COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

SAVANNA AGRICULTURAL RESEARCH INSTITUTE

2009 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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Savanna Agricultural Research Institute

(SARI)

2009 Annual Report

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CSIR-SARI ANNUAL REPORT 2009

FORWARD

The year under review was one of immense activity for all of us associated with CSIR-SARI. Several major projects were at or approaching the end of their first phase and new projects were coming on board. It was the start of an exciting and busy year in the Institute's history that launched us into a substantial financial support through AGRA to implement new projects.

In furtherance of the mandate to conduct agricultural research as it relates to food and fibre crop farming in the three northern regions of Ghana, the Institute recorded various degrees of success in the implementation of programmes and projects. These achievements are captured under the section: Scientific Support Group, Northern Region Farming Systems Research Group, Upper West Region Farming Systems Research Group and Upper East Farming Systems Research Group.

In pursuit of the objective of moving away from hazardous and expensive insecticides, plant-based products continued to be an integral part of our work on IPM in managing insect pests in the region.

Five improved rice varieties namely Gbewaa, Nabogu, Katanga, NERICA 1 and NERICA 2 were released during the year. These varieties were developed to address the constraints of low yield potentials of existing varieties, susceptibility to lodging, leaf blast and brown spot and terminal drought which militate against increased and sustained rice production and productivity. These varieties have the potential to increase significantly the level of rice production from 15-50% and income of rice producers.

The Institute presented three entries for the ICT Competition to climax the CSIR Golden Jubilee Celebration on 21st December, 2009 which were adjudged to have won awards in their various categories.

We cannot conclude this message without mention of the Emergency Rice Initiative Project with the objective to boost total domestic rice production. This Initiative was aimed at improving farmers' access to quality rice seed and fertilizer and expanding knowledge on best-bet rice technologies. With funding from the USAID, the project reached out to 12,635 farmers in 27 districts in the three northern regions and increased paddy production by 28,663 tons. These farmers gained access to best-bet rice technologies through on-the-job training and videos on rice technologies. Rural radio and TV broadcasts on these technologies were also used to reach other farmers not directly involved in the project.

Last but not least, a word of thanks to government, donors, farmers and research collaborators through whose support it managed to record its achievements. It is our hope and expectation that the coming year will be a more fulfilling and successful one to enable the scientists to continue to make even greater strides in helping to provide answers to the many challenges that farmers face in the region.

We hope that you will enjoy reading this Report with as much pleasure as it gives us to present the CSIR-SARI Annual Report 2009 to you.

Dr. Stephen K. Nutsugah
Acting Director

ADMINISTRATION REPORT

Management

The Institute is managed by a 6-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. Alhassan Andani	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	Ag Director, CSIR-SARI
5	Mr. Roy Ayariga	MoFA
6	Alhaji Nashiru Kadri	Private Farmer

Staff Strength

Staff strength as at the beginning of 2009 stood at 435. However, by the end of the year the number had decreased to 419 comprising of 34 Senior members, 78 senior staff and 307 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 48 respectively. With Manga having 6 Senior members, 7 senior staff and 39 junior staff while Wa has 4 senior members, 11 senior staff and 33 junior staff.

Table 1. Promotions, appointments and deaths

	Senior Research	Senior Members	Senior Staff	Junior Staff	Total
Promotion	1	-	-	-	1
Appointment	-	-	-	-	2
Consideration	-	1	4	8	13
Retirement	-	-	-	-	10

Death	-	-	1	3	4
Total	1	1	5	11	

Human Resource Development

The Human Resource Development Committee has received approval for seven staff both local and foreign who qualified for training for 2009/10 academic year.

Name	**Course**	**Finish**	***Place**
Salifu Abdul-Wahab	Ph.D	2012	Univ. of Florida. USA
William Atakora	MSc.	2012	KNUST-Kumasi
Mohammed Haruna	MSc.	2010	KNUST-Kumasi
Abihiba Zulai	B.Sc.	2012	IPS-Accra
Francisca Abaah	BSc.	2012	UEW-Kumasi
Yahaya Inusah	MSc.	2012	KNUST-Kumasi
Nicholas Denwar	Ph.D	2010	Texas State Univ
Mukhtaru Zakaria	B.A	2010	KNUST, Kumasi
Alhassan Sayibu	B. Sc.	2010	KNUST
Joseph Adjabeng Dankwa	Ph. D	2014	Univ. of Ghana-Legon
Mahama George Yakubu	M Sc	2011	Kansas State Univ. USA
Tahiru Fulera	M.Sc	2012	Univ. of Bonn-Germany
Alidu Issah	MSc	2010	Tuskegee Univ. USA
Paul Berko	B. A	2010	UCEW, Kumasi

Table 3. Staff back from training

Name	Grade	Programme
Kwabena Acherimu	Asst. Res. Scientist	MPhil.
Alhassan Muktaru	Asst. Res. Scientist	MSc.
Issah Issifu	Jnr. Library Asst.	Dip. Librarianship

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.

Table 3. National Service.

Institution	**No.**
Kwame Nkrumah University of Science and Technology	1
University of Ghana, Legon	-
Tamale Polytechnic	2
University for Development Studies	7
Total	**10**

Membership of CSIR-SARI Internal Management Committee

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

Staff Distribution Among Divisions

Division	Senior Members	Senior Staff	Junior Staff	Total
Northern Region Farming Systems Research Group	9	3	53	65
Upper East Region Farming Systems Research Group	5	6	42	53
Upper West Region Farming Systems Research Group	4	11	21	36
Scientific Support Group	17	30	63	110
Commercialization and Information Division	2	2	1	5
• Documentation		1	1	2
• Library				

Accounts	1	9	6	16
Administration Division				
• Personnel	1	4	30	35
• Transport/Workshop	-	9	26	35
• Farm Management	-	2	22	24
• Estate	-	1	6	7
• Security	-	1	35	36
Total	**39**	**78**	**307**	**424**

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	Ag. 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)	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
S. Tigbee	RSA III	Accounting	Senior Accounting Assistant
Mahama A. Rufai	HND	Accounting	Principal Accounting Assistant
Zulai Abihiba	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
*Salifu Wahab	BSc	Agric Economics	Assistant Research Scientist
Peter A. Asungre	HND	Agric Engineering	Technical Officer
Zakaria Muntaru	Diploma	General Agriculture	Technical Officer

Northern Region Farming Systems Research Group

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

Upper West Farming Systems Research Group

Name	**Qualifi-cation**	**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	**Qualifi-cations**	**Area of Specialisation**	**Designation**
S. K. Asante	BSc MSc PhD	Agriculture Plant Protection Agricultural Entomology	Principal Research Scientist
I. D. K. Atokple	BSc Dip Ed MSc PhD	Agriculture Education Plant Breeding Plant Breeding	Senior Research Scientist
M. S. Abdulai	BSc MSc PhD	Agriculture Plant Breeding Plant Breeding	Senior Research Scientist
M. Fosu	BSc Dip Ed MSc PhD	Agriculture Education Soil Chemistry Soil Chemistry	Senior Research Scientist

N. N. Denwar	BSc MPhil	Agriculture Plant Breeding	Research Scientist
B. D. K. Ahiabor	BSc MSc PhD	Agriculture Plant Physiologist Mycorrhizology	Research Scientist
A. A. Abunyewa	BSc Dip Ed Mphil PhD	Agriculture Education Soil Chemistry Soil Chemistry	Senior Research Scientist
N. Tabi Amponsah	BSc MSc	Agriculture Nematology	Research Scientist
Adjebeng-Danquah J.	BSc MSc	Agriculture Plant Breeding	Research Scientist
Fulera Tahiru	BSc	Agriculture	Asst Research Scientist
George Oduro	Certificate	General Agriculture	Principal Tech Officer
N. A. Issahaku	Certificate HND	General Agriculture Agriculture	Senior Tech. Officer
H. Mohammed	HND BSc	General Agriculture	Principal Tech. Officer
A. L. Abdulai	BSc MSc	Agriculture Agrometeorology	Research Scientist
Ester Wahaga	BA	Sociology	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	Agriculture	Principal Technical

	Technology		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	Economics/ Sociology Development Economics	Senior Commercial Manager
R. K. Owusu	BSc MSc	Agricultural Mechanisation Postharvest & Food Preservation Engineering	Scientific Secretary
Musah Iddi	Technician III Certificate	Radio, Television & Electronics Radio, Television & Electronics	Principal Superintendent
Mumuni Abukari	HND	Marketing	Marketing Asst
Warihanatu Baako (Miss)	HND	Marketing	Marketing Asst

COMMERCIALIZATION AND INFORMATION DIVISION (CID) REPORT

J. S. Bapule

Introduction

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. Joseph S. Bapule	-	Head, CID
ii)	Mr. Robert Owusu	-	Scientific Secretary
iii)	Mr. Abukari Mumuni	-	Snr. Marketing Assistant
iv)	Miss Baako Warihana	-	Marketing Assistant

Technologies Identified For Commercialization

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

Income Generating Activities

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

- Production and sale of breeder/foundation seed
- Soil and plant analysis
- Agromet data generation
- Consultancy (Millennium Challenge Account project)
- EDIF Groundnut project
- Tractor services/farm management
- Combine harvester services
- Guest House earnings

- Photocopying and documentation services
- Telecommunication services
- Workshop – vehicle hiring

Table of income generated in 2008 and reported on in 2009

Source of Income	**Amount earned Gh¢**
Guest House Services	2,950.70
Soil Analysis	344.07
Consultancy (MCA)	75,624.00
Hiring of Conference Hall	60.00
Rice Processing	2,204.50
Combine Harvester	14,512.69
EDIF Groundnut stock sold	3,650.00
Foundation seed (Rice)	542.96
Agromet Data	1,260.00
TOTAL	**GHC101,148.42**

Significant Achievements of the Division

Millennium Challenge Account Project

Through the initiative of the head of the CID the institute went into a consultancy partnership with IFDC to bid to be the consultants for the implementation of the Millennium Challenge Account project in the northern zone. The first phase of the project covers the period 2008-2011. From this consultancy arrangement the institute is getting significant revenue flows which have made SARI to lead the other CSIR institutes in IGF. The three SARI staff on secondment to the project are contributing significantly to achieving the project objectives. Evidence of this can be seen in the timely quarterly reports they prepare on the project and submit to MiDA.

SARICONSULT

The division has been able to register a company by name SARICONSULT to enable the institute undertake any consultancy jobs in the country and beyond.

Business Plan for Rice Processing Centre

The head of the division collaborated with a consultant hired by the institute to prepare a business plan for the rice processing center.

Business proposal to rehabilitate the institute's articulator trucks

At the prompting of the Chairman of the institute's Management Board the head of CID prepared a business proposal for the rehabilitation of the institute's two articulator trucks. Based on the cost benefit analysis done funds were made available to rehabilitate the trucks and they have started operating.

DOCUMENTATION REPORT

Robert Kwasi Owusu

Introduction

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

Coordination of Industrial Attachment

Within the year a number of students from tertiary and Agric colleges requested and were granted industrial attachment for a period based on their request. Table 1 indicates the request fir the year.

Table 1. Institutions that requested for industrial attachments

Institution	No. of students	Duration (Weeks)
Damongo Agric College	8	10
UDS, Nyankpala Campus	36	6
University of Ghana, Legon	2	8
KNUST, Kumasi	3	8

Besides the industrial attachment a number of institutions also paid a day or two day's educational visit to the institute. Table 2 indicates the institutions.

Table 2. Institutions that paid educational visit to the institute

Institution	No. of students	Duration (days)
Songtaba Girls Club	36	1
University of Cape Coast	200	2
KNUST, Kumasi	200	2

Preparation and submission of Reports

The first, second and third quarter reports were prepared and submitted to head office in time. The fourth quarter report was submitted in February 2010. The Annual Report Summary for 2008 was also prepared and submitted to head office in May 2009.

The 2008 Annual Report has been collated, typeset and proof-read. Copies have been distributed to members of the Editorial Committee to edit and resubmit to me to. Members of the Editorial Committee met four times to do group editing of the 2007 Annual report. The editing is about 25% through. But as a result of the difference in style of reporting the members decided to develop a common format for directors review. The format has so far been circulated to all senior members for use in subsequent reports.

Updating of brochures

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

- SARI Overview
- Cowpea Production Guide
- Rice Production Guide
- Soybean Production Guide
- Groundnut and Bambarranut production guide.

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

- Annual Reports from 1997 to 2000
- In-House Review reports from 2000 to 2008
- Proceedings of the Workshop on Improving Farming Systems in the Interior Savanna Zone of Ghana. 1993 and 1996
- Links Yahoo Mail, Hotmail, Google, AGORA, etc
- Staff Publications

Since the server broke down the site has not been available to staff

Recommendation

There is the need to purchase an internet server to host SARI Website on the LAN to enable staff, both new and old, search for locally produced research information at the comfort from their offices. Management should institute sanctions against for Scientists who fail to submit his report on time. This will enable timely submission of requests to head office. There is the need to recruit an assistant (preferably a National Service Person) to assist the Scientific Secretary.

REPORT ON THE LIBRARY

Robert Kwasi Owusu, Issah Issifu and Ibrahim Sumaya

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 collection 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 subscribes only two daily newspapers and one weekly newspaper. It also depends largely on book donation.

Electronic Resources

Current emphasis is on on-line journals and CD-ROM searches. The institute now has access to AGORA (Access to Online Research in Agriculture), HINARI (Health InterNetwork Access to Research Initiative) and CAB Abstract. The usernames and passwords for the institute can be obtained from the Library Assistant.

Services Rendered

With the installation of two split air conditions, a conducive atmosphere now exist at the Library for research work and learning. Besides that the library offers the following services:

- CAB Abstract CD-ROM literature search
- Lending of books (to staff only)
- Reference service: box files have been created for each scientist to deposit his journal publications in for reference purposes
- Comb binding
- Thermal binding
- Lamination
- Design of complementary cards, wedding cards, etc.

STAFF PUBLICATIONS

A number of technical reports, conference papers, consultancy reports, and journal papers were produced by staff.

Refereed Journal Papers

Ahiabor, B. D. K., Fosu M. and Tibo I. (**2009**). Effect of pre-crop type on growth and yield of maize on two soils in the Guinea Savanna zone of Ghana. *West African Journal of Applied Ecology, V*ol. 17 (***in press***).

Buah, S. S. J., Huudu, A. B., Ahiabor, B. D. K., Yakubu, S. and Abu-Juam, M. (**2009**). Farmer assessment, conservation and utilization of endangered sorghum landraces in the Upper West Region of Ghana. *West African Journal of Applied Ecology, V*ol. 17 (***in press***).

Buah, S.S.J., L.N. Abatania and G.K.S. Aflakpui (**2009**). Quality protein maize response to nitrogen rate and plant density in the Guinea Savanna zone of Ghana. *West African Journal of Applied Ecology, V*ol. 16: 9-21.

Buah, S.S.J and S. Mwinkaara. (**2009**). Response of sorghum to Nitrogen fertilizer and plant density in the Guinea savanna zone. *Journal of Agronomy*. 8 (4): 124-130.

Naab, J.B., Chimphango, S.M.B., Dakora, F.D. (**2009**). N_2 fixation in cowpea plants grown in farmers' fields in the Upper West Region of Ghana, measured using ^{15}N natural abundance. *Symbiosis*, 48: 37-46.

Naab, J.B., Prasad, P.V.V., Boote, K.J., Jones, J.W. (**2009**). Response of Peanut to Fungicide and Phosphorus in On-station and On-farm Tests in Ghana. *Peanut Science*, 36: 157-164**.**

Naab, J.B**.,** S.S. Seini, K.O. Gyasi, G.Y. Mahama, P.V.V. Prasad, K.J. Boote and J.W. Jones (**2009**). Groundnut yield response and economic benefits of fungicide and phosphorus application in farmer-managed trials in Northern Ghana. *Experimental Agriculture*, 45:1-15.

C.H. Porter, J.W. Jones, S.G.K. Adiku, **J.B. Naab**, A.J. Gijsman, and O. Gargiulo and (**2009**). Modeling organic carbon and carbon-mediated soil processes in DSSAT v4.5. Operational Research: *An International Journal, DOI*: 10.1007/s12351-009-0059-1

J. Jones, J. Naab, D. Fatondji, K. Dzotsi, S. Adiku and J. H (**2009**). Uncertainties in simulating crop performance in degraded soils and low input production systems. *In*: Fatondji and Bationo (Eds.). *Improving Soil Fertility Recommendations to Smallholder Farmers in Africa Through the Use of Decision Support Tools* (***in press***).

Naab, J.B**.,** J.W. Jones, S.G.K. Adiku, J. Koo, K.A. Dzotsi, K.J. Boote, and C.H. Porter (**2009**). Evaluation of the DSSAT-CENTURY model for simulating maize growth and yield under nitrogen and phosphorus limited conditions in Ghana, *Agronomy Journal* (***accepted***).

Dzotsi, K.A., Jones, J.W., Adiku, S.G.K., Naab, J.B., Singh, U., Porter, C.H. and Gijsman, A.J. (**2009**). Modeling soil and plant phosphorus within DSSAT, *Ecological Engineering* (***accepted***).

Sugri I and Johnson PNT. (**2009**). Effect of two storage methods on the keeping and sensory qualities of four plantain varieties. *African Journal of Food Agriculture Nutrition and Development.* 9(4): 1091-1109.

Edited Conference Papers/Poster

Wiredu, A. N., K. O. Gyasi and T. Abdoulaye (**2009**). Characterisation of Maize Producing Households in the Northern Region of Ghana. Technical Report under the Drought Tolerant Maize for Africa Project, IITA, Ibadan, Nigeria.

Wiredu, A. N., K. O. Gyasi and T. Abdoulaye (**2009**). Characterisation of Maize Producing Communities in the Northern Region of Ghana. Technical Report under the Drought Tolerant Maize for Africa Project, IITA, Ibadan, Nigeria.

Workshops/Conferences Attended

Ahiabor, B. D. K. (**2009**). Stakeholder Validation Workshop on the Ecological Mapping of the Songor Ramsar Site – UNESCO Man & Biosphere National Committee; EPA Training School, Amasaman, Accra; Sept 10, 2009.

Ahiabor, B. D. K. (**2009**). CSIR-CTA Training Course in Annual Report Production and Writing, CSIR-INSTI, Accra, October 12-17, 2009

Fosu, M. (**2009**). Data analysis, processing, GIS formatting and paper write-up. Bonn, Germany, March 1-31, 2009.

Buah, S. S. J. (**2009**). 2009 Regional Planning Meeting of the Drought Tolerant Maize for Africa. IITA, Ibadan, Nigeria, March 29-April 2, 2009

Buah, S. S. J. (**2009**). Study tour of farmer field school implementation strategies. Tanzania, May 9-19, 2009.

Buah, S. S. J. & Kombiok, J. M. (**2009**). Suitable modernization of agricultural and rural transformation. Ibadan, Nigeria, June 8-12, 2009

Kombiok, J. M. (**2009**). Partnerships, power and equity in global value chain. Bamako, Mali, November 9-10, 2009.

Naab, J. B. (**2009**). Climate adoption project of ICRISAT. Niamey, Niger, March 8-12, 2009

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MAJOR ACHIEVEMENTS AND PROGRESS MADE IN RESEARCH PROGRAMMES

SCIENTIFIC SUPPORT GROUP

The group is made up of agronomists, soil scientists, agrometeorologist, 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' leve.

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 2009.

MAIZE IMPROVEMENT

N .N. Denwar, Gloria Boakyewaa, Ahmed Dawuni and M.S. Abdulai

Executive Summary
Field tests were conducted in Nyankpala, Damongo, Yendi, Manga, and Wa. Progress was made in identifying elite lines, including hybrids, for high grain yield, tolerance to *striga* (M0909-17 and M0909-10) and drought and N-use efficiency. Of particular interest were single cross (TZEI 1 x TZEI 5 and TZEI x 26 x TZEI 5) and top-cross hybrids (TZE-W Pop DT STR x TZEI 22, TZE-W Pop DT STR x TZEI 4) a number of which have been selected and seed of the parents requested from IITA for inclusion in the hybrid seed development program. During 2009 six genotypes (DT-SR-WCOF2, DT-SYN-1-W, GH9163SRS715, TZE-W Pop STR QPM C4, EVDT-W99STR QPM CO and TZEE-Y Pop STR QPPM CO) jointly tested under AGRA and DTMA were accepted for release by March 2010 as commercial varieties by the National Variety Release Committee. Breeder seed of all released varieties was produced. There were also seed increases for all lines earmarked for on-farm demonstration in 2010. Two drought and tolerant lines nearing release were also demonstrated in Nyankpala during 2009.

Introduction
The Guinea and the Sudan Savanna Zones of Ghana have the climatic conditions suitable for the highest production of maize due to the high incident of solar radiation and the lower incidence of disease and pest. Maize is widely cultivated and forms an important part of the daily nutrition of the people of Northern Ghana. However, farmers have not derived the

full benefit from the cultivation of maize. Their yields have remained low, at 1.5 t/ha as compared to the potential yield of 5.0t/ha. Drought, striga infestation, low soil fertility and limited access to improved varieties continue to be major challenges to high productivity of maize in the Guinea and Sudan Savanna zones of Ghana. Under the AGRA maize breeding program initiated in 2008 to address these challenges, progress has been made in identifying suitable parents for hybrid seed program as well as open-pollinated genotypes with considerable tolerance to drought. Some of these have been demonstrated on a limited scale to farmers and will be scaled up appreciably in 2010 to cover the whole of northern Ghana. Field days have been identified as an effective way to introduce such technologies to a wider swathe of farmers and will be a major strategy for dissemination in 2010.

Main objective
The main objective is to develop maize varieties of appropriate maturity that are tolerant/resistant to stresses (drought, Striga infestation and low soil fertility) for cultivation in the Guinea and Sudan savanna zones of Ghana.

Specific objectives:

- Continuous evaluation of germplasm from IITA and CMMYT in on-station nurseries to identify suitable parents for a hybrid program.
- Testing of elite lines and genotypes in multi-locations to determine adaptations to various ecologies.
- Conduct on-farm tests with promising lines.

Materials and Methods
The plant materials used comprised hybrids and Open Pollinated Varieties (OPVs) of maize, developed for grain yield and adaptation to abiotic (mainly drought) and biotic (*Striga* infestation) stress factors. Germplasm was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan and local sources. These were grouped as extra early, early, intermediate-to-late, single crosses, three way crosses and top crosses. They were planted at different geographical locations in Ghana, using Randomized Complete Block Design and lattice design with four replications per location. The locations were Nyankpala, Manga, Yendi and Damongo.

Entries were made in 4-row plots of 5 m each and planted at inter-row spacing of 75 cm and within row spacing of 50 cm to ensure a plant population of about 53,333 per hectare for late maturing genotypes. Three seeds were initially planted on a hill but were later thinned to two at 3 weeks after planting (WAP).

Pre-emergence chemical weed control was practised and comprised of an application of a combination of Pendimethalin [N - (1-ethylpropyl) - 3, 4 - dimethyl-2,6-dinitrobenzenamine] and Gesaprim [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] at 1.5 *l* ha^{-1} and 1.0 *l* ha^{-1} a.i., respectively at planting. Where there was heavy weed growth prior to planting, Paraquat (1,1'-dimethyl - 4, 4' - bipyridinium ion) was also applied at 1.0 l ha^{-1} a.i.

NPK (15-15-15) fertilizer was applied at the rate of 30 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} as basal fertilizer and top-dressed with additional N at 30 kg N ha^{-1} at 1-2 weeks and at four weeks after planting respectively.

Data was collected from the inner two rows of each plot. The data included plant stand (PLST), plant height (PHT). Days to 50% pollen shed (PS) and silking (SK), Maize 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.

Data collected were subjected to analyses using Genstat Statistical Package. Initial analysis was done for individual locations, and then combined analysis across the 4 locations to estimate the significance and magnitude of genotype by location interaction effects. Genotypes were assumed fixed while locations considered random effects.

4. RESULTS AND DISCUSSIONS

Evaluation of genotypes for tolerance to *Striga hermonthica*

S. hermonthica constitutes a major limitation to increased maize production and productivity in the Guinea and Sudan of Ghana. The levels of infestation are often so high that maize can suffer up to 100% losses and farmers may be forced to abandon their fields, reducing the available lands for cropping.

The performance of 18 open pollinated varieties and 16 hybrids, which were resistant and susceptible to *S. hermonthica* were evaluated in two field trials conducted under infested (inf.) and non-infested (noninf.**)** conditions at Nyankpala. Lattice design with four replications was used. The infestation method developed by IITA maize program was used that ensures uniform infestation with no escapes (Kim 1991; Kim and Winslow 1991). Artificial infestation was done using *S. hermonthica* seeds collected from maize and sorghum fields and stored for 7 months. Apart from seed infestation, all management practices for infested and non- infested plots were the same.

Observations were made on the infested plots for the number of emerged plants, the stress rating of the plants, grain produced and several other agronomic traits.

Resistant open pollinated variety trial

The results (Table 1) showed significant differences among varieties for grain yield and most traits under infested and non-infested conditions. However, there were no significant differences among varieties for days to silking, number of plants harvested and plant counts.

Table 1. Mean number of ears harvested, grain yield (t/ha) and damage scores under infested and non- infested conditions.

ENTRY	EHARV INF	EHARV NONINF	GYLD INF	GYLD NONINF	STR_RAT2 10 WEEKS
M0909-1	27.51	28.38	2620.00	2898.00	1.458
M0909-2	20.00	23.90	2459. 00	2015.00	1.347
M0909-3	17.57	21.56	1358. 00	2107.00	1.917
M0909-4	19.32	19.00	2591. 00	2034. 00	1.389
M0909-5	25.49	27.87	2546. 00	2669.00	1.153
M0909-6	26.86	25.07	2542. 00	3105. 00	2.375
M0909-7	25.07	25.43	2141. 00	2274. 00	1.736
M0909-8	24.92	28.15	2149. 00	2769. 00	2.014
M0909-9	22.88	26.92	2122. 00	2659. 00	2.667
M0909-10	27.43	29.07	3007. 00	3062. 00	1.792
M0909-11	23.01	26.72	1889. 00	2692. 00	1.750
M0909-12	24.44	32.76	2241. 00	3431. 00	1.792
M0909-13	26.40	29.65	2917. 00	3296. 00	2.097
M0909-14	18.74	21.06	2315. 00	2584. 00	1.806
M0909-15	19.10	27.85	1801. 00	2370. 00	5.764
M0909-16	15.36	21.29	1237. 00	1424. 00	6.597
M0909-17	26.99	27.75	3064. 00	3004. 00	1.222
M0909-18	13.67	20.57	1681. 00	2232. 00	2.875
Lsd (5%)	8.189	8.138	1681. 00	1084.0	1.2716
s.e.d	4.060	4.035	488.2	537.5	0.6306
CV (%)	23.1	20.1	27.6	26.5	34.8

M0909-17 and M0909-10 ranked high in terms of grain yield under both infested and non-infested conditions as well as damaged score under infestation. M0909-17 had the highest grain yield (3.064t/ha) under infestation with very low damage score. M0909-12 had the highest grain yield under free condition. These varieties also had reduced barrenness as they were among the varieties with highest number of ears harvested under infested and non- infested conditions.

M0909-5 had the lowest damage score (1.15); this also resulted in high grain yield since it was among the highest yielding varieties. The highest damage score (6.6) and lowest grain yield (0.124t/ha) were observed in M0909-16. The following genotypes were selected based on their performance: M0909-10, M0909-12, M0909-17, M0909-13 and M0909-6.

Resistant hybrid variety trial

Significant differences were observed among varieties for grain yield and most traits under infested and non-infested conditions (Table 2). However, there were no significant differences among varieties for days to silking, number of plants harvested and counts. The highest yield under infestation was recorded from 0502-5STR (1.511 t/ha). This hybrid out-yielded the local check by 70.7% under infestation and the 41.7% under non-infestation.

Table 2: Yield performance of maize lines under Striga infested and non-infested plots evaluated in Nyankpala, 2009.

Entry	EHARV INF	EHARV NONINF	GYLD NONINF	GYLD INF	STR_RAT2 10 WEEKS
0501 - 1STR	12.91	17.61	1.644	1.190	1.625
0501 - 2STR	17.07	14.49	1.566	1.382	1.750
0501 - 6STR	17.12	13.49	1.324	1.334	1.438
0502 - 5STR	13.99	14.28	1.415	1.511	1.250
0601 - 6STR	17.51	17.72	1.562	1.510	1.750
0602 - 1STR	12.68	16.07	1.688	1.098	1.000
0702 - 1STR	12.27	16.16	1.315	1.042	1.938
0702 - 2STR	12.71	14.70	1.416	0.992	1.437
0804 - 2	12.23	17.59	1.350	1.283	0.812
0804 - 3	16.82	15.68	1.399	1.357	1.750
0804 - 6	10.04	11.30	1.198	1.021	1.562
0804 - 7	12.59	16.14	1.431	1.213	1.375
8338 - 1	5.93	7.26	0.817	0.510	6.500
9022 - 13	11.21	9.89	1.075	1.065	1.438
Check	3.04	5.86	0.825	0.442	5.562
oba Super 1	6.12	5.76	0.969	0.668	2.812
l.s.d (5%)	5.513	6.216	0.6869	0.6471	1.0185
s.e.d	2.730	3.078	0.3401	0.3204	0.5043

CV (%)	29.4	30.1	33.9	38.1	31.1

Line 0602-1str performed well under both conditions and gave the highest grain yield (1.688t/ha) under non-infested condition. It also recorded the least damage score (1.00). Line Oba super 1 had a very low damage score but performed poorly in terms of grain yield as compared to other genotypes with exception to the local check and 8338-1STR. It was among the genotypes with the lowest grain yield under both infested and non-infested conditions. Line 8338-1STR was severely damaged by Striga infestation and therefore gave the lowest grain yield (0.510t/ha) under infested plots.

From the data the best genotypes were 0502-5STR, 0602-1STR, 0501-1STR, 0501- 2STR, 0602-1STR and 082-7STR. All the selected genotypes have reduced barrenness. Table 2. Mean number of ears harvested, grain yield (t/ha) and damage scores under infested and non- infested conditions.

Station variety trials (SVTs)

Two field trials, SVT1 and SVT2, were carried out at Nyankpala (Table 3). Sixteen genotypes were evaluated in each trial. Genotypes evaluated in SVT1 and SVT2 consisted of extra early and early genotypes, and intermediate and late maturing genotypes respectively. There were significant difference among genotypes evaluated for days to flower, grain yield and number of ears and plants harvested.

Table 3. Mean number of days to flower, grain yield (t/ha), number of ears and plants harvested for genotypes in SVT1.

ENTRY	DAYS TO FLOWER	EARS HARV	GYLD	PLANTS HARV
1	56.25	39	3.086	32.12
2	52.00	18	1.437	16.53
3	55.00	42.75	3.106	30.63
4	52.75	40.75	3.133	28.48
5	52.75	40.25	2.437	32.00
6	53.00	46.50	3.005	34.70
7	55.75	37.50	2.331	30.75
8	54.00	37.50	3.540	29.75
9	53.25	36.25	3.207	28.20
10	53.75	39.75	2.429	31.53
11	54.00	47.00	2.863	35.85
12	55.75	46.25	2.981	33.64
13	56.50	36.00	2.558	32.25
14	55.75	35.75	2.933	24.85

15	55.50	37.25	2.699	28.50
16	57.25	35.00	1.612	33.98
LSD (5%)	3.130	6.147	0.06319	7.667
S.E.D	1.554	3.052	0.3137	3.807
CV (%)	4.0	11.2	16.4	17.8

Genotype 8 in SVT1 had the highest grain yield of 3.54 t/ha. It was also among the genotypes with the highest number of ears harvested (39 ears). Even though genotype 2 flowered earlier with the lowest days to flower (52 days), it had the lowest number of plants and ears harvested, with 16 plants and 18 ears, respectively, and emerged the least yielding genotype in SVT1.

The highest grain yield (4.62 t/ha) in SVT2 was attained by genotype 11. The highest number of ears harvested in SVT2 was from genotype 11 and was also among the genotypes with the highest plants harvested (Table 4). This showed that genotype 11 had very good germination and seedling establishment.

Table 4. Mean number of days to flower, grain yield (t/ha), number of ears and plants harvested for genotypes in SVT2.

ENTRY	DAYS TO FLOWER	EARS HARV	GYLD	PLANTS HARV
1	57.00	39.25	3.999	42.75
2	57.00	32.25	2.609	36.75
3	56.25	37.75	3.587	40.00
4	55.25	38.00	3.973	41.25
5	54.25	31.75	3.453	38.25
6	59.50	30.25	3.175	35.00
7	60.75	23.25	1.780	29.00
8	58.50	37.25	3.536	34.25
9	57.75	39.50	3.928	41.25
10	60.00	34.50	2.885	36.50
11	56.25	40.25	4.617	41.25
12	58.75	39.00	4.035	38.50
13	55.75	37.00	2.805	37.50
14	55.50	39.00	2.982	40.75
15	54.50	37.00	3.248	36.00
16	60.50	35.50	2.051	40.50
LSD (5%)	2.117	6.315	0.9443	5.850
S.E.D	1.051	3.135	0.4688	2.904
CV (%)	2.6	12.4	20.1	10.8

Evaluation of hybrid lines

A hybrid trial was conducted to assess the performance of some selected hybrids in terms of their grain yield potential and adaptation to the Guinea and Sudan Savanna zones for increased maize production. Various types of hybrids: single-, double-, drought tolerant three- way and top- crosses were received from IITA for evaluation.

Thirty entries were planted in RCBD with three replications at Damongo, Manga, Nyankpala and Yendi for evaluation. Results of the combined ANOVA across the four locations showed significant differences among the genotypes, genotype x environment interaction effects for grain yield, number of ears and plants harvested and days to silking at both 0.05 and 0.01 probability levels. Similarly, there were significant differences among genotypes for these traits at the individual locations.

The performance of M0926-6, M0926-7, M0926-10, M0926-8, 0501-1STR and M0926-1 at the four locations were above average in most of the traits observed. The highest yields were observed in Damongo, with line M0926-6 recording 6.181t/ha. Oba super 1 had the lowest yield at Manga. Cultivar Obatanpa, the local check, performed well at all locations but on the average line M0926-6 out yielded it by 57.3%. For the early maturing hybrids, twenty-four genotypes were evaluated in Nyankpala, Manga, Yendi and Damongo. Combined analysis of the data across locations indicated significant differences among the genotypes, genotype x environment effects for grain yield, number of ears and plants harvested and anthesis-silking interval. There were no significant differences among genotypes for grain yield and anthesis-silking interval at the individual locations.

Grain yield figures at Nyankpala were significantly higher than those in Damongo, Yendi and Manga. The highest and lowest yields were 2.987 and 0.761t/ha, respectively. These were recorded for genotypes 11 and genotype 13, respectively. The local check (Mamaba) performed poorly and emerged the lowest-yielding genotype at almost all locations. Generally, the anthesis–silking interval for the genotypes evaluated at Yendi was quite long, ranging from 1 to 7 days. The lowest anthesis–silking interval (-0.67) was recorded at Nyankpala.

Intermediate/Late maturing drought tolerant variety trial

Sixteen genotypes were evaluated in Damongo, Yendi and Nyankpala. There were significant differences among the genotypes, among the locations and genotype by environment interaction effects for grain yield, ears harvested and days to anthesis. Grain yields were very high at Damongo. Those at Nyankpala were also better than those at Yendi. Genotype M0925-14 was very stable in its performance in terms of grain yield. It emerged the most yielding genotype at all locations with 6.036t/ha, 5.225t/ha and 4.252t/ha at Damongo, Nyankpala and Yendi, respectively. The mean number of days to anthesis for Damongo, Nyankpala and Yendi were 1.9, 1.5 and 3.5, respectively. There was negative correlation between anthesis-silking interval and grain yields, explaining in part, the low yields observed in Yendi where the highest anthesis-silking interval was observed. Drought tolerant was highly correlated to anthesis-silking interval, ears harvested, plants harvested and grain yield. The following genotypes were selected M0925-14, M0925-13, M0925- 9, M0925- 2, M0925-3and M0925-6 based on their general performances in grain yield, days to anthesis and number of ears harvested.

Experimental Variety Trial (Yellow endosperm)

Demand for maize as food, animal feed and industrial crop in West and Central Africa is increasing rapidly, fuelled by expanding populations across the sub-region. Yellow maize is specially preferred to white maize for poultry feed and therefore the demand for yellow maize continues to increase.

The performances of 12 genotypes with yellow endosperm were evaluated in Damongo, Nyankpala and Yendi. Genotype x environment interaction effects were significant for grain yield, ears harvested, anthesis-silking interval and plant height at both 0.05 and 0.01 levels of probability. There were also significant differences among the genotypes for these traits at the various locations.

The local check, Golden Jubilee, a popular yellow maize variety, performed poorly at all locations and emerged the least yielding variety at Damongo and Nyankpala. M0902-11 was outstanding in terms of grain yield at all locations, emerging the highest grain yielding genotype at Nyankpala and Yendi, and gave the highest yield (4.641 t/ha) in the trial. The lowest yield (0.354 t/ha) was recorded in Damongo for M0902-12 (Table 5)

Lines M0902-11, M0902-9, M0902-7, M0902-8 and M0902-2 were selected based on their performances in most of the traits measured. These genotypes were among the genotypes with the highest grain yield, ears harvested and least number of days to anthesis.

Table 5. Grain yield (t/ha) of genotypes evaluated in Damongo, Nyankpala and Yendi.

GENOTYPE	DAMONGO	NYANKPALA	YENDI
M0902 - 10	1.705	3.043	2.025

M0902 -1	1.010	2.385	1.115
M0902 -11	1.870	4.641	2.618
M0902 -12	0.354	1.514	0.963
M0902 -2	2.141	4.016	1.560
M0902 -3	2.595	3.383	1.259
M0902 -4	1.681	3.190	0.943
M0902 -5	2.185	3.403	1.707
M0902 -6	1.471	3.456	1.902
M0902 -7	2.107	3.810	1.801
M0902 -8	1.985	3.588	2.725
M0902 -9	2.3630	4.181	2.460
LSD (0.05)	1.109		
CV (%)	34.3		
SED	0.5598		

Experimental Varieties (white endosperms)

Twelve genotypes with white endosperms were evaluated in Damongo, Nyankpala and Yendi. Genotype x environment interaction effects was significant for most traits except anthesis-silking interval. There were no significant differences among the genotypes for grain yield, ears harvested, anthesis-silking interval and number of plants harvested at the individual locations, except those in Nyankpala.

Similar to the yellow endosperms grain yields were significantly higher at Nyankpala. Those at Yendi were better than those in Damongo. The most grain yielding genotype was M0901-10. It gave the highest yield (4.774 t/ha). The lowest yield (1.888t/ha) came from Damongo. The mean grain yield and number of ears harvested per plot for each genotype are presented on Table 11 and 12 in that order. M0901-1, M0901-11, M0901-4, M0901-3 and M0901-8 have been selected based on their performances in most of the traits selected. These genotypes were among the genotypes with the highest grain yield, ears harvested and shorter days to anthesis.

Early Variety Trial

Twenty-four genotypes were planted in two field trials at Damongo and Nyankpala for evaluation. Analysis of variance carried out separately for the two locations indicated significant differences among genotypes for grain yield, number of ears and plants harvested, anthesis-silking interval and plant height at both 0.01 and 0.05 significant levels. Similarly combined analysis across the two locations also showed significant genotype by environmental effects for these traits. The highest yield was recorded from M0903-5 (4.030 t/ha) at Damongo. On the average, this genotype out yielded the local check by 46.3%. Genotype 24 gave the lowest grain yield (0.88t/ha). M0903-5, M0903-3, M0903-10, M0903-15, M0903-20 and

M0903-22 performed remarkably in most of the traits measured. Therefore these genotypes have been selected.

Extra Early Trial

Eighteen genotypes were employed in this trial. After a combined analysis of data from Damongo, Nyankpala and Manga, Significant differences for grain yield, anthesis- silking interval and number of ear harvested were observed. At the individual locations these differences were not significant.

The results showed days to anthesis as an indicator for earliness and also grain yield potential of a genotype. Genotypes evaluated at Nyankpala had shorter days to anthesis as compared to those in Damongo and Manga. 1.7, 4.6 and 4.6 were the mean anthesis- silking interval of genotypes evaluated At Nyankpala, Damongo and Manga respectively. The grain yields from Nyankpala were significantly higher than those from Damongo and Manga. The lowest grain yield was recorded from Manga.

The most grain yielding genotype was TZEE- Y Pop STR C5 with 2.649 t/ha and the least grain yielding genotype was with TZEE - W Pop STR QPM C0 0.875 t/ha (table 14).
The performances of genotype 2004 TZEE- W Pop STR C4, TZEE - W POP STR C4, 2004 TZEE- Y Pop STR C4, 2000 SYN EE - W and TZEE - W Pop STR C5 were consistent at all the three locations in most of the traits measured and for this reason have been selected.

Early Drought Tolerant Trial

Twenty four genotypes were evaluated in Damongo, Nyankpala and Manga. Combined analysis of data across these locations showed Significant differences for genotype by environment effects for grain yield, anthesis-silking interval and number of ears and plants harvested.

The grain yields from Damongo were significantly higher than those from Nyankpala and Manga. The lowest grain yield was recorded from Manga. The most grain yielding genotype was Tillering Early DT with 4.832 t/ha and the least grain yielding genotype was Pool 18 - SR/AK94DMRESRY*2 with 0.841 t/ha. At all the three locations the local check performed better and out yielded Pool 18 - SR/AK94DMRESRY*2 by 39.5 %.

The performances of TZE - W DT STR C4, TZE Comp3 DT C1 F2, TZE COMP3 DT C2 F2, SYN DTE STR - W*2 and TZE - Y DT STR C4 were consistent at all the three locations in most of the traits measured and for this reason have been selected.

CASSAVA IMPROVEMENT

Identification of the physiological and genetic traits of cassava as the most drought tolerant crop under GCP cassava drought project

Kwabena Acheremu, Joseph Adjebeng-Danquah

Executive Summary: Tolerance to drought is a complex trait and efficiency of phenotypic evaluation for drought improvement is considerably affected by the environment (G x E). Measurements were taken at two (2) weeks interval for the growth parameters. Preliminary results of the selected tolerant genotypes were studied based on leaf retention, plant height canopy spread and stem diameter. The genotypes ctsia 48, ctsia 8 and ctsia 110 recorded the highest leaf retention of 160, 142 and 126, respectively. Genotype ctsia 8 recorded the highest values of canopy spread (1.134m), followed by ctsia 110 (1.08m). The highest stem diameter was recorded by 96/409 (1.77cm) and followed by ctsia 48 (1.69cm). However, the highest yield was recorded by the genotype 96/409 (12.50 t/ha), followed by ctsia 45 with an average root yield of 12.08 t/ha, but the lowest root yield was recorded by ctsia 76 (1.58 t/ha).

Introduction:

The Northern Region is noted for its inherent long dry spell and great variability in the distribution and amount of precipitation spread over six months. Reduction in root tuber yield as a result of drought has been estimated to be around 30-60% and even 100% when the crop fails completely.

Tolerance to drought is a complex trait and efficiency of phenotypic evaluation for drought improvement is considerably affected by the environment (G x E). In response to mild drought, cassava reduces transpiration substantially by closing its stomata, as do other species that act to retain water during drought episodes (El Sharkawy *et al.,* 1984; Tardieu and Simonneau, 1998; Alves and Setter, 2000). When water is available, cassava maintains a high stomata conductance and can keep internal CO_2 concentration high; but when water becomes limiting, it closes its stomata in response to even small decreases in soil water potential. In addition, leaf area growth is decreased in response to water stress and is rapidly reversed following the release from stress. Although the combined effects of reducing leaf surface area and stomata closure can improve crop water use efficiency, it also leads to reduction in potential photosynthesis and in turn, total biomass and root yield. Leaf longevity is one of the main traits associated with high yields in cassava (El-Sharkawy *et al.* 1992).

This work aims to find the best biological traits for improving drought tolerance and to identify traits that are associated with drought tolerance for the development of a more cost-effective breeding process for drought tolerance that can be used in cassava breeding programmes. Efforts will be made to establish the relationship between drought tolerance and pests and diseases incidence.

Materials and methods

Eighteen cassava genotypes were arranged in a randomized complete block design with three replications. Data collected were:

- Growth rate (measured as change in plant height) under both drought and wet conditions
- Plant architecture
- Rate of leaf production
- Leaf retention/abscission
- Fresh root yield
- Root dry matter yield
- Harvest index

Results and Discussion

Preliminary results of the selected tolerant genotypes were studied based on leaf retention, plant height, canopy spread and stem diameter. Measurements were taken at two weeks interval for the growth parameters starting from the on-set of the dry season. The genotypes ctsia 48 recorded the highest leaf retention with an average leaf number of 160, followed by ctsia 8 with an average number of 142 leaf retention. The genotype ctsia 8 recorded the highest canopy spread with values of 1.134m, followed by ctsia 110 with a value of 1.08m. The highest stem diameter was recorded by 96/409 (1.77cm) and followed closely by ctsia 48 (1.69cm). However, the highest root yield was recorded by the genotype 96/409 (12.50 t/ha), followed by ctsia 45 with an average root yield of 12.08 t/ha (Table 6), but the lowest root yield was recorded by ctsia 76 (1.58 t/ha). The number of leaves produced by ctsia 8 was translated into the widest canopy, therefore higher exposure of leaves to light interception for photosynthesis. However, this performance did not result in higher final root yield of the genotype. On the contrary, both 96/409 and ctsia 45 recorded poor values in terms of the phenotypic characters. These however, did not affect the final yield (Figure 1 to Figure 5).

This experiment will be carried out for a couple of years to monitor the performance of these genotypes in this environment to select the best traits for drought tolerance.

Table 6. Root yield and yield components of different drought tolerant genotypes

Treatment	Plt. stand	Tuber no.	Top wt. (kg)	Tuber yield (t/ha.)	Mean tub. Wt. (g)
ctsia 48	3.0	18.00	3.00	**11.25**	290
ctsia 110	3.67	14.67	3.17	8.75	241
ctsia 72	3.33	13.00	1.5	2.17	165
ctsia 112	3.67	22.00	2.67	**11.25**	210
ctsia 230	3.67	13.33	2.50	7.50	236
ctsia 76	3.67	15.33	2.83	6.25	158
ctsia 162	3.33	14.00	1.17	7.08	223
ctsia 8	4.0	18.33	3.17	**10.00**	217
96/409	2.67	11.33	3.17	**12.50**	434
ctsia 90	3.67	16.00	3.00	**9.17**	216
ctsia 1	3.00	12.33	2.00	5.42	179
191/02324	4.00	9.67	3.00	7.92	305
ctsia 131	3.33	10.00	2.67	7.08	343
ctsia 65	3.33	11.33	1.83	4.17	186
ctsia 45	4.00	23.00	2.67	**12.08**	206
191934	3.67	13.00	1.83	**9.58**	295
ctsia 133	4.00	11.67	1.67	5.83	217
Biabasse	4.00	13.33	1.83	**10.00**	289
l.SD	1.304	9.591	1.501	4.907	174.3
CV%	22.1	40.0	37.3	35.2	42.9

Figure 1**. Rate of canopy spread of different drought tolerant genotypes during growth**

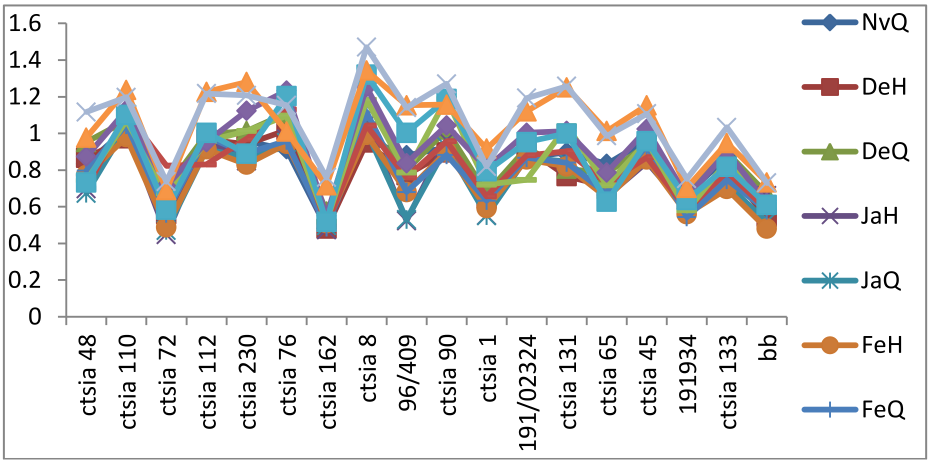


Figure 2**. Average plant height of different drought tolerant genotypes**

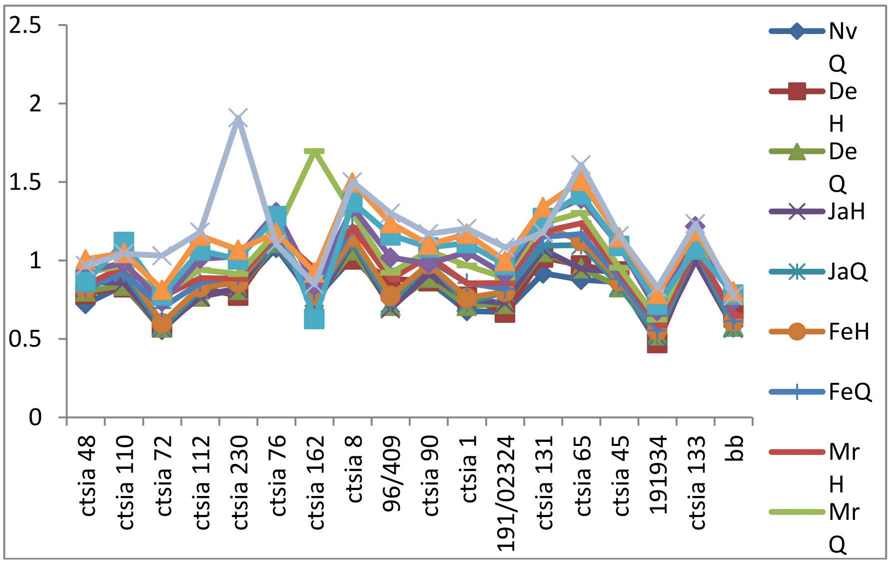


Figure 3.**Number of retained leaves recorded during growth period for the genotypes**

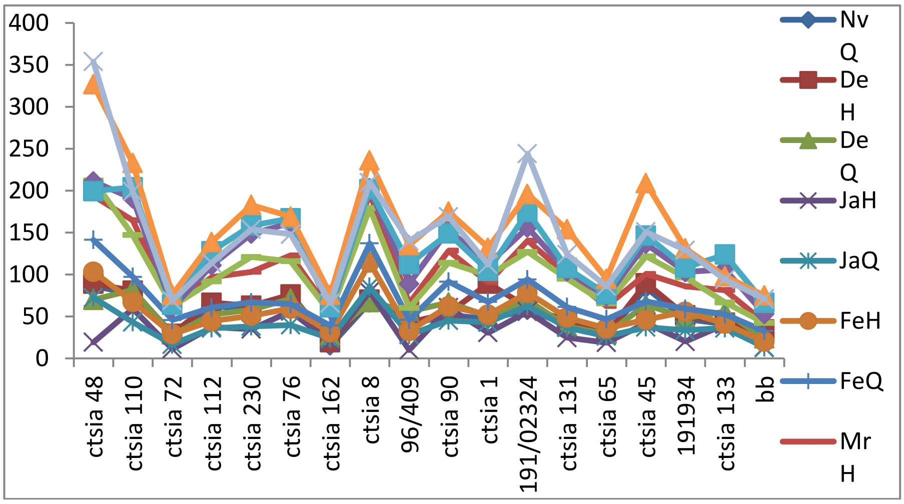


Figure 4. **Average number of leaf scars after abscissions of the different genotypes**

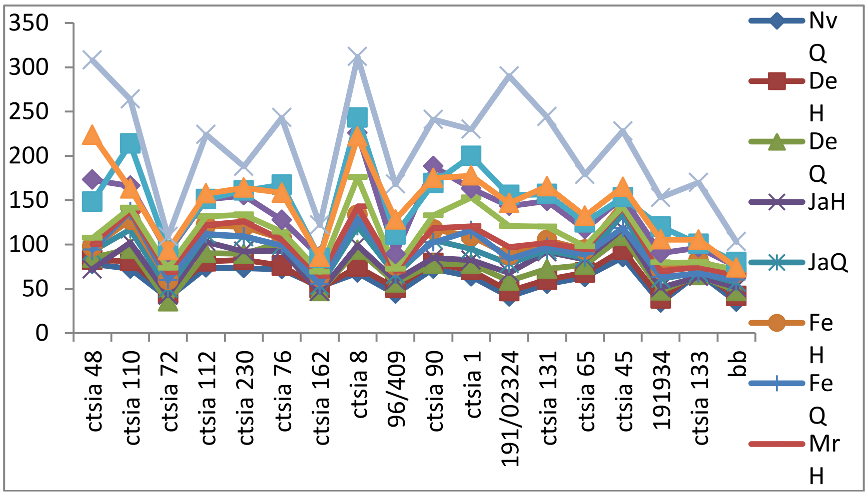
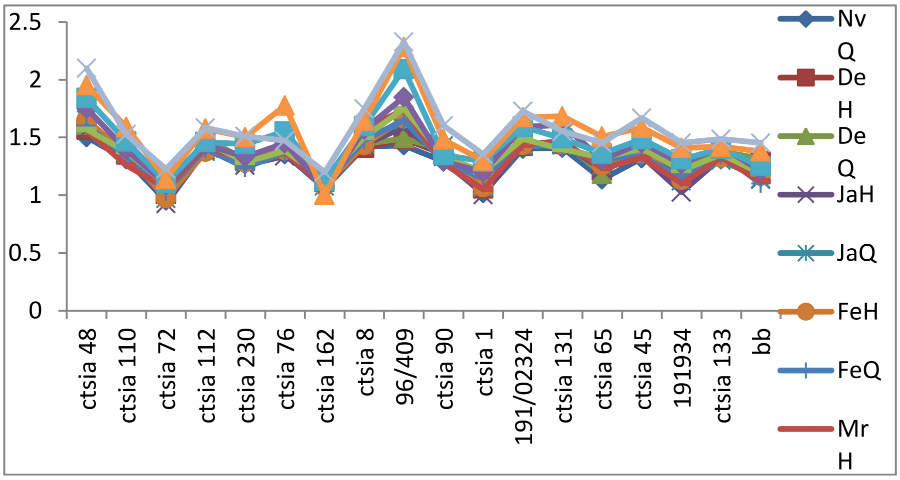


Figure 5. **Rate of increase in stem diameter of different drought tolerant genotypes**



Conclusion

The genotypes 96/409 and ctsia 45 recorded the highest final root yield, although they recorded low values for phenotypic parameters. The genotypes ctsia's 48 and 8 produced highest number of leaves but comparatively low root yield, trailing behind the former two genotypes and higher than the rest of the genotypes.

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AGRONOMY PROGRAMME

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

N. N. Denwar, J. M. Kombiok & S. S. J. Buah

Executive Summary

The objective of this work is to demonstrate various *Striga* control management options to participating farmers in the Northern and Upper West Regions of Ghana for possible adoption to manage *Striga hermonthica* infestation on their cereal fields.

A reconnaissance survey was carried out in four districts, two each in the Northern and Upper West Regions. Mamprusi West and Yendi Districts were surveyed in the Northern Region while Jirapa and Lawra Districts were covered in the Upper West Region. Two communities were covered in each district in UWR: Tabier and Tolibri in the Lawra and Kucheni and Saabalong in the Jirapa. In the Northern Region, Gbimsi in the West Mamprusi and Zang in the Yendi district were selected. The survey revealed that *Striga* infestation was the number one problem facing farmers in both districts of Northern Region, followed by poor soil fertility and inability to afford inputs. An overwhelming majority indicated the *Striga* menace was most devastating on maize, sorghum and millet fields, reducing their yields by over 80%. Farmers expressed eagerness to participate in interventions likely to reduce the negative effects of *Striga* on their crops. The ranking of *Striga* as an agricultural and livelihood challenge was of major concern for both regions. The participating farmers were willing to participate in the on-farm demonstrations planned for 2010.

Introduction

Background and Justification: The menace of *S. hermonthica* infestation in cereal crop fields is a growing phenomenon in peasant agriculture in the three regions of northern Ghana where it is reported (Bolfrey *et al*., 1990) that 83% of cereal fields are infested with *S. hermonthica* with losses in grain yield reaching 78-100% under severe infestation. The situation is not likely to improve significantly in the near future if deliberate and urgent steps are not taken because not only is the parasite spreading to other locations hitherto not seriously infested but also the severity of infestation in endemic areas is likely to increase due in part to ignorance of the biology of the parasite on the part of most farmers. In the 1980s it was estimated that 2.1 million hectares of cereals in Africa were infested with *Striga* with an annual grain production loss of 40% (M'boob, 1986). In monetary terms cereal crop losses due to *Striga* infestation in Africa in the recent past have been estimated to be around $7.0 billion annually (Kim et al., 2004).

Surveys conducted in Ghana (Sprich & Schellinger, 1992; Vogt, 1993) revealed increase prevalence from 12% to 27% within a short period of time.

Even though the most effective control techniques for *Striga* involve the use of chemicals (Eplee, 1981), for most peasant farmers the most appropriate method would be one that uses simple and inexpensive techniques, including host plant resistance, that are adapted to their farming systems. In the absence of resistant cereal crop varieties at the moment one simple yet effective promising control method is the use of non-host or trap-crops in isolation, rotation or intercrop with tolerant cereal crops. Soybean has been identified as one such effective trap-crop against *Striga hermonthica* (Kroschel and Sauerborn, 1988). Variations in the ability to stimulate suicidal germination in *Striga* exist among soybean genotypes. Denwar and Ofori (2003) have indeed identified efficacious soybean varieties (in particular TGX 1834-5E) that can be deployed in the management of the parasite. Abdulai *et al*. (2006) demonstrated the benefits of using soybean and *Striga* tolerant maize varieties. They reported fewer emerged *Striga* plants on plots planted to the tolerant maize varieties with grain yield up to 70% over the farmer's maize varieties under sole cropping. Under intercrop between the soybean and the tolerant maize varieties the results indicated a 17.6% reduction in the number of emerged *Striga* plants. When the tolerant maize and the soybean were grown in rotation for three years there was a drastic reduction in *Striga* emergence. *Striga* count was 87.0% less on the rotation plots compared to plots in the maize after maize rotation using the farmer's variety. Other cultural methods of managing *Striga* have been documented, including application of nitrogen-based fertilizers and manures, fallowing, hand-pulling of emerged Striga plants, biological control, etc. Thus there are several appropriate methods that *S. hermonthica* can be effectively managed. However, the literature suggests that the use of tolerant cereal crop varieties in conjunction with efficacious trap-crop varieties is effectively cheaper and well adapted to the farming systems in northern Ghana. In this proposal we adopt the use of tolerant maize varieties in rotation and in intercrop with efficacious soybean varieties as trap-crop as one effective and sustainable method of managing *S. hermonthica* in northern Ghana for now. Possibilities may arise to use sorghum tolerant varieties.

Objective: The objective of this work is to demonstrate various *Striga* control management options to participating farmers in the Upper East and Upper West Regions of Ghana for possible adoption to manage *Striga hermonthica* on their cereal fields.

Materials and Methodology

Two main approaches are suggested to address the problem:

Reconnaissance Surveys: Even though the problem of *Striga* infestation is widespread in northern Ghana accurate data on districts where the parasite is endemic, the crops that are predominant in these areas, as well as the various copping strategies and indigenous knowledge of *Striga* management has not been updated for a long time. There is therefore the need to conduct reconnaissance surveys in all districts in both regions to determine:

- Endemic areas where immediate intervention is needed
- Copping strategies and indigenous knowledge in endemic areas
- Perceptions of *Striga* infestation as a problem among farmers
- Interventions most likely to be adopted by farmers
- Crops most severely affected by *Striga* for which intervention is needed
- Farmers' knowledge of *Striga* biology.

Reconnaissance surveys were carried out using semi-structured and detailed questionnaire in the districts. The support of agricultural extension agents (AEAs) was enlisted for the surveys. Where training gaps existed, AEAs were trained and they in turn trained farmers.

On-farm Demonstrations: Management options for *Striga* control involving use of *Striga* tolerant maize varieties and efficacious soybean varieties as trap-crop was deployed in rotation and in intercrop to demonstrate the viability of these management options to farmers to enable them take informed decisions on the various options. The design of the demonstrations was as follows:

Plant materials: *Striga*-tolerant maize (STM) variety, efficacious soybean variety (ESV) TGX 1834-5E.

Field plot design:
Rotation (Year 1): 3 plots (20 m x 20 m) each planted to STM, farmer's maize variety (FMV) and intercrop of STM and ESV.

Rotation (Year 2): Rotate STM and ESV but replant FMV on same plot as Year 1.

Intercrop (Year 1): 4 plots (20 m x 20 m); Plot 1: plant STM and ESV as intercrop; Plot 2: plant FMV and ESV as intercrop, Plot 3: plant sole FMV; Plot 4: plant sole STM.

Intercrop (Year 2): plant STM to intercrop plots and plot for sole STM but repeat sole FMV.

Data to be collected: *Striga* count for all plots and years, grain yield for maize and soybean, plant height for maize on all plots for both years. Starter fertilizer of 25 kg N/ha would be applied to all maize plots 7-10 days after sowing and top-dressed with an equal amount of sulfate of ammonia 4-5 weeks after sowing. Weeds would be controlled in the normal practice until the *Striga* begins to emerge.

Results and Discussions

A reconnaissance survey was carried out to determine the importance of Striga hermonthica infestation in selected districts in the Northern and Upper West Regions. It was confirmed that *Striga* infestation was indeed the main challenge to cereal production. An analysis of results detailed coping strategies being employed to manage the problem. Discussions were held among farmers, extension officers and researchers and on-farm demonstrations planned for 2010 in selected communities. Seed of *Striga* tolerant maize varieties and efficacious soybean genotypes have been procured and ready for demonstrations during the growing season of 2010. Farmers' field days have also been included in the years' planned activities to further disseminate the technologies to a wider swathe of farmers in each region. The budget has therefore been adjusted to include these activities hitherto not included but very crucial for the success of the project. This is because it will enhance a greater chance of a widespread adoption of the strategies of managing the parasite by farmers. Thus the necessary preparations to ensure the successful implementation of the project in 2010 have been made.

Conclusions/Recommendations: Opportunity exists to conduct a good research work to develop a workable technology for farmers.

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

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

Executive Summary

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

Introduction

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

The need for this project is pressing because fertile virgin lands which are traditionally used for yam cultivation have become almost non-existent. This, coupled with absence of recommended fertilizer rates for yam on impoverished soils of northern Ghana, has led to a drastic decline in the yields of yam. Indeed farmers are reluctant to apply soil amendments especially inorganic fertilizers because they believe these factors have detrimental effects on cooking and storage qualities of harvested tubers (ICRA, 1996). Despite this perception, the critical fertilizer nutrient levels at which the shelf life is reduced has not been researched into. More so, soils of these parts of Ghana are inherently poor in plant nutrients, especially nitrogen and phosphorus. Consequently, the yields of yam have since been dwindling annually on these soils. In this project therefore, the effects of varying levels of NPK fertilizer nutrients on growth, tuber yield, nutritional responses, culinary qualities and shelf-life of yam will be assessed. An innovative aspect of this project is the involvement of farmers in the development and evaluation of the technology which can help speed up its adoption.

Materials and Methods

Planning session

After the first tranche of the project fund was released in October, 2009, a meeting was held in the first week of November in which some members of the Project Team brainstormed on the implementation of the project. After serious and lengthy discussions, certain aspects of the submitted proposal were amended and fine-tuned.

Site and Farmer Selection

Two yam-growing districts each in Northern and Upper West Regions were selected. These were Tolon-Kumbungu District (Cheshegu, Kpachi, Kpalsawgu) and Nanumba North District (Demonayili, Kpagturi, Jakpaful) in the former and Wa Municipality (Kpongu 1, Kpongu 2, Kpongu 3) and Sissala East District (Sorbelle, Silbelle 1, Silbelle 2) in the latter. Three yam farmers were selected in each of the 4 target districts in the two regions. The coordinates of the respective sites were taken (Table 7).

Soil sampling and characterization

These were carried out in all the four target districts with the assistance of staff of Soil Genesis, Survey and Classification Division of CSIR-Soil Research Institute, Kumasi. The soils from the two regions were air-dried and sieved for analysis for their chemical and physical properties.

Seed- yam acquisition

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

Land preparation and planting

After ploughing, mounds were raised at 1 m intervals in plots of 4m x 4m and the seeds of the yam variety *Laribako* was planted giving a total of 16 mounds per plot. Each plot was separated from the other by a 0.5 m alley.

Fertilizer treatments

The following fertilizer (N, P, K) levels constituted the treatments in a factorial design: N (0, 40, 80, 120 kg/ha), P (0, 40, 80 kgP_2O_5/ha) and K (0, 40, 80, 120 kg K_2O/ha). The combinations resulted in a total of 48 treatments per farmer.

Replication: Three farmers per district were the replicates

Results and Discussion

The coordinates of the trial sites are shown in Table 1 below.

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

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

**His site was not finally planted due to shortage of seed yam.

The soils sampled from the Northern Region were characterized and analysed for their physical and chemical properties. Soils from Cheshegu, Kpachi and Kpalsawgu were identified as Kumayili series (Haplic Lixisol), Nyankpala series (Plinthosol) and Wenchi (deep) series (Petric Plinthosol), respectively. According to WRB (World Reference Base) classification, Jakpaful, Demonayili and Kpagturi soils are respectively a Plinthosol, Plinthosol and Petric Plinthosol.

Apart from Kpachi soil, all the soils are sandy loam with their organic matter content ranging from 1.86% to as high as 3.16% with their pH being between 5.9 and 6.4. Total N ranges from as low as 0.08% to a medium level of 0.17%. Available P is either low or very low (2.31-7.65 mg/kg) in the soils except in Kpachi soil (29.34 mg/kg). Except in Cheshegu (73.65 mg/kg) and Kpachi (56.91 mg/kg) soils, available K is low in the soils (26.78-46.87 mg/kg).

Scientific findings

The World Reference Base classifications of Kumayili series, Nyankpala series and Wenchi (deep) series were identified. These are (Haplic Lixisol, Plinthosol and Petric Plinthosol, respectively.

Future activities

After all the proposed data are collected and analyzed, the three most promising treatments identified in year one experiments would selected and tested (researcher-managed & researcher/farmer-managed) in a split-plot design in which the main plot (32 m x 10 m) would be the yam variety Laribako (V1) to which two other varieties (V0 & V2) would be added:

V0 = farmer's local (preferred) variety if different from Laribako.

V1 = Laribako

V2 = *One improved yam variety (CRI Pona, CRI Kukrupa, or Mankrong Pona)

The sub-plot (10 m x 10 m) would be three fertilizer treatment combinations (T1, T2, T3)

Location: (1) On-station (SARI's experimental field at Nyankpala)
(2) Same locations as in year 1 (i.e. farmer's field)

*CRI Pona : Good storability, pest & disease tolerance
CRI Kukrupa: Multiple tubering/tubers
Makrong Pona: Good storability, pest & disease tolerance

References

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SOIL CHEMISTRY AND FERTILITY PROGRAMME

Row configuration for improved soil water availability and increased maize grain yield under rain-fed conditions

Akwasi A. Abunyewa and Emmanuel Owusu

Executive Summary

Maize is considered an important cash and food crop in many small scale farm household in northern Ghana. Maize production depends on the highly variable rainfall pattern in the region. There is therefore high variability in maize production. Improvement in soil water availability for the crop during critical growth stages will reduce the chances of total crop failure. During years of improve soil water status due to increase and well distributed rainfall, skip-row configuration will have low yield compared to conventional planting. Maize grain yield ranged from 1.4 to 2.4 t/ha. The convention planting significantly out-yield skip-row configurations in grain yield. Grain yield from the skip-rows were similar. Harvest index of s2 and s3 were similar but were significantly higher than that of conventional planting.

Introduction

Northern Ghana is in the sub-humid and semi-arid environment with large variations in total monthly and annual rainfall. The highly variable precipitation is received during the months of April through August or September. Extended period of drought and dry spells at critical growth stages are common. Consequently, dryland production of full-season crops such as corn is a risky enterprise, i.e., the range of possible grain yields is large and unpredictable. Uniform spacing allows the plant root the shortest time to exploit soil water between plants. Water within the inter-row is not reached by roots until later and thus its use is distributed over a longer period of time. Thus the wide inter-row space accumulated and store water early in the growing season and use by the crop later as the crop matures and the roots extend to the inter row space. Various row configurations has been suggested for increased soil water storage and efficient soil water use, improved yield stability, and reduced risk with rain-fed grain production in marginal rainfall regions.

This study will help determine production practices that can make corn more productive in the sub-humid zone of northern Ghana, where inadequate precipitation in the growing season can severely reduce crop production. The study will examine the feasibility of incorporating skip-row planting with early maturity legume intercrop into corn production.

Materials and Methodology

The study was carried out at CSIR-SARI research site at Nyankpala. The field design was a split-plot with three replications. Main plot: Maize intercrop with early maturing cowpea or no intercrop. Subplots were completely randomized four (4) row configurations: Conventional planting (S0), Plant one row: skip one row (S1), Plant two rows: skip one row (S2) and Plant two rows: skip two (S3). Inorganic fertilizer was applied at the rate of 60-40-40 NPK $kgha^{-1}$. For the purposes of this report only grain yield and harvest index were reported.

Results and Discussions

Maize grain yield ranged 1.4 to 2.4 t/ha. Relatively high amount of in-season precipitation fairly well distributed during the growing season may have resulted in the high grain yield. The convention planting (S0) had significantly higher grain yield than the skip-row configurations. Grain yield from the skip-rows were similar (Fig. 1). Harvest index of S2 and S3 were similar and significantly higher than that of S0 and S1 (Fig. 2).

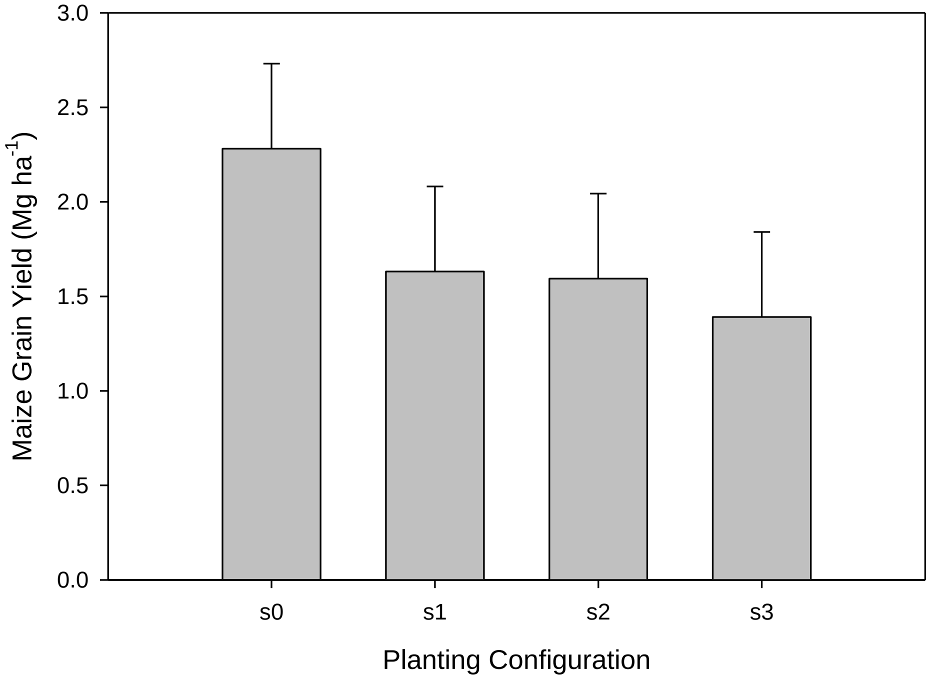

Figure 6. Effect of planting row configuration on maize gran yield

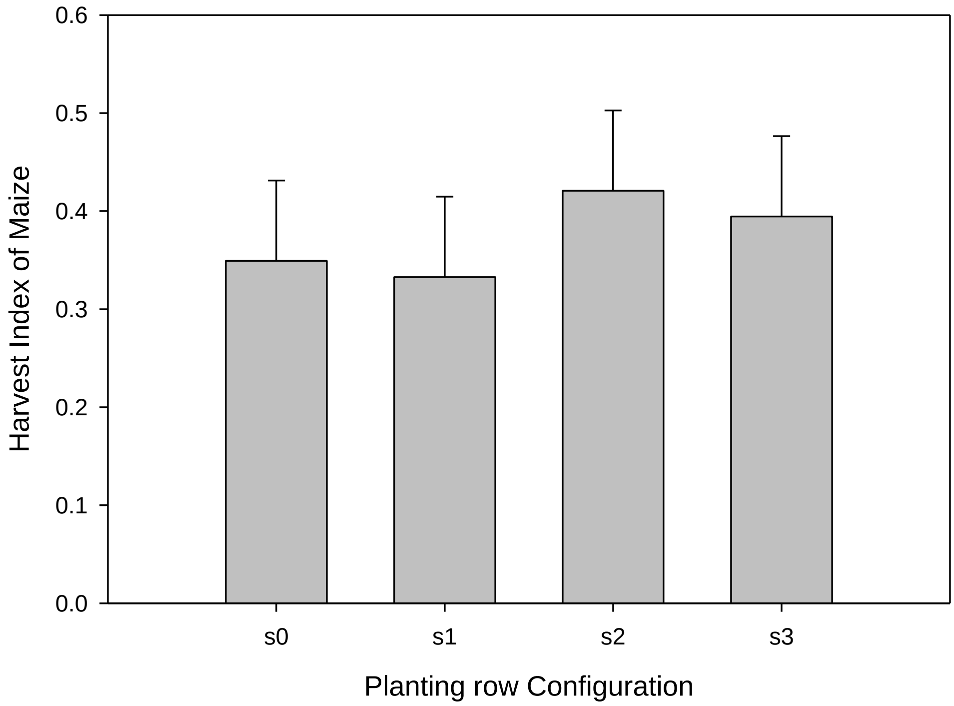

Figure 7. Harvest index of maize as influenced by planting row configuration

Testing the efficacy of different fertilizers types under lowland rainfed rice ecology

Akwasi A. Abunyewa, E. Owusu, and Wilson Dogbe

Executive Summary

There are several fertilizer brands in the open market for rice cultivation. Each of these fertilizer types has its own set of recommendation. A farmer's choice of particular brand of fertilizer may be influenced by several factors including ease of application, availability and price among others. The objectives of this study were to consider the effectiveness of some of the available fertilizers on paddy yield under irrigated and rain-fed lowland condition. Paddy yield ranged from 3 to 5.3 t/ha. With no fertilizer application, the rain-fed ecology produced significantly higher grain than irrigated ecology. Harvest index under irrigated ecology was markedly

higher than under rain-fed lowland condition with each of the fertilizer brands. The head rice recovery ranged from 41% to 59%. The relatively high head rice recovery may be due to the slow drying rate of paddy whilst in storage, thus suffering very little or no cracking grain as a result of low moisture and temperature gradient.

Introduction

Rice is cultivated mainly as cash crop among many small scale household farmers. For profitable rice production, the farmer needs to apply inorganic fertilizer. There are several brands of fertilizers in the Ghanaian market. These brands of inorganic fertilizers have different recommended rate of application for rice. There are yet some fertilizers such as urea super granules (USG) which is not yet in the main stream of fertilizer available to farmers. While many of these fertilizers need top dressings with an inorganic nitrogen source during the reproductive growth stage, USG is applied only once thus reducing labor requirement. The objectives of this study were to compare some of these fertilizer brands: 15-15-15 NPK, Actyva (23-10-5+3S+2MgO+0.3Zn and USG.

The objective of the study was to determine the efficacy of different fertilizer brands applied at the recommended rate on rice grain yield.

Materials and Methodology

There several types of inorganic fertilizer in the market for farmers use. Efficacy and efficiency of applied nutrients are influenced by several factors including availability of a particular nutrient and the proper balance of other nutrients. Four types of fertilizers including the more popular ones like NPK 15-15-15 were compared with newly introduced fertilizers such as urea super granules (USG) and Actyva (23-10-5+3S+2MgO+0.3Zn) and an absolute control where no fertilizer was applied. Each fertilizer was applied as recommended with basal P and K applied at the rate of 60 P_2O_5 kg/ha and 40 K_2O kg/ha to the USG plot. The experimental design was RCBD with 4 replications. The study was sited under two rice ecologies: irrigated condition at Golinga and rain-fed lowland condition at Nyankpala. The rice variety chosen was Gbewaa Rice (Jasmine 85).

The paddy was harvested in November 2009 and stored in sacs till milling in January 2010. Prior to milling the various reps were winnowed and the moisture content taken. After milling the samples were allowed to cool overnight and the weight taken. A sample weighing between 70 g and 90 g was taken from each rep and broken rice manually separated from whole rice. The weights of the two samples were taken and head rice computed.

Results and Discussions

Paddy yield ranged from 3 to 5.3 t/ha. In general, grain yield with each fertilizer brand under irrigated ecology was higher than under rain-fed ecology, though the difference was significant only with Actyva. With no fertilizer application, the rain-fed ecology produced significantly higher grain than irrigated ecology (Fig. 1). Harvest index under irrigated ecology was markedly higher than under rain-fed lowland condition with each of the fertilizer brands (Fig. 2).

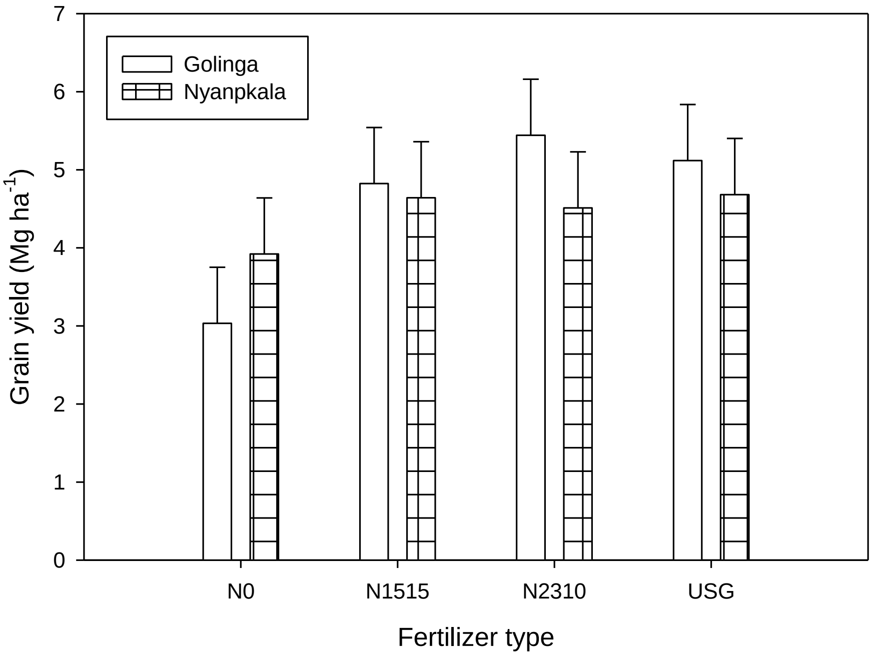

Figure 9. Effect of different fertilizer type on rice grain yield under rainfed and irrigated ecology.

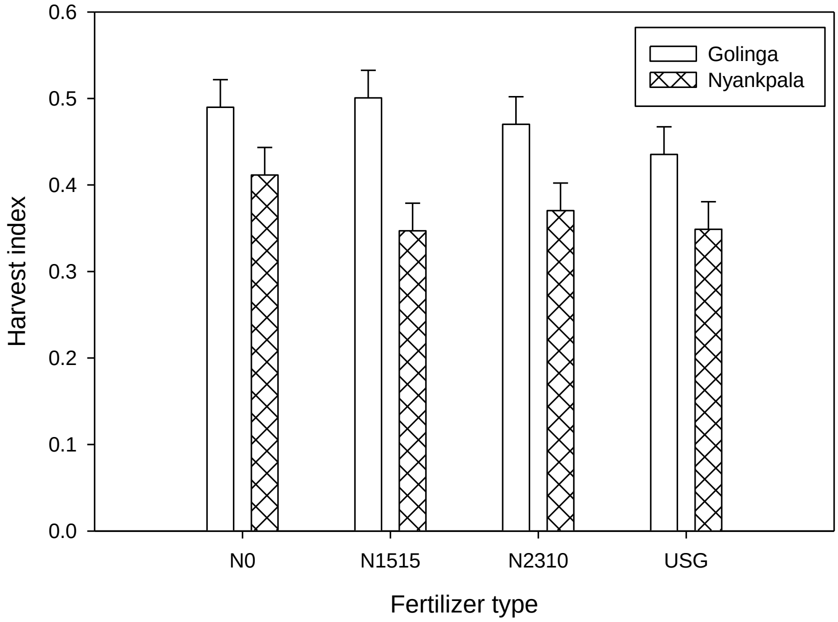

Figure 9. Influence of different fertilizer types on harvest index of rice under rainfed and irrigated ecologies

CROP PROTECTION PROGRAMME

ROOTS AND TUBER CROPS ENTOMOLOGY

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

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

Executive summary

The Farmer Field Fora (FFF) is an on-going project under RTIMP with the objective of bringing researchers, extension agents and farmers together to identify constraints to roots and tuber crops production, conduct experiments to develop technologies to address the constraints and implement or disseminate these technologies together. The FFF ensure that the priorities of farmers, processors, consumers and marketers are ascertained in a systematic manner. So far 20 FFFs have been conducted on cassava, yam and sweet potato in 2008 and 2009. Curriculum was developed for each of the selected Root and Tuber crops to begin Farmer Field Fora (FFF) in ten districts in Zone 1 in 2009. 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, select Fora participants, select site or land for the Fora and develop learning guide. Based on the constraints or challenges identified with the farmers, ten FFF were established in Nkwanta South, Nkwanta North, West Gonja, Nanumba North, Nanumba South, Kassena-Nankana East, Kassena-Nankana West, Kpandai and Saboba (Table 8).

A total of 308 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. Whereas 300 mounds were obtained in the integrated crop management (ICM) plot, the farmers practice plot gave a range of 150-231 mounds from the same land area. Also, percentage sprouting was higher on the ICM plot than the Farmer practice plot. Also, 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 and/or application of fertilizer. 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.

Although more sweet potato tubers were harvested from the Farmer practice (FP) plot, the weight was slightly lower than the fewer tubers harvested from the integrated crop management (ICM) plot. Moreover, the biomass (vine) weight was higher on the ICM plot than that of the FP (Table 8).

Table 8. Thematic areas selected by farmers during the PRA

No.	District	Location of FFF	Crop	Thematic Area
1	Nkwanta South	Bontibor	Cassava	Improved Crop Varieties
2	Nkwanta North	Sibi Hilltop	Yam	Integrated Soil Fertility Management
3	Nanumba North	Taali	Yam	Integrated pests and diseases management
4	Nanumba South	Nyankpani	Yam	Integrated Soil Fertility Management
5	Kpandai	Mbowura	Yam	Integrated pests and diseases management
6	Saboba	Kuonjoni	Yam	Integrated Soil Fertility Management
7	East Gonja	Sissipe	Cassava	Improved Crop Varieties
8	West Gonja	Mempeasem	Cassava	Integrated Soil Fertility Management
9	Kassena-Nankana East	Punyoro	Sweet Potato	Integrated Soil Fertility Management
10	Kassena-Nankana West	Boania	Sweet Potato	Integrated Soil Fertility Management

Background

The Farmer Field Fora (FFF) implementation began in 2007 and is on-going (CSIR-SARI Annual Report 2007). So far 20 FFF have been conducted on cassava, yam and sweet potato in 2008 and 2009. 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 FFF ensure that the priorities of farmers, processors, consumers and marketers are ascertained in a systematic manner. The topics addressed by FFFs were identified by the farmers through Participatory Rural Appraisal (PRA) and were proactively encouraged to take charge of the experiments and trials.

Materials and Methods

Curriculum was developed for each of the selected Root and Tuber crops to begin Farmer Field Fora in ten districts in Zone 1 in 2009. Before the programme started, Participatory Rural Appraisal was conducted to: interact with the farmers; know their farming practices; challenges; select the thematic area for the study, Fora participants, site or land for the Fora and develop learning guide. Based on the constraints or challenges identified with the farmers, ten Farmer Field Fora were established as follows: Nkwanta South (Cassava), Nkwanta North (Yam), West Gonja (Cassava), Nanumba North (Yam), Nanumba South (Yam), Kassena-Nankana East (Sweet potato), Kassena-Nankana West (sweet potato), Kpandae (Yam) and Saboba (Yam) (Table 9). A total of 308 farmers/traders/processors were involved in the training.

Contents of the Farmer Field Fora Learning plots

Crop: Yam

Seed treatment: Seeds for the ICM plot were treated with fungicide (Manzocarb) at the rate of 40g (4 match boxes) in 15 litres of water and Insecticide (Chrolopyrifos + Deltametrin) at 10ml in 15 litres of water

Thematic area*:* Integrated pests and diseases management (IPDM) plots: (i) Fifty ml of 1% solution of Deltametrin (150ml/15litres of water) was applied per mound at 12 weeks after planting.

(ii) Fifty ml of fifteen percent (15%) neem seed extract (1.8kg of seed in 15 litres of water) was applied per mound at 12 and 16 weeks after planting

Thematic area: Integrated Soil Fertility Management (ISFM) plots

Inorganic fertilizer (NPK 15-15-15) was applied at the rate of 60-60-60kg/ha (i.e. 10g/mound was applied) at 12 weeks after planting

Crop: Cassava

Thematic area: Improved Crop Varieties

(i) *Integrated Crop Management (ICM) Plot* at *Bontibor – Nkwanta South District*

Four improved varieties (Tek bankye, Bankye-Hyemaa, Nyeri-Kobga, Fil-Ndiakong) were planted at 1m x 1m apart on flat land in 5 rows x 30 m long per variety

Farmer Practice (FP) plot - Three local varieties (Ankra, Nigeria, Bosome Nsia) were also planted at 1m x1m apart on flat land in 5 rows x 30 m long per variety

Participatory Action Research (PAR) plot - Here two research plots were established (i) Total bury of planting material on flat land against partial bury of stand also on flat land (ii) Planting on the flat land against planting on mound using a local material (Nigeria) and an improved variety (Fil-Ndiakong)

(ii) *Integrated Crop Management (ICM) plot at Sissipe – East Gonja District*
Four improved varieties (Tek bankye, Eskamaye, Fil-Ndiakong, Nyeri-Kobga) each planted in five rows at 1m x 1m spacing on mounds and each row 20m long

Farmer Practice (FP) plot - Three local varieties (Bonsah, Kpontisangi, Biabase) each planted in five rows at 1m x 1m spacing on mounds and each row 20m long

Participatory Action Research (PAR) plot - A local variety was cut and planted the same day against the same variety which was planted 4 days after cutting. Because farmers claim that if you coppice and plant the same day, the roots will taste bitter.

Thematic area: Integrated Soil Fertility Management
Integrated Crop Management (ICM) plot at Mempeasem – West Gonja District
Three improved cassava varieties (Afisiafi, Eskamaye and Tek Bankye) planted in 5 rows of 40m long and fertilized with 80-60-60 kg/ha NPK 15-15-15 at 10g/stand.

Farmer Practice (FP) – A local variety planted in 5 rows of 40m long without fertilizer application.

Participatory Action Research (PAR) Plot - Two plots each 5 rows of 40m long planted with Afisiafi. One applied with manure (inorganic fertilizer) and the other with no manure application.

Crop: Sweet Potato
Integrated Crop Management (ICM) plot at Punyoro and Boania- Kassena-Nankana East and West Districts

The plot was ridged at 1m apart and 6m long, planting was done in one row in the middle of the ridge, there was 30cm between stands/vines, vine length was 30cm. One headpan (12kg) of manure was applied to each bed before planting. Also one teaspoon (6g) of NPK 30-45-60 kg/ha was applied per plant/stand two weeks after planting. The sweet potato variety planted was CRI Otoo

Farmer Practice (FP) - Farmers ridge was about 45cm high, 45cm wide and 6m long. They planted 2 rows on the bed at 15cm apart, vine length was 15cm. One head pan of manure was applied before planting without top dressing.

Participatory Action Research (PAR) Plot - CRI Otoo and Tek-Santum were planted on a bed similar to that of the ICM plot using two vine lengths viz. 15cm and 30cm long

Results

Yam
After the mound preparation, the farmers realized that their practice results in considerably low plant population. Whereas 300 mounds were obtained in the ICM plot, the farmers practice gave a range of 150-231 mounds (Table 9). Also, percentage sprouting was higher on the ICM plot than the Farmer practice plot. The farmers identified the various species of insect and other pests that attack and damage yam in the field and storage and gave names in their local language. They learnt that pests and diseases of yam can reduce the market value of their tubers and also promote fast rotting. 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 and application of fertilizer (Table 9). Also, pest infestation was higher on FP than ICM (Table 10). Therefore, the farmers concluded that the yield from ICM plot would give them more money than their normal practice. Hence, they pledged to adopt ICM practices such as closer mounding, seed treatment, application of fertilizer and farm sanitation during the next cropping season.

Table 9. Number of mounds per unit area and tuber yield of yam in northern region of Ghana

District	Community	Treatment	No. of mounds per 432m^2	Total no. of tubers	Total weight (kg)
Kpandai	Mbowura	**ICM**	**300**	**396**	**581**
		FP	175	256	396

Nanumba South	Nyankpani	**ICM**	**300**	**449**	**454**
		FP	214	292	265
Nanumba North	Taali	**ICM**	**300**	**294**	**200**
		FP	150	176	175
Saboba	Kujoni	**ICM**	**300**	**466**	**523**
		FP	231	336	476

Table 10. Number of yam tubers infested by pests (mealybugs, millipedes, tuber beetles, scale insects, nematodes) at Mbowura, Kpandai District

Treatment	Total number of tubers	Number of tubers infested	% infestation
Farmer Practice plot	256	96	60
Neem seed treated plot	162	42	35
Insecticide treated plot	234	34	17

Sweet potato

Although more tubers were harvested from the Farmer Practice (FP) plot, the weight was slightly lower than the fewer tubers harvested from the integrated crop management (ICM) plot. Moreover, the biomass (vine) weight was higher on the ICM plot (Table 11). Plants on the broad flat bed used for the ICM was found to be easily affected by moisture stress (drought) compared to the narrow raised bed used by the farmers.

Table 11. Yield of sweet potato harvested from FFF plots established at Boania, Kassena-Nankana West District (Area harvested: 6m x 5.5m = 33m^2)

Treatment	Total number of tubers			Weight of tubers (kg)			Weight of vines (kg)
	Marke-table	Non-Marke-table	Total	Marke-table	Non-Marke-table	Total	
ICM plot	366	556	**922**	75.15	29.65	**104.80**	**29.8**
FP plot	486	880	**1366**	64.59	35.52	**100.11**	**21.3**

Cassava

Although the farmers have observed the characteristics of the improved varieties such as vigorous growth, pests and diseases resistance/tolerance etc. they are yet to be harvested to compare the yields to their local varieties.

Biological control of the larger grain borer, *Prostephanus truncatus* 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 started in 2001 and still on-going. *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. From January to December 2009, **72,000** predators were released at **23** locations in **7** districts.

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 in 2001 is still in progress (Annual Reports 2007 and 2008).

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.

Steps for mass rearing of LGB predator (T. nigrescens)

1). Purchase reasonably clean maize grains 2). Deep-freeze for two days a sample of the maize which would half-fill a number of kilner jars available for rearing 3). Oven-dry the sample over night at 55° C 4). After cooling for a day or two, half-fill the kilner jars and place 5). Introduce 5 to 10 LGB adults per kilner jar and observe for 20-30 days and introduce 10-15 predators (adult *T. nigrescens*) into each kilner jar 6). After 6-8 weeks sieve out the predator and remaining LGB adults 7). Pick the *T. nigrescens* and package for release 8). Keep records of the number released as well as the location and date.

Release of the predator

The predator is normally released into the forest/bush since studies in Togo by GTZ have indicated that *T. nigrescens* dispersion is more rapid when released in the field. However, it was observed that the predator is destroyed by bushfire when released into the field between November and April in northern Ghana. Therefore, it was decided to release it into farmers' own infested cassava and maize barns in the later part of 2002. However, it was detected later on that the farmers consume or sell their produce when the predator is released into their barns, thus limiting the ability of the predator to establish. As a result, a decision was made to construct separate barns with the assistance of the farmers in the community and stock them with infested cassava chips and then release the predator there, to facilitate its rapid multiplication and spread.

Questionnaire was developed to conduct baseline survey in the communities before the release of the predator into the infested barns so as to be able to evaluate the results of the intervention.

Explaining to Farmers how the predatory beetle controls the LGB at Taali, Nanumba North District

Results

From August 2001 to December 2009, 343,339 predators have been produced in the laboratory and released in 115 locations in 10 districts in northern, Volta and Brong-Ahafo Regions. The districts are West Gonja, East Gonja, Yendi, Nanumba North, Nanumba South, Zabzugu-Tatale, Tolon-Kumbungu, Central Gonja, Nkwanta North and Kintampo.

However, in 2009, seventy-two thousand (**72,000**) predators were released in **23** locations in **7** districts (Table 12).

Way Forward

Since LGB infestation and damage have been found to be very extensive, very high numbers (> 10,000) of the predator need to be released per community to achieve effective control, which means the current output/capacity of SARI laboratory cannot produce enough for all the LGB infested communities in northern Ghana. Therefore, there is the need to train all AEAs and some literate farmers in these regions on the techniques of laboratory mass rearing, releases, assessment for establishment of the predator to assist in the mass production of the predator since large numbers are needed to achieve the desire impact.

Table 12. Number of Terestrus nigrescence (Tn) released for the control of LGB in northern Ghana in 2009

District	Date	Location/Village	No. Released
East Gonja	29-05-09	Changblungu	4,000
		Gbung	6,000
		Kpalibisi	4,000
		Gidan Turi	4,000
		Bujai	2,000
		Masaka	2,000
		Nakpaayili	2,000
Yendi	22-08-09	Lanja	2,000
		Sambu	2,000
		Jimuli	2,000
		Choo	4,000
Nanumba North	22-08-09	Taali	2,000
Nanumba South	31-09-09	Nakpaayili	4,000
Nkwanta North	31-09-09	Moba	4,000
		Danaaya	4,000
		Damanko	4,000
Central Gonja	28-10-09	Nyangwurupe	4,000
		Fufulso	2,000
		Dagomba Line	2,000
		Kabilpe	2,000
Kintampo North	28-10-09	Lingbingkura	2,000
		Kuguragaguni	4,000
		Alhassan Kura	4,000
Total		**23**	**72,000**

Awareness needs to be created in all communities where the predator has been released through FFF and the opportunity used to advise them on the appropriate methods of storing the produce to avoid attack and damage by the larger grain borer

A study needs to be conducted to assess the impact of the predator in some communities in Yendi, West and East Gonja Districts where the predator was released between 2001 and 2004. There is also the need to construct more storage barns in LGB endemic communities to facilitate in-situ multiplication of the predator.

Evaluation of F_4 interspecific groundnut lines for resistance to early and late leaf spot diseases in Ghana

Denwar NN, MD Burow, JL Ayers, CE Simpson and P Sankara

Introduction

A crossing program was initiated in 2005 to introgress early and late leaf spot resistance genes from adapted United States groundnut cultivars and breeding lines into some genotypes from Africa and Latin America. Crosses were made in the Texas Tech University greenhouse in the spring of 2005 and 2006. The F_1 seeds were planted in the field at Texas Tech University during the summer of 2006. F_2 seeds were planted in plastic trays according to cross identity at the Texas Agricultural Experiment Station (TAES), Lubbock in spring 2007. In West Africa the level of leaf spot infection can be as high as 70% (Waliyar, 1991; Waliyar *et al*., 2000). But the use of fungicides is not economically viable for peasant farmers in Ghana and in most parts of W. Africa, where poverty is prevalent even though research in Ghana (Naab *et al*., 2004) confirmed that foliar application of fungicides can increase biomass and kernel yields in rainfed groundnuts by 39% and 75%, respectively. However, the most practical control method for these farmers would be the use of host plant resistance.

Materials and Methodology

The interspecific hybrids used as parents were a subset of lines selected based on rust, early and late leaf spot disease scores from field evaluations conducted in Yoakum, Texas from 2002-2005, Burkina Faso (2004-2005) and Ghana (2003); the latter two in West Africa. Overall plant appearance, kernel yield, percent pod maturity and stability of performance across these diverse environments were also considered in their choice.

Crosses were made in the Texas Tech University greenhouse in the spring of 2005 and 2006. The F_1 seeds were planted in the field at Texas Tech University during the summer of 2006. F_2 seeds were planted in plastic trays according to cross identity at the Texas Agricultural Experiment Station (TAES), Lubbock in spring 2007.

F_3 populations were then planted in row plots in the field in Yoakum, Lavaca County, Texas during the summer of 2007. Test rows were sandwiched between spreader rows of susceptible cultivar Florunner to provide an even and abundant source of inoculum. Scores for early and late leaf spot diseases were obtained by visual observation using the Florida scale.

A subset of the F4 population was evaluated in Ghana in 2009 to determine their resistance/tolerance to early and late leaf spot diseases. The data were subjected to analysis of variance (ANOVA) using SYSTAT 7.0 GLM procedure and the means separated by Fisher's protected LSD test.

Results and Discussions

There were no significant differences among the entries for both diseases, nor for yield. One possible explanation for this trend is the late planting coupled with heavy rains during the growing period. Due to a delay in the arrival of the seeds from the United States planting was finally done in late July, two months after the usual planting time for groundnuts in the area. Initial and continuous heavy rains adversely affected plant growth. This is reflected in the low pod yields. For 2010 the harvested seed will be multiplied for full trials in 2011. However, some hybrids have scores as low as the tolerant check NkatieSARI and Kpaniele. This indicates that some level of resistance had been introgressed into the susceptible lines. Entry 17 for example had similar scores as Katie SARI while entry 6 was even better.

Conclusions/Recommendations: Considerable opportunity exists for the development of resistant/tolerant lines that will significantly reduce yield losses due to leaf spot diseases.

Future activities/The way forward: Full trials to be conducted for further evaluation and probable further crossing with recurrent parents.

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NORTHERN REGION FARMING SYSTEMS RESEARCH GROUP

Introduction

The Northern Region Farming Systems Research Group (NR-FSRG) is located 16 km West of Tamale at Nyankpala in the Tolon/Kumbungu District. The team has a membership of five research scientists, two Agronomists, two Entomologists and one Agricultural Economist. The group is tasked with analyzing the farming systems of the 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.

AGRICULTURAL ECONOMICS

Introduction

The economic section provides backstop support for technology development processes. Activities for the year 2009 included assessments of the economic viability of proposed technologies and assessments of the potential and actual adoption and impact of technologies developed by the institute. Both qualitative and quantitative analytic procedures are employed for the economic assessments. Focus group discussions, key informant interviews, desk top reviews and formal household and/or producer surveys were useful sources of information and data for the studies. This report features major findings from 2 of such research studies conducted during the 2009 season.

Characterization of Maize Producing Households in Karaga and Tolon/Kumbungu Districts of Northern Region of Ghana

A. N. Wiredu, J. M. Kombiok, R. A. L. Kanton, S. S. J. Buah, H. Asumadu, M. K. Ewool and Abdoulaye Tahirou

Executive Summary

Principal component estimates revealed two wealth categories. Over 80 percent of the sampled households were shown to be in the less endowed category. Regardless of their wealth status, the sampled farmers were challenged by changing climatic patterns, recurrent pest and disease attacks, high input prices and fluctuating price of agricultural produce. Among the list of crops produced by the households, maize was ranked first as the most important food and cash crop. The high rate of adoption of improved maize technologies further confirms the importance of maize. In fact more than 90 percent of the sampled maize farmers used an improved maize variety. In subsequent analysis, household, age of the household head, amount of credit received, cost of fertilizer, number of livestock owned, total income and experience in the cultivation of improved maize were identified as significant factors that affects adoption of improved maize varieties. The sampled farmers were however shown to have minimal contacts with extension through field demonstration, field days and other outreach programs. This is an obvious source of concern for the newly improved drought tolerant maize varieties that are yet to be released. The project should therefore consider an approach that will fully involve extension during the promotion of the varieties after release.

Introduction

The purpose of the study was to provide baseline information on the project areas of the Drought Tolerant Maize for Africa (DTMA) Project. It therefore characterizes maize producing households in Karaga and Tolon-Kumbungu of Northern Region of Ghana. It profiled sampled maize producing households and assessed the adoption of existing maize varieties in the project area.

Methodology/Approach

The study was based on a survey of a cross section of 150 maize producing households systematically selected from Karaga and Tolon-Kumbungu Districts in the Northern Region of Ghana. The two districts are geographically located in the Guinea Savanna Agro-ecological zone and where drought is an annual phenomenon (MiDA, 2008). Focus group discussions, key informant interviews, desk reviews and formal household interviews were means of data collection.

Results and Discussions

Very minimal variations existed in the characteristics of the farm households sampled from the two districts. Results from principal component analysis (PCA) estimates of the wealth indices revealed that over 80 percent of the sampled maize producing households were less endowed and therefore poor (Figure 10).

Droughts, floods, low produce prices and high input prices continue to pose threat to the rural farm households who are largely poor and less endowed. In many instances, the less endowed households will have to reduce their crop land area and engage in collective marketing to mitigate the effect on low produce prices. They sell some of their assets in order to purchase some farm inputs in situations where prices of inputs are high. In addition to these coping strategies, the well endowed farm households diversify their crops when produce prices are high and also engage in bulk purchases when they expect high input prices (MiDA, 2008).

Almost all the maize producers cultivate traditional maize varieties in addition to at least 1 improved variety. In fact the current adoption incidence rate of existing improved maize varieties is very high at about 94 percent of the total sample. The most common variety identified with the maize farmers is Okomasa which is relatively old. The next is Obaatanpa, a quality protein maize variety is found with about 39 percent of the farmers (Table 13).

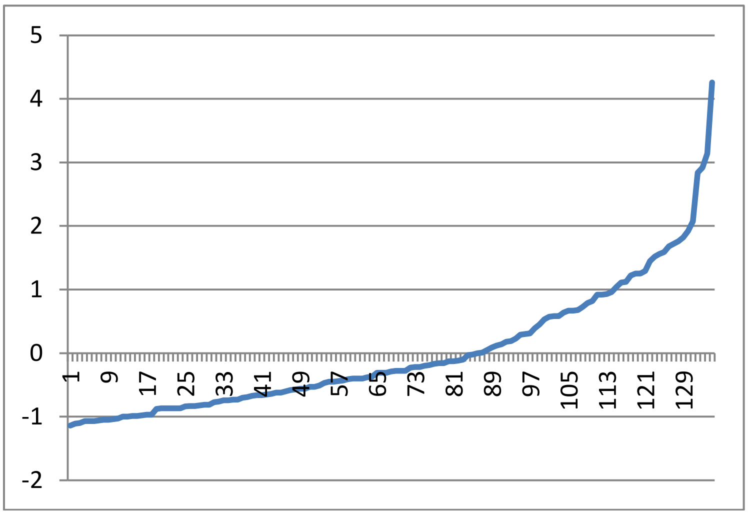

Figure 10: Distribution of Wealth Ranking of Households

Essentially, the household size per unit area, age, amount of credit, cost of fertilizer, number of livestock owned, total income and previous experience with improved maize varieties were identified to have significant effects on the adoption of improved varieties. On the other hand, the geographical location of the farm households and access to extension service do not significantly affect adoption of improved maize varieties (Table 14).

Table 13: Identified Maize Varieties in the Survey Districts

Variety	**Well Endowed**	**Less Endowed**	**Overall**
Improved	91.84	96.51	94.175
Okomasa	65.31	54.65	59.98
Obaatanpa	38.78	40.70	39.74
Popcorn	0	1.16	0.58
Dorke	14.29	8.14	11.215
Dobidi	5.81	2.04	3.925
Laposta	0	2	1
Dodzi	0	2.33	1.165

Source: DTMA household survey data.

Table 14: Factors Affecting Adoption of Okomasa

Variables	**Marginal Effect**	**Std. Err.**
Tolon-Kumbungu	0.0376222	0.15593
Household size per unit area*	0.0384845	0.01846
Age*	-0.066387	0.0317
Age2*	0.0006247	0.0003
Amount of credit*	0.0000175	0.00044
Extension contacts	-0.055691	0.03143
Cost of fertilizer*	-0.002214	0.00118
Tropical livestock unit*	0.0436428	0.0178
Total income*	-0.000193	0.0001
Maize yield in 2006*	0.6941245	0.11253

Source: DTMA household survey data.

The results suggest that high labour-land ratio induces adoption of improved maize varieties. This is true because availability of labour can assure strict adherence to the agronomic practices associated with adoption of improved maize varieties. Younger farmers who are aggressive and willing to take risk are more likely to adopt improved maize varieties. Older farmers on the other hand are risk averse and are reluctant to change. However, beyond a certain threshold of experience farmers tend to be risk loving and are more likely to adopt improved maize varieties as indicated by the model.

Access to credit provides a useful source of finance for effective application of all the component of the technology package. However, high cost of production is a disincentive for investment into improved technologies. More especially in the north where soils are poor, farmers depend heavily on fertilizer. Indeed the cost of fertilizer is a limitation to adequate investment in improved technologies among the less endowed farmers.

The wealth of farmers as represented by the total livestock unit stimulates adoption of improved maize varieties. On the contrary, farmers have high cash income tend to shift from primary agricultural activities to off-farm activities. This confirms the general notion in development paradigm that income propels more secondary activities (Norton, 2005)

The expectation of farmers about the returns or profitability of a technology is shown to influence adoption decisions. Considering the higher performance of improved varieties in previous seasons, farmers would want to continue or adopt new varieties are shown to be promising.

Conclusions/Recommendations

Droughts, floods, low produce prices and high input prices continue to pose threat to the rural farm households in the Northern Region who are largely poor and less endowed. The current adoption rate of existing improved maize varieties is very impressive. Essentially, farmers in Tolon-Kumbungu District are more likely to adopt newly improved maize varieties. The results also suggest that the lesser income category of farmers are more likely to adopt the DT varieties. Therefore in order to record massive impact the poor farmers should also be targeted. The technology development process must also take into account the cost implications in terms of fertilizer and labour requirement to enable the less endowed the opportunity to adopt and use the technologies.

Since the technology development process and dissemination are occurring simultaneously, it is also necessary to progressively track the rate of diffusion and potential impact. Progressive impact assessment can provide the opportunity to capture information that has not been considered in this baseline study.

Future activities/The way forward

The study will be repeated towards the end of the second phase of the DTMA project. Meanwhile data cleaning and in-depth analysis will continued before it is made public.

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Ex-Ante Impact of NERICAs and Complementary Technologies in Ghana

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Executive Summary

This is a baseline study implemented to primarily assess ex-ante the impact of NERICA and other existing improved rice varieties on the project beneficiaries in Ejura-Sekyedumase, Hohoe and Tolon-Kumbungu Districts. Despite the steady improvements in the rice production indicators over the years, rice productivity is still below 1 ton per ha in the study area. The situation is aggravated by the low exposure and uptake of improved rice varieties including Nerica in the study area especially in Ejura-Sekyedumase and Hohoe Districts. There is however the opportunity to improve the level of exposure and adoption if proper targeting of households is done. It has been shown that experience, education and location are important determinant of exposure while age and access to extension are also shown to affect adoption. The results of the study have further indicated a higher potential for adoption by both the exposed and unexposed farmers. The existing adoption gap can therefore be minimized if the promotional activities are improved to include the majority of the rice producer in all the project areas.

Introduction

Until the year 2009, none of the NERICA varieties had been formally released or spread widely through informal sources in Ghana. Besides, there is no evidence of significant diffusion of the NERICA in Ghana. The baseline study was therefore implemented to primarily assess, ex-ante, the impact of NERICA and other existing improved rice varieties on the livelihood of the project beneficiaries. With this an effective monitoring and evaluation (M&E) system for the generation of regularly updated information on adoption and diffusion of the NERICAs and their impacts on farmer livelihoods, poverty reduction and on rice biodiversity in the Africa Rice Initiative (ARI) countries would be established.

Methodology/Approach

The study featured rice producing households in Ejura-Sekyedumase, Hohoe and Tolon-Kumbungu Districts, which are also within the domain of the ARI project. The districts also feature the three main rice ecologies in the country, namely upland, lowland and irrigated ecologies. Following the average treatment effect methodology (Diagne and Demont, 2007), parametric exposure and adoption models were estimated to assess the determinants of adoption. In order to describe the probability of exposure and adoption of improved rice varieties, variables that describe the farmers' characteristics, farm level characteristics and institutional characteristics were used as explanatory variables. Information and data for the study was obtained from focus group discussions, key informant interviews, desk reviews and formal household and farm surveys.

Results and Discussions

The baseline study identified about 4 traditional rice varieties within each district. One NERICA variety was identified in both Ejura-Sekyedumase and Hohoe. Also in Ejura-Sekyedumase an improved NARS rice variety was identified. In Hohoe district another 2 NARS rice varieties were identified. Tolon-Kumbungu District registered the highest number of NARS rice varieties (Table 15).

Table 15: Ecologies of Identified Rice Varieties

	District			
Varieties	**Ejura**	**Hohoe**	**Tolon**	**Overall**
Traditional upland	1	2	0	1
Traditional lowland	2	4	2	3
Nerica upland	1	1	0	1
NARS1 lowland	1	0	0	1
NARS2 upland	0	1	0	0
NARS 2 lowland	0	1	5	2
NARS 3 upland	0	1	0	0
NARS 3 lowland	0	1	0	0

Source: ARI baseline survey data.

Despite the yield increases recorded between 2004 and 2005, productivity is still below 1 ton per ha in the study area (Figure 11). The situation is aggravated by the low exposure and uptake of improved rice varieties including Nerica in the study area especially in Ejura-Sekyedumase and Hohoe Districts (Table 16 and Table 17).

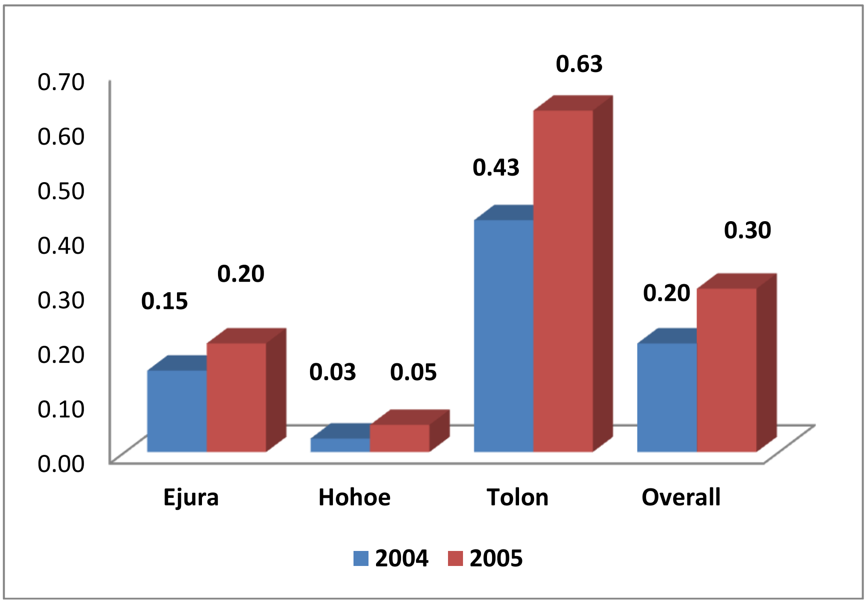

Figure 11: Rice Yields between 2004 and 2005 (ton/ha)

The results from the parametric estimation of adoption incidence rate indicate that the potential adoption rate for the entire population is estimated at about 91%. About 92% of the exposed farmers are also expected to adopt improved rice varieties. The expected rate of adoption among the unexposed farmers is also estimated at about 90%. Due to incomplete diffusion of improved rice varieties there is an adoption gap of about 44%. Moreover, there is no significant difference between the rate of adoption among the exposed and unexposed farmers

Table 16: Knowledge of Improved Varieties

	District			
Varieties	**Ejura**	**Hohoe**	**Tolon**	**Total**
All Improved	29.57	20.2	92.98	47.85
Nerica	17.92	2.03	1.22	5.74

NARS1	15.09	2.7	96.95	42.82
NARS2	13.21	2.7	96.34	42.11
NARS3	0	22.97	0	8.13

Source: ARI baseline survey data.

Table 17: Adoption of Improved Rice Varieties

	District			
Varieties	**Ejura**	**Hohoe**	**Tolon**	**Total**
All Improved	29.57	12.75	90.64	45.6
Nerica	17.92	2.03	1.22	5.74
NARS1	2.83	0	0	0.72
NARS2	13.21	2.03	94.51	41.15
NARS3	0	18.92	0	6.7

Source: ARI baseline survey data.

Table 18: ATE Parametric Estimation of Adoption Incidence Rate

	Parameter	**Std. Err.**	**P>z**
ATE	0.909155	0.029105	0.000
ATE 1	0.916347	0.024903	0.000
ATE 0	0.901636	0.039651	0.000
JEA	0.468405	0.01273	0.000
GAP	-0.44075	0.019383	0.000
PSB	0.007191	0.015101	0.634

Source: ARI baseline survey data.

From the Probit adoption model, age and access to extension services are shown to have significant effect on adoption. Adoption here refers to the use of any of the improved rice varieties by the farmer. The results suggest that younger farmers who are more aggressive and risk loving are more likely to adopt improved rice varieties. Extension as a source of information on the potential and agronomic requirement of improved rice varieties is very necessary for the adoption (Table 19).

Table 19: Probit Adoption Model

Variables	**Marginal Effect**	**Std. Err.**	**P>z**

Male	0.807406	0.776646	0.299
Age	-0.084970	0.035252	0.016
Experience	0.018886	0.024376	0.438
Household size	-0.055100	0.051208	0.282
Education	0.412718	0.593492	0.487
Extension	2.012831	1.039562	0.053
Rice revenue 2004	-8.29E-08	6.89E-08	0.228

Source: ARI baseline survey data

Young farmers are more likely to adopt improved rice varieties. The younger a farmers the more aggressive and the willing to take risk are more likely. Older farmers on the other hand are risk averse and are reluctant to change.

Access to extension service is a source of awareness about existing improved rice varieties. Moreover farmers have the opportunity to learn more about the advantages of adopting an improved variety. This condition stimulates the adoption of improved rice varieties in the study area.

Conclusions/Recommendations

The ARI project is well intended as it targets rural households who are highly dependent on agriculture and rice production for their livelihood. The success of the project can be made real through progressive assessment of the impact. Through the baseline study, a number of key indicators have been measured as the basis of future comparison.

Despite the steady improvements in the rice production indicators over the years, rice productivity is still low, below 1 ton per ha. This situation is worrying as Ghana continues to depend on imports to make up for the gap between domestic production and demand. The situation is further worsened by the low exposure and uptake of improved rice varieties including Nerica in the study area.

There is however the opportunity to improve the level of exposure and adoption if proper targeting of households is done. It has been shown that experience, education and location are important determinant of exposure while age and access to extension are also shown to affect adoption.

The results of the study have further indicated a higher potential for adoption of improved varieties including Nerica varieties by both the exposed and unexposed farmers. The existing adoption gap can therefore be minimized if the promotional activities are improved to include the majority of the rice producer in all the project areas.

a. **Future activities/The way forward**

In the 2010 research season, the ex-post impact study will be implemented to see how the NERICAs have faired so far.

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LOWLAND AGRONOMY PROGRAMME

Nerica and Cowpea Yields and Yield Components as Influenced by Intercropping Configurations

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Executive Summary

This work was carried out under the NERICA Rice Dissemination Project (NRDC), Ghana. Two field experiments were conducted during the 2008 and 2009 cropping seasons at the research field of the SARI, Nyankpala in the Guinea Savanna agro-ecological zone of Ghana to evaluate the effects of NERICA (NERICA 1 & 2) and cowpea (cv. *Apagbaala*) intercropping patterns (intra-row, inter-row, strip and sole croppings) on the growth, yield and productivity of the NERICA/cowpea intercropping system. The field experiments in both years were laid out in a randomized complete block design in a split-plot arrangement and replicated 4 times. The possible combinations of the NERICA and cowpea and their soles were randomized in main plots and the planting configurations for the intercrops, in subplots. NERICA plant heights, percent germination and 1000-seed weights were not influenced by the systems of cropping in both years. Intercropping reduced the weights of cowpea pods by 49% and 57%, and seed yield by 47% and 53% in 2008 and 2009 seasons, respectively. The productivity of the intercropping system indicated yield advantage of intercropping NERICA 1/cowpea at intra-row as depicted by the LER of 1.24 and 1.38 in 2008 and 2009 respectively, and NERICA 2/cowpea at inter-row cropping with LER of 1.13 and 1.24 in 2008 and 2009 seasons, respectively. Over all, yield advantages were more pronounced in the 2009 season compared to that of 2008 showing efficient utilization of land resource by growing the crops together when soil moisture trend was low. The implication of this is that farmers in the study area would profit growing the crops together especially during years with less amount of rainfall.

Introduction

Rice is an important component of food security for upland farmers. The cultivation of rice in Ghana, like other sub-Saharan African countries, is done by small- and medium-scale farm families mostly under upland ecosystems. The systems of cultivations of the upland rice are predominantly sole cropping under bush-fallows with slash-and-burn or shifting cultivation practices (WARDA, 1999). With increasing land shortages due to increasing population to land ratios, the traditional long fallows are no longer tenable. Sustainable crop production in these areas calls for increasing cropping intensity through suitable crop production technologies such as intercropping, sequence cropping. etc. Intercropping systems utilize resources like moisture, soil nutrients and solar radiation more efficiently than sole crops over time and space (Willey, 1979; Ahlawat *et al*., 1985; Keating and Carberry, 1993; and Eskandari and Ghanbari, 2009).

Intercropping is a very common practice in African agriculture, with more than 70% of cereals and 60% of legumes grown as intercrops in West and East Africa (Monyo *et al*., 1976; Okigbo and Greenland, 1976). One of the many possible reasons for practicing intercropping in these areas may be its higher productivity than sole crops (Runkulatile *et al*., 1998). Conceivably, a technology that would be generally adopted by farmers must systematically fit well into existing farming and cropping systems being practiced. Thus, among various ways that could increase upland rice production, increasing the cropping intensity and the yield per unit land area is an option that has a potential of wider adoption and also lead to food security, especially in developing countries.

However, the introduction as an upland crop of the NEw RICe for Africa varieties 'dubbed' NERICA by WARDA in 2000 after a successful interspecific crossing of the two species of cultivated rice, the African rice (*Oryza glaberrima*) and the Asian rice (*Oryza sativa*) that combined the best traits of both parents such as high yielding and tolerant to harsh environments (WARDA, 2008), have not only been assessed on their suitability and sustainability to complementary farming but also, the appropriate planting configuration in intercropping systems. Nyambo *et al.*, (1980) in a study involving plant combinations and configurations of three cereals (maize, sorghum and millet) and two legumes (soybean and green gram) reported significant effects on yields of intercrop components attributable to planting configuration.

Conceivably, if farmers will adopt the NERICA varieties for cropping, they would need information regarding the best pattern of cropping. We therefore undertook to evaluate cowpea and NERICA intercropping using four intercrop configurations (*viz*, strip, inter-row, intra-row and sole croppings).

The objective was to determine the best intercrop configuration for optimum yields or efficient use of land under the savanna upland ecosystem of Ghana. This objective was assessed under the null hypothesis that, intercrops configuration has no effect on crop performances in upland intercropping systems.

Determining Optimum Partner Crop(s) to NERICAs for Upland Intercropping:

The first experiment was to provide findings on suitable crop(s) to partner with NERICAs 1 and 2 varieties. The candidate crops to partner with the NERICAs 1 and 2 on-station were two varieties each of maize (*Dorke SR*, and *Dodzi*), cowpea (*Marfo-tuya*, and *Apagbaala*), soybean (*TGX 1805 -8F*, and *TGX 1485-1D*) and pepper (*Shito Adobe*, and *Akonfem*). A factorial combination that resulted in 16 treatments was arranged in a randomized complete block design with 3 replicates. A plot size of 3 m x 5 m was used with a planting distance of 20 cm x 40 cm. A basal fertilizer application of 30-30-30 (N-P-K) was done at 3 weeks after germination followed by second application of 30 kg N/ha of sulphate of ammonium after 6 weeks of germination.

The plots were 3 m x 5 m and a planting distance of 40 cm x 40 cm for same crop when intercropped, except for sole cropping where the recommended 20 cm x 20 cm was used. First fertilizer application of 30-30-30 NPK was done 3 weeks after germination followed by second application of 30 kg N/ha of sulphate of ammonium after 6 weeks of germination.

When all data were obtained after harvest, the data were subjected to statistical analysis of variance (ANOVA) using the GENSTAT Discovery software. When statistical significance exists, the means were separated using the Fisher protected LSD, following the ANOVA.

Results and Discussions

Determining Optimum Partner Crop(s) to NERICAs for Upland Intercropping: Effects of Intercropping on Yield and Yield Components of NERICA

The effects of intercropping NERICA with four upland crops *viz* cowpea, maize, pepper and soybeans on the yield and yield components of NERICA crops are presented in Tables 20 and Table 21. No significant difference was observed in percentage germination, 1000-grain weight and grains moisture contents of both NERICAs 1 and 2 when intercropped with any of the four crops.

Table 20a. Yield and yield components of NERICA 1 as affected by intercropping with four upland crops

Treatment	Gem. (%)	No. of Tillers/m^2	Plant height (cm)	No. of Panicles/m^2
N1/CP1	96.8	165	131.7	102
N1/CP2	96.9	201	134.0	121
N1/MZ1	94.4	138	118.7	40
N1/MZ2	95.0	156	117.7	49
N1/PP1	93.5	213	134.3	140
N1/PP2	96.4	246	139.3	145
N1/SB1	95.6	156	127.0	106
N1/SB2	95.0	177	134.0	116
Sole N1	89.2	300	132.6	159
$LSD_{(0.05)}$	NS	NS	11.83	50
CV (%)	3.5	24.4	5.2	27.8

Table 20b. Yield and yield components of NERICA 1 as affected by intercropping with four upland crops

Treatment	Panicle weight (kg/ha)	Grain weight (kg/ha)	1000-grain weight (g)	Land equiv. ratio	Moist. cont. (%)
N1/CP1	3269	2524	27.64	0.56	13.80
N1/CP2	5082	2960	26.89	0.66	12.97
N1/MZ1	1158	696	27.49	0.15	11.90
N1/MZ2	1296	878	26.89	0.19	12.33
N1/PP1	4960	3484	29.08	0.77	13.83
N1/PP2	5200	4042	27.52	0.90	11.30
N1/SB1	3049	2062	28.56	0.46	13.47
N1/SB2	4078	2773	27.58	0.61	12.30
Sole N1	7749	4504	28.04	1.00	11.03
$LSD_{(0.05)}$	2172.4	1382.9	NS	0.3052	NS
CV (%)	35.3	32.5	5.3	32.4	10.6

NS = not significant, N1 = NERICA 1, CP1 = *Marfo-tuya*, CP2 = *Apagbaala*, MZ1 = *Dorke SR*, MZ2 = *Dodzi*, PP1 = *Shito Adobe*, PP2 = *Akonfem*, SB1 = *TGX 1805 -8F*, and SB2 = *TGX 1485-1D*

Table 21a. Yield and yield components of NERICA 2 as affected by intercropping with four upland crops

Treatment	Gem. (%)	No. of Tillers/m^2)	Plant height (cm)	No. of Panicles/m^2)

N2/CP1	91.6	153	120.3	87
N2/CP2	97.4	186	122.3	112
N2/MZ1	92.6	135	109.3	50
N2/MZ2	93.3	147	111.7	52
N2/PP1	96.7	213	124.0	112
N2/PP2	96.1	219	122.0	121
N2/SB1	95.7	180	120.7	110
N2/SB2	94.4	135	118.7	94
Sole N2	91.1	300	126.8	138
$LSD_{(0.05)}$	NS	59	8.48	47.5
CV (%)	3.1	19.8	4.1	29.3

In addition, number of tillers per meter square area for NERICA 1 was not affected by intercropping with the other crops (Table 20) but this was statistically not so in the case of NERICA 2 associations with the other crops (Table 21). Thus, for NERICA 2, maximum numbers of tillers were consistently observed (213 and 219 tillers /m^2) were observed when pepper is the companion crop. However, intercropping with either cowpea or soybean produced statistically similar number of tillers per square meter of land.

Table 21b. Yield and yield components of NERICA 2 as affected by intercropping with four upland crops

Treatment	Panicle weight (kg/ha)	Grain weight (kg/ha)	1000-grain weight (g)	Land equiv. ratio	Moist. cont. (%)
N2/CP1	2373	1609	28.43	0.33	10.10
N2/CP2	3584	2560	27.31	0.53	8.30
N2/MZ1	824	456	26.12	0.10	10.47
N2/MZ2	1533	851	26.85	0.18	9.97
N2/PP1	5133	3153	26.99	0.65	9.50
N2/PP2	4638	2827	26.12	0.59	9.23
N2/SB1	2984	1911	28.23	0.39	10.33
N2/SB2	2818	1771	27.13	0.37	10.30
Sole N2	7376	4836	27.26	1.00	10.03
$LSD_{(0.05)}$	1437.9	936.3	NS	0.195	NS
CV (%)	27.5	28.3	3.4	28.5	13.4

NS = not significant, N2=NERICA 2, CP1 = *Marfo-tuya*, CP2 = *Apagbaala*, MZ1 = *Dorke SR*, MZ2 = *Dodzi*, PP1 = *Shito Adobe*, PP2 = *Akonfem*, SB1 = *TGX 1805 -8F*, and SB2 = *TGX 1485-1D*

Number and weight of Panicles per unit Area: The numbers of panicles per square meter of land as well as the panicles weight per hectare of land for NERICA crops were significantly affected when intercropped with any of the other crops (Table 20 and 21). Maximum number of panicles ranged (140-145 and 112-121 panicles/m^2 for NERICAs 1 and 2 respectively) and weights of panicles ranged (4960-5200, and 4638-5133 kg/ha for NERICAs 1 and 2, respectively) were obtained where pepper was the companion crop. Competition for soil nutrients, water and sunlight between individual crops in intercropping systems could potentially affect crop productivity. Since the number of tillers were statistically the same irrespective of the companion crop, the variability in the panicles may be due to the presence of non productive or effective tillers. The non vigorous nature of the pepper crops relative to NERICA renders it less competitive in favour of the NERICAs.

However, cowpea and soybean crops as partner intercrops did not significantly indicate different effects on NERICAs regarding panicles numbers and weights from that observed under pepper intercrops. A general assumption in intercropping cereals with legume crops is that the legume, when associated with the specific *Rhizobium*, may have most of its nitrogen needs supplied through fixation of atmospheric nitrogen, leaving the soil N for the companion cereals. This is evident by the high tiller productive of NERICA when intercropped with either of the legume crops (cowpea and soybean).

Among the partner crops, NERICAs produced significantly lower number of panicles and consequently lower weights of panicles per unit land area when intercropped with maize. This could partly be due to the wider morphophysiological differences between the intercrops especially regarding plant heights.

Grain weights and Land Equivalent Ratios: Intercropping affects grain yield of NERICAs. Data suggested better grain yield of NERICA when intercropped with pepper though not significantly different from the effects of either cowpea or soybean as partner intercrops to NERICAs (Table 20 and Table 21). The efficiency of intercropping systems for the NERICAs expressed as land equivalent ratio (LER) was markedly affected by the companion crop. The results indicated significantly higher LER values for both NERICAs 1 and 2 when intercropped with pepper. This finding corroborated with the better grain yields of NERICA under pepper.

Effects of NERICAs as intercrop on Yield and Yield Components of Partner Crops

Maize

The effect of intercropping NERICAs and maize on the yield and yield components of maize is presented in Table 22. The results indicated that no significant difference could be observed and attributed to the effects of the NERICAs on the yields and yield components of maize crops. Any differences in yield and yield components of maize could therefore be due to genetic differences of the maize varieties.

Cowpea

Table 23 presents the yield and yield components of cowpeas as influenced by NERICAs when intercropped. Clearly, the yields and yield components of the cowpea varieties were not significantly affected when intercropped with either NERICA 1 or 2.

Table 22. Yield and yield components of maize varieties as affected by intercropping with NERICAs 1 and 2 (N1 and N2)

Treatment	Germi-nation (%)	Plant height (cm)	Cob weight (kg/ha)	Unthreshed wt (kg/ha)	Grain weight (kg/ha)
N1/MZ1	98.6	112.3	7920	4602	2864
N1/MZ2	99.2	109.7	5078	3404	2562
N2/MZ1	97.4	123.0	8264	4958	3262
N2/MZ2	97.6	110.7	5058	3322	2433
LSD	NS	NS	NS	NS	NS
CV (%)	0.9	9.8	25.3	29.5	32.4

NS = not significant, MZ1=*Dorke SR*, and MZ2=*Dodzi*.

Table 23. Yield and yield components of cowpea varieties as affected by intercropping with NERICAs 1 and 2 (N1 and N2)

Treatment	Germination (%)	Plant height (cm)	Pod weight (kg/ha)	Grain weight (kg/ha)
N1/CP1	94.7	53.7	958	933
N1/CP2	88.2	55.7	584	571
N2/CP1	93.5	63.0	1200	956
N2/CP2	88.7	61.3	1140	927
LSD	NS	NS	NS	NS
CV (%)	4.7	17.0	59.3	53.5

NS = not significant, CP1=*Marfo-tuya*, and CP2=*Apagbaala*.

Thus any differences associated to the yield and yield components of the cowpea varieties are attributable to their genetic differences. However, the higher variability associated with pods weight and grain weight of the cowpea as indicated by the coefficient of variation (59.3 and 53.5 % respectively) could overshadow the effects of the NERICAs on those parameters resulting in the observed non differences and therefore not suitable enough to draw conclusion from.

Soybean

The effects of intercropping soybean with NERICAs on the yield and yield characters of the soybean indicated no significant difference (Table 24). Thus any differences in the yields and yield components of soybean when intercropped with NERICAs1 and 2 might be due to the genetic differences between the soybean varieties.

Table 24. Yield and yield components of soybean varieties as affected by intercropping with NERICAs 1 and 2 (N1 and N2)

Treatment	Germination (%)	Plant height (cm)	Pod weight (kg/ha)	Grain weight (kg/ha)
N1/SB1	86.3	62.0	2833	860
N1/SB2	91.1	60.3	2193	802
N2/SB1	81.7	69.0	3793	816
N2/SB2	89.1	64.0	3009	896
LSD	NS	NS	NS	NS
CV (%)	8.7	7.0	26.9	31.7

NS = not significant, SB1= *TGX 1805 -8F*, and SB2=*TGX 1485-1D*.

Pepper

The effect of intercropping NERICAs and pepper on the yield and yield components of pepper is presented in Table 25. The results indicated no significant difference could be observed and attributed to the effects of the NERICAs on the yields and yield components of pepper crops. Any differences in yield and yield characters of pepper could therefore be attributed to the genetic differences of the pepper varieties.

Table 25. Yield and yield components of pepper varieties as affected by intercropping with NERICAs 1 and 2 (N1 and N2)

Treatment	Plant height (kg/ha)	Fresh weight (kg/ha)	Dry weight (kg/ha)
N1/PP1	25.3	396	367
N1/PP2	30.7	484	456
N2/PP1	24.0	578	520
N2/PP2	29.0	524	482
LSD	NS	NS	NS
CV (%)	11.6	20.2	18.5

NS = not significant, PP1=*Shito Adobe*, and PP2=*Akonfem*.

Assessment of Potential NERICA/Cowpea Intercropping Systems: Effects of NERICA/Cowpea Intercropping Systems on Yield and Yield Components of NERICA

The effects of four possible NERICA/Cowpea cropping systems on the yield and yield characters of NERICA crops are presented in Table 26 and 27. Depending on the cropping system used, the number of tiller of the NERICAs per square meter of land was significantly affected. However, results indicated that no significant difference could be observed in percentage germination, 1000-grain weight and grains moisture contents of both NERICAs 1 and 2 when any of the four cropping systems is used (Table 26 and 27). Similarly, the plant height, grains weight and land equivalent ratio of NERICA 1 were observed to be non-significantly affected by cropping system involving either sole NERICA1 or in association with cowpea (Table 26). On the other hand, depending on the cropping system used, the plant height, grains weight, and land equivalent ratios of NERICA were observed to be significantly affected. Among the intercropping systems, strip cropping of NERICA and cowpea performed significantly higher grain yield (2856 kg/ha) and efficiency (LER of 0.61) of NERICA 2 (Table 27).

Number and weight of Panicles per unit Area: The numbers of panicles per square meter of land as well as the panicles weight per hectare of land for NERICA crops were significantly affected by the type of cropping system used (Table 26 and 27). Maximum number of panicles were observed under sole cropping of NERICA 1 (7749 panicles/m^2) and NERICA 2 (7376 panicles/m^2). Among the intercropping systems, strip cropping consistently produced higher number and weights of panicles per unit area of land. This means that it is better to intercrop NERICA in strips than alternating hills or rows for better panicle yield.

Table 26a. Yield and yield components of NERICA 1 when intercropped with cowpea under different systems

Cropping System	Gem. %	No. of Tillers/m^2	Plant height (cm)	No. of Panicles/m^2
Alternate hills	96.9	147	69.0	105
Alternate rows	96.6	153	67.6	88
Sole cropping	89.2	300	72.3	159
Strip cropping	94.7	156	67.3	145
$LSD_{(0.05)}$	NS	36.0	NS	47.5
CV (%)	3.0	9.5	5.7	19.1

Table 26b. Yield and yield components of NERICA 1 when intercropped with cowpea under different systems

Cropping System	Panicle weight, (kg/ha)	Grain weight, (kg/ha)	1000-grain weight, (g)	Land equiv. ratio	Moist. Cont. (%)
Alternate hills	4118	2869	26.39	0.67	9.47
Alternate rows	3689	2442	25.86	0.59	9.07
Sole cropping	7749	4504	28.04	1.00	11.03
Strip cropping	4542	2884	27.87	0.66	10.83
$LSD_{(0.05)}$	2012.2	NS	NS	NS	NS
CV (%)	20.0	27.1	5.6	23.1	14.8

NS = not significant

Table 27a. Yield and yield components of NERICA 2 when intercropped with cowpea under different systems

Cropping System	Gem. %	No. of Tillers/m^2	Plant height (cm)	No. of Panicles/m^2
Alternate hills	94.9	150	66.2	79
Alternate rows	96.1	147	70.7	75
Sole cropping	91.1	300	71.7	138
Strip cropping	92.8	171	70.4	137
$LSD_{(0.05)}$	NS	49.7	2.94	28.9
CV (%)	5.4	13.0	2.1	13.4

Grain weights and Land Equivalent Ratios: Data suggested that grain yield and land equivalent ratios of NERICA 1 are not significantly affected by the system of cropping used for production (Table 26). However, in the case of NERICA 2 production, cropping systems have indicated to have significant effects on the grain yields and land equivalent ratios (Table 27). The results indicated significantly higher LER value for NERICA 2 when intercropped in strips as compared to alternate hills or row intercropping.

Table 27b. Yield and yield components of NERICA 2 when intercropped with cowpea under different systems

Cropping System	Panicle weight (kg/ha)	Grain weight (kg/ha)	1000-grain weight (g)	Land equiv. ratio	Moist. cont. (%)
Alternate hills	2924	2089	28.28	0.46	9.83
Alternate rows	2664	1876	27.00	0.41	11.30
Sole cropping	7376	4836	27.26	1.00	10.03
Strip cropping	4493	2856	27.50	0.61	10.13
$LSD_{(0.05)}$	596.4	1258.3	NS	0.182	NS
CV (%)	6.8	21.6	5.3	14.7	22.3

Effects of NERICA/Cowpea Intercropping Systems on Yield and Yield Components of Cowpea

The effects of NERICA/Cowpea intercropping systems on the yield and yield characters of the cowpea are presented in Table 28. The percentage germination and grain yields of cowpea did not differ significantly for any of the cropping systems. Plant height of cowpea from strip cropping and sole cropping however differed significantly from the alternating hills or rows cropping systems (Table 28). The results showed that considerable increase in cowpea crop height occurred under strip cropping system or sole cropping.

Table 28. Yield and yield components of cowpea when intercropped with NERICAs 1 and 2 (N1 & N2) under different systems

Cropping System	Germination (%)		Plant height (cm)		Pod weight, (kg/ha)		Grain weight (kg/ha)	
	N1	N2	N1	N2	N1	N2	N1	N2
Alternate hills	86.5	90.7	46.1	46.3	1211	929	822	640
Alternate rows	89.1	85.6	45.2	57.5	929	1387	922	1047
Sole cropping	88.1	87.6	58.9	69.4	1800	1420	1333	1149
Strip cropping	88.4	88.5	73.6	79.7	556	836	513	760
$LSD_{(0.05)}$	NS	NS	9.58	16.19	526.9	NS	NS	NS
CV (%)	8.6	5.4	8.6	12.8	23.5	35.9	35.9	38.6

NS = not significant

The mean pods weights of cowpea intercropping with NERICA 1 is significantly affected by the intercropping system used but the same is not observed when upon intercropping cowpea with NERICA 2 in this direction. The results indicated considerable increased in pods weights of cowpea with NERICA 1 under sole cropping (1800 kg/ha) and alternating hills intercropping system (1211 kg/ha).

Summary of Main Findings

The following were the main observations made, and though may not be exhaustive they warrant further investigations.

- There were considerable variation in yields and yield components of NERICAs in the presence of other crops.
- Yields and yield components of NERICAs were significantly reduced when intercropped with maize. To this extent, crops with vigorous canopy and/or heights above NERICAs seem to have potential of reducing yields and yield components of the NERICAs
- Optimum yields of NERICAs were obtained when intercropped with pepper, though not statistically different upon intercropping with Cowpea or Soybean.
- Yields and yield components of companion crops were generally not affected when intercropped with NERICAs.
- In the cropping systems (crop spatial arrangements) experiment, NERICAs performed better under strip cropping, but that had impacted negatively on the performance of the companion cowpea.
- Further works are needed on-farm that will include the determination of appropriate crop spacing between tall crops (i.e. maize, yam, and cassava) and NERICAs intercropping, for optimum yields.

UPLAND AGRONOMY

J. M. Kombiok & Haruna Abdulai

Introduction

The Northern Region Farming Systems Research Group (NR-FSRG) is one the four farming systems groups within the Savanna Agricultural Research Institute (SARI). Within the group (NR-FSRG) however, there are units of which the Upland Agronomy programme is just one. This unit is mainly responsible for carrying out adaptive trials (with farmers) of all the crops except cotton and rice within Northern Region. In addition to this, the unit also carries out limited number of basic or on-station agronomic trials on all the crops.

For the year under review, four activities were carried out. These were (i) characterisation of Jatropha (funded by EU), (ii) on-farm participatory selection of *Striga*/drought tolerance maize varieties (funded by IITA/CIMMYT), (iii) Validation of the results (QUAEFTS) Model (IFDC) and (iv) testing of liquid (foliar) fertilizers which was funded by HUMA-GRO, an American-based company.

Validation of the results of Quantitative Evaluation of the Fertility of Tropical Soil (QUAEFTS) Model at Nyankpala and Damongo in the Northern region of Ghana

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Executive Summary

Soils in the northern Savanna zone of Ghana are poor in nutrients. This situation could be blamed on the annual bush burning which exposes the soil to both water and wind erosion during the rainy and dry seasons respectively. As a result, farmers in the northern part of Ghana are unable to obtain reasonable yields of most of the crops without fertilizer application. Since 2007, Omission trials were set up at Nyankpala and Damongo to investigate the most limiting major element of both soil types. Even without the analysis of the soil and plant materials, the yield data alone showed that nitrogen is the most limiting element, which may be responsible for the low maize yields in these areas. The experimental design for the validation was split-plot design with the tillage (manual and bullock) being the main plots while the sub-plots were the fertilizer levels as obtained from the model. The objective of this work was therefore to apply various levels of NPK as

derived from the model to maize in these areas to find out (validate) if similar grain yields attributed to these levels as obtained from the model could be achieved. The treatments were made up of six combinations of NPK for manual and bullock tillage systems as derived from the model. The actual grain yields of maize obtained on the field from Nyankpala and Damongo were all lower than what was calculated from the model. However, the grain yields for all the treatments at Damongo were closer to the yields obtained from the model than at Nyankpala.

Introduction

Generally, soils in the northern Savanna zone of Ghana are poor in nutrients. This situation could be blamed on the annual bush burning which exposes the soil to both water and wind erosion during the rainy and dry seasons respectively. As a result, farmers in northern Ghana are unable to obtain reasonable yields of most of the crops without fertilizer application especially the cereals (maize and sorghum), which are considered to be their staple food crops.

Various attempts have been made to address the problem of low soil fertility levels. These include tillage trials where the yields of maize and soybean in rotation are compared among the common tillage systems (tractor, bullock, hand hoe and zero tillage).

With funding from IFDC since 2007, Omission trials were set up at Nyankpala and Damongo. The objective of these trials was to find out the most limiting major element through maize yields and laboratory analysis of both soil and plant materials. The results showed that nitrogen is the most limiting element, which may be responsible for the low maize yields.

In running the model from a minimum data set involving the grain yield of maize and soil analysis (NPK) from the two years of experimentation, the results showed that one could obtain 1.5t/ha of maize without the application of NPK and manure under both manual and bullock ploughing. However in order to obtain higher yields of maize under both tillage systems after the application of 6t/ha of organic matter, various levels of NPK have to be applied.

Objective

The objective of this work was therefore to apply these various levels of NPK to maize in these areas to find out (validate) if the same grain yields attributed to these levels as obtained from the model could be achieved.

Methodology

Ten farmers who participated in the previous omission trials from each of the two districts were chosen. Seven farmers participated in the trials at Nyankpala and 9 at Damongo during the 2009 cropping season. All the farmers who took part in the trials tilled their soils for crop production by both manual and bullock. Apart from the control (no manure & no fertilizer) each of the plots was fertilized with manure at 6t/ha before the sub-treatments (NPK levels) imposed.

Experimental Design and Treatment

The experimental design was split-plot design with tillage (manual and bullock farmers) being the main plots while the sub-plots were the fertilizer levels as obtained from the model. The treatments were made up of six combinations of NPK for manual and bullock tillage systems respectively as below: Each farmer was considered a replicate.

Data collected:

1. Composite soil samples from each farmer (replicate)
2. Samples from the organic manure used
3. Grain weight

Data were analysed using General Linear Model programme (Statistix). The analysis of Variance procedure for split-plot was used to determine whether differences existed among treatments.

Results and discussion

Results from Nyankpala

The actual grain yields of maize obtained on the field from Nyankpala were all lower than what was calculated from the model (Table 28). This low grain yields could be attributed to the low soil fertility status observed on the fields where the experiments were carried out. The establishment of the trials was conceived late by which time the good arable lands where the omission trials were carried out previously had already been cropped.

Table 28: Grain yield of maize as affected by different rate of NPK at Nyankpala

Treatment (NPK)		Grain yields of maize (kg/ha) Obtained on the field*		
Manual (NPK values)	Bullock(NPK VALUES)	Model yield	Actual yield obtained (Bullock)	Actual yield obtained (Manual)
0-0-0	0-0-0	1500.00	244.44d	244.44d
3-0-0	15-0-0	2000.00	1177.80c	777.78c
32-0-3	32-0-3	2500.00	1266.70ab	1844.40ab
60-1-22	60-1-22	3000.00	1533.30a	1844.40ab
89-9-41	89-9-41	3500.00	1888.9a	2200.00a

117-18-61	101-14-32	4000.00	1755.60a	2333.30a
Lsd $_{(0.05)}$	-	-	518.94	366.72

*For a factor, means followed by same letter in a column is not significantly different at 5% level of probability

This however urged us to look for land elsewhere but it was later felt that the fertility status (visual) was not similar to the area where the omission experiments were conducted. The grain yields from the bullock were not statistically different from that obtained from the manual tillage system. In both cases, the lowest yields were obtained when no fertilizer and no manure were applied and the highest was when 117-18-61 and 101-14-32 were applied for manual and bullock, respectively.

Results from Damongo

The results in Table 29 show that apart from the no fertilization which had grain yield far lower than the yield calculated from the model, the grain yields from the rest of the treatments were almost the same with only a few of them less than a 50kg/ha at Damongo. However, under the bullock, the grain yield obtained from the field from the 101-14-32 treatment was more than the yield calculated from the model by about 2000kg/ha. Just as observed in Nyankpala, the areas where the omission trials were established in the past years were already cropped before the trials in 2009 could be considered. It could therefore also mean that the soil fertility status in these areas were lower than the areas previously used for the omission trials as can be seen from the yields where no fertilizer and no manure were applied to the crops.

Table 29: Grain yield of maize as affected by different rates of NPK at Damongo

Treatment (NPK)		Grain yields of maize (kg/ha) Obtained on the field		
Manual	Bullock	Model	Actual yield obtained (Bullock)	Actual yield obtained (Manual)
0-0-0	0-0-0	1500.00	987.00d	740.60e
3-0-0	15-0-0	2000.00	1869.20c	1851.00d
32-0-3	32-0-3	2500.00	2528.40b	2550.00c
60-1-22	60-1-22	3000.00	3012.70b	3035.60b
89-9-41	89-9-41	3500.00	3659.10a	3535.10a
117-18-61	101-14-32	4000.00	4218.10a	3989.90a
Lsd $_{(0.05)}$	-	-	629.96	419.52

*For a factor, means followed by same letter in a column is not significantly different at 5% level of probability

There are four groups in which the means of the yields of maize were not significantly different from one another in the bullock but five groups for the manual (Table 29). The yields from the 117-18-61 and 101-14-32 treatments were the highest in the bullock and manual respectively but these were also not different from those obtained when 89-9-41 was applied to crops in the bullock and manual main plots. Next in value were yields from 60-1-22 and 32-0-3 treatments, which were also similar in both the manual and bullock treatments. Yields were lower when 3-0-0 and 15-0-0 treatments were applied but these were also significantly higher when no fertilizer was applied to crops in both tillage systems.

Conclusion

In conclusion, it has been observed that the results of manual and bullock tillage systems at both Damongo and Nyankpala did not correspond to the results of the yields obtained from the model. However, the grain yields for all the treatments at Damongo were closer to the yields obtained from the model than at Nyankpala. The reasons probably being that the trials were not established on the soils where the omission trials were cited. Even though the soils samples have not been analysed, it seems the soils on which the validation trials were set up in Nyankpala and Damongo were poorer in nutrients than where the omission trials were established for the past two years

Participatory on-farm testing of drought tolerant varieties of maize lines in the Northern Region of Ghana (Mother and Baby trials)

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Executive Summary

It has become necessary to develop crop varieties to cope with the ever decreasing amount of rain and the erratic nature of the rainfall in the savanna zone of Ghana. These newly released crop varieties which may be early maturing or drought tolerant are therefore made to replace the existing ones used by farmers. However, before these lines are officially released as varieties, they are tested widely with farmers (on-farm) to ensure that they are not rejected. Four mother trials (comprising of extra early/early and medium/intermediate maturing varieties) were planted on farmers' fields at two sites each in the Tolon/Kumbungu and West Mamprusi Districts. Also, baby trials, which are farmer-managed, were also conducted on a total of 18 farmers in both Districts. The results showed that most of the improved drought tolerant lines from IITA in this study performed similar to or better than the best available local varieties at the various locations under rain fed conditions. Based on the performance of the lines, two early lines DT SR-

WCOF2 and DT SYN-I-W were selected for further testing before being released as new drought tolerant maize varieties. Some of the lines the farmers preferred were selected from the 2008 trials and planted on their fields in 2009, suggesting that these lines would be adopted if they are released as new varieties.

Introduction

The development of new maize varieties is the joint efforts of Scientists from the National Research Systems (NARS) of the individual countries in collaboration with international Agricultural Research Centres such as IITA. Due to the breakdown of the genetic potential of the old crop varieties coupled with the ever decreasing amount and the erratic nature of the rainfall in the savanna region, it has become necessary to develop varieties to cope with this situation. These new releases which may be early maturing or drought tolerant are therefore made to replace the existing ones used by farmers. However, before these lines are officially released as varieties, they are tested widely with farmers (on-farm) to ensure that they are not rejected.

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

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

- For farmers' to validate the drought/*striga* tolerant maize lines
- Farmers to compare the performance of the drought tolerant lines among their existing varieties.
- Introduce farmers to drought/*striga* tolerant maize lines

Materials and Methods

Northern Region of Ghana

Tolon/Kumbungu and the West Mamprusi Districts have persistently recorded high infestation of *Striga* and have been experiencing dry days in June for some years now. For 2009, there were four mother trials two each of the intermediate and early maize lines. A set of one intermediate and early maturing varieties was established with farmers at Kpachi and the second set at Walewale. The intermediate varieties in these trials were 5 namely **TZU TSR-WSGY-SYN, DT SR-W CO F2, DT-SYN-1-W and IWD C2 SYN F2 with Mamaba** being the check while for the early, the lines were 4 composed of **TZEE Y-POP STR QPM CO, TZEE Y-POP STR C4** and **2004 TZE Y POP STR C4 with Akposoe** being the check. With two mother trials at each location, the quantities of seed available could do for a total of 18 farmers (12 for the intermediate and 6 for the early categories) at Kpachi and Walewale.

Mother trial: Four mother (comprising of extra early/early and medium/intermediate maturing varieties) trials were planted on farmers' fields at two sites each in the Tolon/Kumbungu and West Mamprusi Districts. With the collaboration of the extension staff of MoFA, interested maize farmers who participated in these trials in 2008 were contacted. The rest of the farmers who made up the number in these areas were also identified and selected by their colleagues. The intermediate mother trial consisted of 4 drought tolerant maize varieties and one local check. The early maturity was also made up of 4 varieties including a check.

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

Baby trials: Baby trials, which are farmer-managed, were also conducted with a total of 18 farmers in both the Tolon/Kumbungu and West Mamprusi Districts. With two Mother trials of each intermediate and early maturing varieties, the quantities of seed available could do for only 12 farmers for the intermediate and 6 for the early maturing categories.

The farmers selected participants among themselves to test these varieties from the mother trials. A set of two drought tolerant varieties was tested on each farmer's field alongside the farmers' variety in each case. Each farmer was a replicate of the four treatments, which was planted in parallel plots for comparison. Each variety occupied an area of 400 m^2 (20 x 20 m). Planting of the mother trials of both the early and the Intermediate lines was carried out on the 27/06/09. There was no intermittent drought after planting for this year (2009).

Results

Mother trials in Nyankpala an Walewale (Early maturing lines)

(i) Days to 50 % silking

The days to 50 % silking of early maturing varieties of maize at Nyankpala and Walewale are presented in Table 30. The variety that showed significant longer days to silk was Akpasoe while the variety with the shortest days to silking was 2004 TZE Y POP STR C4 at both sites. There was no significant difference between TZEEY-POP-STR C4 and TZEEY-POP-STR QPM CO at both sites (Table 30).

(ii) Grain yield (t/ha) of early maturing lines of maize

The highest grain yield was recorded by TZEEY-POP-STR QPM CO at both Nyankpala and Walewale. Also, the lowest grain yield was from 2004 TZE Y POP STR C4. However, there were no significant differences in grain yield among treatments at both sites (Table 31). It was observed that with the exception of AKPOSOE, the yields of the rest of the lines were higher in Walewale than those at Nyankpala.

Table 30: Days to 50% silking, of early maturing varieties of maize in Nyakpala and Walewale.

Maize Lines	Nyankpala	Walewale	Mean across
TZEEY-POP-STR QPM CO	50	52	51
TZEEY-POP-STR C4	51	52	51.5
2004 TZE Y POP STR C4	48	50	50.5
AKPOSOE	53	55	54
Lsd (0.05)	2	1.5	
CV (%)	8	6	

Table 31: Grain yield of early maturing varieties of maize tested with farmers at Nyankpala and Walewale

Maize Lines	Nyankpala	Walewale	Mean across
TZEEY – POP – STR QPM CO	3.18	3.69	3.44
TZEEY – POP – STR C4	3.08	3.20	3.14
2004 TZE Y POP STR C4	2.78	3.06	2.92
AKPOSOE	3.12	3.02	3.07
Lsd (0.05)	NS	NS	
CV (%)	10.5	8	

Mother trials in Nyankpala and Walewale (Intermediate maturing lines)

(i) Days to 50 % silking

The number of days to silking for all the intermediate maturing test lines including the check were not significantly different at both the Nyankpala and Walewale sites (Table 32). The longest days to silking was registered by

IWD C2 SYN F2 at both sites while the line with the shortest days to silking was Mamaba.

Table 32: Days to 50% silking of intermediate maturing varieties of maize in Nyakpala and Walewale

Maize lines	Nyankpala	Walewale	Mean across
TZU TSR-SGY-SYN	65	63	64
DT SR-W CO F2	64	66	65
DT SYN-1-W	66	64	65
IWD C2 SYN F2	66	68	67
MAMABA	63	62	62.5
Lsd (0.05)	NS	NS	
CV (%)	6	9	

(ii) Grain yield (t/ha) of intermediate maturing lines of maize

With the exception of **TZU TSR-SGY-SYN** where the grain yield was significantly low, all the grain yields of intermediate maize lines in Nyankapala including the check (Mamaba) were not significantly different (Table 3). The highest yield was therefore obtained from **DT SR-W CO F2** and the lowest yield from **TZU TSR-SGY-SYN**. At Walewale however, the grain yields of all the maize lines were comparatively lower than those obtained in Nyankpala. The crops were destroyed by animals just about two weeks after planting and that could have been the cause of such low yields. The grain yields of **DT SYN-1-W** and **TZU TSR-SGY-SYN** were statistically similar but were both significantly lower than the rest of the other maize lines (Table 3).

Table 33: Grain yield (t/ha) of intermediate maturing lines of maize in Nyankpala and Walewale

Maize lines	Nyankpala	Walewale	Mean across
TZU TSR – SGY –SYN	3.04	2.89	2.96
DT SR – W CO F2	5.47	3.24	4.56
DT SYN -1 –W	4.67	3.36	4.01
IWD C2 SYN F2	5.21	2.80	4.00
MAMABA	4.81	3.47	4.14
Lsd (0.05)	0.91	0.23	
CV (%)	12	12	

Baby Trials

Generally, the results from the baby trials show that days to silking for both the intermediate and early were similar to that obtained from the mother trials. However, the grain yields for all the lines in the baby trials were comparatively lower than obtained from the mother trials.

Intermediate maturing lines

(i) Days to silking

It was observed that in the baby trials for intermediate maturing varieties, the days to silking were similar to what were obtained from the mother trials (Table 34). The longest days to silking at both the Walewale and Nyankpala sites was recorded by IWD-C2-SYN-F2 and the shortest days to silking from the TZUTSY-W-SGY-SYN maize line. However, the days to silking at both sites were not significantly different among the maize lines including the farmers' varieties.

Intermediate maturing lines

(i) Grain yields

At both Nyankpala and Walewale sites all the intermediate maize lines including the farmers' varieties had grain yield more than 2t/ha (Table 35). The highest grain yield at both sites was obtained from the **DT-SYN-1-W** and the lowest from the farmers' varieties. The grain yields of all the intermediate lines including the local check (Mamaba) and farmers' varieties at both sites were not significantly different.

Table 34: Days to 50% silking of intermediate maturing maize lines evaluated in baby trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	Walewale	Nyankpala	Mean across
TZUTSY-W-SGY-SYN	54	56	55
DT-SR-W-COF2	57	59	58
DT-SYN-1-W	62	64	63
IWD- C2- SYN-F2	65	67	66
Mamaba	60	62	61
Farmers variety	61	62	61.5
LSD(0.05)	NS	NS	
CV (%)	10	12	

Table 35: Grain yields (t/ha) of intermediate maturing maize lines evaluated in baby trials at Nyankpala and Walewale districts of Northern Region

Maize lines	Walewale	Nyankpala	Mean across
TZUTSY-W-SGY-SYN	2.10	2.15	2.13
DT-SR-W-COF2	2.32	2.35	2.33
DT-SYN-1-W	2.36	2.37	2.37
IWD- C2- SYN-F2	2.21	2.33	2.27
Mamaba	2.28	2.25	2.27
Farmers variety	2.09	2.13	2.11

LSD(0.05)	0.97	0.89	
CV (%)	28	25	

Early maturing lines

(i) Days to 50 % silking

Even though the farmers' varieties had the longest days to 50% silking at both Walewale and Nyankpala sites, these were not significant differences among the maize lines (Table 36). Comparatively, all the early maturing lines including the farmers' varieties, the days to 50% flowering were longer at the Nyankpala site than those obtained at the Walewale site.

II) Grain yields

There were significant differences in grain yields among the early maturing maize lines in both the Nyankpala and Walewale sites in the baby trials (Table 37). At Walewale, the yields of all the lines tested were similar but the farmers' varieties which were checks gave significant lower yields compared with each of them. The significant lower yield obtained from the farmers' varieties could be due to mixture of several varieties. It has been observed that farmers select their own seed from their grain and for a long time, their varieties tend not to be pure in nature but mixed with others and that can affect the grain yield negatively. Similarly, at Nyankpala, the grain yield obtained from the farmers' varieties was similar to the yields from 2004 TZE Y POP STR C4 and TZEEY-POP-STR C4 but significantly lower than the yields recorded by TZEEY-POP-STR-QPM-CO and AKPASOE (Table 37).

Table 36: Days to 50 % silking of early maturing maize varieties evaluated in baby trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	**Walewale**	**Nyankpala**	**Mean across**
TZEEY-POP-STR-QPM-CO	53	55	54
TZEEY-POP-STR C4	55	57	56
2004 TZE Y POP STR C4	56	55	55.5
AKPOSOE	57	56	56.5
Farmers variety	50	52	51
CV(%)	6	4	
LSD(0.05)	NS	NS	

Table 37: Grain yield of early maturing maize varieties evaluated in baby trials at Nyankpala and Walewale districts of Northern region, Ghana

Maize lines	**Walewale**	**Nyankpala**	**Mean across**

TZEEY-POP-STR-QPM-CO	1.62	1.91	1.77
TZEEY-POP-STR C4	1.56	1.59	1.58
2004 TZE Y POP STR C4	1.52	1.48	1.50
AKPOSOE	1.75	1.88	1.82
Farmers variety	1.04	1.15	1.10
LSD(0.05)	0.26	0.45	
CV (%)	21	26	

Farmer assessment of the test lines

Due to lack of time, farmers could not assess the early/extra early lines for 2009 again. Only the intermediate lines were assessed individually. The results of the exercise showed that farmers at Nyankpala suggested **TZUTSY-W-SGY-SYN** and **DT-SR-W-COF2** to be most preferred intermediate maturing lines. Even though **TZUTSY-W-SGY-SYN** gave considerably lower yields, it was still preferred and this could be due the fact that the same people did the assessments last year. However in Walewale, the farmers preferred **DT-SR-W-COF2** and Mamaba**.** Just as last year, the QPM hybrid, Mamaba which is a released variety was also considered alongside the new lines. Crop features and characters considered included earliness, cob size, grain size, and drought/striga resistance. All the IITA maize lines were considered to be better than the local checks (farmers' varieties).

Conclusions

Generally for the second year now, most of the improved drought tolerant lines from IITA assessed in this study performed similar to or better than the best available local varieties at the various locations under rainfed conditions. Some of the farmers who participated in the last year (2008) mother and baby trials selected some of the lines they preferred and had planted on their fields in 2009 which suggests that these would be adopted by farmers if they were released as new varieties.

Characterization of Jatropha lines for earliness and for high yields in the Savanna zone of Ghana

S. K. Nutsugah and J. M. Kombiok

Executive Summary

The Jatropha plant is mostly used by farmers as a life fence for their gardens or as hedges around their compounds in their communities. Even though most of the farmers know Jatropha is an oil producing crop and therefore oil can be extracted from the seeds, until of late the plant has never been

planted for oil production. With one of the objective of introducing Jatropha to rural communities to produce oil as an income generating activity to reduce poverty, it became necessary to characterize the germplasm available for earliness and for high oil content. Seven varieties were collected from Nankpanduri, Bunkpurugu, Langbensi, Nyankpala, Sogakope *(Worsunu)*, Sri-Lankan and Indian varieties from a commercial farm on the Tamale-Yendi road. The Indian variety was also transplanted and direct seeded in August at Nyankpala. Varieties collected from the Volta Region (VR) scored very low germination percentages of 5 and 10 % for Sri-Lankan and Worsonu varieties, respectively. Also, in terms of the percentage flowered plants, the lowest was again recorded for the Indian variety collected from the Volta Region. Another observation made was that there was no great difference in the percent flowered plants whether it was direct seeding or transplanted as they recorded 44% and 58% for direct seeding and transplanted, respectively.

Introduction

Jatropha is found in almost every community in Northern Ghana as a border crop or as a life fence of gardens and other portions of the house or farms. However, it has never been considered as a crop and for that matter one is not able to tell whether the plants found in these areas are of the same variety or they are made up of different varieties.

With the inception of the EU-Sponsored Jatropha Project which is community oriented, SARI was mandated to assemble the readily available germplasm, characterize them for earliness and for high yields. The purpose of this work was to recommend a variety which is either early maturing or has high yielding ability for adoption by farmers in the West Mamprusi District of the Northern Region of Ghana where the project is sited.

Methodology

The collection of germplasm started in April 2009 from both the recently established commercial farms by BioFuel Ltd (Norwegian Company) at Yendi in the Northern Region (NR) and the other in the Volta Region (VR) of Ghana. Other collections were from communities in the NR and one from the VR.

These were planted on the Experimental field at Nyankpala on the 17th August, 2009. At the same time, over grown seedlings were also purchased from the Yendi Commercial farm and planted on the same day.

Preliminary Results/Discussion

A total of seven varieties were collected from the Yendi commercial farm and local communities. The results (Table 38) showed that there was 100%

germination of all the varieties collected from the northern part of the country. The varieties that were collected from the VR scored very low germination percentages of 5% and 10% for Sri-Lankan and Worsonu varieties, respectively. Also, in terms of the percentage flowered plants, the lowest was recorded for the Indian variety collected from the VR. The low percent germination and flowered plants from the VR could be attributed to either long period in storage or the differences in environmental conditions. It has been observed that oily seeds such as soybean and groundnut lose their viability when stored for long and this may not be different from Jatropha.

Even though it is too early to conclude, one could say that based on the percent flowered plants, most of the collections from Bunkpurugu, Nyankpala, Langbensi and Nakpanduri could be the same as the Indian variety cultivated by BioFuel Ltd at Yendi.

With the exception of the varieties collected from the VR almost all the varieties recorded more than 50 % flowered plants by December 2009 (5 months after planting). This also suggests that the Indian variety collected from the NR is early maturing compared to those from the VR.

Table 38: The germination of germplasm collected and the percentage plants flowered by December 2009

Treatment (Indian Variety)	No. Planted	No. Germinated	No. Plants flowered	% flowered
Transplanted (Indian Variety)	1,120	1,120	650	58
Direct seeding (Indian Variety)	1,120	1,120	500	44
Bunkpurugu	110	110	69	62
Nakpanduri	110	110	71	64
Indian Variety (NR)	110	110	54	49
Indian Variety (VR)	110	110	20	18
Sri-Lankan Variety (VR)	110	6	3	50
Worsonu (VR)	110	9	3	33
Nyankpala	110	110	70	63
Langbensi	110	110	71	64

Another observation made was that there was no great difference in the percent flowered plants whether it was direct seeding or transplanted as they recorded 44% and 58 % for direct seeding and transplanted respectively. It was expected that the transplanted crops will flower first since the seedlings were over-grown (over six months) before transplanting. The percent germination of the seeds and percent take-up of the seedlings were each more than 90 %.

Recommendation and Conclusion
It is therefore recommended that the Indian variety should be used in the nursery to raise seedlings for farmers in the project district because it has both high percent germination and high percent take-up of seedlings. Secondly, the commercial farm at Yendi by BioFuel Ltd could be a source of seed supply to the nursery and direct to farmers.

From the results so far, and for the fact that nursery establishment is very expensive coupled with the fact that MoFA may not be able to meet the demand for the seedlings by the seven communities in the project area when the project is at its peak, direct seeding of Jatropha is highly recommended.

Insect pest survey of Jatropha

Afia Serwaa Karikari, SK Nutsugah**,** JM Kombiok and J Nboyine

Executive Summary
Jatropha curcas (the physic nut tree) originated in Central America and is currently found throughout the world in the tropics. It belongs to the family of Euphorbiaceae.

The Ghana Jatropha (GhaJa) Project is a 5-year project which will be undertaken in 7 communities during the 1st year (new communities will be added in the course of project implementation). These selected communities are within the West Mamprusi District of the Northern Region of Ghana. The project is being sponsored by the European Union and would be implemented by 4 partners in Ghana, namely TCC, CSIR-SARI, MoFA and NewEnergy.

The goal of the project is in two-fold; to combat desertification by accessing marginal lands and to provide alternate livelihoods through renewable energy production. One of the key CSIR-SARI's agronomic researches of Jatropha plant is entomological study. This is critical to ensure that insect pests of Jatropha are identified and managed for improved yield in order to achieve the second broad objective of the project.

Simple Direct Field Observation Technique was employed to identify the pests of the *Jatropha curcas* for which are reported on in the results below.

Introduction
Jatropha curcas is gaining importance commercially as a bio-diesel plant and is being advocated for development of Wastelands and dry lands. Thus it is popularly called energy plantation. Currently, Jatropha appears to be

one of the most promising feedstocks upon which the energy industry will be built.

Ghana Government has devoted a great deal of attention to bio-fuels, particularly those derived from the multi-purpose perennial crop *Jatropha curcas* L. on the basis of several successful experiences in other Sub-Saharan neighbouring countries (Mali, Burkina Faso, Tanzania and Niger).
Contrary to popular belief that toxicity and insecticidal properties of *J. curcas* are a sufficient deterrent for insects that cause economic damage in plantations, several groups of insects have overcome this barrier, particularly noteworthy is the insect order Heteroptera (Chitra and Dhyani, 2006). In Nicaragua alone there are at least 15 species with the key pest, identified as *Pachycoris klugii* Burmeister (Scutellaridae: Heteroptera), occurring at a density of 1,234 to 3,455 insects per hectare (Grimm, 1996). It is against this background that insect pest studies are being conducted for the EU-Jatropha Project to safeguard against insect pest infestation and resultant yield loss.

Materials and Methods

About 2-acre jatropha field was developed at the CSIR-SARI Experimental Station and used for the monitoring. The field was subdivided into a direct seeding and transplanted plots. A weekly visit was made to the field to monitor the plants from the seedling stage through to the fruiting stage. This was to ensure that all the insect visitors and pests at the various stages of the plant growth are recorded.

Using the direct field observation method, 10 randomly selected plants per plot were observed for 10 minutes each to record the insect visitors on the plant, their number and activities on the plants as well as disease symptoms on the plants.

Results and Discussion

Various insects were found visiting the plants. The major pests found were identified as the Scutellarid Bugs, *Calidea dregii* Germar. These pests were first observed at the beginning of flowering and their population rose sharply. At floral initiation about 1-5 insects per plant were observed, however at the peak of flowering the numbers increased to 10-30 per plant. It was observed that when the insects were not on the flowers, they were found aggregating on the leaf surfaces (Plates A&B).

Plates A&B: ***Calidea dregii*** **Germar aggregating on leaf surface**

Other insects which are assumed to be minor pests of the jatropha plants were also found. These include some moths, caterpillars, beetles and some other bugs. These insects are however yet to be identified.

Way forward

SARI is to provide agronomic expertise in the implementation of the 5-year Project. Thus the project farmers have already been trained in agronomic practices such as site selection and land preparation and would soon be trained in the identification and management of the insect pests.

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Effect of some liquid (foliar) fertilizers on the yield of maize in the Northern Region of Ghana

James M. Kombiok and Ahmed Dawuni

Executive Summary

Crop farmers in the northern part of Ghana are unable to obtain reasonable yields of most of their cereal crops without the application of fertilizers because of low soil fertility of the area. In order to address this problem of low soil fertility levels, various attempts have been made by research including the use of liquid fertilizers. However, some of these products have been made and calibrated outside the country with different soil, climatic and environmental conditions. To validate some of these products, they were compared with some of the solid fertilizers commonly used by farmers (Compound fertilizer (15-15-15), urea, Sulphate of ammonia and actyva). All the combinations of the solid fertilizers gave higher maize grain yields than the various combinations of the liquid fertilizers. The only combination that gave appreciable maize yield was Start max + Gro max and Lucky 7 +

Gro max but this was still far below the maize yields obtained from the application of half rates of the solid fertilizers.

Introduction

Major stakeholders in Agricultural development in the Northern Region of Ghana such as Researchers, Extensionists and farmers have attributed the low maize yields to low plant nutrients in the soil especially nitrogen. The results of the soil and plant tissue analysis confirm the relatively low plant nutrients which among other factors might have been responsible for the low crop yields obtained in Northern Ghana. This situation of low soil nutrients could be attributed to the annual bush burning which exposes the soil to both water and wind erosion during the rainy and dry seasons. As a result, farmers in northern Ghana are unable to obtain reasonable yields of crops without the application of fertilizers.

In order to address the problem of low soil fertility, various attempts have been made through a number of experiments established on-station. These include tillage trials with the application of both organic and in-organic fertilizers where the yields of maize and soybean in rotation are compared among the common tillage systems (tractor, bullock, hand hoe and zero tillage) (Kombiok *et al*, 2003).

Omission trials at Nyankpala and Damongo with the objective of finding out the most limiting major element through maize yields and laboratory analysis of both soil and plant materials showed that nitrogen is the most limiting element in the the North.

A lot of fertilizer companies both new and old have presented various nutrient enhancing products to be applied to the soil or on crops to assist farmers in the region who are very desperate to increase their crop yields to enhance their food security. However, these products have been made and calibrated outside the country with different soil, climatic and environmental conditions. It is in this light that it became necessary to validate such products within our socio-cultural and environmental set up before farmers are advised to purchase for use.

Objective

The objectives of this work were therefore to

- assess the effects of some liquid (foliar) fertilizers on the yield of maize.
- It was also to compare these yields with the yields obtained from the application of some of the solid fertilizers used by farmers

Materials and Methods

Site: The experimental site was at Bontanga Irrigation Project in Northern Region.

Treatments: The treatments were made up of several combinations of the liquid fertilizers as both basal and top-dressing materials with two commonly used solid fertilizers and no fertilization as controls or checks as:
1. Actyva + Actyva
2. NPK+ SA
3. ½ NPK+½ NPK+ SA
4. Start max +Gro max + Bloom max + Finish max
5. Lucky 7 + Lucky 7+ Gro max
6. Lucky 7 + Gro max
7. No fertilization (check)

Design: The treatments were laid in a Randomised Complete Block Design (RCBD) replicated three times with a plot size of 15 m^2 and the net plot of 7.5 m^2 (two rows of maize) where plants were harvested and analysed for yield and converted to per hectare basis.

Planting :The maize variety Obatampa was planted on the 17th September 2009 with a spacing of 75 cm 45 cm inter-row and intra-row respectively (2 seeds per stand).

Data collected:
1. Composite soil samples from each farmer (replicate)
3. Agronomic parameters

Data were analysed using General Linear Model programme (Statistix). The analysis of variance procedure for split-plot was used to determine whether differences existed among treatments.

Results and discussions

Generally, the grain yields of maize as affected by the various treatments were more than 2 tons/ha which is far and above what the average farmer obtains in the north.

The analysis showed that there are three groups in which the means are not significantly different from each other (Table 39). The group with the highest yield value was when Activa was used as a basal and as top-dressing fertilizer. This was closely followed by NPK +SA and ½ NPK+½ NPK+ SA in the second group which was not significantly different from the yield obtained when Start max +Gro max + Bloom max + Finish max were applied. It therefore means that with the exception of the Activa fertilizer, the yields from all the solid fertilizers are not significantly different while among the liquid fertilizers only the fourth treatment (Start max +Gro max +

Bloom max + Finish max) had similar yield as the third treatment (½ NPK+½ NPK+ SA).

Table 39: Effect of various combinations of liquid and solid fertilizer on the yield of maize at Bontanga under irrigation

Treatment	Grain yield kg/ha
1. Actyva + Activa	3866.70 ***a****
2. NPK+ SA	3377.80***ab***
3. ½ NPK+½ NPK+ SA	2933.30***abc***
4. Start max +Gro max + Bloom max + Finish max	2355.60***bc***
5. Lucky 7 + Lucky 7+ Gro max	2266.70***c***
6. Lucky 7 + Gro max	2088.90***c***
7. No fertilization	2000.00***c***
Lsd $_{(0.05)}$	508.97

*For a factor, means followed by same letter in a column are not significantly different at 5 % of probability

The higher grain yields obtained from the maize fertilized by solid fertilizers than those treated with liquid or foliar fertilizers could be due to the period of experimentation. The idea of the experimentation was conceived almost at the end of the rainy season and therefore could not be carried out during the rainy season. The experiment was therefore established under irrigation during the dry season where there was high insect infestation.

The insect pests considerably reduced the photosynthetic surface or source (leaves) of the crop hence limiting the absorption of the liquid fertilizers into the plants. Consequently, there was need for the application of some insecticides to control the insect pests which could have also competed with the foliar fertilizer for absorption since both chemicals had to pass through the stomates. These probably negatively affected the grain yields of the maize treated by liquid fertilizers while favouring those treated by the solid fertilizers.

Recommendation

There is the need to repeat the experiment during the rainy season. This will remove the adverse effects posed by insect pests as experienced during the dry season when the experiment was carried out under irrigation.

Since foliar fertilizers are new in the system, it is recommended that a technical person from the manufacturers of these products should personally carry out some demonstrations on the method and time of application of the product during the next trial period in 2010.

Conclusion

It is too early to conclude with data obtained from one year experimentation. However, it can be seen that some of the foliar fertilizers such as the combinations of Start max + Gro max and Lucky 7 + Gro max have the potentials to give maize grain yields to those obtained when solid fertilizers are applied if these difficulties of time of experimentation and method of fertilizer application are properly carried out.

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FIELD ENTOMOLOGY PROGRAMME

Dr. Abudulai Mumuni and Afia Serwaa Karkari

Introduction

Three activities were executed under the Entomology Program of the Northern Region Farming System Research Group. These were:

1. Improved production efficiency through the development and deployment of IPM programs on groundnut in West Africa. Sub-activities carried out included:

   a) Participatory integrated pest management in groundnut
   b) Field efficacy of neem products for the management of soil arthropod pests and diseases of groundnut
   c) Yield response and economics of fungicide and herbicide treatments in groundnut

2. Participatory development, diffusion and adoption of cowpea technologies for poverty reduction and sustainable livelihoods in West Africa. Sub-activities carried out included

   a) Participatory variety screening and seed multiplication by small farmers
   b) Strengthening of capacities and empowerment of grassroots through farmer field fora

3) Evaluation of neem-based products for control of bollworms in cotton

Improved Production Efficiency Through The Development And Deployment Of IPM Programs On Groundnut In West Africa

Mumuni Abudulai

Activity 1: Participatory Integrated Pest Management in Groundnut

Introduction

Groundnut or peanut or 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, groundnut yields on farmers' fields in Ghana are low averaging less than 1000 kg/ha compared to an average of 2500 kg/ha obtained in developed countries such as the United States of America. Soil arthropod pests and diseases are the main causes for the poor yields. Major soil arthropod pests include termites, white grubs, millipedes and wireworms while early and late leaf spots are the major diseases of groundnut in Ghana. Yield losses up to 70% have been attributed to these pests in West Africa.

Farmers currently do not carry out any control for these pests in groundnut farms due largely to inadequate knowledge about these pests and the available control options for them. Some farmers perceive leaf spots disease for signs of maturity. This poor knowledge is due to inadequate extension service delivery system and the fact that technologies are generally developed in isolation of farmers. Farmer participatory IPM is one approach that can build the capacity and confidence of farmers to enable them make informed decisions about their farm operations. Farmer participatory IPM recognizes the indigenous knowledge of farmers and puts farmers at the forefront of technology generation (van Huis and Merrman 1997). This empowers farmers with the capability and capacity to make good choices for sustainable crop production.

The objective of this study were (i) to improve groundnut yields for farmers through integrated pest management (IPM) -based farmer participatory research through Farmer Field School, (ii) Build the capacity of farmers on the identification and control of field pests on groundnuts.

Materials and Methods

The study involved group training of farmers in groundnut crop and pest management. Participating farmers were selected from three communities, Bagurugu, Tamalgu and Nyong, all in the Karaga District of the Northern Region, with the assistance of staff of the Ministry of Food and Agriculture. The farmers grew and monitored the groundnut crop throughout the season. The two treatments studied were 1) Farmers' practice (FP) and 2) IPM. Farmers practice plots were not treated for protection against soil pests or diseases whereas IPM plots were given at pegging treatment of soil with chlorpyrifos for control of soil pests. Thirty farmers participated in the training. They composed of 6 women and 24 men. Farmers worked in five groups representing five replications, and each group tested the two treatments on their plots. The training sessions were interactive and held once every two weeks. Components of the training included learning crop growth habits, preventive measures for soil arthropod pests and diseases such as maintaining good farm hygiene, skills in arthropod pests and diseases identification and their management. Also, special topics on relevant areas of groundnut production were held to further build capacity of farmers.

Results and Discussion

The results of the study showed that percentage of bored pods was significantly lower on IPM plots compared with FP plots. Percentage of scarified pods and pod yield were not significantly different between IPM and FP plots, although damage tended to be lower and yields higher in IPM plots compared to FP plots.

A check box interview conducted at the end of the season showed that 90% of the participating farmers said the training was beneficial to them. They indicated that through the training they could identify the major soil pests and diseases attacking groundnut and how to manage them in their fields. They also agreed that the closer spacing on the IPM plots were better than that on their FP plots as the former resulted in increased plant population and probably resulted in the higher pod yield.

Activity 2: Field Efficacy of Neem products for the Management of Soil Arthropod Pests and Diseases of Groundnut

Introduction

The soil arthropods, termite, white grubs, millipedes and wireworms, and leaf spot diseases are major constraints to groundnut production in Ghana (Abudulai *et al*. 2007, 2010). Soil pests damage plants by feeding on developing pegs, pods and seeds inside pods. The damage is usually done before the pests are seen due to their subterranean and cryptic nature of feeding. Some of these pests are also implicated for transmitting plant pathogens such as the fungus *Aspergillus flavus* that can cause cancer in humans. Leaf spot diseases limit the effective photosynthetic area of the leaf resulting in poor yields. Together, these biotic constraints can cause up to 70 percent yield loss in groundnut. The conventional method of control for these pests in the developed countries such as the United States is the use of chlorpyrifos soil treatment against soil pests and fungicide sprays for leaf spot diseases. However, in Ghana farmers seldom control these pests in their fields, which may be attributed to limited financial resources to use chemical control.

Products of the neem tree, which is ubiquitous in Africa have, demonstrated effectiveness against many pest species on crops (Schmutterer, 1990) and could be a cheap source of biopesticide for control of soil arthropod pests and diseases of groundnut. The objective of this study therefore was to evaluate neem products for the management of soil arthropod pests and diseases of groundnut.

Materials and Methods

The study was conducted on-station at Nyankpala and on-farm at Bagurugu, both in the Northern Region during the 2009 crop season. The experimental layout was a randomized complete block design and treatments were replicated four times. Each plot consisted of six rows 5 m long with spacing of 0.4 m between rows and 0.1 m between plants in a row. The groundnut cv Chinese was used and planted on 10 June at Nyankpala and 25 June at Bagurugu. Treatments consisted of neem seed extract (NSE) and neem seed powder (NSP) applied separately at the rates of 10.5 and 21.0 kg ha^{-1} at either planting or at pegging stage (50 days after planting) of the crop. Untreated control and plots treated with Chlorpyrifos were included as checks. All treatments were applied into the soil as soil drench along planting rows.

Data collection

Randomly selected samples of 5 plants were dug with the associated soil around the root zone for soil pests. The samples were taken at harvest from within the outer two rows of each plot and data were recorded on the numbers of pests on plants and soil samples. Samples of 100 pods were taken to determine numbers of pods that were scarified or bored into by soil pests and were converted to percentages. Severity of leaf spot disease ratings was conducted on 10 randomly selected plants at 30, 60 and 90 days after planting using the Florida scale of 1-10 (Chiteka *et al*. 1997). Percentage leaf defoliation was assessed once at 90 DAP before harvest. The middle four rows of each plot were harvested to determine yield

Results and Discussions

At Nyankpala, neem treatments lowered populations of millipedes but not those for white grubs and wireworms compared with control. Termites were not recorded on test plots. Neem treatment also lowered the severity of both early and late leaf spot diseases as well as leaf defoliation than the control. Percentage of bored pods was reduced in neem-treated plots than the control. There were however no significant differences detected among the treatments in percentages of scarified pods and pod yield.

At Bagurugu, millipede, white grub and termite were recorded but there were no significant differences detected in their populations among the treatments. Severity of early and late leaf spot diseases were generally reduced in neem and chlorpyrifos treatments than in control. Also, percentage leaf defoliation was lower in neem treatments than control. Neem treatments also resulted in significantly lower percentages of scarified and bored pods by soil arthropods and a higher pod yield than control.

These results demonstrate the potential of neem products for control of soil arthropod and disease pests in groundnut.

Activity 3: Yield Response and Economics of Fungicide and Herbicide Treatments in Groundnut in Ghana

Introduction
Early leaf spots caused by *Cercospora arachidicola* Hori and late leaf spots caused by *Cercosporidium personatum* (Berk. & M.A. Curtis Deighton) and weeds are major biotic constraints to groundnut production in Ghana (Abudulai *et al* 2007, Dzomeku *et al*. 2009). Pod yield losses of up to 50% are reported in West Africa without disease management (Subrahmaniyan *et al.*, 2002) and between 50 to 80% due to weed interference (Akobundu 1987).

Until recently, most farmers in Ghana mistook leaf spot diseases for signs of maturity especially when they became more severe towards the end of the growing cycle. Elsewhere, in the developed nations, fungicides are applied to control foliar diseases in groundnut. In Ghana, however, farmers are yet to adopt the practice of controlling leaf spot diseases in groundnut. For weed control, farmers use both manual hand weeding and herbicides. The pre-emergent herbicide Pendimethalin is the most commonly used in groundnuts.

The objective of this study was to determine yield response to fungicide and herbicide treatments as well as an evaluation of economics of their use in groundnut.

Materials and Methods
The trial was conducted at Nyankpala and Bagurugu in the Northern Region during the 2009 cropping season. The experiment was factorial in a randomized complete block design, with four herbicide and two fungicide treatment levels. The herbicide treatments composed of 1) hand-weeded, 2) No hand-weeding or herbicide (weed check), 3) herbicide with hand-weeding, 4) herbicide with no hand weeding. The pre-emergent herbicide Pendimethalin (Stomp 4E) was used. The fungicide treatments were sprayed

and unsprayed. Fungicide applications were made at two weeks interval starting 28 DAP with chlorothalonil applied as first and third spray and Trical 250 EC applied as second and forth spray. All treatments were replicated four times. The cultivar Chinese was used in the study. Each experimental plot consisted of 8 rows 8 m long by 4 m wide, with 1.5 m alley between the plots and replicates to minimize inter-plot interference.

Results and Discussions

Among weed control strategies, severity of early leaf spot was significantly reduced in fungicide sprayed plots compared to unsprayed plots (Table 40). Within fungicide spayed plots early leaf spot severity was greater in plots that received herbicide weed protection without an additional hand weeding compared to the other weed control strategy plots. It is probable that the herbicide led to emergence of weed species later in the season that acted as refuge for the disease. Pendimethalin is effective against broad leaf and grass weeds. In unsprayed plots, early leaf spot severity was similar among weed control strategies. Similar trends of severity were observed for late leaf spot diseases both within weed control strategies and fungicide protection treatments (Table 41).

Within weed control strategies, percent leaf defoliation was lower in fungicide sprayed plots compared to unsprayed plots. Within fungicide protection treatments, percent leaf defoliation was significantly lower in plots that received herbicide treatment without an additional hand weeding than the other treatments except the weedy check plots. In unsprayed plots, leaf defoliation was lowest in the hand weeded plots and greatest in the weedy check plots. The number of pods per plant was generally lower in the weedy check plot than the other weed control strategy plots. Pod count was greater in fungicide sprayed than unsprayed plots. Pod yield was greatest in fungicide sprayed plots than unsprayed plots for all the weed control strategies. On sprayed plots, pod yield was generally greater in all weed control strategy plots than the weedy check plots. Haulm weight was not significantly different among the weed control strategy treatments. However, fungicide treatment significantly increased haulm weight than unsprayed plots. This was probably due to the retention of leaves in fungicide treated plots than unsprayed plots as was observed on the field at the time of harvest.

Table 40. Effect of weed control strategy and fungicide protection on severity of early leaf spot disease on groundnut

Weed Control Strategy	Fungicide Protection		
	Sprayed	Unsprayed	**Mean**
Hand weeded	1.6 b B	3.1 a A	**2.3**
No weeding or	1.6 b B	3.4 a A	**2.5**

herbicide			
Herbicide with weeding	1.8 b B	3.3 a A	**2.5**
Herbicide without weeding	2.6 a B	3.5 a A	**3.0**
Mean	**1.9**	**3.5**	

Table 41. Effect of weed control strategy and fungicide protection on severity of late leaf spot disease on groundnut

Weed Control Strategy	Fungicide Protection		
	Sprayed	Unsprayed	**Mean**
Hand weeded	2.3 bc B	3.7 a A	**3.0**
No weeding or herbicide	2.1 c B	3.9 a A	**3.0**
Herbicide with weeding	2.5 b B	3.9 a A	**3.2**
Herbicide without weeding	3.0 a B	4.1 a A	**3.5**
Mean	**2.5**	**3.9**	

Participatory Development, Diffusion And Adoption Of Cowpea Technologies For Poverty Reduction And Sustainable Livelihoods In West Africa

Activity 1: Participatory Variety Screening and Seed Multiplication by Small Farmers

Introduction

Scientists from both national and international research institutes have developed improved technologies including high yielding cowpea varieties but only a few are adopted by farmers. The reasons include inadequate exposure to the new varieties or the varieties do not adequately satisfy farmers' needs (Richards, 1985). The seed industry is also not well developed for most crops including cowpea, which sometimes leaves farmers with no option but to continue to use their own seed albeit low yielding. Participatory variety screening (PVS) has shown success in identifying cultivars preferred by farmers and accelerating their dissemination (Joshi and Witcombe, 1996).

The objective of this study was to improve farmers' access to quality cowpea seeds through participatory variety screening and seed multiplication.

Materials and Methods

Twenty two cowpea varieties were evaluated at Bukpomo and Savelugu communities in the Northern Region. The varieties included both released and those still under evaluation for release. The experiments were planted by 38 participating farmers at Bukpomo on 04 August 2009 and by 42 farmers at Savelugu on 15 August 2009. Each variety was planted in four rows, 5 m long by 2.4 m wide. The experimental design was a randomized complete block and treatments were replicated three times. Normal agronomic practices were followed and plots were protected against insects with Lambda cyhalothrin (PAWA 2.5 EC). Farmers, working in five groups, assessed the varieties at the vegetative stage at 20 days after planting (DAP) and during podding at 50 DAP. The varieties were assessed based on a preference score of 1 to 3, where 1 = least preferred and 3 = most preferred. Reasons advanced by farmers for a preference of a variety over another were documented. The experimental plots were harvested on 21 and 28 October 2009, respectively.

Results and Discussions

The scores given as preferences by farmers for the 22 cowpea varieties and yields obtained at the two locations are presented in Table 42. The scores were significantly different for the varieties when they were assessed at the vegetative stage at Savelugu and at podding stage at both Bukpomo and Savelugu. At the vegetative stage, nine varieties including Padi-Tuya, SARC 1-13-1, SARC 1-71-2, Songotra, Zaayura, SARC 1-136-1, SARC 3-103-1, SARC 3-74A-2 and Apagbaala were the most preferred by farmers at Savelugu. Across locations, SARC 1-71-2 had the highest mean score of 2.6 followed by SARC1-13-1, SARC 3-103-1, Bawutawuta and Zaayura with mean scores of 2.5 each and thus were the most preferred varieties by farmers at the vegetative stage. At the podding stage, 10 varieties including SARC 3-154-1, IT 98K-506-1, Padi-Tuya, Songotra, Zaayura, SARC 3-74A-2, SARC 3-90-2, SARC 2-115-1, SARC 1-18-2 and SARC 1-82-1 had the highest mean scores ranging from 2.5 to 2.9 and were the most preferred by farmers at Savelugu.

At Bukpomo, Bawutawuta, Songotra, Zaayura, Padi-Tuya, SARC 1-136-1, SARC 1-82-1, SARC 1-13-1, SARC 4-40 and Apagbaala were the most preferred at the podding stage. Across locations, SARC 1-18-2, SARC 1-13-1, IT 98k-506-1, SARC 3-154-1, Padi-Tuya, Bawutawuta, SARC 3-74A-2, Apagbaala, Zaayura, Songotra and SARC 1-82-1 had mean scores ranging from 2.5 to 2.8 at podding and were considered the best by farmers. At the vegetative stage, reasons advanced for their preference scores were plant vigor, weed competitive ability of the variety, level of branching and ability to withstand insect pest damage. Those with high levels of these traits were given high scores and low scores for those with low levels of the traits. At podding, farmers gave high scores for varieties that showed earliness, heavy pod load, long pods and large grain size in pods when indicating their preferences for the varieties. The selection criteria and preference scores for the varieties were similar to those obtained in 2008.

Yields did not differ significantly among the varieties at Bukpomo, but differed at Savelugu. At Savelugu, varieties with the greatest yield included Bawutawuta, IT 98k-506-1, Songotra, Zaayura, SARC 1-71-2, SARC 2-51-1, SARC 3-154-1, SARC 2-115-1, SARC 1-92-1, SARC 1-13-1, SARC 1-71-1 and Marfo Tuya. Across locations, yields were highest and similar for 12 varieties including Bawutawuta, IT 98k-506-1, Songotra, Zaayura, SARC 2-51-1, SARC 3-154-1, SARC 2-115-1, SARC 1-82-1, SARC 1-13-1, SARC 1-71-1 and Marfo Tuya. Some of these high yielding varieties (e.g. Zaayura, Bawutawuta and Songotra) were also selected by farmers as their most preferred varieties especially at the podding stage assessment.

Table 42. Mean scores[1] of farmers' preferences for cowpea varieties at the vegetative and podding,stages and cowpea yields in a participatory varietal selection conducted at Bukpomo and Savelugu in 2009.

	Scores at vegetative stage		**Mean**	Scores at podding stage		**Mean**	Yield kg/ha		**Mean**
Variety[1]	Savelugu	Bukpomo		Savelugu	Bukpomo		Savelugu	Bukpomo	
BAWUTAWUTA	2.3 c-g	2.7	2.5 ab	2.3 c-f	2.9 a	2.6 a-c	1077.8 a-c	780.6	929.2
SARC 3-129-2	2.4 b-f	2.2	2.3 a-e	2.1 fg	2.1 d-g	2.1 gh	719.4 e-h	816.7	768.1
IT 98K-506-1	1.7 h-j	2.6	2.2 b-f	2.6 a-d	2.3 c-f	2.5 a-e	1052.8 a-d	925.0	988.9
SONGOTRA	2.5 a-e	2.1	2.3 a-e	2.8 ab	2.7 a-c	2.8 ab	1122.2 ab	900.0	1011.1
ZAAYURA	2.6 a-d	2.3	2.5 ab	2.6 a-d	3.0 a	2.8 a	969.4 a-e	1008.3	988.9
SARC 1-71-2	2.8 a-c	2.3	2.6 a	2.3 c-f	2.1 d-g	2.2 e-h	927.8 a-e	994.4	961.1
SARC 2-51-1	2.2 d-h	2.0	2.1 c-f	2.2 d-f	1.5 h	1.9 h	1152.8 a	955.6	1054.2
SARC 3-154-1	1.9 f-j	1.9	1.9 e-g	2.9 a	2.3 c-f	2.6 a-d	1125.0 ab	1030.6	1077.8
SARC 3-90-2	1.9 f-j	1.8	1.9 fg	2.7 a-c	1.9 gh	2.3 d-g	897.2 b-f	822.2	859.7
Padi-Tuya	2.9 a	1.9	2.4 a-d	2.5 a-e	2.7 a-c	2.6 a-d	900.0 b-f	772.2	836.1
SARC 1-136-1	2.5 a-e	2.1	2.3 a-e	2.1 ef	2.7 a-c	2.4 b-g	833.3 c-g	608.3	720.8
SARC 3-103-1	2.6 a-d	2.3	2.5 ab	2.1 ef	2.1 d-g	2.1 f-h	805.6 d-g	869.4	837.5
SARC 2-115-1	1.7 h-j	2.1	1.9 f-g	2.8 ab	2.0 f-h	2.4 b-g	983.3 a-d	902.8	943.1
SARC 1-18-2	1.8 h-j	2.2	2.0 e-g	2.6 a-d	2.4 b-f	2.5 a-e	497.2 h	633.3	565.3

SARC 4-51	1.5 j	1.8	1.7 g	1.7 gh	2.1 d-g	1.9 h	891.7 b-f	838.9	865.3
SARC 3-74A-2	2.7 a-c	2.1	2.4 a-c	2.9 a	2.4 b-f	2.7 ab	622.2 gh	716.7	669.5
SARC 1-82-1	2.1 e-i	2.5	2.3 a-e	2.8 ab	2.6 a-d	2.7 ab	908.3 a-e	763.9	836.1
SARC 1-13-1	2.9 a	2.1	2.5 ab	2.4 b-f	2.5 a-e	2.5 a-f	925.0 a-e	866.7	895.0
SARC 1-71-1	1.9 f-j	2.1	2.0 e-g	2.1 ef	2.4 b-f	2.3 d-g	1002.8 a-d	783.3	893.1
SARC 4-40	1.9 f-j	2.1	2.0 d-f	1.5 h	2.6 a-d	2.1 gh	655.6 f-h	741.7	698.7
MARFO-TUYA	2.1 e-i	1.7	1.9 fg	2.3 c-f	2.3 c-f	2.3 c-g	905.6 a-f	841.7	873.7
APAGBAALA	2.5 a-e	2.3	2.4 a-d	2.4 b-f	2.9 ab	2.7 a-c	730.6 e-h	891.7	811.2
P > F	< 0.0001	0.0604	<0.0001	< 0.0001	< 0.0001	<0.0001	0.0001	0.1078	0.0509

A score of 1 = least preferred and 3 = most preferred. Scores ≥ 2.3 at the vegetative stage and ≥ 2.5 at podding were considered best by farmers according to LSD mean separation test at P < 0.05.

Activity 2: Strengthening of capacities and empowerment of grassroots through farmer field fora

Introduction

Farmers operate in a heterogeneous environment that requires site-specific solutions. There is therefore the need for a paradigm shift from the system where technologies are developed and passed on to farmers to one that involves scientists, extension officers and farmers in the technology development and dissemination process. With the farmer field fora (FFF) approach, farmers are empowered with the requisite knowledge and skills to enable them make informed decisions about their farm operations.

The objective of this study was to strengthen the capacities of small-scale farmers on proper management practices for cowpea through participatory diagnostic farmer field fora.

Materials and Methods

This study involved group training of farmers using integrated pest management (IPM) approach and through farmer field fora. Farmers grew and monitored cowpea throughout the 2009 crop season at Bukpomo and Savelugu communities. The two treatments studied included 1) Farmers' practice (FP), and 2) Integrated Pest Management (IPM). Plants on IPM plots were treated with 10% aqueous suspension of neem seed extract (NSE) with one round of a pyrethroid insecticide (Lambda cyhalothrin) at initiation of flowering while those on FP plots were treated wholly with insecticide. Plot sizes were 10 x 10 m. IPM and FP plots were laid side by side. Plots at Bukpomo were planted on 4th August, 2009 while those at Savelugu were planted on 15th August, 2009. Participating farmers were divided into five groups and each group was considered as a replicate to test the two treatments on their plots. The training sessions were interactive and were held once a week. At each session, farmers met during Agro-ecosystem analysis (AESA) to diagnose problems on their plots which they discussed at a plenary session and suggested possible interventions for their fields. Researchers, technicians and MoFA staff facilitated the training. Farmers learnt crop growth habits, early preventive measures for insect pests and diseases, and acquired skills in insect pests and disease identification and management practices. A pre- and post-training ballot box tests were conducted to evaluate the knowledge and skills of participants.

Results and Discussion

At Bukpomo community, 40 farmers comprising 25 males and 15 females participated in the training. Twenty farmers of the 40 farmers had previous training as farmer facilitators while the remaining 20 farmers received training as new facilitators. At Savelugu community, 42 farmers comprising

21 males and 21 females were trained during the FFF. Out of this number, 17 farmers had previous training while the remaining 25 farmers received training as new farmer facilitators.

Results of the ballot box test showed that 80% of the participants across locations had improved knowledge in identifying insect pests and their damage to cowpea as well as skills in general pest management. Farmers' capacities also were strengthened through presentation of special topics on relevant areas of cowpea production by resource persons.

Grain yield from Bukpomo was significantly higher for the FP than IPM plots . Yields at Savelugu were not significantly different between the two treatments. Yields were however lower at Savelugu compared to those at Bukpomo. This was probably due to the differences in the planting dates as the planting for Savelugu was delayed and also coincided with the period of heavy rains which probably affected plants growth and yield. There were no significant differences observed between the two treatments in lowing pest population densities and damage.

Evaluation of Neem-based Products for Control of Bollworm in Cotton

Introduction

The bollworm complex comprising the American bollworm *Helicoverpa armigera* (Hubner), Spiny bollworm *Earias* spp, Pink bollworm *Pectinophora gossypiella,* Sudan bollworm *Diparopsis watersii* (Rothschild) and the False codling moth *Cryptophlebia leucotreta* are the most destructive insect pests of cotton in Ghana and throughout Africa. The adults invade cotton fields for oviposition from the square formation stage. The emerging larvae, which are the destructive stage, damage plant terminals and also chew into squares and developing bolls, resulting in abscision of these floral organs and loss in seed cotton yield. The feeding damage also predisposes the fruiting structures to infection by rot organisms. Other insect pests of cotton albeit of lower importance include Cotton strainers, Aphids, Whiteflies, Leafhoppers and leaf worm.

Current control practice relies primarily on chemical insecticides. However, this pesticide dependence has led to the development of bollworm populations that are highly resistant to commonly used insecticides in West Africa (Matin *et al*., 2000). There is also increased cost to farmers and pollution of the environment from insecticide control. These problems have heightened the need to develop alternative strategies and tactics for management of bollworms in cotton.

Extracts from the neem (*Azadirachta indica*) have demonstrated activity as a potent insecticide against over 400 insect pest species. Neem acts as an antifeedant and a repellent as well as a growth regulator in insects (Schmutterer 1990, Isman 2005). Neem extracts are less persistent in the environment and also benign to non-target organisms. Moreover, the tree is ubiquitous in Africa and therefore can be a cheap source of biopesticides for control of pests in cotton.

The objective of the study was to evaluate neem-based products for control of insect pests, particularly bollworms in cotton

Materials and Methods

The research was carried out on-station at Nyankpala during the 2009 cropping season. A randomized complete block design was used for the experiment. Treatments were 1) 5% neem seed extract (NSE), 2) 10% NSE, 3) 2% neem seed oil (NSO), 4) 5% NSO, 5) lambda cyhalothrin (PAWA) and 6) water-treated control. Plot size was 10 rows 10 m long, with 2 m between plots and blocks. Applications of neem began at square formation stage during which time bollworms start to invade cotton fields.

Bollworm incidence and densities were recorded on 20 plants per plot from square formation stage until harvest. Densities were averaged to obtain means for analysis. Natural enemies of insects were also recorded. Data were recorded on the number of damaged bolls and number of bolls per plant. Additionally, data were recorded on seed cotton yield and percent yield loss was calculated.

Results and Discussions

Populations of bollworms were similar and significantly lower in neem and insecticide-treatments than control (Table 43). Numbers of bolls per plant were significantly greater when plots were treated with NSE or with insecticide than the control. There were no significant differences detected between control and plots that were treated with 2 and 5% NSO. Seed cotton yield was greatest when plots were treated with insecticide. However, yield was significantly higher in neem-treated plots than control. As expected, percent yield loss was greatest in control plots than in neem and insecticide-treated plots. These results demonstrate that neem was efficacious for control of bollworms in cotton. Several authors (e.g. Gajmer *et al*., 2002; De-Ling *et al*., 2004; Greenberg *et al*., 2005) have reported similar findings for neem in cotton.

Table 43. Efficacy of Neem for Control of Bollworms in Cotton

Treatment	No. bollworms/ plant	No. bolls/ plant	Yield Kg ha^{1}	Yield loss %
5 % neem seed extract	2.2 b	102.0 ab	350.8 b	31.7 b
10 % neem seed extract	1.9 b	98.7 b	351.0 b	35.4 b
2 % neem oil	2.4 b	85.7 bc	292.7 b	33.9 b
5 % neem oil	2.1 b	93.3 bc	341.7 b	29.8 b
Endosulfan	1.8 b	123.0 a	614.0 a	18.4 c
Control	4.3 a	72.8 c	144.0 c	56.8 a
P > F	0.0065	0.0072	<0.0001	<0.0001

An emergency initiative to boost rice production in Ghana

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Executive Summary

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

Two key meetings were held at CSIR-SARI, Nyankpala on March 17 and April 17 2009 as a follow up to taking major decisions to advance the smooth implementation of the project with emphasis on the roles of the various stakeholders. The second meeting was the result of the recommendations and conclusions emanating from the 1st Regional

Coordination meeting held on April 8-10, 2009 at Cotonou, Benin. Dr. O. Ajayi, Project Manager for Ghana and Nigeria visited Ghana from April 15-17, 2009 to facilitate and finalize the Workplan for Ghana. He also participated in the monitoring of seed quality of Ghana's seed stock. The meeting afforded the actors in the seed sector the opportunity to plan for the production of Breeder, Foundation and Certified seeds for 2010 cropping season and also for Dr. Ajayi to conduct quality assessment of Ghana's seed stock and report appropriately.

During the second quarter, Grains and Legumes Development Board collected 20 kg of Breeder seed of Jasmine 85 to produce Foundation seed for 2010 cropping season. SARI facilitated the supply of 3,125 kg of Foundation seed (Digan, GR 18 and Jasmine 85) to SeedPAG to produce Certified seed for distribution to project farmers. SARI also facilitated the packaging and distribution of Certified seed to 4,300 farmers across the three project regions through the assistance of CRS/Ghana and Diocesan Partners, IFDC, Agro-Input Dealers, SeedPAG and MoFA. SARI in collaboration with CRS/Ghana and Partners and other key stakeholders organized seed fairs for farmers in the three project regions. The events were very successful and aired on the national radio and television. The seed fairs afforded the opportunity for mass and media sensitization of the project in the three regions.

The training of trainers on best-bet practices was an on-going activity and would continue throughout the season. Selected agricultural extension agents (AEAs) and their supervisors were taken through the theory of the best-bet rice management options in all the three regions. The English version of the video clips on the management practices were multiplied and supplied to all the regional coordinators, CRS/Ghana and Partners and AEAs to enhance dissemination. Translation into 4 major languages namely Dagbani, Kusal, Gonja and Dagaari was completed while Buli, Sissali and Kassin are still in progress. Delay in translation was due to unavailability of radio scripts of the key rice management practices from land preparation to harvest and post-harvest activities at the time of taking delivery of the videos.

The third quarter gave a clearer picture of the farmers who implemented the project across the regions. A total of **2,740 registered farmers** collected and planted improved seed supplied by the project. The break down for the regions was as follows: **Northern Region, 900; Upper West Region, 773; and Upper East Region, 1,067**. Two types of demonstrations were planned and implemented in each of the project districts. The objectives of the demonstration were to show the beneficial effects of fertilizer use in rice production and assess the agronomic and economic benefits of efficient placement of fertilizer.

During the fourth quarter, field and open days were carried out across the regions to show the performance of demonstration farms in terms of yield difference in treatment effects. Thirteen field and open days were held in the three project regions with a total of 1,514 farmers participating in the event. Yield assessments were carried out to determine the performance of paddy yield across the regions. The average paddy yields were 2,990, 3,040 and 3,020 kg/ha for Northern, Upper East and Upper West Regions, respectively. The beneficial effects of fertilizer use in rice production and agronomic and economic benefits of efficient placement of fertilizer were clearly visible during the field days.

Country Coordinating Unit meetings to review progress reports and well-being analysis to improve upon project activity in Yr 2 were some of the focal activities undertaken. Well-being analysis workshops were held in Upper East and Upper West Regions in December 2009 with over 70 extension agents and district development officers participating to engage the community members in poverty classification and ranking of households. Regional and Coordinating level meetings were held to review the performance of the actors in the implementation of the project activities. These review meetings largely contributed to the achievement of the intermediate results of the project. The project produced the required quantity of Breeder and Foundation seeds for the 2010 cropping season. SARI supplied Foundation seed of Digan, GR 18 and Jasmine 85 to SeedPAG to produce Certified seed for distribution to project farmers during the 2010 cropping season.

The way forward has been mapped out with the selection of new project sites to meet the target of 10,000 farmers, organization of well-being analysis workshops to be followed up with farmer registration exercise, training of SeedPAG members across the three regions and plans to link up with Government’s rice block farming project to acquire fertilizer for the project farmers through the coupon system. The Activity Plan for the next quarter (January –March 2010) is included in the way forward.

Background

The Africa Rice Center, Catholic Relief Services (CRS) and the International Center for Soil Fertility and Agricultural Development (IFDC) led a network of national agricultural research organizations, NGOs and local implementing partners in proposing an Emergency Rice Initiative, a two-year initiative to boost rice production in West Africa. The USAID provided the sum of 5.1 million USD to boost rice production in 4 West African countries – Ghana, Mali, Nigeria and Senegal.

The Initiative is targeting 10,000 poor rice farm families in each of the 4 countries. The objective is to boost total domestic rice production in these countries by a total of 30,000 tonnes of paddy rice with a current market value of about US$21 million. This Initiative aims to improve farmers' access to rice seed and fertilizer and to expand knowledge on best-bet rice technologies. It aims to provide certified rice seed and mineral fertilizer inputs to 10,000 farmers through existing distribution channels such as the private sector, government and non-government agencies (i.e. Catholic Relief Services).

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

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

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

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

Achievements

Intermediate Result	Output	Achievements
IR 1.2: Partners & target farmers & implementation & M&E mechanisms are identified	Country Coordination Unit (CCU) was established Collaborative linkages well	CCU is functional; meets quarterly to review progress report Ecologies selected, coverage area and number of farmers known Criteria for beneficiary selection documented Check list for baseline survey

	developed and functional Target farmers identified, selected and registered	documented Site selected and documented Mode of access to seed and fertilizer finalized 4,282 farmers registered across the 3 regions (see breakdown in CRS/Ghana report & regional reports)

Intermediate Result	Output	Achievements
IR 2.1: Rice seed is multiplied in sufficient quantities for distribution to target farmers in 2009 & 2010 cropping seasons	87 kg of Breeder seed, 3,125 kg of Foundation seed & 125,000 kg of Certified seed produced & distributed	SARI, MoFA, SeedPAG, GLDB &CRS/Ghana involved in seed packaging and distribution Seed cleaning and certification conducted by Seed Inspection Unit of MoFA Seed fairs organized in all the 3 project regions

Intermediate Result	Output	Achievements
IR 4.2: Best-bet rice management options identified & distributed to farmers through a variety of methodologies including video	Videos translated into Dagbani, Kusal, Sissali, Dagaari, Gonja, Buli & Kassin	CDs of best-bet practices made available to regional coordinators & CRS/Ghana for extension purposes TOT on best-bet practices was conducted in all the three project regions Radio programs were carried out in the local languages

Problems and Solutions

Problem 1. Funds were not transferred to SARI as initially communicated to the National Coordinator by the Project Manager.

Solution 1. SARI has pre-financed all operations up to date.

Problem 2. In-country travel budget is inadequate. The geographical location of the sites are far apart; for example one needs to cover 6 hours by

Land cruiser or Nissan Patrol to get to Upper West Region before proceeding to the districts for M&E.

Solution 2. Permission is being sought to veer funds from indirect cost to supplement the budget for in-country travel.

Problem 3. Logistics to travel in-country for M&E to project sites is very critical to the success of the project.

Solution 3. There is the need to hire a vehicle for M&E from the indirect cost.

Problem 4. Seed distribution to the regional capitals and subsequent delivery to the districts was very hectic and expensive due to the fact that the agro-input dealers are not well resourced.

Solution 4. SARI facilitated the distribution and delivery of seed to a large extent by providing logistics and other assistance to conclude the exercise.

Problem 5. Provision of per diem, fuel and lubricant to AEAs and their Supervisors for monitoring and evaluation is becoming expensive.

Solution 5. SARI supported AEAs and Supervisors for June and July to cater for this activity.

Problem 6. CRS/Ghana exceeded its budgetary limit to meet the expenses involved in the seed fairs in the three project regions.

Solution 6. SARI supported CRS/Ghana by absorbing 60% of the expenses incurred on the seed fairs.

Problem 7. One of the three rice varieties GR 18 was in short supply.

Solution 7. Rice variety CT 8837-1-17-1P was substituted to meet the demand.

Problem 8. Some farmers opted out of the project to plant their own seed due to late delivery of the seed materials.

Solution 8. AEAs and DDOs were advised to find replacement for them.

Problem 9. Input Dealers enthusiasm to send inputs to rural communities was very low thereby affected timely delivery.

Solution 9. AEAs and DDOs got involved in input distribution in some instances.

Problem 10. Government fertilizer coupons were not easily accessible. Further, there were fertilizer shortages in some communities.

Solution 11. DDOs used personal contact to facilitate the process. Fertilizer was purchased on the open market to augment what was obtained through government coupons. CRS Head of Agriculture worked with DDOs to obtain fertilizer from YARA.

Problem 12. Collection of quantitative data was overwhelming for the AEAs and therefore affected yield comparison to a large extent.

Solution 12. Decision was taken to restrict data collection to at least 25% of farmers who put into practice the best-bet rice management practices.

Meetings and Visits (Objectives and Recommendations)

i). Pre-Launching Meeting, Accra, January 14, 2009: In-house preparation for the launch of the USAID Emergency Rice Initiative Project; Agreed on the main actors in the rice sector to participate in the Launching Ceremony; Review the entire project milestones.

ii). Launching Workshop/Meeting, Accra, January 30, 2009: Launch of project and Project Implementation Team; National Coordinator and Administrative Assistant in place and functioning well.

iii). Project Manager (Nigeria & Ghana) and Ghana National Coordinator's Meeting, Cotonou, Benin, March 5-6, 2009: Discuss Ghana workplan with Dr. O. Ajayi for compilation and submission to WARDA. I took the opportunity to interact with Dr. Wopereis Marco about the readiness of Ghana to participate in the project implementation.

iv). Key Stakeholders' Meeting, Nyankpala, Tamale, March 17, 2009: Interact with key stakeholders for the smooth take off of the project; Key decisions were taken and roles assigned for prompt action.

v). 1st Regional Coordination Meeting, Cotonou, Benin, April 8-10, 2009: Give update of project progress report: Significant decisions taken to review Ghana workplan and monitor seed quality of Ghana seed stock.

vi). Facilitation and Finalization of Workplan for Ghana and Seed Quality Monitoring Meeting, Nyankpala, Tamale, April 17, 2009: Follow up visit to Ghana by Dr. O. Ajayi, Project Manager for Ghana & Nigeria.

vii). Regional Coordinators Meeting, Nyankpala, Tamale, April 25, 2009: Review Ghana workplan and give update on regional activities to beef up quarterly report.

viii). Country Coordinating Unit (CCU) Meeting, Wa on 1st June, 2009: Pre-seed fair meeting to discuss the preparation and programme for the event.

ix). CCU Meeting, Nyankpala on 5th June, 2009: Review the constraints encountered during the seed distribution to the regions.

x). CCU Meeting at SARI, Nyankpala on 8th June, 2009: Review seed fairs and strategize on smooth implementation of the project.

xi). Regional Coordinators Meeting, Nyankpala, 18th June, Wa, 23rd June and Bolgatanga, 26th June, 2009: Discussion meeting with AEAs and Supervisors on per diem and fuel for monitoring and evaluation of project activities.

xii). Regional Coordinators Meeting, Nyankpala, Tamale, 30th June, 2009: Review Ghana workplan for the quarter under review and give update on regional activities to beef up quarterly report.

xiii). CCU Meeting, Nyankpala on 14th September, 2009: Project Review meeting to discuss the seed and fertilizer distribution in the three regions. AEAs and DDOs were charged to retrieve the remaining seed from Dealers for delivery to SARI.

xiv). UE Regional Coordinator's Meeting with AEAs and Input Dealers, Bolga on 16th September, 2009: Review the progress of project implementation and update on activities of AEAs and Input Dealers in input acquisition and distribution. AEAs and DDOs were charged to retrieve the remaining seed from Dealers for delivery to SARI.

xv). UW Regional Coordinator's Meeting with AEAs and Input Dealers, Wa on 18th September, 2009: Review the progress of project implementation and update on activities of AEAs and Input Dealers in input acquisition and distribution. AEAs and DDOs were charged to retrieve the remaining seed from Dealers for delivery to SARI.

xvi). NR Regional Coordinator's Meeting with AEAs and Input Dealers, Nyankpala on 23rd September, 2009: Review the progress of project implementation and update on activities of AEAs and Input Dealers in input acquisition and distribution. AEAs and DDOs were charged to retrieve the remaining seed from Dealers for delivery to SARI.

xvii). CCU Meeting with ERI Project Manager, Ghana & Nigeria and Regional Coordinator – Drs. Olupomi Ajayi & Ndiaye Kabirou, Nyankpala on 12th October, 2009: Project Review meeting to plan monitoring and evaluation of field activities in the three project regions. Strategies were mapped out for effective monitoring tour of the project fields in the regions.

xviii). M&E tour of fields in Upper West Region on 13-14, October 2009: Five out of the 6 pilot districts (Wa East, Sissala East, Nadowli, Jirapa & Lawra) were covered during the field visits. Lessons learnt were communicated and documented.

xix). M&E tour of fields in Upper East Region on 14, October 2009: Builsa district (Wiaga & nearby villages) was covered during the field visits Lessons learnt were communicated and documented.

xx). M&E tour of fields in Northern Region on 15, October 2009: Tolon & Tamale districts were covered during the field visits. Lessons learnt were communicated and documented.

xxi). CCU Meeting, Nyankpala on 17th November, 2009: Project Review meeting to discuss feedback from the ERI Workshop in Cotonou, Benin from November 9-13, 2009. Action was expedited to conduct well-being analysis workshop for the AEAs and Supervisors.

xxii). CCU Meeting, Nyankpala on 1st December, 2009: Project Review meeting to discuss and confirm dates and arrangement for logistics for well-being analysis workshop. Regional Coordinators were charged to see to the organization of the workshop.

UPPER WEST REGION FARMING SYSTEMS RESEARCH GROUP

Introduction

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 PROGRAM

Evaluation of the effect of various fertilizers in enhancing sorghum productivity

Dr. S. S. J. Buah

Executive Summary

In savanna zone of Ghana, soil fertility depletion is already high; relatively small amount of crop residues and animal manures are produced, hence mineral fertilizers will remain the principal sources for building up nutrients in soils. An experiment was conducted in 2009 to assess the agronomic and economic benefits of using different levels of compound fertilizers on the grain yield of various sorghum varieties in the savanna zone of Ghana. Preliminary results of this study demonstrated that in general, using compound fertilizer on sorghum was economically attractive. The application of compound fertilizer containing both macro- and micronutrients (e.g Actyva fertilizer: 23-10-5-3-2-0.3 (as N, P, K S, Mg and Zn) would increase grain yield and sustain soil fertility in the zone. Nonetheless, the fertilizer should be applied at the right time, in the right quantity and at the right spot. The practice will ensure food security; reduce nutrient mining and environmental degradation. Basal application of 250 kg/ha of Actyva followed by top dressing of 125 kg/ha of Actyva produced the highest grain yield of 2.37 t/ha although this was not significantly greater than grain yield (2.32 t/ha) obtained from 250 kg/ha of Actyva followed by top dressing of 125 kg/ha of sulphate of ammonia or 125 kg/ha of Actyva followed by top dressing of 250 kg/ha of Actyva. Late-maturing sorghum varieties were highly susceptible to midge damage and therefore recorded lower yields.

Introduction

Sorghum (*Sorghum bicolor*) is an important staple crop in northern Guinea savanna zone and also has tremendous potential in the brewing industry. However, average yields from farmers' fields are often below 1.0 t/ha. Understanding the interaction between the environment and the plant and developing management systems that reduce the risk of environmental stress existing during critical growth stages offers good opportunity to increase grain yields without additional expense. Across most of the savanna regions, low crop grain yields are common due to low rainfall and soil nutrient levels, use of varieties with low yield potential and low management levels. Despite the low fertility of soils, most farmers plant sorghum at low plant stand with inadequate fertilization resulting in low yields. Fertilizers remain costly and unavailable to most resource-poor farmers. The high cost and unavailability of fertilizers require that the limited amounts that are available must be used judiciously for maximum benefit. As majority of these farmers have low income, technical packages to increase and sustain agricultural production must be affordable, profitable and applicable to ensure their acceptability.

Traditionally, soil fertility in Ghana has been maintained through shifting cultivation where farmers abandoned land to fallow as productivity declined, but increasing population pressure has shortened the fallow periods in many areas. Within this constraint, supply of N to crops in this region through mineral fertilizer is increasingly becoming important.

The most common compound fertilizers available in the market contain only the macronutrients – NPK. However a compound fertilizer called Actyva containing both macro- and micro nutrients (23-10-5-3-2-0.3 - as N, P, K S, Mg and Zn) was recently introduced into the market by the YARA fertilizer company. This company has often recommended 125 kg/ha of Actyva for basal dressing to maize and 250 kg/ha of the same Actyva for topdressing. Meanwhile, the blanket sorghum fertilizer-N recommendation for Ghana is about 64 kg N/ha. This recommendation is more than two decades old and not specific to any agro-ecology. To achieve this rate, one has to apply 250 kg/ha of NPK (15-15-15) compound for basal application and top dress with 125 kg/ha of sulphate of ammonia. There is the temptation for farmers to use 250 kg/ha of Actyva for the basal application instead of NPK fertilizer because Actyva is cheaper than NPK (15-15-15) compound fertilizer. However, considering the fact that P is needed early in sorghum growth cycle and should therefore be applied early enough and coupled with the fact that Actyva has 10% P_2O_5 as against 15% for NPK (15-15-15), it may be prudent to apply 250 kg/ha Actyva and rather topdress with 125 kg/ha of sulphate of ammonia or if one has to go by YARA recommendation then you topdress with 125 kg/ha of Actyva instead. There was therefore the need to evaluate sorghum response to the different combinations of Actyva and NPK fertilizers in the savanna zone in order to come out with the most economic fertilizer combination for sorghum farmers.

Materials and methods

The experiment was conducted at the SARI Research Farm at Wa to assess the agronomic and economic responsiveness of sorghum to different levels of macronutrients (N, P and K) and micronutrients (S, Mg and Zn). Eight fertilizer treatments were evaluated (Table 44):

Improved production package were followed that included growing four improved cultivars (Dorado, IRAT 204, Tiebile and Sounalenba) using the 8 fertilizer treatments. Dorado is often used as substitute for imported barley malt in the brewing industry. Thus the interest of Guinness Ghana Ltd., in this variety has stimulated widespread interest in scaling up its production. The fertilizer treatments included different levels of two compound fertilizers - one containing macronutrients N, P, and K and the other micronutrients (S, Mg and Zn). The basal application was done within 10 days after sowing followed by topdressing at 35 days after sowing. The experiment was replicated three times.

Table 44. List of fertilizer tretaments tested in 2009

Treatment code	Treatment Description
T1	No fertilizer
T2	250 kg of NPK as basal dose + 125 kg of sulphate of ammonia per ha as topdressing
T3	125 kg of NPK as basal dose + 125 kg of sulphate of ammonia per ha as topdressing
T4	250kg of YARA Actyva as basal dose + 125 kg of YARA Actyva per ha as topdressing
T5	250 kg of Actyva as basal dose + 125 kg of sulphate of ammonia per ha as topdressing
T6	125 kg of YARA Actyva as basal dose + 250 kg of YARA Actyva per ha as topdressing
T7	125 kg of YARA Actyva as basal dose + 125 kg of YARA Actyva per ha as topdressing
T8	125kg of YARA Actyva as basal dose + 125 kg of sulphate of ammonia per ha as topdressing

YARA Actyva fertilizer: 23-10-5-3-2-0.3 (as N, P, K S, Mg and Zn)

Results and discussions

Sounalenba and Tieble grew taller (< 3 m) and produced more biomass than Dorado and IRAT 2004 (Table 45). Moreover Dorado and IRAT 204 flowered much earlier than Sounalenba and Tieble. These two late-maturing varieties were highly susceptible to midge damage. In general, a series of flowerings (as a result of planting sorghum of different growth cycles close to each other) results in midge build-up, which was observed in the experiment. Timing the planting of sorghum so that flowering occurs simultaneously is important to minimize midge damage. Apparently, midge infestation reduced the grain yield of Sounalenba and Tieble; hence Dorado had the highest grain yield of 2.54 t/ha followed by IRAT 204. Generally, because of low yields of Tieble and Sounalenba as a result of midge infestation, grain yield was negatively associated with plant height and days to flowering.

On average, different fertilizer treatments did not affect plant height significantly (Table 45). However, the application of fertilizer significantly affected days to flowering, biomass and grain production. Unfertilized sorghum plants (T1) flowered late and were relatively shorter. In addition, unfertilized sorghum generally had lower biomass and grain yields. Basal application of 250 kg/ha of Actyva, followed by top dressing of 125 kg/ha of Actyva (T4) produced the highest grain yield of 2.37 t/ha. This, however, was not significantly greater than grain yield (2.32 t/ha) obtained from 250 kg/ha of Actyva followed by top dressing of 125 kg/ha of sulphate of ammonia or 125 kg/ha of Actyva followed by top dressing of 250 kg/ha of Actyva (T6). Basal application of 250 kg/ha of Actyva followed by top dressing of 125 kg/ha of sulphate of ammonia or 125 kg/ha of Actyva resulted in the highest dry matter production.

Table 45. Fertilizer and Variety effect on grain yield of sorghum at Dokpong, Wa

Treatment code	**Days to flowering**	**Plant height (m)**	**Biomass yield (t/ha)**	**Grain yield (t/ha)**
T1	80	2.70	4.05	1.40
T2	78	2.73	5.99	2.13
T3	78	2.73	5.96	2.11
T4	78	2.73	6.57	2.37
T5	78	2.73	6.69	2.32
T6	77	2.73	5.92	2.31
T7	78	2.73	5.23	2.14
T8	78	2.73	5.56	2.09
Lsd (0.05)	1.0	NS	1.05	0.26
Variety				
Sounalenba	100	>3.00	9.26	1.75
Tieble	80	>3.00	8.06	1.94
IRAT 204	63	1.46	2.51	2.20
Dorado	69	1.45	3.17	2.54
Lsd (0.05)	1.0	0.02	0.74	0.18

CV (%)	2.0	1.0	22	15
Mean	78	2.73	5.75	2.11

Conclusion and recommendations

Data were obtained from one season only and could not be used to draw firm conclusions. Nonetheless, the preliminary results provided useful information for fine-tuning management options to maximize sorghum yields and reduce costs. Further studies were required for an additional season in order to obtain data from at least two seasons in order to draw valid conclusions and make firm recommendations. Therefore the experiment would be repeated in 2010.

- Fertilizer application to sorghum is economically viable.
- Avoid planting sorghum of different growth cycles close to each other as this results in midge build-up
- The appropriate fertilizer preferably coumpound fertilizer with both macro and micronutrients (eg Actyva) should be applied to sorghum at the right time, in the right quantity and at the right spot.
- Returns can be maximized from a small investment in fertilizer.
- Application of minimal amounts of inorganic fertilizers near the seed can increase yields while minimizing input cost.
- Planting in rows to obtain optimum plant stand is desirable for optimum grain yields

On-farm Testing and Demonstration of Drought Tolerant Maize Varieties and/or Hybrids

Executive Summary

Studies were initiated in 2009 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. Genotypic differences for grain yield were observed at Kpongu and not at Tuori where yields were generally lower. 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 the fields were not Striga endemic plots. Many of the improved drought tolerant varieties from International Institute of Agriculture (IITA) evaluated in this study performed similarly as or better than the best available local varieties in the various locations under rainfed conditions. Moreover, most of the IITA elite varieties are also known to show good performance when Striga infestation and drought

conditions occur simultaneously. Over the years, the results of both the mother and baby trials for the early and extra-early maturing varieties suggested that EVDT-W-99 STR QPM CO, TZEE-Y-POP STR QPM C0 and TZE W Pop DT QPM CO were relatively stable in grain yield performance in several locations. These were subsequently released respectively, as CSIR-Aburohemaa, CSIR-Abontem and CSIR-Omankwa for commercial production. Among the intermediate varieties, the QPM hybrid, Mamaba was the most preferred hybrid.

Introduction

Maize (*Zea mays*) is an important staple crop in Ghana but drought and Striga infestation are serious constraints to its production, especially in the northern Guinea savanna zone. Over the years, the National maize breeding program in Ghana has been collaborating with the IITA to develop and evaluate improved maize varieties and hybrids suitable for the various agro-ecological systems in Ghana. Thus, promising high yielding and drought tolerant maize varieties and hybrids selected based on trial results were evaluated in farmer participatory on-farm trials and demonstrations. These trials served as important vehicle to showcase the effectiveness of new technology to farmers. Additionally, the participatory on-farm testing of the varieties could also facilitate the rapid transfer and adoption or acceptance of these drought tolerant maize varieties by farmers. In order to increase maize production in Ghana drought and Striga tolerant varieties were introduced to farmers in drought prone areas of the savanna zone of Ghana. The mother-baby on-farm testing approach has been widely adopted by the Drought Tolerant Maize for Africa (DTMA) Project as a strategy for testing and promoting the release and adoption of maize varieties and hybrids. It is a new approach consisting of a central researcher-managed "mother' trial comprising all tested varieties and satellites or "baby' trials, which are farmers managed and test a subset of varieties from the mother trial.

In 2009, two sub-projects were implemented in the 2009 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 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.

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. The mother baby trials is a new approach consisting of a central researcher-managed "mother' trial comprising all tested varieties and satellites or "baby' trials, which are farmers' managed and consist of varieties from the mother trial. Two sets maize mother trials managed by researchers, comprising extra-early (80-85 days to maturity) and early maturing (90-95 days to maturity) varieties were planted in farmers' fields at Kpongu in Wa Municipality and Tuori in Nadowli District. Another two sets maize mother trials, comprising intermediate/medium maturing (110 days to maturity) varieties were planted at Biihee in Wa Municipality and Silbelle in Sissala West District. Row and hill spacings were 0.75 and 0.40 m, respectively with one plant per hill. About 64 kg N/ha was split applied at planting and at about 35 DAP. The total fertilizer rate was 64-38-38 kg/ha as N, P_2O_5 and K_2O, respectively. Recommended cultural practices were followed.

Results and discussions

At Kpongu, EVDT-W-99 STR QPM CO and 2004 TZE-W-DT STR C4 were the top-ranking varieties in grain yield. The lowest yielding variety was Akposoe. On average, the elite varieties from IITA produced 19 to 41% more grain than Akposoe and 24 to 46% more grain than the farmers' variety. At Tuori, EVDT-W-99 STR QPM CO tended to have the highest yields although its yields were not statistically different from the other varieties. At both sites, all the IITA intermediate maturing varieties had similar yields which were; however, lower than the yield of the QPM hybrid, Mamaba. The highest yielding hybrid was Mamaba at Biihee and Silbelle. Mamaba had 14% and 58% more grain than the local check at Biihee and Silbelle, respectively. All the varieties and hybrids had similar days to 50% silking and plant height. Field days drew much attention and participation from farmers and the voting exercise suggested that EVDT-W-99 STR QPM CO and 2004 TZE-W-DT STR C4 were the most preferred early maturing varieties at Kpongu and Tuori. Farmers also preferred the extra-early yellow maize variety, TZEE-Y-Pop-STR C4 because it could be planted with the early rains and sold or eaten fresh. Among the intermediate varieties, the QPM hybrid, Mamaba was the most preferred genotype at Biihee and Silbelle. This was followed by IWD C_2 SYN F_2 and DT SR W COF_2. It seems farmers like a range of varieties (i.e., a range of diversity). All the IITA varieties were considered to be better than the local checks (farmers' varieties). In decreasing order of importance, the criteria that were most frequently cited by farmers for preference of a variety at all locations were heavier ears (bigger cobs), earliness, drought tolerance and endosperm colour.

Conclusion

Most of the improved drought tolerant varieties from IITA evaluated in this study performed similarly as or better than the best available local varieties in the various locations under rainfed conditions. Moreover, most of the IITA elite varieties are also known to show good performance when Striga infestation and drought conditions occur simultaneously. Thus, the 2004

TZE-W-DT-STR C4 variety should be vigorously promoted for adoption by farmers in drought prone and Striga endemic areas in the Savanna zone of Ghana. Furthermore, the results of both the mother and baby trials for the early and extra-early maturing varieties suggested that on average, EVDT-W-99 STR QPM CO, TZEE-Y-POP STR QPM C0 and TZE W Pop DT QPM CO were relatively stable in grain yield performance in several locations. These were subsequently released respectively as CSIR-Aburohemaa, CSIR-Abontem and CSIR-Omankwa for commercial production.

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

S. S. J. Buah

Executive summary

In 2009, 20.9 t of drought/tolerant maize seed was produced from 15 ha and 6.54 t of processed seed was made available to farmers. This included the three released varieties (Abontem, Aburohemaa and Omankwa). In general, economic analysis revealed that seed production is a profitable venture in this drought prone area of Ghana. Other farmers who received some support from the project to produce seed in 2008 were able to produce 3.3 t of seed of the various varieties on their own without additional support from the project. This is particularly important because the farmers were not expected to develop a dependency syndrome but to be financially self-sustaining. Through the project, farmers were trained in seed selection and management techniques and learned principles to assist them in mainataining the characteristics of maize varieties they valued.

Introduction

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

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

Objectives:

(i) Promote and sustain availability of drought and Striga tolerant maize seed.

(ii) Establish community groups to manage drought and Striga tolerant seed production and distribution within the communities.

(iii) Train community groups, extension staff in drought tolerant maize seed production techniques

Materials and methods

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 one extra-early maturing (80-85 days to maturity) drought tolerant variety, 4 early maturing (90-95 days to maturity) varieties and 3 intermediate/medium maturing (110 days to maturity) varieties were obtained from IITA and multiplied in the Upper West Region of Ghana during the 2009 cropping season (Table 46) Additionally, an extra-early maturing drought tolerant variety, Dorke from the national maize program was multiplied. 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. The farmers are not expected to develop a dependency syndrome but to be financially self-sustaining. Thus to ensure the sustainability of the project and the involvement of more farmers each year, funds from the sale of the seed will 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 neighboring maize fields of similar maturity rating). Thus, we were selective in choosing the communities. Row and hill spacings were 0.75 and 0.40 m, respectively. Recommended cultural practices were followed. The total fertilizer rate was 64-38-38 kg/ha as N, P_2O_5 and K_2O, respectively. Observations recorded for each variety included days to 50% silking and anthesis, plant height, ear number, percentage root and stalk lodging and grain yield.

Results and discussions

Planting was significantly delayed until mid-July at most sites due to prolonged pre-season drought. The pre-season drought affected seedling establishment at most sites hence the optimum plant stand of 66,600 plants/ha was not achieved for most varieties. Refilling was not possible because of insufficient seed. 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 drier areas of Ghana

In 2009, 20.9 t of seed was produced from 15 ha and 6.54 t of processed seed was recovered from farmers as payment for input (Table 46). The overall mean grain yield of the varieties was 1.84 t/ha. A kilogram of seed maize sold for GH¢0.80 during the 2009 cropping season. Thus, if we assume a seed price of GH¢1.00 per kg and a production cost of GH¢541/ha, then we expect a profit of GH¢1,316/ha (1 US $ = GH¢1.42). Thus seed production appears profitable in this drought prone area of Ghana. Other farmers who received some support from the project to produce seed in 2008 were able to produce 3.3 t of seed of the various varieties on their own without 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.

Training

Farmers were trained on seed selection and management techniques and learned principles to assist them in mainataining the characteristics of maize varieties they valued. In general, farmers 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.

Table 46. Grain yield of maize varieties planted in the community seed production program in UWR, Ghana, 2009.

Variety	Quantity of seed produced (kg)	Quantity of recovered seed (kg)	Quantity of seed produced by farmers on their own	Mean grain yield (kg/ha)
TZEE Y Pop QPM CO	2200	1050	1400	1333
2004 TZE W POP DT STR C4	6300	1710	450	1475
2004 TZE W POP STR C4	4700	900	560	1958
TZE W Pop DT QPM CO	1750	450	300	1458
EVDT-W-99 STR QPM CO	1500	900	-	3750
Dorke	800	250	100	1500
DT SR W COF_2	1650	360	200	2003
DT SYN-1-W	1100	570	450	1750
IWD C_2 SYN F_2	900	300	-	1250
Total	**20900**	**6490**	**3460**	

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 and in the household (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. We have so far been able to build the capacity (train) of at least one hundred (100) farmers and six (6) extension agents to produce high quality maize seeds.

Conclusion

Several farmers have 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 mainataining the characteristics of maize varieties they valued. It seems a fundamental step towards promoting adoption of a technology would be to develop mechanisms for providing knowledge and inputs

Soybean Cluster in Upper West Region

Executive summary

In order to increase soybean production and utilization in a cost-effective manner in the Upper West region of Ghana, a number of activities were carried out during the 2009 cropping season. The soybean system covered in this action plan involved 170 groups of farmers that mimics an out grower scheme producing for the Upper West Agro-Industries (UWAI) Ltd. So far the company has been providing the farmers with tractor services at subsidized cost and input credit (seed and fertility). The regional branch of Seed producers Association of Ghana (SEEDPAG) is the key source of seed. UWAI buys fertilizer in bulk from Dizengoff and Wienco for its farmers. Key buyers of the soybean cake the company produces are AFARIWA farms in Tema and Poultry farmers cooperative in Dormaa Ahenkro. The oil is sold in a retail shop in Wa for household consumption. Upper West Agro-Industry and Savanna Marketing Company (SMC) have both expressed interest in purchasing the produce from farmers. The export market also provides an important outlet for farmers' produce. Some exporters outside the region have expressed interest in purchasing from the farmers

Introduction

Soybean (*Glycine max*) is becoming an important cash crop in Ghana. It is also an important oil seed crop which requires lower production inputs. It may also serve the dual purpose for cash and food in any household food and nutrition security program development. Like all other crops soybean require a number of plant nutrients to ensure good grain yields. Most farmers generally plant soybean with little or no fertilizer input. Moreover delay in harvesting leads to post harvest shattering losses. Yields from farmers fields are low (<0.96 t/ha). Farmers traditionally use very low plant populations in order to reduce the risk of potential yield loss due to water stress. Thus low crop grain yields are common due to erratic rainfall pattern, low soil nutrient levels, use of unimproved varieties and low management levels. Increased plant population combined with fertilizer application and improved varieties have been used to increase crop yield in field trials and demonstration trials. It is therefore important that farmers observe the optimum planting distances and harvest on time else they loose the grains through shattering of the pods. Hence there is the need to introduce the non-shattering soybean variety, Jenguma, to the farmers. To strengthen the soybean cake and oil value chain in the region a number of activities were carried out during the 2009 cropping season.

Objectives

(i) To increase soybean production and utilization in a cost-effective manner in the Upper West region of Ghana

(ii) To demonstrate and promote the application of modern technologies for the production of promising non-shattering soybean varieties

Materials and methods

- Demonstrations carried out on the effect of fertilization and plant population in soybean cultivation with UWAI out-growers in the Upper West Region.
- Create learning centres and hold discussion fora with farmers groups on appropriate soybean production processes for higher yields and document as folders/posters.
- Strengthen farmer groups to take their own loans and be responsible for its payment
- Develop the concept of community seed production of released soybean varieties among producers in Upper West region.
- Organize training on CASE and other agribusiness related fields for Research and mid-level staff of MoFA, other soybean cluster actors, micro-finance institutions, and staff of NGOs in agriculture and rural development in the region.

Results and discussions

Improved production practice on average, produced 31% or 421 kg/ha more grain than the farmer's practice. Lower grain yields associated with farmer's practice may be attributed to low plant stand, numerically fewer pods per plant, inadequate fertilization and poor weed management. Compared to farmer's practice, improved management resulted in increased mean income.

Outputs for 2009

- Productivity of soybean with improved management increased by an average of 140%
- 200 farmers acquire knowledge in soybean production
- 110 groups were formed
- At least 3 meetings held between the leaders of the farmers groups and credit providers.
- 10 groups benefited from production credit from various financial institutions
- Seed production technologies of selected farming communities improved.

- 3.0 t of Jenguma seed has been produced
- 300 farmers will have access to seed of improved varieties at affordable prices to plant 200 acres.
- Capacity of 550 (350 men and 200 women) farmers to produced soybean enhanced
- Farmer-to-farmer transfer of seed technology
- Increased understanding of CASE will help to propagate the concept in the design and implementation of agricultural and rural development program in the region. Five research technicians and 2 NGO staff in the region trained in the CASE approach and agribusiness concepts.
- Participation of project actors improved
- Results widely communicated among project actors
- Capacity of 4 SARI technicians in participatory M and E of soybean cluster activities improved

UPPER EAST REGION FARMING SYSTEMS RESEARCH GROUP

R. A. L. Kanton, Julius Yirzagla, Francis Kusi, Issah Sugri, E. Y. Ansoba, P. A. Asungre and S. Lamini

Introduction

The Upper East Region Farming Systems Research Group (UE-FSRG) is based at the Manga Agricultural Research Station about 4 km south-east of the Bawku Municipal. The Team has a membership of five Research Scientists comprising of two Agronomists, an Entomologist and a Post-harvest Scientist. The Agricultural Economist is presently pursuing a PhD in the USA. Three technical staff that embarked on BSc Programmes (2 at KNUST and one at Methodist University, Wenchi campus) have all successfully completed and are back to post. The Group is tasked to generate and disseminate to farmers appropriate technologies for improved productivity leading to enhanced livelihoods of the people within the region. Besides, the team also has oversight responsibility of coordinating Research, Extension and Farmer Linkage Committee (RELC) activities in the region.

Other activities undertaken by the group were as follows:

- Trainings, workshops and meetings
- Emergency Rice Initiative Project with sponsorship from the USAID
- Provision of technical backstopping to the Municipal Food Security Networking group
- Conservation Agriculture Project undertaken by CARE International Ghana in 8 communities in the Bawku Municipal

AGRONOMY PROGRAMME

Roger A. L. Kanton

The objective of the agronomy programme is to identify production constraints and missed opportunities and to develop appropriate and cost effective agronomic technologies to address these constraints with a view to increasing and sustaining food crop 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 2009 cropping season. The results of the studies are presented below:

Effects of sorghum variety, rate of nitrogen fertilizer, plant spacing and density on the performance of sorghum in a semi-arid agro-ecology in northern Ghana.

(Roger A. L. Kanton, Julius Yirzagla, Peter A. Asungre, Salim Lamini and Emmanuel Y. Ansoba)

Objectives

The objective of the study was to determine the optimal spacing, plant density and rate of nitrogen fertiliser on the performance of sorghum.

Materials and methods

Two improved sorghum varieties (Dorado and Kapaala) were used as test crops. The fertilizer rates adopted were 0N, 30 kg N/ha, 60 kg N/ha, 90 kg N/ha and 120 kg N/ha. Intra-row spacing of 0.20m, 0.30m and 0.40m as well as plant densities of 1 plant/stand and 2 plants/stand were used. The experimental design was a randomized complete block with 4 replications. Plot size was 3.5m x 5m with an inter-row spacing of 0.75m. The experimental field was prepared by harrowing and ridging using a tractor. Sorghum seeds were sowed using 3 to 4 seeds per hole and later thinned to 2 plants per stand at exactly 2 weeks after sowing (WAS). Compound fertilizer in the form of 15-15-15 was applied at 2 WAS and sulphate of ammonia(S/A) used to top-dress at 4 WAS. Prior to sowing, initial soil samples at a sampling depth of 30 cm from 5 random sites were taken, mixed, bulked and about 500g taken for individual plots. This was repeated at harvest for laboratory analyses. Agronomic data were taken on following parameters: Stand count at 1 WAS, 6 WAS and at harvest, days to first head emergence, days to 50% flowering, days to maturity, plant height at 2, 4, 6, 8, 10 and 12 WAS, stem girth at 2, 4, 6, 8, 10 and 12 WAS, leaf number per plant at 2, 4, 6, 8, 10 and 12 WAS, number of heads at harvest, number of lodged plants at harvest, head weight/plot, 1000-grain weight, grain and straw weight/plot. These data were then subjected to the appropriate statistical analysis.

Results

There was a significant ($P \leq 0.05$) variety by nitrogen by plant density interaction regarding sorghum stand count at harvest. Sorghum plant population increased with increase in plant density. Kapaala had a relatively higher plant population at harvest than Dorado at both plant densities (Table 47). There was also a general increase in plant population at harvest with increase in nitrogen fertilizer application except for Dorado at a plant density of 1plant/stand. Kapaala at 0N recorded the highest stand count at harvest, which was significantly high compared to those recorded for Dorado at 0N, 30N and Kapaala at 30N.

There was a significant (P≤0.001) interaction between sorghum variety and rate of nitrogen, with Kapaala at 90 kg/ha recording the tallest plants and Dorado at 0N recording the shortest plants (Table 48). Dorado produced plants that were generally shorter compared to those produced by Kapaala. There was no clear effect of the rate of increase in nitrogen on sorghum height.

Table 47. Sorghum stand count as affected by variety, rate of nitrogen fertilizer, plant spacing and density in a semi-arid agro-ecology in northern Ghana in the 2009 cropping season.

Rate of Nitrogen Fertilizer (kg/ha)	Plant density	1 plant/stand		2 plants/stand	
	Sorghum variety	Dorado	Kapaala	Dorado	Kapaala
0		67	60	74	84
30		68	70	73	78
60		73	73	78	76
90		70	73	67	83
120		60	79	78	77
Mean		68	71	74	80
LSD	10.3				
C.V. (%)	3.5				

Table 48. Sorghum plant height at harvest as affected by variety, rate of nitrogen fertilizer, plant spacing and density in a semi-arid agro-ecology in northern Ghana in the 2009 cropping season.

Rate of Nitrogen Fertilizer (kg/ha)	Sorghum variety	Dorado	Kapaala
0		123	189
30		130	207
60		154	179
90		139	209
120		131	203
Mean		135	197
LSD	17.2		
C.V. (%)	2.1		

There was a significant (P≤0.001) variety by rate of nitrogen by plant density effect on sorghum grain yield. Kapaala recording the highest sorghum yield at a nitrogen level of 60 kg/ha with 2 plants per stand and Dorado recorded the lowest grain yield at 0N kg/ha with 1 plant per stand

(Table 49). Generally, there was an increase in sorghum grain yield from 0 N to 60 kg N ha-1, however only Kapaala with 1 plant per stand recorded a uniform increase in yield with a corresponding increase in N applied from 0 N to 120 kg N ha-1. With the other treatments there was uniform increase in sorghum yields with an increment with N applied.

Table 49. Sorghum grain yield (kg/ha) as affected by variety, rate of nitrogen fertilizer, plant spacing and density in a semi-arid agro-ecology in northern Ghana in the 2009 cropping season.

Rate of Nitrogen Fertilizer (kg/ha)	Plant density	1 plant/stand		2 plants/stand	
	Sorghum variety	Dorado	Kapaala	Dorado	Kapaala
0		549	1076	696	1385
30		978	1622	1345	1452
60		1135	1800	1195	2444
90		1748	1993	952	2807
120		1064	2378	1659	2030
Mean		1095	1774	1169	2024
LSD	632				
C.V. (%)	27.2				

On-farm testing of improved sorghum varieties and lines for adaptation to the Upper East Region Agro-ecology in northern Ghana.

Roger A. L. Kanton, Julius Yirzagla, Peter A. Asungre, Salim Lamini and Emmanuel Y. Ansoba

Introduction

Sorghum (Sorghum Bicolor) is one of the most important staple food crops in northern Ghana. However the lack of suitable improved sorghum varieties have affected increased sorghum production in Ghana. Farmers participating in the Annual Research Extension and Farmer Linkage Committee (RELC) meetings have often complained of head insects problems of the newly released sorghum variety ‘Kapaala. This is due to the panicle morphology of Kapaala, which is very compact leading to the trapping moisture during rains, thereby creating an ideal environment for all manner head insects leading to drastic grain yield reductions. In response to farmers’ demand the Sorghum breeder bred for open heads Kapaala derivatives to reduce this problem of head insects and make the derivatives more attractive to farmers.

Objectives

The objective of the study was to test improved sorghum lines on farmers' farms with a view to recommend the best lines for released for increased sorghum production and productivity in northern Ghana.

Materials and methods

Sorghum varieties, Dorado, Kapaala, and derivatives of Kapaala (2460 and 2520) and farmers' variety were tested on-farm in the Talensi-Nabdam and Bawku West Districts in the Upper East Region. Five farmers in each district participated in the implementation of the trials. Each farmer served as a replicate. The experimental design was a randomized complete block. Plot size was 10m x 10m, and sorghum was planted on ridges spaced at 0.75m between ridges and 0.30m between plants. Sorghum seeds were planted using 3 to 4 seeds per hole and thinned to 2 plants per stand at exactly 2 weeks after sowing (WAS). Land preparation was done using bullocks. Compound fertilizer was applied at the rate of 60 kg N/ha and 30 kg P_2O_5 and K_2O, with half of the nitrogen and all of the P_2O_5 and K_2O at 2 WAS with the remaining nitrogen in the form of sulphate of ammonia (S/A) applied 4WAS. Each fertilizer application was preceded by weeding. The agronomic data taken included stand count at establishment, mid-season and at harvest, plant height, days to 50% flowering, sorghum yield and its components. The data were subsequently subjected to the appropriate statistical analysis.

Results

Bawku West

The farmers' variety had the highest plant population at harvest, which was higher than the trial mean with Dorado recording the lowest plant population. Kapaala was the earliest to attain the first flowering, which was significantly ($P \leq 0.001$) earlier compared to that recorded for the farmers' variety and Dorado (Table 1). Days to 50% flowering had a similar trend to that of days to first bloom, with Kapaala attaining the 50% flowering significantly ($P \leq 0.001$) earlier compared to the farmers' variety. Kapaala, 2520 and the farmers' variety produced the tallest plants, which were significantly ($P \leq 0.001$) taller than the plants produced by Dorado. Dorado recorded the highest grain and the farmers' variety the lowest. The yield recorded by Dorado was significantly ($P \leq 0.001$) higher than those recorded for the farmers' variety and sorghum line 2460.

Talensi-Nabdam

Kapaala was the earliest to bloom whilst the farmers' variety was the latest. All the improved varieties attained first bloom significantly earlier as compared to the farmers' variety (Table 50). Days to 50% bloom followed a similar trend like days to first bloom, with Kapaala being the earliest to attain 50% bloom and the farmers' variety the latest. All the improved varieties attained 50% bloom significantly ($P \leq 0.001$) earlier as compared to the farmer's variety.

Sorghum line 2520 and the farmers' variety produced the tallest plants, which were significantly ($P \leq 0.001$) taller than those produced by Dorado. Dorado was the only variety that produced plants shorter than those of the trial mean. The farmers' variety produced the highest plant population at harvest, which was significantly ($P \leq 0.001$) higher than those recorded by the improved varieties (Table 50). Sorghum grain yields obtained in the Talensi-Nabdam District were far less compared to their counterparts in the Bawku West District. Mean sorghum yields obtained in the Bawku West District were about 3 times greater as compared to those obtained by their counterparts in the Talensi-Nabdam District.

Table 50. Stand count, plant height (cm), grain and straw yields of sorghum as affected by variety/line in a semi-arid agro-ecology (Bawku West) in northern Ghana during the 2009 cropping season.

Sorghum variety/line	Stand count at harvest	Plant height at harvest (cm)	Grain yield (kg/ha)	Straw yield (t/ha)
2460	224	2.30	1200	2.2
2520	221	2.35	2733	2.1
Dorado	223	1.20	3150	2.5
Kapaala	221	2.33	2950	1.9
Farmers' variety	227	2.65	550	1.8
Mean	224	2.37	2117	2.1
LSD (5%)	3.45	7.77	1065	0.97
C.V. (%)	0.4	1.4	10.6	12.1

Table 51. Days to first bloom, 50% bloom, plant height (cm) grain and straw yields as affected by sorghum variety in a semi-arid agro-ecology (Talensi-Nabdam) in northern Ghana during the 2009 cropping season.

Sorghum variety/line	Days to first bloom	Days to 50% bloom	Plant height at harvest (cm)	Stand count at harvest	Grain yield (t/ha)
2460	62.9	68.8	2.30	224	720
2520	62.2	67.6	2.35	223	745
Dorado	66.4	67.8	1.20	223	700

Kapaala	61.0	66.5	2.34	221	650
Farmers' variety	72.4	77.80	3.65	227	670
Mean	65.0	69.7	2.37	224	697
LSD (5%)	2.51	4.02	7.77	3.35	479
C.V. (%)	3.6	1.6	11.4	0.4	33.4

Dorado produced the highest grain yield, whilst the farmers' variety produced the lowest. All the improved varieties significantly ($P \leq 0.001$) out-yielded the farmers' variety. Dorado and Kapaala yielded about 1.5 times higher than the new sorghum lines.

On-farm testing of Drought Tolerant Maize Varieties/ Hybrids for Africa (DTMA) in northern Ghana

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

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 Africa sub of the Sahara is mainly 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 harvest rainwater more efficiently in these arid regions. The release of promising drought tolerant maize hybrids and varieties by IITA is therefore welcome news.

Objectives

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

Field trials were conducted in 3 districts namely, the Bawku Municipal, Garu-Tempane and Bawku West districts all in the Sudan Savanna Agro-ecology of the Upper East Region during the 2009 cropping season. The trials were to evaluate drought tolerant maize varieties under the Drought Tolerant Maize for Africa (DTMA) initiative. The Mother and Baby trial concept of on-farm experimentation was adopted for the trial. For the Mother trial, a complete complement of the varieties were laid out in one farmers field and replicated just like is done on-station whilst for the baby trial 2 or 3 varieties were permutated and allotted to 5 other farmers in each of the 3 districts serving. Farmers from the baby trials were occasionally invited to the mother trial where they compared the varieties they had with their Mother trial counterparts. The randomised complete block design was adopted for the trials. The mother trial had 3 replications whilst for the baby trial each collaborating farmer served as a replicate. The plot size for each mother trial was 4.5 m x 5m whilst for the baby trial it was 20 x 10 m. Experimental data were taken on the 4 central rows whilst harvesting was done leaving out the 2 outer rows. The number of farmers that planted baby trials was 5 in Garu-Tempane, 4 in Bawku Municipal and 2 in Bawku West giving a total of 11for the baby trials. Together with the 3 farmers for the mother trial a total of 14 farmers participated in the evaluation of the drought tolerant maize varieties/hybrids. Farmers were selected based upon their previous experiences in conducting on-farm adaptive trial with the Station as well as their willingness to collaborate in the study. Maize varieties/hybrids tested included 2004 TZE-W DT STR $C_{4,}$ 2004 TZE-Y Pop STR $C_{4,}$ 2004 TZEE-Y Pop STR $C_{4,}$ 2004 TZEE-Y Pop STR QPM C_O, EV DT W-99 STR QPM C_O, the local check Akposoe and the farmers' variety. Standard agronomic practices as recommended for maize cultivation in Ghana were strictly adhered to. Standard experimental data such as stand establishment, growth, development yield and its components were taken on both mother and baby trials and the data subjected to statistical analysis on GENSTAT 3rd Edition.

Results

Long-term rainfall data at the Manga Agricultural Research Station revealed that in 2008 the rainfall received in the months of June and July were above normal whereas in 2009 the rainfall received in the months of August and September were also above normal. Generally the rainfall distribution in 2009 was far better than that of 2008. This might account for the higher maize yields recorded in 2009 compared to those obtained in 2008. The higher rainfall experienced in 2009 coincided with critical maize developments such as at silking and also at anthesis through to grain filling stage, thereby enhancing maize performance in 2009.

Baby trial

Garu-Tempane District

2004 TZEE Y Pop STR C4 produced the highest cobs at harvest whilst 2004 TZE WDT STR C4 produced the least. The yield of TZEE Y Pop STR C4 was significantly ($P \leq 0.05$) higher compared to all the other lines except EVDT W99 STR QPM (Table 52). Similarly EVDT W99 STR QPM C0 and 2004 TZEE Y Pop STR QPM C0 produced significantly more cobs than the rest of the varieties/hybrids tested. Also 2004 TZE Y Pop STR C4 and the farmers' variety produced superior cobs compared to 2004 TZE WDT STR C4 and the local check Akposoe. EVDT W99 STR QPM C0 produced the broadest cobs and 2004 TZEE Y Pop STR C4 QPM C0 the smallest. However, the local check Akposoe produced cobs that were bigger than the remaining lines. 2004 TZEE Y Pop STR QPM C0 produced the boldest kernels and 2004 TZE WDT STR C4 the smallest followed by Akposoe (Table 52). The kernels produced by 2004 TZEE Y Pop STR QPM C0 were significantly ($P \leq 0.09$) higher compared to those produced by 2004 TZE WDT STR C4 and the local check Akposoe. Maize harvest indices reported in this study are generally higher compared to those reported last season. 2004 TZEE Y Pop STR QPM CO produced the highest harvest index whilst the farmers' variety and 2004 TZE WDT STR C4 the least. 2004 TZEE Y Pop STR QPM CO and 2004 TZEE Y Pop STR C4 had significantly greater harvest indices compared to those obtained by the farmers' variety and 2004 TZE WDT STR C4. Maize kernel yields reported this year were significantly greater than those reported last year, with 2004 TZEE Y Pop STR QPM CO recording the highest yield and the local check Akposoe the lowest (Table 2). The yields reported for 2004 TZEE Y Pop STR QPM CO, EVDT W99 STR QPM CO and 2004 TZEE Y Pop STR C4 were significantly ($P \leq 0.05$) higher than that obtained by Akposoe. The improved varieties/hybrids evaluated in this study recorded a mean kernel yield of over 69% compared to the mean yield obtained by the local varieties. EVDT W99 STR QOPM C0 recorded the highest straw yield whilst the local check Akposoe obtained the lowest. EVDT W99 STR QOPM C0 and farmers' variety produced significantly ($P \leq 0.05$) higher straw yields than

Akposoe. The improved varieties/hybrids tested recorded an increased mean straw of 17% over the local varieties.

Bawku Municipal

General maize growth and development parameters this year were better compared to those obtained last season. TZEE Y Pop STR C4 recorded the highest number of cobs whilst EVDWT TZEE Y Pop STR C4 QPM CO recorded the lowest. Cobs harvested under TZEE Y Pop STR C4, 2004 TZE Y Pop STR C4 and by the farmers' variety were greater than the trial mean (Table 53).

Table 52: Cobs dimensions, no. of cobs harvested, 1000-kernel weight (g), kernel and straw yield of drought tolerant maize varieties and hybrids evaluated at the Garu-Tempane district in a semi-arid agro-ecology in northern Ghana in 2009.

Maize variety/hybrid	No. of cobs	Cob girth (mm)	1000-kernel wt (g)	Harvest index	Kernel yield (kg/ha	Stover yield (t/ha)
2004 TZE WDT STR C4	718	40.8	164.1	0.39	1775	2.4
2004 TZE Y Pop STR C4	936	41.1	209.1	0.45	1897	2.4
2004 TZEE Y Pop STR C4	1119	41.0	210.7	0.49	2837	2.9
2004 TZEE Y Pop STR QPM CO	1009	39.7	237.6	0.51	3070	3.1
EVDT W99 STR QPM C0	1100	44.9	208.9	0.43	2840	3.8
Akposoe	772	42.3	172.0	0.46	1382	1.7
Farmers' variety	990	41.2	212.2	0.39	2039	3.3
Mean	949	41.6	202.1	0.46	2263	2.8
s.e.d	25.7	2.52	25.6	0.039	5773	5773
L.S.D. (0.001)	56.6	NS	56.6	0.082	1298	1298
C.V. (%)	12.6	6.1	12.6	8.28	27. 5	27. 5

Table 53. Cobs dimensions, no. of cobs harvested, 1000-kernel weight (g) and kernel yield of drought tolerant maize varieties and hybrids evaluated at the Bawku Municipal in a semi-arid agro-ecology in northern Ghana in 2009.

Maize variety/hybrid	No. of cobs	Cob girth (mm)	Cob length (cm)	1000-kernel wt (g)	Kernel yield (kg/ha
2004 TZE WDT STR C4	816	23.0	24.6	183.7	1672
2004 TZE Y Pop STR C4	1188	24.4	22.9	188.3	2031
2004 TZEE Y Pop STR	1411	27.9	21.8	192.8	2383

C4					
2004 TZEE Y Pop STR QPM CO	972	24.4	24.7	181.8	1622
EVDT W99 STR QPM C0	699	23.4	28.5	181.6	1077
Akposoe	795	25.6	25.5	176.5	1042
Farmers' variety	741	24.5	25.4	196.5	986
Mean	946	24.74	24.8	185.9	1545
L.S.D. (0.05)	NS	NS	NS	NS	NS
C.V. (%)	27.3	10.5	5.5	9.34	43.3

TZEE Y Pop STR C4 produced the broadest cobs and 2004 TZE WDT STR C4 the smallest. EVDT W99 STR QPM C0 produced the longest cobs whilst 2004 TZEE Y Pop STR C4 the shortest. The local checks produced slightly longer mean cobs compared to their varieties/hybrids. The farmers' variety produced the boldest kernels followed closely by 2004 TZEE Y Pop STR C4 and the local check Akposoe the lightest kernels. 2004 TZEE Y Pop STR C4 produced the highest kernel yields and the farmers' variety the lowest. TZEE Y Pop STR C4 produced 142% and 128% more grain than the farmers' variety and the local check Akposoe respectively.

Mother trials

There was a significant ($P \leq 0.003$) interaction between district and maize variety, with Bawku West recording the highest number of cobs at harvest (134) followed by Garu-Tempane (129) and Bawku Municipal (128). EVDT W99 STR QPM CO produced the highest number of cobs whilst the local check Akposoe produced the lowest number of cobs. The number of cobs produced by EVDT W99 STR QPM CO was significantly ($P \leq 0.003$) compared to those produced by Akposoe, the farmers' variety and 2004 TZE Y Pop STR C4 (Table 3). EVDT W99 STR QPM C0 produced the broadest cobs and Akposoe the smallest cobs. The cobs produced by EVDT W99 STR QPM C0 were significantly broader compared to those produced by the other treatments except the farmers' variety. TZEE Y Pop STR C4, TZEE Y Pop STR QPM CO and Akposoe produced cobs with dimension smaller than the trial mean. The farmers' variety produced the boldest kernel with the local check Akposoe producing the smallest kernels. The farmers' variety produced kernels that were significantly ($P \leq 0.001$) heavier compared to the rest of the treatments except 2004 TZE WDT STR C4. Maize harvest index this year were generally higher compared to those obtained last year. 2004 TZEE Y Pop STR C4 and Akposoe produced the highest harvest indices whilst the farmers' variety produced the lowest harvest index. Akposoe, 2004 TZE Y Pop STR C4, 2004 TZEE Y Pop STR C4 TZEE Y Pop STR QPM CO Pproduced significantly higher harvest indices compared to the farmers' variety (Table 53). There were significant differences among the locations with Garu-Tempane recording the highest kernel yield of 2610 kg/ha and followed by Bawku West (2583 kg/ha) and Bawku Municipal the lowest of 2198 kg/ha. EVDT W99 Y Pop STR C4 produced the highest kernel yield (2802 kg/ha) with Akposoe recording lowest (1707 kg/ha). All the varieties/hybrids evaluated in this study significantly out-yielded Akposoe (Table 53). There were significant ($P \leq 0.001$) differences among locations with regards to maize straw yield, with Garu-Tempane recording the highest straw yield of 3.0 t/ha followed by Bawku West (2.8 t/ha) and Bawku Municipal (2.0 t/ha). The highest straw yield was recorded by the farmers' variety (3.3 t/ha) followed closely by EVDT W99 STR QPM C0 (3.2 t/ha) and the lowest by Akposoe (1.7 t/ha). All the treatments produced straw that was significantly higher compared to that produced by the local check Akposoe.

Table 54. No. of cobs, cob girth, 1000-kernel weight (g), harvest index, kernel and straw yield across location of drought tolerant maize varieties and hybrids evaluated in a semi-arid agro-ecology in northern Ghana in 2009.

Maize variety/hybrid	No. of cobs	Cob girth (mm)	1000-kernel wt (g)	Harvest index	Kernel yield (kg/ha	Stover yield (t/ha)
2004 TZE WDT STR C4	133	40.0	246.4	0.48	2546	2.3
2004 TZE Y Pop STR C4	129	40.1	224.2	0.50	2571	2.6
EVDT W99 STR QPM C0	146	43.6	225.8	0.47	2802	3.2
TZEE Y Pop STR C4	132	39.4	219.3	0.51	2522	2.5
TZEE Y Pop STR QPM CO	136	39.5	219.5	0.50	2466	2.5
Akposoe	111	39.8	191.4	0.51	1707	1.7
Farmers' variety	127	41.8	249.5	0.44	2633	3.3
Mean	130	40.6	225.6	0.49	2464	2.6
s.e.d.	7.82	1.23	9.17	0.015	177.5	0.17
L.S.D. (0.05)	15.7	2.47	18.34	0.031	355.0	0.34
C.V. (%)						

Analysis of the maize kernel yields across locations, which participated in the two years of the conduct of the trials revealed that maize kernel yields were significantly influenced by location ($P \leq 0.001$), maize variety/hybrid ($P \leq 0.004$), year ($P \leq 0.001$), location*variety ($P \leq 0.05$), and location*year ($P \leq 0.001$). Across locations and years Garu-Tempane recorded the highest kernel yield of 2239 kg/ha compared to the Bawku Municipal, which recorded only 1802 kg/ha (Table 54). Similarly maize kernel yields recorded for the 2009 cropping season were about 24% higher compared to those obtained during the 2008 cropping season. For the two cropping seasons across the two locations maize variety/hybrid 2004 TZE WDT STR C4 and

2004 TZEE Y Pop STR C4 were most stable whilst the local check Akposoe and 2004 TZE Y Pop STR C4 were the most variable (Table 55).

Maize yields at Garu-Tempane district were generally higher compared to their counterparts in the Bawku Municipal in both seasons. The farmers' variety produced the highest mean kernel yield across locations and years, followed by the 2004 TZE WDT STR C4, whilst the local check Akposoe recorded the least. The highest kernel yield was produced by EVDT W99 STR QPM CO and followed by 2004 TZE WDT STR C4 both at Garu-Tempane in 2009. However the local check Akposoe recorded lowest mean kernel yield across the locations over the two year period that the varieties were tested. 2004 TZEE Y Pop STR C4 was the most stable variety/hybrid in terms of yield followed by the local Akposoe and the farmers' variety (Table 56). Generally maize yields reported in the current study are well within the range reported for hybrid maize on-farm in Sallah *et al*. (2007).

Table 55. Drought tolerant maize kernel yields (kg/ha) as affected by interaction between variety and year in a semi-arid agro-ecology in Northern Ghana in 2008 and 2009 cropping seasons.

Location	**Maize variety/hybrid**	**2008**	**2009**
Bawku Municipal	2004 TZE WDT STR C4	1703	2358
	2004 TZE Y Pop STR C4	1083	2136
	2004 TZEE Y Pop STR C4	1957	2247
	2004 TZEE Y Pop STR QPM CO	1377	2173
	Akposoe	1587	1593
	EVDT W99 STR QPM CO	800	2321
	Farmers' variety	1277	2618
Mean		**1398**	**2207**
Garu-Tempane	2004 TZE WDT STR C4	1910	2803
	2004 TZE Y Pop STR C4	1747	2803
	2004 TZEE Y Pop STR C4	1837	2679
	2004 TZEE Y Pop STR QPM CO	1897	2655
	Akposoe	1750	1753
	EVDT W99 STR QPM CO	1957	3111
	Farmers' variety	1737	2716
Mean		**1834**	**2646**
s.e.d.	98.5		
L.S.D. (5%)	139.7		
C.V. (%)	15.8		

Table 56. Drought tolerant maize kernel yields across locations and years 2008 and 2009 in a semi-arid agro-ecology in northern Ghana.

Maize variety / Location	1	2	3	4	5	6	7
Bawku-Municipal	2030	1610	2102	1775	1590	1560	1947
Garu-Tempane	2356	2275	2258	2276	1752	2534	2226
Mean	2193	1942	2180	2025	1671	2047	2587
s.e.d.	184.3						
L. S. D. (0.05)	369.5**						
C.V. (%)	15.8						

1 = 2004 TZE WDT STR C4, 2 = 2004 TZE Y Pop STR C4, 3 = 2004 TZEE Y Pop STR C4; 4 = 2004 TZEE Y Pop STR QPM CO, 5 = Akposoe, 6 = EVDT W99 STR QPM CO and 7 = Farmers' variety.

Conclusion

The results in 2009 cropping season were the same as those reported the previous season. The maize varieties/hybrids have the potential to increase and sustain maize productivity within the Upper East Region, which of late used to be cultivated to millet and sorghum. 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 were therefore recommended for release to increase and sustain maize yields in the Upper East Region to ensure food security for farm families.

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Plant spacing and rate of Nitrogen fertiliser on growth, development and yield of sesame in Northern Ghana

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

Introduction

Sesame (*Sesamum indicum* L.) also known as benni seed in West Africa and sim-sim in East Africa, is the most important tropical crop from which semi-drying oils are obtained and perhaps the oldest cultivated for its oil. Except for one, which is found in India, all the other 19 wild species of sesame are found in Africa. This suggests that sesame was domesticated in Africa, probably from Ethiopia. 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, the 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. The oil contains mainly unsaturated fatty acids (oleic and linoleic about 40% each) and about 14% of saturated acids. It contains no linolenic acid. 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, iron and vitamins such as thiamin, riboflavin and niacin. Sesame cake produced after extraction of oil from un-hulled seed is an excellent feed for poultry, ruminants and pigs.

Objectives

The objective of the study was to determine the optimal rate of nitrogen fertilizer and plant spacing for increase production and productivity of sesame in Ghana.

Materials and Methods

The field trial was conducted at the Manga Agricultural Research Station during the 2009 cropping season. Using the randomized complete block design (RCBD) with 4 replications, the 2 factors studied (rate of nitrogen and intra-row spacing) were factorially combined in plots of dimension of 6 ridges each measuring 0.75 m apart and 5 m long. Seeds of the sesame variety were brought from Burkina Faso by the Association of Church Development Projects (ACDEP) based in Tamale. The factors studied were: different intra-row spacing (20cm, 30cm, 40cm, and 50cm each by a constant inter-row spacing of 75cm) and levels of nitrogen (0kg, 20kg, 40kg, 60kg, and 80kg) on the performance of Sesame. A fixed inter-row spacing of 75cm was maintained since that was the predominant practice of the farmers within the study area.

Within the second week of June, the trial field was harrowed and ridged and sesame seeds sown using 3 to 4 seeds per hill. Two weeks later, seedlings were thinned to 2 plants per hill followed by the basal application of compound fertilizer (15-15-15) at the various rates of nitrogen under study. Half of the nitrogen fertilizer was applied at 2 weeks after sowing (WAS) with the remaining half in the form of Sulphate of ammonia applied as a top-dress 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. On plot basis, 5 plants were selected at random and tagged from the middle rows for the purpose of agronomic data collection. The parameters were stand establishment count, plant height, number of capsules per plant, mean capsule weight, grain yield and biomass yield. The data were subjected to analysis of variance after which means resulting from significant treatment effects were separated using the least significance test.

Results

Mean capsule weight of sesame was significantly affected by the main effects of nitrogen ($P \leq 0.05$) and spacing ($P \leq 0.001$). The highest capsule weight was recorded by the interaction effect of nitrogen rate and intra-row spacing when 80 kg N/ha was applied at 30 cm. The response of sesame to the imposed treatments followed similar trends for capsule weight and grain yield when 80 kg N ha^{-1} was applied at 30cm spacing (Tables 57). Mean sesame capsule weight generally increased with increase in nitrogen fertilizer application.

Table 57. Mean capsule weight (kg/ha) of sesame as affected by rate of nitrogen fertilizer application and intra-row spacing in a semi-arid agro-ecology in northern Ghana in the 2009 cropping season.

N rate (kg/ha)	Intra-row spacing (cm)				
	20	30	40	50	Mean
0	2.6	2.5	2.9	2.6	2.7
20	4.0	4.1	3.7	4.0	4.0
40	5.2	5.8	5.4	4.8	5.3
60	6.2	6.2	6.3	5.7	6.1
80	6.9	7.1	6.7	6.3	6.8
Mean	4.9	5.1	4.4	4.7	
s.e.d.	0.275				
LSD	0.56				

Generally, there was an increase in sesame grain yield with decrease in intra-row spacing. This response could also be due to the crowding effect of plants grown under narrow to medium sized rows (intra row spacing of 20-40cm) with corresponding greater concentration of yield and yield components. Sesame plant spacing of 75cm x 30cm at N application of

80kgN/ha recorded the highest grain yield (273 kg/ha) while 75cm x 30cm at 0kgN/ha recorded the least grain yield (83kg/ha) in this study (Table 58). In Nigeria, a similar study by Olowe and Busari (1994) reported that 60cm x 5cm and 60cm x 10cm were the appropriate plant spacing for sesame in southern Guinea savannah of Nigeria. Ashely (1993) reported optimum population for sesame at about 170–200, 000 plants per ha. The plant population densities used in the current study ranged from 53,333 to 133,333 plants per ha. There is therefore the need to explore varying inter row against varying intra-row spacing so as to observe the response of sesame under these conditions. Marginal insignificant yield response was observed with increased in N level attaining a 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 N ha^{-1} by Subramaniah *et al*., (1979) and Daulay and Singh (1982). The relatively low performance of sesame in this study could partially be attributed to the lower plant densities or late planting of sesame or a combination of both factors. Instead of planting around May or June planting in this study was in July due to some technical challenges.

Table 58. Grain yield (kg/ha) of sesame as affected by rate of nitrogen fertilizer application and intra-row spacing in a semi-arid agro-ecology in northern Ghana in the 2009 cropping season.

N rate (kg/ha)	Intra-row spacing (cm)				
	20	30	40	50	Mean
0	100	83	125	80	97
20	161	168	167	174	168
40	198	218	222	212	213
60	199	226	263	235	231
80	267	273	246	235	255
Mean	185	194	205	187	
s.e.d.	22.14				
LSD	45				

The main effects of nitrogen rates and intra-row spacing significantly ($P \leq 0.001$) affected most of the traits evaluated more than the interaction effects. Plant spacing of 75cm x 30cm at N application of 80kgN/ha recorded the highest grain yield (273kg/ha) while 75cm x 30cm at 0kgN/ha (control) recorded the least grain yield (83kg/ha). Even though there was no significant interaction effect on plant population, the interaction effects of 20 cm and 30cm at 80kg N/ha produced the highest plant populations of 6.9 and 7.1 respectively. Sesame plant height was significantly ($P \leq 0.001$)

influenced by N application with plant height increasing with increase in N rate, attaining a maximum height of 142cm at 60kgN/ha. The highest number of capsules per plant was obtained when 60 kg N/ha was applied at 50 cm and the lowest when no fertilizer was applied at 20 cm intra-row spacing. Also the highest capsule weight was recorded by the interaction effect of 80 kg N/ha and 30 cm intra-row spacing. Nitrogen rate of 80 kgN/ha applied at 30cm intra-row spacing accounted for the highest biomass of sesame (7.1kg/ha) whilst the lowest (2.5kg/ha) was recorded when no nitrogen fertilizer was applied at 30 cm.

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Incorporation of improved cowpea varieties for increased production and productivity of maize-cowpea intercropping systems in northern Ghana

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Introduction

Although cowpea varieties with grain yield potentials in excess of 2.5t/ha have been developed for cultivation in the Guinea and Sudan savanna zones of northern Ghana, average farm level yields of cowpea are within the range of 0.3 to 0.65 t/ha (SARI 1996 &1997). This is because within these production zones, the majority of households who practice low-input farming are particularly dependent upon intercropping, and a large proportion of cowpea is produced under cereal-based intercropping systems. This poses a major challenge to sustainable cowpea production in these zones. This is largely because the improved cowpea varieties available for cultivation in this area have been developed for high input sole cropping systems. To address these challenges SARI has developed four varieties of cowpea (*Padi Tuya*, *Zaayura*, *Bawutawuta* and *Songotra*) that have varied adaptive traits to the predominant and emerging cropping systems in Northern Ghana.

Objectives

The objective of this study was to incorporate superior cowpea varieties for maize-cowpea intercropping systems in northern Ghana.

Materials and Methods

The on-farm trials were conducted within the Bawku Municipality from June to September 2009 on the 4 improved cowpea varieties as well as one local (farmer) variety. Sole cowpea plots were nested together with cowpea-maize intercrop plots in a randomized complete block design. Four farmers were involved in the trial. For the intercropping plots, Dorke was planted using alternate row cropping pattern at a spacing of 75cm between rows and 20 cm within rows, one plant per stand. A sole maize plot was included in the trial to serve as a basis for comparison with the intercrop maize. All agronomic practices such as weed and pest control, fertilizer application were observed. From cowpea plants randomly selected within the 2 central rows, data were collected on days to 50 % flowering, pods/plant, branches/plant, biomass, 100-seed weight, seeds/pod. Grain yield were taken on both cowpea and the maize. Land equivalent ratio (LER) was also estimated. All statistical analyses were conducted using the GenStat Statistical Program (GenStat Discovery Edition 3, version 7.2.0.220). The lsd (P = 0.05) method by Steel and Torrie (1980) was used to separate means of treatments that were significant.

Results

There was significant ($p<0.05$) but lower cropping system effect than variety effect on days to 50% flowering, cowpea grain yield and 100SW, implying that cropping system effect could be disregarded in favour of variety effect on these traits. In addition, there was insignificant variety x cropping system interaction effect on these traits ($p<0.05$) coupled with high land equivalent ratios (all above 1.0) of all varieties implying that the intercropping systems resulted in increased land productivity and therefore would increase farmers' income for improved livelihoods. It also implies that the varieties are broadly adapted to the 2 cropping systems in terms of grain yield stability. Even though there were no significant differences in grain yield (P=0.05) among the improved cowpea varieties under each cropping system (Table 59). *Zaayura* recorded the highest grain yield followed by *Padi Tuya* and *Songotra*. There was consistent grain yield superiority of the 4 improved varieties over the farmer's variety under intercropping system suggesting that the use of the 4 cowpea varieties rather than the farmer's variety would be suitable under intercropping system for the area. This could be the reason majority of the participating farmers preferred the 4 improved varieties to their local variety as reflected in the farmer preference data analysis. The pronounced biomass depression for the farmer's variety under intercropping condition suggests that this variety cannot be the best option under intercropping system especially when the farmer has fodder production as an alternative use for the cowpea. Generally intercropping reduced vegetative biomass and the pod load on cowpea plants considerably especially for the farmer's variety, which was among the cowpea variety with the smallest number of matured pods per plant. This observation is an indication that the shading effect from the maize crop adversely affected photosynthetic efficiency and subsequent accumulation of assimilates into biomass and pod load in the cowpea crop especially for the farmer's variety which produced a lot more biomass under sole cropping, and much less biomass under intercropping. These observations are consistent with reports that under intercropping, such varieties are unable to develop adequate foliage, and branching is reduced with consequent reduction in grain and biomass yields (N'tare *et al.,* 1993).

Conclusion

The challenges in producing cowpea on a sustainable basis within the Upper East Region can be addressed if efforts are focused on promoting the adoption of improved cowpea varieties. Being broadly adapted, the 4 intercrop-compatible cowpea varieties (*Padi Tuya*, *Zaayura*, *Bawutawuta* and *Songotra*) were intended for adoption under the predominant cereal-based intercropping system by resource-poor farmers within the region. It is hoped that these improved varieties, if adopted by majority of the farmers, have the potential of reducing malnutrition due to protein deficiency and thus enhance the livelihood of the resource poor within the region.

Table 59: Mean agronomic traits of cowpea varieties evaluated by 4 farmers under intercropping and sole crop conditions as well as their accompanying maize yields and LERs

Cowpea variety under	100 SW (g)	DFF	PPP	Bran-ches	GY (t/ha)	VB (kg/ha	Maize yield (t/ha)	LER
Intercropping								
Bawutawuta	12.07	48.75	5.75	3.25	1.199	8.12	3.2	1.64
Songotra	12.38	41.75	7	2.25	1.212	5.35	2.8	1.62
Padi Tuya	17.3	43.25	7.5	2.5	1.236	7.97	3.1	1.62
Zanyura	17.4	49.25	6.25	2.25	1.238	7.5	2.4	1.54
FV	8.92	49.5	4	1.25	1.175	4	1.9	1.64
Mean	13.61	46.5	6.1	2.25	1.232	6.59		
Sole cropping								
Bawutawuta	14.2	48	7	3	1.225	14.62	3.4	
Songotra	14.32	41.5	8.75	3	1.239	5.65	3.0	
Padi Tuya	19.77	43.75	8	2.25	1.28	7.62	3.4	
Zaayura	19.5	48.25	5.75	2.5	1.283	8.5	2.8	

FV	9.82	48	4.5	1.5	1.185	5.5	
Mean	15.5	45.9	6.8	2.45	1.34	8.38	2.2
LSD $_{(0.05)}$ CS	0.79*	0.45*	ns,	ns	0.010*	ns	
VAR	1.25	0.715	1.39	0.63	0.017	3.494	
VAR*CS	ns	ns	ns	ns	ns		
CV	8.4	1.5	5.3	21.6	7.6	27.7	

The way forward:
It is also imperative to include farmers in other districts in order to promote large scale adoption of the varieties. Even though it was the intention of the project team to continue with the adoption process during the 2010 cropping season to involve more farmers within the district, this intention could not be realized due to lack of funding. More funding is therefore required to continue with the project.

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ENTOMOLOGY PROGRAMME

Francis Kusi and Mukhtharu Zakaria

Executive Summary

Insect pests rank high among the constraints to increased crop production in the Upper East Region (UER). They attack all the crops grown in the existing farming systems and cause losses both in the field and storage. In an effort to address insect pests' problems, the following research activities were conducted in 2009: i) Mapping of aphid resistance gene in cowpea, ii) Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation and iii) Integrated management of field and storage pests to extend shelf life of yam. One DNA marker (CP171F, CP172R) was identified out of 50 markers screened which showed amplified bands that suggest linkage with the resistance locus. Concerning pests and diseases of onion, pepper, tomato and yam, IPM strategies were evaluated by a team comprising of Research, MoFA and Farmers. Training

programmes were also organised for the AEAs and the farmers. The detailed research activities and major achievements are as follows.

Mapping of aphid resistance loci in two cowpea populations

Francis Kusi, Francis K. Padi and Daniel Obeng-Ofori

Introduction

In cowpea cultivation, attack by insect pests represents an important constraint to obtaining economic yields. In the savanna regions of West Africa where the bulk of the crop is produced, *Aphis craccivora* is the most important insect pest during the vegetative phase of the crop. The pest primarily infests the seedlings of cowpea and causes direct damage on the crop by sucking plant sap, resulting in stunted plants and distorted leaves and indirect damage by transmitting aphid-borne cowpea mosaic viruses (Singh and Jackai, 1985). The existence of alternative plant hosts during the off season, intermittent drought spells during the rainy season and favourable temperatures during cowpea crop growth have resulted in this insect establishing a major pest status for cowpea. Moreover

Work at the IITA identified resistant sources in cowpea against the aphid, with antibiosis as the main basis for resistance (Singh, 1977; Ansari 1984). Following this, a number of breeding lines with resistance to the pest were developed at IITA and distributed to cowpea breeding stations worldwide (Singh, 2004; Ofuya, 1997; Bata, *et al*., 1987). Field tests in many locations including Ghana have shown that the IITA type of resistance was not effective against local biotypes of the aphid in many locations (Messina *et a*l., 1985). Resistance tests in Ghana with IT 84S-2246 and IT 97K-499-35, bred with the IITA source of resistance, for example, have shown to be highly susceptible to the aphid.

On-going research to identify resistance sources in cowpea to the cowpea aphid has uncovered a number of advanced breeding lines with high levels of resistance to the pest (Kusi *et al*., 2008). In these tests, lines with the IT 84S-2246 source of resistance were not more resistant than the susceptible check, *Apagbaala*. Segregation ratios in two independent F_2 populations generated between two resistant lines and *Apagbaala* suggests that a single dominant gene controls resistance to the aphid in these breeding lines. As such they present valuable sources of resistance for developing cowpea cultivars with resistance to the cowpea aphid in the field.

On-going efforts at mapping the cowpea genome presents an opportunity to tag these resistance loci with co-dominant PCR based markers to facilitate marker-based selection of aphid resistant progenies in large segregating populations designed to develop superior cultivars. Marker-based selection enhances the efficiency of selection with simply inherited traits (such as aphid resistance) for which phenotypic screening is laborious, expensive and dependent on favourable environmental conditions. Availability of tightly linked markers will therefore facilitate early generation selection, reducing the effective size of breeding populations and enhancing the overall efficiency of cultivar development.

The research was conducted to identify co-dominant PCR based markers linked to aphid resistance loci in two cowpea lines with high levels of resistance to aphid to facilitate the use of these sources in resistance breeding of cowpea.

Materials and Methodology

Fifty primers were received from Kirkhouse Trust to be screened for those that will be tightly linked to the loci controlling resistance to cowpea aphid in the populations. DNA samples were extracted from the resistant and susceptible lines and the two susceptible and resistant parents, *Apagbaala* and SARC1-57-2 using CTAB method. The DNA from these groups was run against all the 50 primers using the following programme:

Denaturing: 94° C for 4 minutes
Denaturing: 94° C for 15 seconds
Annealing: 50° C, 52° C, 56° C or 60° C (depending on the primer) for 30 seconds
Extension: 72° C for 30seconds
Extension: 72° C for 7 minutes
Hold: 4°C for infinity
Cycles: 35

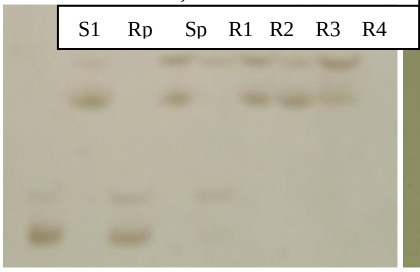
Results and Discussions

In general, 32 primers out of the 50 amplified the cowpea genome, however, only one primer (CP171F, CP172R) consistently showed amplified bands that suggest linkage with the resistance locus (Fig. 12 and 13). Three other primers (MS50F, MS50R; Y31F, Y31R and CP573F, CP574R) were also found with band patterns that seem to link with the loci controlling resistance to cowpea aphid, however, these primers were not consistent when they were re-evaluated later. The quality of the DNA samples at this time of the study was not the best; hence it was difficult to conclude on these primers. It was therefore decided to develop new lines to re-evaluate these primers, since all the seeds for both the resistant and susceptible lines have been used.

Follow-up studies

Following the results above, cowpea aphid culture was subsequently established at SARI to screen the F_2 population of SARC1-57-2 x *Apagbaala* after DNA samples have been taken. This was to assess the consistency between the results from the insectary screening and the molecular screening using primer CP171F, CP172R. However, the F_2 population which was produced in April 2007 did not germinate; the unfortunate situation could be attributed to the unstable power supply which affected the storage condition of the seeds. The parents will be planted in February, 2010, when the weather condition is expected to be favourable for cowpea growth, to generate F_1 and subsequently the F_2 populations so that the screening can commence by June-July 2010.

CP171F, CP172R



I. Fig. 12

Confirmation of CP171F, CP172R

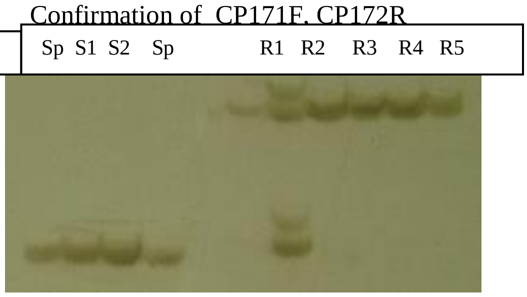


Fig. 13

Conclusion

The implementation of the project so far has equipped the scientists with basic molecular technique, a useful tool to rely on to advance the objective of developing strategies to manage insect pests problem of crops in northern Ghana. The project team intend expanding this study to cover all the major cowpea production areas in Ghana by evaluating the stability of the resistant line across the country. The reaction of the resistant genotype across the country will also inform on the possible existence of biotypes within *A. craccivora* in Ghana. This study would also deploy DNA Marker Assisted Selection (MAS) through back crossing to introgress the aphid resistance gene into *Songotra*, *Padi Tuya*, *Bawutawuta* and *Zaayura*.

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Development of strategies to manage pests and diseases of onion, tomato and pepper under irrigation

Francis Kusi, Stephen K. Nutsugah, Roger A. L. Kanton, Fuachie-Sobreh D. and Alexander N. Wiredu

Background and justification

Over the years the rainfall pattern has been erratic in distribution and low in intensity. This has resulted in decline in total annual rainfall in this part of Ghana. In Upper East Region (UER) in particular, frequent drought and subsequent crop failure has made rain fed agriculture unreliable and as a source of livelihood.

The intensification of vegetable production coupled with the cultivation of vegetables that share the same pests and diseases could be attributed to the proliferation of pests and diseases on irrigated fields in the region (Obeng-Ofori, 1998; Tanzubil, 1991; Tanzubil and Yakubu, 1996).

Tomatoes, onion and pepper production currently face the greatest threat from pests and diseases (Tanzubil, 2004). At a stakeholders forum at MoFA office in the Bawku East Municipal Area in 2004, Thrips (*Thrips tabaci*), Onion fly (*Delia spp*) and Bulb rot were identified as important constraints to sustainable onion production. A diagnostic survey carried out in the same year also supported these findings (Tanzubil and Kusi, 2004)

Diagnostic survey carried out by a team of scientists identified Yellow Leave Curls Virus (TYLCV) with white fly as a vector, Pepper Venal Virus with aphid as a vector, sclerotium wilt and early blight (fungal diseases) and nematodes as key constraints to sustainable tomatoes production in Upper East region.

The direct feeding effects of insects and indirect as vectors to viral diseases, fungal diseases and nematodes infections have also been the production constraints of pepper production in the region. Attempts by farmers to control these pests and diseases over the years has led to high cost of production and misused of insecticides leading to poisoning of human beings, livestock and the environment. The project therefore aim at determine the optimum integrated pests and diseases management strategies (IPDM) for onion, tomato and pepper production under irrigation in UER.

Objectives

1. Evaluating different IPDM strategies for onion, tomatoes and pepper production under irrigation.
2. To determine the socio-economically feasible IPDM strategy for onion, tomatoes and pepper production under irrigation.
3. Promoting the adoption of the economically feasible IPDM strategy by Participatory technology development.

Methodology

The type of technology the project is developing for adoption is IPM strategies consisting of safe and judicious use of chemical insecticides and fungicides to supplement botanicals, use of host plant resistance and cultural practices in a more efficient and environmentally friendly manner.

Locations

Onion - Binduri and Bugri
Pepper - Tilli and Goo
Tomato - Tono

Treatments

Six Nursery treatments
Five post-transplanting treatments

Design: RCBD

Replication: 3

Treatments at nursery

N1 – Seeds treated with Benlate T
N2 – Seeds dressed with Seed power 44 WS (Imidacloprid + Metalaxyl + Anthraquinone)
N3 – Seedbed drenched with Neem seed extract
N4 – Seedbed sterilized with heat
N5 – Seedbed dressed with Carbofuran (Check)
N6 – Control

Treatments after transplanting

S1 – Spray with insecticide + fungicide solution (alternate the insecticide and the fungicide)
S2 – Alternate neem seed extract and insecticide + fungicide spray
S3 – Control
S4 – Spray with insecticide + fungicide solution (use same insecticide and fungicide)
S5 – Spray with neem seed extract

All plots were subjected to recommended agronomic practices such as timely planting, judicious watering, recommended fertilizer application, mulching, etc.

Data collected

Incidence of pests and diseases at nursery
Nematode Load assessment
Effect of treatments on seed germination
Effect of treatments on seedling vigour
Symptoms of nematode attack (seedlings)
Incidence of pests and diseases on permanent fields
Assessment of insect pests resistance to the treatments (especially white flies)
Bored, rotten and sun scald fruits (Tomato)
Bulbs with Basal rot and bulb rot (onion)
Data were taken to carry out partial budget analysis to determine the most economically feasible strategy

Results and Discussions

The project implementation for the first year is on-going and the results gathered so far are as follows:

Pre-implementation survey

The survey was conducted to assess the level of technology use among the vegetable farmers and it revealed the following:

1. Most of the farmers do not use seed dressers
2. The practice of heat sterilization of seed bed and incorporation of the ashes before nursing is not a common practice among the farmers.
3. Few of the farmers were found to be using both insecticide and fungicide when there is the need to protect their crops, majority of them use only insecticides.
4. Neem seed extract as an insecticide is known among the farmers, yet only very few of them use it to protect their crops.
5. The use of hybrid seeds treated with insecticide and fungicide was popular only among tomato farmers at Tono, the rest either produce their own seeds or buy the seeds from the market women.

The research team together with MoFA embarked on training of vegetable farmers based on the findings of the survey. Five hundred vegetable farmers and twelve AEAs from four districts in UER (Garu Tempane, Kasena Nankana East, Bawku West and Bawku Municipal) were trained on basic practices for raising nursery and nursery management. Two more of such training has been earmark to address transplanting and field management as well as pre-harvest and post harvest handling.

Five treatments were evaluated at nursery namely, seeds treated with Benlate T, seed power 44 WS (Imidacloprid + Metalaxyl + Anthraquinone), seedbed drenched with neem extract, seedbed dressed with Carbofuran (check) and heat sterilization of seed bed by burning rice straw. Among these treatments heat sterilization of seed bed using rice straw produced the healthiest seedlings; no incidence of damping off and symptoms of nematode attack, the seedlings look vigorous and healthier than others planted at the same day using different treatments. The next best treatments were the seed power and the benlate T which also recorded very low incidence of damping off as compare to the neem and control plots.

Conclusion

These results have very positive implications on the achievement of the objective of the project in that healthy seedlings will be transplanted to give a better establishment on the permanent field as compare to seedlings with diseases and pests attack. Adoption of the heat sterilization treatment will require no or little chemical pesticides, hence the elimination or reduction of hazards associated with chemical pesticides.

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

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Background and justification

In West Africa, yams are cultivated in the fairly high rainfall areas with distinct dry and wet seasons. The 'yam zone' extends from the drier part of the forest zone through the derived savannah zone to the Guinea savannah zone (Tweneboah, 2000). Countries in this zone are Cote d'Ivoire, Ghana, Togo, Benin, Nigeria and Cameroon. West Africa produces over 90% of the total world production of 20-25 million tonnes annually (Obeng-Ofori, 1998).

High cost and often unavailability of planting materials, scarcity and high cost of labour, declining soil fertility, lack of staking materials especially in the Guinea savannah zone and incidence of pests and diseases have been identified as major constraints to yam production on large scale (Obeng-Ofori, 1998). Short shelf life of yam in storage is also a major post harvest constraint that could be attributed to two major factors: predisposing factors during production and storage (i.e. insect pests' infestation, nematode and disease infection).

Lack of pre-storage treatment of yam tubers coupled with poorly constructed storage structures also contribute to the short shelf life of yam tubers. Losses as high as 46% has been recorded over a period of just two months in yams stored under ambient conditions (Lyonga, 1984). Morse *et al*, (2000), demonstrated that damage caused by pests during storage is as important as damage inflicted in the field prior to storage to the incidence of fungal disease of yam.

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

Objectives

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

- To Promote the adoption of the economically feasible IPDM strategy

Methodology

The different treatments being evaluated comprised of site selection, treatment of yam setts before planting, control of pests infestation after crop establishment and treatment of yam tubers prior to storage. With the exception of pests control practices, all other recommended agronomic practices (e.g. spacing, weed control, staking, fertilizer application, etc.) were observed. Randomized Complete Block Design was used in a 4 x 2 factorial experiment in 3 replications. There were 4 pre-planting treatments of yam setts combined with 2 after sprouting treatments.

The storage studies were conducted in an improved storage structure which was put into 2 groups:

1. Subjecting half of the tubers produced from the integrated pests and diseases management field to Brine + Actellic dust treatments and half as control (no treatment). It was expected that the results from this experiment would indicate if tubers produced with IPDM strategies still required storage treatment or not.
2. The second experiment was to examine 6 different storage IPM strategies on tubers produced under farmers' practices and it was expected that the results from this experiment would indicate whether it was enough to restrict treatment to only stored yam or field treatment was equally important.

Results and Discussion

The project implementation for the first year is on-going and the results gathered so far are as follows:

Research site was selected in Yendi and yam setts and other research materials had been purchased.

The MoFA staff involved in the project had been briefed about the project.

Pre-implementation survey

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

1. Farmers do not treat yam setts against pests and diseases at planting.
2. Most of the farmers are aware of termites, yam tuber beetles, and mealy bugs as pests of yam.
3. When asked to distinguish the symptoms of termites, yam tuber beetles and nematode attack, most of the farmers could not clearly distinguish them.
4. Farmers rely on heavy rains to control pests on yam vines.

Based on the above results and other observations, a decision was taken to team up with MoFA to conduct periodic training of yam farmers and AEAs alongside the research programme. This is to enhance the skills and knowledge of the farmer to produce healthy yam tubers and to practice appropriate post-harvest handling and storage of yam.

Yam farmers groups were formed during the period by AEAs to be trained on topics developed from the findings of the pre-implementation survey. These include: pests and diseases of yam, factors that predispose the tubers/setts to pests and diseases attack, symptoms of attack by various pests and diseases and existing technologies to control them.

Conclusion

These results have very positive implications on the achievement of the objective of the project. The indication from the survey is that farmers do very little or nothing to control pests and diseases on the field which eventually affect shelf life of yam tubers. The treatments currently being evaluated by the project to control pests and diseases of yam would be a welcome intervention to extend shelf life of yam. The training of yam farmers, AEAs from MoFA and other stakeholders will form the basis of the efforts towards dissemination of the technology that will be recommended after the studies.

POST-HARVEST PROGRAMME

Analysis of seed size and moisture content relations on the viability of eight Pearl Millet Varieties

Issah Sugri

Introduction

A critical constraint in pearl millet production is the irregular seed viability which leads to poor stand establishment and subsequent yield performance. Farmers generally use high seeding rate of 8-12 seeds per hill and the overcrowded stands are often thinned out to fill up the vacant hills. In instances where laboratory tests show optimum viability above 70%, poor germination is recorded under field conditions. This study examined the effect of seed size and moisture content relations on the viability of eight pearl millet varieties during one year of storage.

Materials and Methods

Pearl millet varieties used in the study were Tongo Yellow, Arrow millet, Bristle millet and Bongo short head. The seeds were fractionated into three sizes: <2mm, >2mm and 1-3mm sieve ranges, and subjected to standard germination test. Germination counts were made on day 3, 5 and 7 after incubation, and up to day 9 for field testing. Days to 3-leaf and 5-leaf stages were determined as when 50% of the seedlings attained the 3 and 5 leaves stages, respectively. The incidence of seedling growth abnormalities was recorded using a three-point visual score; where score 1= normal seedlings, score 2= root growth abnormalities, score 3= shoot abnormalities.

Results

Table 60 shows that Tongo Yellow, Arrow millet, Bristle millet and Bongo short head were distinct for grain size characteristics compared to Salma-1, Salma-3, Langbensi millet and Indiana-05. The former recorded below 5% of proportion of seeds below 2mm sieve range compare to *Salma-1*, *Salma-3*, Langbensi millet and Indiana-05 which recorded as high as 8 to 30%. Principal component analysis established that seed size characteristics controlled up to 71.85% of data variation, whilst sorption characteristics accounted for 24.91%. For any variety, seeds of the >2mm sieve range recorded germination rates above 90% under controlled conditions except *salma-1* which had 84% germination (Table 61).

Table 60: Seed physical characteristics of eight pearl millet varieties used for the viability test

Variety (%)	<2mm sieve range (%)	>2mm sieve range (%)	Bulk density (kg/m^3)	1000 grain weight (g)	Moisture content (%db)	Seed purity
Arrow millet	2.85	97.28	84.73	13.18	8.90	99.80
Bongo short head	3.92	95.65	82.17	14.88	8.20	99.75
Bristled millet	4.18	95.87	81.65	14.05	10.75	99.77
Indiana -05	10.77	89.42	74.93	11.20	12.29	99.67
Langbensi millet	17.97	82.25	80.63	9.02	10.68	99.63
Salma -1	8.42	91.50	76.00	11.63	12.45	99.65
Salma-3	30.08	71.20	78.10	7.83	13.86	99.62
Tongo yellow	0.27	99.62	81.77	17.92	10.68	99.88
Mean	8.81	91.50	80.00	12.47	10.97	99.72
LSD $_{(0.05)}$	0.75	1.6	1.47	0.55	0.78	NS
CV (%)	6.5	1.5	1.6	3.7	6.0	

Decrease in viability was not significant (P<0.05) within 6 months of storage, and averaged above 70% viability across varieties. A sharp reduction in viability was noticed after 9 months probably due to the large proportion of seeds damaged by insect pests. Under field conditions abysmal germination rates of 65-75% and 53.3-65.8% across varieties were recorded by 9 and 12 months of storage, respectively. The number of days to 3-and-5-leaf stages (Table 62) shows a direct relationship between seed size and initial vigour across all varieties. These relations usually extend to plant establishment and yield performance. As high as 8.18% of seedlings recorded root growth abnormalities such as decaying, stunted or stubby primary root, and/or negative geotropism, and 3.97% recorded constricted or twisted and/or glassy-decaying shoot due to primary infection.

Table 61: Effect of seed size on the viability of eight pearl millet varieties

Variety Control	Mean	Laboratory viability test		Mean		Field viability test		
		<2mm sieve ranges	>2mm variet y			Contr ol sieve	<2mm ranges	>2mm variet y
Arrow millet	94.17	96.00	97.17	95.78	55.33	42.00	65.65	54.33
Bongo short head	88.33	87.00	97.00	90.78	53.33	40.50	60.33	51.39
Bristled millet	89.33	87.00	95.67	90.83	57.00	44.33	65.33	55.22
Indiana -05	73.83	77.33	90.83	80.67	51.33	34.00	62.50	49.28
Langbensi millet	90.00	89.17	94.33	91.17	51.00	36.17	62.83	50.00
Salma -1	80.00	77.17	87.67	81.61	34.17	30.17	53.33	39.22
Salma-3	88.17	85.17	94.67	89.33	50.50	40.67	57.17	49.44
Tongo yellow	87.67	84.67	90.67	87.67	58.33	46.17	65.83	56.78
Mean	86.44	85.50	93.50	88.84	51.25	39.25	61.2	50.79
LSD $_{(0.05)}$	4.69							
CV(%)	4.6							
LSD$_{(0.05)}$	NS							
CV(%)	11.9							

Table 62: Effect of seed size on seedling establishment of eight pearl millet varieties (days)

Variety	Control	Days to 3-leaf stage			Control	Days to 5-leaf stage		
		< 2mm sieve	>2mm ranges	Mean (variety)		<2mm sieve	>2mm ranges	Mean (variety)
Arrow millet	6.83	6.33	6.67	6.11	12.67	10.17	10.00	10.94
Bongo short head	6.33	5.67	6.67	6.22	10.50	8.33	10.00	9.78
Bristled millet	12.83	6.50	5.50	8.28	17.33	11.00	10.00	12.83
Indiana -05	9.33	7.83	7.17	8.11	12.83	11.33	9.83	11.33
Langbensi millet	7.5	6.85	6.50	6.94	10.67	9.50	8.67	9.61
Salma -1	9.33	7.83	7.17	8.11	12.83	11.33	9.83	11.33
Salma-3	9.67	8.00	8.18	8.61	13.33	12.00	11.00	12.11
Tongo yellow	8.33	7.00	7.33	7.56	12.50	9.50	10.83	10.94
Mean	8.77	7.00	6.90	7.56	12.83	10.94	10.04	11.11
LSD $_{(0.05)}$	1.07							
CV(%)	12.4							
LSD$_{(0.05)}$	0.75							
CV(%)	16.6							

Conclusion
The contributory influence of genotype, seed size and sorption characteristics on seed viability of pearl millet is complexly interwoven, and can be strongly modified by the environmental conditions at storage and planting. Delays in harvesting and sporadic rainfalls at harvests are other stress factors with the local farmers. However, the high moisture deficit resulting from the drier conditions which coincides with the period of seed storage provides favourable condition for further drying. Therefore, efforts to achieve higher germination in pearl millet should concentrate on issues of prompt harvesting, adequate drying, reducing dockage and appropriate storage; since these are within the capacity of the local farmers.

Review of crop storage practices and estimates of post-harvest losses in the Upper East Region of Ghana

Issah Sugri

Introduction
In developing countries where farmers lack access to sophisticated storage structures, post-harvest losses have been estimated conservatively as high as 10–30% in the cereals and 20–40% in roots and tubers, fruits and vegetables. The traditional methods of storage do not satisfactorily protect the produce from biological, physical and environmental hazards such as pests, disease pathogens, water imbibitions and high temperatures. In general, storage of agricultural produce is necessary because the production of major food crops is seasonal and the produce is highly perishable. Consequently, the food is produced in just one harvest period and must be stored for gradual consumption until the next harvest. This requires some level of processing, preservation and storage in order to maintain quality until the produce is needed.

Objective
To review the current methods of storage and assess the nature and quantities of losses incurred under farmer handling conditions using a field survey and standardized loss assessment methods.

Methods
The region was stratified into three broad zones based on ethnic, cultural diversities and agricultural potentials. Two methodologies comprising a field survey and standard loss assessments were adopted. The survey employed a structured questionnaire and focus group discussions to capture data on demographic and socio-economic factors, cropping systems, crop

storage practices, safety of agro-chemicals among others. Specific emphasis was placed on pest management options, loss mitigating measures and safety of post-harvest chemicals used. Grain samples (~0.5-1kg) were obtained from farmers and local markets from each zone of the region. The gravimetric method ('count and weigh') was used for the standard loss assessment to calculate weight losses.

Results

The gender distribution of respondents was 78.8% male and 20.2% female, and an average of 13 members per household. Majority of the respondents (79.8%) were between 20 to 60 years. Around 75% of respondents had no formal education, 22.1% had basic education, and only 2.9% had tertiary education. Four crops, maize, sorghum, millet and rice provided most of the dietary energy requirements. The average farm size was 2.5 ha per crop with yields below average potentials (Table 63). Where storage was anticipated above 4 months, over 50% of farmers used some kind of protection. Farmers applied chemicals only when infestation was noticed during storage. The common grain protectants were *Actellic* (Pyriphos methyl), *bioresmethrin* (pyrethroid) p*hostoxin*, *gastoxin*, *Gastox* (Aluminium phosphine) and *Wander77 powde*r. Only 16.3% of farmers acquired agro-chemicals from accredited sources, a large majority (80.6%) obtained chemicals from the informal sources. Consequently only 17.3% received training on responsive use of chemicals; such as pre-harvest internal, dosage, protective clothing and chemical disposal. As high as 13.5 and 11.0 % losses were incurred in cowpea and bambara beans compared to 3.5, 4.8, 6.7, 2.2, 1.7 and 3.1 % in maize, sorghum, millet, rice, soybean and groundnut, respectively (Table 64).

Table 63: Average farm size, yield and proportion of use.

Crop	Farm size (ha)	Yield kg/ha	% of farmers cultivating	Proportion of harvested produce (% response)		
				Consumed	As Gifts	Marketed
Maize	2.02	9.60	93.3	65.00	10.28	39.45
Sorghum	2.48	5.94	96.7	70.52	10.63	37.35
Early millet	2.92	6.41	96.2	84.85	10.69	28.41
Late millet	2.77	5.48	57.7	80.98	12.78	36.90
Rice	1.43	7.27	82.7	27.29	10.64	77.05
Cowpea	1.31	2.46	81.6	30.57	9.00	72.39
Soybean	1.51	2.47	61.5	14.44	0.00	94.26
Groundnut	1.91	7.81	87.5	20.01	9.88	77.52
Bambara nut	1.08	3.03	56.7	30.36	11.43	65.00
Tomato	1.06	16.57	14.4	12.69	8.75	81.21
Onion	0.72	7.59	35.	10.18	9.00	90.44

Sweet potato	0.70	15.53	13.56	30.18	7.50	81.50
Water melon	0.67	252	15.4	9.42	7.50	84.56
Yam	0.50	450	1.90	77.75	5.00	40.00

Table 64: Percent post harvest losses under farmer storage in the Upper East Region of Ghana

Crop	Farmer Estimation of Losses (%)			Standardized Loss Estimates (%)		
	Min	Mean (±std)	Max	Min	Mean (±std)	Max
Maize	1.0	11.0±7	30	1.50	3.5±2	7.0
Sorghum	1.0	9.9±6	30	1.10	4.8±3	10.0
Early millet	1.0	10.3±5	25	1.10	6.6±4	12.0
Late millet	1.0	9.6±5	20	1.10	6.7±4	11.89
Rice	1.0	8.1±5	20	0.50	2.2±2	5.50
Cowpea	2.0	21.4±15	80	3.30	13.5±7	25.5
Soybean	1.0	5.7±4	12	0.50	1.7±1	5.00
Groundnut	1.0	6.7±4	20	0.50	3.1±2	6.20
Bambara nut	1.5	13.1±10	50	6.00	11.0±2	24.0
Tomato	10.0	23.2±12	50	*	*	*
Onion	10.0	24.5±13	70	*	*	*
Sweet potato	10.0	22.3±10	50	*	*	*
Water melon	10.0	21.4±9	50	*	*	*
Yam	20.0	25.0±7	50	*	*	*

However, farmers' estimation showed much higher losses (21.4 and 13.12 %) in cowpea and bambara beans and around 5-11% losses in the other cereals. Extreme losses of 23.2, 24.5, 22.3, 21.4 and 25.0 % were incurred in tomato, onion, sweet potato water melon and yam respectively; over 50% of the losses were due to delayed marketing arrangements. Around 10-15 % losses incurred at sorting and grading were due to surface blemishes, rots and high internal infestation of insects. Quality losses in fruits included off-flavours, external and internal blemishes due to insect infestation, sprouting and mechanical injury.

Conclusion

Though these quantities of losses may seem inconsequential at the individual farmer level their cumulative effect on the national food balance sheet is huge. Subsequent loss assessment must meet minimum standards for each crop; taking into consideration climate data, scale of production, and the form, method and length of storage. Preferably, the losses should be also tracked along the value chain from harvesting to storage and subsequent marketing.

Effect of Season and Ripening Stage on Marketable Shelf Life of Three Tomato Varieties

Issah Sugri

Introduction

Prolonged shelf life of harvested tomatoes is critical in Africa where the produce is handled under stressful conditions because the handlers cannot afford controlled-environment storage. In Ghana, the appropriate stage of ripeness that tomatoes should be harvested to meet best sensory quality, price and prolonged shelf life is still in controversy. It has been suggested that if tomatoes are harvested at the green-mature stage, the shelf life can be prolonged to 1-3 weeks at ambient tropical conditions (Johnson and Hodari-Okae,1999). The tomatoes are currently harvested at the full-ripe stage because that is the consumer preference. This study attempted to identify the appropriate harvest index that would present best sensory quality and still meet other flexibilities such as price and shelf life.

Objective:

To evaluate the effect of three stages of ripening on the marketable shelf life of tomatoes cultivated in both the dry and wet seasons.

Materials and Methods

Three exotic varieties of tomato, *No Name*, *Pectomech* and *Tropimech*, were cultivated in the dry and wet seasons and harvested at green-mature, half-ripe and full-ripe stages for the study. All standard agronomic practices as well as pest and disease management were observed. Susceptibility to mechanical injury was determined as the percentage of fruits per treatment that were bruised when the samples were transported from the point of production to storage. The total weight loss was determined as the percentage of the original weight to the final weight during the storage period as below. Weight loss per day (%) was further calculated by dividing total weight loss by the shelf life (days). The terminal shelf life was expressed as the number of days between harvesting and when over 75% fruits became unwholesome due to rotten odour, fermentation, sour taste or microbial spoilage.

Results and Discussion

All varieties showed large fruit characteristics in the wet season except for dry weight which was higher in dry season (Table 5). The variety No Name was distinctive for most traits studied in the dry season but showed abysmal performance in the wet season. The average fruit weights of *No* Name, Pectomech and Tropimech were 60.1, 57.6 and 56 g respectively. Fruits of the wet season were more susceptible (9.9%) to injury than dry season (7.8%). Also, fruits harvested at the full-ripe stage were more susceptible (12.3%) to mechanical injury compared with those harvested at the green-mature (7.3%) and half-ripe (8.1%) stages. A progressive weight loss of 2.8% with prolonged storage and a strong correlation (r^2=87) between weight loss and shelf life was established. Fruits suffered severe weight loss per day (2.8%) in the dry season than the wet season (1.8%) (Figure 1). Prolonged shelf life was influenced largely by the season of storage and variety, but the effect of the stage of ripeness was not consistent (Table 66). Apparently longer shelf life of 8.5, 10.4 and 10.3 days for No Name, Pectomech and Tropimech was recorded in the wet season, but reduced to 8.1, 5.1 and 6.2 days respectively in the dry season. The onset of senescence in the dry season indicates that Pectomech and Tropimech should preferably be marketed within 3-4 days and up to 5 days for No Name (Figure 14). However, all varieties will maintain some appreciable quality for up to 7 days in the wet season, though the fruits would be sold at a trade-off price.

Table 65: Fruit characteristics of the three tomato varieties

Varieties	Fresh wt (g)	Ten fruits wt (g)	Dry wet (g)	Fruit length (cm)	Fruit diameter (cm)	Susceptibility Mechanical injury (%)
No Name	60.1	558.7	14.1	9.3	16.2	16.1
Pectomech	57.6	522.3	13.7	8.9	3.6	10.6
Tropimech	56.0	499.8	13.7	8.4	15.7	5.5
LSD $_{(0.05)}$	2.8	20.8	1.8	0.6	0.5	3.4
CV (%)	14.3	8.3	19.7	14.7	6.3	15.1

Table 66: Effect of season and ripening on the shelf life of three tomato varieties (days)

	Dry season				**Wet season**			
Variety	Green Mature	Half Ripe	Full Ripe	Mean	Green Mature	Half Ripe	Full Ripe	Mean
No Name	8.5	8.2	7.7	8.1	7.5	8.3	9.5	8.4
Pectomech	5.3	5.3	4.7	5.1	8.8	11.8	10.5	10.4
Tropimech	6.2	6.3	6.2	6.2	10.3	10.7	9.8	10.3
Mean	6.7	6.6	6.17	6.5	8.9	10.3	9.9	9.7

LSD $_{(0.05)}$ = Var. =0.79, Season =0.64, ripening =0.79, Var. x season =1.11, Var. x ripening = 1.36, CV =12%

An analysis of the fruit characteristics and physical environment revealed that tomatoes harvested in wet season were more turgid, susceptible to injury and prone to pest and fungi infestations which relates inversely to shelf life. However, a favourable environment for storage (25±3 to 30±3 ^{o}C, 70±5 to 84±5 rh%) as well as moderate respiration rate of 239-516 mg

CO_2/Kg/h may prevail (Doganlar *et al.*, 1998). A reverse environment occurs in the dry season, the fruits are less turgid and perhaps low incidence of pests and diseases but a harsh storage environment (29±3 to 39±3 ^{o}C, 44±5 rh%) and high respiration rate (1053-1600 mg CO_2/Kg/h) exist. These extreme conditions, particularly thawing day and night temperatures, may account for the non significant difference in shelf life across the three stages of ripening which was highly expected.

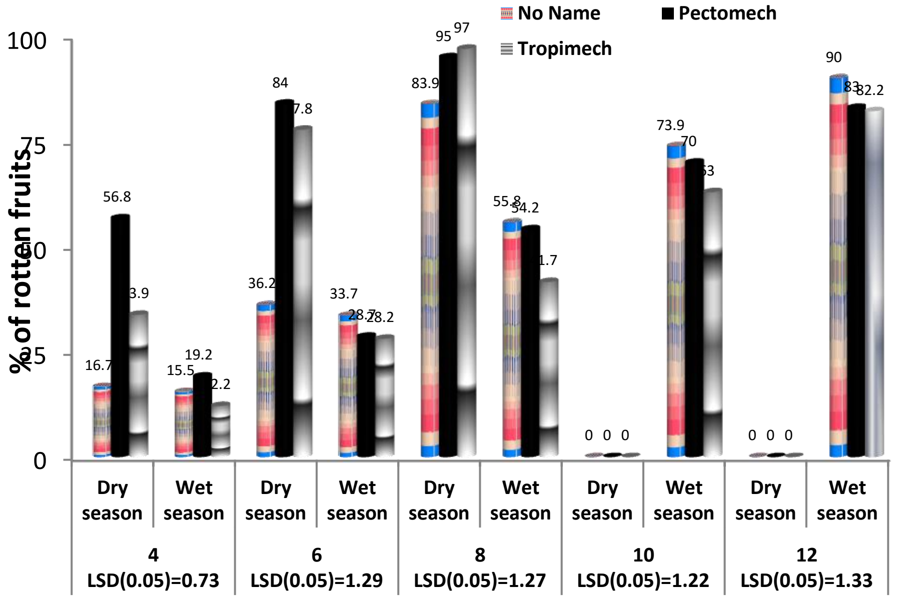

Figure 14: Effect of season of storage on shelf life and quality deterioration (days after storage)

Conclusion

Recommendations on harvest index in relation to shelf life of tomatoes should consider the growth season and climate zone due to the extreme of environments for storage. At the green-mature and half-ripe stages, the fruits still have firm texture to withstand the cumbersome handling. Harvesting at the full-ripe stage can be recommended where the current difficulties with regards to transport and marketing arrangements are mitigated. If the producers have ample time to harvest twice a week, harvesting at the full-ripe stage has advantages of good yield, competitive pricing and adequate nutrient accumulation. But where harvesting interval is prolonged (eg. weekly interval) all the green-mature, half-and-full-ripe fruits should be picked in order to minimize harvest losses.

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