potential. Besides, with crops, such as cowpea, several insect species usually occur simultaneously. To avoid the situation of natural infestation failing to give good discrimination among plant genotypes under natural infestation, there is the need to augment this with artificial infestation. This phenomenon warranted the execution of this experiment.

Materials and Methodology

The experiment which started on 28 July 2011 involved six cowpea varieties, Apagbala, Zaayura, Songotra, Bawutawuta, Padi Tuya and IT86D 1010 with four planting dates at weekly intervals. The design was split-plot with three replications, where the planting times were the main plots and the varieties the sub-plots. Twenty (20) flowers per variety were sampled on the three occasions (Fig.9). Data on Maruca infestation (count per flower) (Fig. 2) were collected as the crops came into flowers. Visual assessments of pods damage on a 1-5 scale were used; where 1 represented the least damaged and 5 the most damaged. The data were analysed using the GENSTAT statistical package to separate means.

Fig. 6. Data collection on the field

Fig. 7. Maruca counts in the lab

Results and Discussions

Maruca damages were visible on the fresh pods in the field (Fig. 8). For all the cowpea lines tested, Maruca infestation increased over time during the season resulting in the highest damage registered on the late planted crops (Fig. 9). This observation was corroborated by the significant positive correlation between date of planting and Maruca infestation (Fig. 10). On the contrary, the results showed significant negative correlation ($p \leq 0.5$) between grain yield and intensity of *Maruca* infestation (Fig. 10). This calls for a further monitoring of the pest dynamics with the introduction of the pre-cereal cowpea production system in northern Ghana. Both *Maruca* and *thrips* were found in the same flowers sampled; a phenomenon that calls for an integrated control measure for the two key pests of cowpea.

Fig. 8. Maruca damages of pods and leaves.

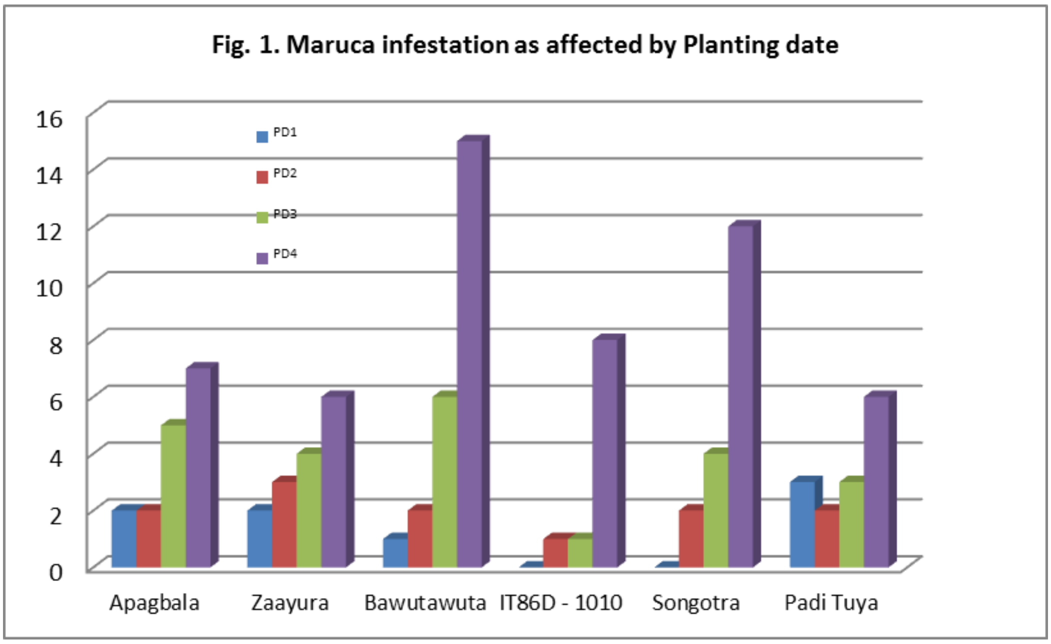

Fig. 9. Maruca infestation as affected by Planting date

Fig. 10. Correlation Coefficients among Parameters

	DFF	Maruca Infestation	Grain Wt.	Planting Date
DFF	-	0.169	0.183	0.354
Maruca Infestation		-	-0.503*	0.722*
Grain Wt.			-	-0.275
Planting Date				-

RTIMP ENTOMOLOGY

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

S. K. Asante and Alhassan Sayibu

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 2011), 548,339 predators have been produced in the laboratory and released in 187 locations in 13 districts in northern, Volta and Brong-Ahafo regions of Ghana. During the year under review, 115,000 predators were reared and released in 39 locations in 9 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, 2009, 2010).

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

From August 2001 to December 2011, 548,339 predators have been produced in the laboratory and released in 187 locations in 13 districts/municipal/metro in northern, Volta and Brong-Ahafo regions. The districts/municipal/metro are West Gonja, East Gonja, Yendi, Nanumba north, Nanumba south, Zabzugu-Tatale,Tolon-Kumbungu, Tamale, Central Gonja, Nkwanta north, Nkwanta south, Kpandai and Kintampo north. 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, 115,000 predators were reared in the laboratory and released in 39 locations in 9 districts (see the table below).

Table 26: The larger grain borer (LGB) predators reared and released at CSIR-SARI in 2011

Date	**District**	**Community**	**Number released**
29-05-2011	Kpandai	Kojoboni	8,000
30 – 06 - 2011	East Gonja	Lantinkpa	11,000
29 – 07 - 2011	Nkwanta South	Kacheibi Nsuaja	4,000
		Kacheibi	2,000
		Ashiabre	4,000
		Odumasi	3,000
30– 08 - 2011	Yendi	Kpalkori	2,000
		Jimli	2,000
		Kpligine	2,000
		Salinkpang	2,000
		Sang	2,000
		Puriya	2,000
30 – 08 - 2011	Tamale	Zakaliyili	2,000
		Tugu	2,000
31 – 08 - 2011	East Gonja	Lantinkpa	2,000
		Bunjai	2,000
		Gushei Zongo	2,000
		Garin Shani	2,000
		Mariche	2,000
21 – 09 - 2011	Nanumba North	Makayili	4,000
		Lepusi	2,000

		Bincheratanga	2,000
		Buariyili	3,000
29 – 09 - 2011	Savelugu-Nanton	Gushei	3,000
		Diare	4,000
		Kadia	2,000
		Pigu	2,000
		Kukobila	3,000
30/09/2011	Tolon-Kumbungu	Tunayili	2,000
		Gbulahugu	2,000
	Central Gonja	Mpaha Junction	2,000
		Fufulso	2,000
		Macheli Kura	2,000
23 – 11 - 2011	East Gonja	Kura	2,000
		Kpalayili	4,000
		Taanga	4,000
		Dikingh	4,000
		Bunjai	4,000
		Gidanture	4,000
Total (2011)	**9**	**39**	**115, 000**

Farmer Field Fora (FFF) Implementation under the Root and Tuber Improvement and Marketing Programme (RTIMP)

S. K. Asante, A. Abunyewa, J. Adjebeng-Danquah, A. Nimo Wiredu, S. Alhassan

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 66 FFFs have been conducted on cassava, yam, sweet potato and frafra potato in 2008, 2009, 2010 and 2011. 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 training, fora participants, site or land for the Fora and develop learning guide.

Twenty six (26) Farmer Field Fora (FFFs) were established during the year under review in the following districts: Nkwanta south, Nkwanta north, West Gonja, Nanumba North, Nanumba south, Kassena-Nankana East, Kassena-Nankana West, Kpandai, Saboba, Bongo and Bawku West. A total of 1,040 farmers/traders/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. Three hundred (300) mounds were obtained in the integrated crop management (ICM) plot whilst 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 the Farmer practice plot. Moreover, pest infestation was higher on FP than ICM. At harvest, the farmers observed that the number of tubers obtained from the ICM plot was more and also weighed higher 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. Improved sweet potato varieties (Teksantum and Santumpuna) gave higher yields than Fara and CRI-Otoo in three communities in Kassena-Nankana West district.

Application of inorganic fertilizer (NPK) to the improved varieties results in vegetative growth and low tuber yields. Tuber yield from 30cm and 20cm vine lengths were not significantly different suggesting that 20cm vine length can be used in situations where there is a shortage of planting material. Also, planting at double row on 1m x 1m bed size gave significantly higher yield than the recommended 1m x 1m single row planting.

Background

The Farmer Field Fora (FFF) implementation which began in 2007 is still on-going (CSIR-SARI Annual Report 2007). So far 66 FFFs have been conducted on cassava, yam, sweet potato and frafra potato in 2008, 2009, 2010 and 2011. Twenty six (26) FFFs were established during the year under review with one thousand and forty (1,040) farmers as participants. The Farmer Field Fora (FFF) is an innovation introduced by the Root and Tuber Improvement and Marketing Programme (RTIMP) as a platform for mutual learning for smallholder farmers, extension agents and researchers. 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 December 2011)

The Farmer Field Fora (FFF) implementation is usually preceded by sensitization of communities and conduct of Participatory Rural Appraisal (PRA) to: (i) interact with the farmers to know their farming practices, challenges or constraints (ii) select the thematic area, participants and site for the Fora.

Table 27. Communities and crops on which the PRA was conducted

District	Community	Date	No. of participants M	F	Crop
West Gonja	Sori no. 2	05-04-11	25	14	Cassava
	Sori no.3	06-04-11	49	39	Cassava
East Gonja	Lantinkpa	22-03-11	70	25	Cassava
	Meriche	03-04-11	42	39	Cassava
Nanumba South	Sakpe	17-03-11	31	19	Yam
	Tampoaya	18-03-11	38	12	Yam
Saboba	Chakpong	15-03-11	25	22	Yam
	Kpalba	26-06-10	29	23	Yam
Kpandai	Kojoboni	16-03-11	68	36	Yam
	Buya	19-03-11	37	13	Yam
Nanumba North	Chakpong	17-03-11	25	22	Yam
	Kpalga	15-03-11	26	10	Yam
	Jilo	29-03-11	28	16	Yam
Nkwanta North	Ogyiri	20-03-11	43	47	Yam
	Kamachu	21-03-11	42	22	Yam
Nkwanta South	Brewaniase	25-05-11	39	25	Cassava

	Tutukpene	26-05-11	41	61	Cassava
	Nyankoma	27-05-11	40	13	Cassava
Kassena-Nankana East	Bawin	19-04-11	40	10	Sweetpotato
	Wusungu	19-04-11	54	36	Sweetpotato
	Nimbasinia	20-04-11	28	22	Sweet potato
Kassena-Nankana West	Awuntanga	21-03-11	23	27	Sweetpotato
	Buru-Navio	18-04-11	29	28	Sweetpotato
	Saaka	25-05-11	24	15	Sweet potato
Bongo	Ayelbia	13-07-11	17	3	Frafra potato
Bawku West	Buluugu	14-07-11	34	36	Frafra potato
Total	**26**		**935**	**622**	
Percentage (%)			**60**	**40**	

Some major constraints mentioned by farmers:
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

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 and Frafra potatoes

- 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

Table 28. 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, Yam	Integrated pests and diseases management
Nanumba south	2	Yam	Integrated soil fertility management
Nanumba north	3	Yam	Integrated pests and diseases management
Kpandai	2	Yam	Integrated pests and diseases & soil fertility management
Saboba	2	Yam	Integrated soil fertility management
Kassena-Nankana East	3	Sweet potato	Integrated soil fertility management
Kassena-Nankana West	3	Sweet potato	Improved cultivation practices
Nkwanta north	2	Yam	Integrated soil fertility management
Nkwanta south	2	Cassava	Improved cultivation practices

Bawku West	1	Frafra potato	Improved varieties
Bongo	1	Frafra potato	Improved varieties

Table 29. Learning plots for Yam FFFs

No.	Plots	Description
1	Farmer Practice (FP)	Haphazard and widely spaced mounding (15-2.2 m apart) on 24m x 18m land area which gave 144-231 mounds. Some staked and others non-staked, no seed treatment
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; (i) Fungicide: Manzocarb (4 match boxes/15 litres of water) (ii) Insecticide: Deltametrin (50 ml in 15 litres of water)

Table 30. 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 15cm planted 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. Varieties used: Amuntanga – Nankaripeliga, Navio – Nanuchichera (Burkina), Saaka – Naanu-yaara (Burkina Orange fresh)
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: Fara, Tek-Santum, Santum-Puna and CRI-Otoo (iii) Inorganic fertilizer (NPK) 30-45-60kg/ha (one tea spoon about 6g) was applied two weeks after planting
3	Participatory Action Research (PAR)	(i) Effect of **(a)** bed type (1.0 m, 0.8m and 0.7m) **(b)** vine length (30cm, 20cm and 15cm), **(c)** plant density (1m bed size of single role, and 1m bed size of double role) on yield of sweet potato

Yam FFF results

After mounding, the farmers realized that their practice results in low plant population and therefore wasting the land. Three hundred (300) mounds were obtained from the ICM plot of 24m x 18m (432m^2) land area (i.e. 6,944 mounds/ha) whereas the farmer practice plot gave a range of 144 – 225 mounds on the same land area (i.e., 333 – 5,347 mounds/ha) cross the districts (Table 31). Farmers in Saboba districts were found to mound closer than those in the other districts. Percentage sprouting was higher on the ICM plot where seeds were treated with fungicide and insecticide mixture 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 (Tables 32 and 33). Both the insecticide and fertilizer treated plots yielded higher than the untreated (FP) plots. Also pest infestation was higher on FP than ICM (Table 34). Moreover, they found the fertilizer treated yam to taste better than the untreated. 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 31. Number of mounds per unit area for Integrated Crop Management (ICM) and Farmer Practice (FP) plots

District	Community	No. of mounds/ 432m^2 (ICM)	Estimated no. of mounds/ha (ICM)	No. of mounds /432m^2 (FP)	Estimated no. of mounds/ha (FP)[1]
Kpandai	Kojoboni	300	6,944	180	4,167 (**40.0**)
	Buya	300	6,944	144	3,333 (**52.0**)
Nanumba South	Tampoaya	300	6,944	187	4,328 (**37.7**)
	Sakpe	300	6,944	183	4,326 (**37.7**)
Nanumba North	Makayili	300	6,944	182	4,213 (**39.3**)
	Jilo	300	6,944	188	4,351 (**37.3**)
	Kpalga	300	6,944	179	4,144 (**40.3**)
Nkwanta North	Ogyiri	300	6,944	183	4,236 (**39.0**)
	Kamachu	300	6,944	164	3,796 (**45.3**)
Saboba	Chakpong	300	6,944	231	5,347 (**23.0**)
	Kpalba	300	6,944	225	5,208 (**25.0**)
East Gonja	Lantinkpa	300	6,944	192	4,444 (**36.0**)

[1] Percentage reduction in plant population per Hectare is in parenthesis

Table 32. Yield of yam treated with inorganic fertilizer at Kojoboni, Kpandai district

Treatment	Plot size (m^2)	Total no. of mounds per plot	Total no. of tubers harvested	Total wt of tubers (kg)	Estimated no. of tubers per ha	Yield (ton/ha)
FP (No. treatment)	432	180	195	351	4,514	8.0
ICM (Inorganic fertilizer)	432	300	350	597	8,102	13.0 (**62.5%**)

*Percentage increase over the farmer practice

Table 33. Yield of yam treated with insecticide at Lantinkpa, East Gonja District

Treatment	Plot size	Total no. of mounds per plot	Total no. of tubers harvested	Total weight of tubers (kg)	Estimated no. of tubers per ha	Yield (ton/ha)
FP (No. treatment)	432	192	175	200.5	4,051	4.64
ICM (Insecticide treated)	432	300	249	240.6	5,764	5.57 (**20%**)*

*Percentage increase over the farmer practice

Table 34. Percentage of yam tubers infested by pests and diseases at Lantinkpa in East Gonja district

Treatment	Termite	Mealy bug	Scale insect	Tuber beetle	Millipede	Nematode	No. of rotten tubers
FP	6.9	4.6	0	18.8	25.7	12.6	4.6
ICM	2.3	17	0	5.7	17.1	7.4	1.7

Sweet potato

The farmer varieties were found to be early maturing and yielded higher than the improved varieties (Table 35). Teksantum and Santumpuna are the varieties found to be suitable for the communities. Fara and CRI-Otoo are late maturing so they could not complete maturity before the end of the rainy season since planting was done late (end of July). Application of inorganic fertilizer (NPK) to the improved varieties resulted in vegetative growth and low yields. The yield of 30cm and 20cm vine lengths were not different suggesting that 20cm vine length can be used in situations where there is shortage of vines (Table 36). Also, bed size of 1m apart was found to give higher yield in all the three locations (Table 37). However, planting at 1m x 1m double row was found to be better in terms of yield than the recommended 1m x 1m single row (Table 38).

Table 35: Yield (Kg/100m^2) of improved sweet potato varieties in Kassena-Nankana West District

Community	Variety	Yield (kg/100 m^2)	Yield (ton/ha)
Amuntanga	**Improved**[1]		
	Fara	2.0	0.20
	Santumpuna	9.8	0.98
	CRI-Otoo	11.7	1.17
	Local*		
	Maanga	11.8	1.18
	Nankaripeliga	13.2	1.32
Buru-Navio	**Improved**		
	Fara	0.25	0.03
	Teksatum	16.6	1.66
	Santumpuna	9.20	0.92
	CRI-Otoo	2.20	0.22
	Local		
	Benagnapuna	13.2	1.32
	Nankaripeliga	32.4	3.24
Saaka	**Improved**		
	Fara	0.40	0.04
	Teksantum	9.20	0.92
	Santumpuna	4.40	0.44
	CRI-Otoo	4.40	0.44
	Local		
	Nanukasinga	10.00	1.00
	Burkina	24.70	2.47

*Farmer varieties planted on Farmer Practice plot
[1] Improved varieties were planted on ICM plot using the recommended 1m x 1m bed size

Table 36. Effect of vine length on the yield of sweet potato

Community	**Vine length**	**Yield (kg/80m^2)**	**Variety**
Amuntanga	30cm 20cm 15cm	9.6 14.0 9.3	Santumpuna
Buru-Navio	30cm 20cm 15cm	3.6 3.8 1.6	Teksantum
Saaka	30cm 20cm 15cm	14.0 13.6 2.5	Teksantum

Table 37. Effect of bed size on the yield of sweet potato

Community	Bed size	Yield (kg/80m^2)	Variety
Amuntanga	1.0m 0.8m 0.7m	3.7 2.8 2.0	Fara
Buru-Navio	1.0m 0.8m 0.7m	2.1 1.9 1.5	Tek Santum
Saaka	1.0m 0.8m 0.7m	4.2 3.4 1.4	Tek Santum

Table 38. Effect of plant density on the yield of sweet potato (Teksantum)

Community	Yield (kg/100m^2) at plant density of 1m x1m double role	Yield (kg/100m^2) at plant density of 1m x 1m single role
Amuntanga	36.6 (123.2%)*	16.4
Saaka	13.0 (58.5%)	8.2

- Percentage increase in yield

SOIL FERTILITY AND MICROBIOLOGY

Boosting maize cropping system productivity in northern Ghana through widespread adoption of Integrated soil Fertility Management

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

Executive Summary

Five Demonstrations were carried out 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 under low fertility levels. 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 Phosphorus fertilizer (P) application on soybean yield. The demonstrations were carried out incollaboration with MoFA and managed by Farmer-based Organizations (FBOs). The FBOs were trained in governance, managing farming as a business, and credit management. The AEAs were trained in Farmer Field School (FFS) facilitation and extension communication. Adaptive research was carried out in two agro-ecologies (Guinea and Sudan savanna) on selected benchmark soils to determine site specific fertilizer recommendations for northern Ghana.

Averaged over the three northern regions, one-year rotation of cowpea with maize resulted in maize yield of 1.9 t/ha that is statistically similar to the mean for full fertilizer rate of 2.2 t/ha. The yield of Obatampa (2.5 t/ha) was similar to that of hybrid maize Etubi (2.3 t/ha). DT Maize Aburohema (2.2 t/ha) and Omankwa (2.4 t/ha) out-yielded Farmer varieties (1.7 t/ha). Organic fertilizer (fertisoil) increased maize yield (1.8 t/ha) similar to cowdung (1.8 t/ha) and mineral fertilizer (2.3 t/ha). When soybean was inoculated and fertilized with P and K, the yield (1.7 t/ha) was more than double that of the control (0.81 t/ha). Maize yield without soil amendment was below 0.5t/ha. The fertilizer recommendation obtained from DSSAT modelling was NPK 120 90 60 as N, P_2O_5 and K_2O, kg/ha. Hundred AEAs and 85 agro-dealers were trained. Radio programs, exchange visits and FFS were used to up-scale ISFM in all regions.

Introduction

Project rationale/Background

Northern Ghana is considered as the bread basket 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 quality seed, fertilizers, credit and market. The rational of this project was to contribute to agricultural production and reduce poverty through up-scaling integrated soil fertility management (ISFM) practices, strengthening capacity of extension agents and farmers, developing fertilizer recommendations and monitoring the impact of ISFM adoption on livelihoods of farmers.

Materials and Methodology

Sixteen ISFM technologies were packaged into 5 Demonstration and installed in 150 communities in northern Ghana comprising Northern, Upper East and Upper West Regions. 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 under different fertilizer levels. 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 in collaboration with MoFA and managed by Farmer-based Organizations (FBOs). FBOs and agro-dealers were profiled and trained. FBOs were trained in governance, managing farming as a business, and credit management. AEAs were trained in Farmer Field School (FFS) facilitation and extension communication. Radio and TV programs were used to reach farmers with extension messages. Adaptive research was carried out in two agro-ecologies (Guinea and Sudan savanna) on selected benchmark soils to determine site specific fertilizer recommendations for northern Ghana.

Results and Discussions

Scientific findings

Averaged over the three northern regions, one-year rotation of cowpea with maize resulted in maize yield of 1.9 t/ha that is similar to the mean for full fertilizer rate of 2.2 t/ha. The yield of Obatanpa (2.5 t/ha) was similar to that of hybrid maize Etubi (2.3 t/ha). DT Maize Aburohema (2.2 t/ha) and Omankwa (2.4 t/ha) out-yielded Farmer varieties (1.7 t/ha). Organic fertilizer (fertisoil) increased maize yield (1.8 t/ha) similar to cowdung (1.8 t/ha) and mineral fertilizer (2.3 t/ha). When soybean was inoculated and fertilized with P and K, the yield (1.7 t/ha) was more than double that of the control (0.81 t/ha). Maize yield without soil amendment was below 0.5t/ha. The fertilizer recommendation obtained from DSSAT modelling was NPK 120-90-60 and NPK 80-60-60 kg/ha as N, P_2O_5 and K_2O for Tolon/ Kunbungu.

Technology Developed: DSSAT was calibrated for Northern Region

Technology transferred

Integrated Soil fertility management technologies were transferred in 150 communities in 35 districts in the 3 northern regions. 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 seed before planting.

Conclusions/Recommendations

Maize productivity can be increased substantially by use of ISFM. Without fertilizer application, maize production is not viable in northern Ghana. Use of organic fertilizers and crop rotation are important for increased maize yield. DT Maize has high potential in northern Ghana. Farmers can more than double their soybean yield with the use of rhizobium inoculant.

Future activities/The way forward: The above activities will be continued in 2012.

Enhancing small-holder cowpea legume production using rhizobium inoculants

Mathias Fosu, Robert Boddey and William Atakora.

Executive Summary

The response of cowpea to two levels of N (40 and 80 kg/ha) and three cowpea rhizobium strains (BR 3262, BR 3267 and BR 3299) from EMBRAPA, Brazil, were evaluated in on-station and on-farm trials. On-station data showed that inoculation did not increase the yield of cowpea and application of N at 40 and 80 kg/ha depressed the yield of cowpea. On-farm data, however, showed that cowpea yield could be significantly increased when inoculated with BR 3267 (1062 kg/ha) and BR 3299 (859 kg/ha) compared with control (675 kg/ha) and N at 40 kg/ha (616 kg/ha). Nodule weight was significantly increased by inoculation.

Introduction

Project rationale/Background

Cowpea is an important legume in the diet of smallholder farmers in Ghana. Over 150,000 ha are allocated to the crop in the three northern regions with Upper West Region being the leading producer accounting for 43% of the fields (MoFA SRID, 2011). Cowpea is usually cropped on marginal soils that are either too poor to support cereals or soils that are gravelly and unsuitable for most crops. As a legume it nodulates freely and has the ability to fix nitrogen and therefore able to give reasonable yields on most poor soils. However, yields commonly attained by smallholder farmers in northern Ghana are usually below 1.0 kg/ha. Previous attempts to increase the yield of the crop through inoculation have not been successful as the rhizobium strains used did not compete better than the local strains. Recently EMBRAPA in Brazil isolated a number of strains that have been shown to improve yield of cowpea. The objective of this project was to evaluate three of the strains on local cowpea varieties.

Materials and Methodology

There were on-station and on-farm experiments.

The On-station experiment consisted of 7 treatments using cowpea variety Padi Tuya as follows:

T1: Cowpea inoculated with Rhizobium strain BR 3262.
T2: Cowpea inoculated with Rhizobium strain BR 3267.
T3: Cowpea inoculated with Rhizobium strain BR 3299.
T4: Cowpea with no inoculation (control).
T5: Cowpea with no inoculation and with the addition of 40 kg N as ammonium sulphate.
T6: Cowpea with no inoculation and with the addition of 80 kg N as ammonium sulphate.
T7: Cowpea seed sterilized 5 min in ethanol to eliminate any native rhizobium on the seed surface.

Plot size was 150 m^2, with five replications.

The on-farm experiment consisted of four treatments using the same cowpea variety Padi Tuya.

T1: Cowpea inoculated with Rhizobium strain BR 3267.
T2: Cowpea inoculated with Rhizobium strain BR 3299.
T3: Cowpea with no inoculation (control).
T4: Cowpea with no inoculation and with the addition of 40 kg N as ammonium sulphate.

Plot size varied from farmer to farmer between 15 x 10 m and 25 x 20 m. One kg of seed was inoculated with 5g of inoculant in 30 ml of 20% sugar solution mixed with the seeds and spread to dry for 1 hr before planting.

Results and Discussions

Scientific findings

On-station data showed that inoculation did not increase the yield of cowpea. Addition of N at 40 and 80 kg/ha depressed the yield of cowpea and nodulation significantly.

On-farm data however showed a significant effect of inoculation on cowpea grain yield with BR 3267 giving a better performance (1062 kg/ha) than BR 3299 (859 kg/ha) compared with the control (675 kg/ha). BR 3267 gave significantly higher nodule number and nodule weight than all the other treatments. Both strains gave higher nodule number than the control but the nodule weight for the control was higher than BR 3299.

Farmers showed interest in the use of inoculants on cowpea and were enthusiastic about using it. They are already familiar with the use of inoculums on soybean

Technology Developed

Rhizobium inoculant was produced in SARI and distributed to farmers. Capacity has been developed at the institute to produce inoculants for cowpea and soybean.

Technology transferred

Inoculation of cowpea seeds with rhizobium was transferred to farmers. Fifteen (15) farmers were trained in three districts in Northern Region on inoculation.

Conclusions/Recommendations

The rhizobium strains have potential to increase nodulation and grain yield of cowpea in northern Ghana.

Future activities/The way forward

More experiments will be set up on-farm and on-station. A SARI Technician will be trained in Brazil in inoculant production. A rhizobiology laboratory will be set up in SARI to produce inoculants for farmers.

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

Mathias Fosu and B.D.K. Ahiabor.

Introduction

Project rationale/Background

Maize requires fertile soil for optimum production. Its response to organic and inorganic fertilizers has been fairly well documented in northern Ghana. However, the interactive effect of integrated soil fertility management and different forms of tillage practices has not been investigated. The objective of the study was to assess the effect of tillage and ISFM options on maize yield.

Materials and Methodology

A split-plot experiment with two factors- fertilizer and tillage replicated 4 times was installed at Nyankpala. The four levels of fertilizer were: no fertilizer, NPK 60-30-30, 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 weeds on the zero tillage plots were killed with Roundup (Glyphosate) at 2 *l*/ha. After planting, the entire field was sprayed with pre-emergence herbicide Atrazine at 4*l*/ha.

Results and Discussions

Scientific findings

The yield under manual, zero and bullock tillage were similar. However, manual tillage was the best in terms of maize grain yield (3.6 t/ha) followed by zero tillage (3.1 t/ha) and bullock (2.9 t/ha) in that order. Tractor tillage gave the lowest yield of 2.4t/ha. Mineral fertilizer at recommended rate (NPK 60-30-30 as N, P_2O_5 and K_2O) gave the highest grain yield of maize (3.7 t/ha) followed by manure + mineral fertilizer application (3.5 t/ha). Maize yield with manure alone was 2.9 t/ha while no soil amendment produced maize yield of 1.2 t/ha. The relatively high yield without soil amendment was largely derived from the no till plots.

Conclusions/Recommendations

Best maize yield is obtained when manual and zero tillage are practiced. Mixture of mineral and organic fertilizer at half rate gave high yield of maize. Conservation agriculture practice will increase maize yield in the Guinea Savanna.

Evaluation of different soybean, cowpea and groundnut varieties for yield, BNF potential and acceptability by farmers in northern Ghana

Rev-Dr. Benjamin D. K. Ahiabor

Executive Summary

The relative performances of six soybean, eight cowpea and six groundnut genotypes were evaluated in on-station trials with respect to biomass production, nodulation and grain yield. In addition, responses of the soybean genotypes to Rhizobium inoculation were studied. All these crops were fertilized with fertisoil (an organic manure) and BoostXtra. Of the soybean varieties grain yield in Anidaso was remarkably enhanced by rhizobium inoculation whereas grain yield of Jenguma remained the same whether inoculated or not. Bawutawuta tended to be the most prolific of all the cowpea varieties tested in terms of nodulation, pod and grain yields whilst Zayura produced the highest biomass and the largest seed. Nkatiesari and Samnut 22 tended to be the best of the groundnut varieties evaluated in terms of grain yield and biomass production, respectively. These two groundnut varieties had the highest pod weights and largest seed sizes

Introduction

There are currently many productive varieties of various grain legumes with strong biological nitrogen fixation (BNF) efficiency available from local and international research institutes in Africa that are ready for deployment to farmers. It is important that these lines be compared with those currently available and their need for rhizobium inoculants established. Soybean has a specific requirement for rhizobia and thus a high potential to respond to inoculation. These must be field-tested using inoculants currently available on the market after quality testing.

The other target grain legumes (cowpea and groundnut) are promiscuous and unlikely to respond to inoculation in most soils without intensive research on strain competition and inoculant delivery systems. The objectives of the variety trials therefore were (i) to evaluate the yield and BNF potential of different varieties of soybean, groundnut and cowpea in different agro ecological zones of northern Ghana and (ii) to evaluate the impact of biophysical conditions on the above responses.

Materials and methods

On-station soybean variety trial at Nyankpala was planted on 12th July, 2011 on 4.5 m x 3.0 m plots and that of cowpea was installed on 7th August, 2011 on 4.2 m x 3.0 m plots whereas that of groundnut was established on 4.2 m x 3.0 m plots on 9th August, 2011. Six soybean genotypes (Salintuya 1, Jenguma, TGX1834-5E, Anidaso, TGX1448-2E, Quarshie) were used for the trials whereas eight (8) cowpea materials (Bawutawuta, Apagbaala, Songotura, Zayura, Padi-tuya, Omondao, IT99-573-1-1, IT98K-205-8) were tested. The first five of these cowpea varieties were improved varieties that have been released by CSIR-SARI. The last two (IT98K-205-8 and IT99K-273-1-1) were dual-purpose varieties obtained from the TLII system in Nigeria.

Of the six varieties of groundnut used, two (Samnut 22 and Samnut 23) were obtained from Nigeria. The other four genotypes were Chinese, Nkatiesari, Manipinta and Bogla with the first three being released varieties. Bogla was obtained from the open market in Tamale. Soybean was sown at three seeds per hill and spaced at 50 cm (inter-row) x 10 cm (intra-row) whereas cowpea and groundnut were each sown at three seeds per hill (which were later thinned to two stands per hill) at an inter-row and intra-row distance of 60 cm and 20 cm, respectively. Before sowing, all plots received basal applications of fertisoil (a poultry manure-base organic manure) at least two (2) weeks before sowing at the rate of 4.0 t/ha as well as basal applications of P and K in the form of TSP and KCl, respectively at the rates of 30 kg P and 30 kg K /ha. The fertisoil was broadcast and incorporated in the soil by shallow tillage before sowing whereas the TSP and the MoP were applied in bands in a trench made 5 cm away from the plant stands and covered after application at varying days after sowing depending on the site. BoostXtra (a foliar fertilizer complex) was also applied to the plants through foliar spraying at 4 *l*/ha at least twice during the growth period of the plant. The soybean seed sown in the variety trials were either inoculated with *Rhizobium* inoculants (*Legumefix*) or not.

Results and discussion

Scientific findings

Most of the soybean varieties did not respond to rhizobium inoculation with respect to nodulation, plant biomass, pod and grain yields, with clear trends of suppression of nodulation due to inoculation (Table 39). Only in Anidaso did inoculation significantly increased grain yield, whereas grain yield responses of Salintuya 1 and Quarshie to inoculation were very poor with their non-inoculated counterparts significantly yielding more. The general lack of significant nodulation responses may have been due to a possible high amount of residual soil N since the previous maize crop was fertilized with sulphate of ammonia. Inoculation, however, increased the seed size of Jenguma in the absence of urea (Table 39). Bawutawuta tended to be the most prolific of the cowpea varieties tested in terms of nodulation, pod and grain yields whilst Zayura produced the highest biomass and the largest seeds (Table 40). Generally, Nkatiesari and Samnut 22 seemed to be the best performing varieties of the groundnut varieties evaluated in terms of grain yield and biomass production but Nkatiesari, Chinese and Bogla had the highest shelling per cent (Table 41). The small size of seeds of Chinese was confirmed by the lowest value of its 100-seed weight in this trial (Table 41).

Table 39. Responses of six soybean varieties grown on-station at Nyankpala to rhizobium inoculation in 2011

Treatment	Nodule score (no./plant)	Nodule dry wt. (mg/plant)	Biomass dry wt. (kg/ha)	Grain air dry wt (kg/ha)	I000-seed wt (g)
Salintuya 1+Ino	66 cd*	2911ab	3372.4b	1561.3e	112.00d
Salintuya 1-Ino	112 a	1805abc	5692.5a	2560.2bcd	123.50cd
Anidaso +Ino	66 cd	2915ab	4925.9ab	2558.1bcd	125.0bcd
Anidaso-Ino	91 abc	2915ab	4579.9ab	1601.3e	114.75d
Jenguma + Ino	71 bcd	2164abc	5211.2ab	3329.3ab	149.75a
Jenguma + Ino + Urea	84 abc	2949a	5147.4ab	2772.6abc	125.50bcd
Jenguma - Ino	94 abc	1806abc	5382.0ab	2778.2abc	130.50bcd
Quarshie +Ino	47 d	1299c	4172.8ab	2337.3cde	123.00cd
Quarshie -Ino	91 abc	1275c	4502.3ab	3470.5 a	131.0bc
TGX 1448 - 2E + Ino	69 bcd	2194abc	3798.4ab	3160.6ab	140.0ab
TGX 1448 - 2E - Ino	84 abc	1981abc	3294.8b	2993.3abc	126.50bcd
TGX1834-5E+ Ino	71 bcd	2886ab	3180.9b	1937.6ed	122.75cd
TGX 1834-5E - Ino	102 ab	2886abc	3337.9b	1715.4d	122.75cd
CV (%)	39.71	48.0	41.36	32.9	10.8

* Means in the same column followed by the same letter are not significantly different at the 5% level of probability.

Technology Developed;

Inoculation of soybean with Rhizobium inoculants for increased nodulation, biological nitrogen fixation (BNF) and increased grain yield

Table 40. Growth and yield performance of different cowpea varieties grown on-station at Nyankpala in 2011

Variety	Nodule score (no./plant)	Nodule dry wt. (mg/plant)	Oven dry biomass (kg/plant)	Grain dry wt (kg/plant)	Pod dry wt (kg/ha)	1000 seed wt (g)
Apagbaala	29ab	923.2ab	2920.3ab	969.63b	1699.0b	98.000e
Bawutawuta	46a	1255.3ab	3332.3a	1445.7a	2803.5a	123.00cd
IT98K-205-8	10b	493.0b	1414.6d	527.66c	1013.6c	105.75de
IT 99-573-1-1	21b	1438.3a	3222.0ab	661.28bc	1283.1bc	157.00b
Omondao	20b	449.0 b	2413.1bc	812.91bc	1157.1bc	112.00cde
Padi-tuya	22ab	478.1 b	3155.0ab	634.79c	1170.6bc	163.75b
Songotura	27ab	961.2 ab	1683.8cd	776.81bc	1374.4bc	126.50c
Zayura	24ab	860.0 ab	3665.3a	757.45bc	1339.9bc	174.50a
CV (%)	71.14	68.32	35.02	42.42	46.43	22.14

* Means in the same column followed by the same letter are not significantly different at the 5% level of probability.

Table 41. Growth and yield responses of six groundnut genotypes grown at Nyankpala in 2011

Variety	Biomass oven dry wt. (kg/ha)	Haulm dry wt. (kg/ha)	Pod dry wt. (kg/ha)	Grain yield (kg/ha)	Shelling %	100 seed wt (g)
Chinese	5269.9 ab	3217.5 ab	926.1 ab	647.62 ab	69.3 a	33.1 b
Nkatiesari	4202.2 b	2925.5 ab	1155.1 a	790.17 a	69.0 a	45.65 a
Manipinta	5247.4 ab	2145.2 ab	833.1 ab	517.22 b	61.5 c	37.65 ab
Samnut 22	6279.2 a	3310.8 a	1067.6 a	665.57 ab	61.8 c	41.55 a
Samnut 23	4450.1 ab	2563.8 ab	818.1 ab	527.44 b	63.5 bc	39.43 ab
Bogla	3927.5 b	1908.4 b	675.7 b	461.53 b	67.8 ab	38.85 ab
CV (%)	27.02	34.44	29.07	28.42	6.92	15.43

* Means in the same column followed by the same letter are not significantly different at the 5% level of probability.

Technology transferred

The technology mentioned above has been disseminated throughout northern Ghana and some parts of the Brong Ahafo Region through on-farm demonstrations. More than 24,000 soybean farmers have been covered in addition to agro-input dealers, students and research scientists.

Conclusions/Recommendations

Where there is a history of high nitrogen application, Rhizobium inoculants does not fully express its positive effect. It is recommended that this work be repeated in a soil with a history of low N input.

Future activities/The way forward

This work will be repeated in 2012 cropping season to further confirm the findings from the 2011 work

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

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

Executive Summary

Effects of varying levels of N, P, & K fertilizer nutrients on growth, tuber yield, tuber size, nutritional responses, taste, and shelf-life of yam were assessed in trials established in the Nanumba North, Tolon-Kumbungu and Sissala West Districts of northern Ghana using the yam cultivar Laribako and the existing farmers' cultivars in the respective districts. In the Sissala West District, mineral fertilizer application had no positive effect on tuber yield but the fertilizer rate of 120-40-80 (N-P_2O_5-K_2O) with organic fertilizer integrated increased the yield of the farmers' variety, Sanjiwale. The combination, however, only increased tuberization (i.e. increased tuber number) in Laribako in the absence of OM. The fertilizer combination 120-40-40 enhanced the tuber yields of both Laribako and the farmers' variety (a mixture of Chentito, Zugulangbon and Laribako) with or without organic manure application in the Tolon district. The yield increases in both varieties may be due to large tuber sizes. In the Nanumba North District, Laribako can be grown without both organic manure and mineral fertilizer applications. With organic manure, the 40N-40P_2O_5-80K_2O fertilizer combination may be appropriate to increase the yield of Alodo but without organic manure application, 40N-80P_2O_5-0K_2O can enhance the yield of Alodo. The results revealed that the effect of inorganic fertilizer (especially N) on the taste of yam was variable depending on whether organic manure was added or not, the variety used and the people engaged in the evaluation. However, in general, application of mineral fertilizer at the rates used did not reduce the taste of the yam cultivars assessed. It was also observed that mineral fertilizer application did not increase the rate of rotting in yam but when it was applied in combination with organic manure, it encouraged rotting.

Introduction

In spite of the enormous importance attributed to yam (*Dioscorea rotundata)* in northern Ghana, the crop has been the least considered on the scale of preference for fertilizer application aimed at yield improvements by farmers. In Ghana yam yield is estimated at 5.5 t/ha (unpublished data, MoFA, 1990) but it is recognized that yields of over 10 t/ha are achievable in the country. Mineral fertilizers can enhance the yields of yam but farmers are reluctant to apply soil amendments especially mineral fertilizers because they believe these factors have detrimental effects on cooking, palatability and storage qualities of harvested tubers (ICRA, 1996) despite the fact that soils of northern Ghana are inherently poor in plant nutrients especially, nitrogen and phosphorus. 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. It was observed from the results of the first year study that the different N, P, K fertilizer combinations applied to the yam did not have any differential effects on the parameters measured. In repeating the experiment, the three most promising treatments identified in year one (2010) experiments were selected and tested in on-farm researcher/farmer-managed trials in 2011 in Sissala West, Nanumba North and Tolon-Kum Districts in northern Ghana.

Materials and methodology

The trials were established at Demonayili in the Nanumba North District (with two farmers), at Kpalsawgu, Kpachi and Cheshegu in the Tolon-Kumbungu District (with five farmers), and at Silbelle and Sorbelle in the Sissala West District (with five farmers). On each farmer's field, the land was ploughed and mounds made with the hand-hoe at a spacing of 1 m x 1 m on 4 m x 4 m plots. Two cultivars of yam, Laribako and any existing farmers' (local) variety were tested. The trials were laid out in a split-plot design in which the yam cultivars were the main plots and the sub-plots were the selected best three fertilizer treatment combinations (T1, T2, T3) for each target district from the year 2010 work in combination with or without 3 t/ha of fertisoil (an organic manure). A control treatment, T0 (0-0-0) was also included. Each sub-plot was separated from the other by a 2.0-m alley. The respective treatment combinations (N-P_2O_5-K_2O) were 0-0-0, 40-80-0, 40-40-80 and 120-0-80 for the Nanumba North district, 0-0-0, 120-40-40, 80-80-120 and 0-80-80 for the Tolon-Kumbungu district and 0-0-0, 120-40-80, 120-40-120 and 80-80-120 for the Sissala West District as indicated in Table 1.

The fertisoil was generally applied simultaneously with the basal application of the mineral fertilizer except on the Cheshegu trials where the basal mineral fertilizer was applied ten days after the organic manure was applied.

The top-dressing of the mineral fertilizers was done generally four (4) weeks after the basal dose. Weeding was done as and when necessary and during the weeding exercise, collapsing mounds were reshaped where necessary. At harvest, tubers from four innermost mounds (plants) were dug out from each plot using hand-hoe and were counted, cleaned and weighed fresh. After weighing, pieces were cut from around the middle of one or two randomly-selected tubers, chopped and then weighed. These chopped samples were oven-dried at 80°C for 96 h dry weight measurement.

Palatability test was carried out at Cheshegu and Silbelle. At Cheshegu, Laribako and Alodo harvested at Demonayili were used for the evaluation using two groups of women consisting of five (5) women per group and two (2) groups of men comprising five (5) men per group. At Silbelle, the two yam genotypes, Laribako and Sanjiwale were used. Two groups of women and men, with each group comprising five (5) persons were used. For the shelf life studies, tubers of yam harvested from the Demonayili trials were arranged on rafters inside a straw (*zana* mat) barn constructed on SARI's experimental which has a concrete wall erected around it for protection against rodents. The weight loss in the tubers was monitored and measured weekly and the ambient temperature inside the barn was also recorded at the time of measuring the weights.

Results and discussion

Scientific findings:

Soil classification

Soils of the trial sites in the Nanumba North District, Tolon-Kumbungu District and Sissala West District belong to the Kumayili series, Kpalsawgu series and Varempere series, respectively.

Tuber yield

In the Sissala West District, the fertilizer combination120-40-80 (N-P_2O_5-K_2O) in association with fertisoil increased dry tuber yield of the farmers' variety, Sanjiwale by 35% and therefore can be recommended for it. This combination, however, only increased tuberization (i.e. increased tuber number) in Laribako in the absence of OM without a commensurate tuber dry matter increase. The fertilizer combination 120-40-40 (N-P_2O_5-K_2O) can be recommended without organic manure application to increase the yields (through increased tuber size) of both Laribako and the farmers' variety in the Tolon district. In the absence of the organic manure, the tuber dry matter yields of 5.8 t/ha and 4.0 t/ha for Laribako and farmers' variety, respectively caused by the 120-40-40 combination were equivalent to 64.5% and 63% increases over their respective non-fertilized controls. The tuber dry matter yield of 5.6 t/ha produced by the application of the same fertilizer combination with organic manure also caused a 43% yield increase in Laribako. In the Nanumba North District, Laribako can be grown without both organic manure and chemical fertilizer applications. With organic manure, the combination 40-40-80 may enhance the tuber yield of Alodo but without organic manure application, 40-80-0 can be recommended for tuber yield increase in Alodo. However, in the soils of this district, low applied fertilizer-N levels enhanced the effect of organic manure on tuber dry weight to the extent that in the presence of organic manure, the highest N rate applied depressed tuber yield in Laribako by 46%.

Palatability

For Laribako at both Silbelle and Cheshegu, the highest palatability scores were given by both men and women. These scores ranged between 3.1 and 3.7 on the scale of 1 to 4 where 4 was the most palatable. At Silbelle, these scores were for Laribako fertilized with 120N-40P_2O_5-80K_2O integrated with organic manure whereas at Cheshegu, the high scores were for yams that received organic manure but no chemical fertilizer. For the farmers' varieties, women ranked Sanjiwale fertilized with 80-80-120 in combination with organic manure highest (a score of 3.4) and women again ranked Alodo from the 0-0-0 and 120-0-80 fertilizer treatments in association with organic manure highest (scores of 3.6 and 4.0, respectively).It appeared that where a particular chemical fertilizer nutrient combination enhanced the palatability of yam, it did so when organic manure was co-applied.

Shelf life

In the absence of organic manure (OM), the fertilizer formulation with the highest N level (120-0-80) caused the least weight loss of 12.5% (a decrease of 25% over the unfertilized treatment) which means an increase in shelf life. However, in the presence of OM, the same level of N increased rotting in Laribako by 62% which was equivalent to a tuber weight loss of 33.3%. In the absence of both OM and chemical fertilizer (0-0-0-OM treatment), rotting in Alodo was quite high (33.3% weight loss) but in the presence of OM (0-0-0+OM), the level of rotting was halved (16.7% weight loss). Even though the effects of different fertilizer applications on shelf life of Alodo were inconsistent, the relatively highest weight losses were observed in fertilizer formulations that lacked potassium whether organic manure was applied or not.

Major Findings

Palatability (taste) of yam was enhanced with application of high amounts of fertilizer nitrogen to yam and this quality was enhanced in the presence of organic manure. The shelf-life of yam was also generally increased by application of high rates of fertilizer nitrogen but when applied together with organic manure the shelf life was reduced.

Technology developed

- The fertilizer combination 120-40-40 kg/ha ($N-P_2O_5-K_2O$) can be recommended with or without organic manure application for the cultivation of Laribako in the Tolon-Kumbungu District.
- Laribako can be produced in both the Nanumba North and Sissala East Districts without any chemical fertilizer amendments to the soil. But for the farmers' variety Alodo grown in the Nanumba North District, the combination 40-40-80 kg/ha ($N-P_2O_5-K_2O$) is recommended. Also, for the farmers' variety Sanjiwale grown in the Sissala East District the combination 120-40-80 kg/ha ($N-P_2O_5-K_2O$) can be recommended.
- Chemical fertilizers do not negatively affect the palatability (taste) of yam but they do so in the presence of organic manure
- Application of high rates of fertilizer nitrogen to Laribako generally increases tuber shelf life but when applied together with organic manure the shelf life is reduced.

Technology transferred: The developed technologies have not been transferred yet.

Conclusions/Recommendations

Farmers' beliefs that mineral fertilizers reduce the taste of yam and also increase rotting of yam are only perceptions.

Future activities/the way forward

The same work done in 2011 will be repeated in 2012 on-farm in the same districts to validate the results.

Reference

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, Wagningen, The Netherlands.

POSTHARVEST

Title of project: 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, Benjamin Ahiabor, Richard Yaw Agyare, Ayuba Jalilatu

Executive Summary

As per the agreement reached between the donor (IFDC) and the implementing agency (SARI), a trial was to be conducted to evaluate the performance of a newly bred rainy season tomato by the IFDC team in Nigeria against commonly cultivated varieties in Ghana. This trial was to measure the adaptability to local conditions, 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 IFDC team, 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, insecticide. An experiment was conducted at the station of the Savanna Agricultural Research Institute (SARI-Nyankpala) of the Council for Scientific and Industrial Research (CSIR-Ghana). Seeds were nursed on 6th June, 2011 and transplanted on the 10th July, 2011. The RCBD design was used with four replicates. Data was taken on plant height at anthesis (cm), Days to 50% flowering, number of fruits per plant, fruit size (mm), weight per fruit (g), weight (tons/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 weight (tons/ha). 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. The new variety however recorded higher values for titrable acidity and shelf life and came second after Tropimech for percent brix

Table 42. Agronomic characteristics of the three tomato varieities

Variety	Plant height (cm)	Days to 50% flowering	Number of fruits per plant	Fruit size (mm)	Fresh weight/ fruit (g)
ICRISIND	62.40	24.50	21.00	42.77	72.20
Petomech	57.80	30.75	7.25	44.85	67.90
Tropimech	65.30	28.75	7.50	50.01	83.30
Sed	3.25	1.47	0.76	1.480	9.75
CV%	7.40	7.40	9.00	4.6	18.50
Grand mean	61.80	28.00	11.92	45.88	74.50
Level of Significance	Ns	*	**	*	ns

Table 43 Quality attributes of the tomato varieties.

Variety	Weight (tons/ ha)	Soluble solids (% brix)	Titrable acidity	Shelf life
ICRISIND	47.30	3.65	0.54	9.25
Petomech	15.90	3.63	0.40	7.75
Tropimech	20.00	3.95	0.43	7.00
Sed	3.29	0.531	0.075	0.89
CV%	16.80	20.1	23.30	15.70
Grand mean	27.70	3.74	0.45	8.00
Level of Significance	**	Ns	ns	ns

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.

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.

RICE IMPROVEMENT

Agricultural Value Chain Mentorship Project (AVCMP)

Wilson Dogbe, Etwire M.P., Tampulia A. B, Owusu R.K, Inusah B., Abebrsse S.O, Siise A, Krofa E. O., Mahama A., Danaa A., Edem H.,Sarkodie E.

Executive Summary

The Savanna Agricultural Research Institute, IFDC and GAABIC under the Agricultural Value Chain Mentorship Project (AVCMP) are addressing the problems associated with productivity, (Input access, access to cultivation equipment, Credit and market) for three major crops (Rice, Soybean and Maize) in the Northern Region Bread Basket. The objective of the productivity component being implemented by CSIR-SARI is to improve entrepreneurial and technical skills of Farmer Based Organizations and their member farmers to scale up application of Integrated Soil Fertility Management (ISFM) technologies for rice soybean and Maize cropping systems while also strengthening their linkages with actors across the agricultural value chain specifically agro-dealers, SMEs, commercial banks, seed and fertilizer producers and suppliers and extension agents. A total of 238 FBOs (about 8500 farmers) out of the target 400 FBO's have been identified and are being primed to access agro-inputs and other services. Partnership agreements have been signed with major stakeholders (eg. MoFA, Tamale Youth home Cultural group, Radio station) to upscale ISFM

technology. Results from 53 ISFM demonstrations comprising 14 technologies in different combinations implemented indicate significant yield increases and profit margins for ISFM use. Mean yield increase as a result of improved management of rice and soybean compared to farmers practice for example were 92.8% and 81% respectively. Whereas every cedi invested in improved rice management yielded 52 pesewas interest, the farmers practice yielded 17 pesewa. Fertilizer use on certified rice seed was more profitable than its use on mixed farmers own seed. Yield advantage due to certified seed use ranged from 19% to 30% compared to farmer's own seed. Whereas profitability of the use of certified seed increased with increasing fertilizer rate, that of farmers own seed plateau at half the recommended fertilizer rate and decreased thereafter.

Introduction

The International Fertilizer Development Center (IFDC), Savanna Agricultural Research Institute (SARI) and the Ghana Agricultural Associations Business Information Centre (GAABIC) are grantees implementing the Agricultural Value Chain Mentorship Project (AVCMP) funded by the Danish International Development Agency (DANIDA) through the Alliance for a Green Revolution in Africa (AGRA). The project is an integral part of DANIDA's Support to Private Sector Development (SPSD) Phase II, and falls under Component 2: Enterprise Growth and Job Creation.

IFDC, SARI and GAABIC implement *sub-component 2.2: Agricultural Value Chain Facility* in sixteen of the twenty Districts in the Northern Region Breadbasket of Ghana focusing on rice, soybeans and maize value chains.

The overall goal of the AVCMP is to contribute towards the Government of Ghana's objective of achieving food security and becoming an agro-industrial economy by strengthening the capacity of agro-dealers, SMEs, Farmer Based Organizations and farmers in the agricultural sector of Ghana throughout the value chain turning it to a highly productive, efficient, competitive and sustainable system.

Problems being addressed by AVCMP

The project seeks to address the following underlying factors to low agricultural productivity, and income, food insecurity and poverty in the Northern region of Ghana:

- Low use of improved seeds and fertilizers
- Poor Soil Health

- Low agricultural land use and poor crop management practices by farmers mainly lack of timely field.
- Inadequate extension services and poor-research linkages.
- Insufficient agricultural marketing system to spur supply response from smallholder producers due to a myriad of factors including: lack of sufficient access to market outlets, high post - harvest losses.
- High transaction costs due to inadequate road and transport infrastructure
- Limited access to credit due to high interest rates and stringent collateral requirements and low investment in agriculture.

Expected outcomes

A1: Increased farmer access to farm inputs (seeds and fertilizers) from agro-dealers.

A2: Improved capacity of national institutions and FBOs to upscale ISFM technologies.

A3: Increased awareness on and use of ISFM technologies among smallholder farmers.

C1: Increased access to commercial finance by agro-dealers, SMEs and FBOs.

C2: Increased agro-dealers access to farm inputs.

C3: Increased access to commercial finance by SME/FBOs to expand agricultural productivity, food security and employment.

C4: Increased access to storage and processing services.

C5: Increased smallholder farmer access to output markets.

CSIR-SARI is implementing the Productivity component of the project which addresses outcomes A1 – A3. The objective of the productivity component is to improve entrepreneurial and technical skills of Farmer Based Organizations and their member farmers to scale up application of Integrated Soil Fertility Management (ISFM) technologies for rice and soybean cropping systems while also strengthening their linkages with actors across the agricultural value chain specifically agro-dealers, SMEs, commercial banks, seed and fertilizer producers and suppliers and extension agents.

Materials and Methodology

Implementation Strategy

As a Value Chain Facility the partners apply a holistic and integrated approach to address the problems of inadequate management, business and technical skills, as well as poor access to finance and markets among actors along the value chain. Developing entrepreneurial and technical skills of farmers, agro-dealers and SMEs for example is done by training FBOs, agro-input dealers, and SMEs in business and technical skills development and assisting them to develop bankable business plans to access loans from the commercial banks. We also link agro-dealers to fertilizer suppliers and seed producers and help develop strong networks of agro-dealers and SMEs. We support the development and operations of agribusiness centers for provision of processing and cultivation equipment services and link them to domestic, regional and international markets. In order to create a conducive environment for increased productivity the project creates awareness on ISFM technologies through the medium of On-Farm-Demonstrations, radios, drama and digital video, print media and farm learning centers and capacity building of national institutions to support wide scale up of ISFM technologies.

Results and Discussions

Outcome A1: Increased smallholder farmers' access to farm inputs (seeds and fertilizers) and ISFM technology. A total of 238 FBOs (about 8500 farmers) out of the target 400 were identified and are
being primed to access agro-inputs and other services. To facilitate FBO's access to input credit and services, they are being linked to Nucleus farmers, equipment service providers and input dealers who are to act as intermediary between the FBO's and the commercial banks.

Outcome A 2. Improved capacity of national institutions to upscale ISFM technologies: The following institutions, NGO's , Press and banks have been selected to support ISFM technology scale up (MoFA, UDS, Damongo Agric College, EPDRA, CARD, SEND Foundation, PAS, GAIDA, GNA, APFOG, SeedPAG, Stanbic Bank, ADB and Bonzali rural Bank , Tamale Youth Home Cultural Group, Bishara, Radio Savanna, Simli radio, Radio Kitawoln and Countrywise communication).
One on one meetings had been held with the various stakeholders to identify their roles. MoU's have been signed, with Tamale Youth Home Cultural Group, Bishara Radio, Radio Savanna, Simli Radio, Radio Kitawoln and Countrywise Communication, Ghana. MoU's are yet to be signed with the other stakeholders

Outcome A3: Increase awareness and use of Integrated Soil Fertility Management (ISFM) technologies among smallholder farmers
Results from 53 ISFM demonstrations comprising 14 technologies in different combinations implemented at two farmer learning centres (Libi and Nyankpala) and fields of 34 FBO's working with the AVCMP across

the 16 project districts in 2011 are presented in Table 1. All the twelve demos at the learning centres and 18 at the districts were harvested. After yield assessment from the demos, economic analysis was conducted and documented. The Value cost ratio (V**/C = value of yield due to technology divided by cost of production with technology**) was used in adjudging whether a technology is profitable or otherwise. A value cost ratio greater than one means a technology is profitable whiles V/C less than one means the technology is not profitable.

Table 44 describes the mean grain yield due to technology use or otherwise, cost of using the technology (input and labour), profitability and value to cost ratio for the different technologies demonstrated. Almost 50% of the demonstrations sent to the districts failed as a result of terminal drought. This was not surprising given that the demos were established late (between 3rd week of July and 3rd week of August) and also there was an early ceasure of the rains last year mid-October. The above reasons also explain the generally low yields recorded for the different technologies. Despite the above setbacks most of the improved technologies showed superiority over the farmers practice.

Mean yields increased as a result of improved management of rice and soybean compared to farmers practice for example were 92.8% and 81% respectively (Table 44). Whereas every cedi invested in improved rice management yielded 52 pesewas, the farmer practice yielded 17 pesewas.

Fertilizer use on certified rice seed was more profitable than its use on mixed farmers own seed (Table 44). We recorded yield advantage ranging from 19% when certified seed was used without fertilizer application to 30% when certified seed was used with the full rate of recommended fertilizer (250kg NPK + 100kg S/A or 50kg Urea) compared to farmer's own seed. Whereas the profitability of the use of certified seed increased with increased fertilizer rate (Fig 11), that of farmers own seed peaked at half the recommended fertilizer rate and decreased thereafter.

Table 44: Benefit and cost of technologies demonstrated in 2011 by the AVCMP project

Technology	Mean Yield kg/ha	Total Cost	Value of produce	Gross margin	Value cost ratio
Improved management of lowland rice	2614	861.68	1307	445.32	1.52
Farmers management of lowland rice	1356	579.21	678	98.79	1.17
Improved management of soya	1336	579.8	801.6	221.8	1.38
Farmers management of soya	739	406.6	443.4	36.8	1.09
Certified rice seed without fertilizer	2016.9	676	1008.5	332	1.49
Certified rice seed with 0.5 RF	2876.9	776	1438.5	662	1.85
Certified rice seed with full rate of RF	3408.1	876	1704	828	1.95
Farmer’ rice seed without fertilizer	1694.9	640	847.5	207	1.32
Farmer’ rice seed with 0.5 RF	2583.3	746	1291.5	545	1.73
Farmer’ rice seed with full rate of RF	2618.4	837	1309	472	1.56
Soybean with inoculants	974	460.8	550	34	1.06
Soybean with phosphorus	1006	460.99	591	13	1.02
Soybean without fertilizer and inoculants	766	459.56	547	-87	0.84
Lowland rice with no fertilizer	1207	562.18	636.55	-33.05	0.95
Lowland Rice with NPK only	1697	585.1	815.3	33.2	1.04
Lowland Rice with NPK+Urea	2494	589.85	859.54	387.46	1.45
Lowland Rice with NPK+Sulfan	2538	590.11	882.32	386.68	1.44
Lowland Rice with NPK+USG	2603	590.5	866.48	435.02	1.5
Improved mgt of upland rice	2400	589.29	858	342	1.4

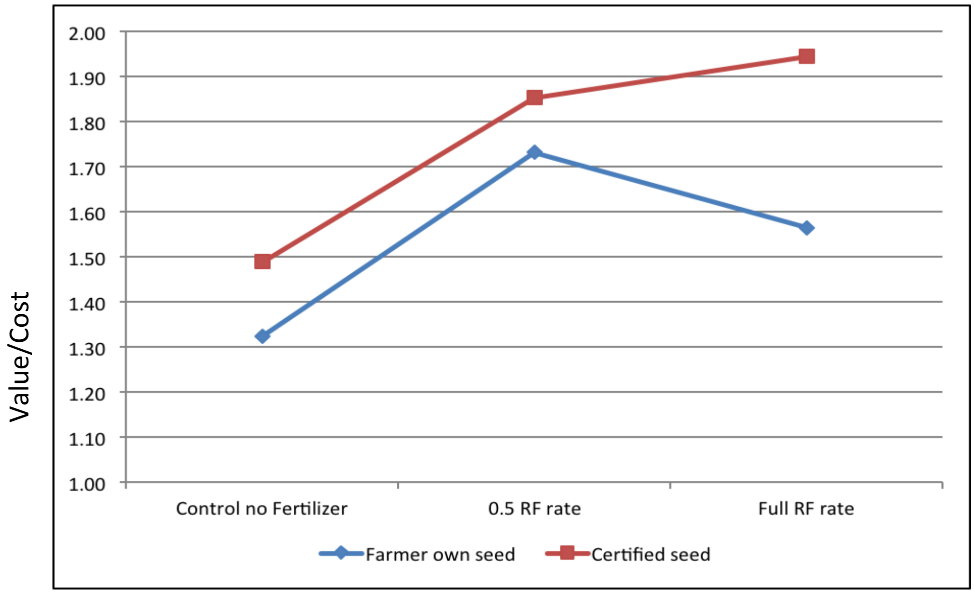

Figure 11: Value cost ratio for the use of certified and farmer own rice seed under different fertilizer rates

Rice Sector Support Project

Wilson Dogbe, Buah S.S., Kanton RAL, Nimo wiredu A., Etwire P. M, Abebrsse S.O, Siise A, Owusu R.K, Inusah B., Tampulia A. B, Krofa E. O., Mahama A., Danaa A., Edem H.,

Executive summary

RSSP is a project of Government of Ghana implemented by the Ministry of Food and Agriculture (MoFA) and funded through loan and grant from French Development Agency (AFD). RSSP is collaborating with SARI to enhance adaptive research and to disseminate improved techniques to increase the rice productivity with reducing the risks in the farming system (MOFA, 2011). The project is supporting SARI to strengthen the seed production sector. In 2011 the institute coordinated the production of 10 tonnes of foundation seed of 4 varieties (Gbewaa, TOX 3107, Katanga and Nabogu). Certified seed production was enhanced and small scale farmers were introduced to seed production. They were trained in certified seed production and then monitored in the field. Furthermore links between stakeholders were strengthened to ensure an efficient seed certification process. On farm trials were established to evaluate the suitability of improved varieties and to increase awareness in using and producing good quality seed. Six (6) new varieties were introduced to 8 communities in 8 districts in Northern and Upper West Regions. A baseline survey was conducted to collect data on socio economical status of rice farmers. A research program on polyaptitude rice and cover crop/direct seeding crop system was launched.

Introduction

The Rice Sector Support Project (RSSP) was formally launched in December 2009, though work started earlier in April 2009. The project is expected to end in December 2012. The Projects goal is to contribute to Ghana's self-sufficiency in rice production and consumption, and to improve the livelihood of resource-poor farmers through increased food security and farm incomes and strengthened rice sector stakeholders. The project is focusing on 5 components:

- Land development to improve water management in the lowlands,
- Improve access to agricultural credit by rice value chain actors,
- Enhance adaptive research,
- Develop rice sector based organizations and
- Build the capacity of MoFA.

The project is implemented in 4 regions in Ghana: Northern Region, Upper West Region, Upper East Region and Volta Region.

Though the project started in 2009, implementation of adaptive research activities at SARI officially began in 2011. SARI is in charge of the following 4 activities:

- Coordination of seed production,
- On-farm evaluation of suitable lowland varieties,
- Conducting a socio-economic baseline survey and
- Development of new cropping systems based on cover crop and poly-aptitude rice.

All these activities were executed and monitored through a close cooperation with staff from MoFA regional and district offices. Below are highlights of activities conducted in 2011.

Breeder and Foundation seed production

Material and method

A total of 12.35 hectares of foundation seed and 0.4 hectares of breeder seed of four released varieties (Gbewaa, TOX3107, Katanga, Nabogu) were planted on SARI research field at Nyankpala in the Tolon-Kumbungu district (9°24'19.78"N and 0°57'57.64"W) and in a field newly dedicated to research in Libi in the East Gonja District (9°10'49.17"N and 0°38'9.84"W).

The followed technical itinerary were implemented:

- Bunding and levelling
- Ploughing (20 cm deep)
- Harrowing (two weeks after)
- Pre-emergence herbicide spraying (Sarosate 6 *l*/ha)
- Planting (50 kg/ha) and refilling
- Fertilizer application (30-60-30 kg/ha as N, P_2O_5 and K_2O respectively, 3 weeks after planting and urea 30 kgN/ha 8-10 weeks after planting)
- Weeding (2 times)
- Post emergence herbicide spraying (Orizo plus 3 *l*/ha)
- Roguing
- Harvesting, threshing, winnowing, cleaning and drying.

Results and discussion

Atotal of 10.73 tonnes of foundation seed were produced (Table 45). The rainfall pattern during the years was not as expected in June and July, which delayed the planting date and contributed adversely to the management of the rice fields. Terminal drought as a result of the early stop of the rains affected most of the fields resulting in very low yields. Although all plots could not be harvested the target of 10 tonnes foundation seed was met as a result of the large acreage cultivated.

Table 45: Area harvested and quantity of foundation seed produced

Variety	Area harvested (ha)	Cleaned seed (t)	Yield (t/ha)
Gbewaa	2	2.66	1.33
Nabogu	3.6	5.58	1.55
TOX 3107	0.6	0.81	1.35
Katanga	0.7	1.68	2.4
Total	**6.9**	**10.73**	**1.6**

Germination test has been conducted on samples of the 4 varieties. The results showed a germination percentage of 92% for Gbewaa and above 95% for Nabogu, TOX 3107 and Katanga. Off type grains are less than 2% and broken rice less than 5% for all 4 varieties.

The breeder seed plots suffered from drought and disease infestation and harvested paddy did not meet the standard for breeder seed. Healthy panicles, free of diseases, were collected for each variety to ensure conservation and multiplication of the varieties.
Production of Breeder and Foundation seed will continue in 2012.

Certified seed production

Materials and method

A stakeholders' meeting was held in March 2011 to develop a seed production plan and to establish role and responsibilities of each partner. The RSSP seed needs were discussed and a strategy to enhance farmers' access to quality seed under the project was drawn. Seed growers from the SeedPAG organization and from 4 community groups of seed growers were given a one-day training on good quality rice seed production, good agronomic practices and seed certification process. SARI provided foundation seed of 4 varieties (Gbewaa, TOX3107, Katanga and Nabogu) to the seed growers involved in the program. During the season SARI monitored the field activities and provided technical support to community seed growers and SeedPAG members. SARI strengthened and developed links between seed growers and Ghanaian Seed Inspection Unit (GSIU) to ensure a reliable certification process.

Results and discussion

Eighty six (86) community seed growers and 19 SeedPAG members were involved in 2011 certified seed production in seven districts in the three northern regions. The districts were Tolon Kumbungu, Karaga, East Gonja, Tamale Metropolitan, Wa Municipal, Builsa and Kassena Nakena (Table 46). A total of 85 ha were planted.

Table 46: Seed growers involved in certified seed production under SARI initiative in 2011

	NR	**UE**	**UW**	**Total**
Community seed growers	56	30	0	86
SeedPAG	11	3	5	19
Total	**67**	**33**	**5**	**105**

The production of certified seed in the 3 northern regions was affected by the terminal drought in 2011. In Northern Region 21.1 tonnes of seed was receive for certification. In UWR and UER a total of 23 tonnes of seed were produced and analyzed for purity and germination test. The quantity of seed produced was below target of production set before the season. To meet the needs for improved seed for RSSP farmers, the minimum required purity and germination percentage was reviewed (e.g. 94% instead of 95% for purity).

New seed growers introduced to improved cropping practices such as levelling, rouging, timely fertilizer application and water management seed production were grateful and were willing to continue their seed production business for the next cropping season. Moreover some farmers who were introduced to new improved high yielding varieties such as Nabogu and Katanga appreciated the introduction.

New communities from the three regions will be involved in seed production in 2012. Monitoring will be reinforced to emphasize the importance of field levelling and roguing for an efficient and quality seed production. Since MoFA is creating awareness on use of certified seed of improved cultivars, the need for certified seed will increase and the production should be supported.

On farm evaluation of new rice varieties

Materials and methods

In 2011 a participatory variety selection was implemented through the Mother and Baby trials approach in Northern Region and Upper West Region in 8 communities from 8 districts. MoFA staff (AEAs and DAO) and representatives of FBOs were trained in the methodology before the season started. Six (6) news improved varieties developed on station (Exbaika, WAS 163-B-5-3, Perfume irrigated, L2-4, Long grain ordinary 2, WAS 122-13-WAS-10-WAR) were introduced to farmers to crop in their field beside their own variety (Craufurd *et al*, 2003). On farm evaluations were conducted along the season to assess the performance of the varieties. Agronomic and farmer preferences data on varieties were collected using qualitative (Participatory) and quantitative methods. At vegetative, maturity and post harvest stages farmers ranked each trait of interest as better, same or worse than their own variety. Crop performance data (yield) was measured for each variety. The seed were provided by SARI but the other inputs were provided by the farmers. The farmers were advised to follow the recommended technical itinerary.

Results and discussion

Farmers' choices in baby trials in Northern Region

Evaluating the varieties at the vegetative stage, farmers considered tillering ability, plant height, vigour of the plant and the growth rate as significant for them. During the maturity stage plant height, panicle size, grain yield and grain shape were the characteristics most considered.

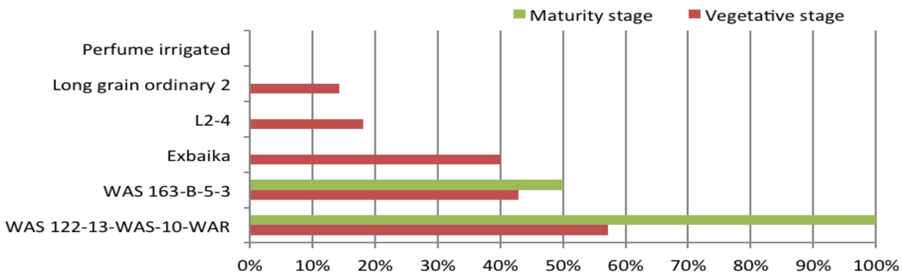

Figure 12: Frequency of first choice between variety 1 and variety 2 in baby trials

Evaluation of baby trials at vegetative stage was done in 5 communities while evaluation at maturity stage was conducted in only 2 communities. Therefore the number of varieties evaluated at maturity stage was considerably reduced so the above frequencies were just declarative. WAS 122-13-WAS-10-WAR and WAS 163-B-5-3 were the two varieties most frequently chosen by farmers (Figure 12).

Jasmine 85 and TOX 3107 were released varieties newly introduced to farmers. Using them as farmers' variety reduced the significance of the control variety supposed to be local and well known by farmers. Nevertheless farmers could compare varieties and increase their awareness and sensitivity to the broad differences existing between performance of the varieties. WAS 122-13-WAS-10-WAR was appreciated for its vigour, good tillering ability, insect resistance and big and healthy panicles. The variety is a long duration one adapted to the lowland valleys. Farmers were attracted to WAS 163-B-5-3 because of its height (tall), its vigour and fast growth rate, its grain size (long) and the expected high yield.

Farmers' choices in Mother Trials in Northern Region

Mother trials were visited by all participating farmers during the cropping season. During evaluations all farmers were asked to examine every variety. The host farmer was asked to rank varieties according to his preferences, scoring 6 to the most preferred variety and 1 to the one he dislikes (Fig. 13).

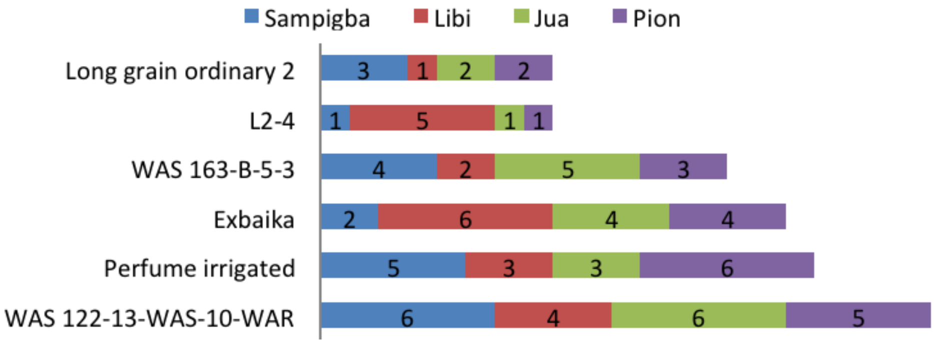

Fig 13: Variety ranking by farmers in each community for the Mother trial

WAS 122-13-WAS-10-WAR was the most preferred variety among the communities, followed by Perfume irrigated and Exbaika. L2-4 and Long grain ordinary 2 seemed less preferred by the farmers. WAS 122-13-WAS-10-WAR, Perfume irrigated and Exbaika gave good yield and seemed to be tolerant to drought and diseases. Drought affected the crop but enabled farmers to determine varietal resistance against diseases.

Conclusion and Recommendation

Mother and baby trial evaluations highlighted farmers acceptability for one Lowland NERICA variety (WAS 122-13-WAS-10-WAR). This variety seems to meet farmers' expectations in the field. Exbaika, WAS 163-B-5-3 and Perfume irrigated are also appreciated by farmers. L2-4 and Long grain ordinary 2 however didn't attract farmers. Further assessment for palatability and consumers' acceptance should be conducted. Exbaika is known to be aromatic. It should be a strong criterion for farmers to choose this variety. There is therefore the need to investigate milling and parboiling quality of the new varieties.

In 2012 Mother and Baby trials would be repeated to assess the reliability of results and to confirm 2011 results. More communities would be involved in the process and Upper East Region would also take part in this activity.

Cropping system research program using polyaptitude rice and cover crop

W. Dogbe, Maila, Aliu Siise

A technical mission of 2 Agronomists from CIRAD paid a working visit to draw a research agenda on poly aptitude rice and direct mulch cropping system. Mr Bruno Lidon, specialist in Hydrology came to Ghana from 05/04/2011 to 21/04/2011 and Mr Francis Forest, Agronomist came from 05/04/2011 to 15/04/2011. The RSSP Research coordinator from SARI and the CIRAD Agronomists agreed on a research program and on a budget for implementation of on-station and on-farm research on poly aptitude rice varieties and direct mulch cropping system.

Outputs of CIRAD’s first mission included strategies for:

i. Evaluation and multiplication of introduced poly aptitude rice and cover crop for their potential use in lowland. It includes the multiplication and conservation of cover crop and rice seeds (2011-2013)

ii. Development of poly aptitude rice and cover cropping systems through replicated trials on direct mulch cropping system in Nyankpala and Libi on experimental fields (2012 -2013)

iii. On-farm testing of poly aptitude rice and cover cropping systems through Mother and Baby approach in Libi valley in 2012 and in 6 other sites developed by RSSP projects in 2013.

iv. Implementation of a specific base line survey and of a scientific monitoring of activities in accordance with the baby and mother approach in order to produce impact indicators (2011-2013).

The methodology has been developed to reach the expected outputs of the phase:

- At least 10 cover crops species and 5 poly aptitude Sebota rice varieties introduced and tested by SARI in conditions of bunded lowlands.
- At least four cover cropping demonstrations conducted with their impacts on farmers measured in conditions of bunded lowlands.
- At least 5 poly aptitude rice demonstrations conducted with their impacts on farmers measured.
- At least 2 rice-oriented performing cropping systems developed by SARI in rain-fed lowland and are selected and successfully used by a first group of champions farmers within the “Mother and Baby” approach.

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Multi-Location Evaluation of Aromatic Rice Genotypes

Wilson Dogbe, Abebrsse S.O, Julius Yirzagla, Siise A, Owusu R.K, Inusah B., Tampulia A. B, Krofa E. O., Mahama A., Danaa A.

Executive Summary

Rice genotypes with aromatic traits are very much desired in Ghana. Against this backdrop, a multi-locational trial was set up in a randomised complete block design (RCBD) to evaluate the yield potentials and agronomic adaptability to the rice growing ecologies of northern Ghana 9 rice genotypes (including one control) with aromatic traits. Analysis of variance (ANOVA) showed significant differences ($p<0.05$) among genotypes for all parameters measured among the genotypes except germination percentage. Significant genotype by environment interaction was also observed for most parameters measured. Across all locations, Jasmine 85 was the highest yielding genotype.

Introduction

Food security for the ever growing population of the world has become one of the most pressing issues of humanity in this 21st century. With the world population expected to hit nine billion by 2050 (Hodges, 2005; Borlaug, 2002), ensuring a sustainable food security for humanity (both qualitative and quantitative aspect) has become an important issue for discussion among policymakers and all the stakeholders within the agricultural sector from production to postharvest and storage of agricultural produce. With many factors coming into play such as population growth, consumer habit changes, globalization and/or urbanization, rice has gradually become a major food staple in Ghana (Nyanteng, 1987). With a per capita consumption of 22kg per annum and an annual production increase of 5% (MoFA, 2009), the significance of rice with respect to food security in Ghana cannot be under estimated. Ghana has a huge rice import deficit ($ 700 million) which is having a negative effect on the foreign exchange earnings of the country. Domestic production by resource poor farmers is also affected due to trade liberalization and the issue of subsidy which farmers in the developed world receive. This has resulted in Ghana and most Sub-Saharan African countries becoming dumping grounds for all sorts of rice brands. The issue has been compounded further because Ghanaians have developed a particular likeness for rice genotypes with fragrance (perfume rice). Against this backdrop, the availability of aromatic genotypes of rice adaptable to the northern ecological zones of Ghana could contribute to food security, enhance farmers' livelihood and lead to reduction in rice import deficit of the country.

Objective(s): To evaluate rice genotypes with aromatic characteristics for their yield potential and general agronomic adaptability to the rice growing ecologies of northern Ghana.

Materials and Methodology

A total of 9 genotypes (Table 47) were evaluated at Nyankpala, Libi and Manga in a Randomised Complete Block Design (RCBD) with four replications. Each plot measured 15m^2 with an alley of 0.5 m between two adjacent plots.

Table 47: Names and sources of genotypes

Genotype	Source of material
Anyofula	CSIR-PGRI, Ghana
Basmati 112	IRRI, Philippines
Basmati 113	IRRI, Philippines
Basmati 123	IRRI, Philippines
Basmati 370-1	IRRI, Philippines
Basmati 370-5	IRRI, Philippines
JASMINE 85 (Local Check)	CSIR-SARI, Ghana
Local Basmati-2	IRRI, Philippines
PERFUME(Short Type)	Thailand

Seed were dibbled (maximum of two per hill) at a planting distance of 20cm x 20cm on 30th June, 13th July, and 9th July, 2011 at Nyankpala, Libi and Manga, respectively. The recommended fertilizer application rate of 60-60-30 NPK kg/ha was adopted for the trial (applied through broadcasting) with the N component applied in split dose. All other cultural practices were carried out as and when it became necessary. A generalized linear model fo ANOVA in Genstat was the model used for all data analyses.

Results and Discussions

Analysis of variance (ANOVA) for all parameters measured indicated statistical significance ($p<0.05$) among the genotypes except for germination percentage (Table 48). There was significant genotype by location interaction for most parameters namely, 50% flowering, lodging, days to maturity, 1000 grain weight and grain yield. However, the remaining parameters were not differentially influenced by interaction of the two factors (Table 48).

Table 48: Results of the ANOVA for the parameters measured among the genotypes

Source of variance	Df	MS	F-pr (genotype)	F-Pr (location)	F-pr (Inter)	CV	LSD
Days to 50% flowering	8	483.4	<.001	<.001	<0.001	2.1	1.5
Germination %	8	403.6	0.120	<.001	0.822	20.5	12.7
Lodging	8	54.6	<0.001	<.001	<0.001	48.9	1.2
Days to maturity	8	469.2	<0.001	<0.001	<0.001	1.1	1.0
Panicle count	8	55.8	<0.001	<0.001	0.024	15.5	1.59
Plant height	8	6229.9	<0.001	0.024	0.0219	9.4	10.1
Tiller count	8	34.8	<0.001	<.001	0.743	20.0	2.1
1000 grain weight	8	61.2	<0.001	0.819	<0.001	4.9	0.94
Yield kg/ha (14% MC)	8	5628940	<0.001	<.001	0.005	16.6	464.4

NB: MS, CV and LSD reported are for factor "genotype" (location and interaction not reported)

Across all three locations, Jasmine 85 (control) was the highest yielding genotype (Table 49). A significant difference between Jasmine 85 and the second highest yielding genotype (Perfume Short Type) was observed at Manga but not at Libi and Nyankpala, where Perfume Short Type and Anyofula were the respective second highest yielding genotype (LSD= 804.4, Table 49). In all it could be concluded that the five highest yielding genotypes across all the locations were Jasmine 85, Anyofula, Perfume short type, Basmati-123 and Basmati-112 in order of decreasing yield performance. Jasmine 85 still remains the highest yielding genotypes among the evaluated lowland aromatic materials for the year under review. The trial would be repeated in 2012 at all locations.

Table 49: Mean grain yield of the evaluated rice genotypes across the three locations

Genotype	Yield across locations (kg/ha)				Rank
	Libi	Manga	Nyankpala	Average (across locations)	
Anyofula	2545	5044	4340	3976.3	2
Basmati 112	2388	4569	2430	3129.0	5
Basmati 113	1423	4718	2129	2756.7	9
Basmati 123	2276	5033	2291	3200.0	4
Basmati 370-1	1852	4266	2861	2993.0	8
Basmati 370-5	1734	4814	2621	3056.3	7
Jasmine 85 (Check)	3003	7033	4626	4887.3	1
Local Basmati-2	1883	5136	2208	3075.7	6
Perfume (Short Type)	2720	5797	3362	3959.7	3
LSD	804.4				

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Multi-Location Evaluation of Red Rice Genotypes

Abebrsse S.O, Julius Yirzagla, Siise A, Owusu, R.K, Inusah B., Tampulia A. B, Krofa E. O., Mahama A., Danaa A.

Executive Summary

Rice genotypes with red coloured caryopsis are now in higher demand on the Ghanaian market compared to the white polished rice mainly due to their health and nutritional benefits. To evaluate the yield potentials and general agronomic adaptability of 8 rice genotypes with red coloured caryopsis, a multi-locational experimental (Nyankpala, Libi and Manga) was set up using Randomised Complete Block Design (RCBD) and replicated four times. The differences among the genotypes were statistically significant

(p< 0.05) for all the parameters measured. Statistically significant differences were also observed across the three locations for all parameters except lodging. Genotype by environmental interactions also showed significant differences (P< 0.05) for all the parameters measured. Across all the three locations, the first three highest yielding genotypes are in the order, Jasmine 85 (red), Matigey and GH 1837. The trial will be repeated in 2012.

Introduction

Rice has become a symbol of food security worldwide. Red coloured caryopsis (the dehulled rice grain) has a particular place in the Ghanaian society. This is due to the unique role it plays in most culinary preparations in most Ghanaian cultures. More importantly, red coloured caryopsis genotypes of rice have comparative nutritional and health advantages. Some of these advantages include;

1. Good source of **iron** and **zinc** compared to other coloured caryopsis.
2. **Anthocyanins,** the colour pigments that give grains and leaves their deep rich red, blue, and purple colours (responsible for the red coloured caryopsis of red rice genotypes) have antioxidant properties. The antioxidant properties of anthocyanins lower the risk of heart problems notably **atherosclerosis**.
3. Red rice contains high level of **fibre** compared to polished white rice.

With these health and nutritional benefits of red rice as against the current increase in the level of health consciousness of an average Ghanaian with respect to his/her choice of food, there is now an unprecedented interest/demand for red rice on the market. The traditional red rice verities currently being grown by farmers are low yielding with numerous less desirable agronomic traits.

Objective: To evaluate rice genotypes with red coloured caryopsis for their yield potentials and general adaptability to the rice growing ecologies of northern Ghana.

Materials and Methodology

The experimental setup consisted of multi-locational trials (Nyankpala, Libi and Manga) in Randomised Complete Block Design (RCBD) with four replications. A total of 8 genotypes (one check) were evaluated (Table 50). Each plot measured 15m^2 with an alley of 0.5 in between two adjacent plots.

Seeds were dibbled (maximum of two per hill) at planting distance of 20x20cm with 23rd June, 2011, 13th July, 2011, and 9th July, 2011 being the respective planting dates for Nyankpala, Libi and Manga. The recommended fertilizer application rate of 60-60-30 NPK kg/ha was adopted for the trial (applied through broadcasting) with the N component applied in split dose. All other cultural practices were carried out as and when it becomes necessary. Generalized linear model ANOVA in Genstat was the model used for all data analyses.

***Table 50**: Names of genotypes and their sources used in the present study*

Genotype	**Source**
GH 1837	CSIR-PGRRI, Ghana
Jasmine 85 (red)	CSIR-SARI, Ghana (Identified 'wild' genotype of Jasmine 85)
Kawawa (red)	CSIR-PGRRI, Ghana
Local red (check)	Farmer collection
Matigey	CSIR-PGRRI, Ghana
NERICA 14	AfricaRice, Cotonou
V 47	CSIR-PGRRI, Ghana
Viwornor	CSIR-PGRRI, Ghana

Results and Discussions

The analysis of variance (ANOVA) showed statistically significant differences ($p < 0.05$) for all the parameters measured (Table 51). Across locations, all parameters measured were statistically significantly different ($P < 0.05$) except lodging. Genotype by environment interaction was also significant ($P < 0.05$) for all the parameters measured.

Across the three locations, the first three highest yielding genotypes were in the order, Jasmine 85 (red), Matigey and GH 1837 (Table 52). Nerica 14 being a typical upland material therefore may not have gotten the right environment for proper phenotypic expression of its genetic potentials (nonetheless noting that the NERICAs are not particularly super yielding genotypes). It is worth noting that jasmine 85 (red) in this experiment is actually a wild type harvested from the variety Gbewa rice. It has all the good qualities of Jasmine 85, just that the caryopsis is red coloured. Against the backdrop of the fact that all whites coloured caryopsis evolved from red coloured via mutations (Ramanujan, 2007; Prathepha, 2009) coupled with the report of Brooks *et al.,* (2008) on similar observation we can cautiously conclude/suspect the possibility of mutation within the genome of Jasmine 85 (Gbewa) given rise to the observed wild phenotype.

Table 51*: Results of the ANOVA for the parameters measured on the rice genotypes*

Source of variance	Df	MS	F-pr (genotype)	F-Pr (location)	F-pr (Inter)	CV	LSD
Days to 50% flowering	7	2418.5	<.001	<.001	<.001	2.4	1.810
Germination %	7	365.1	0.003	<.001	0.005	12.2	8.30
Lodging	7	61.0	<.001	0.140	<.001	76.4	1.01
Days to maturity	7	2810.4	<.001	<.001	<.001	6.1	6.02
Panicle count	7	25.330	<.001	<.001	<.001	16.8	1.334
Plant height	7	5814.3	<.001	<.001	<.001	7.4	7.911
Tiller count	7	129.75	<.001	<.001	<.001	20.0	2.203
1000 grain weight	7	56.4	<.001	<.001	<.001	4.8	1.089
Yield kg/ha (14% mc)	7	822423	<.001	<.001	<.001	22.8	675.1

NB: MS, CV and LSD reported are for factor "Variety" (location and interaction not reported)

Table 52*: Mean grain yield of the evaluated rice genotypes across the three locations*

	Yield across locations (kg/ha)			
Genotype	Libi	Manga	Nyankpala	Average (across locations)
GH 1837	3441	3441	4010	3630.7^{3}
Jasmine 85 (red)	3420	3420	6085	4308.3^{1}
Kawawa (red)	2591	2591	4919	3367.0^{4}
Local red (check)	1654	1654	6159	3155.7^{5}
Matigey	2689	2689	5697	3691.7^{2}
NERICA 14	2336	2336	3538	2736.7^{6}
V 47	715	715	2987	1472.3^{8}
Viwornor	902	902	4818	2207.3^{7}
LSD				1169.3

NB: Superscript on mean values denotes their ranking in terms of yield performance

In conclusion, Jasmine 85 (red) has all the good traits (short duration, perfumed, desirable plant height, high tillering ability etc.) of the original released 'jasmine 85' variety. As such it is a good inclusion to our germplasm for promotion. Nerica 14 though not among the best yielding material observed in this study will be recommended for further trials. This is because of the ecological niche (Upland ecology) it will serve. The entire trial will be repeated in 2012.

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Participatory Varietal Selection (PVS) of Lowland Rice Genotypes

Wilson Dogbe, Abebresse S.O, Siise A, Owusu R.K, Inusah B., Tampulia A. B, Krofa E. O., Mahama A., Danaa A.,Halolo E., Sarkodie E.,

Executive Summary

Thirty new genotypes of lowland rice were evaluated with farmers using the PVS model at three locations (Nyankpala, Manguli and Libi). Three local checks (Gbewa, Nabogo, and Katanga) were included in the exercise. The analysis of variance for grain yield among the genotypes did not show significant difference (p=0.992). Three out of the ten most selected genotypes by farmers namely L4, L28 and L33 were among the top ten yielding materials from the total genotypes evaluated. Moreover, only one of the checks (Katanga) ranked among the top ten yielding genotypes. This

is an indication that some of the new genotypes have other desirable agronomic traits desired by farmers aside their yielding potentials. The six most selected genotypes by farmers will be advanced to on-farm trial using the mother and baby concept in 2012.

Introduction

To facilitate variety development and adoption, the Participatory Varietal Selection (PVS) concept was deployed (AfricaRice, 2010) and is being championed by both the Consultative Group on International Agricultural Research (CGIAR) centres, and the National Agricultural Research Institutes (NARs). As part of the collaboration between the Institutes within the council (CSIR) thirty new rice genotypes were received from the breeding programme of CSIR-CRI. These materials were evaluated together with three local checks with farmers at three locations (Nyankpala, Libi and Mangouli) in a PVS model.

Materials and Methodology

PVS nurseries were established in all the three locations namely, Nyankpala, Libi and Mangouli. Each nursery plot measured $6m^2$ and a total of thirty genotypes with three local checks (Gbewa, Nabogo and Katanga) were evaluated at each of these three locations. The respective planting dates were 28-07-2011, 29-06-2011 and 26-07-2011 for Nyankpala, Manguli and Libi, respectively. Famers were invited to evaluate the genotypes at both the vegetative and reproductive stages of the crop. Invited farmers were asked to select three preferred and one disliked variety and give reasons for their choices. Yield data were taken at each of the three locations for statistical analysis.

Results and Discussions

The analysis of variance for grain yield did not show significant difference (p=0.992) among the genotypes. The ten most selected genotypes by farmers during PVS evaluation are presented in table 54 with their average yield potentials across the three locations. Three out of these ten most selected genotypes namely L4, L28 and L33 were among the top ten yielding materials from the total genotypes evaluated (Table 53 and Table 54). This is an indication that some of the new genotypes have other desirable agronomic traits liked by farmers aside their yielding potentials.

Table 53: *The top 10 yielding genotypes and their agronomic characteristics*

Ranking	Genotype	Tiller	50% flw	Plt hght	Leaf blast	leaf scald	Brown spot	Average yield (kg/ha)
1	L27	12	87	109	2	4	2	4365.3
2	L15	14	89	93	2	1	3	4080.8
3	L34	18	93	95	2	2	1	4051.5
4	L63	15	93	87	2	2	1	4017.1
5	L62	16	93	87	1	3	3	3955.0
6	L40	16	89	95	2	2	1	3898.5
7	Katanga	13	91	95	2	3	2	3890.5
8	L4	13	81	81	1	3	2	3865.8
9	L28	12	81	127	1	2	1	3862.3
10	L33	14	89	97	1	1	3	3812.1

Table 54: Ten most frequently selected genotypes by farmers during PVS evaluation.

No.	Genotype		Frequency of selection			Yield (kg/ha)
			Maturity	Vegetative	Total	
1	L33	NERICA-L-41	14	8	22	3812.1
2	L28	NERICA-L-19 ex Togo	10	10	20	3862.3
3	L4	DKA4	13	6	19	3865.8
4	L25	WAS 127 -12-1-6-3-1	2	16	18	3313.5
5	L18	Sahel 209	6	11	17	3079.5
6	L32	NERICA-L-20	14	1	15	3265.3
7	L38	ITA320	1	14	15	2911.5
8	L24	WAS 127-12-1-2-3	10	4	14	3650.8
9	Nabogo	Nabogo	5	6	11	3493.0
10	L6	DKA10	4	6	10	3029.2

Farmers' reasons for prefering certain genotypes included good vegetative vigour, good tillering ability, desirable plant height, superior weed competiveness, large panicle size and grain shape etc. Reasons for nonpreference of other genotypes included poor tillering, too early maturity period, excessive shortness and tallness of some of the genotypes etc. These characteristics were well-noted and would be considered in future breeding programs. The local checks included in this study (Nabogo, Katanga and Gbewa) were not among the most frequently selected genotypes by farmers (Table 53 and Table 54). Preliminary observations had indicated that some of the genotypes were aromatic. However, this was not taken into consideration since thes trait is difficult to detect on the field. L62 and L63 displayed high level of resistance to RYMV. This observations would be studied in 2012 and subsequent years to come.

In conclusion, the six most selected genotypes will be advanced to on-farm trial using the mother and baby concept in 2012.

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Observational Nursery Yield Evaluation of Upland Rice Genotypes

Wilson Dogbe, Abebrsse S.O, Julius Yirzagla, Siise A, Owusu R.K, Inusah B., Tampulia A. B, Krofa E. O., Mahama A., Danaa A.,Halolo E., Sarkodie

Executive Summary

An initial observational nursery for the evaluation of 96 upland rice genotypes received from AfricaRice (part of the new generations of NERICAs) was set up on-station at Nyankpala. The yield figures of the new materials ranged from 144.0kg/ha to 3412.1kg/ha. The 20 top yielding genotypes did not include any of the control genotypes. This is an indication that the new materials have comparative yield advantage. The top 20 yielding genotypes will be advanced to further on-station trials in 2012.

Introduction

The upland ecologies have become an important part of rice production systems with the potential to supplement the lowland systems and increase rice production. Since the introduction of the NERICAs, the upland ecologies have received particular attention and more of such ecologies are now being put under rice cultivation.

Objective(s): To evaluate a total of ninety-six upland rice genotypes with two control genotypes for initial yield performance in a nursery establishment.

Materials and Methodology

A total of 96 genotypes of upland rice (received from the AfricaRice, Cotonon) with two local checks (Nerica 1 and 2) were evaluated in this study. An on-station observational nursery was established at Nyankpala. Each nursery plot measured 5m^2. Seeds were dibbled (maximum of two per hill) at planting distance of 20x20cm on 27th July, 2011, being the planting date. The recommended fertilizer application rate of 60-60-30 NPK kg/ha was adopted for the trial (applied through broadcasting) with the N component applied in split dose. All other cultural practices were carried out as and when it became necessary

Results and Discussions

The average agronomic performances of the top 20 yielding genotypes are presented in table 55. It is however worth mentioning that data for genotypes V6 and V28 are not reported as those plots were destroyed by ant hills. The new materials appear promising as most did better than the control genotypes (Nerica1 and 2) in terms of yield potential. The best twenty high yielding genotypes did not include any of the control varieties in this study. This is an indication that the new genotypes nave comparative yield advantage to Nerica 1 and 2, the two common varieties for upland ecologies currently.

In conclusion, The 20 best yielding genotypes will be promoted to advance on-station yield trials for further observation of their agronomic adaptability.

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Table 55: *Agronomic performances of the top 20 yielding genotypes*

Genotype	Tiller	50% flowering	Maturity (Days)	Plant height	Lodging	Yield kg/ha (14% mc)
V65	35	70	97	108	9	3412.1
V85	40	69	97	107	9	3287.6
V66	42	75	102	100	9	3100.0
V73	36	69	97	105	7	2989.8
V64	30	72	99	99	9	2939.9
V59	27	75	102	98	9	2883.0
V97	41	72	99	89	1	2820.1
V19	21	75	102	88	9	2607.8
V54	31	72	100	102	0	2559.1
V96	38	69	97	91	3	2481.0
V88	23.8	70	97	105.2	9	2424.8
v7	33.6	75	102	92.4	9	2407.4
V94	25	78	105	106.4	3	2330.4
V56	50	72	102	113	5	2310.0
V90	34.2	69	97	97.8	9	2269.3
V18	30.3	70	97	79.6	9	2262.6
V55	47.8	75	102	97.4	3	2257.8
V77	38.4	78	105	118.2	5	2248.1
V99	39.2	70	97	98.6	9	2240.8
V63	44.2	69	97	107.6	9	2231.1

AGRONOMY

Soil amendment STAYMOIST influence on maize productivity in Guinea savannah agro ecological zone of Ghana.

Inusah I. Y. Baba

Executive summary

Field experiments were carried out in 2011 to evaluate the efficacy and optimum dosage rate of soil amendment, Staymoist (SM), in moisture absorption and retention for crop use in the Guinea Savannah zone. The trials consisted of five treatments in a Randomized Complete Block Design with four replications. The test crop was maize varieties Dorke SR and Dodzi. The results indicated that the presence of Staymoist enhanced the absorption and retention of soil moisture available for plant crop use. Maize grain, stover and total biomass yields in relation to different *NPK+Staymoist* treatments showed correlation. Economic analysis indicated that the treatment of 15kg/ha SM+NPK fertilizer was dominant.

Introduction

Information gathered from rainfall data showed that it is not the total amount of rainfall that is limiting crop production in the northern part of Ghana. It is the regularity of the occurrence and the quantity of water during rainfall that negatively affects crop production. Available data show that the annual mean rainfall in the study area is 1000mm, concentrated in a five month growing period has significant deviations coupled with low water holding capacities of the soils and lack of drought resistant maize varieties often lead to temporary water stress and consequent yield losses. It has been established that sudden droughts in the rainy season can lead to total crop failures especially when they coincide with drought sensitive stages of plant development during the taselling of maize (Benneh,1993).

As low as five days and as high as five weeks of drought periods (without rain) have been documented during rainy periods in the Guinea Savannah zone of Ghana (Benneh, 1993; NAES Report, 1993). Strategically, maize has not been a very effective crop for bridging the ***Hunger Gap*** in Guinea Savannah zone in Ghana. Significant work has done by the maize breeders to address this Hunger Gap problem. These efforts included the development of early maturing maize cultivars such as ***Abeleehi*** and ***NAES Pool 16*** (SARI Annual Report 1996).

More recently, on 15th March, 2010 four new drought tolerant (DT) varieties of maize were released as a result of collaborative work between SARI & CRI and IITA.The released extra early DT maize varieties were noted to be capable of bridging the “Hunger gap” during the planting season and farmers could plant early, harvest and sell or use it as food before the main season began.

The above notwithstanding, intermittent droughts remain a regular feature of most rainy or cropping seasons in the Guinea Savannah agro ecological zone in northern Ghana. SARI is constantly evolving new technologies as part of a comprehensive strategy of managing these vagaries of the weather exacerbated by the adverse effects of Climate change. This work therefore envisaged to minimize the damage that could be caused by intermittent droughts in a cropping season through the appropriate application of soil water conservation strategies such as the use of soil conditioner Staymoist (SM).

For some time now, it has been found that some materials are capable of absorbing and retaining soil moisture from rains and making this water available for crop use during the intermittent drought periods which are regularly experienced every rainy season in the Guinea and Sudan Savannah zones of northern Ghana (SARI, 2009). One of these materials has been named by the suppliers as ***Staymoist*** (SM), identified as an environmentally friendly soil conditioner (Entry et al., 2003, Bacalski et al., 2003, Bologna et al., 1999, Alexander, 1994, Brown et al,, 1982). Elsewhere such products have been variously named as ***Agra Gel, Jalma, poly-DADMAC*** and so on. A host of researchers have shown that gel-forming soil conditioners, such as Superabsorbent Polyacrylamides (SAPs), Hydrogels, bentonite and so on have many attributes that can lead to improved soil physical properties and enhanced crop production, especially in arid and semi-arid agro-ecological zones such as the Guinea Savannah agro-ecological zone of the northern regions of Ghana (Talebnezhad and Sepaskhah., 2012, Li et al., 2009, Mahana et al., 2002, Prodo et al., 2000, Sojka et al.,2000, Al-Darby ,1996, Johnson.1984). Some of the attributes of these soil conditioners include:

- Absorption of water many times their own weight and thus can be used to improve moisture storage in sandy soils and mitigate drought;
- Their use in irrigation erosion control and in increasing infiltration;
- Their use to reduce the accumulation of Arsenic and other hazardous pesticide residue such as of 2,4-dichlorophenoxyacetate acid (or 2,4-D herbicide);

- Effectiveness in immobilizing many kinds of harmful microorganisms in flowing water and thus controlling transport of some pathogens from animal waste in runoff and groundwater.

Staymoist is manufactured outside Ghana. It therefore became necessary to validate its performance for moisture absorption and retention for use in intermittent drought mitigation in maize production under our local conditions before it may be promoted for farmers' use.

Objective

The objective of the research was to validate the effectiveness of SM on the growth of maize crop as affected by periods of moisture availability and intermittent droughts.

Materials and Methods.

Experiments were carried out in 2011 rainy season at the SARI, Nyankpala (latitude 9^0 $25^/$ N, longitude 0^0 $58^/$ W, and altitude 183 m above sea level) from early June to late November in 2011 cropping season. The trials were established in a sandy loam soil with pH 5.8. The field had previously been used for traditional rice cultivation without any nutrient additions (either manure or plant residues).

The trial comprised five treatments laid in a Randomised Complete Block Design (RCBD) with four replications. Treatment plot size was 2m x 2.5m or 5 m^2 .The test crops were *Dorke SE and Dodzi,* both early-medium duration maize cultivars. The experiment was planted on the 15th June in 2011. Spacing was 30cm × 30cm with one plant per stand. Compound fertilizer NPK (15-15-15) used in appropriate treatments was applied 15 days after planting. Top- dressing fertilizer was applied to all treatments at taselling stage, using Sulphate of Ammonia at a the recommended rate of 125kg/ha or one bag per acre. The Staymoist was applied with basal fertilization to the appropriate treatments. All other recommended agronomic practices were carried out.
Data collected included plant height, days to maturity, grain, stover and total biomass yields of maize. Rainfall distribution, maximum, mean and minimum daily temperatures, evapo-transpiration and other agro-climatic data for the area were monitored at the SARI Agro meteorological station for the growing seasons from May to September.

Treatments: Treatments in the trial comprised : No NPK, No SM (control); NPK only; 7.5kg/haSM+ NPK;15kg/haSM+NPK and 22.5kg/haSM+NPK

Economic analysis: In order to make sound recommendation about the use of the Staymoist, economic analysis was conducted. Additional data on the quantities and prices of inputs used were collected. Market prices of the harvested maize were also collected. Key indicators include the operations costs, profit and their respective changes. The benefit-cost ratios and marginal rates of returns of the technology were also computed (Anandarup, 1984) Dominance analysis was also conducted to identify the most superior technology (CIMMYT, 1988).

Days to maturity: In all the treatments Days to maturity for Dorke SR were slightly higher than those of Dodzi which appears to be a varietal trait.

Plant Height: Soil conditioner SM effect on plant height varied for the two cultivars. The least plant height was seen in the Control treatment (No NPK, No SM); followed by the NPK only plots. For Cultivar Dodzi, the SM treatments produced plants either equal in height or slightly taller than the No SM plot plants, but increasing amounts of SM did not significantly affect plant height. For cultivar Dorke SR, the trend was similar: all SM treatment plots were generally taller than those without SM, and for all treatments, Dorke SR plants were taller than Dodzi plants, but increasing amounts of SM did not yield significant differences in plant height.

Grain Yield: For both varieties the control (No SM , No NPK) treatment together with the NPK Only treatment produced the least grain, between 200 and 800kg/ha. The remaining treatments with increasing amounts of SM with NPK all showed significant increases in grain yield from 7.5 to 22.5 kg/ha increments in SM. While T_5 gave the highest grain yield for both varieties this yield was yet higher for Dodzi than Dorke SR at that treatment level

***Stover* Yields:** Stover yields in all other treatments in the trial were higher significantly, than the control for both varieties. However, SM incremental with NPK, did not positively reflect in significant stover yield increases and for Dorke SR depressed stover yields as more SM was added up to 22.5 kg/ha. More stover was also produced at T_2 for Dorke SR than in all the other treatments. In all, stover production for the variety Dorke SR out stripped that for Dodzi in all the treatments.

Total Biomass: The grand mean total biomass production for Dodzi was 2934 kg/ha compared to 4470 kg/ha for Dorke RS and but at T_5 , Dodzi (3913kg/ha) still outstripped Dorke SR (3750kg/ha) in total biomass production.

Discussions

Weather conditions*:* The growing season for maize in the study area is between May and September. October and November usually mark the end of the wet season. The two weather period show a generally erratic distribution of rainfall.

The low yield for T_1 and T_2 for both Dodzi and Dorke SR was a predictable poor outcome for many farmers in a droughty year. However under similar conditions, applying 15kg/ha SM with basal NPK fertilizer, improved productivity of grain compared to typical NPK fertilizer Only treatmet by over 110 % and 130 % for Dodzi and Dorke SR respectively. In a similar vein Gunes *et a*l (2005) have demonstrated that soil incorporation of Salicylic acid (0.10mM and 0.50mM) contributed to regulate the response of maize plants to droughty environmental stress.

Agronomic Characteristics: In general, key agronomic characteristics of maize were influenced by the different treatments of SM. The least agronomic parameters in plant height, days to maturity, grain and stover yields - were attributable to the treatment lacking basal NPK fertilizer and SM (T1). This was not unexpected because similar findings for maize have been well documented in literature establishing that maize grain yields in most parts of Northern Ghana are low and uneconomical when cultivated without fertilizers (SARI Annual Report,1996; NAES Report,1993)

Maiz plant growth and development was affected by the different treatments of SM as demonstrated. For both maize varieties significant differences were not detected in days to maturity as a result of the treatments. However, the plant height of the maize varieties were , significantly lower at the control (No SM, No NPK) in comparison to all three substantive treatments (T_3 to T_5).

Plant heights in treatments 3 to 5 did not significantly differ from one another. This suggests additional SM beyond 7.5 kg /ha rate had no significant bearing on this agronomic parameter.

Productivity: Grain, stover and total biomasss productivity in all three main SM treatments for both varieties, were significantly higher than both the control and NPK Only treatments. The effects of SAPs on media water retention, water loss, nutrient availability to plants, and net photosynthesis during water stress have been detailed in the works of a number of authors (Taylor *et a*l,1986; Tu *et al*,1985). They express an opinion that water stress adversely influences nutrient availability to crop plants which is directly related to normal growth cycle and appropriate a melioration with SAPs positively influenced growth and development of several crops.

Findings: From the above results, there is ample evidence that ***Staymoist (SM)*** can absorb and retain moisture for the uptake by plants during intermittent drought as demonstrated by the responses of the two maize varieties in the trial.

The trial results underline the positive influence of Staymoist on the agronomic characteristics and yields of maize, under intermittent drought situations. Data presented clearly indicated that grain and stover yields of all three SM treatments were significantly higher than both the control and NPK only treatment.

More work, however is still required to explore the effects of much smaller dosage rates of SM.

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UPLAND AGRONOMY

J. M. Kombiok

Introduction:

The Northern Region Farming Systems Research Group (NR-FSRG) is one of the three Regional Farming Systems Research Groups of SARI. The Upland Agronomy programme based at Nyankpala is charged with the responsibility of carrying out adaptive trials (with farmers) of all the crops except cotton and rice within Northern region. To help in the backstopping of the on-farm work, the unit also carries out limited number of on-station agronomic trials on all the crops at Nyankpala, Yendi Damongo and Walewale.

Three activities were carried out by the Unit in 2011. These were made up of intercropping studies involving Jatropha and some food crops (cereals and legumes), the On-farm participatory selection of Striga/drought tolerance maize varieties the effects of organic and in-organic fertilizers and bunding on the yield of Maize.

Effect of bunding and soil fertility management on maize grain yield in the Northern Savanna Zone of Ghana.

J. M. Kombiok, M. S. Abdulai,F. H. Andan, H. Abdulai

Executive Summary

For the past decade, low soil fertility has been ranked first among all the constraints affecting cereal crop production in northern Ghana. In collaboration with Ministry of Food and Agriculture (MoFA) in the northern region, fifteen farmer groups were selected from three districts (Tolon/Kumbungu, West Mamprusi and Bunkpurugu/Yunyoo) representing areas with very low soil fertility status. At each site, an acre of land was ploughed and harrowed with a tractor. This was divided into two parts along the slope. The recommended fertilizer (2 bags compound and one bag ammonia/acre) was applied to the maize in the first part. Half rate (3 tons/ha) of organic manure from the farmers' pen was used to apply to the second part of the plot and worked in before planting the maize. In addition, half the rate of compound fertilizer and sulphate of ammonia/acre was also applied to the same plot and earth bunds constructed around it. The test crop was maize (var, Obatanpa). The maize yields ranged from 2,245.72 kg/ha to 3,866.70 for the bunded plots while for the fertilizer alone without bunding these were from 1,852.35 to 3,493.30kg/ha. The results further showed that Tolon district (Nyankpala) with higher and relatively good distribution of

rains gave higher maize yields compared to Bunkpurugu/Yunyoo and West Mamprusi (Walewale) districts with lower and more erratic rainfall. The difference in maize yield between the bunded and non-bunded was also not significant in Tolon while in Bunkpurugu/Yunyoo and Walewale the maize yields between these two treatments were significant. At Bunkpurugu/Yunyoo district the bunded plots out-yielded the non-bunded by 17.5 % and at Walewale by 29.5%. In all, 425 farmers participated in the demonstrations in the three districts.

Introduction

Low grain yields of cereals *(maize, rice and sorghum)* in Northern Ghana have been attributed to poor soils. For the past decade, low soil fertility status of soils has been ranked first among the constraints collated from all the districts of northern region at the regional planning sessions.

The effect of both organic and in-organic fertilizers separately and in combination of both to enrich the soil of its nutrients for high grain yields of cereals have been for the past years compared. Results from experiments in this direction indicate that the best yields of maize were obtained when half the recommended dose of in-organic fertilizer was combined with three tons (3 tons/ha) of manure (organic fertilizer) and applied to the soil by SARI scientists in Upper-East region. The role of integrated soil fertility management (ISFM, i.e. combined application of organics and minerals) with different tillage systems on nutrient (N) and water use efficiency has however been investigated on station but not on farmers fields (On-farm).

Objective

The objective of this work was to establish on-farm demonstrations on the use of ISFM and in bunded plots in some communities for possible adoption by farmers in northern Ghana.

Methodology

In collaboration with MoFA, five farmer groups were selected from three districts with very low soil fertility status. These are the Tolon/Kumbungu, West Mamprusi and Bunkpurugu/Yunyoo districts. In all, 15 farmer groups participated in the demonstration on the effect of bunding on water conservation and maize yield.

Location and Number of farmers involved

There were fifteen demonstrations in three districts (Tolon/Kumbugu,West Mamprusi and Bunkpurugu/Yunyoo). In each district, five active Farmer based organisations were identified and registered for the demonstrations.

An acre of land at each site was ploughed and harrowed with a tractor. The acre was then divided into two parts along the slope. The recommended fertilizer (2 bags compound and one bag ammonia/acre) was applied to the maize in the first part. The maize variety used as the test crop in the demonstration was Obatampa.

Half rate of organic manure/ha from the farmers' pen (3 tons/ha) was used to apply to the second part of the plot and worked in before planting the maize. In addition, half the rate of compound fertilizer and ammonia/acre was also applied to the same plot at the appropriate periods. This second plot treated with both organic and in organic at half-rates was in each case bunded. Earth bund was constructed round this second plot in each case to enable the plot retain moisture after rains. The farmers were sensitized to cut open the bunds in the case of frequent rains since maize cannot tolerate standing water. The bunds are therefore effective in times of intermittent drought during the cropping season.

Before the establishments of these demonstrations, both the field officers and some of the participating farmers were trained in the identification of slope and the construction of bunds at Walewale and Bunkpurugu using the A-frame**.**

Data analysis

Yields of maize were taken from the half acre each of the bunding and non-bunding and converted to per hectare basis. These were analysed using the Statistix Program and the differences were compared using the T-test.

Results for 2011

Number of farmers reached.

In all, 425 farmers directly participated in the 15 demonstration plots in the three districts of the Northern region. These were made up of the following:

- Tolon/Kumbugu district-125 farmers
- West Mamprusi district-150 farmers
- Bunkpurugu/Yunyoo: 150 farmers

They were all sensitized on the benefits of bunding on the yield of crops (maize) in an environment where rainfall was scanty and erratic. A demonstration was also carried out on the identification of slope and bund construction for those who did not attend the training session of bund construction.

Maize yields

The grain yields of maize as affected by the application of organic and inorganic fertilizers coupled with bunding are presented in Table 56. The maize yields ranged from 2,245.72 kg/ha to 3,866.70 for the bunded areas while for the fertilizer alone without bunding the yields were as from 1,852.35 to 3,493.30kg/ha.

Table 56: Maize yields (Kg/ha) as affected by different fertilizers and bunding in three Districts of Northern region

Treatments	Tolon	Walewale	Bunkpurugu
Fert/Organic/Bunded	3866.70 a	2987.90a	2245.72a
Fert/no organic,no bunds	3493.30 a	2105.65b	1852.35b
Total	**7360.00**	**5093.55**	**4098.07**

It was observed that the yield of maize was higher in Tolon district followed by Walewale and the least was in the Bunkpurugu district (Table 56). This is probably because the rainfall was better both in terms of intensity and regularity in Tolon than the other two districts. There was also no significant difference in yield of maize between the bunded and the non-bunded plots in Tolon. This suggests that where rainfall is regular and there is no dry spell, there will not be any difference in yields in maize whether bunded or not.

For districts such as Walewale and Bunkpurugu, where there were dry spells numbering up to two weeks (without rains) on occasions within the cropping season, yields in the bunded area were significantly higher than yields of maize in the non-bunded plots (Table 56). Bunding in upland fields are therefore very important for high yields in areas where rainfall is erratic.

The bunds help in trapping and retaining water after rains which is available for the crops if there is no rain in the next few days. However, farmers should be cautioned to break up part of the bunds if the rain is so heavy that there is standing water on the maize plot.

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

Executive Summary

It has become necessary to develop varieties to cope with the ever decreasing amount of rainfall and the erratic nature of it in the savanna region. In collaboration with international Agricultural Research Centres, a total of 6 mother trials (3 sets each of early and medium maturing varieties) and 15 baby trials were planted between June and July, 2011 at three (3) sites around Nyankpala, Walewale and Karaga within the Guinea savannah zone of Ghana. This was to evaluate and select drought/striga tolerant varieties/hybrids by the use of mother-baby model approach and to collect data on the performance of these lines on-farm to support the release of these materials as new varieties to farmers. Eventhough there were no significant differences in grain yield between the maize varieties used by farmers and the newly introduced ones, the farmers preferred the new varieties. The reason given was because they are early maturing and are tolerant to both drought and striga. For the second time, during farmers' preference test, **IWD-C2-SYN-F2** and **DT-SR-W-COF2** from the intermediate and **TZE W DT STR C4** and **TZE Y DT STR C4** from the early maturity category were chosen as the varieties they preferred. These will be advanced to the next stage in the process of releasing them as new varieties by planting them in the various sites in 2012 season and inviting the Varietal Release committee for the first round of inspection.

Introduction

Due to the breakdown of the genetic potential of the old crop varieties coupled with the ever decreasing amount of rainfall and its erratic nature in the savanna region, it has become necessary to develop varieties to cope with this situation.

Some of the qualities of the new varieties to be developed and released should be early maturing or drought and Striga resistant which should be made to replace the existing ones used by farmers. However, before these lines are officially released as varieties, they are to be tested widely across the agro-ecological zone of Northern region with farmers (on-farm) to ensure that they are not rejected when released.

It was therefore based on this that a good number of maize lines which have been proven to have these qualities by IITA on station were tested with farmers (on farm):

1. To evaluate and select drought/striga tolerant varieties/hybrids by the use of mother-baby model approach to on-farm research.
2. To collect data on the performance of these lines on-farm to support the Maize Breeding Programme of SARI, Ghana for release to farmers.

Materials and Methods

A total of 6 mother trials (3 sets each of early and medium maturing varieties) and 15 baby trials were planted between June and July, 2011 at three (3) sites around Nyankpala, Walewale and Karaga within Guinea savannah zone of Ghana. Five baby trials were planted along with two mother trials (early and medium varieties) at each site. Both early and medium maturing mother trials contained 4 drought tolerant varieties/hybrids and a local check and Farmers' varieties. Each plot contained six rows six meters long and replicated three times at each location. Plant spacings of 75m x 40m and 80m x 40m were used for early and medium varieties, respectively. Baby trials were not replicated and contained 2 drought tolerant varieties/hybrids and a local check with plot size of 20 m x 20 m each. Varieties used in the baby trials were selected from the mother trials.

Field days were organised at various mother trial sites when maize were about 90 days old. An average of 50 farmers attended each field day. Farmers were allowed to select their preferred varieties based on their own selection criteria (e.g. grain type, maturity group, and varietal reaction to biotic and abiotic stresses). Farmers were also enlightened on the recommended crop management practices for maize production during the field day.

Results and Discussions

Intermediate maize lines

Across locations, yields were highest in Nyankpala followed by Karaga and the lowest yields of the intermediate maize lines were obtained from Walewale (Table 57). These differences in yields could be due to differences in the amount and distribution of rainfall during the season. Both Nyankpala and Karaga had rainfall more than 1000 mm and they were more evenly distributed than in Walewale where the amount of rainfall was less than a 1000 mm and was more erratic and ceased abruptly in early September.

Table 57: Yield of intermediate maize lines tested at three sites in Northern Region of Ghana

Maize lines	Mean Yield (kg/ha)		
	Nyankpala	Walewale	Karaga
DT SYN 1 F2	5200.0	1777.8	4256.4
TZL COMP.3 C3	4888.9	1688.9	3458.6
IWD C2 SYN F2	4666.7	1866.7	3845.3
DT SR W CO F2	4488.9	1600.0	3768.9
OBATAMPA	4222.2	1022.2	2836.5
FARMERS VARIETY	3911.1	711.11	1548.2
$LSD_{(0.05)}$	NS	NS	NS

At the Nyankpala site, yields ranged from about 3.9 t/ha for the farmers' variety which was observed to be Obatanpa to more tha 5 t/ha for DT SYN 1 F2 (Table 57). Comparatively, there were no significant differences in the yields of maize among the lines in Nyankpala.

At Walewale, the lowest maize yield was obtained from the farmers' variety which was not also different from the yield of Obatampa (check) suggesting that it could also be Obatanpa but in a mixed situation. The rest of the lines tested even though out yielded the checks (Farmers' variety and Obatanpa) there were no significant differences in yield among them.

Even though the yields of maize were generally higher in Karaga than at Walwale, the trend was similar. The lowest yield was obtained from the farmers' variety which was similar to the local check (Obatanpa). The yields of the rest of the test crops were high but there were no significant differences observed among them.

Early Maize lines

Four early maize lines were also tested at the three sites with Dorke and farmers' varieties as checks. The results of the yields of maize showed a similar trend across the sites tested. There were no significant differences in maize yield observed among the four lines tested at each of the sites (Table 58).

Table 58: Yield of early maize lines tested at three sites in Northern region of Ghana

Maize lines	Mean Yield (kg/ha)		
	Nyankpala	Walewale	Karaga
TZE W DT STR C4	2800.0	3288.9	2785.2
TZE Y DT STR C4	2577.8	2088.9	2465.4
EVDT Y 2008 STR	2488.9	2133.3	2122.0
TZE COMP3 DT C2F2	2355.6	2977.8	2565.4
DORKE	2133.3	2000.0	2198.4
FARMERS VARIETY	1822.2	2622.2	2098.2
$LSD_{(0.05)}$	NS	NS	NS

Among the yields of all the maize lines tested including the two local checks at all the sites, Walewale recorded the highest maize yields for TZE DT STR C4. This suggests that the amount of rainfall at Walewale could not support the performance of the intermediate lines but favoured the production of the early lines (Table 58). Comparatively, despite the fact that the rains were erratic and ceased earlier than the other sites the yields across the sites were quite similar. The Farmers' varieties across the sites were mixed varieties made up of various improved maize varieties with different maturity periods with yield differences.

Baby Trials of Intermediate and Early Lines

The yields of both the intermediate and early lines of the baby trials were lower than the yields of the mother trials of the same test lines probably because of the differences involved in the management of these crops by the various farmers. Mother trials are researcher managed with a lot of intensive care and attention while baby trials are managed by the various farmers with varying methods, care and attention.

Intermediate maize lines

Even though both the mother and the baby trials had the same inputs such as fertilizers, the mother trials were managed by the researchers while the baby trials were managed by the farmers. However, the yields observed across the sites for the intermediate lines showed that Walewale recorded comparatively lower yields than the other two sites. One of the reasons for this could be similar reasons such as the nature of the rains as advanced for the mother trials (Table 59). The other reason could be due to differences involved in the individual management of these trials at the various sites. The intermediate maize yields at Nyankpala and Karaga were similar but higher than the yields at Walewale.

Table 59: Yields of intermediate maize lines of the baby trials at 3 sites

Maize lines	Mean Yield (kg/ha)		
	Nyankpala	Walewale	Karaga
DT SYN 1 F2	2533.3	1289.8	2746.9
TZL COMP.3 C3	2335.7	1808.9	2565.2
IWD C2 SYN F2	2666.7	1765.6	2892.6
DT SR W CO F2	2655.6	1744.2	2805.8
OBATAMPA	2622.2	1685.8	2675.3
FARMERS VARIETY	2622.2	1564.5	2045.2
$LSD_{(0.05)}$	NS	NS	NS

The analysed yield data shown in Table 59 indicate that there were no significant differences in yields among the maize lines at each of the sites. This suggests that despite the differences in the rainfall duration and amounts, each of the maize lines performed similarly across the locations.

Early Maturity maize lines

Comparatively, the grain yields of the short duration lines or early maturing maize lines were higher in Walewale than for Karaga and Nyankpala (Table 4). The higher maize yields in Walewale could be due to the short duration nature of the crop where the planting period coincided with period of optimum moisture produced by the rains of the season at the site.

Table 60: Yields of Early maize lines of the baby trials at 3 sites

Maize lines	Mean Yield (kg/ha)		
	Nyankpala	Walewale	Karaga
TZE W DT STR C4	1500.0	1602.5	1574.3
TZE Y DT STR C4	1733.3	2232.4	1685.5
EVDT Y 2008 STR	1200.0	2060.6	1346.2
TZE COMP3 DT C2F2	1500.5	2335.4	1498.8
DORKEY	1375.0	1852.2	1485.6
FARMERS VARIETY.	1800.0	1267.9	1958.4
$LSD_{(0.05)}$	NS	NS	NS

It was observed that **TZE W DT STR C4** which is both striga and drought resistant produced stable yields across the sites. **TZE Y DT STR C4** which has similar qualities**,** even though produced more than 2 tons/ha grain yield at Walwale, its yields were lower at Nyankpala and Karaga. In general, all the early maize lines tested performed better under the drought proned site than in Nyakpala and Karaga where rains were more stable and came in a larger quantities than in Walewale.

Farmers' preference
During field days both at the vegetative phase and at harvesting, Farmers were made to select the lines tested in the baby trials as contained in the mother trials at each site.

In the first place, the farmers chose the early as against the intermediate lines with the reason that rains do not come early and are now short in duration therefore they need short duration varieties to cope with this change.

Eventhough at each site the yields of both the intermediate and early were not statistically different, farmers' preferences among the lines were made. For the intermediate, the results of the exercise conducted showed that farmers at all the sites preferred **IWD-C2-SYN-F2** and **DT-SR-W-COF2** to the other intermediate maturing lines. This is the second year the farmers expressed interest of these materials over the others in the region. The selection was based on Crop features and characters considered included plant stand, cob size, grain size, and drought/striga resistance.

For the early maturing lines, **TZE W DT STR C4** and **TZE Y DT STR C4** were preferred to the other lines for reasons such as earliness and yield.

Recommendations/Conclusions
We therefore recommend that both **IWD-C2-SYN-F2** and **DT-SR-W-COF2** in the intermediate and **TZE W DT STR C4** and **TZE Y DT STR C4** in the early categories of the maize lines should be advanced in the process of releasing them as varieties. This could be done by planting them in the various sites this year (2012) and inviting the Varietal Release committee to come for inspection.

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

James M. Kombiok, S. K. Nutsugah, A. Karikari, Haruna Abdula, Ahmed Dawuni

Executive Summary
Jatropha plants have been used as fencing materials or as a boarder crop in the northern part of Ghana. Of late however, it has been considered in several countries as one of the plants used to produce bio-fuel. This new role it now plays has however encouraged entrepreneurs and governments of

some countries to initiate the establishment of Jatropha plantations with the aim of producing fuel. Since intercropping and mixed cropping are the most prominent cropping systems in Ghana, it became necessary to initiate studies on intercropping Jatropha with some food crops. The objective of the trial was therefore to assess the performance of some legumes (soyabean and cowpea) and cereals (maize and sorghum) in intercropping systems with Jatropha. The results showed that only maize in the sole significantly out-yielded those in the intercrop situation. The yields of the rest of the crops in the sole were similar to those intercropped. The yield of maize in the sole was more than 50% higher than the yield obtained from the Jatropha/maize intercrop. The yield of sorghum in the sole situation was not different from the yield of sorghum intercropped with Jatropha. Also, the grain yields of both soybean and cowpea in the sole and in the intercropped situations were not significantly different. Since the Jatropha was not yet fruiting, there were no yields to be compared indicating that the plant would have been too young to influence the yields of these crops like soybean and cowpea in the intercropping systems. The trial will be repeated for several years for a meaningful conclusion.

Introduction

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

With the inception of the EU-Sponsored Jatropha Project which is community oriented, SARI among other things was mandated to carry out field trials involving Jatropha. One of the trials was to find out how compatible Jatropha is as an inter crop plant with food crops. This is because farmers in the sub-region practice intercropping widely of which Jatropha will not be left out if it is accepted as a crop. It was therefore based on this reason that it became necessary in 2010 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 (soybean and cowpea) and cereals (maize and sorghum) in intercropping systems with Jatropha.

Materials and methods

The two sets of trials involving legumes and cereals were conducted at the SARI experiment fields at Nyankpala. Each of the trial as laid in a Randomized Complete Block design (RCBD) and replicated three times. Regular weeding was carried out on both trials to make sure the plants were weed free at most of the stages of crop growth.

Treatments:

a. Jatropha/cereal inter cropping system

Crops: maize, Sorghum and Jatropha

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

This was replicated three (3) times

b. Jatropha/Legume intercropping system

Crops : Soybean, cowpea and Jatropha

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

Results of Intercropping trials in 2011

Cereals: Maize and Sorghum

The yield of maize as affected by intercropping it with Jatropha has been assessed for the second time. The yield of maize in 2011 showed that sole maize significantly out-yielded the maize intercropped with Jatropha (Table 61).

Table 61: Yields of maize and sorghum as affected by intercropping with Jatropha 2011

Treatment/crop	Mean yield kg/ha
Sole maize	623.89
Jatropha/ Maize	305.56
LSD $_{(0.05)}$	98.32
Jatropha /sorghum	108.21
Sole sorghum	68.41
LSD$_{(0.05)}$	NS

This could be as a result of the scanty and erratic rainfall of 2011 that could not favour the maize in the intercrop due to Jatropha being a better competitor for water and nutrients than the maize.

The yield of sorghum showed no significant difference between the sole and the intercrop (Table 61). The trial needs to be repeated several years before a meaningful conclusion could be drawn.

Table 62: Yields of cowpea and Soybean as affected by intercropping with Jatropha 2011

Treatment/crop	**Mean yield kg/ha**
Sole soybean	314.81
Jatropha/ soybean	555.56
LSD $_{(0.05)}$	NS
Sole cowpea	500.00
Jatropha /cowpea	851.85
LSD$_{(0.05)}$	NS

Legumes: Cowpea and Soybean

In 2011 the yields of cowpea and soybean were similar in both the sole and in their intercrops (Table 62). Further investigations are required for meaningful conclusions.

ENTOMOLOGY PROGRAM

Executive Summary

The Entomology Programs consist of research activities to address insect pest problems of food and fibre crops in Northern Region. During 2011, three projects covering three commodity crops, peanut, soybean and cotton were executed. On peanut, research efforts were geared at screening of cultivars and lines for resistance to leaf spot diseases that are serious constraint to peanut production. Studies also were conducted to evaluate pre- and post- emergence herbicides for weed control. Additionally, farmer participatory approaches were adopted to empower farmers with knowledge and skills in integrated pest management under a Farmer Field School setting. On soybean, our previous studies showed that insect pests can cause up to 35% yield loss. Studies were therefore conducted to evaluate the effect of planting date and cultivar on the incidence of insect pests, damage and on yield. For cotton entomology, efforts were geared at evaluating various insecticides for control of insect pests with special reference to the bollworm complex, and impact on nontarget arthropods. This has become necessary following the banning and withdrawal of endosulphan, which though was the most effective insecticide for cotton, but also was very toxic to the environment. The major findings from the studies are discussed below.

Field Screening of Peanut Genotypes for Resistance to Leaf spot Diseases

Mumuni Abudulai and Jerry Asalma Nboyine

Introduction

Peanut is important as a food and cash crop in Ghana. About 439,030 MT was produced on 464,710 hectares in 2003 (SRID 2004). However, peanut yields in Ghana are low averaging less than 1000 kg/ha compared to an average of 2500 kg/ha obtained in developed countries such as USA. Early and late leaf spot caused respectively by *Cercospora arachidicola* and *Cercosporidium personatum*, are major diseases of peanut that can reduce yield by as much as 50% (Shokes and Culbreath 1997). The principal recourse for control is the use of fungicides. However, in Ghana farmers currently do not carry out any control for these diseases in their peanut farms due largely to lack of resources to use recommended chemical control. Therefore, the objective of this study was to screen peanut genotypes and cultivars for resistance to early and late leaf spot diseases.

This will enable us to select for and advance cultivars that are resistant and better adapted to the farming conditions of northern Ghana.

Materials and Methods

Field tests were conducted at Nyankpala in 2011 to evaluate 20 peanut genotypes or cultivars for resistance to early and late leaf spot diseases. Eleven of the genotypes or cultivars were obtained from the breeding program in CSIR-SARI while the remaining nine were obtained from our collaborators in Burkina Faso (Table 63). The experimental design was a randomized complete block with three replicates of each genotype or cultivar. Plot sizes were four rows 4 m long by 2 m wide. Leaf spot disease ratings were conducted at harvest using the Florida scale of 1-10 based on visual observations (Chiteka et al. 1997). The genotypes were also assessed for defoliation at harvest.

Results and Discussions

The results showed significant differences among the peanut genotypes or cultivars in the severity of early and late leaf spot diseases, pod yield and haulm weight. For early leaf spots, the genotypes F-Mix, G122-TX 95, ICGV (FDRS)-20 × F-Mix-39, B106 TX95, NKATIESARI, PC 7979 and F-MIX × SINK-24 had the lowest severity scores compared to the others. Also, F-Mix, G122 TX95, F-MIX × SINK-24 and B106 TX95 had the lowest severity scores for late leaf spots. These genotypes or cultivars therefore exhibited some level of resistance to early and late leaf spots. The cultivars Chinese and DOUMBALA and the genotypes TS 32-1, , GM57 = BC3.60-02-07-03, GM123 = BC3.41-10-09-02 had the highest disease scores for early and late leaf spots and therefore were the most susceptible to leaf spot diseases among the genotypes screened.

Correlation analyses showed that pod yield and peanut haulm weight were both negatively related to leaf spot disease ratings. This showed that leaf spots affected yield. Also, early leaf spots were highly positively correlated with late leaf spots, which also showed that cultivars with high severity of early leaf spots also suffered high severity scores for late spots.

Table 63. List of peanut genotypes or cultivars and origin evaluated for resistance to leaf spot diseases in Nyankpala, 2011.

Entry	Identity of genotype or cultivar	Origin
1	NC 7	Tamale-Ghana
2	F-MIX	Tamale-Ghana
3	NKATIESARI	Tamale-Ghana
4	ICGV-IS 96814	Tamale-Ghana

5	ICGV-IS 92093	Tamale-Ghana
6	ICGV-IS 96895	Tamale-Ghana
7	ICGV-IS 92101	Tamale-Ghana
8	GUSIE-BALIN (92099)	Tamale-Ghana
9	F-MIX × SINK-24	Tamale-Ghana
10	ICGV (FDRS)-20×F-MIX-39	Tamale-Ghana
11	CHINESE	Tamale-Ghana
12	GM57 = BC3.60-02-07-03	Burkina Faso
13	GM123 = BC3.41-10-09-02	Burkina Faso
14	GM515 = BC3.43-09-03-02	Burkina Faso
15	B106 TX95	Burkina Faso
16	G122 TX95	Burkina Faso
17	G204 TX95	Burkina Faso
18	PC 79-79	Burkina Faso
19	TS 32-1	Burkina Faso
20	DOUMBALA	Burkina Faso

Field Evaluation of Pre- and Post- Emergence Herbicides for Weed Control in Peanut

Mumuni Abudulai and Jerry Asalma Nboyine

Introduction

Weeds constitute an important biotic constraint to peanut production in northern Ghana. Peanut has a slow initial growth and can be suppressed by weeds resulting in significant yield loss if not protected. Yield loss due to weed interference in West Africa has been estimated to be 50 to 80% (Akobundu 1987).

Farmers in Ghana use both manual hand weeding and herbicides for control of weeds in crops. The pre-emergence herbicide Pendimethalin is the most commonly used herbicide in peanut. The objective of the present study was to evaluate various pre- and post- emergence herbicides for control of weeds in peanut.

Materials and Methods

Field experiments were conducted at Nyankpala to evaluate the efficacy of four herbicides applied sole or in alternation with each other and/or with supplementary weeding (Table 64) for control of weeds in peanut. Unweeded control and farmers' practice of two hand weedings at 3 and 6 weeks after planting (WAP) were included as checks.

Data were collected on weed species present and their dominance on the field before and after treatment application, Weed biomass, number of pods per plant, pod yield and haulm weight were taken at harvest.

Summary of Results and Discussions

The results showed that the farmers practice of two hand weedings at 3 and 6 WAP, application of pendimethaline plus one hand weeding, and application of the post-emergence herbicide gallant at 3-4 WAP and one hand weeding at 6-7 WAP resulted in significantly highest number of pods per plant. However, the application of agil, basagram or gallant at 3-4 WAP plus one hand weeding at 6-7 WAP or after pendimethaline treatment at 4-5 WAP showed significant increase in number of pods per plant over the weedy check. Pod yield was the highest in the farmers practice treatment plots. Plots treated with pendimethaline followed by gallant at 4-5 WAP, pendimethaline plus one hand weeding at 4 WAP, or a treatment with gallant or agil or basagram at 3-4 plus one hand weeding at 6-7 WAP resulted in significantly higher yield than sole treatment of either of the post emergence herbicides agil or gallant, and the weedy check.

Table 64. Pre and post emergence herbicide treatments applied to peanut fields in Nyankpala, 2011

Treatments	Time of application
Pendimethanlin (Pre-E)	Pre-E + HW 4 weeks after planting (WAP)
Gallant Super (Post-E)	3-4 WAP + HW 6-7 WAP
Agil (Post-E)	3-4 WAP + HW 6-7 WAP
Basagram (Post-E)	3-4 WAP + HW 6-7 WAP
Pendimethalin + Gallant	Pre + 4-5 WAP
Pendimethalin + Agil	Pre + 4-5 WAP
Pendimethalin + Basagram	Pre + 4-5 WAP
Pendimethalin alone	Pre-E-
Gallant alone	3-4 WAP
Agil alone	3-4 WAP
Basagram alone	3-4 WAP
Weedy check	Control
Farmers method (2 hand weedings)	HW 3 WAP + HW 6 WAP

HW – Hand weeding

Effect of Planting Date and Cultivar on Insect Pest Incidence, Damage and Yield of Soybean

Mumuni Abudulai and Jerry Asalma Nboyine

Introduction

Soybean was said to be free from insect pests attack in the earlier years of its introduction in Africa (Jackai et al. 1984). However, with the increased popularity of the crop over the years and increased area of cultivation, insect pests have now become important as damage by insects have been widely reported (Abudulai et al 2011; Jackai et al., 1988, 1990). A pest survey conducted at Nyankpala in northern Ghana revealed that *Spodoptera* spp., *Zonocerus variegatus* L. *Sylepta derogata* F. and a complex of pod-sucking bugs (PSBs) including *Nezara viridula* L, and *Riptortus dentipes* F. attack the crop (Abudulai 2004; Salifu 1993). Yield losses due to these insects are up to 43% in unprotected soybean fields in Ghana (Abudulai et al.2011) and up to 60% in Nigeria (Anyim 2003; Jackai and Keuenaman 1982; Jackai et al. 1985). Much of the yield lost is attributed to attack by the pod-sucking bugs (PSBs) complex that is the most important insect pests of soybean in Africa (Jackai and Singh (1987). PSBs feed on developing pods and seeds resulting in pod and seed abscission as well as seed shriveling and decay (Abudulai and Shepard 2001).

Despite the importance of these pests, farmers seldom control pests on their soybean fields resulting in poor yields. Insecticide control is the recommended practice for these insects in soybean. However, majority of soybean farmers are peasants and cannot afford insecticide control. The objective of this study therefore was to exploit host plant resistance in existing soybean cultivars and different planting dates for sustainable pest management in soybean.

Materials and Methods

Field experiments were conducted at Nyankpala and Yendi in the Northern Region. The factorial experiment comprised four soybean cultivars of different maturity groups and four planting dates arranged in a randomized complete block plot design with four replications. The soybean cultivars tested included TGX 1799-8F (early maturity), TGX 1834-5F (medium maturity), Jenguma (medium maturity) and Salintuya II (late maturity). They were planted at two weeks intervals starting from 28 June 2011 in Nyankpala and 20 July in Yendi. June is the normal planting time for soybean in the Northern Region. Plots consisted of six row 5 m long. Inter and intra row distances of 0.60 m and 0.05 m were maintained.

Insects were sampled on plants beginning two weeks (V2) after planting of each maturity group and planting date using the beet cloth method of Kogan and Herzog (1980). Data on pests' incidence and densities were recorded until harvest (V8) (Fehr and Caviness 1977). Defoliation by leaf eating insects were estimated in each plot by randomly selecting two trifoliate leaves on 10 plants to assess the percent leaf surface missing using a scale of 5-100%. At maturity, pods were harvested for yield data from the middle four rows. A sample of 100 pods was examined for characteristic pod and seed damage by PSBs, which was shriveling and decay of pods and seeds. The pods were shelled to determine seed damage. All data were analyzed using SAS (SAS Institute 1998).

Results and Discussions

Nyankpala

Populations of PSBs and pod damage did not differ significantly among the soybean cultivars. However, PSB populations were lower at the second and third planting dates than at the last planting date. Pod damage due to PSBs was lower at the earlier plantings than at the last planting date. Similarly, seed damage was lowest at the first and second planting dates and highest at the forth planting date, with TGX-1834-5F and TGX 1799-8F sustaining the lowest damage and Salintuya II the highest damage. TGX-1834-5F was the highest yielder among the genotypes. Yield was greatest at the first planting date followed by the second planting date and least at the third and forth planting dates.

Yendi

Populations of PSBs were fewer on TGX 1799-8F at the first planting date than at later planting dates. Similar observations as for TGX 1799-8F were made for TGX 1834-5F. PSB Populations in Salintuya II, were lower at the first and forth planting dates while in Jenguma, populations were lower at the second planting date.

Seed damage was generally low and uniform in TGX 1799-8F across planting dates. In TGX 1834-5F, damage was lower at the first and second planting dates than at the other planting dates. For Salintuya II, seed damage was lower at the second planting date while in Jenguma, damage was lower at the first and third planting dates. TGX 1799-8F had the lowest damage at the third and forth planting dates. For all the varieties and lines, the greatest yields were recorded at the first planting date. Yields diminished at planting was delayed with e least yield recorded at the last planting date

Field Evaluation of Insecticides for Control of Insect Pests in Cotton, with Special Reference to the Bollworm Complex, and Impact on Non-target Beneficial Arthropods

Mumuni Abudulai and Jerry Asalma Nboyine

Introduction

The bollworm complex comprising the American bollworm, *Helicoverpa armigera* (Hubner); Spiny bollworm, *Earias* spp.; Pink bollworm, *Pectinophora gossypiella* Saunders; Sudan bollworm, *Diparopsis watersii* (Rothschild); and the False codling moth, *Thaumatotibia* (=*Cryptophlebia*) *leucotreta* Meyrick are the most destructive insect pests of cotton in Ghana and in the West African sub-region (Abudulai et al 2006). The larvae damage plant terminals and also chew into squares and developing bolls, resulting in abscission of these floral parts and loss in seed cotton yield. Also, the cotton stainer, *Dysdercus* sp., and other hemipteran bugs feed on the seed in open bolls affecting seed quality for germination while the extreta of these insects stain the lint.

In Ghana, endosulfan, an organochlorine insecticide was one of the most effective and widely used insecticides for pest control in cotton until 2006 when it was banned, because of abuse and hazards to the environment. There is therefore increased search for suitable alternatives to endosulfan that are effective and yet less toxic to nontarget organisms and the environment. The objective of the present study was therefore to evaluate two new insecticides, Tihan 175 O-Teq (Spirotetramat + Flubendiamide) and Thunder 145 O-Teq (Imidacloprid + betacyfluthrin) manufactured by Bayer CropScience for control of insect pests in cotton.

Materials and Methods

Field experiments were conducted at Nyankpala and on a farmer's field at Walewale in 2011 using five insecticide treatments, 1) Tihan 175 O-Teq alone, 2) Thunder 145 O-Teq alone, 3) Tihan 175 O-Teq (1st 3 sprays) and Thunder 145 O-Teq (4th to 6th sprays), 4) Chlorpyrifos (Dursban 4 EC) (1st 3 sprays) and Lambda cyhalothrin (Karate 2.5 EC) (4th to 6th sprays) and 5) untreated control (Table 65). The treatments were arranged in a randomized complete block design and replicated four times. Plots consisted of 10 rows 10 m long, with spacing of 0.75 m between rows and 0.30 m between plants in a row. Plots were planted to the cotton cv FK 290. Plots were sampled for insects before the first spray and subsequently at two weeks intervals until harvest.

Results and Discussions

Nyankpala Tests

There were fewer bollworms per plant in treated plots compared with untreated plots. Also, percentages of damaged bolls were significantly lower and similar in treated than untreated plots. The highest seed cotton yield was recorded in plots that were treated with the manufacturer's recommendation of three sprays of Tihan 175 O-Teq followed by another three sprays of Thunder 145 O-Teq. Yield also was significantly higher when plots were treated with chlorpyrifos for the first three sprays followed by lambda cyhalothrin for the next three sprays than either treatment with Tihan 175 O-Teq alone or Thunder 145 O-Teq alone in the season.

There were significant and positive correlations between bollworm densities and percentage damaged bolls and percentage yield loss. Bollworm densities and percentage damaged bolls were both negatively correlated with seed cotton yield

Walewale Tests

There were fewer bollworms per plant in the Tihan 175 O-Teq alone and Tihan 175 O-Teq plus Thunder 145 O-Teq treatments compared with the Thunder 145 O-Teq alone treatment. Percentage damaged bolls was lowest in the Tihan 175 O-Teq plus Thunder 145 O-Teq treatment while the highest damage was recorded in untreated plots. However, the damage in the Tihan 175 O-Teq plus Thunder 145 O-Teq treatment were not lower than either Tihan 175 O-Teq alone or the Thunder 145 O-Teq alone treatments. As at Nyankpala, the greatest seed cotton yield was recorded in the Tihan 175 O-Teq plus Thunder 145 O-Teq treatment while the lowest was recorded in untreated control.

There were no significant correlations between bollworm densities and percentage damaged bolls or between bollworm densities and seed cotton yield. However, percentage damaged bolls was negatively correlated with seed cotton yield

Some Ecological Studies of Insect Pests Of *Jatropha Curcas* In Northern Region Of Ghana

Afia Serwaa Karikari, J. Nboyine and F. Agyepong

Executive Summary

Contrary to popular belief that toxicity and insecticidal properties of *Jatropha curcas* are a sufficient deterrent for insects that cause economic damage in plantations, several groups of insects have overcome this barrier. The attack of insect pests is a limiting factor in achieving optimum production, and some time even makes harvests fail. If *J. curcas* is cultivated as fences or in intercropping systems, the problem of pests is not very significant, and can in this case be overcome easily. But if the cultivation is being done in monocultures, pest control may become important.

In Ghana, knowledge of Jatropha insect pests is virtually non-existent. The study sought to identify the insect pests of *J. curcas* towards the development of management strategies. The data was undertaken on-farm in 4 locations in the northern region. Using direct observation in a randomized complete block design, the insects, their damage and numbers were recorded on plants which were few weeks to 11/2 years old.

Six insects were identified within the four locations to be the insect pests of *J. curcas.* These are namely; *Calidea dregii*, *Aphthona sp* (flea beetle), grasshoppers (all kinds), *Halymorpha halys*, *Leptoglossus sp* and *Nezara viridula*. Among the six insect species identified, flea beetles were the most occurring and the most abundant within the locations followed by the *calidea* species.

The conclusion was that the fields in most of the locations were very young and flea beetles are defoliators of young growing plants with a lot of new young leaves. It was also observed and concluded that poorly managed fields contributed immensely to high insect pests of *J. curcas*. As part of the activities, a simple training module was designed to train the farmers to know what insect pests are, how to identify an insect visitor as pest, how to identify the key pest of jatropha and what to do in case of pest attack. Also the farmers were given a simple laminated picture of the key pests of jatropha to help with their identification on the field.

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 (Chitra and Dhyani, 2006). In Ghana, *Jatropha curcas* in recent times, is gaining importance as a biodiesel plant and is being advocated for as an alternate livelihood source especially for poor smallholder farmers and for the development of wastelands and dry lands. 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. 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).

The attack of insect pests is a limiting factor in achieving optimum production, and some time even makes harvests fail. If *J. curcas* is cultivated as fences or in intercropping systems, the problem of pests is not very significant, and can in this case be overcome easily. But if the cultivation is being done in monocultures, pest control may become important (Fact, assessed, April, 2012). In Ghana, knowledge of Jatropha insect pests is non-existent. This study sought to identify the insect pests of *J. curcas* towards the development of management strategies.

Materials and Methods

The study was undertaken on-farm in 4 locations namely Bimbini ($10^o 19.819^1$ N, 001^o 03.783^1W), Janga (-), Wungu (10^o 19.247^1N, 000^o 50.359^1W) and Yama (10^o 19.551^1N, 001^o 00.537^1 W) all in the northern region. Using direct observation in a randomized complete block design, the insects, their damage and numbers were recorded on plants which were few weeks to 11/2 years old.

Results and Discussion

Six insects were identified within the five locations to be the insect pests of *J. curcas.* These are namely; *Calidea dregii*, *Aphthona sp* (flea beetle), grasshoppers (all kinds), *Halymorpha halys*, *Leptoglossus sp* and *Nezara viridula*. Their damage and numbers are enumerated below.

Table 66. Pests of Jathropha and damage caused

Pest	Damage
Calidea	Suck sap from the bud, fruits and seed, leading to fruits and seed abscission. Their damage affects both the yield and quality of the oil produced.
Flea beetle	Mostly eat the young reddish leaves but sometimes the large green leaves also.
Grasshoppers	Both the nymphs and adults eat the leaves of the young and mature plants, often left the leaves bited. If the attack is heavy, only bones of the leaves are left, and plant becomes bald.
Halymorpha	This brown mamorated bug suck sap from both the vegetative and floral parts of the plant.
Leptoglossus	Have similar damage as in calidea and nezara. They cause serious fruit abscission (major pest in Central America)
Nezara	Damage similar to that of calidea. They destroy the tip of the plant, the flower and capsule, causing sporadic falling of the capsule up to the death of a whole bunch/panicle.

Other Results

Pests densities at the four On-farm locations

Within the four locations, Janga recorded the highest pest density. This could be attributed to the fact that it was poorly managed and the plants were almost being choked with weeds.

Relative importance/occurrence of pests in Jatropha fields

Among the six insect species identified, flea beetles were the most occurring within the locations followed by the *calidea* species. This confirms flea beetles feeding preference as defoliators of young growing plants with a lot of new young leaves. The fields in most of the locations were very young.

Abundance of the Insect

Calidea species were recorded as the most abundant pests in only Janga community. All the three remaining locations had flea beetles as the most abundant. This is also a confirmation that calidea species attacks during the reproductive stage of jatropha. Janga was the only community with a lot of flowering and fruiting plants.

Technology Transfer

A simple training module was designed to equip the farmers to know what insect pests are, how to identify an insect visitor as pest, how to identify the key pest of jatropha and what to do in case of pest attack. As part of the training, farmers were given a simple laminated picture of the key pests of jatropha to help with their identification on the field.

Conclusion

Good field sanitation will minimize insect pest infestation of *J. curcas* which would result in improved yields and quality oil. The proof for the assertion is the high pest densities of Janga followed by Yama, which had the poorly managed fields.

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Baseline Studies of Insect Pests of Rainfed Lowland Rice Ecologies

Afia Serwaa Karikari, A.N. Wiredu and J. A. Nboyine

Executive Summary

The rice plant is an ideal host for a large number of insect species in West Africa. All parts of the plant, from the root to the developing grains, are attacked by various species. In West Africa, about 10 species are of major importance.

One of the problems associated with the lowland ecology is insect pest damage. However in Ghana knowledge of lowland rice insect pests' infestation is virtually non-existent. This ignorance stems from a lack of comprehensive research and established database of insect pests' studies in the lowland rice cropping systems.

The current study sought to undertake indigenous and scientific surveys to establish a database of insect pests of rainfed lowland rice ecologies for management purposes.

Due to drought drought and financial constraints the scientific studies were curtailed.

For the results of the indigenous survey, the farmers were able to identify some insect pests of rice that were in line with Tanzubil & Dekuku, 1991 findings. This shows that farmers may not be educated but their long years of experience make them knowledgeable. It is therefore recommended that

researchers adopt indigenous knowledge as a baseline to their scientific research.

Introduction

Rice has become the second most important staple food after maize in Ghana and its consumption keeps increasing as a result of population growth, urbanization and change in consumer habits (MOFA, 2009) especially in the northern region of the country. The rice plant is an ideal host for a large number of insect species in West Africa. All parts of the plant, from the root to the developing grains, are attacked by various species. In West Africa, about 10 species are of major importance.

Rice is produced in Ghana under three main ecologies; rain-fed lowland, irrigated and upland. Upland rice production was once important, but the area under this type of cultivation is now 6% and the irrigated rice schemes contribute about 16% of the total national rice production. In the present the rain-fed lowland ecology is dominant, covering over 78% of total harvested area.

Studies undertaken in 1996 and confirmed in 2000 showed that the rain fed lowland ecology is the most profitable for rice production (MOFA, 2009). This means that enhancing the yields of rainfed lowland rice will boost food security and incomes especially of resource- poor farmers in the northern region which cultivate the highest percentage of lowland rice (MoFA, 2009).

According to Kranjac-Berisavljevic *et al*., 2003, one of the problems associated with the lowland ecology is insect pest damage. However in Ghana knowledge of lowland rice insect pests' infestation is virtually non-existent. This ignorance stems from a lack of comprehensive research and established database of insect pests' studies in the lowland rice cropping systems.

The current study sought to undertake indigenous and scientific surveys to establish a database of insect pests of rainfed lowland rice ecologies for management purposes.

Materials and Methods

Scientific survey:

The scientific survey was carried out in the East Gonja (Libi), Savelugu-Nanton (Manguli) and Tolon-Kunbungu (Nyankpala) districts of the northern region. The data was collected in an RCB design, at the critical stages of growth. The observations were made twice per stage.

Indigenous survey:
The data for the study was obtained from a cross section of rice producing communities and households. At the first stage, 10 rice producing districts (6 from Northern region; 2 from Upper East region; 2 from Upper West region) were purposely selected. Within each district, two communities were then selected randomly. At the community level 10 households were randomly selected from a list of rice producing households. Overall the study involved 400 rice producing households drawn from 40 communities selected from the 10 districts.

Results and Discussion
Scientific survey:
The scientific survey could not be completed due to drought and financial constraints.

Indigenous survey:
Rice producing households in northern Ghana are mostly managed by male household heads (Table 67), who usually serve as liaison, spokesperson or representative of the members of the households.

Table 67: Characteristics of sampled households

	Region			Overall
Characteristics of head	Northern	Upper West	Upper East	
Male (%)	98.56	100	92.50	97.56
Female (%)	1.44	0	7.50	2.44
Age (Years)	50.46	55.73	49.27	51.34
Experience in rice farming (Years)	18.69	13.29	19.96	17.79
Educated (%)	14.83	27.5	17.5	18.16
Natives (%)	85.65	100	95	90.79

Source: RSSP baseline data, 2011.

The result suggests that the heads of the rice producing households have considerable years of experience in rice production. On the average each household head have spent about 30 percent of their lifetime on rice cultivation. With about 20 years of experience, the rice producers in Upper East Region for instance are expected to have acquired rich store of knowledge from practice and are very conversant with the pests of rice even just about 19% were educated. Also a higher percentage of the respondents are natives which means they know the history of pests' problems of rice in the areas.

About 48 percent of the rice producers identified various insect pests on their rice fields. These including stem borers, aphids, bugs, grasshoppers, and caterpillars caused various forms of damages to the rice plants. They also identified spiders as natural predators of some of the harmful insect pests. Birds were also identified as important pest of rice by about 35 percent of the farmers. Some farmers also identified rodents such as grasscutters and rats, fishes as important pests on their rice fields.

Attacks were mostly observed when the plants matured, during the vegetative stage, flowering and germination stages. Although some farmers (about 29%) had no strategy to control these infestations, the remaining farmers applied insecticides, adopted cultural practices and resistant varieties. Birds were scared off the rice fields while rodents were trapped and destroyed.

Table 68: Pest and disease conditions

	Region			Overall
Pests & diseases	Northern	Upper West	Upper East	
Insects	48.33	42.5	52.5	47.97
Birds	5.74	100	42.5	34.5
Diseases	8.61	1.25	10	7.32
Period of attack				
Germination	10.05	1.25	23.75	11.11
Vegetative	43.54	41.25	31.25	40.38
Flowering	21.53		12.5	14.91
Maturity	46.41	100	45	57.72
Control				
Nothing	18.66	83.75		28.73
Neem extract			1.25	0.27
Insecticides	12.92		27.5	17.88
Cultural practices	7.66		26.25	10.03
Resistant varieties	1.44		6.25	2.17
Scaring	19.62	32.5	6.25	19.51
Capture		18.75		4.07

Source: RSSP baseline data, 2012.

Conclusions

The farmers' observations, thus the identified pests, are in line with some of the findings of Tanzubil & Dekuku, 1991. This shows that though the farmers may not be educated but their long years of experience make them knowledgeable. It is therefore recommended that researchers adopt indigenous knowledge as a baseline to their scientific research.

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AGRICULTURAL ECONOMIST

Background
At the head office the activities of the Socio-economic Section (SeC) inform research and development (R&D) programs of the all the research groupings including the all the Regional Farming Systems Research Groups (RFSRGs) and the Scientific Support Group (SSG). In this report are highlights of specific socioeconomic activities conducted in 2011. The activities include strategies to manage annual yam glut in Brong-Ahafo Region, ex-ante impact study for the Rice Sector Support Project (RSSP), adoption monitoring study for the AGRA Soil Health Program (SHP) and a review of millet and sorghum production systems for the project to Promote Millet and Sorghum Production 2 (PROMISO 2). For the Drought Tolerant Maize for Africa (DTMA) project the section continued to evaluate new drought tolerant varieties and also reviewed the new Plant and Fertilizer Act of the republic of Ghana.

Strategies to Manage Yam Glut at Peak of Harvest in the Brong-Ahafo Region of Ghana

Alexander Nimo Wiredu, Prince Maxwell Etwire, John Nortey (Statistician, MoFA/SRID), Richard W. N. Yeboah (Agricultural Economist, UDS)

Executive Summary
Despite the importance of yam as a high value commodity, annual gluts peaking in July and August has negatively affects producers and traders in Brong-Ahafo Region. Constraints including agronomic, finance, postharvest and processing were identified. The study also revealed that the most efficient channels were those with the least number of intermediaries. Proposed strategies to manage the glut situation include, varietal development, improvement in post harvest technologies, market infrastructure and information systems.

Introduction
Yam (*Dioscorea* species) is a high value commodity with the potential to contribute significantly to food security, income, culture and tradition in the Brong-Ahafo region and Ghana as a whole (Hahn et al., 1987). Yam glut is however an annual occurrence in the Brong-Ahafo region that negatively affects both producers and traders in diverse ways. This project was therefore expected to develop strategies to manage yam glut situation. More specifically the project described the incidence and causes and effect of glut,

described and determined the most efficient yam market chain and then proposed strategies for managing yam glut in the region.

Methodology/Approach

The study was participatory involving all the relevant stakeholders. Data generated from surveys of selected yam communities and markets together with some secondary data provided the basis for analysis of the yam industry. Trend analysis was used to describe the incidence of glut. The efficiencies of the marketing channels were assessed by examining how well the channels respond to consumers and producers demand for services in relation to their preferences.

Results and Discussions

Scientific findings

The causes of yam glut include agronomic, postharvest, utilization and finance. Yam in the domestic market is handled by producers, assemblers, wholesalers and retailers with specific functions. The channel of distribution also includes an export chain. During the peak of glut (i.e July-August) yam producers record losses while exporters record the highest margins. The results however shows that yam marketing should not necessary include exporters to make it efficient, reducing the number of intermediaries domestically can help improve the efficiency of the marketing channels significantly.

Conclusions/Recommendations

The study provides evidence and causes of glut. It is therefore recommended that investment in yam improvement should focus on the development of varieties that are marketable and storable. Research should also consider the development of alternate uses for yam as well as the development of appropriate storage technologies. The district offices of the MoFA should be strengthened to serve as market intelligence centres for accessing information on the domestic market and international market for yam. The use of information technology, mass media and mobile phones to access market information should be encouraged. Training on appropriate production practices, particularly harvesting and postharvest practices is also required. There is also the need to develop technologies that would enable the production of yam all year round. There is the need to increase the efficiency of the various channels of distribution by strengthening the linkages between the various actors.

Future activities/The way forward

The project will come to a close in June 2012. A results validation stakeholder workshop will be organised in May 2012. This will be followed by the development and distribution of extension guides to facilitate the dissemination of the findings. At least 1 journal article will be published from the data generated from the study.

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Ex-Ante Impact of Rice Sector Support Project in Northern Ghana

Alexander Nimo Wiredu, Prince Maxwell Etwire, SK Nutsugah, AS Karikari, W Dogbe, RAL Kanton, AA Abunyewa

Executive Summary

Efforts to improve the performance of the rice industry in Ghana include the implementation of the Rice Sector Support Project (RSSP). As part of the project, a baseline study was conducted to characterize the rice production system in northern Ghana and assess, ex-ante, the potential impact of the RSSP on livelihoods in the project communities. Preliminary results show that the project has high potential impact on the intended beneficiaries. It revealed that about 70 percent of the farmers did not have access quality seeds. However, more than 60 percent of the farmers were willing to adopt hydromophic rice varieties.

Introduction

Rice has become a strategic commodity for most economies of Sub-Saharan Africa including Ghana. Efforts to improve domestic rice production include the implementation of the Rice Sector Support Project (RSSP). As part of the activities of the project is a baseline study purported to characterize the rice production systems in northern Ghana. It also intended to assess ex-ante the potential impact of RSSP on the targeted beneficiaries.

Materials and Methodology

The core data for the study was obtained from a cross section of rice producing communities and households. Community level data was obtained through focus group discussions and key informant interviews. This captured generalized information about the characteristics of the rice producing communities particularly resources, crop cycle and infrastructure. The second level involved formal interviews with heads of rice producing households. Secondary data on aggregate production and prices was obtained from the Statistics Research and Information Directorate (SRID) of Ministry of Food and Agriculture (MoFA) of Ghana.

Results and Discussions

Scientific findings

The crop calendar for rice which follows the rain-fall pattern, generally beginning from March and November, provides useful guide for timely execution of the field activities of RSSP. Prior to RSSP, about 27 percent of the farmers had participated in rice specific projects with benefits such as bunds, water canals and credits facilities. Be it kind or cash, the credit facilities provided means of finance for rice production activities. Unlike fertilizers, access to quality seeds was limited to less than 30 percent of the farmers. The seeds and fertilizers are either broadcasted or dibbled. The rice producers consider yield, market, maturity, grain price, palatability and seed availability in the choice of rice varieties.

Awareness of integrated rice-cover cropping was limited to Northern and Upper East regions. However after explanation of the potential benefits of the technology, about 88 percent of the farmers expressed their willingness to adopt. Presently, about 2 percent of the farmers were already practicing the technology.

Conclusion/Recommendation

The results from the study suggest high potential impact of the RSSP project. There is the need to incorporate the findings of the baseline study into the field research and development activities.

Future activities/The war forward

The targeting and assessment process will continue in year 2. Detailed analysis of the baseline data will be conducted to produce a typology of the rice production system. This will provide specific guidelines for the project implementation process. Journal articles are also being drafted from the baseline database for publication. Meanwhile preparation for will continue for the ex-post impact assessment of the project.

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M&E and Impact of AGRA Soil Health Project in Northern Ghana

Alexander Nimo Wiredu, Prince Maxwell Etwire, Mathias Fosu, Francis Kusi, SSJ Buah, John Bidzakin

Executive Summary

More than 50% of the project participants had adopted the ISFM technology. There is the need to continue with the current trend of promotional activities with complementary technologies in the package. Farmer exchange visits are potential channel for technology dissemination. A study to assess the impact of the AGRA Soil Health Project (SHP) will be conducted in 2012.

Introduction

The season under review featured the implementation of a monitoring and evaluation (M&E) system for the project. The monitoring and evaluation system was intended to generate relevant information to track the performance of the AGRA soil health project. The system collated and analyzed project activities including training and adoption of new technologies. It also expected to inform the design of the impact study for the project.

Materials and Methodology

A two-day training workshop climaxed the development of the M&E system. The workshop involve project desk officers from the Ministry of Food and Agriculture (MoFA), the regional coordinators and technicians from Savanna Agricultural Research Institute (SARI) and the monitoring and evaluation team also from SARI. The training workshop also provided the opportunity for the M&E team to normalize the M&E data sheet and improved on the analysis. The data sheet has critical performance indicators that will be useful for the assessment process.

Results and Discussions

Scientific findings

The project featured training activities, workshops and exchange visits. With a total of 8947 man/days, training activities dominated among the list of activities undertaken. Workshops provided the platform for results sharing and planning. It also featured both male and female participants with 1839 man/days of interactions. Exchange visits to neighboring project sites also facilitated effective learning as farmers understood their colleagues better.

The results also show that fertilizers are important aspect of crop production among the project participants with over 90 per rate of adoption of inorganic fertilizers. In all, about 45 percent of the participants have adopted the ISFM technology (i.e. use both organic and inorganic fertilizers). Scarcity of organic materials however constrains adopt the technology. The use of rhizobium on the other hand was limited to less than 1 percent of the project participants. Further investigations revealed that the inoculants are less available among farmers.

Conclusions/Recommendations

The M&E process has generated reasonable estimates of adoption incidence in the project domain. More than 50 percent adoption among project participants is a sign of success of the project. There is the need to consolidate the achievement with special attention to exchange visits for wider and effective coverage.

Future activities/Way forward

Lessons learnt from the M&E process will be adapted to other projects. A study has been initiated to evaluate the credit facility of the project. This will be followed by the ex-post impact study will also be conducted during the season of 2012.

Review of millet and sorghum production systems for PROMISO 2 in Northern Region

Alexander Nimo Wiredu, Prince Maxwell Etwire, IDK Atokple, AS Karikari, SSJ Buah, RAL Kanton

Executive Summary

Contribution to the project to Promote Millet and Sorghum 2 (PROMISO 2), a sector wide review is being conducted. Field data collection is completed and data analysis is underway.

Introduction

The project promoting millet and sorghum 2 (PROMISO 2) is expected to make meaningful contribution to the global and continental efforts to adapt vulnerable livelihoods and also to consolidate gains made in the past. It project seeks to increase the production of sorghum and pearl millet in response to critical food shortages resulting from severe climatic changes. In this regard, the capacities of resource poor farm households, especially women in Ghana were built. In contribution, a study was initiated to provide an overview of the sorghum and millet production system as a basis for a policy brief on the two industries. In addition a M&E system was also developed.

Materials and Methodology

The project employed participatory approach in all the implementation process. The sorghum and millet sector study was done through in-depth surveys.

Results and Discussions

Scientific findings

Analysis of survey data is on-going.

Way forward/Future

A draft policy brief will be presented to the appropriate authorities for publication. Journal articles will be developed and submitted for publication.

Assessment and targeting for the DTMA project in Ghana

Alexander Nimo Wiredu, Prince Maxwell Etwire, JM. Kombiok, RAL Kanton, SSJ Buah, MS Abdulai, H Alidu, A Tahirou (Agric Economist, IITA)

Executive Summary

Economic evaluation of the new drought tolerant maize varieties for 2011 is in progress. The analysis will focus on the sensitivity of the variation to annual variations in climate and price environment. In addition to the economic evaluation, the Plant and Fertilizer Act is being reviewed to provide basis for sensitization of relevant stakeholder in the agricultural input industry.

Introduction

The purpose of targeting and assessment is to provide information to guide the DTMA project. Assessment of the economic potentials of the newly developed drought tolerant maize varieties is expected to provide additional evidence to justify the release of the varieties. Potential investors can make informed decisions about the available alternatives. In addition the review of the seed law will aid the sensitization of stakeholders about the new maize varieties.

Methodology/Approach

Partial budgets for the drought tolerant maize varieties are being conducted. The sensitivities of the varieties will also be evaluated.

Results and Discussions

Scientific findings

Analysis is on-going.

Future activities/The way forward

The results of the analysis will be disseminated at various stakeholder forums. The next season ushers in the 3rd phase of the project. During this period studies will be initiated to monitor the adoption of the drought tolerant maize varieties and farmer preference evaluation.

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

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 nitrogen (N) and phosphorus (P). Traditionally, farmers in northern Ghana grow soybean (*Glycine max*) under low plant stand without any fertilizer addition, thus leading to lower grain yields. An experiment was conducted in 2010 and 2011 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 in 2010 showed that soybean varieties response to rhizobium inoculation and mineral fertilizer were similar. Pod shattering was visually more severe in Salintuya 1 than in Anidaso and Jenguma. Over the years, soybean fertilized with mineral fertilizer with or without rhizobium had similar yields as those that did not receive fertilizer or rhizobium.

Introduction

Soybean 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. In addition, it requires lower production inputs. 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 N which frequently results in low crop yields or soil productivity. Traditionally, farmers in northern Ghana plant soybean with little or no fertilizer input. 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 inoculums to enhance nitrogen fixation in grain legumes could address declining soil fertility problems. Mean grain yield of soybean 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. Therefore 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. Hence, there was the need to evaluate soybean response to mineral fertilizers and rhizobium inoculation in the savanna zone in order to find 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. Preliminary results in 2010 showed that soybean varieties responded similarly to rhizobium inoculation and mineral fertilizer, hence only the non-shattering variety Jenguma was selected for further evaluation in 2011. Thus in 2011, the experiment was in a randomized complete block design with four replications. The five (5) fertilizer treatments used in the study are presented in Table 69.

Table 69. List of fertilizer treatments tested in 2011

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
T5	Rhizobium +60 kg P_2O_5+30 kg K_2O/ha

* T4 is the recommended fertilizer rate for soybean in the northern savanna zone

Improved production package were followed that included growing the soybean variety (cv Jenguma) using the 5 fertilizer treatments. Jenguma is a non-shattering variety which is quite popular among soybean farmers. 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.

Results and discussion

Data for 2010 and 2011 cropping seasons showed that on average, fertilizer treatment did not significantly influence flowering date, plant height, grain yield and its components when compared with no fertilizer treatment (Table 70). 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. The soil at this site is slightly acidic (pH=5.46).

Table 70. 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	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

The Way Forward

The experiment was initiated in 2010. Consequently responses to fertilizer and rhizobium were measured during one season. The study will continue for two more seasons in order to reach definite conclusions.

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

S.S. J. Buah

Executive Summary

Studies were initiated in 2008 and continued through 2011 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. In 2011, two sub-projects were implemented during the cropping season in the Upper West region of Ghana which is a drought prone area. The two sub-projects concentrated on On-farm testing of extra-early, early and intermediate maturing drought tolerant maize varieties and hybrids and seed production of normal endosperm and quality protein maize (QPM) varieties which combine *Striga*

and drought tolerance. These activities were carried out in Nadowli, Sissala East and Sissala West districts as well as Wa municipal in the Upper West region of Ghana. A total of 60 farmers (44 males and16 females) were directly involved in the project in 2011. The variable weather in 2011 affected plant growth and development and ultimate grain yield at most sites. Genotypic differences among the maize varieties for grain yield were significant at Sissala West and East districts only. For the extra-early maturing genotypes, grain yield was highest for 2004 TZEE W POP STR C4 but least for the farmer's variety and TZEE W POP STR C3 at Tumu in the Sissala East dictrict. Consistent with results obtained in 2009 and 2010 across sites, grain yield was highest for the intermediate maturing varieties DT SR W COF2 and DT SYN 1-W at Silbelle in the Sissala West district. The early maturing genotypes produced similar grain yields at Kpongu in the Wa Municipal. Similarly the extra early maturing genotypes had similar grain yields in both the mother and baby trials in the Nadowli district. In general, grain yield of the QPM hybrid, Etubi was lower due to low plant stand as a result of poor seedling establishment. 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. In general, 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 most of the fields were not Striga endemic plots.

Introduction

The Maize Improvement Program of Ghana has been collaborating with the International Institute of Agriculture (IITA) over the years to develop and evaluate improved maize varieties and hybrids suitable for the various agro-ecological systems in Ghana. Since 2008, promising high yielding and drought tolerant maize varieties and hybrids selected based on trial results were evaluated in farmer participatory on-farm trials and demonstrations. These trials served as important vehicle to showcase the effectiveness of new technology to farmers. Additionally, the participatory on-farm testing of the varieties could also facilitate the rapid transfer and adoption or acceptance of these drought tolerant maize varieties by farmers. In order to increase the production and productivity of maize in drought prone areas of Ghana as a way of improving food security and rural incomes, drought and Striga tolerant varieties were introduced to farmers in such drought prone areas 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 test a subset 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 four locations in the Upper West region (Kpongu in Wa municipality, Goriyiri in the Nadowli District, Silbelle in the Sissala West District and Tumu in Sissala East District). Three sets of 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 Nadowli, Kpongu and Silbelle, respectively. The extra-early mother trial consisted of eight (8) 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) at Tumu and Goriyiri. 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. 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 four sites using extra-early, early as well as intermediate sets of maize varieties. Farmers' fields near to mother sites were selected for each baby trial. For each maturity group, 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. However, the local checks differed among locations and farmers. Farmers managed all plots similarly. In general, 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 mid to late July due to prolonged pre-season drought. However, wet conditions and floods were experienced 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 at Tumu, genotypic differences among the extra-early DT maize for grain yield were significant (Table 71). Grain yield was highest for 2004 TZEE W POP STR C4 and 2008 TZEE W POP STR F2 but least for TZEE W POP STR C5 and the farmer's variety. The genotypes had similar grain yields at Goriyiri in the Nadowli District (Table 2). Differences among the varieties for plant height, days to 50% silking and anthesis were also significant at both sites (Tables 71 and 72). The farmers' varieties were taller and tended to flower late. 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, probably because most of the fields were not *Striga* endemic plots.

Table 71. Some agronomic parameters of extra-early maturing maize varieties evaluated in mother trial at Tumu, Sissala East district, Upper West Region, Ghana, 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
2004 TZEE W POP STR C4	3182	51	54	1.71
99 TZEE Y STR C1	2933	53	57	1.65
TZEE W POP STR C5	1120	54	57	1.51
TZEE W POP STR QPM C0	2862	51	54	1.62
TZEE W POP STR C4	2506	54	58	1.54
2000 SYN EE W	1938	52	56	1.48
2008 TZEE W POP STR F2	2969	49	52	1,46
Abontem	2649	51	54	1.54
Farmers variety	1333	55	59	1.71
Lsd(0.05)	791	1	1	1
CV(%)	19	2	6	2

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

Table 72. Some agronomic parameters of extra-early maturing maize varieties evaluated in mother trial at Goriyiri, Nadowli district, Upper West Region, Ghana, 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
2004 TZEE W POP STR C4	2347	52	58	1.90
99 TZEE Y STR C1	2234	45	51	1.47
TZEE W POP STR C5	2311	53	60	1.63
TZEE W POP STR QPM C0	2317	53	59	1.56
TZEE W POP STR C4	2270	49	54	1.63
2000 SYN EE W	2305	51	56	1.56
2008 TZEE W POP STR F2	2293	49	54	1.63
Abontem	2270	47	53	1.72
Farmers variety	2228	58	65	2.08
Lsd(0.05)	NS	2	4	1
CV(%)	3	2	4	9

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

In the baby trials, although the extra-early maturing varieties had similar grain production at Tumu and Goriyiri, 2008 TZEE W POP STR F2 and TZEE W POP STR QPM CO tended to have high grain production at Tumu and Goriyiri, respectively (Tables 73 and 74).

Table 73. Some agronomic parameters of extra-early maturing maize varieties evaluated in baby trials at Tumu, Upper West Region, Ghana, 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
2004 TZEE W POP STR C4	1920	51	54	1.63
99 TZEE Y STR C1	1664	53	57	1.53
TZEE W POP STR C5	1845	53	56	1.63
TZEE W POP STR QPM C0	1504	53	56	1.70
TZEE W POP STR C4	1877	52	56	1.60
2000 SYN EE W	1440	52	54	1.60
2008 TZEE W POP STR F2	2656	50	55	1.70
Abontem	1365	52	54	1.60

Farmers variety	1518	56	59	1.81
Lsd(0.05)	NS	3	3	NS
CV(%)	23	2	2	6

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

The farmers' varieties tended to have lower grain production at both sites. The grain yields of the new varieties were comparable to the yields of Abontem which was released in 2010. Overall, the elite varieties from IITA tended to produce more grain than the farmers' varieties at both sites. 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 2011 affected seedling establishment at most sites hence the optimum plant stand of 66,600 plants/ha was not achieved for most varieties.

Table 74. Some agronomic parameters of extra-early maturing maize varieties evaluated in baby trials at Goriyiri, Nadowli District, Upper West Region, Ghana, 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
2004 TZEE W POP STR C4	1840	47	54	1.36
99 TZEE Y STR C1	1779	42	49	1.34
TZEE W POP STR C5	1624	47	53	1.30
TZEE W POP STR QPM C0	2339	50	56	1.31
TZEE W POP STR C4	1875	47	55	1.38
2000 SYN EE W	1621	52	59	1.25
2008 TZEE W POP STR F2	1835	47	57	1.36
Abontem	1544	48	56	1.30
Farmers variety	1321	57	64	1.57
Lsd(0.05)	NS	3	3	NS
CV(%)	21	7	5	12

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

Early maturing maize variety trials

One early mother trial was planted at Kpongu in the Wa municipality in 2011. Genotypic differences among the early DT maize for grain yield were not significant (Table 75). Grain yield tended to be highest for TZE COMP 3 DT C2F2 but least for the farmer's variety. Also 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 2011 affected seedling establishment hence the optimum plant stand was not achieved for most varieties.

In the baby trials, all the early maturing genotypes had similar grain production (Table 76). However, EVDT Y 2008 STR tended to produce the most grain. The lowest yielding variety was the farmer's variety. Overall, the elite varieties from IITA tended to produce more grain than the farmers' varieties. 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 75. Some agronomic parameters of early maturing maize varieties evaluated in mother trial at Kpongu, Wa Municipality in 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
TZE Y DT STR C4	3274	54	59	2.17
EVDT Y 2008 STR	3404	51	56	2.20
TZE COMP 3 DT C2F2	3973	51	55	2.23
TZE W DT STR C4	3333	54	58	2.17
Aburohemaa	3073	53	57	2.23
Farmers variety	2989	53	58	2.57
Lsd(0.05)	NS	NS	NS	NS
CV%	17	6	5	11

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

Table 76. Some agronomic parameters of early maturing maize varieties evaluated in baby trials at Kpongu, Wa Municipality, in 2011

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
TZE Y DT STR C4	2401	54	59	2.15
EVDT Y 2008 STR	2892	52	57	1.96
TZE COMP 3 DT C2F2	2557	53	58	1.96
TZE W DT STR C4	2604	55	60	2.17
Farmers variety	2244	57	62	2.27

Lsd(0.05)	NS	NS	NS	NS
CV%	34	6	6	15

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

Medium/Intermediate maturing maize variety trials

In the intermediate mother trial conducted at Silbelle in the Sissala West district, differences among the varieties for grain yield were significant (Table 77). 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 varieties were DT SR W COF2 and DT SYN 1 W. These two varieties have over the years consistently produced the highest grain yield among the intermediate maturing varieties. Also differences among the varieties for days to silk emergence and plant height were significant. The farmers' varieties were often taller and flowered later that the IITA varieties. 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.

Table 77. Some agronomic parameters of intermediate maturing maize varieties evaluated in mother trial at Silbelle, Sissala West District, Upper West Region, Ghana, 2011.

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
DT SR W COF2	5049	52	57	1.80
DT SYN 1 W	4907	53	58	1.90
IWD C2 SYN F2	4871	54	60	1.87
DT SYN 1 F2	4231	54	59	1.90
DT ST W COF2	3876	51	56	1.90
Obatanpa	3591	51	57	2.10
Etubi	3164	53	58	1.80
Farmers variety	3378	57	60	1.90
IWD C3 SYN F2	3307	55	59	1.90
Lsd(0.05)	1119	1	1	0.10
CV%	16	1	4	1

In the baby trials for intermediate maturing varieties, the varieties had similar days to 50% anthesis, plant height and grain yields (Table 78). The variety IWD C3 SYN F2 tended to have the highest grain production at Silbelle. The yield of the hybrid, Etubi was lower under farmers' management. Again, all the IITA intermediate maturing varieties had similar yields which were; however, higher than the yield of the farmer's variety and Obatanpa. The local checks were the best available intermediate maturing varieties at each site, which differed among locations.

Table 78. Some agronomic parameters of intermediate maturing maize varieties evaluated in baby trial at Silbelle, Sissala West district, Upper West Region, Ghana, 2011.

Variety	Grain yield (kg/ha)	Days to 50% anthesis	Days to 50% silking	Plant height (m)
DT SR W COF2	2363	53	57	1.60
DT SYN 1 W	1656	53	56	1.59
IWD C2 SYN F2	1691	54	59	1.60
DT SYN 1 F2	1712	54	58	1.60
DT ST W COF2	2440	51	56	1.64
Obatanpa	2280	51	57	1.64
Etubi	2459	53	57	1.63
Farmers variety	2326	55	59	1.82
IWD C3 SYN F2	3248	54	59	1.73
Lsd(0.05)	NS	3	3	NS
CV%	32	1	2	8

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. Farmers valued many characteristics in maize varieties, especially traits related to consumption. Several farmers did not prefer yellow maize for food. Field days were organized at all the sites and these 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 varieties because they 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 sites 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 in northern Ghana. 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 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, several 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. Extra-early and early maturing yellow maize is preferred for its earliness and yellow endosperm. The project allowed farmers to gain access to the diversity of drought tolerant maize varieties.

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

Executive Summary
In 2011, about 43.5 t of seed was produced from about 26 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 previously received some support from the project to produce seed were able to produce 25t of seed of the various varieties and hybrids 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 and for brewing, and the stover is used for construction, animal feed and as 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.

Availability of quality seed is a crucial factor in any efforts to ensure food security in such a semi-arid 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*:* The objectives of the study was to

- Promote and sustain availability of drought and *Striga* tolerant maize seed.
- Establish community groups to manage drought and *Striga* tolerant seed production and distribution within the communities
    - Train community groups, extension staff in drought tolerant maize seed production techniques.

Materials and methods

During the 2011 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 6 extra-early maturing (80-85 days to maturity) drought tolerant variety, 2 early maturing (90-95 days to maturity) varieties and 2 intermediate/medium maturing (110 days to maturity) varieties were multiplied in the Upper West region of Ghana during the 2011 cropping season (Table 79). 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 to late-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 2011, 43.5 t of seed was produced from about 26 ha (Table 79). The overall mean grain yield of the varieties was 1.25 t/ha. A kilogram of seed maize sold for Gh¢1.20 during the 2010 cropping season. Thus, if we assume a seed price of Gh¢1.30 per kg for the 2012 cropping season and a production cost of Gh¢820/ha, then we expect a profit of Gh¢805/ha (1 US $ = Gh¢1.75). 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 25 tonnes of seed of the various varieties including 15 t of hybrid seed 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 79. Grain yield of maize varieties planted in the community seed production program in UWR, Ghana, 2011.

Variety	Quantity of seed processed
Abontem (foundation seed)	0.10
Abontem (certified seed)	16.5
99 TZEE Y STR	0.20
TZEE W POP STR QPM CO	0.10
2008 SYN EE W	0.10
2000 SYN EE W STR	0.16
2008 TZEE W POP STR F2	0.16
2004 TZEE W POP STR C4	0.27
TZE W DT STR C4	0.34
2004 TZE W POP DT STR C4	0.75
Aburohemma	3.80
Omankwa	2.04
DT ST W C0F2	1.58
DT SYN 1 W	1.48
Sammaz 15	0.16

Obatanpa	2.20
Dodzi	1.36
Etubi	12.15
Total	**43.45**

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

Training

In 2011, 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 two hundred (200) farmers and fifteen (15) extension service providers to produce high quality maize seeds. They also received training on seed selection and management techniques.

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 005) activities in Upper West Region

S.S.J. Buah and M. Fosu

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, open fora 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 best-bet crop production practices in Tamale. Also 39 extension staff (4 females +35 males) participated in a two-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 throughout 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 80). 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. 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 districts were 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.

Table 80. 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) Wa West Wa East Sissala East Sissala West Nadowli Lambussie/Karni	Yaamosahyiri Wongtogirah Ti-suntaa Challu farmers Assoc. Jeffisi farmers Group Bombbo ve-ele Bapaara Group
Soil fertility in maize with organic and inorganic fertilizers	Wa municipal Wa West Wa East Sissala East Sissala West Nadowli	Tambileju farmers Assoc. Kawulubeyi Kong farmers Assoc. Mwini Numbu Mahama Benjamin Yendaw Eugene
Evaluation of different drought tolerant maize cultivars/varieties under fertilized conditions	Wa municipal Wa West Wa East Sissala East Sissala West Nadowli Jirapa Lawra	Sombo farmers Assoc. Lantaa maali Nuntaa Kong farmers Assoc. Sumani Sulemani Ligire Ben Bayor Koli Pour
Evaluation of hybrid and open-pollinated maize varieties under fertilized conditions	Wa municipal, Wa West Wa East Sissala East Sissala West Nadowli Lambussie/Karni Jirapa Lawra	Wawanayiri - Suntaa Challu Farmers Assoc. Ali Abass Baarta Imora Sumpuo Bapaara Group Godfred Dorsaah Tanchara cooperative farmers
Increasing Soybean productivity with	Wa (carried out by SARI)	

rhizobium inoculation and mineral fertilizer application		

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 81.

Table 81. 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 82. 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.

Table 82. 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		

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. The highest 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 82)

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 83.

Table 83. 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 84. 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. Highest grain yields were obtained at Tampaala in Wa East District while yields were lowest at Liplime in the Sissala West District (Table 84).

Table 84. 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		

3. 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 85.

Table 85. 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

Data are for one season only. Grain yields averaged over 6 sites are presented in Table 86. Grain yields as affected by fertilizer treatment ranged from 275 to 1,871 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. Highest grain yields were obtained at Kouli junction in the Lawra district. Grain yields were lowest at Woggu in the Nadowli district (Table 86).

Table 86. 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
Recommended fertilizer rate		Bullu (Sissala West)	800
Omankwa	1781	Woggu (Nadowli)	778
Farmers' variety	1871	Lsd (0.05)	458
Aburohemaa	1512		
Lsd (0.05)	458		
CV%	32		
Mean	1001		
No. of sites	6		

4. 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 87.

Table 87. 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 1,991 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.

Table 88. 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
Recommended fertilizer rate		Buu (Nadowli)	566
Etubi	1991	Dondole (Wa municipal)	537
Farmers' variety	1228	Lsd (0.05)	580
Obatanpa	1378		
Lsd (0.05)	580		
CV%	34		
Mean	911		
No. of sites	6		

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. Highest grain yields were obtained at Kunta in the Wa East district. Grain yields were lowest at Dondole in the Wa Municipality (Table 88).

Results of individual site analysis

Results for each individual site in each district are presented in Tables 89 to 92. These summaries would be useful to select treatments specifically adapted to one or a group of testing sites.

Table 89. 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	

Table 90. 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 91. 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 92. 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 Upper West 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 93. 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 93. 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

The Way Forward

The experiment was initiated in 2010. Consequently *Striga* count was taken during one season. The study will continue in 2011in order to reach definite conclusions.

ENTOMOLOGY

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.

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.

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 65%. Other crops affected to a lesser degree are millet, sorghum, groundnuts, yam and cassava with damage levels of up to 13%.
- Across the survey area two genera of termites were encountered viz: Macrotermes 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 – 47 % in the untreated control plots. Treatments with Jatropha and Neem seed powder reduced maize stalk damage significantly to between 2.0 – 24%, 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 620 – 766kg/ha of maize grain yield. This was lower than that of the treated plots which recorded between 900 – 1450 kg/ha maize grain yield.($P>0.05$) From these results yield loss due to termites in maize is estimated to be about 34%.

Conclusions/Recommendations

Jatropha seed powder therefore 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.

Future activities

Development of technology transfer modules for training MoFA AEAs on use of Jatropha for termite control

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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.

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

- During survey of groundnut farm stores the groundnut pod borer, Caryedon serratus was found to attack unshelled groundnuts causing an estimated 22% loss in grain weight in the most seriously infested stores. Caryedon serratus was present in 58% of farm stores inspected.

- In the on-station trials, groundnut pod damage due to soil arthropods was generally between 7 – 11 % 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 63% ($P < 0.05$).
- Comparing the fresh pod yield in all treated plots there was no significant difference between the neem and Jatropha treated plots ($P>0.05$). The control plots in general recorded between 650 – 800kg/ha of fresh pod yield. This was lower than that of the treated plots which recorded between 920 – 1250 kg/ha fresh pod yield ($P>0.05$) From these results yield loss due to soil arthropods in groundnuts is estimated to be about 24%.

  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 14%; that in the chlorpyrifos lot was 5% and that in the seed extract lots was 8.1

- Jatropha seed extract has the ability, just as in neem to protect stored groundnuts against storage pests. It can be postulated that two treatments with Jatropha seed extract at 2 to 3 month intervals can offer enough protection for a storage period of six months.

Conclusions/Recommendations

Jatropha seed powder therefore 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.

Future activities

Development of technology transfer modules for training MoFA AEAs on use of Jatropha for termite control

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

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

General Introduction:

The Upper East Region Farming Systems Research Group (UER-FSRG) was established in May 1993 and based at the Manga Agricultural Research Station about 4 km South-East of the Bawku Municipal. Currently, the team has a membership of four research scientists, two agronomists, entomologist and a post-harvest specialist. The group also has oversight responsibility for the Co-ordination of Research, Extension and Farmer Linkage Committee (RELC) activities in the Upper East Region.

AGRONOMY PROGRAMME:

The overall objective of the agronomy programme of the UER-FSRG is to identify production constraints and to develop appropriate and cost effective agronomic technologies to address them with a view to increasing and sustaining food crops production and productivity at the farm level. To achieve this noble objective a number of trials were conducted both on-station and on-farm during the 2011 rainy season. Some of the results of the studies are presented below:

Effect of method of sowing on the growth, development, yield and it`s components of sesame (*Sesamum indicum* L.) in semi-arid agro-ecology of UER.

Roger A. L. Kanton

Executive Summary

A field experiment was conducted in the 2011 cropping season at the Manga Station to evaluate contrasting methods of sowing sesame comprising of drilling, dibbling and broadcasting. The trial field was established as a factorial in a randomized complete design with 4 replications. The tallest sesame plants were produced under dibbling, which were significantly ($P<0.01$) taller than their counterparts that were broadcast. Similarly, sesame plants under drilling were also significantly taller than those under broadcast. The highest number of pods per plant was obtained when sesame was dibbled compared to the other methods of sowing. Dibbling produced the highest sesame seed yield, which was significantly higher than those

produced by broadcast or drilling. Similarly, drilling produced superior sesame seed yield than broadcast. A similar trend was also obtained for sesame biomass, with dibbling producing superior biomass than broadcast and drilling. These preliminary results indicate that for increased and stable sesame yields dibbling would be the most optimal sowing method in the semi-arid agro-ecology of northern Ghana.

Introduction

Sesame (*Sesamum indicum* L.) is the most important tropical crop from which semi-drying oils are obtained. Sesame is now grown in tropical and subtropical regions of Africa, Asia and Latin America. India and China provide almost half of the world production of 2.35 million tones of seed per year, whereas Africa produces only 0.59 million tones. The major producing countries are India, China, Myanmar, Bangladesh, Korea Republic and Turkey in Asia; Sudan, Nigeria, Somalia, Uganda, Ethiopia, Tanzania and Central African Republic in Africa and Venezuela, Mexico and Guatemala in the Americas. In West Africa, sesame is an important crop in Nigeria; it is also grown in northern Ghana, Burkina Faso, Mali and Guinea. Sesame is drought tolerant and can thrive on as little as 400mm rain on light soils. It can also be grown on residual moisture provided the soil is thoroughly moist at sowing. The crop needs warmth and plenty of light as most varieties are photoperiod sensitive. The oil contains mainly unsaturated fatty acids (oleic and linoleic about 40% each) and about 14% of saturated acids. The oil is also used in some medicinal drugs and perfumes. Sesame meal produced after extraction from de-hulled seed is a very rich source of protein. Both the entire seed and the meal are high in calcium, phosphorus, and iron as well as vitamins thiamin, riboflavin and niacin. Sesame cake produced after extraction of oil from un-hulled seed is an excellent feed for poultry ruminants and pigs.

Overall objective

The overall objective of the study is to increase upon the productivity and production of sesame in northern Ghana,

Specific objectives: To determine the optimal sowing method for sesame

Materials and Methods

An on-station trial was conducted at the Manga Agricultural Research Station to study the effect of intra-row spacing and Nitrogen fertilization on the performance of Sesame. The Sesame variety was brought from the Burkina Faso by the Association of Church Development Projects (ACDEP) based in Tamale. The factors studied were drilling, dibbling and broadcast. The trial field was harrowed with a tractor in the second week of June and ridged immediately after harrowing. The trial was established as a factorial in a randomized complete design. The trial had 4 replications with a plot dimension of 6 ridges each measuring 0.75 m apart and 5 m long. Sesame seeds were sowed using the 3 methods. In the case of the dibbled, sesame plants were thinned to 2 plants per hill, whilst the drilled ones were also thinned at exactly 2 weeks after sowing (WAS). Compound fertilizer (15-15-15) was applied as basal using the various rates of nitrogen under study. Half of the nitrogen fertilizer was applied at 2 WAS with the remaining half as Sulphate of ammonia and applied as a top-dress at exactly 4 WAS. Phosphorus (P_2O_5) and Potassium (K_2O) were applied together with the nitrogen as basal fertilizer. Each fertilizer application was preceded by weeding so as to reduce the effect of weed competition. Agronomic data taken during the season include the following stand establishment count, plant height, leaf number, stem girth, days to 50% maturity and physiological maturity, yield and its components. The data was subsequently subjected to statistical analysis and mean separation done using the least significance test.

Results

Sesame number of branches per plant was significantly ($P<0.01$) affected by method of seeding with dibbling producing significantly higher number of branches compared to broadcast and drilling. However sesame attained 50% bloom significantly (($P<0.01$) earlier when broadcast as compared to when dibbled (Table 94). The tallest sesame plants were produced under dibbling, which were significantly ($P<0.01$) taller than their counterparts that were broadcast. Similarly sesame plants under drilling were also significantly taller than their broadcast counterparts. The highest number of pods per plant was obtained when sesame was dibbled compared to the other methods of sowing. Dibbling produced the highest sesame seed yield, which was significantly higher than those produced by broadcast or drilling. Similarly drilling produced superior sesame seed yield than broadcast (Table 94). A similar trend was also obtained for sesame biomass, with dibbling producing superior biomass than broadcast and drilling.

Discussion

Sesame yields reported this season were generally higher compared to those reported in 2009. Nitrogen at the rate of 60 kg/ha has produced the best sesame yields under the 2-years of the study compared to the other rates, whereas 30 and 40 cm intra row spacing consistently also produced the best results. Generally the performance of sesame in the current study is comparable to what is usually reported in the literature for Africa. Sesame yields in Africa are usually within the range of 200 to 300 kg/ha. Nitrogen fertilizer application significantly affected the performance of most of the parameters recorded in the present study.

Table 94. Effect of sowing method on the growth, development and yield of sesame in a semi-arid agro-ecology in northern Ghana in 2011 cropping season.

Method of sowing	No. of branches/ plant	Days to 50% flowering	Plant height at harvest (m)	No. of pods/plant	Seed yield (kg/ha)	Biomass yield (t/ha)
Broadcast	4.3	77	0.95	37	39	1.8
Drilling	5.5	82	1.20	66	134	5.2
Dibbling	8.8	83	1.27	108	231	6.5
Mean	6.2	80.1	1.1	70	134	4.5
s.e.d.	0.98	2.1	0.028	26.3	13.4	0.33
C.V. (%)	9.4	1.5	13.4	13.5	13.2	7.9

Intra-row spacing affected only some of the parameters studied in the present study. The low yields reported in the present study could be ascribed to the wider inter row spacing adopted compared to closer inter row spacing as reported in the literature. Also sesame grain yield increased significantly with increase in the rate of nitrogen fertilization, implying that sesame yields could be boosted through an increase in nitrogen feriliser application. Marginal insignificant yield response was observed with increased nitrogen level attaining the peak at 80kgN/ha. This observation is consistent with reports by Olowe (2006) who suggested that sesame is a low N response crop. Earlier reports have shown that maximum grain yield of sesame was recorded on relatively low to medium levels of 30-60 kg /ha by Subramaniah *et al*., (1979) and Daulay and Singh (1982). This observation is supported by the findings of the current work, whereby the yields obtained at 40 and 60 kg N/ha were either superior or comparable to those obtained at 80 kg N ha^{-1}. It will therefore be very important to reduce the intra-row spacing from 0.75m to 0.60 m and also increase the rate of nitrogen fertilization to 120 kg/ha next year so as to observe the behavior of sesame under these conditions. Literature reports that sesame is mainly sowed by broadcast in most African countries. Ashely (1993) reported optimum population for sesame to be at about 170–200, 000 plants per ha.

Conclusion/Recommendation

The study is relevant considering that no research work on sesame has been carried out in Ghana to the best of our knowledge. These results will therefore serve as very useful research information for further work on sesame improvement in the country, as the crop has an enormous export potential. Given the contrasting results regarding both N application and intra row spacing, whereas in 2009, N at 80 kg/ha gave the best results whereas in 2010 N at 60 kg/ha gave superior results compared to the other rates. Similarly in 2009 intra row spacing of 40 cm gave the best results whereas in 2010, 30 cm spacing turned out to be the best. There is therefore the need to repeat the trial so as to come out with a suitable rate of nitrogen and optimal population for increased and stable sesame production in northern Ghana

On-farm testing of extra early and early drought tolerant maize for Africa (DTMA) in a semi-arid agro-ecology in Upper East Region in Ghana.

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

Executive Summary

Field trials were conducted in 2011 cropping season, to evaluate the performance of Drought Tolerant Maize for Africa (DTMA) varieties using the Mother and Baby concept at Garu-Tempane, Bawku Municipal and Bawku West districts in the Upper East Region. The trials were set up as randomized complete block design with 4 replicates for the mother trials and 3 to 5 farmers each serving as a replicate. Plots sizes for the mother trials were 4.5m x 10m for mother trial and 20m x 20m for Baby trials. For the extra early maize trial in the Bawku Municipal maize grain 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. For extra early maize in the Garu-Tempane district, TZEE-W STR C5 produced the highest grain yield followed closely by TZEE-W Pop STR QPM C0, whilst the farmers' variety and 99 TZEE-W Pop STR C1 recorded the lowest yields. All the improved varieties with the exception of 99 TZEE-W Pop STR C1 and 2000 SYN EE-W produced higher maize grain yields than the trial mean. For the Bawku West District the extra early trial varieties 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. The farmers' variety produced the highest straw yield followed closely by TZEE-Y Pop STR QPM C0, whilst 99 TZEE-Y STR C4. For the early maize varieties in the mother trials, there were significant ($P<0.001$) differences across districts in 1000-grain weight, maize grain and straw yields, with Bawku West district recording the highest followed by Garu-

Tempane and Bawku Municipal district recorded the lowest maize yields. TZE Comp 3 DT C2 F2 produced the highest yield amongst the hybrids/varieties evaluated across the locations followed closely by TZE-Y DT STR C4, whist the farmers' variety produced the lowest. Mean increase in maize grain yield recorded by the Bawku West over and Garu-Tempane and Bawku Municipal are 37% and 86% respectively. For the early maize baby trials across the region, produced superior grain 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. Maize grain yield in Garu-Tempane were generally higher as compared to those obtained in the Bawku Municipal and Talensi-Nabdam districts. Maize grain yield was generally similar for all the varieties except for TZE-W DT STR C4, which recorded the lowest grain yield. TZE-W DT STR C4 produced the highest kernel yield followed by TZE-Y DT STR C4, with the farmers' variety producing the lowest.

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

1. test evaluate on farmers' field drought tolerant maize varieties and hybrids;
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 Agro-ecology of the Upper East Region during the 2011 cropping season. The Mother and Baby concept of on-farm experimentation was adopted whereby the complete complement of the varieties were laid out in one farmers field and replicated just like is done on-station whilst 2 or 3 varieties were permutated and allotted to 3 or 5 other farmers depending upon seed availability in each of the 4 districts serving as the Baby trial. Farmers from the baby trial were occasionally invited to the mother trial where they compared the varieties they have with their Mother trial counterparts. In Garu-Tempane, Bawku Municipal and Bawku West 3 to 5 farmers 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 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 and Farmers variety.

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, Dr. Kanton and Farmers variety.

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 4.5m x 5m whilst for the baby trial it was 20m x 10 m. Experimental data were taken on the 4 central rows whilst harvesting was done leaving out the outer 2 rows. Sowing of maize was done on ridges 0.75m apart and on hills spaced at 0.4 m and seeds 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 2011, 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 2011. 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 as recommended for maize in Ghana was taken on both the mother and baby trials. Insect pests and disease were not found to have any economic effect on maize yields. Data was analysed using GenStat 9th 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 2). However, 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. However, 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 95). Similarly TZEE-W Pop STR C4 produced the highest straw yield followed close 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 kernel and straw yields across location 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 95. Cobs harvested, 100-kernel weight (g), cob dimensions, grain and straw yield of baby trial of extra early DTMA varieties tested on-farm in the Upper East Region in northern Ghana in the 2011 cropping season.

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

General 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 kernel yields at Garu-Tempane and Bawku West districts were significantly higher as compared to obtained in the Bawku Municipal.

Garu-Tempane Extra Early DTMA Mother Trial

All the drought tolerant maize hybrids/varieties tasseled earlier than the farmers' variety. However, 2008 TZEE-W Pop STR F2 and TZEE-W Pop STR C5 tasseled closer to the farmers' variety. A similarly trend was also observed for the days taken to 1st silking and anthesis, with the DTMA materials, achieving early silking and anthesis compared to the far variety (Table 96). Maize variety 99 TZEE-Y Pop STR C1 was the earliest to silk and also attain flowering compared to the rest of the varieties. This trend was similar for days taken to achieve 50% silking and anthesis, with the farmers' variety taking the longest days to reach 50% silking and anthesis. Anthesis silking interval (ASI), which is the difference in the days taken to produce silk and flowers, was generally similar for all the varieties; however the farmers' variety and TZEE-W Pop STR C5 were the only treatments that took a longer time to produce flowers. The farmers' variety produced the tallest plants whilst 00TZEE-W Pop STR F2 produced the shortest plants (Table 96).

Table 96. Days to first tasseling, silking, anthesis, 50% silking and anthesis, antheisi silking interval (ASI) and plant height of extra early maize varieties tested on-farm at the Garu-Tempane district in the Upper East Region in northern Ghana in the 2011 cropping season.

Maize variety	Days to 1st tasseling	Days to 1st silking	Days to 1st anthesis	Days to 50% silking	Days to 50% anthesis	ASI	Plant height at 12 WAS
2000 SYN EE-W	46.0	51.8	47.8	54.8	52.5	2.25	130.2
2004 TZEE-W Pop STR C4	46.0	53.0	48.0	55.8	53.5	2.25	152.8
2008 TZEE-W Pop STR F2	47.0	54.8	48.8	55.8	53.5	2.25	156.0
99 TZEE-Y STR C4	44.0	50.0	46.3	52.5	48.8	2.50	119.5
TZEE-W Pop STR C4	46.5	55.3	48.5	56.8	54.0	2.75	151.5
TZEE-W Pop STR C5	46.8	54.3	49.0	55.5	52.8	2.75	174.0
TZEE-Y Pop STR QPM C0	47.5	58.0	50.3	59.0	56.8	2.25	163.0
Farmers' variety	49.0	59.3	51.3	61.0	58.0	2.75	181.8
Mean	46.6	54.5	48.7	56.3	53.72	2.47	153.6
s.e.d.	0.65	1.35	0.82	1.59	1.46	0.434	11.25
C.V. (%)	2.0	3.5	2.4	4.0	3.8	24.9	10.4

The 2004 TZEE-W Pop STR C4 and TZEE-W Pop STR C5 produced the highest number of cobs at harvest with the farmers' variety recording the lowest cobs at harvest. 2004 TZEE-W Pop STR C4, TZEE-W Pop STR C5, and TZEE-W Pop STR F2 produced more cobs than the trial mean (Table 4). However, TZEE-W Pop STR C5 produced the broadest cobs whilst 99 TZEE-W Pop STR C1 produced the smallest cobs (Table 97). TZEE-W Pop STR QPM C0 produced the boldest kernels followed closely by TZEE-W Pop STR C5, whilst 99 TZEE-Y Pop STR C1produced the smallest kernels. 2000 SYN EE-W and the farmers' variety produced kernels that were lower than the trial mean. Maize harvest index this year were generally lower compared to those recorded in 2010. 99 TZEE-W Pop STR C1 recorded the highest harvest index followed by 2000 SYN EE-W and TZEE-W Pop STR C5, whilst the lowest harvest index was obtained by farmers' variety (Table 97). Maize grain yield in 2011 was generally lower as compared to those recorded in 2010. However, TZEE-W STR C5 produced the highest grain yield followed closely by TZEE-W Pop STR QPM C0, whilst the farmers' variety and 99 TZEE-W Pop STR C1 recorded the lowest yields. All the improved varieties with the exception of 99 TZEE-W Pop STR C1 and 2000 SYN EE-W produced higher maize grain yields than the trial mean. The highest straw yield was produced by the farmers' variety, whilst 99 TZEE-W Pop STR C1 produced the lowest straw yield (Table 97). Maize performance in the Garu-Tempane district was far better than those obtained for the Bawku Municipal.

Table 97. Cobs harvested, 100-kernel weight (g), cob dimensions, grain and straw yield of extra early DTMA varieties tested at the Garu-Tempane district in the Upper East Region in northern Ghana in the 2011 cropping season.

Maize variety	No. of cobs harvested	Cob girth (mm)	1000-kernel weight (g)	Harvest index	Grain yield (kg/ha	Straw yield (t/ha)
2000 SYN EE-W	80.8	42.5	239.8	0.46	2.8	3.3
2004 TZEE-W Pop STR C4	86.0	40.7	252.8	0.41	3.1	4.5
2008 TZEE-W Pop STR F2	84.5	45.2	257.8	0.44	3.2	4.2
99 TZEE-Y STR C4	83.8	42.0	211.8	0.54	2.5	2.1
TZEE-W Pop STR C4	81.0	43.7	242.5	0.44	3.0	3.8
TZEE-W Pop STR C5	85.5	43.7	256.0	0.46	3.5	4.3
TZEE-Y Pop STR QPM C0	78.8	41.5	268.0	0.45	3.3	4.1
Farmers' variety	71.5	43.5	245.0	0.33	2.5	5.2
Mean	81.5	42.8	246.7	0.44	2.98	3.9
s.e.d.	6.18	1.84	13.65	0.023	0.313	0.414
C.V. (%)	10.7	4.8	7.8	7.4	3.2	14.9

Bawku Municipal Extra Early DTMA Mother Trial

Maize performance in the Bawku Municipal in 2011 was generally poor as compared to the other districts due to late planting and drought. Maize cobs at harvest for the Bawku Municipal were generally very low as compared to those recorded for the Garu_tempan and Bawku West districts. 2000 SYN EE-W produced the highest cobs at harvest whilst TZEE-W Pop STR QPM C0 recorded the lowest (Table 98). Maize harvest indices were generally low as compared to those recorded in 2010, with 2004 TZEE-W Pop STR C4 and 2008 TZEE-Y Pop STR F2 recording the highest harvest indices, whilst TZEE-W Pop STR QPM C0 recorded the lowest. Maize kernel yield in 2011 was quite low as compared to the yields recorded in 2010, due to a combination delayed planting and drought at the grain filling stage. However, TZEE-W Pop STR C5 recorded the highest kernel yield followed closely by 2000 SYN EE-W whilst TZEE-W Pop STR QPM C0 produced the lowest grain yields (Table 98). All the maize varieties with the exception of TZEE-W STR C5, 2000 SYN EE-W and 2008 TZEE-W Pop STR C4 produced grain yields that were lower than the trial mean.

Table 98. Cobs harvested, 100-kernel weight (g), harvest index, kernel and straw yield of extra early DTMA varieties evaluated at the Bawku Municipal in the Upper East Region in northern Ghana in the 2011 cropping season.

Maize variety	No. of cobs harvest	100-kernel weight (g	Harvest index	Grain yield (t/ha)	Straw yield (t/ha)
2000 SYN EE-W	32.5	222.3	0.46	1.02	1.6
2004 TZEE-W Pop STR C4	19.8	184.8	0.48	0.66	1.5
2008 TZEE-W Pop STR F2	23.5	188.8	0.48	0.74	2.0
99 TZEE-Y STR C1	25.5	171.5	0.44	0.61	1.3
TZEE-W Pop STR C4	18.8	186.0	0.46	0.62	4.1
TZEE-W Pop STR C5	28.2	199.8	0.45	1.2	1.4
TZEE-Y Pop STR QPM C0	17.5	159.5	0.43	0.41	1.2
Farmers' variety	26.0	186.0	0.45	0.65	4.1
Mean	24.0	187.5	0.45	0.73	1.9
s.e.d,	4.01	23.86	0.028	0.218	0.604
C.V. (%)	23.6	18.0	2.8	42.0	44.3

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 99). 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. 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 99). 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.

Table 99. Plant height, ASI, cobs harvested, 100-kernel weight (g), harvest index, grain and straw yields of extra early DTMA varieties evaluated at the Bawku West district in the Upper East Region in the 2011 cropping season.

Maize variety	Plant height (cm) 12WAS	ASI	No. of cobs harvested	100-kernel weight (g)	Harvest index	Grain yield (t/ha)	Straw yield (t/ha)
2000 SYN EE-W	150.0	3.0	150.0	211.5	0.43	3.5	4.8
2004 TZEE-W Pop STR C4	143.5	3.0	143.5	194.5	0.52	3.1	4.5
2008 TZEE-W Pop STR F2	157.2	2.8	157.2	191.8	0.39	3.0	4.7
99 TZEE-Y STR C4	139.0	2.8	139.0	181.0	0.41	3.3	5.0
TZEE-W Pop STR C4	123.5	3.0	123.5	194.8	0.41	3.3	4.8
TZEE-W Pop STR C5	169.8	3.2	169.8	202.2	0.44	3.8	5.0
TZEE-Y Pop STR QPM C0	118.0	2.0	118.0	196.8	0.42	3.7	5.0
Farmers' variety	131.8	3.3	131.8	182.0	0.42	3.2	4.3
Mean	142.2	2.9	142.2	195.1	0.43	3.4	4.8
s.e.d.	17.76	0.28	17.76	13.46	0.229	0.46	0.88
C.V. (%)	17.7	13.7	17.7	26.1	20.2	19.4	26.1

General Early DTMA Mother Trial:

There were significant (P<0.001) differences across districts in 1000-grain weight, maize grain and straw yields, with Bawku West district recording the highest followed by Garu-Tempane and Bawku Municipal district recorded the lowest maize yields. TZE Comp 3 DT C2 F2 produced the highest yield amongst the hybrids/varieties evaluated across the locations followed closely by TZE-Y DT STR C4, whist the farmers' variety produced the lowest (Table 100). Mean increase in maize grain yield recorded by the Bawku West over and Garu-Tempane and Bawku Municipal are 37% and 86% respectively.

Table 100. Across locations kernel yield (t/ha) of early drought tolerant maize varieties in the Upper East Region in northern Ghana in the 2011 cropping season.

District	EVDT-Y 2006 STR	TZE-W DT STR C4	TZE-Y COMP 3. DT C2F2	TZE-Y DT STR C4	Dr. Kanton	Farmers' variety	Mean
Bawku West	4.0	4.3	4.8	4.6	3.5	3.5	4.1
Garu-Tempane	3.1	2.6	3.1	3.0	3.0	3.1	3.0
Bawku Municipal	2.2	2.4	2.3	2.0	2.2	1.9	2.2
Mean	3.1	3.1	3.4	3.2	2.9	2.8	
LSD (5%).	0.529						
CV(%)	20.9						

Early DTMA Baby Trials

TZE-Y DT STR C4 produced the tallest, whilst EVDT-Y 2006 STR produced the shortest plants (Table 101). 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 8). These yields were about double those produced by their counterparts in the 2010 cropping season.

Table 101. 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 2011 cropping season.

Maize variety	Plant height (m)	No. of cobs harvested	Cob length (mm)	1000-kernel weight (g)	Harvest index	Kernel yield (t/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.	10.26	27.75	1.84	1.69	0.074	0.97
C.V. (%)	7.25	10.40	17.5	8.25	20.3	27.7

Garu-Tempane Early DTMA Mother Trial

EVDT-Y2006 STR was the earliest to attain 50% anthesis whilst the farmers variety was the latest. All the drought tolerant maize varieties attained 50% anthesis significantly (P<0.001) earlier than the farmers' variety (Table 102). TZE-Y Comp3 DT C2F2 and TZE-W DT STR C4 had the lowest anthesis silking intervals, which were significantly (P<0.001) smaller compared to the rest of the varieties. Similarly, all the remaining drought tolerant maize varieites recorded significantly smaller anthesis silking interval values as compare to the farmers' variety (Table 102). 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 102). 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. Maize grain 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 102. Maize kernel yield and its components of early drought tolerant maize varieties evaluated in the Garu-Tempane in the Upper East Region in northern Ghana in the 2011 cropping season.

Maize variety	Days to 50% anthesis	ASI	No. of cobs harvested	Cob girth (mm)	1000-kernel weight (g)	Grain yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	48.5	2.5	69.8	41.0	235.0	3.1	3.9
TZE-Y Comp3 DT C2F2	50.8	2.0	73.5	40.1	210.2	3.1	4.0
TZE-W DT STR C4	50.5	2.0	65.0	43.1	267.2	2.8	3.3
TZE-Y DT STR C4	50.0	2.8	71.2	39.9	231.2	3.0	3.8
Dr. Kanton	50.8	3.0	81.8	40.7	249.2	3.0	3.9
Farmers' variety	54.8	3.0	66.8	43.5	245.2	3.1	3.8
Mean	50.9	2.54	71.3	41.4	239.7	3.1	3.79
s.e.d.	0.718	0.348	7.31	1.055	13.46	0.384	0.532
C.V. (%)	2.0	19.3	14.5	3.6	7.9	18.1	19.8

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 103). 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 103). The Drought Tolerant Maize for Africa varieties/hybrids recorded a mean yield increment of 65% higher than the farmers' variety.

Table 103. Maize kernel 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 2011 cropping season.

Maize variety	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	67.8	15.87	39.63	235.0	0.40	2.2	3.3
TZE-Y Comp3 DT C2F2	72.0	14.27	38.25	210.2	0.43	2.3	3.0
TZE-W DT STR C4	80.2	13.67	40.15	267.2	0.41	2.4	3.4
TZE-Y DT STR C4	59.8	15.00	40.98	231.2	0.41	2.0	3.0
Dr. Kanton	63.2	15.2	40.55	249.2	0.42	2.2	3.1
Farmers' variety	59.0	14.4	41.33	245.2	0.52	1.9	2.7
Mean	67.0	14.75	40.15	239.7	0.43	2.14	3.1
s.e.d.	12.29	0.818	1.430	13.46	0.113	0.401	0.582
C.V. (%)	25.9	7.8	5.0	7.9	37.0	26.4	26.7

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 2011 were generally smaller in dimension compared to their counterparts in the 2010 season. TZE-W DT STR C4 and farmers' variety produced longer cobs compared to those produced by the other varieties (Table 104). Maize 100-kermel weight in 2011 was higher compared to that obtained in 2010. 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 2011 in the Bawku West district were generally higher as compared to those produced in 2009. EVDT-Y 2006 STR produced the highest grain yield and TZE-Comp3 DT C2F2 the lowest (Table 104). 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 104. Maize grain 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 2011 cropping season.

Maize variety	No. of cobs harvested	Cob length (cm)	1000-kernel weight (g)	Grain yield (kg/ha)	Straw yield (t/ha)
EVDT-Y2006 STR	39.7	13.7	199.7	4.0	13.0
TZE-Y Comp3 DT C2F2	39.6	15.5	222.2	4.8	17.3
TZE-W DT STR C4	41.1	15.3	212.0	4.3	13.2
TZE-Y DT STR C4	41.5	14.9	206.7	4.6	16.7
Dr. Kanton	40.5	13.2	188.5	3.5	9.8
Farmers' variety	37.0	15.2	198.2	3.3	11.0
Mean	39.9	14.6	204.6	4.1	13.5
s.e.d.	2.021	0.880	16.91	0.582	1.113
C.V. (%)	7.2	8.5	11.7	20.1	11.7

Discussion

Maize yield and its components this season were generally low. 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 by TZEE-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. 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.

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. 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. 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. 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 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).

Conclusions/Recommendations

The results this year are in consonance with those reported last year. 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 would recommend them to the National Variety Release Committee for consideration for release to maize farmers for enhanced and stable maize production in the Upper East Region in particular and Ghana at large to ensure food security for farm families.

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Compatibility of Millet and Legume under Relay Cropping Condition

Yirzagla J., R.A.L. Kanton and N. Denwar

Executive Summary

Double-cropping millet and legumes is a popular cropping system in the Upper East Region (UER) of Ghana. For improved production efficiency, suitable millet-legume combinations with short life cycles that permit extension of the growing season to facilitate double-cropping need to be explored. The objective of this study was therefore to use performance data to identify millet-legume combinations compatible for relay cropping within the UER. The various legumes could not yield grain due to terminal drought. Notwithstanding, Bongo Short Head millet (BSH)-cowpea combinations have the greatest prospect of accounting for superiority in grain yield judging from its performance in the yield components, most especially the dry matter. Thus, while cowpea is likely to provide the most compatible combination with any of the millet cultivars, groundnut offered the least promising combination with the millet cultivars.

Introduction

Conventional double-cropping, a sequential planting of legumes after millet harvest, is often fraught with poor stands, weed infestations, and delayed legume planting due to adverse weather. For improved production efficiency, suitable millet-legume combinations with short life cycles that permit extension of the growing season to facilitate double-cropping need to be explored. The objective of this study was therefore to use performance data to identify millet-legume combinations compatible for relay cropping within the UER. Specifically, the study was to examine the grain yield and yield components of three millet cultivars and three legumes, namely, soybean (Quarshie), groundnut (Chinese) and cowpea (SARC 4-75) under the relay conditions.

Materials and methods

In a RCBD of three replications, the three millet cultivars, Arrow millet (AM), Bongo Short Head (BSH) and Bristled millet (BM) were planted in July 2011. Factorial inter-seeding of the legumes in the standing millet was done one week to the harvest of each millet cultivar. Fertilizer was applied to the millet in accordance with the recommended rate using 60 kg N/ha and 30 kg each of P_2O_5 and K_2O 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_2O_5 and K_2O was applied in the form of compound fertilizer 15:15:15. The legume plants were sprayed to control flower thrips (*Megalurothrips sjostedti*) and a complex of pod sucking insects using lambda cyhalothrin (Product Karate) at the rate of 20g active ingredient per hectare. Hand weeding at 2 and 4 weeks after sowing was done followed by re-shaping with bullocks at 60 days after sowing. Data was collected of millet on the following parameters: Stand count at establishment, Stand count at mid-season, Stand count at harvest, Days to 50% bloom, Stover weight (Kg), Grain yield.

Data was collected of legumes on the following parameters: Stand count at establishment, Stand count at mid-season, Stand count at harvest, Days to 50% flowering (DFF), Vine weight (Kg),

Results and discussion

Even though plant stand count at establishment was not significantly different among the millet cultivars. BSH accounted for the highest plant count at harvest. This could be due to differences in tillering abilities of the different cultivars. In terms of earliness in flowering, there were no statistical differences among the various cultivars as days to flower ranged between 57.67 and 58.67. Arrow Millet accounted for the lowest stover weight and grain yield. Even though stover weight of Bristled Millet (BM) was far more than all others, there were only marginal differences in grain yield between BSH and BM. BSH was among the best in terms of grain yield, yielding between 2.447 to 2.66kg. Higher tillering of BSH might have accounted for its superiority in grain yield.

For the legumes, plant stand count was significantly different among the legumes from establishment to harvest with cowpea accounting for the highest while soybean the lowest. This could be due to differences in their inherent tolerance to drought condition which characterized the cropping season from establishment to harvest. Cowpea and groundnut flowered almost around the same period (46-48 days) while Soybean flowered later (61.33-61.67 days). Groundnut produced the lowest fresh vine weight of 1.47kg and 0.15 dry matter under BSH while cowpea produced the highest fresh vine weight of 4.5kg as well as the highest dry matter value of 0.41 under BSH. BSH-cowpea combinations had the greatest prospect of accounting for superiority in grain yield judging from its performance in the yield components, most especially the dry matter. BSH was among the best in terms of grain yield and cowpea produced the highest fresh vine weight as well as the highest dry matter among the legumes planted under the millet cultivars. Thus, while cowpea is likely to provide the most compatible combination with any of the millet cultivars, groundnut offered the least promising combination with the millet cultivars.

Conclusion

The results of the study presented have good prospects of promoting double cropping within the farming system in the UER. The study will therefore be repeated during the 2012 cropping season and if possible in several locations in order to validate the current results.

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

Yirzagla, J., Kanton, Roger A. L., Asungre, Peter A., Lamini, S. and Ansoba, E. Y.

Executive Summary

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). As a major component of the traditional cropping systems within the Upper East Region of Ghana cowpea 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.

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. There is limited information on the effect of different cereals-legume spatial arrangements 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

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. Recommended agronomic practices in terms of fertilizer application, weed, pest and disease control were executed timely

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. 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

The Grain yields and other agronomic traits of millet as presented in Table 105 shows that millet grain yield was highest under 1M1C and lowest under 2M2C as well as sole millet condition. There were no significant differences (P >0.05) among the arrangements in terms of initial plant count.

Table 105: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

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 106 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. There were no significant differences among the arrangements in terms of stover weight (Table 3). 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.

Table 106: 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			

Table 107: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 is 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. Comparison of the different cropping patterns indicated that 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

Executive Summary
The Upper East region – Farming System Research Group (UER-FSRG) of CSIR-SARI based in Manga conducted a number of research activities to contribute to the coordinated efforts to address the enormous insect pests' problem in agricultural production. The research activities conducted in 2011 includes: promotion for adoption of the strategies developed to manage pests and diseases of onion, tomato and pepper under irrigation, Integrated management of field and storage pests to extend shelf life of yam and integration of aphid resistant cowpea cultivars and biological control of cowpea aphids using parasitic wasp. A participatory technology development and dissemination approach was used by a team comprising of Research, MoFA, NGOs and Farmer Based Organizations (FBOs). The methodology used in implementing these programmes include: on-station and on-farm experiments, multi-location validation of the findings, dissemination of findings using demonstrations, farmer field schools, exchange visits and field days The detailed research activities and the major achievements so far are as follows.

Combine effect of parasitic wasp and aphid resistance gene against cowpea aphid infestation.

Francis Kusi, Mukhtharu Zakaria and J. N. Azure

Introduction
The stability of SARC1-57-2 was tested against cowpea aphids in 6 regions in Ghana. The regions were Volta, central Brong Ahafo, Northern, Upper East and West. The genotype, SARC1-57-2 was found to be resistant to aphids in all the 6 regions whiles Apagbaala and Songotra remain susceptible to the aphids in all the regions.

In course of sampling of cowpea aphids for the stability tests in Upper East region, we came across aphid infested cowpea fields along the White Volta. The aphids were heavily parasitized by a parasitic wasp, a parasitoid which deposits its eggs inside the aphid and as the wasp develops inside the aphid, the aphid is killed and becomes mummified. This presented an opportunity for the research team to carry out in-depth investigations into the activities of the parasitic wasp. The objectives of the studies include:

Objectives

1. To determine the rate at which cowpea aphid colony is parasitized on daily basis.
2. To determine the ability of the parasitic wasp to prevent the cowpea aphids from causing economic damage to the susceptible genotype.
3. To determine the combine effect of the parasitic wasp and the cowpea aphid resistant genotype against cowpea aphids' infestation.

Methodology

To determine the rate at which cowpea aphid colony is parasitized on daily basis

Cowpea seedlings were infested with one, four-day old aphid per leaf at ten days after planting and within 48 hours after infestation the aphids starts to reproduce nymphs. A culture of parasitic wasp, cultured on cowpea aphids, was then introduced into the chamber where the aphid infested seedlings were kept. Upon emergence, the adult wasp feed on honeydew, nectar and exuded plant saps. The adult female wasp deposits single eggs inside the immature aphid's body. The egg hatches into a larva that grows and consumes the aphid's internal parts, eventually killing it. The parasitised aphid then takes on a mummified appearance. The set up was monitored on daily basis to count the number of life and mummified aphids per colony for a period of fourteen days.

To determine the ability of the parasitic wasp to prevent the cowpea aphids from causing economic damage to the susceptible genotype

Cowpea seedlings were raised from Apagbaala, a susceptible genotype, and at two leaf stage, 3-4 days after emergence, each seedling was infested with five, four-day old nymphs. The aphids were monitored within twenty-four hours to ensure that each seedling has five aphids settled on it. By forty-eight hours after infestation the aphids start to reproduce. A culture of parasitic wasp was introduced into the study area to parasitise the aphids growing on the seedlings. At fourteen days after infestation, cowpea leaves that have been colonized by aphids were carefully removed from the seedlings, the aphids, life and mummified, were carefully brushed off the leaves using a soft camel hair brush. The leaves were then physically examined to determine the degree of aphid damage to the leaves. This was compared with leaves from similar experiment under similar condition which were only infested with aphids without the parasitic wasps.

To determine the combine effect of the parasitic wasp and the cowpea aphid resistant genotype against cowpea aphids' infestation

Three set of experiments were set up to gather data to meet this objective. Four cowpea genotypes were evaluated: Apagbaala, Songotra (IT97K-499-35), SARC1-57-2 and SARC1-91-1, each genotype was replicated 4 times. All the three experiments were terminated twenty-one days after infestation for data collection.

Experiment one

Seedlings of the 4 cowpea genotypes were infested with five, four-day old aphids ten days after planting. A culture of parasitic wasp was introduced into the study area to expose the aphids to the parasitoids. Data were collected twenty-one days after infestation

Experiment two

Seedlings of the 4 cowpea genotypes were infested with five, four-day old aphids ten days after planting. The aphids were allowed to reproduce freely on the seedlings without any interference from the parasitic wasps for a period of twenty-one days when the experiment was terminated for data collection.

Experiment three

Seedlings of the 4 cowpea genotypes were raised without aphid infestation. The seedlings were sprayed with insecticide on weekly basis to avoid natural infestation by aphids and any other pest.

The three experiments were planted and the terminated at the same time and among the data collected include aphid population per seedling and biomass yield per genotype.

The study is in progress, full results will be ready by the second quarter of the year.

The study is on-going, results will be presented in 2012 annual report.

Challenge to the study

The mobile screen house currently being used in Manga is suitable during the dry season since it has no protection against effect of rain drops. To be able to keep the culture of the parasitoid year round there is urgent need for a transparent roofed screen house (similar to the LGB centre at Nyankpala). A simple microscope is also need for effective studies on the biology of the parasitoid.

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

Francis Kusi, Mukthāru Zakaria and J. N. Azure

Introduction

WAAPP 003: Integrated management of field, storage pests and post-harvest handling to extend shelf life of yam, has been implemented for two years now, 2010 and 2011 cropping seasons. The project within this period has develop and recommended pre-planting treatments of yam setts against early attack of the sprouts against pests and diseases. Post sprouting treatments against yam beetle infested has also been developed. Critical evaluation of three yam storage structures used by yam farmers in the Northern Ghana revealed their limitations and the project is currently addressing these limitations. Among the limitations include rodent attack, poor ventilation and high mealy bug infestation.

The following activities were carried out during 2011 cropping season under WAAPP 003 project.

Field studies

- The 2010 results on pre-planting treatments were confirmed in 2011 and packaged for dissemination.
- The post sprouting treatments were in improved in 2011 by spraying on weekly basis for 3 weeks starting from 12 weeks after planting. This significantly reduced the number of feeding holes of yam beetles per tuber when compared with the control plots.

Results and discussion

Yam storage studies

The following were identified as the limiting factors in the storage structures evaluated in 2010:

1. High incidence of rodent damage in all the structures
2. High mealy bug infestation in the mud structure due mainly to poor ventilation

The structures were improved in 2011as follows:

1. Fencing the thatch yam storage structure with roofing sheets. The surfaces of the sheets are smooth such that the rodents cannot grasp it to climb. To prevent the rodents from burrowing beneath the sheet to enter the structure, the sheets were buried one foot deep in the soil.

Table 108. Effect of IPM strategies on yield and incidence of pests and diseases of yam

	2010			2011		
Treatment	Tuber Yield (t/ha)	Vigour Score	Feeding points /Tuber	Tuber Yield (t/ha)	Vigour Score	Feeding points /Tuber
Hot water + Neem	22.10	4.33	2.67	23.67	4.67	1.33
Hot water + Insecticide	22.92	5.00	2.00	24.20	4.33	0.67
Wood ash + Neem	23.54	4.67	3.00	23.73	5.00	1.33
Wood ash + Insecticide	22.92	5.00	2.33	23.43	4.00	1.00
(Insecticide + Fungicide) + Neem	23.3	4.67	3.00	24.03	4.67	1.00
(Insecticide + Fungicide) + Insecticide	21.67	4.33	2.67	23.40	5.00	1.00
Neem powder + Neem	21.88	4.33	2.67	23.87	4.00	1.33
Neem powder + Insecticide	22.92	4.33	2.00	24.37	4.33	0.67
Control	20.83	3.33	1.33	19.77	2.67	4.00
Mean	22.50	4.44	2.41	23.39	1.37	4.30
s. e. d.	0.78	0.44	0.84	0.67	0.54	0.45
CV (%)	4.2	12.2	42.9	3.5	12.8	48.4

2. Another method is by building a round wall of about 70 cm high around the structure. The outer surface of the wall is smoothly plastered with cement and this also prevents the rodents from climbing the wall. There is a foundation of one foot deep that also prevents the rodents from burrowing to enter the structure.

3. The project has improved the mud structure by covering the base of the structure with roofing sheets to prevent the rodents from climbing to enter the structure through the roof. Also about 70 cm height from the base of the structure could be plastered smoothly with cement to prevent the rodents from entering.

4. The ventilation has been improved by creating between 2 - 4 windows depending on the size of the structure.

Inducing dormancy in stored yam

Method used by the farmers to induced dormancy in stored yam was evaluated for improvement. The farmers rely on the drier environment during the dry season to cure the exposed surfaces after removing the sprouts. The project is currently evaluating application of slurry of wood ash or neem seed powder to the exposed surfaces and the results so far looks promising.

Dissemination of findings from the field and storage trials

The findings from both the field and the storage studies have been introduced to Six Hundred yam farmers, four hundred in Northern region and Two Hundred in Upper West region. The Six Hundred farmers are from twelve FBOs consisting of fifty farmers per FBO. The farmers have been trained in the pre-planting treatments, post sprouting treatment, the improved storage structure and treatment of tubers against infestation and infection by pests and diseases after removing sprouts in storage.

Nine improved yam storage structure have been constructed in both Northern and Upper West regions to demonstrate how rodents can be eliminated from the structures. These are also serving as training centres in the communities.

Below are the communities where the dissemination took place:

Northern Region

Kpabia – Suglo mboribuni farmers group
Kpabia – Tiyumtaba farmers group
Adiboo – Timtooni yam farmers group
Adiboo - Tisomtaba farm farmers group
Pion – Pion yam farmers group
Pion – Mabada yam farmers yam farmers group
Tingoli - Tingoli yam farmers group

Upper West Region

Wa Municipal

1. Kpongu yam farmers
2. Dandafuro

Wa East

1. Loggu yam farmers
2. Kparisaga

Further Funding

There is urgent need for more funds to scale up the technologies to the entire yam producing districts and communities in Northern and Upper West regions. Demonstration fields need to be established in the districts to promote for adoption the pre-planting and post sprouting treatments. Equally the improved yam storage structures are to be constructed in the districts as a demonstration to promote their adoption. Yam production and storage guide has also been prepared from the findings of the project. Funds are therefore needed to publish this and make copies for distribution to enhance the dissemination of the technologies.

Another observation made in course of the study among the farmers is the widely use of weedicides in yam production. There is therefore the need for funds to conduct research to determine the effect of pre-emergence and post-emergence weedicides on sprouting and plant establishment most especially on pre-sprouted yam setts.

Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation

Francis Kusi, Muktharu Zakaria and J. N. Azure

Introduction

FABS 001 project: Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation, successfully evaluated IPM strategies between November and March 2009/2010 and 2010/2011. The IPM strategies developed over the period (2010 annual report) to manage pests and diseases of onion, tomato and pepper under irrigation were demonstrated to farmers who were also trained in the IPM strategies during the year under review.

The components of the IPM strategies

- Production within the favourable climatic condition for each of the crops
- Good nursery management practices, good land preparation
- Early transplanting within the favourable climatic condition
- Efficient water management
- Setting action thresholds for the key pests and diseases of the crops
- Monitoring and identification of pests and disease
- Managing the crop to prevent pests and diseases from becoming a threat using cultural practices

- Once monitoring, identification, and action thresholds indicate that pest and diseases control were required, control methods were evaluated both for effectiveness and less risky. Timely, adequate and safe application of pesticides was used as the last resort.

Six demonstrations were established at the following irrigation sites in Upper East region and the sites were: Bugri, Binduri, Azum Sapeliga, Saka, Tilli and Tono. The demonstration fields served as training centres for the farmers of the 3 crops (onion. Pepper and tomato).

Vegetable farmers were also trained in the following communities;

Garu Tempane District

1. Akara
2. Tarivaag
3. Kpalsako No.1

Kasena Nankana East

1. Goo
2. Saboro

Bawku Municipal

1. Benguri
2. Azum Sapeliga

Bawku West

Northing Foundation, NGO, also sponsored the dissemination of the IPM strategies to Five Hundred onion farmers in the following communities in Bawku West.

1. Nagberi
2. Saka
3. Sapeliga

It is recommended that the dissemination of the IPM strategies should be scale up to other irrigation sites and communities along the White Volta River for adoption to increase vegetable production quantitative and qualitatively in Upper East region.

Areas that need further Funding

1. Evaluation of onion varieties other than Bawku red for adaption eg. Galmi, Malavi, Red creole etc to identify alternative onion variety for the farmers.

2. Screening to identify varieties of tomatoes with high paste yield adapted to rainfed condition to ensure year round supply to the tomato processing factory at Pwalugu.

3. Funds to publish and produce copies of vegetable production guide prepared from the project findings to enhance the dissemination of the IPM strategies.

4. Demonstration of the IPM strategies in other irrigation sites in upper East region.

POSTHARVEST

Improving marketable quality of tomato: a simulation of shipping conditions in Ghana

Issah Sugri

Executive Summary

The study assessed the influence of a sequence of anticipated hazard elements (impact, compression, vibration) and shipment conditions on marketable quality under varying temperatures and ripeness stages. The vibration test simulates a truck operating at highway speed and determines the ability of shipping units to withstand vertical and compression forces resulting from stacking during transport. Storage at 30^{o}C depicted ambient conditions; 15 and 20 ^{o}C are optimum temperatures for ripening; and pink and light-red ripeness depict typical harvest maturity in Ghana. Critical data was taken on days to red-ripe, CO_2, ethylene production, color, firmness, weight loss, pH, titratable acidity and soluble solids content. Overall, the influence of vibration and ripeness on marketable shelf life was marginal; however temperature significantly ($P \leq 0.05$) influenced shelf life. Vibration increased weight loss, respiration and ethylene production, which were plummeted at lower temperature. Days to red-ripe indicated that tomato should preferably be marketed by 2-4, 8-12 and 10-15 days at 30, 20 and 15 ^{o}C respectively, at pink to light-red ripeness under current distribution conditions. Best chemical properties were maintained at 15 and 20 ^{o}C; vibration and ripeness did not influence chemical properties, but increasing temperature affected all physico-chemical properties. The study concludes that despite the cumbersome shipping conditions, tomatoes could be marketed at premium quality if lower storage temperatures were accessible.

Introduction

Tomato (Solanum *Lycopersycum* Mill) production is a major source of income for majority of households in the Upper East region of Ghana. During the dry season, large-scale production is carried out under irrigated conditions around dug-outs, small irrigation dams and along the White and Black *Volta* river banks. As high as 10-20% postharvest losses occur due to delays in transport arrangements and long distances to urban markets. This huge loss is unacceptable since economic resources would have been expended. Large cargo trucks without temperature, humidity and vibration controls are used to ship tomato to urban markets, which ranges from 100-800km. In most parts of Africa, tomatoes are harvested at vine-ripe due to lack of cool-chain and ripening facilities to handle mature-green to turning stages. However, as tomatoes ripen and senesce during typical shipping operations, greater care is required to minimize physical damage. Processing the fruits into preserved products could ameliorate this situation, unfortunately processing equipment is lacking, and some families prefer to use fresh tomato for cooking. The test design simulates a truck operating at highway speed and determines the ability of shipping units to withstand vertical vibration and dynamic compression forces resulting from stacking during transport.

Objectives: To assess the influence of a sequence of anticipated hazard elements (impact, compression, vibration) and shipment conditions on marketable quality under varying temperatures and ripeness stages.

Methodology

Round-type tomatoes at pink (30-60% red) and light-red (60-90% red) ripeness were subjected to a vibration test and incubated in ripening chambers set at 15, 20 and 30 ^{o}C. Storage at 30^{o}C depicted ambient conditions in Ghana whereas 15 and 20 ^{o}C are recommended temperatures for ripening tomatoes. Three lugs of fruit (each containing 70 fruits) were stacked on top of another to simulate stacking on a pallet, then placed on a vibration table and vibrated for 1 hour. Average shelf life was expressed as the number of days from storage to red-ripe stage (stage 6 or table-ripe). Experiments were terminated when fruit softening could be detected by hand. Critical data was taken on respiration rate, ethylene production, color, firmness, weight loss, pH, total titratable acidity, soluble solids content and Brix:acid ratio.

Results

Overall, the influence of vibration and ripeness on marketable shelf life was marginal; however temperature significantly ($P \leq 0.05$) influenced shelf life (Table 109). Days to red-ripe indicated that tomato should preferably be marketed by 2-4, 8-12 and 10-15 days at 30, 20 and 15 ^{o}C respectively, at pink to light-red ripeness under current distribution conditions. Vibration increased weight loss, respiration and ethylene production, which were plummeted at lower temperature. A general rise of CO_2 was noticed from day 1 to 3 after storage, but fruits held at 30^{o}C showed a marginal decline (Table 110). After 1 d of storage fruits either vibrated or held at higher temperatures showed higher CO_2 production rate than the control. Difference in CO_2 production between fruits held at 15^{o}C and 20^{o}C was 2 times higher, and 3 times higher between 15^{o}C and 30^{o}C (Table 110). Fruits held at 20^{o}C showed normal ethylene rate (8.03 $\mu Lkg^{-1}h^{-1}$) compared with 15^{o}C (4.5 $\mu Lkg^{-1}h^{-1}$) and 30^{o}C (5.4 $\mu Lkg^{-1}h^{-1}$). Ethylene production ranges were 3-5.1 $\mu Lkg^{-1}h^{-1}$ at 15^{o}C and 6.3-9.1 $\mu Lkg^{-1}h^{-1}$ at 20^{o}C after 1 d of storage. Fruits held at 30°C showed intermediate ethylene response (4.4-6.9 $\mu Lkg^{-1}h^{-1}$) after 1 d of storage.

Table 109: Effect of vibration, temeperature and maturity on shelf life

Temp of storage	Treatments	Maturity stage	Days to red-ripe		Days to Softening	
			Mean	Range	Mean	Range
	Vibration	Pink	9.6^{a}	7-12	12.2^{ab}	10-14
15°C		Light-red	7.1^{b}	6-9	11.7^{b}	10-13
	Control	Pink	7.4^{b}	6-8	13.7^{a}	12-15
		Light-red	6.7^{bc}	6-8	13.0^{ab}	12-15
20°C	Vibration	Pink	6.8^{bc}	5-8	11.3^{b}	8-12
		Light-red	5.8^{c}	5-8	9.0^{c}	9-12
	Control	Pink	6.3^{bc}	5-8	9.1^{c}	9-10
		Light-red	5.2^{c}	4-8	8.2^{c}	7-9
30°C	Vibration	Pink	3.7^{d}	2-4	4^{d}	2-4
		Light-red	2.9^{d}	2-4	4^{d}	2-4
	Control	Pink	3.1^{d}	2-4	4^{d}	2-4
		Light-red	3.2^{d}	2-4	4^{d}	2-4

Mean values along columns with same letters are not significantly different at *P≤0.05*

Table 110a: Effect of vibration, temperature and maturity on some physiological processes

Temperature of storage	Treatments	Maturity stage	Fruit firmness (Nmm^{-1})		Ethylene production ($\mu lkg^{-1}h^{-1}$)	
			Initial	Final	Day 1	Day 3
15°C	Vibration	Pink	12.3^{a}	10.8^{a}	3.01d	5.7^{ab}
		Light-red	8.9^{bc}	8.8^{ab}	6.3bc	4.4^{bc}
	Control	Pink	11.2^{ab}	9.5^{ab}	3.5d	4.6^{bc}
		Light-red	11.2^{ab}	9.3^{ab}	5.1cd	4.1^{bc}
20°C	Vibration	Pink	11.3^{ab}	10.2^{a}	9.1a	7.8^{a}
		Light-red	9.6^{bc}	$8.4b^{c}$	8.9ab	5.9^{ab}
	Control	Pink	9.9^{bc}	$8.7b^{c}$	7.9ab	6^{ab}
		Light-red	10.7^{a}	10.1^{a}	6.3bc	4.8^{bc}
30°C	Vibration	Pink	8.4^{bc}	6.9^{c}	6.9bc	3.9^{c}
		Light-red	10^{ab}	8.7^{bc}	5.9cd	3.5^{c}
	Control	Pink	9.5^{bc}	8.5^{bc}	4.4cd	2.5^{cd}
		Light-red	9.2^{bc}	8.4^{bc}	4.8cd	3^{c}

*Mean values along columns with same letters are not significantly different at *P≤0 .05*

Table 110b: Effect of vibration, temperature and maturity on some physiological processes

Temperature of storage	Treatments	Maturity stage	Respiration rate ($mgkg^{-1}hr^{-1}$)		Weight loss (%)	
			Day 1	Day 3	Day 1	Day 3
15°C	Vibration	Pink	13.9^{e}	29.7^{d}	0.14^{c}	0.40^{d}
		Light-red	7.6^{e}	27.1^{d}	0.16^{c}	0.45^{d}
	Control	Pink	6.4^{e}	33.9^{d}	0.17^{c}	0.39^{d}
		Light-red	15.6^{e}	32.1^{d}	0.20^{c}	0.38^{d}
20°C	Vibration	Pink	49.1^{c}	51.2^{ab}	0.34^{b}	1.14^{c}
		Light-red	45.5^{c}	55.5^{ab}	0.43^{b}	1.17^{c}
	Control	Pink	30.5^{d}	34^{d}	0.36^{b}	0.96^{c}
		Light-red	37.8^{cd}	45.7^{c}	0.35^{b}	0.99^{c}
30°C	Vibration	Pink	74.1^{ab}	50.7^{ab}	0.77^{a}	1.65^{a}
		Light-red	75.6^{a}	58.1^{a}	0.79^{a}	1.55^{ab}
	Control	Pink	62.4^{b}	44.8^{c}	0.74^{a}	1.32^{bc}
		Light-red	64.9^{ab}	46.7^{bc}	0.82^{a}	1.66^{a}

*Mean values along columns with same letters are not significantly different at *P≤0 .05*

Table 111a: Effect of vibration, temeperature and maturity on chemical properties at red-ripe

Temp of storage	Treatments	Maturity stage	Total Titratable Acidity (%citric acid)	Brix/Acid ratio
15°C	Vibration	Pink	0.5 ± 0.01^{bc}	8.8 ± 0.29^{ab}
		Light-red	0.5 ± 0.11^{bc}	8.3 ± 2.24^{ab}
	Control	Pink	0.4 ± 0.07^{c}	9.2 ± 1.43^{a}
		Light-red	0.6 ± 0.19^{bc}	6.4 ± 2.53^{bc}
20°C	Vibration	Pink	0.5 ± 0.04^{bc}	8.2 ± 1.08^{ab}
		Light-red	0.5 ± 0.03^{bc}	8.0 ± 0.38^{ab}
	Control	Pink	0.5 ± 0.01^{bc}	8.2 ± 0.10^{ab}
		Light-red	0.4 ± 0.02^{c}	9.5 ± 0.37^{a}
30°C	Vibration	Pink	0.7 ± 0.17^{ab}	5.0 ± 1.13^{cd}
		Light-red	0.8 ± 0.07^{a}	4.3 ± 0.19^{d}
	Control	Pink	0.7 ± 0.22^{ab}	5.8 ± 1.66^{cd}
		Light-red	0.5 ± 0.09^{bc}	7.5 ± 1.47^{abc}

*Mean values along columns with same letters are not significantly different at *P≤0.05*

Table 111b: Effect of vibration, temeperature and maturity on chemical properties at red-ripe

Temp of storage	Treatments	Maturity stage	pH	Soluble solids content (°Brix)
15°C	Vibration	Pink	4.5±0.02[a]	3.9±0.25[a]
		Light-red	4.4±0.11[ab]	3.8±0.26[a]
	Control	Pink	4.5±0.07[ab]	3.9±0.06[a]
		Light-red	4.3±0.27[bc]	3.7±0.12[ab]
20°C	Vibration	Pink	4.6±0.04[a]	3.9±0.15[a]
		Light-red	4.5±0.05[ab]	3.7±0.31[ab]
	Control	Pink	4.4±0.03[ab]	3.9±0.10[a]
		Light-red	4.5±0.06[ab]	4.0±0.12[a]
30°C	Vibration	Pink	4.1±0.12[c]	3.4±0.00[b]
		Light-red	4.0±0.02[dc]	3.4±0.17[b]
	Control	Pink	4.2±0.13[bc]	3.7±0.06[ab]
		Light-red	4.3±0.14[bc]	3.7±0.21[ab]

*Mean values along columns with same letters are not significantly different at *P≤0.05*

By 3 d after storage, ethylene production ranges were 15°C (4.1-5.7 $\mu Lkg^{-1}h^{-1}$), 20°C (4.8-7.8 $\mu Lkg^{-1}h^{-1}$) and 30°C (2.5-3.9 $\mu Lkg^{-1}h^{-1}$). In all interactions, best chemical properties occurred at 15 and 20 °C (Table 3). Higher acidity (pH: 4.0-4.3) was recorded at 30°C compared with ranges at 15°C (pH: 4.3-4.5) and 20°C (pH: 4.4-4.6). Higher soluble solids content (3.7-4.0) was recorded at lower temperatures 15°C (3.7-3.9) and 20°C (3.7-4.9) compared with 30°C (3.4-3.7). This trend reflected in the brix/acid ratio, which relates to taste of products. Higher ratios were recorded at lower temperatures of 15°C (6.4-9.2) and 20°C (8.0-9.5) compared with 30°C (4.3-7.5).

Conclusion

The study concludes that despite the cumbersome shipping conditions in Ghana, tomatoes could be marketed at premium quality if lower storage temperatures were accessible. These facilities are beyond the purchasing power of small-holder traders, thus the involvement of the State and/or Private Sector to providing these facilities would be beneficial; particularly in urban markets where retail prices will merit such investments.

SOCIO-ECONOMICS

Baseline Study: Onion farmer's livelihood and value chain improvement project

J. K. Bidzakin, Yahaya Iddrisu

Executive Summary

The onion farmers' livelihood and value chain improvement project started at the beginning of the onion production season (August, 2011). A baseline study is required against which progress can be monitored. The data required are data on impact level, i.e. data on the livelihood of the onion farmers. Therefore the baseline study is a livelihood study, involving different data collection methods. These are both quantitative methods (questionnaires) and qualitative (participatory rural appraisal tools, focus group discussions, key informants interviews) methods. Secondary data was also collected through research of literature and existing studies already done on the on onion production. Average farm gross margin calculated was Gh₵1803.62, however the average onion enterprise gross margin per hectare calculated was GHS1,315.50 which is very low as compared to the district estimate of GhS 3,770.00 per ha. Farm households were generally food secured in the month of August 2011. Generally from the survey, onion production is a profitable business to undertake if the challenges of farmers are addressed especially in the area of sufficient water supply, efficient storage systems, good market conditions, improvement in road network, training on integrated pest management practices and good agronomic practices, availability of certified seed and other inputs and provision of credit facility.

Project background:

Bawku West district is an up-coming onion producing district in Ghana's Upper East Region (Bawku West District MoFA, 2010). An estimated 4,000 farmers are involved in onion production (Ghana statistical services, 2000). Onion production is taking place in the dry season on irrigated farming land alongside rivers, dams and streams or on land irrigated by water pumps. Onions are a cash crop and the main source of livelihood for farmers in the dry-season. Through the sale of onion, farmers and their families are able to meet expenses, such as food, school fees, medical bills and expenses on funerals and weddings. Traditionally onion farming has been a male activity due to the high level of investments required. Nowadays, more and more women also take up onion farming as a source of income (Bawku West District MoFA, 2010). The sale of onions at the local markets is completely in hands of women.

Onion farmers face numerous challenges in production, storage and marketing. Moreover their level of organization is low. Some farmers are organized in local producers groups consisting of an average of 25 farmers. There are no higher level farmer organizations (village and district level organizations). Consequently collective purchase of farming inputs, collective sales of onions to traders and access to credit are difficult to achieve. In addition, socio-economic concerns are not heard at district, regional and national policy levels.

Onion yield per hectare is low in the two districts compared to other onion producing areas in West African countries. In Ghana, the average yields per unit area is 7.7 ton per ha (NARSP, 1994; L. Abbey, *et al*, 2000). This is on average five times lower than that of Niger (35 ton per ha), three times as low as Senegal, Mali and Burkina Faso (23 ton per ha) and 2.5 times as low as the average of all countries in West Africa (18 ton per ha). Several factors account for the low production of onion: low yielding variety (Bawku Red); inadequate access to farming inputs (such as seeds and fertilizers); high incidences of pests and diseases; poor production and poor genetic quality of the onion seeds; limited use of (organic) soil and water conservation techniques insufficient water for irrigation; and limited suitable land for onion production.

Poor traditional storage methods result in post-harvest losses of up to 70% in some cases. Most farmers therefore sell the bulk of their produce shortly after harvest because of problems with storage (L. Abbey, *et al*, 2000). The weather at the time of harvesting is extremely hot and dry and traditional storage facilities are inappropriate for the storage of the onions.

Profit margins of onions are very low (field survey, 2011). There is very little information available to farmers about prices of the crop elsewhere in the country. Soon after the main harvesting season has ended, the price of onions falls drastically due to an excess of supply in local markets. Farmers are often in need of cash and are forced to sell their produce immediately after the harvest. Apart from low incomes resulting from poor market for the crop, farmers are faced with high cost of production arising from the high costs of tractor services for land preparation, high cost of seed, fertilizers and other chemicals; high labour costs required for the intensive cultural practices required to bring the bulbs to full maturity.

Objective of baseline Study

The objectives of the baseline study was to identify, collect and analyse primary and secondary data on the livelihoods of onion farmers in the

Bawku West District to establish data base (reference point/measuring scale) against which progress could be measured.

Methodology used:

The Bawku West District lies within the Upper East Region of Ghana. It was created in 1988 under the new local government system of 1988 by legislative Instrument (LI) 1442. It lies roughly between latitudes 10° 30'N and 11° 10'N, and between longitudes 0° 20'E and 0° 35'E. The District covers an area of approximately 1,070 square kilometers, which constitutes about 12% of the total land area of the Upper East Region (www.ghanadistricts.com). The baseline study was a livelihood study, involving different data collection methods. These are both quantitative methods (questionnaires) and qualitative (participatory rural appraisal tools, focus group discussions, key informants interviews) methods.

A total of 180 onion farmers were randomly sampled from a purposive sample of 36 FBOs in 9 communities in the Bawku West District of the Upper East region. The communities were selected because of the existence of onion farmer based organizations (FBOs) in the communities and their working relationship with the local NGOs (ZOVFA). Out of the 180 farmer's, 160 were classified as the intervention farmers and 20 were as the non-intervention farmers. This segregation is to enable comparison in the future.

Data analysis was undertaken using different methods depending on the summary indicator involved. The Statistical Package for Social Scientist (SPSS) software was used to analyse the data. Percentages of respondents were computed for such indicators as sex, farming systems, crops held in storage etc. Other indicators, depending on the context, were computed at their arithmetic means. These include age, farming experience, size of household, and crop yields. Still, some other variables were presented simply as summations of the indicators observed, e.g. household asset and livestock ownership.

Household Food Insecurity Access Scale (HFIAS) for measurement of food access developed by FANTA and adopted by FAO for food insecurity studies was also adopted for the food insecurity assessment in this study. The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days). First, a HFIAS score *variable* is calculated for each household by summing the codes for each frequency-of-occurrence question. Before summing the frequency-of-occurrence codes, the data analyst should code frequency-of-occurrence as 0 for all cases where the answer to the corresponding occurrence question was "no" (i.e., if Q1=0 then Q1a=0, if Q2=0 then Q2a =0, etc.). The maximum score for a household is 27 (the household response to all nine frequency-of-occurrence questions was "often", coded with response code of 3); the minimum score is 0 (the household responded "no" to all occurrence questions, frequency-of-occurrence questions were skipped by the interviewer, and subsequently coded as 0 by the data analyst.) The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household experienced.

Results

Key findings:

Generally, there was an even distribution of both adults and children in a household with an average age of male household head being 47 years and their wives was estimated as 38 years. Majority of the household heads and their wives had no education and their primary occupation was crop production. Household wealth was largely concentrated on Livestock. Farmers cultivate on more than one piece of land which is direct ownership and takes about 58 minutes to walk to the plot. Inputs of all kinds except labor use are very low. Major crops produced in the area include; maize, millet, peanuts, bambara beans, soybeans, rice, and cassava. Vegetables grown in the area are onion, okro, hot pepper, sweet pepper and tomatoes. Household heads and their wives participate in groups to receive information on agricultural production. Knowledge on conservation practices in all categories was very high for households (field survey, 2011). However, knowledge on no-tillage (zero-tillage) varied. Average farm gross margin calculated for the study area was Gh¢ 1803.62, however the average onion enterprise gross margin per hectare calculated was Gh¢ 1,315.50 which is very low as compared to the district estimate of Gh¢3,770.00 per hectare Bawku West District, DADU).

Farmer household were generally food secured in the month of August, the reason been that Early millet had been harvested. Farmers are challenged with lack of onion storage facilities. The market situation is not favorable to them and they feel exploited by middle men. They are also faced with yearly water shortage in their dams. They identified the challenges of onion farming and even suggested possible remedies to them. Generally from the survey, onion production is a profitable business to undertake if the challenges of farmers are addressed especially in the area of sufficient water supply, efficient storage systems, good market conditions, improvement in road network, training on integrated pest management practices and good agronomic practices, availability of certified seed and other inputs and provision of credit facility.

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