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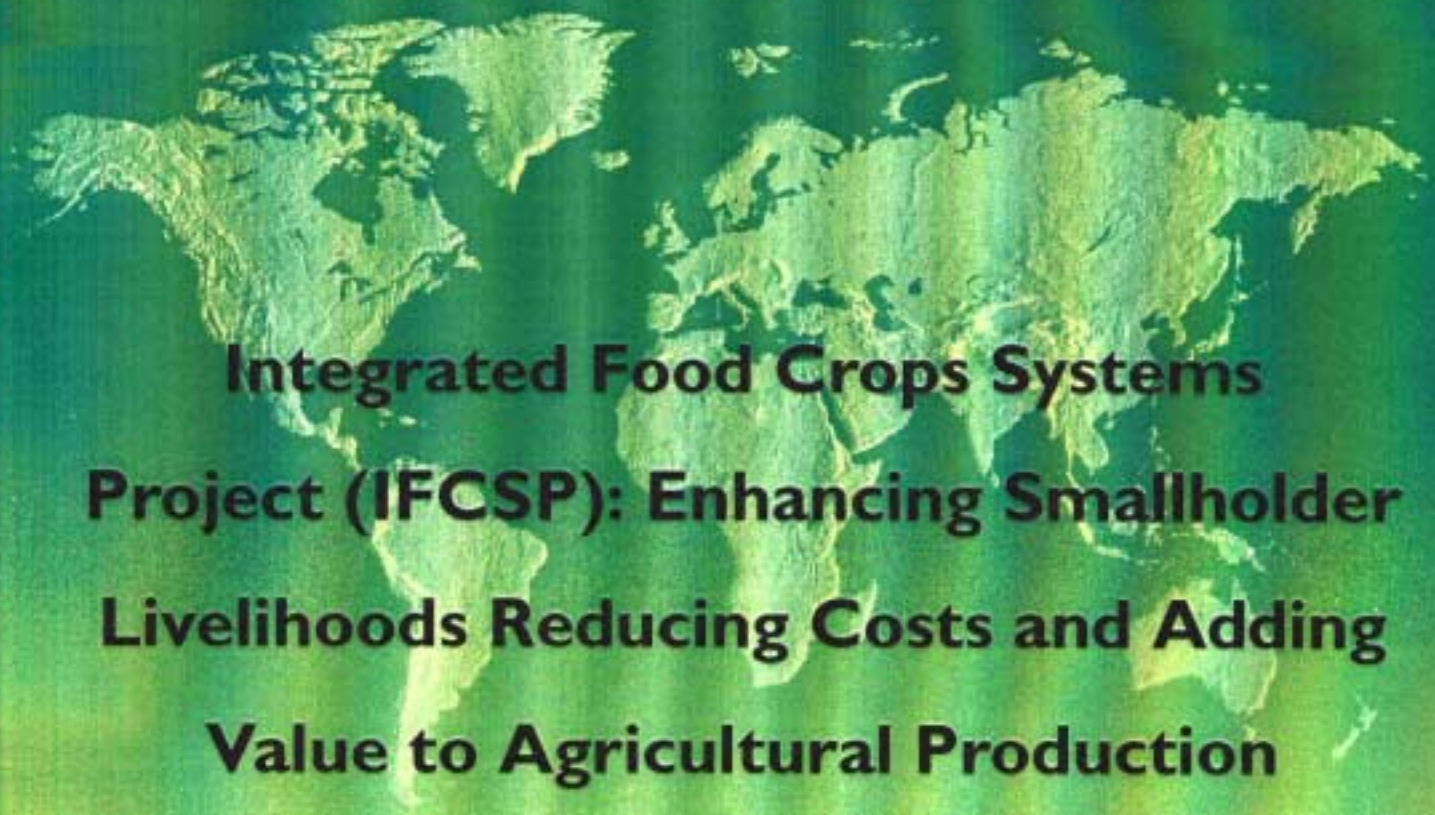

Integrated Food Crops Systems Project (IFCSP): Enhancing Smallholder Livelihoods Reducing Costs and Adding Value to Agricultural Production

Workhop to Evaluate Project Outputs and Identify Further Vegetable Research Priorities in the Brong Ahafo Region of Ghana

10–11 September 1998
Sunyani, Ghana

Workshop Proceedings

Natural Resources Institute

TABLE OF CONTENTS

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Editors: K.Boa-Amponsem, E. K. J. Suglo and J. E. Orchard

ACRONYMS

ARI	Adaptive Research Initiative
AVRCD	Asian Vegetable Resrearch and Development Centre
CBO	Community Based Organization
CRI	Crops Research Institute
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
GSID	Ghana Seed Inspection Division
IPM	Integrated Pest Management
KNUST	Kwame Nkrumah University of Science and Technology
MoFA	Ministry of Food and Agriculture
NGO	Non Governmental Organization
NRI	Natural Resource Institute
NARP	National Agricultural Research Project
RDA	Regional Director of Agriculture
RELC	Research and Extension Linkage Committee
SARI	Savannah Agricultural Research Institute
SRI	Soil Research Institute
UK	United Kingdom
WFSDTP	Wenchi Farming System Development and Training Institute
WRS	Wenchi Research Station
31st DWM	31st December Women's Movement

EXECUTIVE SUMMARY

The Integrated Food Crops Systems Project (IFCSP) is a vegetable research project funded by the United Kingdom Government's Department for International Development (DFID) and managed jointly by the Natural Resource Institute (NRI), the Council For Scientific and Industrial Research (CSIR) and the Ministry of Food and Agriculture (MOFA).

The IFCSP originated from an Adaptive Research Initiative (ARI) project, which started in 1994 and identified vegetable production as an important and increasing part of Ghana's farming systems, providing both income and food security.

The current project aims to alleviate poverty and encourage economic growth through the creation of income-generating opportunities and the addition of value to vegetable production. In order to achieve these, the project initiated a research programme in April 1995, which aimed at providing:

- improved marketing systems;
- sustainable supply of improved varieties;
- improved/new processing technologies;
- improved soil and water management;
- integrated control of pests;
- viable post-harvest practices.

The areas for research were selected after extensive surveys and consultations with vegetable farmers, extension officers, researchers and other stakeholders in the vegetable production system. The current phase of the project ends in March 1999 with the possibility of another phase. The workshop was therefore held to report on project progress and to identify potential areas for further research and extension to be submitted to DFID and other donors for funding support.

The workshop was attended by managers of the project, research scientists, MOFA staff, collaborators, traders, and farmers who have experience in the vegetable production system.

The project objectives were outlined by the Project Co-ordinator and an overview of the research and extension activities carried out by the project in meeting the objectives were presented by the collaborators responsible. Following the presentations, four groups were formed to discuss the achievements in line with the project objectives and to identify areas that needed further research and extension attention by the Project. Each discussion group focused on one of the following areas:

- Processing;
- Seed and Varietal Work;
- Post-Harvest Handling and Marketing;
- Soil and Water Management.

At the end of deliberations, potential research and technology transfer areas under the above themes were identified for consideration as a next phase of the project to further improve vegetable production in the project area and in Ghana at large.

WORKSHOP PROGRAMME

Thursday, 10th September

0900-0930 Registration
0930-1000 Opening of workshop (Mr. A. A. Osei-Frimpong - RDA)
1000-1030 Keynote Address - J. Orchard, IFCSP manager, NRI, UK
1030-1100 Break/Exhibition
1100-1130 Vegetable Research Needs in Ghana - K. Boa, RELC Co-ordinator. Middle Zone
1130-1145 Project Profile for IFCSP. E. K. J. Suglo, IFCSP manager, Ghana
1145- 1230 Vegetable Seed Sources and Supply. L. L. Delimini, Head GSID
1230-1315 Vegetable Varietal Trials. Kofi Biney, IFCSP, WARS/MOFA Staff
1315-1400 Lunch
1400-1500 Garden Egg and Okra Research. G. Nkansah, E. O. Owusu and K. O. Bonsu. (CRI)
1500-1600 Tomato Paste Processing. W. O. Ellis and R. Agbemafle. Biochemistry Dept. KNUST
1600-1615 Break
1615-1715 Vegetable Drying. S. Awiti-Kuffour, IFCSP
1715-1800 Soil and Water Management. D. Jackson, NRI / Anneke Meijer, IFCSP

Friday 11th September

0900-0930 Vegetable Post-harvest Handling and Marketing. J. Orchard, NRI
0930-1100 Group Discussion
1. Processing
2. Seed and Varietal Work
3. Post-harvest and Marketing
4. Soil and water Management

1100-1151 Break
1115-1315 Plenary session
1315-1400 Lunch
1400-1500 Development of Potential Research Areas
1500-1600 Closing Programme

OPENING ADDRESS

Mr. A. A. Osei-Frimpong, Regional Director of Agriculture, Brong Ahafo

Dr. John Orchard - UK Manager - IFCSP
Dr. David Jackson - NRI
Other members of NRI team
Research Scientists - CRI, SARI, SRI
District Directors of Agriculture
Head, Seed Inspection Unit, MOFA, Accra
Project Co-ordinator, IFCSP, Ghana
Hard working Farmers
Ladies and Gentlemen

I want to thank you all for the opportunity to be part of the IFCSP implemented by partnership between MOFA, NRI and CSIR.

Before I proceed, I wish to formally welcome you all far and near to Sunyani, Brong Ahafo.

Agriculture, you are no doubt aware, occupies a central position in the economy of this country. The sector contributes over 40% of total GDP and happens to be the source of employment for the people in the rural areas who form the majority of the population of the country.

Ladies and gentlemen, in view of the predominance of agriculture as a major source of foreign earnings, employment and food supply in the country, the performance of the sector has a multiplying effect on the overall performance of the National Economy. Government is therefore concerned about the slow pace of growth in the Agricultural sector which averages about 1.8% and this has necessitated in the radical shake up in line with the Decentralization Policy to re-organise and refashion the sector to ensure that they are disposed to provide the services they render more efficiently. This is the reason for the MOFA decentralization since October 1997.

You shall be here in Sunyani for the next two days to look at the achievements, constraints, opportunities, challenges of the IFCSP, a NRI/MOFA/CSIR Project which aims to help alleviate rural poverty through the creation and dissemination of income generating opportunities through research.

The project was developed like other on-going NRI projects as part of DFID's Renewable Natural Resources Research strategy to generate new knowledge and convert into technologies on commodities and cross cutting issues of generic and/or regional significance.

It is in the light of this that IFCSP is located in the Brong Ahafo region to support:

1. Development of appropriate technologies relevant to the production and marketing of vegetables in Brong Ahafo region.
2. Create opportunities for collaborative research in vegetables between NRI and

government institutions such as CSIR (NARP), universities and MOFA.
3. As a means to train MOFA Extension staff and farmers (target group) through participatory technology development, and
4. Further development of collaboration between MOFA, CSIR, NGOs, CBOs and stakeholders to enhance sustainable and effective dissemination of vegetable research outputs.

I am sure you shall look at all the issues and collate ideas and strategies that will help to:

1. Prioritise and consolidate the results of various research programmes conducted under IFCSP in the past four years having in mind the target group – farmers;
2. Review the collaborating agencies with the view to include other agencies to ensure the harnessing of resources and enhance impact;
3. Make available findings that need to be extended to the target group through partnership of collaboration with MOFA, NGOs, CBOs, etc.;
4. Through the implementation of IFCSP, strengthen the partnership between the UK and Ghana Government to achieve the elimination in poverty.

The co-operation is already extensive and we must strive to help build on it.

Ladies and gentlemen, I wish to conclude by wishing you fruitful discussions and an enjoyable stay in Sunyani.

On this note, I have the singular honour to declare the two-day workshop on the further identification of vegetable research priorities in Brong Ahafo Region duly opened.

Thank you.

VEGETABLE RESEARCH NEEDS IN GHANA

K. Boa, Crops Research Institute, Kumasi

Abstract

Several indigenous and exotic vegetables are grown and eaten in Ghana as a complement to staple foods. Vegetable production in Ghana ranges from backyard farming on small plots to the mixed crop system for home consumption and the highly intensive system with an intensive use of inputs. Many problems exist with vegetable production in Ghana. These include lack of water for dry season vegetable farming, no reliable source of improved seeds, pest and disease infestation, poor post-harvest handling and insecure market prices of vegetable products. In order to improve vegetable production in the country, the National Agricultural Research Project (NARP) and other related projects, like the Integrated Food Crops Systems Project (IFCSP), have initiated research and extension programmes to solve some of the problem facing the vegetable industry. With NARP just ending, provision is being made under the Agricultural Services Sector Investment Programme (AGSSIP) to continue vegetable production through research. In spite of the current research efforts, intensified science and technology development are needed to further improve productivity, quality and post-harvest processing methods so as to turn vegetables into high value commodities.

Vegetables and their importance

Vegetables are referred to as a group of crops, which are eaten as a complement to staple foods (Susanne, 1995). There are over 100 varieties of leguminous and leafy vegetables eaten across the world (Chen, 1995). They can be grown in almost any soil and under many water regimes, and in any season. Vegetable producers frequently undertake extra efforts to grow vegetables under difficult conditions.

Vegetables contain various kinds of dietary nutrients necessary for human health. For example, 90 % of the world's total amount of vitamin C comes from vegetables, and in the developing countries, retinol provided by vegetables accounts for 80 % of the total retinol intake (FAO yearbook, v.44, 1990). In addition, their colours and flavours meet several peoples' different tastes. Vegetables are good sources of active natural substances and fibre, which play an obvious and active part in improving human health, increasing human immunity to diseases and promoting metabolism (Chen, 1995). Some vegetables are also used in traditional medicine as curative and protective means of health (Chen, 1995). Increased vegetable production may improve food security on the one hand, and on the other hand offer income opportunities to small farmers and especially to women who still lag behind with regard to development benefits.

Current production practices in the country

Vegetable production is a very important commercial activity in the lowlands during the dry season and a good complement to food crop farming in the wet season. Several exotic and indigenous vegetables are widely grown and eaten in Ghana. At the moment, a wide range of systems exist, - from backyard farming on small plots in mixed cropping systems for home consumption to the highly intensive vegetable growing with a considerable use of inputs.

With some few exceptions, the bulk of vegetables in Ghana are grown under rain-fed conditions in the lowlands during the minor rainy season. Water supply becomes a

serious matter of concern especially when streams dry up due to extended drought. With limitations on available lowland areas, most farmers continuously use the same piece of land every year for vegetable production, with little or no consideration for crop rotation. Unlike the case of cereals and legumes, where a farmer can purchase locally-produced certified improved seed, vegetable farmers rely mostly on seeds saved from the previous season, from friends, the open market or imported from abroad. A variety of production practices is employed. Such practices range from ridging along the slope to intensive use of pesticides especially, fungicides and insecticides. These practices leave vegetable growers with many problems, which need to be addressed by research and extension interventions.

Problems of vegetable production

Vegetable production in Ghana as indicated above is besieged with many problems. In the middle zone of Ghana (Ashanti and Brong Ahafo regions), the annual Research and Extension Liaison Committee (RELC) planning workshop reports (1996-1998) have the following problems listed.

General problems

1. Lack of water for dry season vegetable production.
2. High incidence of pests and diseases.
3. Misuse of agrochemicals.
4. High post-harvest losses.
5. Lack of improved seeds.
6. Poor processing and storage facilities.
7. Price insecurity of vegetable products.

Crop specific problems

1. Collar rot disease in shallot.
2. High incidence of nematodes on tomato fields.
3. Fruit drop in pepper.
4. Onion bulb rot.

The above problems, together with several others from other parts of the country, need to be addressed by research in order to improve vegetable production in the country.

Current research

The vegetable programme of the National Agricultural Research Project (NARP) and the Integrated Food Crops Systems Project (IFCSP) in the Brong Ahafo region have embarked on a number of research activities to solve some of the problems facing the vegetable industry. The research activities being carried out by the NARP include the following (NARSP, 1994).

1. Environmental impact assessment of pesticide usage in tomato production in Ghana.
2. Effect of N, P and K fertilizer application strategies on growth and yield of vegetables.
3. Studies on current pest and disease problems of major vegetables in Ghana and their control.
4. Design of tomato storage units for small-scale tomato growers in the rural areas and a study of the effects of transportation on tomato quality.
5. The development of a windmill for small farmer irrigation on the Accra plains.

6. Biological control of vegetable pests in Ghana.
7. Eggplant improvement and production.
8. Onion improvement and production.
9. Okro improvement and production.
10. Pepper improvement.
11. Evaluation of intercropping of pepper with plantain in the forest zone of Ghana.

With NARP and the related agricultural projects coming to an end, the Government of Ghana has proposed the Agricultural Services Sector Investment Programme (AGSSIP) which will be the main instrument for implementing the Accelerated Agricultural Growth Strategy (AAGS). Research proposals being considered for possible implementation by the Council for Scientific and Industrial Research (CSIR, unpublished) under the AGSSIP include:

1. Production of quality seed of vegetable crops in Ghana.
2. Multi-locational evaluation trials of selected vegetable germplasm.
3. Integrated Pest Management of Insect Pests and Diseases of vegetables in the Middle and Accra agro-ecological zones.
4. Evaluation of legumes and a nematicide for the control of root knot nematodes in vegetables.
5. Optimization of the dehydration of some Ghanaian vegetables.
6. Management of waste waters for irrigation of vegetables in Urban Communities in Ghana.

Conclusion

Although research efforts have lately been intensified to address most of the vegetable problems, new science and technology are urgently needed for further improving production, quality and post-harvest processing methods to turn vegetables into high value commodities.

References

Chen H. (1995). Vegetables for food security and health. In: Vegetable Production in Peri-urban Areas in the Tropics and Subtropics - Food, Income and Quality of Life. Richter, Schnitzler and Gura (eds.). Proceedings of the International Workshop held from 14 to 17 November 1994 in Zschotau, Germany.

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Susanne G. (1995). Tropical and subtropical vegetable research and development- A documentation on activities of Institutions in Europe. In: Vegetable Production in Peri-urban Areas in the Tropics and Subtropics - Food, Income and Quality of Life. Richter, Schnitzler and Gura (eds.). Proceedings of the International Workshop held from 14 to 17 November 1994 in Zschotau, Germany.

PROJECT PROFILE FOR IFCSP

Integrated Food Crops Systems Project: Enhancing Smallholder Livelihoods Through Reducing Costs and Adding Value to Agricultural Production (01/04/95-31/03/99)

E. K. Suglo. Project Manager, IFCSP, Ghana

Background

The project originated from an Adaptive Research Initiative (ARI) started in 1994, which identified vegetable production as an important and increasing part of Ghana's farming systems, providing both income and food security. However, vegetable production evolved from a primarily subsistence-oriented farming system without the capacity to address constraining factors such as low productivity, periodic over capacity and large fluctuations in prices, high losses and limited opportunities for value-added products.

A research programme was initiated in April 1995 aiming to integrate pre- and post-production systems, and to provide an improved marketing system, sustainable supply of improved varieties, improved/new processing technologies, viable post-harvest practices, integrated pest management and improved soil and water management practices.

Project Purpose

The overall purpose of the project is to increase the value of fresh and processed vegetables and improve their post-harvest handling and marketing for smallholders.

Project Objectives

The project objectives encompass six main areas, namely:

- to develop improved tomato and garden egg germplasm adapted to the vegetable farming and marketing systems;
- to establish seed delivery systems and storage technology;
- to improve small-scale rural processing of vegetable;
- to develop post-harvest and marketing systems that maximise returns to the stakeholders in the vegetable production systems;
- to develop strategies for integrated control of vegetable pests; and
- to develop strategies for the alleviation of the agronomic constraints that limit dry-season vegetable-based systems.

To achieve the above objectives the project activities were grouped into various components and sub-components as follows.

Post-harvest components

1. Improved vegetable processing technology development through:
   i. on-station solar drying trials of various vegetables;
   ii. on-farm trials on solar drying of pepper;

iii. rural-level production of tomato paste through:
- laboratory production and analysis;
- socio-economic studies.

2. Post-harvest handling, storage, transport, and marketing studies:
   i. socio-economic studies on trading and marketing;
   ii. critical point analysis of the post-harvest chain;
   iii. shelf-life assessment of vegetables.

3. Variety improvement programme

   Multi-locational on-station trials to select tomato and garden egg at:
   i. Wenchi Farming Research Institute;
   ii. Crops Research Institute;
   iii. Sunyani;
   iv. Kwame Nkrumah University of Science and Technology;
   v. Plant Genetic Resources Centre.

   On-farm trials (Participatory Technology Development) at:
   i. Wenchi;
   ii. Wa.

4. Training, workshops and technology dissemination.

Integrated Pest Management components

1. IPM manual for vegetable pests.

2. Research on biological control of root knot nematodes.

Agronomy components

1. Development of on-station trials to study the use of:
   i. animal manures (Sunyani);
   ii. green manures (Sunyani);
   iii. compost (Sunyani);
   iv. manure application rates (Wenchi).

2. Development of on-farm trials (Participatory Technology Development) to evaluate:
   i. animal manures;
   ii. green manures.

3. Soil analysis.

4. Socio-economic studies.

Expected Project Outputs

Crop Post-Harvest Component

1. Introduction of new varieties with improved characteristics meeting demands of farmers, traders and consumers.

2. Methodologies for farmers to produce and maintain their own supply of quality seed, and to provide a framework that would define the requirements to produce affordable high quality vegetable seed.

3. Technologies to improve post-harvest handling and marketing systems.

4. Improved or new small-scale processing technologies and integration of processing and marketing, development of strategy for medium/large scale vegetable processing.

Pest Management Component

1. Major pre-harvest pest constraints in horticultural-based systems identified and prioritised for cultivation in low fertility areas (Brong Ahafo, Ghana).

2. Strategies for integrated pest management (IPM) developed for low-input mixed cropping systems, in accordance with the socio-economic needs and capabilities of the beneficiaries and the market requirements identified through liaison with the associated Crop Post-harvest Project.

3. Production of a pest manual and database on literature related to the IPM of vegetable pests and progress reports on other aspects of work.

4. Completion of one PhD thesis in applied nematology by the end of the project, and counterpart personnel with in-service training.

1. Farmer perception of diseases and pests studied.

Agronomic Component

1. Identification of improved composting/mulching technologies suited to dry season vegetable systems.

2. Assessment of the potential for the use of green manure.

3. Technology for more efficient use of fertiliser and/or organic manure.

4. Manual of improved agronomic techniques.

OPPORTUNITIES AND CHALLENGES FOR VEGETABLE SEED PRODUCTION IN GHANA

L. L. Delimini, Ghana Seed Inspection Division, MoFA.

The production, availability and supply of good quality seed of high yielding crop varieties in any agricultural country are of high national interest. The level of agricultural production and crop choice based on monetary returns primarily depends on the quality of seeds. The effectiveness of a seed industry therefore, depends on its ability to deliver high quality seed in a cost-effective manner.

Ghana's seed programme started with cereals, e.g. maize and later legumes, as the lead crops in research, primarily because of the place they occupy in the Ghanaian diet as staple crops. Furthermore, cereals and legumes research received national and international support leading to rapid crop improvement and development of improved crop varieties that are currently in production. One such international organisation is the Canadian International Development Agency (CIDA) which assisted the Ghana Grains & Legumes Development Project to develop these improved varieties.

Although vegetables are an integral part of the Ghanaian diet, it has long been recognised that good quality high yielding and disease-free seed supplied in sufficient quantities is a major constraint in increasing yields and adding value to farmers' produce. Current systems of seed supply rely largely on farmers' seed extraction, or from limited imports. Both systems have their inherent weaknesses of poor seed-extraction methodology, which may result in poor quality seed in the case of home-produced seed or limited and irregular importation due to foreign exchange constraints.

Despite these weaknesses, vegetable production is still a major farming activity that is encompassing the commercial and subsistent rural farmer on a small plot, as well as the urban backyard gardener. Vegetable production therefore is a nation-wide agricultural activity. The Brong Ahafo region in particular emerges pre-eminently as a major producer of vegetables as a commercial venture and to a lesser extent for local dietary needs. The four main types of vegetables that are grown nation-wide are okra, tomatoes, garden eggs and pepper. Other well-known species, which are cultivated on a lesser scale, are onion, shallots, leafy vegetables (e.g. corchorus), and amaranth.

Earlier Efforts at Varietal Improvement and Development

Towards the end of the 1960's and in the 1970's, crop improvement programs in tomato, garden eggs and okra were initiated at the Crop Research Institute (CRI) and the Universities in Ghana. This led to development of a few varieties such as Wosowoso in Legon and improved Zuarungu, (a local selection recommended for dry season gardening in the north). Other selections were also carried out in other vegetables such as garden eggs. Because the due processes of varietal development and release were not followed, some of these earlier selections soon disappeared and others deteriorated for lack of maintenance breeding.

Recent Research by the Integrated Food Crops Systems Project

A preliminary survey of farmers was carried out on vegetable varieties and cropping systems in the Brong Ahafo region (the report by K. Biney on the Variety Improvement Programme provides details). A number of varieties and landraces of tomatoes, garden eggs and okra were identified and documented. Following this survey, a number of varieties were selected by farmers for evaluation together with a range of varieties developed outside Ghana. This germplasm was screened and selected at the research and farmers level, based on superior and acceptable attributes. Out of forty-two tomato lines screened, five varieties were recommended for further multiplication. Very small quantities of these varieties, code named rasta, power, nkwanpa, ohienasa and akate were sent to the Upper West Region for further multiplication by out-growers. Rasta and power are existing varieties in the region. The aim of the multiplication exercise is to explore the possibility of introducing vegetable seed production as a commercial venture to private entrepreneurs. This is in line with the current seed industry's strategy of private sector ownership of seed production and marketing in the country.

Germplasm introductions and screening are still in progress for other crops such as garden eggs and okra.

The main objective of this paper therefore is to provide a brain-storming forum where we can discuss fully the implications of seed development and production, stages of the seed chain and the entire gamut of seed industry operation, albeit the vegetable seed sector.

Areas of Commercial Vegetable Production

Although it has been stated that vegetable production is a nation-wide affair involving largely small-scale farmers, nonetheless, the country is also characterised by commercial producers. Common commercial vegetable production areas are:

- a belt extending from Ashiama/Dawhenya to Sege and Ada in the Greater Accra Region;
- Ohawu-Keta areas in the Volta Region;
- Wenchi-Kintampo areas in the Brong Ahafo Region;
- Offinso (Akomadan) and Mampong areas in the Ashanti Region;
- dry season gardening around small dams and large irrigation sites in the Upper East and Northern Regions.

The Vea and Tono irrigation dam sites are well noted for their commercial activity in tomato production during the dry season. In addition, based on the various differences in the ecology of the regions, vegetable supplies are maintained throughout the year. These areas draw substantial numbers of traders from the south to purchase tomatoes.

Production of tomatoes and other minor vegetables including onion, pepper, okro and leafy vegetable has always been encouraged by the Ministry of Food and Agriculture. Consequently, several trials have been undertaken by the Ministry to select well-adapted and preferred varieties by traders who commute to the buying centres when these crops are in season.

Common Varieties Grown in Ghana

Several tomato and other vegetable varieties have been introduced and tried in Ghana with varying degrees of success. The most popular of the tomato varieties are: Power and Reno grown mainly in the Brong Ahafo Region; Laureno, Roma, Indian River and Heinz grown in the northern and upper regions; and Marglobe, Marvel and money maker in the other parts of the country.

Most of the above mentioned varieties were imported into the country. They were brought in for commercial reasons such as suitability for canning. Some of these varieties are hybrid for which reason their seeds cannot be produced and they have deteriorated for lack of maintenance breeding. Some of the imported varieties are susceptible to a host of viruses and fungal diseases as well as nematode infestation. Local varieties on the other hand produce large ridged fruits with thin skin, which split and bruise easily. Their fruits contain a large number of seeds and have other characteristics that are not suitable for canning purposes.

Source of Seed Supply

Local sources

The traditional method of vegetable seed production is a major source of vegetable seed supply. Just as for cereals and legumes, most vegetable producers obtain their seed from the informal sector, whereby seed is either home-produced, out-sourced from a neighbour through exchange or purchase or bought from a local market. Farmers who do not save seed or who are new entrants into the vegetable business either purchase seed from a professional seed merchant or from a local vegetable market.

At the markets, some individuals specialise in extracting seeds from commercial crops purchased towards the close of the market when commodities become cheap. Fruits used for this purpose are almost by definition 'left-overs', including fruits which are rotten, and almost invariably have seed transmittable diseases such as early blight or stem rot on tomatoes, pod spot on okra, phomopsis fruit rot on garden eggs, etc. Seeds can also be obtained from traders for contract production for preferred varieties. This source of seed supply may rely on market traders who want to guarantee a market for their produce. Traders obtain seed from a reliable farmer who has selected plants for seed purposes only. In all cases, where seeds are obtained through the informal sector farmers adopt their own seed extraction methodology.

Seed extraction practices in Ghana

Traditionally, okra and garden eggs seeds are obtained from mature fruits, which do not have commercial value as a vegetable. Most farmers do not select plants or fruits before extraction and consequently seeds extracted from left over fruit tend to be less viable or vigorous.

For okra, farmers have realised that seeds are best stored inside the pod, so farmers harvest fully ripe dry pods and do not break them open until sowing time. Seeds extracted by this methodology have a high quality, germination capacity and vigour and therefore are comparatively more marketable than other vegetable seed.

In the case of garden egg, ripe fruits are collected and left for almost three days to soften during which time seeds start to become loose. The fruits will then be mashed and put in water for one night to allow the seeds to become separated from the surrounding flesh. Part of the seeds will have dropped to the bottom but others will be removed manually. Seeds are then washed and dried.

Farmers extract tomato seeds through a fermentation process whereby fruits are placed in a container with water and are then squeezed or broken to a rough pulp. After one day, the heavy seeds fall to the bottom and the remainder floats to the top, thus facilitating their separation. After collecting and washing the seed, they are left to dry in layers. Another method is occasionally used whereby fruits are cut in two and seeds removed by hand or by using a spoon, often together with parts of the core. Some water is added and the mixture fermented for one day. After washing and removal of debris, seeds are dried in the shade for about three days during which time they are turned and rubbed to avoid lumping of the seeds.

There are two systems for peppers. The best quality seed is obtained from ripe fruits of selected plants, which are cut length-wise and placed in water for less than a day. Often people use a piece of wood to remove the seeds since direct contact of hot peppers with the skin can be highly irritating. Seeds are then dried. This system produces better quality seed than that extracted as a by-product of processing peppers, which are fully dried in the sun. Those fruits to be used for seed are not submitted to the normal step of dipping in scalding water prior to sun drying. These dried fruits are then placed in a bag and beaten after which the seeds are sieved out and the remainder will be ground up for the spice trade. Such seeds are dark brown or greyish in colour and could produce some abnormal seedlings due to internal damage, but seeds extracted using the earlier described method, are golden yellow in colour and have a higher germination capacity.

Estimated Annual Vegetable Seed Requirement in Ghana

For most of the important crops such as okra, garden egg, tomato and pepper, Ghanaian farmers extract seed locally. It is doubtful that such farmers are likely to buy seeds annually, as most of these crops are largely self-pollinating. Experience from other countries, such as Kenya and Tanzania, shows that traditional farmers change their seed source or variety once every three or four years on average and buy new seeds from markets or seed merchants once in every seven years when there are new varieties available. Farmers, who are used to high quality or hybrid seeds in order to produce export quality normally buy seed for every crop they grow.

Using this information and working with the average seed rates used by those farmers, the seed requirements per annum can be calculated as follows:

Crop	Est. Cultivated Area (ha.)	Average Seed Rates used (gms/ha)	Total Requirement (kg)
Pepper	120,000	400	48,000
Okra	40,000	4,000	160,000
Tomato	55,000	500	27,500

Garden egg	20,000	250	5,000
Onion	3,000	2,000	6,000

Realising that not all farmers can afford or are prepared to buy improved seeds, at probably a higher price than they are used to, an assumption is made that only about 25 - 30% of the farmers will buy improved seeds. This assumption combined with a purchase once in every 7 years means that only about 4% of the annual requirement could be expected for purchases of the more expensive quality seeds. In this case, one can estimate that a company which aims to produce quality seeds only can find an annual market for about 1100 kg tomato seeds and 250 kg of onion seeds. Similar calculations can be made for the other major crops once new or improved varieties have become available. To these figures, we could add a certain quantity used by growers producing for high value markets including export markets, where farmers would need quality seeds at every planting season.

Case for Improved Production Techniques

A viable, profitable and sustaining vegetable seed industry would require the production and supply of improved good quality seed in sufficient quantities to farmers all year round. The systems of seed extraction and delivery, as described for the informal section, could be adequate for the small-scale farmer but will not cater adequately in the long run as some farmers begin to graduate from their present stature to a more commercial operation.

Since vegetable production on a larger scale requires large-scale production of high quality seed, tomato and other vegetable producers in the country who grow tomato and other vegetables for export to the urban areas resort to imported seed mainly from a few importers such as Aglow. It is also possible to add value to vegetable seed through a better production and extraction technology. This is perhaps why in Brong Ahafo and other regions, some farmers who realise that quality seeds can only be obtained from the best plant have a selective approach and do not extract seeds from rotten fruits. These farmers produce a crop that is mostly uniform and less infested with seed-transmittable diseases than the average farmer. Such extraction technology and storage can become an example to other farmers. Seed produced by these farmers can then be distributed or sold to vegetable growers in surrounding villages. To be able to do this would require a wide range of varieties with superior attributes. At the moment, this possibility is limited due to inadequate breeding and varietal improvement in vegetable seed in Ghana. This definitely throws a challenge to the research and our varietal improvement programme in vegetables. When a formal or partly formal system emerges in our vegetable seed programme the possibility of farmers multiplying seed-transmittable diseases is reduced to very low levels. It also offers a wider varietal choice for both farmers and marketeers.

Imported Seed as an Alternative or Complimentary Option

Comparatively, the quantity of vegetable seed imported is not significant when one considers total potential seed demand as highlighted above. This is mainly due to their high cost. Cross boarder trade by road is negligible and most imports come by air through commercial seed merchants. Although no accurate figures are available, it is estimated that imported seed constitutes less than two percent of total seed requirement.

However, seeds for cabbage, carrots, cauliflower that cannot be produced locally because of climatic conditions are imported. Most imported seeds are from Denmark, Holland, Italy and some very small quantities from Japan and USA.

Average imports of vegetables seeds range as follows: tomato - 400/500 kg; okra - 50 kg; onion - 140 kg; egg plant - 30 kg. Other vegetable seeds produced are the exotic varieties whose seed cannot be produced efficiently in Ghana for climatic reasons.

From the above figures, it follows that only a small percentage of vegetable seed is imported into the country, generally less than 5%. This means that almost all the quantities of seed needed for the country is produced internally. This follows that to be able to fill this gap with quality seed will require a vigorous vegetable seed programme.

Ghana Seed Industry And The Vegetable Seed Programme

The state-owned Ghana Seed Company, which was a major source of seed for Ghanaian farmers, was identified for re-structuring and privatised in 1990, following various studies conducted between 1984 and 1989. From 1990 onwards, a number of small and medium sized enterprises have engaged themselves in seed production, processing and marketing, aided by public sector institutions through research and production of breeders' seed plus quality control and seed certification schemes.

Since the inception of this privatisation, support has mainly been provided by the NGO Sasakawa Global 2000 and by agencies including USAID, DANIDA, GTZ, IFAD and the World Bank. This support has been in various forms, e.g. through building and strengthening the institutional base of the public sector, which would support the private sector. This included supplies of processing and seed testing equipment. Staff from the Ghana Seed Inspection Unit and others has received extensive training both in-country and overseas.

The seed programme in Ghana started with maize through the Ghana Grains and Legumes Development Board. This has been followed by other crops including sorghum, cowpea, soyabeans and groundnut. Certified seed for all these crops is now available to farmers. Rice seed is also available as commercial seed but is not certified due to lack of breeders seed. Seeds are being tested and quality control does take place. Agricultural seeds are offered to farmers in units of 1 kg, 2 kg, 5 kg and 9 kg.

The approximately 100 seed dealers have formed a seed dealers' association with about 25 active members. The largest of these, Aglow Agricultural Products, distributes about 150 tons of cereal and legume seeds annually, representing approximately 20% of the country's production. Aglow's market share of imported vegetable seeds is said to be approximately 60%. In addition, the seed growers have organised themselves into a seed growers' association with sectors in the North (Tamale), the Brong Ahafo and Ashanti area (Techiman) and the southern sector based in Winneba. Membership of this association now stands at 120.

The Ghana Seed Inspection Unit registers both seed growers and seed dealers. It monitors seed production and processing and carries out a seed certification programme. Activities are undertaken at the National Seed Testing Station and at five zonal areas in Ho, Winneba, Kumasi, Tamale and Bolgatanga. The seed testing station at Pokoase

carries out reference testing of samples drawn from all five zonal areas with the view to establish uniformity in seed testing.

So far, vegetables seeds have not been given the same attention as cereal and legume seeds. There is, however, a clear interest both from government circles and from the farming community to act at an early date. This is clearly manifested in our seed law, which seeks to give the same importance to vegetables as cereals and legumes. What will be needed is technical support and guidance to establish the industry on a sound footing.

Constraints and Opportunities for the Vegetable Seed Industry

The range of vegetables cultivated and consumed in Ghana is rather limited when compared with other countries in the tropics. Apart from the Northern and Volta Regions, leafy vegetables are hardly known in other parts of the country. This may partly explain the high incidence of anaemia in certain parts of the country, caused by a shortage of iron in the diet. Most vegetables are either used in stews or in soups or used as a spice. Only a few vegetables are used in salads and this is mainly the case in restaurants rather than at home. However, the first signs of change are there already through increasing popularity of cabbage and lettuce. In addition, there is a renewed interest in exports of vegetables such as French beans for which seeds will be needed. The potential for change and expansion of the industry is therefore significant.

Due to limited foreign exchange, imported vegetable seeds (mainly tomatoes) were not always of the best quality and certainly did not represent the latest varieties. There is evidence that in the case of tomatoes, seeds supplied were by-products of the tomato processing industry. Varietal purity, trueness to type and freedom from seed transmittable diseases should be issues to be addressed. Again, the potential to improve the varietal range through selection of locally available germplasm and through new introduction and performance trial is undoubtedly great.

A wider range of diseases which could be carried either on the seed coat (e.g. many fungi and some viruses) or in the seeds themselves (especially bacteria but also some fungi and even nematodes in case of onions) are known to occur in Ghana. The habit of multiplying seeds at the farm without having the knowledge or the facilities to prevent seed-born pathogens has led to the current widespread occurrence of such diseases. The result is not only a reduction in yield and quality but also the high cost (in foreign exchange and environmental impact) of agro-chemicals. Seed production from selected and control parent material, carried out in isolated areas with dry climatic conditions may result in a considerable reduction of seed transmittable diseases. Unfortunately, farmers are not likely to benefit from this until their production plots plus the surrounding area are free from the vegetable crop in question and have been without this crop for such a time that there are no spores left of particular pathogen species.

The best areas to produce seed are those where relative humidity is low and where there is limited farming activity, especially activity related to the crop from which seeds would be multiplied. For this reason, vegetable seed production in Brong Ahafo region is not recommended. The driest areas in the country can be found in the north. However, in the dry north-eastern parts of Ghana there is also an intense cultivation of vegetables, especially tomatoes and onions near most of the dams. In the north-western parts, a number of dams are known where vegetable production is very limited or zero. These

include the Sankana dam, approximately 30 km west of Wa where there appears to be a good potential, but which will however need to be investigated further by means of small-scale trials.

Meteorological data were obtained in Wa, where the average maximum relative humidity (RH) measured between 1986 and 1994 were as follows:

Period/Time	**06.00 hrs**	**15.00 hrs**
January-March	55%	15%
April-May	70%	50%
June-October	90%	65%
November-December	60%	25%

Judging by these figures, Wa looks like a very good place to dry, pack and store vegetable seeds for most of the year. The comparatively humid months of April to the end of October are the crop production months in most parts of the country during which seed stocks are likely to be low. Generally speaking, there are almost no problems to be expected for vegetable seeds stored at a RH of 60% and below.

A potential problem, at least for the beginning of a new venture, is the relatively low demand for seed due to the expected low seed replacement rate and competition from low priced, low quality seed sales by non professional seed extractors at produce markets. If however the quality offered and new varieties introduced are found to be distinctly better, then one could foresee a demand which might not be met by supplies during the first years of operation. Legislation could similarly be enforced whereby only registered seed merchants would be allowed to sell seeds, which would need to be approved by the Ghana Seed Inspection Division. Such legislation has been introduced in Kenya where enforcement took place through seed import permits, which were tied to registration as a seed merchant. The Ministry of Food and Agriculture encourages the use of improved seed and can be expected to promote vegetable seeds as well once they become available in adequate quantities.

Additional demand may well be found in neighbouring countries such as Burkina Faso, Togo, Niger, Benin, Liberia, etc. These countries produce both indigenous and exotic vegetables but are not traditional producers of vegetable seed. Seeds produced in Ghana could be exported to these countries especially when their quality/price ratio is favourable in comparison with competitive sources. In addition, there is often a demand for local vegetables e.g. garden egg, which cannot normally be met by established international seed merchants.

Presently, interest rates in Ghana are very high which makes it difficult, if not impossible, for a customer to obtain a long-term loan from a bank and to be able to repay the capital plus interest. For the seed venture envisaged, this means that most of the capital will need to come from money made available by the shareholders directly. Probably, it also means that the venture would need to start on a modest scale, making use of readily available facilities including the equipment available at the Ghana Seed Division. Where possible, equipment should be leased. In the case of sealing seed containers, a possible co-operation should be sought with a vegetable processing company, where cans could be filled with seeds and sealed using their machinery.

Steps Towards The Establishment Of A Local Vegetable Seed Industry

Call for investors

It has become clear that the public sector only can support a vegetable seed industry but it would not participate financially. This therefore offers a challenge to the private sector to invest in a new industry. Such investors are likely to be merchants who are presently dealing in cereal and legume seeds but they could also be a group of farmers wishing to specialise in vegetable seeds or even large-scale users of seeds such as farmers' associations or farm services organisations. One of the first actions to be taken therefore is to discuss the issue and to sensitize potentially interested parties.

Ideally, interested parties should sit together and form a company with shareholders. Management and staff could then be appointed to run the company on a day to day basis. If this approach is considered feasible, a lawyer would need to be consulted to arrange for the legal aspects.

Initially, such a company can have a small capital base. What would be the minimum requirement is a manager plus an assistant. They will need transport and an office with a telephone. In the initial stages use could possibly be made of public sector services for the supply of basic seed and for seed quality control. Simple, laboratory-sized seed cleaning equipment such as a clipper need to be obtained. The same applies to packaging material, which could initially be simple polythene bags but that will soon have to be changed to more professional packaging material such as cans and coated aluminium foil. In addition some working capital is needed to pay the farmers for their produce (fruits or dried seeds).

Varietal screening and selection of basic seeds

Country-wide collections will need to be made of promising germplasm of both major and minor crops. These will include the most important five vegetables (tomato, pepper, okra, onion and garden egg) as well as shallots, lettuce, cucumber, watermelon, amaranth, corchorus, vegetable rape and others of local interest. Specific attention will need to be made to selecting from a range of varieties. Seeds or bulbs should be collected from plants that show a good yield potential, be of good plant shape for the species concerned, early producing and disease free. It is important to make a note on the exact location of the collection in case further material is needed.

Simultaneously, a request should be made to international seed merchants or institutes (e.g. Asian Vegetable Resrearch and Development Centre and horticultural research institutes of African countries) to send samples of non-hybrid seeds of varieties which are likely to grow well under Ghana's climatic conditions. Such seeds should be limited to tomatoes, pepper (hot and sweet) and onions.

These collections would need to be catalogued, described and judged on their performance. Screening to be initially conducted in three areas (forest zone, intermediate zone and Savannah area) and plants to be grown both during the rainy season and under irrigation in the dry season. Small plots to be established for each entry and randomly

replicated at each study site. Where possible performance should be scored on plant habit, earliness (with flowering dates), crop yield plus seed yield, quality attributes (size, shape, colour, firmness, keeping quality, taste, etc.) and where possible tolerance to pests and diseases. An effort should be made to collect enough seeds from the observation plots to be able to repeat the trials at a later date.

Once screening has resulted in a limited number of selections and their seeds have been extracted, a larger trial should be conducted with other selected varieties to obtain basic seed. This screening may be of particular interest for onions where individual bulbs could be multiplied using family pollination, which will result in a more uniform crop than the current mixtures.

Seed production

When a seed company has been formed and organised and basic seeds have been identified, the next step is to look for an ideal production site. As explained above, the best sites are those which are isolated from other vegetable farming activities for reasons of avoiding diseases but also to prevent potential customers from multiplying their own seeds. Copying other farmers' activities is quite normal but in this case this is not recommended because non-registered seed growers will not get access to basic seeds and will not be monitored and could in theory be multiplying problems rather than quality seeds.

As soon as farmers have been found who would like to grow seeds on contract, they will need to be trained in the production technology. This training can be given on the spot and would continue throughout the crop production phase and would mainly be geared towards prevention of diseases, varietal purity and seed yield (extra Phosphorous rather than extra Nitrogen). It will also deal with seed extraction and drying techniques.

Seed processing

Once seeds have been dried by the farmers and their quality checked, delivery can be made. Seeds may then be dried even further but not below a critical minimum when seeds become brittle and can easily be damaged producing abnormal seedlings. A very low moisture content may result is a complete loss of viability. Once seeds have dried to a moisture equilibrium with RH% of about 35, it is advisable to store them for up to one week in an open container. This is necessary to slow down the respiration of the seeds themselves. If this precaution is not taken then it is quite possible that the seeds will consume all available oxygen from within an airtight container (seed packet or can), resulting in an alcoholic fermentation process and complete loss of germination capacity.

During the drying process cleaning could start. The first stage of a cleaning process will remove the obvious elements like non-seed plant residue (fruit skins in tomatoes, stalks in onions, etc.) plus small stones or dust. In the second part, screens will be used to separate seeds into various sizes whereby often the smaller sizes will be discarded because such seeds are not likely to produce strong plants. A laboratory-sized clipper can combine both functions and is therefore recommended for the start of a small company. Further details on seed cleaning could be dealt with during a follow-up.

Packing of seeds into material with a low air permeability is essential especially when

such seeds will be used in more humid areas. Polythene material is certainly better than paper packets but if used, preference should be given to a rather heavy quality. Once the seed company has gone through the preliminary stages it is recommended to change from polythene seed packets into the use of laminated aluminium foil with a polythene coating. Further details on this topic including the use of lacquered cans could be given during a follow-up.

Seed bulk storage can be either in jute bags or in large plastic containers. Care must be taken that the storage room will not contain any shelves made of plywood. The glues used in plywood often contain formaldehyde, which is usually lethal to seeds.

Extension information dissemination

Many farmers lack technical guidance in their crop production efforts. A lot of information on basic agronomy is available at universities and elsewhere but this knowledge is hardly or not presented to the farming community. A good marketing ploy would be to sell seeds and provide the farmer with a hand-out as to what she/he should do to get maximum results.

Plant breeding

Landraces can, in theory, build up a tolerance against local stress conditions including certain diseases or pests. This will however have to be established first whereas for common crops like tomatoes it is probably much easier to find genetically built-in tolerance or resistance in commercially available varieties. In Ghana, the major pest and disease-related constraints for tomatoes include nematodes and Fusarium. Most modern varieties now have these resistances built-in. Therefore, rather than conducting an expensive search for tolerances in local landraces of tomatoes, faster results could be expected from varietal introductions to be screened on performance under local conditions.

Relatively little research has been carried out on garden eggs or African eggplant as they are also called. Although Dr. Seck carried out extensive studies in Senegal and Dr. Pannekoek from Ghent University did the same, only limited breeding work with incorporation of disease resistance in garden egg has been undertaken. One could start with a germplasm collection locally and by requesting small seed samples of garden egg from gene banks such as the one at Birmingham University and to build on work already undertaken elsewhere such as in Senegal (but also south east Asia).

At the Horticultural Development Centre in Camberene, Dakar, Senegal, African eggplants have been found with genes resistant to spider mites. In addition, a high level of resistance has been noticed against nematodes, *Stemphylium* rot and against *Pseudomonas solanacearum*. In the Brong Ahafo region however, many other plants have been found with symptoms of these diseases. This indicates scope for further selection and breeding from the local landraces which could lead to a marked improvement over their current performance.

TOMATO VARIETAL IMPROVEMENT PROGRAMME

K. Biney, IFCSP

Background

In Brong Ahafo and other regions in Ghana, farmers use a limited range of vegetable varieties. These were introduced many years ago and have since been multiplied without maintenance breeding. In most countries, farmers recognize that good seed is the key to successful farming and determines the profitability of their produce. Yet, vegetable seed distributing agencies in Ghana hardly exist and the few sales outlets dealing with local or imported seeds have a very limited choice of the same old varieties. Consequently, farmers choose to extract seeds from their crops because better material is simply not available. A survey conducted by the IFCSP in 1996 noted that over 70 percent of vegetable farmers in the area extract and use seed from their previous crop.

Tomato production in Brong Ahafo can be traced back half a century as judged by the types of varieties that are found in the landraces. Old French varieties like Super Marmande or old English ones like Oxheart can be found, but also the occasional Roma from Italy or American Heinz 1350 processing types. There is substantial outcrossing and the typical self-pollinated character of modern tomato varieties must have been broken down some time ago as seen by the stigma that sticks out of the anthers from approximately 5-10% of the population. The resultant mixture can reasonably withstand local stress factors such as the unpredictable weather with both periods of high humidity and periods of drought but yield is relatively low.

The need for a wide range of varietal characteristics has constantly been expressed by farmers. This need was identified as a potential research area by the IFCSP and front-line staff of MoFA in 1995 during a review of the research needs for first phase of the project.

The Project initiated a variety improvement programme to meet the specific germplasm needs of various types of growers, traders, processors and consumers, using two main approaches:

- purification and subsequent screening of established local tomato landraces, selected by farmers, using the pure line selection method of breeding;
- screening for local acceptability of exotic tomato accessions from the Asian Vegetable Research Development Centre (AVRDC) and other sources.

Varietal selection is particularly difficult for highly heterogeneous environments where smallholders have a range of preferences. To address these issues, the Project involved farmers, traders and scientists in a programme of on-station and on-farm research to assess a range of varieties.

A. Purification Of Local Landraces

Purpose

To select, from currently available germplasm to farmers in Brong Ahafo, 10 and 15 plants per land race which are the best in yield potential, shape and other quality and marketing criteria and are also free, or nearly so, from diseases.

Fruit selection

Tomato landraces were collected from farmers. Plants/fruits were selected by farmers based on their own criteria with project staff guiding on the need to start from disease-free material. Tomato fruits were collected at Manso in Techiman district and Awisa in Wenchi district (Table 1). For each landrace, 15 plants were pegged and fruits of each plant (representing a line) collected separately.

Table 1. Characteristics of tomato landraces selected by local farmers

Crop	*Landrace/ line No.*	*Seed Source*	*Farmer*	*Location*	*Selection Criteria*
Tomato (Power)	M1 - M15	From friend, self selection /extraction	Seth Ankumah	Manso	Uniformity, fruiting, fruit skin thickness
Tomato (Power-Reno)	M16 - M30	Trader, self selection /extraction	Effah Appiah	Manso	Fruit No., size, cracking, shelf life, variety.
Tomato (Reno)	Aw1 - Aw15	Market, self extraction	Richard Antwi	Awisa	Fruit size, shape, shelf life, variety
Tomato (Cobas)	Aw16 - Aw30	Farmers, self selection	Kojo Yensu	Awisa	Fruit No., size.

Criteria for selecting plants and fruits varied among farmers. Farmers would select seed from fruits in the middle and tail end of harvesting period but not the early stages of harvesting. Diverse reasons were given including seed number per fruit, seed viability and maturity. Some of the farmers were concerned about diseases but none could differentiate between seed-transmissible and non-transmissible diseases.

Market-driven factors including fruit size, shape, colour (for garden egg) and shelf life as well as fruit numbers per plant and length of production period of landraces were paramount to farmers.

Seed extraction was done separately for fruits of each plant. Farmers' method of fermentation was applied. Extracted seeds were dried in paper napkins, packaged in small polythene sachets and labelled.

Nursery

Seeds were sown in boxes, 30 cm x 30 cm x 10 cm, and three-quarters filled with forest topsoil. Seed boxes were placed on benches. Temporary shade was removed at two weeks. Seedlings were sprayed with Dithane M45 (Mancozeb) at 15g/10 litres of water in week 3 against fungal development. Phostrogen, a foliar fertilizer, was applied at

5g/10 litres of water in the second week to boast seedling growth. Weeds were removed by hand as and when they appeared.

Data was collected on germination, hypocotyl colour and leaf colour.

Field maintenance

The field was slashed, cleaned, ploughed and ridged. Lines were allocated to plots (ridges) by randomization and identification pegs labelled against them: 25 plants per ridge (line) at a spacing of 60 cm between plants and 90 cm between varieties. Three manual weedings (earthing up at each weeding) in the 3rd, 6th and 9th weeks were undertaken after transplanting. Fortnightly insecticidal and weekly fungicidal sprays were undertaken with Sebon (300 ml/15l water) and Dithane M45(50g/15l water), respectively. Compound fertilizer (23-15-5) was applied at 20g per plant in 2nd and 4th weeks and 10g per plant ammonium sulphate at 6 weeks after planting.

Harvesting and data

Fruits were harvested once weekly initially and twice weekly later when yield was at its peak. For post-harvest characterisation, fruits were harvested red ripe. Fruits were also harvested at the orange ripe stage from healthy plants for seed extraction. At each harvesting fruits were counted and weighed. Field data was collected on the morphological features, diseases and insect pests.

Results

Diseases and pests

Diseases and pests together constitute a major constraint in vegetable production. Farmers perceive the activity of insect pests as damaging but do not really conceive losses due to pathogenic diseases. Pesticide spraying is considered a routine cultural practice and not in relation to pest and disease threshold levels. Farmers may spray fungicides because they think it enhances flowering and ripening.

Few seed-borne diseases were encountered. Bacteria scab (*Xanthomonas campestris* pv. vesicatoria) and unidentified virus symptoms were observed in tomato lines. Symptoms of fungal diseases including Sclerotium wilt (*Sclerotium rolfsii*), Early blight (*Alternaria solani*) and Septoria leafspot (*Septoria lycopersici*) were also identified on tomato.

There were fruit borers on tomato (*Heliothis armigera*) and garden egg (*Leucinodes orbinalis*). See table 2 below.

Table 2. Diseases and pests of local tomato landraces

Line no.	Septoria leafspot	Early blight	Sclerotium Wilt	Bacteria wilt	Viruses (unidentified)	Fruit borer
M 01	x	x				
M 02	x		x			x
M 03		x			x	
M 04	x	x				
M 05	x	x			x	
M 06 *	x	x		x	x	
M 07		x				
M 08	x	x				

M 09				x	x	
M 10	x	x			x	
M 11	x	x			x	
M 12	x	x			x	
M 13	x	x				x
M 14	x	x			x	
M 15 *	x	x		x	x	
M 16	x	x			x	
M 17	x	x			x	
M 18 *	x	x			x	
M 19	x	x			x	
M 20					x(1 plant)	
M 21 *	x	x		x	x	
M 22 *		x		x	x	
M 23	x					x
M 24	x	x			x	
M 25	x	x		x		
M 26				x	x	
M 27	x	x				x
M 28	x	x			x	
M 29	x	x			x	
M 30	x	x			x	
AW 01	x	x				x
AW 02	x	x			x	
AW 03	x			x		
AW 04		x			x	
AW 05	x					x
AW 06	x			x		
AW 07		x				x
AW 08	x				x	
AW 09 *			x		x	
AW 10	x	x				x
AW 11					x	
AW 12	x	x				
AW 13	x					x
AW 14		x		x		
AW 15 *						
AW 16		x			x	
AW 17 *			x			
AW 18	x					x
AW 19	x	x				
AW 20		x				x
AW 21		x		x		x
AW 22 *						
AW 23	x					
AW 24 *						
AW 25 *						
AW 26	x	x				x
AW 27 *				x	x	
AW 28 *		x	x		x	
AW 29 *				x	x	
AW 30 *		x		x	x	

Yield

Some lines did not reach the harvesting stage due to high disease incidence. Below is an

outline of average yield per plant of remaining lines at harvest.

Table 3. Yield data of tomato purification trial at WARS (Wenchi)

Landrace number	Average yield (grams) / plant
M1	561.2
M2	192.7
M4	167.0
M5	106.3
M7	262.9
M8	227.0
M10	471.6
M13	546.2
M14	166.3
M16	398.3
M17	371.0
M19	333.0
M20	303.5
M23	316.0
M24	254.7
M25	240.5
M26	290.0
M27	276.5
M28	175.0
M29	313.7
M30	291.0
AW1	265.0
AW2	190.6
AW3	433.1
AW4	192.2
AW5	603.5
AW6	253.3
AW7	171.6
AW8	207.9
AW10	218.0
AW11	164.5
AW12	264.5
AW13	343.5
AW14	410.5
AW16	235.8
AW18	313.5
AW19	210.5
AW20	205.0
AW21	217.0
AW23	211.0
AW26	208.6

The great diversity indicated by the yield data is an expression of the level of heterogeneity of the local landraces farmers are currently growing. A wide range of diversity can be observed between lines of same landrace. Additional contributory factors

include soil and other environmental characteristics. Yield of Power (M1-M15) ranged between 166.3 g/plant and 561.2 g/plant while that of Power/Reno (M15 -M30) and Reno (Aw1-Aw15) was 175.0 - 398.3g/plant and 164.5 -603.5g/plant. Average yield of Cobas or Rasta (Aw16-Aw30) ranged between 208.6 and 313.5g/plant.

Conclusions and recommendations

Results from the trials confirm the wide range of diversity that exists within landraces currently used by farmers. Though farmers did not express desire for uniform lines, there is a clear need for tomato varieties with definite characteristics if the industry is to grow and serve not only local markets but industry and for export.

Intensive farmer education on line selection is essential to enhance farmers' capacity to produce good quality fruit and seed that would meet the demand of different market and consumer types and industry.

B. Comparative Variety Performance Trial

Farmers in Brong Ahafo cultivate a limited range of local tomato varieties. The need to broaden the range of varieties for selection by farmers, traders processors and consumers was identified. For such a proposal to be relevant, local adaptability and acceptability of introduced varieties had to be evaluated. One consideration was to increase the number of varieties available to farmers by introducing exotic varieties from AVRDC and other sources. Varieties were mainly introduced from AVRDC's screening trials in Tanzania. With the assistance of the AVRDC representative, a range of varieties were selected that could be of potential use in Ghana. Given the clear preference expressed by the farming community to bring in varieties that would not require supporting material, a choice was made for determinate bush types only, but with one or two semi-determinate types. There were rather many processing types amongst these accessions. Other varieties were brought in from Tanzania, Israel and from AVRDC-Taiwan.

All these varieties were given an accession number, rather than using their original code or varietal name.

Screening Trial - Plant Genetics Resources Centre (PGRC), Bunso

These introduced accessions needed phyto-sanitary documents and were subjected to a first screening by PGRC, which is responsible for plant introductions. PGRC therefore had a multiple task to act as a quarantine centre, as seed multiplication agent and to provide a first judgement on their performance:

All varieties were sown on 14 September 1995. Planting dates from 9 - 16 October 1995. During the screening process at Bunso, many records were taken, describing vegetative and fruit characters according to UPOV guidelines and collecting data on mature fruits, thereby allowing substantial observations to be made for an initial evaluation. After this plant introduction, characterisation, seed multiplication and pre-screening, two accessions (nr 12 and 25) were removed due to high disease pressure. The more promising lines after the first screening in Bunso included the following numbers: 1, 2, 5, 6, 8, 9, 14, 23, 29, 31, 37, 39, 40, 41, 42, and 43. A summary of some of the characteristics is presented below (Table 4).

Table 4. First impressions of introduced varieties

Number	Days*	Yield	Notes
1	95	heavy	
2	91	heavy	
3	95	medium	Medium large fruits
4	95	medium	Heat tolerant
5	95	very heavy	Short harvest period very few diseases
6	88	heavy	Concentrated yield very few diseases
7	95	heavy	
8	99	low/medium	Large fruits, indeterminate type.
9	101	low	Large fruits
10	110	low	
11	103	high	
12	105	? high	Removed due to diseases -fruit rot
13	99	medium	
14	101	medium	Large fruits
15	101	low	
16	101	medium	Thick fruit wall, sweet fruits, few seeds
17	103	low	
18	105	low	
19	101	low/medium	
20	101	medium	
21	110	low	
22	105	medium	
23	99	low	Large fruits
24	99	low/medium	
25	101	low	Removed due to diseases
26	105	low	
27	114	medium	
28	116	?medium	
29	101	med/high	
30	97	low/medium	
31	101	low/medium	Large fruits
32	89	high-very hi	Too small fruits
33	99	medium	
34	91	low	Indeterminate
35	91	med /high	Virus? too small fruits
36	95	? medium	Fruit like Ghanaian but more firm. virus?
37	101	low	Large fruits, indeterminate
38	99	low/medium	
39	110	low/medium	Virus? large fruits
40	101	medium-high	
41	101	medium ? high	Large fruits
42	101	high late	
43	99	medium	Virus? large fruits

* Days from sowing to first harvest

Varietal Performance Trials - Wenchi Agricultural Research Station

Whilst screening of external varieties took place in Bunso, selections were made from plants found at farmers fields in Techimantia, Brong Ahafo (see above). The best three of

these selections (Rasta, Power and Reno) were added to the 'Bunso' accessions and were given the numbers 44, 45 and 46. From the Bunso trials, two varieties did not have enough seed for further multiplication and they had to be dropped together with the earlier rejects, nr 12 and 25. The remaining number of accessions for trials was thus 39 + 3 = 42.

These performance trials were carried out at Wenchi, using a 6 x 7 'lattice design'. There were three replicates, each with 7 blocks of 6 plots. The first replicate was located along a stream and the second at a higher place in an adjacent plot, which was more sandy and rocky. The third replication was located about 1 km away.

This trial aimed at testing the performance and acceptability of introduced exotic varieties under local farmer and trader conditions.

Nursery

Seeds were sown on February 16 1996 in seed boxes 80 x 80 cm, three-quarters filled with topsoil from a fallow piece of land. Boxes were placed on raised platforms to avoid soil borne pathogens and destructive pests. Initially watering was done every other day until the rains fully set in.

Weeds were removed weekly by hand and Dithane M 45 applied at 15 grams per 10 litres of water in the 2nd and 4th weeks after sowing to suppress fungal development. Foliar fertiliser (Phostrogen) at 5 g/10L water was applied weekly to boost seedling development. Temporary shade was provided at sowing but completely removed after 2 weeks to harden plants for the field.

Field practices

Cultural practices were close to farmers' methods. The field was cleared, ploughed and ridged. Seedlings were transplanted on March 25th, adopting a 7 x 6 randomised rectangular lattice design in 3 replications (42 varieties). See appendix for layout. Varieties were allocated to ridges (plots) by randomisation. Each ridge, 15m long accommodated 25 plants at a spacing of 60 cm between plants and 90 cm between varieties. Plots were labelled with numbered pegs for identification.

Plants were treated with 2 applications of compound fertiliser (23-15-5) at 30g per plant in the 2nd and 4th weeks respectively after planting and sulphate of ammonia at 10g per plant at 6 weeks. *Cyperus rotundas, Imperita cylindrica* and *Pennisetum purperum* were common weeds on trial plots. These were treated with Round-up, a systemic/contact herbicide before ploughing. After planting, 3 manual weedings at the 3rd, 6th and 9th weeks respectively were done.

Both cultural and chemical control methods were employed. Sebon and Biobit (*Bacillus thuringiensis)*, both insecticides, were applied at 300 ml/15L water, and 20 g/15L water, respectively. Dithane (Mancozeb) was also sprayed at 50 g/15L water to control fungal infection. Fungicides were sprayed weekly and insecticides fortnightly.

Phenotypic characteristics

Tomato varieties were observed from germination through all stages of growth and development (Table 5). There was wide variability in the performance of the varieties.

Table 5. Nursery data

Accession number	germination date	germination %	Hypocotyl colour	leaf colour	2 weeks seedling height (cm min)	2 weeks seedling height (cm max)	4 weeks seedling height (cm min)	4 weeks seedling height (cm max)
NR01	23-2-96	100	1	1	0.5	3.0	5.5	11.5
NR02	23-2-96	80	1	1	1.5	3.5	6.0	10.0
NR03	21-2-96	40	1, 2 ,5	1	2.0	4.0	10.5	12.5
NR04	20-2-96	100	1	4	2.5	4.0	12.5	16.5
NR05	20-2-96	100	1	3	3.0	4.5	12.0	20.5
NR06	21-2-96	100	2	3	1.5	2.5	10.5	13.5
NR07	21-2-96	80	2	3	2.5	4.5	8.5	13.5
NR08	22-2-96	90	1, 2 ,5	3	2.5	4.5	14.5	18.5
NR09	20-2-96	90	3	3	2.5	4.5	12.0	16.0
NR10	21-2-96	80	3	3	0.5	2.5	7.5	12.0
NR11	21-2-96	80	4	4	2.5	5.0	7.5	15.5
NR13	20-2-96	80	4	4	0.5	4.0	12.5	15.5
NR14	21-2-96	90	1, 4 ,5	3	4.5	7.0	15.0	21.0
NR15	20-2-96	100	5	3	2.0	5.0	13.0	19.0
NR16	23-2-96	70	3	3	1.0	4.0	9.5	13.5
NR17	23-2-96	80	4	3	2.0	4.5	13.0	18.0
NR18	24-2-96	80	5	4	1.5	3.0	9.5	13.0
NR19	24-2-96	80	2, 4, 5	3	1.0	3.5	6.0	10.0
NR20	24-2-96	70	5	3	1.0	3.0	6.5	10.5
NR21	24-2-96	100	2, 3	3	1.5	4.5	10.5	17.0
NR22	23-2-96	100	3	3	3.0	5.0	10.0	13.5
NR23	21-2-96	80	2	3	2.5	4.5	10.0	12.5
NR24	23-2-96	100	2	3	2.5	5.5	8.0	13.0
NR26	21-2-96	90	3	3	3.5	6.5	9.5	14.0
NR27	23-2-96	100	1	3	3.0	5.0	9.0	12.0
NR28	23-2-96	60	2	3	2.0	3.0	5.5	9.5
NR29	20-2-96	80	3	3	4.5	6.5	14.0	21.5
NR30	20-2-96	100	3	3	4.5	8.0	14.0	19.5
NR31	20-2-96	80	2	2	3.5	8.0	15.5	19.5
NR32	22-2-96	100	3	3	2.0	2.5	4.5	8.0
NR33	22-2-96	100	3	3	2.5	3.5	6.0	9.0
NR34	20-2-96	80	3	3	2.5	5.0	13.5	20.5
NR35	23-2-96	100	2	3	2.5	3.5	8.0	10.5
NR36	21-2-96	60	3	3	1.5	4.5	9.5	13.0
NR37	21-2-96	100	3	3	1.5	4.5	8.0	13.0
NR38	24-2-96	60	3	3	2.0	4.0	9.0	10.5
NR39	23-2-96	50	3	3	2.5	3.5	9.5	15.0
NR40	24-2-96	90	3	3	1.5	3.5	8.5	11.5
NR41	24-2-96	80	3	3	0.5	2.5	9.5	12.5
NR42	22-2-96	100	3	3	2.5	6.5	7.5	14.0
NR43	24-2-96	80	3	3	2.5	4.5	10.0	12.5
NR44	23-2-96	100	2	3	3.0	6.0	10.5	17.5
NR45	23-2-96	60	2	3	3.0	5.5	13.0	16.0
NR46	22-2-96	100	2	3	2.5	4.5	12.5	17.5

Key: *Colour*

1 = purple 2 = light purple 3 = green 4 = light green 5 = dark green

Germination dates and percentage varied between accessions. The number of days to germination varied between four and eight while germination percentage ranged from 40 to 100.

Leaf and hypocotyl colour was variable among varieties as was seedling height at the 2nd and 4th weeks after sowing. Minimum seedling height at two weeks ranged between 0.5 cm and 4.5 cm while the maximum ranged between 2.5 and 8.0 cm. At 4 weeks, the minimum ranged between 4.5 and 15.5 cm while the maximum was between 8 cm and 21.5 cm. Apart from providing information on the structure, which is a varietal characteristic, seedling height at transplanting is of research interest. Farmers would always select taller and vigorous seedlings in their nurseries for transplanting with the aim of making good yield. It may be necessary to find out if there is any relationship between seedling structure and yield. This would be useful in determining the right stage to transplant for optimum yield.

Diseases and pests

Pathogenic and non-pathogenic diseases and insect pests were encountered. Symptoms of fungal diseases of Early blight (*Alternaria solani*), Septoria leaf spot (*Septoria lycopersici*), and Sclerotium wilt (*Sclerotium rolfsii*) were identified. Bacteria wilt caused by *Xanthomonas compestris* pv vesicatoria and isolated cases of Root knot nematode (Meloidogyne spp) were observed. A number of unidentified viruses and their complexities were noted.

Tomato plants were also infested by a few insect pests including fruit borer, *Heliothis armigera* and white fly, *Bemisia tabaci.*

Physiological disorders of blossom-end rot, radial and concentric cracks, sun scald and rot were experienced Nutrient deficiency symptoms especially of phosphorus and zinc were observed in only a few varieties.

Table 6. Incidence of diseases and pests

Accession No. (NR)	Alternaria leaf spots	Septoria leaf spots	Sclerotium wilt	Bacteria spots	Virus	Root knot nematode	Fruit-borers
01	x	x		x	x		
02	x	x		x	x		
03	x	x		x			
04							
05				x			
06				x	x	x	
07					x	x	
08	x	x			x		x
09	x	x		x	x	x	x
10		x			x		
11	x	x		x	x	x	
13	x	x		x	x		x
14	x	x		x	x		
15	x	x		x	x		
16							
17	x	x		x			
18	x	x		x	x		
19	x	x		x	x		x
20	x	x	X	x		x	
21	x	x	X		x		
22	x	x					

23	x	x		x			x
24	x	x		x	x		x
26	x	x		x		x	x
27	x	x			x		
28							
29	x	x					
30	x	x		x			
31	x	x		x			
32	x	x		x		x	
33			X		x		x
34	x	x					
35	x	x					
36	x	x					
37							x
38		x		x			
39	x			x			
40	x	x	X			x	
41	x	x				x	
42							
43		x		x			x
44		x				x	
45	x	x		x			x
46		x			x		

Yield

To meet the specific needs of smallholder target groups both quantitative (number and weight of fruits) and qualitative (shape, shelf-life of fruits) characteristics were evaluated. The data obtained were not very conclusive due to rather significant differences between the various replications. In addition, problems with water, weeding, etc. played an important role. This is not dissimilar to the situation faced by farmers. Often soil conditions in farmers fields are poor, labour is frequently problematic whereas weather conditions are far from favourable, often resulting in drought or, when the rains are good, diseases.

Below (Table 7), the weight of good quality fruits is presented rather than total weight. This comparison will favourably bias those varieties with a high percentage of marketable fruits which is one of the key selection criteria for farmers. When conditions are more favourable, the percentage of poor quality fruits is likely to be lower but trials were conducted under conditions prevailing at Wenchi. Average values from each replicate are presented to highlight variability between replicate blocks. Statistical analysis of the data, by analysis of variance, revealed that the overall coefficient of variation for the trial was 49%.

Table 7. First performance trials with 42 varieties at Wenchi

Accession NR	Average weight of marketable fruits per plant (in grams)			
	Rep. 1	Rep. 2	Rep. 3	Average
1	219	241	65	175
2	87	334	157	193
3	93	82	59	78
4	74	93	30	66
5	187	206	74	156
6	207	410	109	242
7	37	109	34	60
8	8	22	7	12
9	106	153	96	118
10	30	25	33	29
11	122	187	46	118
13	26	77	36	46
14	191	191	71	151
15	103	126	50	93
16	110	178	24	104
17	52	67	46	55
18	48	43	16	36
19	80	78	37	65
20	103	259	34	132
21	39	69	31	46
22	54	60	49	54
23	103	139	158	133
24	271	244	152	222
26	35	61	65	54
27	29	0	16	15
28	0	0	0	0
29	99	233	116	149
30	163	102	113	126
31	64	78	69	70
32	232	203	66	167
34	192	357	90	213
35	127	207	65	133
37	138	132	38	103
38	90	63	55	69
39	72	88	35	65
40	45	79	59	61
41	28	141	47	72
42	30	172	35	79
43	39	109	42	63
44	75	210	48	111
45	172	99	81	117
46	213	262	39	171
CV (%)				49.2

There was considerable variation between the replicate blocks (CV of 49.2%) making it difficult to select varieties for further evaluation. Therefore, judgement was based on observations of the plants during the growing season, making allowances for adverse conditions. In addition, it was considered of paramount importance to get the opinion of both traders and tomato growers from the area and accordingly, these were invited to evaluate the accessions and select their top twelve. A separate report for this activity is available. The ranking given by farmers and by traders is scored below, which was used to narrow down the number of varieties for the next screening (Table 8).

Further use has been made of the data supplied by Dr Olimpio, who carried out similar trials on these accessions at KNUST.

Table 8. Selected varieties for phase 2 performance trials

Accession Number	Gross Yield Ranking	Farmers Ranking	Traders Ranking	Dr Olimpio recommends	Promising in Bunso*	Origin
1	7	2	12	✓	✓	Israel
2	4	1	10	✓	✓	Israel
5	8	5	9		✓	Israel
6	3	7	1		✓	Israel
9	17				✓	AVRDC-Tanzania
11	13					AVRDC-Tanzania
14	11				✓	AVRDC-Tanzania
15	21					AVRDC-Tanzania
20	18					AVRDC-Tanzania
23	15	3			✓	AVRDC-Tanzania
24	1	10				AVRDC-Tanzania
29	9	4			✓	AVRDC-Tanzania
30	12	6				AVRDC-Tanzania
31	24	12			✓	AVRDC-Tanzania
32	5		6	✓		AVRDC-Taiwan
33	26		8			AVRDC-Taiwan
34	2	11	7			AVRDC-Taiwan
35	16					AVRDC-Taiwan
36	??	8	1			AVRDC-Taiwan
37	19		5	✓	✓	AVRDC-Taiwan
38	>30		4			AVRDC-Taiwan
43	23	8	11	✓	✓	AVRDC-Taiwan
44	14		3			Brong Ahafo
45	10		14			Brong Ahafo
46	6		13	✓		Brong Ahafo

Subsequent discussions with the trial field managers and project staff allowed for some changes whereby nrs 16 and 42 were added and nrs 36, 37 and 38 were removed because of their below average performance, yield wise, despite the recommendations given by traders.

Consequently, 24 varieties remained for further performance testing in the second phase. These were sown on 31 August 1996 and transplanted on 26 September 1996. The final harvest took place in February 1997. Records were taken on pest and disease incidence,

earliness, harvesting data and finally total fruit yield expressed in weight and number of fruits. The summary results from these trials are as below:

Table 9. Yield data of 2nd phase performance trials at Wenchi with 24 varieties

Accession number	Fruit weight per plant (g)				Selected for next phase *
	Rep 1	Rep 2	Rep 3	Average	
NR1	211	342	380	311	*
NR2	296	226	432	318	*
NR5	357	396	261	338	*
NR6	285	296	428	336	*
NR9	136	182	299	206	
NR11	314	191	272	259	
NR14	184	179	260	208	
NR15	418	234	436	363	*
NR16	177	119	174	157	
NR20	99	299	230	209	
NR23	109	228	237	191	
NR24	193	284	262	246	*
NR29	180	235	348	254	
NR30	136	342	480	319	
NR31	327	172	281	260	
NR32	194	285	422	300	
NR33	166	254	226	215	
NR34	185	262	229	225	
NR35	181	200	181	187	
NR42	176	36	87	100	
NR43	66	114	128	103	
NR44	818	784	164	589	*
NR45	319	332	241	297	*
NR46	403	539	444	461	*
CV (%)				40.6	

Although experimental error was less in this trial than the first, variability was still too high to allow meaningful selection. It was too expensive to continue repeating selection trials with the same material and there was a need to reduce the number of accessions because of the sheer volume of data obtained. It was therefore decided to limit the next round to outstanding performers only. This should be based not merely on the last set of data but on all data obtained so far.

Differences between replications were still significant but not as large as those of the first screening trials at Wenchi and Kumasi. Additional elements were considered such as the size of fruits. Amongst the best varieties, with regard to total number of fruits and even weight, was accession nr 32. This accession has been a high yielder almost everywhere. However, their fruit size was so small that traders showed no interest in them although some women commented that this variety would be good for home use. Since most farmers did prefer to choose a variety that could be used both for subsistence and for generation of an income, these small types were not favoured and were consequently dropped.

Accessions nr 1, 2, 5 and 6 have consistently been in the top ten throughout the trials and were appreciated by farmers and traders alike. There was therefore a unanimous vote for their acceptance for the next round.

Accession nr 30 appeared to perform well this time and especially in one replication. When judging other data however, its performance was not outstanding and it was thus not listed amongst top performers. Accession nr 15 similarly performed much better this time than previously recorded and this was seen in two replications. Despite their earlier average performance, nr 15 was selected for the next round.

Other good performers from the 'new' varieties were nrs 11, 24 and 31. Nr 11 was not recommended by either farmers or traders whereas in the first trial it did not do well and was consequently dropped. Nr 24 was given a 10th place by farmers, did quite well during the first screening, and was thus selected for the next round. Finally, nr 31 performed poorly during the first screening and was not recommended by Dr Olympio and by the traders whereas farmers ranked it as 12th and this variety was consequently dropped as well.

Accordingly, six newly introduced varieties were chosen for the next round. These are the varieties with Nrs 1, 2, 5, 6, 15 and 24. In addition, local selections with nrs 44, 45 and 46 were added for comparison reason.

Background on the nine varieties selected for final screening

Nr 1. According to their breeder, it is resistant to Fusarium wilt race 1, Verticilium and Stemphylium. Determinate plants. High round processing type fruits of small to medium size which can be kept on the plant for some time. Uniform ripening with most fruits maturing in a 3-week period. 97 days from sowing to first harvest

Nr 2. Similar to Nr 1 in virtually all aspects. Good foliage cover. Said to be suitable for industrial peeling. 95 days from sowing to first harvest and with a longer harvesting period than Nr 1.

Nr 5. Determinate plants, processing type with high round fruits. Found to be generally disease tolerant. Plants are somewhat heterogeneous and are generally more bushy than Nrs 1 and 2 and with larger, medium-sized fruits. 97 days to first harvest. Fruits slightly ribbed, less firm than Nr 6.

Nr 6. Determinate plants, processing type with high round fruits. Field notes show a high level of disease tolerance. Fruit colouring starts from the lower parts (white back). About 95 days to first harvest, less concentrated than nrs 1 and 2 and picking could continue for up to 2 months . It was much appreciated by traders for its medium sized, strong fruits. Easily recognized by its relatively undivided leaves.

Nr 15. A determinant processing type, moderately heat tolerant, TMV resistant, and tolerant to bacterial wilt. 101 days to first harvest. Pedicel is jointless

Nr 24. Similar to Nr 15, TMV resistant and has moderate bacterial wilt resistance. In

Wenchi, it was found to be prone to the leaf spot diseases Septoria and Alternaria. Good quality, small-medium sized fruits, maturing over an extended period. 99 days to first harvest. Pedicel is jointless.

Nr 44. Wenchi farmers' selection from *Rasta* type, resembling the old indeterminate variety Super Marmande. Of the local types (44-46), it was most liked by traders and also by farmers. Harvest over an extended period, starting from about 103 days, thus about one week after Nr 6.

Nr. 45 Wenchi farmers' selection from *Reno* type, resembling the old Heinz 1350 with large fruited smooth, oblate fruits. Indeterminate. Harvest over an extended period, starting from about 100 days

Nr 46. Wenchi farmers' selection from *Power* type. Relatively high yielding indeterminate variety with few grooves in the fruit which have a tendency of cracking. Harvest over an extended period, starting from about 100 days

Final Screening

The nine varieties as above were sown/transplanted at Wenchi in March/April 1997. The data obtained from this final screening was as follows:

Table 10. Yield data of 3rd phase performance trials at Wenchi with 9 varieties

Accession number	Fruit weight per plant (g)				Selected for registration *
	Rep. 1	Rep. 2	Rep. 3	Mean*	
NR1	105	266	182	184 cd	0.5 *
NR2	172	256	264	231 cd	0.5 *
NR5	95	134	202	144 d	
NR6	257	304	347	303 bc	*
NR15	106	101	135	114 d	
NR24	126	162	178	155 cd	*
NR44	423	365	684	491 a	*
NR45	188	273	251	237 cd	
NR46	173	520	637	443 ab	*
CV (%)				34.2	

* mean values with the same letter are not significantly different (p= 0.05) using least significance difference test

On-farm Trials

Seeds of the above mentioned nine varieties were given at the same time to farmers and to the manager in Wenchi for on-station trials. This was done to compare results under similar climatic conditions and to get the farmers' impression on performance under their own conditions, the so-called 'on farm' trials.

Trials were conducted in two places near Wenchi: at Nchiraa and Akate. The first trial was a disaster since the rains stopped soon after transplanting and farmers were left without a crop to harvest. The second planting was more successful despite the usual climatic constraints facing farmers in the Wenchi area.

Farmers showed much interest in the introduced varieties and Nr 6 was chosen as the best variety overall because of its small size, when compared with their traditional crop, whose size is much liked by the traders. Farmers also appreciated the very long shelf-life and observed that they can leave the fruits on the plant for even a few weeks which is a great advantage.

Farmers did not see any difference between numbers 1 and 2 and did not like nr 5. The varieties 15 and 24 were not doing well in Nchiraa because of diseases but nr24 performed well in Akate.

Accordingly, out of the 6 exotic varieties, farmers chose nr 6 as the best followed by nr1/2 and nr 24. Of the local varieties nr 44 and 46 were much appreciated. After talking to Marc Adabla, trial field manager at Wenchi about his choice, it was interesting to note that his choice was identical (6, 2, 24 44, 46) and in the same sequence! Accordingly, a decision was reached whereby the numbers 1 and 2 were mixed since their morphological characteristics were similar, and were combined to make a single new variety.

A decision was thus reached to present three new varieties to the variety release committee, the numbers 1/2, 6 and 24. It was similarly suggested to introduce nrs 44 and 46 (Rasta and Power) as local standard varieties and these will therefore need to go through the variety release procedures as well.

Naming five tomato varieties for varietal registration

Project staff, the regional director of MoFA, staff from the Seed Inspection Division of MoFA, and farmers were asked to select names for the five selected tomato varieties. They agreed that the local selections should use the existing local names i.e. *Rasta* for NR 44 and *Power* for NR 46.

The favourite exotic, NR 6 was given the name *Ohienosa* which in Twi means 'poverty has finished', since this reflects one of the main goals of DFID, to eliminate poverty.

For the combined NR1 and 2, the name chosen is *Nkwenpa*, meaning delicious soup with reference to the final product for which most tomatoes are being used.

Lastly, NR 24 has been given the name *Akate* after the village where farmers much appreciated this variety

Further Tomato Performance Trials

Having established the methodologies for conducting evaluation trials for tomato, a further series of trials were initiated to evaluate more AVRDC selections. These trials were undertaken at two locations by CRI with the support of the IFCSP. Twelve varieties have been selected with promising traits and are undergoing further screening.

PRELIMINARY CHARACTERIZATION OF S. MACROCARPON GERMPLASM FROM DIFFERENT ECOLOGICAL ZONES IN GHANA.

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Abstract

Thirteen *S. macrocarpon* accessions from Ghana were characterized using their morphological and phenological characters. Considerable variation existed between them. Plant height at 50% flowering ranged between 23 cm and 60.8 cm. 92.7% of the accessions had a good branching system. Two stem colours, green and purple, found in the population were in the ratio of 84.6% and 15.45%. Leaves were all large but accession number VR-SM-108 had the largest dimensions of 240 mm for width and 375 for length. Number of days to 50% flowering ranged between 61 - 100 days. Three fruit shapes were observed, flat round and heart shaped. Fruit sizes also fell into three groups small, intermediate and large. Two main fruit colours were observed, green and milk white.

Introduction

The eggplant is a major vegetable crop in west Africa (Norman 1992). Among the types found in Ghana, there are two horticulturally distinct types, which are indigenous to Africa. They are *Solanum aethiopicum* and *Solanum macrocarpon* (Schippers, 1997). There is a third one, *Solanum melongena*, also found within the sub-region but it is exotic. However, according to Norman (1992) the indigenous ones are more popular in west Africa. In spite of their importance, little work seems to have been done on them in the area of improvement compared to the *S. melongena* group which has known a lot of improvement. The literature reveals that most of the work published on the African eggplant is on agronomy, pest and disease control. For any meaningful work in breeding/improvement, germplasm collection and their characterization to identify sources of variation is pre-eminent. The objective of this work, which is part of the NRI sponsored collaborative work with CRI on germplasm evaluation of the African eggplant, is to characterize some *Solanum macrocarpon* accessions using morphological and phenological characters.

Materials and Methods

Thirteen accessions of *Solanum macrocarpon* were assessed for morphological and phenological traits. They were nursed on the 27 April and transplanted on the 1 June 1998. They were planted in row of 7 plants per accession. Data was taken on the middle five plants. There was no replication. The plants were spaced 1m between rows and 90 cm within rows. A fertilizer rate of 250 kg of NPK (15-15-15) and 125 kg of sulphate of ammonia per hectare were applied. Other cultural practices like weeding, spraying of insecticides/fungicides and irrigation were carried out when necessary. Data collected included morphological characters of the plant at both the vegetative and reproductive phases. Phenological characters including time of first flower and time to 50% flowering were also measured.

Results

General

Of the 13 accessions studied, nine were from the Central region (CR-), two from the Volta region (VR-) and two from the Brong Ahafo Region (BA-). Table 1 is a list of the accessions used, source of sample and the state in which they were received. Eight out of the nine accessions from the Central Region were obtained from Ajumako-Mando market. All the accessions from the Central Region were fruity *S. macrocarpon*. Those from the Volta and the Brong Ahafo Regions had one fruity and one leafy type each.

Vegetative Characteristics

The vegetative characters observed are summarized in Tables 2 and 3. Plant height at 50% flowering ranged between 23 - 67.8 cm, although most fell between 31 -50 cm. Branching was poor for accession CR-SM- 006. The rest, however, had a relatively good branching habit. Two stem colours were observed, green and purple. Most of the accessions were of the green type (84.6%) the rest were purple. Prickles on leaf and stem were almost out of the sampled population except accession CR-SM- 003 (Tables 3 and 4) a fruity type.

All the accessions had glossy leaf surfaces. Leaf lengths ranged between 149 - 375 mm. Thirty per cent (30%) of the accession fell into the 301 - 380 mm group. Leaf blade width was also between 102 - 240 mm. Accession number VR-SM-018 from the Volta region had the largest leaf dimensions of 375 mm for length and 240 mm for width.

Reproductive Characteristics

Reproductive characters are summarized in Tables 4 and 5. All accessions had purple flower colour and the corolla diameter was between 4-5 mm. The number of days to the opening of the first flower ranged between 56 - 84, while days to 50% flower opening ranged between 64 -98 days (Table 4).

Three fruit shapes - flat, round and heart shaped were observed in the sampled population. Two main fruit colours ran through the sampled population; green and milk white; 15.4% were of the milk white colour and the rest green. Within the green ones, 63.6 % had deeper green stripes and mottling on them while 34.6% had no such markings. The green colouring ranged from very light green dark green. The pattern of stripes and mottling on the accessions that had them were the same except for the intensity of colour. Three fruit sizes were observed small, intermediate and large. The fruit lengths ranged from 48.9 - 81 mm and width 68 - 115.3 mm (Table 5). Fruit weight ranged between 82 - 550 grams. Accession numbers CR-SM-003 CR-SM-010 and BA-SM- 046 had their weights falling between 400 and 550 grams while VR-SM-043 and BA-SM-044 had 82 and 98 grams respectively. The rest fell between 133 and 200 grams.

Discussion

Generally, there existed some amount of variability within the 13 macrocarpon accessions studied. For the vegetative characters, the tall character and greater branching in some of the accessions will be useful in further improvement work. In addition, the purple stem colour would be very useful as a marker in breeding and selection once its mode of inheritance has been established.

As a leafy vegetable, large leaves are very desirable to increase yield. Thus, accessions such as VR-SM-018 will be good for further improvement. It must be noted that it was obtained from an area where importance is placed on the leaves rather than the fruits.

There was a wide variation (61 - 100 days) in the number of days to 50% flowering. This gives a wider room to manoeuvre in development of cultivars for leaves, fruit or both. For fruiting types, early flowering will be an advantage but for leafy types a longer vegetative phase is preferred. The fruity types had larger fruits than the non-fruity types VR-SM-043 and BA-SM-044. The different sizes, weight, and colour in the fruits observed will also present a larger area for cultivars to be chosen from in development of fruity types.

Conclusion

The study indicates that there is a lot of variation within the *S. macrocarpon* group in the country. Most of the accessions studied were the fruity types. There is the need to collect and document them (both fruity and leafy) before they are eroded.

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Table 1. List of the accessions used, source of sample, state in which they were received.

Accession Name	Locality	Source of sample	Form in which sampled was received
CR-SM-001	Agamic-Mando	Market	Fruit
CR-SM-003	-do-	-do-	-do-
CR-SM-005	-do-	-do-	-do-
CR-SM-006	-do-	-do-	-do-
CR-SM-009	-do-	-do-	-do-
CR-SM-010	-do-	-do-	-do-
CR-SM-011	-do-	-do-	-do-
CR-SM-013	-do-	-do-	-do-
CR-SM-014	Winneba	-do-	-do-
VR-SM-018	Logba-Ogome	-do-	Seed
VR-SM-043	-do-	-do-	-do-
BA-SM-044	Unknown	unknown	Fruit
BA-SM-046	-do-	-do-	Seed

Table 2. Stem and Branching characteristics of some *Solanum macrocarpon* accessions:

A. Plant height/cm	% of accession with character
21 – 30	7.7
31 – 40	30.7
41 – 50	46.1
51 – 60	7.7
61 – 70	7.7
B. Type of branching	% of accession with character
Few primary branches only	7.7
Several to many primary branches but few secondary ones	92.3
C. Stem colour	% of accession with character
Green	84.6
Purple	15.4
D. Prickles on main stem and branches	% of accession with character
Present	7.7
Absent	92.3

Table 3. Leaves characteristics of some *Solanum macrocarpon* accessions

A. Leaf blade length/cm	% of accessions with character
141 – 180	7.6
181 – 220	15.4
221 – 260	23.1
261 – 300	23.1
301 – 340	15.4
341 – 380	15.4
B. Leaf blade width/cm	
101 – 104	30.8
141 – 180	30.8
181 – 220	30.8
221 – 260	7.6
C. Presence of prickles on veins of leaf blade	
Present	7.7
Absent	92.3

Table 4. Number of days to flowering in some *Solanum macrocarpon* accessions

A. No. of days to 1st flower	% of accessions with character
51 – 60	23.1
61 – 70	23.1
71 – 81	38.5
81 – 90	15.4
B. No. of days to 50% flower	
61 – 70	30.8
71 – 81	15.4
81 – 90	46.26
91 – 100	7.6

Table 5. Fruit characteristics of some *Solanum macrocarpon* accessions :

A. Fruit length/mm	% of accessions with character
41 – 50	15.4
51 – 60	0
61 – 70	15.4
71 – 80	61.6
81 – 90	7.6
B. Fruit width/mm	
61 –70	7.75
71 – 80	23.1
81 – 90	15.4
91 – 100	30.8
101 – 110	15.4
111 – 120	7.7

PROMOTING WEST AFRICAN OKRA, ABELMOSCHUS CAILLEI (A. SHEV.) STEVELS: THE NEED FOR RESEARCH

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Background

Okra is one of the most popular indigenous fruity vegetables found in Africa. It is the one crop that is widely grown successfully in all the agro-ecological zones of Ghana. Although principally grown as a rain-fed crop, it is now cultivated in the dry season under irrigation or along river valleys.

In Ghana, okra production is important as it provides employment and generates income especially for women who constitute the bulk of the growers. Production is entirely in the hands of small-scale framers. In 1995, for example, okra was cultivated on over 3,370 ha with a production of 35,000 MT. The major producing regions are Volta, Eastern, Northern and Greater Accra regions.

Okra has an immense export potential. Over 28,000 metric tons of fresh okra valued at US$12,129,000 was exported between the period January - June 1997 (Anon, 1997). The crop is also important for its high nutritive value; the seeds are rich in calcium and amino acids. The immature green pods are boiled in soups and used as a soup or stew thickener which are eaten alongside 'banku', 'akple', 'konkonte' and 'tuo zaafi'. There is hardly a home in the Volta region that does not use this vegetable daily. The slimy fruits of okra are particularly suitable for those suffering from stomach trouble (Lotchert and Beese, 1983). Secondary uses of okra include oil (up to 25% oil) which is extracted from the ripe fruits and used in the manufacturing of margarine. Fresh okra leaves are also eaten and are high in Vitamins A and C.

In spite of the positive contributions of okra to the economy of Ghana and its importance in the home as food, very little information has been documented for the west African okra. Most available information on okra are on *Abelmoschus esculentus* which has benefited from world wide research.

The west African okra is becoming rare and there is the need to save it from genetic erosion. There are hardly any cultivars available to the farmer for planting. The few land races available are heterogeneous and almost every village has its own 'cultivar' selected over a long period. Market demand for uniform fruits and good quality in terms of sliminess, and also the need for the growing of uniform material that are early and high yielding call for research into this crop. Fortunately, there is a wide diversity of okra in terms of leaf forms, pod shape, size and colour, sliminess, maturity dates, fruit number, number of branches, yield per hectare and resistance to pest and diseases which can be tapped for improvement.

Before any meaningful improvement in production can be carried out, characterization and evaluation need to be done to select those with desirable attributes for further agronomic studies. The need to initiate characterization and evaluation work of all available west African okra accessions is paramount.

Literature Review

The cultivated okra belongs to the genus *Abelmoschus* and comprises 9 species native to subtropical and tropical regions. However, the most widely grown species are *A. esculentus* and *A. caillei*. *A. esculentus* is more common towards the east and drier regions (Schippers, 1998) while *A. caillei* is mainly found in the humid forest and coastal zones of west and central Africa.

The advantage of planting the west African okra is that they have a high degree of tolerance to diseases, nematodes and insect pests. They fruit during the end of the rainy season and thereby provide fruits and leaf vegetables in the home, and are more slimy than the exotics (Norman, 1992; Schippers, 1998). However, some specific cultivars are photosensitive, making them require specific growing conditions.

Research on okra has been irregular and no conclusions have been made. The few studies are mostly student dissertations on evaluation (Ofori, 1981; Fianu, 1991). One of the earliest attempt at okra improvement at Crops Research Institute (CRI) was in 1967 when studies on genetic variation in 16 local and exotic varieties of okra were carried out. Variations in shape, size and colour of mature fruits were observed (CRI annual Report, 1967). Other notable work initiated, but not completed, was on the effect of sowing date on the incidence of okra mosaic virus and leaf and disease (CRI Annual Report 1986 & 1987). Even though collection and characterization of okra have been done under NARP funding, most of the collections are the exotic ones. However, when travelling through the country one comes across a diversity of local okra. Given the right research support, cultivars can be developed to suit the various agro-ecological zones. There is also the need to make selections of extra early, early, medium and late maturing types.

Research Needs

Among the lists of constraints to okra production in the country are:

- lack of uniform planting materials;
- susceptibility of some cultivars to viral diseases especially okra leaf curl virus disease;
- insect and nematode problems;
- lack of better management practices;
- loss of viability of seeds during storage.

The proposed project will also focus on breeding and agronomic practices to raise the present yield of 7.0 metric tones per hectare by 30%. The project will be a multi-disciplinary team comprising breeders, agronomist, physiologist, soil fertility specialists, entomologist, pathologist, virologist, nematologist and extensionist. The study will be multi-locational but mostly at Kwadaso, Wenchi and Tamale. International collaboration is also needed to exploit all available material for cultivar development.

Research Proposal

Research on collection, characterization and evaluation of west African okra in the forest, forest savannah and savannah zones of Ghana is being proposed.

Objectives

The project objectives are:

1. To characterize and evaluate accessions of West African okra for selection based on morphological characters, earliness, sliminess, yield, pest and disease resistance;
2. To develop agronomic packages (spacing, fertilizer and irrigation regimes etc.) for optimum yield;
3. To develop cultivars for both the local and export market.

Anticipated benefits

The target of this research is to increase the present yield of about 7.0 tons/ha by 30%. Increased and economic production of okra will open up more employment opportunities for the many young men and women who roam in the villages. This will also help reduce the rural-urban migration. Women who are traditional farmers of vegetables will improve their standard of living through higher income from increased production of okra.

Uniform high yielding material will be available for recommendation to farmers. Early, medium and late maturing cultivars will be available to meet the needs of farmers. Increased export of okra for foreign exchange earnings.

Collections and storage of germplasm materials in gene banks.

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SEED MULTIPLICATION, EVALUATION AND POST-HARVEST CHARACTERISTICS OF SOME TOMATO LINES GROWN IN THE FOREST ZONE OF GHANA

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Introduction

Tomato, *Lycopersicon esculentum*, is one of the most important and very popular vegetables grown in the Ashanti and Brong Ahafo Regions. In 1995 for example, the two regions produced about 43% of the nation's tomatoes (Anon, 1996). It is moderately high in vitamins A and C, high in cash value and serves as a source of income to farmers who produce this crop. Tomato cultivation also provides job opportunities for young people in the rural community especially women.

Yield (averaging 5t/ha) is very low in the country. This low yield can be attributed to unfavourable environmental conditions like high temperatures, sporadic periods of drought, pest and diseases occurrence. Improper cultural and management practices also contribute to the low yields.

In view of the low yields of existing varieties, there was the need to get new tomato varieties that will be able to withstand the adverse environmental and disease problems prevailing in the country. Some tomato lines were therefore obtained from the Asian Vegetable Research and Development Centre for multiplication and evaluation in the country.

The objectives of the study were to:

- observe and multiply the tomato seeds received;
- evaluate the lines for their growth, yield, fruit quality characteristics, shelf-life and pest and diseases in the Ashanti Region.

Materials and Methods

Four experiments were carried out at Crops Research Institute, Kwadaso, Kumasi in the forest zone of Ghana. The last one is still in progress.

Experiment 1 (Seed multiplication trial)

Seeds of 21 tomato lines were sown on 10/4/97. Seedlings were transplanted on 10/5/97. Plants were planted in rows of 10 per cultivar. A randomised complete block design was used with 2 replications.

Experiment 2 (Evaluation trial)

Seeds of 21 tomato lines sown on 15/6/97 were transplanted to the field on 11/8/97.
A randomised complete block design was used with 3 replications.

Experiment 3 (Evaluation trial)

Seeds of 23 tomato lines sown on 14/11/97 were transplanted to the field on 12/12/97.
A randomised complete block design was used with 3 replications.

Experiment 4 (Fruit quality studies) is in progress. Data is being analysed.

In all the experiments, the spacing between rows was 1m and that between plants 40 cm. Plants were planted in rows of 10 per cultivar. A fertiliser rate of 375 kg/ha 15-15-15 NPK was applied. At the flowering stage ammonium sulphate at the rate of 250 kg/ha was applied. Plants were ridged and staked. Weeding and spraying were done when found to be necessary.

The following characteristics were assessed; plant height at fortnightly intervals, date of flowering, percent fruit set, number of fruits/plant and fruit weight (kg) per plant. Data were subjected to analysis of variance and means separated by Duncan's multiple range test (p=0.05).

Results and Discussions

Experiment 1

General observation

Plants were affected by drought and viral infection which wiped away some of the tomato lines and reduced the yield of the remaining ones. Out of the 21 lines, only 8 were able to produce fruits.

Yield and yield attributes

Fruit number and yield are presented in Table 1. Line 57 had the highest fruit number and yield. Fruit size ranged from 6.3 to 28.3g.

Seed weight

Seed weights of 0.34, 0.76, 0.06, 0.50, 1.33, 2.95 and 0.12g were obtained for lines 50, 51, 52, 53, 55, 57 and 58 respectively. Seeds obtained from this trial and some from the Integrated Food Crops Project, Sunyani were used for experiment 2.

Experiment 2

Significant differences (P=0.05) in terms of percent fruit set, number and fruit weight were observed among the lines (Table 2). Lines 57 and 58 had the highest fruit set while lines 69 and 66 recorded the lowest. Fruit number was highest for 57 while 63 had the lowest. Fruit weight of line 57 differed from the others. Fruit weight was generally low due to disease incidence. Fruit size ranged between 10.6 - 38.6g.

Experiment 3

General Observation

Plants were severely attacked by the whitefly-transmitted tomato yellow leaf curl virus disease. Out of the 23 lines, only 15 lines were able to produce fruits.

Yield and yield components

Fruit number and weight are presented in Table 3. On the average, five fruits were harvested from lines 51, 53 and 57 and four each from lines 44, 50, 54 and 55. Fruit yield per plant was highest in the local material, line 44 followed by 57 and 46 respectively (Table 3). The other cultivars had yields below 60g/plant.

Conclusion

Studies conducted so far indicate that the lines were susceptible to leaf curl virus, leaf spot and verticillium wilt. However, considering their high fruit set, some lines can be used as parents to impact better fruit set and earliness into our local materials.

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Table 1. Yield and yield attributes of 8 tomato lines (Experiment 1)

Line no. NRI/	Fruit set (%)	Fruit no. (no./plant)	Fruit weight (g/plant)	Yield (t/ha)	Fruit size (g/fruit)
50	72	8.6	143.3	1.43	16.7
51	75	4.3	26.9	0.30	6.3
52	79	1.0	30.0	0.30	30.0
53	73	3.6	61.3	0.61	17.0
54	63	10.9	172.8	1.73	15.9
55	73	8.4	149.5	1.50	17.8
57	80	12.8	251.0	2.51	19.6
58	71	1.4	30.0	0.30	28.3

Table 2. Yield and yield attributes of 21 tomato lines (Experiment 2)

Line no.	Fruit set (%)	Fruit no. (no./plant)	Yield (t/ha)	Fruit size (g/fruit)
50	75.3c*	6.9bcd	2.76de	16.0
51	87.3b	7.7bc	2.98cde	15.5
52	77.7c	4.4fgh	1.77gh	16.1
53	76.7c	6.5cd	2.10fgh	12.9
54	78.7c	7.9b	2.44ef	12.4
55	84.7b	6.5cd	1.72hf	10.6
56	73.0c	2.5j	1.19i	19.0
57	93.0a	11.4a	4.86a	19.0
58	90.0ab	4.5efg	3.45b	30.7
59	56.3d	5.1ef	2.78de	21.8
60	58.3d	4.9ef	3.83bc	31.3
61	49.0e	2.9ij	2.80de	38.6
62	50.3e	3.8fghi	2.38efg	25.0
63	50.3e	2.2j	2.08fgh	37.8
64	58.0d	5.7de	3.06de	21.4
65	59.2d	4.1fghi	3.31bcd	32.2
66	45.0f	2.8ij	1.78gh	25.4
67	51.0e	3.2hij	2.00fgh	25.0
68	52.2e	7.1bc	2.80de	15.7
69	42.6f	4.0fghi	1.88fgh	18.8
70	50.4e	3.4ghij	2.09fgh	24.6

*Same values within the same column are not significantly different by Duncan's multiple range test (P=0.05).

Table 3. Yield and yield attributes of some tomato lines (Experiment 3)

Line no.	Fruit no. (no./plant)	Fruit weight (g/plant)	Fruit size (g/fruit)
44	4.3	164.0	38.1
46	2.5	66.7	26.7
50	3.9	45.0	15.0
51	4.9	57.0	11.6
52	1.9	21.0	11.1
53	4.7	43.0	9.1
54	4.4	55.0	12.5
55	4.3	46.0	10.7
56	1.0	20.0	20.0
57	4.9	74.3	15.2
58	1.3	21.0	16.2
60	1.0	33.0	33.0
64	1.0	17.0	17.0
65	2.5	39.3	15.7
69	1.0	10.7	10.7

INTEGRATION OF INDIGENOUS LEAFY VEGETABLES INTO FARMING SYSTEMS OF GHANA

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Background

Indigenous leafy vegetables are known to be important in almost all homes in Ghana. Their production and commercialization generates employment, food security, income for growers and the country when marketed for export. Leafy vegetables have been confirmed by numerous studies to be comparatively higher in nutrients and fibre, and therefore reduce ill health and general disorder in humans.

Abbey and Bonsu (1997) observed that a large proportion of indigenous African leafy vegetables is under-exploited, and their existence is endangered. This could be attributed to inadequate information especially in the area of germplasm collection and evaluation, and promotion through recipe formulation and research. PROSEA (1993) reported large variability in indigenous tropical leafy vegetables, their nutritional qualities and neglect in agricultural research.

Farming systems comprising vegetable and animal production enterprises have been found to be one of the most sustainable production systems in tropical Africa (Okigbo, 1990). This needs to be explored for leafy vegetable production. In a preliminary study, it was revealed that row planting of leafy eggplant (*Solanum macrocarpon*) with onions (*Allium cepa*) reduced the unwarranted activities of leafy cutting insects by serving as a trap crop (Abbey, unpublished). Thus , incorporating leafy vegetables into a multiple cropping system has the prospect of increasing income, improving nutritional status and health, and reducing risk of losing main crops to pests and diseases. This will also facilitate low external input, reduce cost of production and sustain production in Ghana and tropical Africa.

Justification

Recent studies on 19 indigenous green leafy vegetables in Ghana showed high levels of minerals (Ca, K, Na and N), and crude fibre (Abbey and Bonsu, 1997). Many studies have also shown these plants are high in vitamins A, B and C. By virtue of their richness, they are recommended by dieticians to patients, nursing and pregnant women, and for baby food formulation. In a report by the Research-Extension Linkage Committee (Anon) in 1998, it was indicated that malnutrition-related problems were found prevalent in some farming communities in the country. Most of the people found in these communities are resource-poor whose problems could be solved through proper production and utilisation of indigenous African leafy vegetables at a cheaper cost.

Growers of vegetables viz. tomato, onion, pepper, okra and eggplant often face problems of insect pests cutting the shoots at the nursery and/or young stage. These insects may also serve as vectors of disease pathogens.

It is therefore imperative to develop a package of technology for the integration of leafy vegetables into farming systems of Ghana, especially, small to medium-scale vegetable

growers (about 60% being women), to enhance their production, broaden their income base, improve the nutritional status of their diets, and the standard of living of farm families. These have a positive effect of boosting leafy vegetable exports, consumption, poverty alleviation and malnutrition reduction.

Objectives

To collect germplasm of selected leafy vegetables for characterization evaluation and selection.
To develop leafy vegetable cultivars for the local market.
To establish appropriate methods of integration of leafy vegetables into the Ghanaian farming systems.
To demonstrate and create awareness of the availability of the range of plants which are nutrient rich.
To improve on the income and intake of quality food by farm-households.

Procedure

In addition to assembled germplasm at Crops Research Institute, collections will be made nation-wide for characterization and evaluation based on agro-morphology and growth characteristics, yield, nutrition and post-harvest (storage, processing utilization and consumer preference) qualities. A breeding programme will be initiated to improve selected plants with high potential. Plants to be included in the main study are leafy eggplant (*Solanum macrocarpon*), vegetable jute (*Corchorus* sp.), African spinach (*Amaranthus* sp.) and rosselle (*Hybiscus sabdariffa*).

The target group will be women vegetable growers, associations/groups. Multiple cropping systems will be set up with leafy vegetable serving as the minor crop, and the major crop will be tomato, pepper, onion, eggplant and okra. However, other crops will be considered depending on farmers' interest.

Socio-economic studies will be conducted to assess the impact of the project on the living standards (i. e. income, clothing, food, shelter, etc.) of the group or communities involved, their production levels, cost/benefit analyses, etc.

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ENHANCEMENT OF AFRICAN EGGPLANT (SOLANUM AETHIOPICUM) LAND RACES IN GHANA: CHARACTERIZATION, EVALUATION AND SELECTION

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Abstract

Studies on characterization, evaluation and selection of African eggplant *Solanum aethiopicum* was carried out at Kwadaso in the forest ecological zone of Ghana. Seventeen accessions of *Solanum aethiopicum* were used. Morphological, phenological, fruit characteristics and yield were measured for each accession. Plant height at peak of harvest ranged from 66.0 to 111.0 cm. Some accessions were found to be early, reaching 50% flowering in 75 days after sowing while others were late (102 days). Fruit number per plant varied from 45 to 161 while yield was from 23.1 to 46.2 t/ha. Seven of the accessions; SE 003, 006, 008, 009, 011, 012 and 015 were selected based on fruit size, shape, colour, plant architecture and total yield for further purification.

Introduction

African indigenous vegetables are currently gaining widespread recognition. Some of these vegetables include garden eggs (*Solanum aethiopicum*), gboma eggplant (*Solanum macrocarpon*) and Okra (*Abelmoschus caillei*) and are very important to Ghanaians. The fruits and leaves are used in soups and stews. *S. aethiopicum* species is diversified not only with different forms of fruits but also different forms of leaves both of which can be eaten. The garden egg can be found in most parts of Ghana where it is often grown as a cash crop. There are almost no uniform varieties of *S. aethiopicum* present in the country and the heterogeneous land races seen on farmers' fields are not high yielding. Market demand for uniform fruits, coupled with good post-harvest characteristics and good eating qualities offer a challenge to researchers to develop new varieties that meet the demands of producers as well as consumers.

Fortunately, the genetic pool of *S. aethiopicum* is highly diverse and most, if not all, desirable characteristics can be found in the country. After preliminary characterization, some lines of garden eggs were chosen for further evaluation at two locations.

The purpose of this study was to characterise, evaluate, select and purify available *S. aethiopicum* group for onward release to farmers.

Materials and methods

The experiment was conducted at Crops Research Institute Experimental Farm at Kwadaso, Kumasi in the forest ecological zones of Ghana. Seventeen eggplant accessions obtained from various sources were used (Table 1). Seeds were sown on February 16, 1998 and transplanted to the field on April 8, 1998. The experimental

design used was randomized complete block with 2 replications. A spacing of 90-x 90 cm was adopted. Each treatment or accession had a plot size of 22.5m x 22.5m, i.e. 25 plants/plot.

Fertilizer rates of 250 kg/ha of NPK (15-15-15) and 125 kg/ha of ammonium sulphate were applied. Other cultural practices like weeding, spraying and irrigation were carried out when found necessary.

Morphological characters like leaf shape, hairiness, branching, etc., were assessed. Phenological parameters such as time of first flower and 50% flowering, time to maturity, etc. were measured. Fruit characteristics including fruit size, shape, skin colour, length, diameter were evaluated. Fruit number and weight (g) were recorded at each harvest and the totals calculated at the end of the harvesting period. Harvesting lasted for 9 weeks. Data were subjected to analysis of variance and means separated by the Least Squares Difference test (P=0.05).

Results

The results are presented in Tables 1, 2 and 3. Significant differences (P=0.05) were observed among all the 17 accessions for plant height, days to first and 50% flowering, number of fruits, fruit length and total yield per plant. There were large variations in all the characters studied.

Phenological Characteristics

Plant height at first flowering varied from 17.2 cm for SE006 to 34 cm for accession SE 010. At the harvesting peak, six accessions: SE 001, 003, 008, 010, 016 and 004 were below 100 cm in height (Table 1).

In terms of earliness, as indicated by the number of days from sowing to first flowering and 50% flowering, significant differences (P=0.05) were detected among the accessions (Table 1). Accession number SE008 flowered first at 71 days after sowing. By the 80th day after sowing all the accession except number SE013 had flowered. A majority (88%) of the accessions reached 50% flowering before 90 days after sowing. The earliest accession to reach 50% flowering was SE015. Accession SE 013 is a late flowering type.

Fruit Characteristics

Fruit characteristics are presented in Table 2 and were also observed to be variable. Fruit length varied from 26 mm for accession SE 014 to 60.8 for SE 006. Fruit width also ranged from 32 mm to 58 mm. In respect to fruit shape, 47% had oval fruits, 17.6% cylindrical long fruit with round tips, while another 17.% had flattened fruits with many deep lobes. SE 004 was the only accession with round fruits. SE 002 fruits had a peculiar fruit shape. The fruits were somewhat round with 4 to 5 protuberances at the stylar end. Fruit size ranged from 22g to 48g with (76%) of accessions reaching sizes above 40g. Most (94%) of the accessions bore single fruits per node and the remaining, accessions SE 001 and SE 014 had two fruits per node.

Yield and Yield Components

Significant differences (P=0.05) were observed among all the accessions for number of fruits and total yield per plant (Table 3). Fruit number per plant ranged from 45 for SE 002 to 161 for SE 013. Yield (kg/plant) ranged from 1.87 for SE 016 to 3.74 for SE 003 which give 23.1 and 46.2 tonnes per hectare respectively (Table 3). There was no significant yield differences among the seven top performers.

Discussion

The accessions studied showed greater diversity in all the characters studied. The significant differences obtained in plant height, number of days to 50% flowering number of fruits per plant and total yield per plant showed that, these accessions were genetically different. Height of plant at harvesting may be an indicator of ease of lodging. Plants with heavy fruits though easier to harvest, lodge easily during heavy storms. Thus, there is the possibility that plants of medium height will be in a better position to resist lodging. It was also observed that seven top yielding lines were of medium height less than 100 cm. Such characters may be of importance when it comes to response to fertilizer as well as selecting for lodging resistance. These medium height plants may respond better to fertilizer than the tall accession; SE 011 and 014 which are likely to lodge under high fertility.

Earliness is of great importance in terms of market value. Lines which fruit early may be preferred by farmers or growers since they will fruit at a time when fruits are scarce in the market and will therefore fetch high prices. Earliness may also mean higher cropping. That is cropping 3 or more times in a year.

Although fruit number correlates highly with yield in some egg plants, and one would have expected Accessions SE 013 and 014 to yield high, their fruit sizes were small, below 20g, and hence their low yield. Seven of the lines studied; SE 003, 006, 008, 009 011, 012 and 015 had yield comparable to SE 004 an improved cultivar bred at the University of Ghana. Yield obtained at Kwadaso is far above the national average of 15 t/ha. The high yield may be attributed to better agronomic practices, which allowed the materials to express their genetic potentials.

Fruit size of lines SE 015 and 011 were less than 30g, which may not be accepted by the consumer. However, they may be of importance when it comes to whole fruit canning where smaller fruits are taken into consideration.

In terms of fruits per node, accessions SE 001 and 014 may be of interest to the breeder because they bear two or more fruits at a node. Crosses can therefore be made to improve the fruit numbers of some of the selected lines.

Conclusions/Future Directions

Based on the results of this study, 7 accessions would be selected for selfing and crossing with each other. The wide variations in the plant architecture also calls for the need to conduct work on spacing and fertilizer rates of the selected lines to come out with their agronomic packages when the best accessions are ready for release to farmers.

Table 1. Phenological characters of African eggplant accessions

Cultivar/Line name	Height at first flowering (cm)	Height at peak of harvest (cm)	Days from sowing to first flowering	Days from sowing to 50% flowering
SE 001	29.9	71.0	74	77
SE 002	28.9	111.1	76	81
SE 003	17.5	75.5	75	76
SE 004	28.0	96.0	74	78
SE 005	19.6	103.1	76	80
SE 006	17.2	108.0	77	84
SE 007	23.0	111.0	83	84
SE 008	27.1	76.5	71	82
SE 009	32.3	93.5	77	79
SE 010	34.2	66.5	72	78
SE 011	19.5	111.5	78	95
SE 012	26.5	113.5	75	80
SE 013	17.7	113.5	94	102
SE 014	28.9	116.5	80	86
SE 015	25.8	116.5	72	75
SE 016	25.6	86.0	76	84
SE 017	32.0	108.0	76	79
LSD (0.05)			2.04	3.55
CV%			1.25	2.04

Table 2. Fruit characteristics of African eggplant accessions

Cultivar/Line name	Fruit Length (mm)	Fruit Width (mm)	Number of fruits per cyme	Size of Fruits (g)	Fruit Shape
SE 001	44.2	36.5	3-4	26.3	Oval
SE 002	46.4	43.2	1	48.1	-
SE 003	55.1	45.2	1	43.1	Oval
SE 004	44.5	52.2	1	42.4	Round
SE 005	53.9	48.8	1	43.1	Oval
SE 006	58.8	43.9	1	42.6	Cylindrical
SE 007	46.7	35.9	1	26.6	Oval
SE 008	42.4	39.5	1	39.8	Oval
SE 009	47.6	40.5	1	36.8	Oval
SE 010	41.6	58.0	1	31.8	Flattened
SE 011	33.1	35.9	1	26.3	Oval
SE 012	53.4	41.7	1	45.8	Oval
SE 013	53.5	43.0	1	25.6	Oval
SE 014	25.6	35.8	2	23.7	Cylindrical
SE 015	53.3	38.8	1	27.5	Flattened
SE 016	26.2	38.5	1	22.3	Flattened
SE 017	42.1	32.0	1	33.2	Oval
LSD (0.05)	8.78	NS			
CV%	9.17	18.75			

NS: Not significant at P=0.05

Table 3. Yield and yield components of African eggplant accessions: Marketable/Fruit yield (Total of 10 harvests)

Cultivar/Line name	No. of fruits per plant	Total yield kg/plant	Yield(MT/ha)
SE 001	101.6	2.67	33.0
SE 002	45.5	2.19	27.0
SE 003	86.4	3.74	46.2
SE 004	75.2	3.19	39.4
SE 005	58.3	2.51	30.9
SE 006	68.3	2.91	35.9
SE 007	90.9	2.42	29.9
SE 008	74.7	2.97	36.7
SE 009	89.3	3.29	40.6
SE 010	61.0	1.94	23.9
SE 011	108.7	2.86	35.3
SE 012	79.3	3.71	45.8
SE 013	161.1	2.08	25.6
SE 014	113.7	1.92	23.7
SE 015	53.8	2.23	41.4
SE 016	83.7	1.87	23.1
SE 017	71.5	2.37	29.3
LSD (P=0.05)	46.66	1.18	
CV%	26.3	20.9	

TOMATO PASTE PRODUCTION AT THE RURAL/SMALL SCALE LEVEL

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Introduction

Tomato is basic ingredient in the diet of most Ghanaians and is used in the preparation of soups, sauces, stews, salad preparations, etc. Despite the large domestic market for fresh processing tomatoes, there is no significant commercial tomato processing enterprise within Ghana. All semi-processed tomato products (purees, juices, ketchup, etc.) are imported, mainly from Europe.

Based on a market survey carried out by the Project in Kumasi and Accra, it was evident that utilisation of semi-processed tomato products was widespread, especially of paste in 'chopbars', restaurants, educational institutions (secondary and tertiary) and in the home. Thus, an alternative source of obtaining a less expensive, readily available and good quality paste would be highly appreciated and would offer income-generating opportunities for poor rural farmers who often suffer from periods of overproduction and low returns. However, there was a need to develop an appropriate processing system that would allow resource-poor farmers to take part in processing activities.

- The objectives of the study were:

  ⇒ Analysis of current processing activities and potential options.

  ⇒ Market research and initial consumer analysis.

  ⇒ Preliminary feasibility trials for tomato paste production.

Analysis of current medium/large-scale processing activities and potential options

Methodology

The project gathered information on current usage and demand for tomato-based products through a review of government data and interviews with end-users of semi-processed tomato products.

Output

Demand for tomato paste

An assessment of the processing opportunities for vegetables revealed the widespread importance of tomato in the national diet and was the only commodity that offered the potential for significant income generation.

Evidence of the size of the tomato market is provided by the 1995 Ghana Living

Standards Survey (GLSS). According to this survey, fresh tomato accounts for 38% of total household expenditure on vegetables, more than any other vegetable (Table 1). For tomato puree, the figure is 2%. The GLSS also estimated that 42% of rural households (and 8% of urban) reported consumption of home-produced tomato.

Table 1. Average annual per capita cash expenditure on fresh and processed tomatoes (percentage of total expenditure on vegetables)

	Urban	Rural	Ghana
Fresh tomato	3389	1679	2248 (38%)
Tomato puree (can)	158	93	114 (2%)

Source: GLSS (1995) from Lyon et al (1996) {1995 Exchange rate: US $1 = C400}

Tomato-based food products are produced in Ghana. One of the most popular locally produced vegetable-based condiment, shito, is produced by a number of cottage industries all over the country and uses imported tomato puree. Processing also occurs in the city markets. Here, lower quality tomatoes (over-ripe ones) are pulped with onion using hand or electric blenders and sold to the chop bars. There is also a red powdered product marketed as dried tomato but interviews with sellers revealed that this product may sometimes be adulterated with maize flour and a seed (type unknown).

Given that all semi-processed tomato products are imported, the size of the market was to have been estimated from data on the volume and value of imports compiled by the Ghana Statistical Services. Unfortunately, the import data is very sketchy. Prior to 1992-94, nothing had been published since 1984. Table 2 shows estimates for 1992-1994, based on the available data.

Table 2. Volume of value of imported processed tomato products (current prices)

Year	Volume (tonnes)	CIF value (Cedi)	Cedis/kg
1994e	1,110	1,015 m	914/kg
1993e	3,662	2,124 m	580/kg
1992	875	374 m	427/kg

e = estimate
Source: Ghana Statistical Service

Status of former processing plants

There are three state-owned canneries for processing various fruits and vegetables (including tomato puree) under the management of GIHOC (Ghana industrial holding corporation) but all are out of action. The three plants, Nsawam, Wenchi and Pwalugu were all built by a Yugoslavian company in 1967. Wenchi ceased production in 1989 and Nsawam in 1990 due to a combination of events such as: frequent breakdowns (lack of spare parts and old machinery - many of the cannery's machines were installed in 1968 and are now obsolete), difficulties in procuring a regular supply of raw materials,

inefficient financial management, lack of technical competence and poor marketing. It was reported that each cannery was designed to process 600 tonnes of fresh tomato per year. However, because of these problems, actual production was only 30 tonnes (5% of capacity). The canneries are unlikely to re-open in the short run.

Heinz has allegedly bought the Pwalugu cannery but according to their managing director, they calculated they could only offer Cedi 6,000/crate as their farmgate-buying price throughout the year. This was much too low for farmers where farmgate prices for fresh tomatoes currently range from Cedi 15,000-72,000.

Research on the fresh tomato market has documented the seasonal nature of supply. Most tomato production is in the wet season and prices can be so low that large proportions of the tomatoes are not even harvested. By contrast, in the dry season, production is only possible in irrigated areas and prices are relatively higher

Among the options explored to help smooth out farmer incomes, or even secure income during the wet season, was the idea of processing tomatoes into a concentrated form such as paste (less concentrated than puree). Fresh tomatoes that could not be sold profitably during the glut period could be processed at the village level into a product that could be stored and sold/consumed throughout the year.

Market research and consumer analysis

Before assessing technical options for producing tomato paste, it was important to determine the demand for a locally-produced product. Therefore, market research was initiated. Managers/owners of chop bars and restaurants in Accra and Kumasi were interviewed and asked the following questions:

- Do you use fresh tomatoes or tinned tomato products?
- Which do you prefer / use the most? Why?
- Which brand of tinned tomato product do you usually buy?
- What characteristics do you look for in the product? Which are the most important? Rank in order of importance - to be used in assessing experimental paste.
- Which size do you buy? How long does it last? How do you store it once opened?
- Would you be interested in testing a locally-produced paste?
- Where do you obtain your bottles/packaging? (for *Shito* manufacturers)

For this tomato product to be successful, it will have to be not only price-competitive but also acceptable to end-users. It had been assumed that the use of paste was seasonal with demand for tomato paste peaking at the same time of the price of fresh tomatoes (in the dry season) but this does not appear to be the case. Demand for paste by restaurants is constant throughout the year and is used in conjunction with fresh tomatoes. Paste is popular because it helps thicken stews/soups and has a pleasing deep red colour. The most popular brand appears to be *Salsa* from Italy. Common complaints included that often tins were sold past their official sell by date being a pinkish red.

Cottage industries that used imported paste said that they would be interested in buying locally produced paste if it was available in sufficient and regular quantities.

Preliminary technical feasibility trials for tomato paste production

The aim of the study was to develop a 'stable' paste based on a technology developed in Sri Lanka where a network of rural processors had been established that were using a simple low-cost technique to produce paste. The relatively large number of small-scale processors meant that there was sufficient output to meet food manufacturers needs.

Methodology

Source of tomatoes

The varieties of tomatoes (Power, Rasta and Reno) used in the study were obtained from trials being conducted by the Integrated Food Crops Systems Project at Wenchi in the Brong-Ahafo Region.

Preparation of Paste

The methods used in the production of paste are shown in Figures 1 and 2 and described as Processes A and B, respectively. These two methods were used taking into consideration several factors including the ease of adapting the process and availability of processing equipment. The processes are a modification used by Guus de Klein (1989).

1. ***Preparation of tomatoes***

The fresh tomatoes received from Wenchi were first sorted out to remove unripe and spoilt fruits to reduce cross contamination. The selected (sorted) fruits were then washed thoroughly (three times) with fresh water to remove all dirt and to reduce surface microbes. The washed tomatoes were then weighed and divided into two sets for the two different methodologies. These production processes outlined in figures 1 and 2 were carried out for each variety.

2. ***Production of pulp***

Using the method in figure 1 (Process A), twenty kilograms of each variety was sliced, seeds removed and then milled into a pulp using a Waring blender (model 36BL23, Dynamics Corp., CT, USA). In Process B (Figure 2), twenty kilograms of each variety was blanched using steam for 10 minutes. This was done to soften the tomato tissue for easy pulping, to kill surface microbes and to reduce enzymatic activity within the tomato. The blanched tomatoes were then pulped using a local pestle and colander made of galvanized aluminium. The pulp was collected into a plastic bowl attached to the base of the colander leaving the seeds and the peels in the colander. The pulp produced from both processes were then sieved using a 2mm size sieve followed by 1mm size sieve. Weight of pulp obtained was then determined and additives added.

3. ***Pre-treatment of pulp***

The pulp obtained was pre-treated by adding selected additives as following:

(i) sodium benzoate was used as a preservative in the following concentration, 0.03g per litre of pulp and stirred;

(ii) lemon juice as pH adjuster in the following concentration, quarter (1/4) size lemon

fruit per litre of pulp and stirred;

(iii) citric acid as pH adjuster in the concentration of 0.25g per litre of pulp and stirred;

(iv) mixture of lemon juice and sodium benzoate - The juice from a quarter size lemon fruit was mixed with 0.03g sodium benzoate, added per litre of pulp and stirred;

(v) mixture of citric acid and sodium benzoate - 0.03g of sodium benzoate and 0.25g of citrate were mixed per litre of pulp and stirred;

(vi) control - a control was prepared which contained neither preservative nor acid.

4. *Concentration of pulp to produce paste*

The pre-treated pulps were then placed in sacks made of cheese cloth and hanged on retort supports. The time taken for complete draining (until no more juice is collected) was measured. This time is however dependent on the quantity of pulp to be concentrated. Quantities of concentrated pulp (paste) and extract (tomato juice) were determined.

5. *Packaging*

The concentrated pulp (paste) in each sack was carefully scooped out and packaged. Two packaging materials were used, glass bottles and plastic pouches (polyethylene pouches). The empty glass bottles were thoroughly washed and pasteurized.

One hundred and fifty grams (150g) of paste from each treatment was packaged into glass bottles and the polyethylene pouches. The plastic pouches were then sealed using the Kiran Impex sealing machine ((CD-400), Taipei, Taiwan).

6. *Pasteurization*

The packaged pastes were then pasteurized using a simple locally designed and manufactured steam generator and pasteurizer. The polyethylene pouches were pasteurized for 45 minutes and the glass bottles for 60 minutes. The packages were then cooled in cold water immediately after pasteurization and stored under ambient conditions.

Storage and Shelf-life studies

Based on the results of the first part of the study taking into consideration yield, Process B was discarded and shelf-life studies carried with paste from Process A. Thus the packaged pastes produced using Process A were stored and monitored under room temperature. Physical examinations of the samples were carried daily for the first two weeks. Chemical analyses were also done every two weeks for two months and monthly for two months.

Physical Examination
- changes in colour
- presence of exudates (extract)
- microbial growth
- offensive odour
- leakages (polythene pouches).

Chemical Analysis
This was carried out on the fresh tomato varieties (Power, Rasta and Reno) and the paste obtained from two tomato varieties (Power and Rasta). The Reno variety was not considered because it was not available on the farms (lean season). The following were monitored; moisture, ash, pH, colour, titratable acidity, ascorbic acid (Vitamin C), total soluble solids, total sugar content, microbial load and minerals.

The moisture, ash, vitamin C and pH were determined based on the Official Methods of Analysis (AOAC, 1984). Colour was determined using a Minolta chroma meter (Model CR 200, Minolta Camera Co. Ltd., Japan). Total soluble solids and total sugar content were determined by refractometry using the hand refractometer (Carl Zeiss 121554, Germany). Titratable acidity was determined by titration and microbial load by pour plating technique. Mineral analysis was determined based on the methods of Pearson (1981). Prior to chemical analysis the fresh tomato samples were blended using a Waring blender (model 36BL23, Dynamics Corp., CT, USA) and samples taken.

Results and Discussion

Analysis of fresh fruits

The Power variety had the highest ash content, vitamin C level and a very intense red colour relative to the other varieties.

The Reno variety had the highest percent total sugar followed by Power and Rasta. For colour, the Rasta variety was redder relative to the Reno. There was not much difference in the total titratable acidity level of the three tomato varieties used. With respect to mineral content, there was no significant difference between the sodium and phosphorus levels of the Power and Rasta varieties. However, the Power variety had higher potassium and calcium levels relative to the Rasta variety. These variations may be due to conditions for cultivation such as the inputs (agrochemicals) used during production and varietal difference.

Yield of pulp and extract

Comparing the two process regimes in terms of efficiency, yield and quality of product, process A was the better (Tables 23 and 24). This is because the paste contained no seeds compared to process B, which had white patches resulting from the breakdown of the seeds during the pulping step. Process A also had a very red colour, important for tomato paste end-users, and gave a higher yield of paste. Of the three tomato varieties, Rasta produced a very high paste content. However, a limitation of process A is the labour intensive nature of the technique. This happens during the seed removal step. However, based on the superior quality attributes, further storage studies were undertaken using paste from process A.

Shelf life studies

Analysis of paste
The principal results of this trial are reported here, a more detailed account is given in the

full technical report. There was a significant difference ($P < 0.05$) in the total soluble solids and total sugar contents of the paste from both varieties. Storage time, pasteurization, pre-treatment and type of packaging material did not significantly affect total soluble solids and total sugar contents of the pastes from the two varieties. Total sugar content was however, significantly affected by processing the whole fruit in to paste. Comparing the total sugar content of the fresh tomato fruits to the paste, the level of total sugar of the paste was about 6 times higher for the Power variety and about 13 times higher for the Rasta variety. The higher total sugar content of the paste may be attributed to the concentration effect of the procedure.

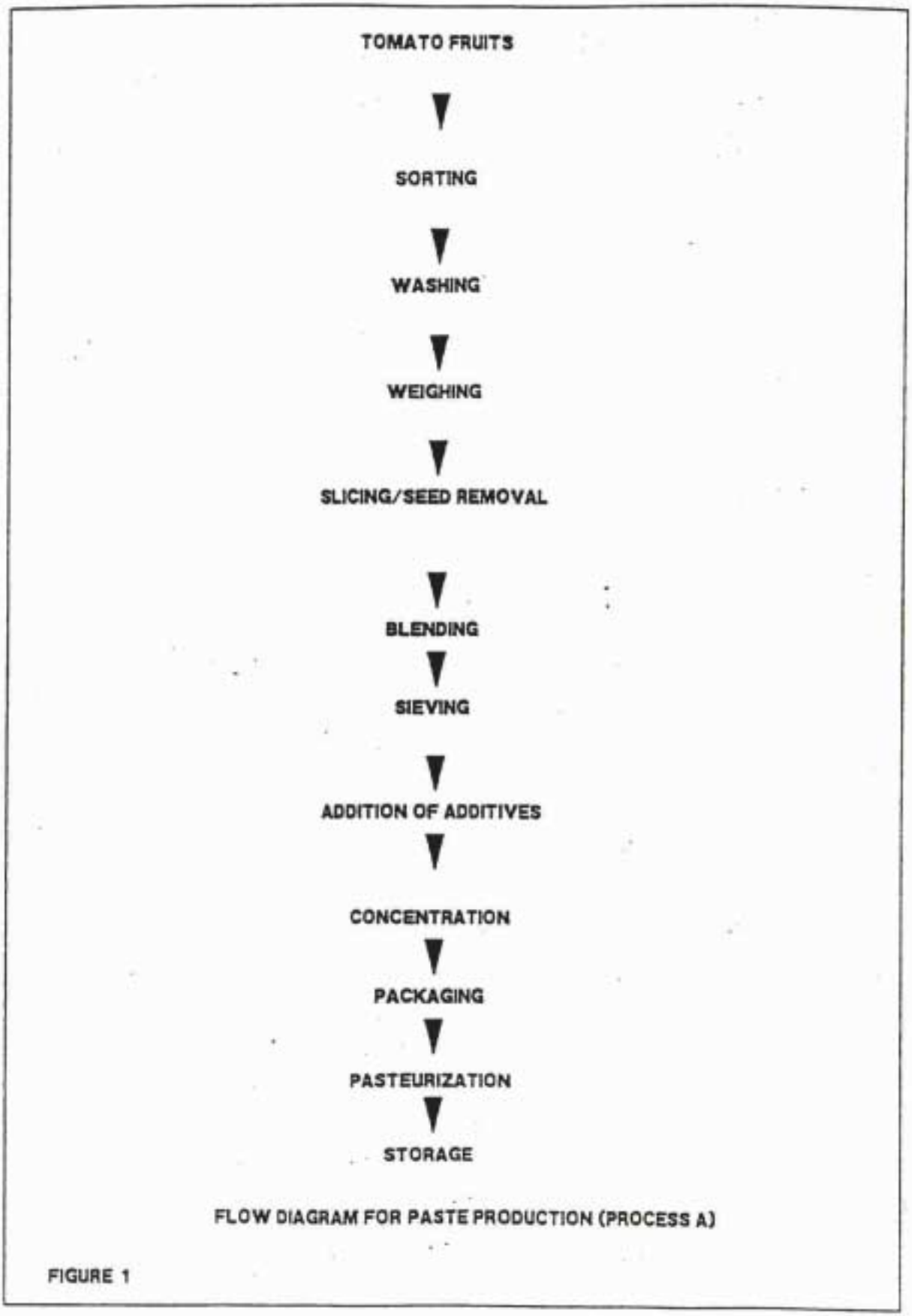
There was a significant ($P < 0.05$) decrease in the vitamin C content of the pasteurized paste compared to the unpasteurized paste due to the heat applied. The vitamin C level of the unpasteurized paste was lower compared to that of the fresh tomato fruits for both varieties. Vitamin C is water soluble and very heat labile. Thus during the gravity concentration step vitamin C is lost from the samples. However, the extent of loss is not as extensive as during the pasteurization process due to the heat-unstable nature of the vitamin. Pre-treatment (additives) had a slight effect on the vitamin C level of the paste samples especially for the Power variety. Samples containing lemon juice had higher vitamin C levels relative to the others. Storage time and type of packaging material significantly reduced vitamin C levels of the samples.

For colour, the a* values (red) of the processed samples for both varieties were significantly ($P < 0.05$) higher than that of the fresh tomato fruits. However, processing by pasteurization caused a decrease in the a* values of the pasteurized paste thus a reduction in the red colour of the samples. The colour of the pasteurized paste decreased with storage time and this was more pronounced in the polythene packaged samples.

Importantly, coliforms were not observed in any of the processed paste samples. This is an indication of good processing. A high mould count was observed in unpasteurized paste samples especially in the unpasteurized paste samples from the Power variety. However, after pasteurization, growth was absent from the paste of Rasta until the 8th and 16th week in the polythene and glass, respectively (Tables 25 and 26). For the Power variety, mould growth occurred after week 12 for the glass packaged paste samples (table 27). Paste samples with sodium benzoate as additive gave lower microbial load especially in the glass packaged samples.

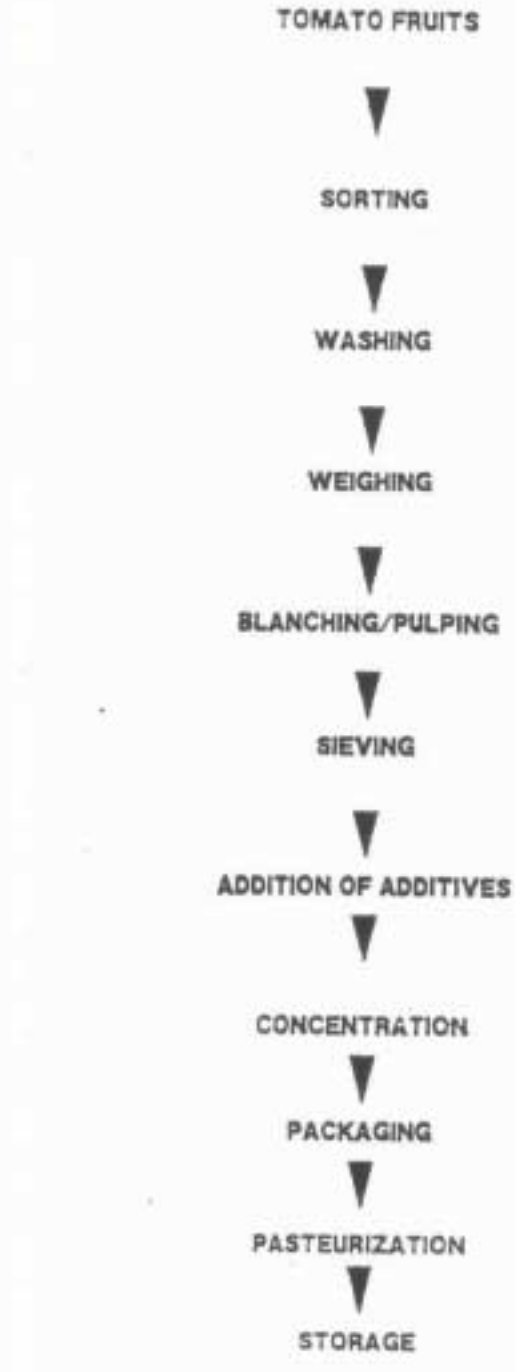
The polythene samples were discarded due to leakages. The polythene packages were not reliable due to extensive leakages and the increase in pore size on heating.

Mineral analysis was done on the fresh tomato fruits and the unpasteurized tomato paste for the Power and Rasta varieties. There was a significant decrease ($P < 0.05$) in the mineral content of the unpasteurized paste compared to the fresh fruit. The decrease may be attributed to its loss during the gravity concentration process.



FLOW DIAGRAM FOR PASTE PRODUCTION (PROCESS A)

FIGURE 1



FLOW DIAGRAM FOR PASTE PRODUCTION (PROCESS B)

FIGURE 2

TABLE 23

YIELD OF PASTE AND EXTRACT FROM PROCESS A

PARAMETER	VARIETY OF TOMATO		
	POWER	RASTA	RENO
Wt. of Fresh tomato (kg)	20.01	20.98	20.41
Wt. of Pulp (kg)	12.20	11.51	12.55
Volume of extract (juice)(L)	10.02	8.24	10.51
Av. time of hanging (Hrs)	2.5	2.5	2.5
Wt. of Paste (kg)	2.18	3.26	2.02
% Yield of Paste (fresh tomato)	10.89	15.55	9.90
% Yield of Paste (Pulp)	16.48	39.56	16.10

TABLE 24

YIELD OF PASTE AND EXTRACT FROM PROCESS B

PARAMETER	VARIETY OF TOMATO	
	POWER	RASTA
Wt. of Fresh tomato (kg)	20.05	19.93
Wt. of Pulp (kg)	10.41	9.32
Volume of extract (Juice)(L)	8.35	7.06
Av. time of hanging (Hrs)	2.5	2.5
Wt. of Paste (kg)	1.73	2.12
% Yield of Paste (fresh tomato)	8.63	10.64
% Yield of Paste (Pulp)	16.62	22.75

Table 25

MOLD COUNT (Log CFU/g) (POLYTHENE) - RASTA VARIETY

TREATMENTS	F/UNH	0	2	4	6	8	12	16
CON	7.14	0	0	0	0	5.28	5.39	5.46
SAM/LJ	6.22	0	0	0	0	5.04	5.17	4.31
SAM/CA	6.14	0	0	0	0	4.86	5.01	5.14
SAM/SB	3.72	0	0	0	0	4.93	5.00	5.08
SAM/LJ/SB	3.46	0	0	0	0	4.64	4.83	4.94
SAM/CA/SB	3.86	0	0	0	0	4.87	4.99	5.16

* F/UNH - Fresh/Unheated
CON - Control
SAM/LJ - Sample with Lime juice
SAM/CA - Sample with Citric acid
SAM/SB - Sample with Sodium benzoate
SAM/LJ/SB - Sample/Lime juice/Benzoate
SAM/CA/SB - Sample/Citrate/Benzoate

Table 26

MICROBIAL LOAD (log CFU/g) (GLASS) - RASTA VARIETY

TREATMENTS	F/UNH	0	2	4	6	8	12	16
CON	7.14	0	0	0	0	0	0	0.00
SAM/LJ	6.22	0	0	0	0	0	0	1.00
SAM/CA	6.14	0	0	0	0	0	0	0.00
SAM/SB	3.72	0	0	0	0	0	0	2.48
SAM/LJ/SB	3.46	0	0	0	0	0	0	2.00
SAM/CA/SB	3.86	0	0	0	0	0	0	2.78

* F/UNH - Fresh/Unheated
CON - Control
SAM/LJ - Sample with Lime juice
SAM/CA - Sample with Citric acid
SAM/SB - Sample with Sodium benzoate
SAM/LJ/SB - Sample/Lime juice/Benzoate
SAM/CA/SB - Sample/Citrate/Benzoate

Table 27

MOLD COUNT (log CFU/g) (GLASS) - POWER VARIETY

TREATMENTS	F/UNH	0	2	4	6	8	12	16
CON	7.31	0	0	0	0	0	4.00	4.71
SAM/LJ	7.03	0	0	0	0	0	3.48	3.88
SAM/CA	7.17	0	0	0	0	0	3.30	3.48
SAM/SB	7.04	0	0	0	0	0	1.30	1.48
SAM/LJ/SB	7.06	0	0	0	0	0	1.48	1.87
SAM/CA/SB	7.09	0	0	0	0	0	2.48	2.48

* F/UNH - Fresh/Unheated
CON - Control
SAM/LJ - Sample with Lime juice
SAM/CA - Sample with Citric acid
SAM/SB - Sample with Sodium benzoate
SAM/LJ/SB - Sample/Lime juice/Benzoate
SAM/CA/SB - Sample/Citrate/Benzoate

Overall assessment

The results of this study show that of the two techniques considered, process A is the best for producing high quality tomato paste, and Rasta the best variety giving the highest yield of paste. Irrespective of the low vitamin C level, the paste from the Power and Rasta varieties was very good due to its appreciably high mineral content, high total sugar levels, high total titratable acidity, low pH, appreciable total soluble solids and good red colour. The technique is viable because it has been able to store the products for more than 3 months. The only limitation with the plastic pouches is leakages arising from the poor sealing of the pouches at the factory.

Although a limiting factor in the process, the separation of seeds from the fruit at an early stage offers further business opportunities for seed supply as long as known varieties are used.

Sensory analysis and product acceptability testing

Importantly, consumer sensory and acceptability tests, using restaurants, chopbars, institutional kitchens and householders, demonstrated that pastes are of high quality (Table 28) and comparable to the imported canned tomato pastes. The pastes were highly acceptable to the target groups and could be used for a wide range of major Ghanaian dishes.

Table 28. Frequency distribution of panellists responses to tomato paste utilisation in cooking (in jolly rice, light soup, stew, etc.)

Sensory property	Colour		Flavour		Taste		Overall acceptability	
PASTE	A	B	A	B	A	B	A	B
LMV	10	9	7	10	11	7	5	7
LM	9	4	10	7	4	6	13	8
LS	1	6	2	2	5	4	1	3
NLND	0	0	0	1	0	1	0	0
DS	0	0	1	0	0	1	0	2
DM	0	0	0	0	0	0	1	0
DVM	0	0	0	0	0	1	0	0
MEAN SCORE	1.55	2.1	1.9	1.7	1.7	2.35	2.0	2.1

LVM - Like very much - 1
LM - Like moderately - 2
LS - Like slightly - 3
NLND - Neither like nor dislike - 4
DS - Dislike slightly - 5
DM - Dislike moderately - 6
DVM - Dislike very much - 7

A - Sample contains added salt (1%) and 5% sugar
B - Sample contains neither added salt nor sugar

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VEGETABLE DRYING WORK BY THE INTEGRATED FOOD CROPS SYSTEMS PROJECT IN THE BRONG AHAFO REGION OF GHANA.

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Abstract

The Integrated Food Crops Systems Project was initiated following a request from the Ghana Government for assistance to develop and validate sustainable strategies to increase incomes of smallholders in the Brong Ahafo Region of Ghana. The processing component of the project examined the construction and testing of appropriate technologies for the preservation of fresh vegetables in order to reduce both post-harvest losses and seasonal gluts leading to low price. This was add value to small-scale holders' produce and increase income.

The drawbacks in traditional drying can be eliminated by using solar energy as a heat source in improved drying systems. This would improve product quality, save time and labour by leaving the product unattended to while drying and increase the rate of drying.

The Project concentrated on improving the traditional technologies used for the dehydration of vegetables because sun dried vegetables were already an acceptable commodity.

Based on the success of the on-station comparative drying tests with three types of solar dryers, on-farm trials were carried out with farmers/processors in two districts, Sunyani and Tano, from August to December, 1997.

Purpose

The main purpose of this work is the addition of value through the improvement of small-scale rural processing technologies of chilli pepper.

To achieve the above objective, the following activities were carried out:

1. a technical appraisal of the needs in the post harvest processing of commodities in the project area to assess the main vegetables being processed and the problems of agro-processing in the Brong Ahafo Region;

2. assessment of the present practice of drying pepper in the region when it was found to be the main vegetable being processed through interviews and surveys of producers and processors;

3. construction of four solar dryers using local materials and determination of their cost, durability and efficiency for similar capacities;

4. comparative drying trials with chilli pepper using the four dryers as against traditional open air sun drying;

5. monitoring of price trends of dried chilli pepper in the Sunyani Techiman weekly markets in the lean season to assess the demand and market potential of dried pepper;

6. evaluation, through farmer participatory on-farm research, of solar dryers under real farmer conditions to confirm the acceptability of the dryers in the Sunyani and Tano districts.

Introduction

The solar dryer work of the IFCS project has been a need-based and demand-driven research activity. The major post-harvest constraints in vegetable production included periodic over capacity and large price fluctuations, high losses and limited opportunities for value-added products. Inadequate processing facilities were identified as one of the major constraints of vegetable production in the Brong Ahafo Region.

Following a baseline survey, needs assessment studies revealed that preservation of fruit and vegetables using low-cost sun drying techniques appeared to be the main post-harvest processing activity. Simple sun-drying techniques are used mainly by smallholders for the production of dried chilli pepper, and to a lesser extent for okra, for home consumption and sale in local markets. It is widely practised on a small scale at the household and farm level by the farmers themselves and their families. Traders in the markets also dry any excess produce they are unable to sell for the day.

The project aims at introducing into the Brong Ahafo Region, through adaptive research, improved drying and associated techniques for fruits and vegetable preservation in the rural sector, with the express purpose of enhancing smallholder incomes. Due account is being made of product quality, saving of time and labour, marketing and local requirements for improving dissemination of the adapted technologies. The building and testing of appropriate technologies for the preservation of fresh produce in order to reduce post-harvest loses was undertaken by the project.

In general, drying takes place in order to:

- reduce the moisture content and thus lengthen the shelf-life and the storage period of the crop;

- prevent losses due to deterioration of the fresh produce by providing an environment which is unfavourable to the growth of spoilage organisms; and

- add value to the crop in relation to seasonal gluts and prices.

The quality of the dehydrated products (pepper and okra) offered for sale on the local markets was observed to be variable and often poor in quality. This seems to be associate with several factors including the time taken to dry them and the method of drying. Traditional methods of drying, although satisfactory, suffer from certain drawbacks. It must be noted that whilst sun drying is a technique which requires virtually no costs or expertise, farmers perceived the under-mentioned problems:

- rotting and discoloration of the products during drying;
- slow rate of drying due to low sunshine and high relative humidity;
- contamination of the product with dirt, soil, insect, bird and animal droppings due to the method of drying which exposes the products to the open air;

- time consuming as the risk of rains means there is the need to have someone always present;
- improper/inadequate drying leading to inferior products.

From the foregoing drawbacks in traditional drying, there was a need for an improved solar energy technology as a heat source to change the method of drying systems in order to:

- speed up the rate of drying;
- improve the quality of the products by reducing rotting and discoloration during drying;
- save time and labour by leaving the product unattended to during drying;
- provide an environment in which the product is less likely to be contaminated by dirt, insect, rodent and bird droppings;
- addition of value by good drying methods;
- drying other products like sliced tomato, cut pieces of okra and garden egg.

The economic conditions in the Brong Ahafo Region, however, dictate the use of low-cost drying systems in attempting to improve traditional methods.

The project concentrated on improving the traditional technologies used for the dehydration of vegetables. This appropriate low-cost solar energy technology will serve as an alternative method to the traditional open-air sun drying. However, any introduced technology must be appropriate to the society. It must fit their system, be socially acceptable and must be economically affordable to the target group whose capital is often the scarcest resource.

Solar drying relies, as does sun drying, on the sun as its major source of energy. Compared with sun drying, however, solar dryers can generate higher air temperatures and lower relative humidity, which are both conducive to improved drying rates and lower moisture content of the dried product. Consequently, the risk of spoilage is reduced, both during the actual process of drying and subsequent storage. The higher temperatures attainable are also a deterrent to insect and microbial infestation. Additionally, protection against dust, insects and other animals is enhanced by drying in an enclosed structure. All these factors contribute to an improved and more consistent product quality. Solar dryers can also be relatively waterproof, minimising the requirement for labour to be on hand in case of rain to cover or move the crop under cover. Comparatively unskilled labour can be used to construct, operate and maintain solar dryers utilising materials that are readily and cheaply available in rural areas. Alternatively, existing drying structures such as the traditional drying platform can be modified to incorporate a solar collector to supplement conventional fuel supplies.

On-Station Solar Drying Trials

Four types of solar dryers were constructed and a series of comparative drying trials with chilli pepper were carried out on-station. The aim was to evaluate the solar drying technique against the traditional open-air sun drying and comparing the efficiency of the different dryers under the weather conditions. Chilli pepper was chosen as the test crop because it is the most commonly sun-dried vegetable at the village and farm level in the Brong Ahafo Region. Pre-treatments such as blanching and steaming in boiling water to increase the rate of drying, reduce deterioration and improve the quality and fix the colour

were evaluated. Product quality in terms of colour, moisture contents and drying times were assessed from the trials.

Better quality dried chilli pepper was produced from the solar dryers as compared with the open-air sun drying technology.

Cut pieces of garden eggs and okra and later sliced tomatoes were solar dried. Good quality dried garden eggs and okra was produced. However, acceptable dried tomato could be produced only in the dry months of December to February when there was adequate long hours of sunshine with high temperature and low relative humidity.

In operation, the dryers should be sighted in a flat area, unsecured by trees or buildings so that it is fully exposed to the sun throughout the whole day

Because of the success of the on-station solar drying trials, the need to extend the technology to rural farmers in the Brong Ahafo Region through On-Farm Trials became necessary. As a precursor to the on- farm trials, background data on chilli pepper production and processing, how the processing was done and the problems encountered was collected by surveys in the Sunyani, Tano and Techiman Districts. Visits were also made to Kumasi, Techiman, Sunyani, Wenchi, Yamfo and Susuanso daily and weekly markets to assess the marketing and pricing of chilli pepper. Furthermore, price trends of dried chilli pepper in the Sunyani, Techiman weekly markets were monitored between mid-October 1996 to mid-June 1997 to assess the demand, sale, and price trend of dried chilli pepper during the lean season.

The on-farm solar drying trials

This was a collaborative work between the CSIR/NRI - Integrated Food Crops Systems Project (IFCSP) and the MOFA/GTZ - Sedentary Farming Systems Project (in collaboration with the 31 December Women's Movement. The objective of the on-farm trails was to evaluate the use and acceptability of solar dryers for the production of dried pepper in the Brong Ahafo region.

Location
Sunyani and Tano Districts.

Duration
Peak harvesting and processing season of August to December 1997.

Participants
Individual farmers and processors who are already engaged in chilli production and processing for sale in local markets or to traders. Nineteen farmers/processors, 15 women and 4 men took part in the trials.

Farmer selection
The selection was done in collaboration with the Agricultural Extension Agents (AEAs) and the 31 December Women's Movement by walking through villages/towns and identifying those engaged in processing activities. This was followed by formal interviews to find out the quantities of chilli pepper processed per harvest for the year,

why they carry out processing, if quality could affect sales and pricing, how they store the dried product and for how long, when sales are made, and what problems they encounter during drying and storage. The criteria used for the farmer selection was the past record in chilli pepper production and processing activities, and the interest and enthusiasm shown by him/her in the whole exercise. Selected farmers were given training on the basic principles of the workings of the dryers such as the importance of the orientation of the dryers, proper ventilation, loading capacity of drying trays and dryers, the preparation of the chilli pepper before drying, laying of the trays and the correct completion of the drying record sheets.

Solar Dryer Types
The following solar dryers were used:

- Improved Traditional Drying Rack for-
  - five women and one women's group in the Tano district;
  - five women and one man in the Sunyani district.

- Legon Box single layer dryer for:
  - one women in the Tano district;
  - one woman in the Sunyani district.

- Legon box Cabinet dryer for:
  - one man in the Tano district;
  - two women in the Sunyani district.

- NRI/Kawanda Cabinet dryer for:
  - one man in the Tano district;
  - one man in the Sunyani District.

Solar Dryer Installation:
Installation of the dryers started in the last week of August 19997 and continued to the middle of September 1997 in phases depending on the readiness of the farmer/processor. Delays by some farmers affected the installation schedule as a few of the farmers could not fulfill their part of the contract. Three of the farmers/processors had to be changed when it was realized that they would pose problems if the team should continue working with them. They had not constructed the platform for the dryers and kept on giving excuses whenever the team visited them.

Record Sheets:
Record sheets were designed and supplied to the farmers/processors for completion whenever they carried out any drying. They were expected to provide answers to the questions on the forms as attached.

Monitoring:
Fortnightly visits were made to all the farmers/processors engaged in the trials to check on the record sheets, assess the quality of the dried products and discuss and find solutions to any problems encountered during the drying process.

Results

Efficiency of the Solar Dryers:
The Improved Traditional Drying Rack, one of the NRI/Kawanda, one of the Legon Cabinet and the two Legon box solar dryers were very efficient. However, one of the NRI/Kawanda and three of the Legon Cabinet Solar dryers with four drying trays had very serious technical problems. Products kept in the lower drying trays failed to dry well and were of poor quality. They were either rotten or discoloured in most cases. The problem was traced to wrong siting in the case of the NRI/Kawanda dryer and bad construction in the case of the Legon Cabinet dryers. The Legon type Cabinet dryers were either changed or repaired but the lower trays of the repaired ones still failed to work as expected. This highlights the need for care in construction and subsequent siting of the dryer.

Quality of Products
The chilli pepper dried in the solar dryers was of the highest quality in terms of colour, shape (whole unbroken fruits), low moisture content, few or no discoloured fruits and good storage potential even in the humid months of August to October as compared with the traditional open air sun dried products.

Drying Rate:
The drying rate did not increase much in the months of August to the middle of October due to inadequate sunshine, cloudy atmosphere, intermittent rains, low temperatures and low relative humidity for most of the period. However, from mid-October to December the rate was much faster. It took 11 days to dry a batch of fresh chilli pepper in the solar dryers in August to mid-October and 4 days from then to December as compared with 15 and 6 days respectively for the traditional open-air sun drying method.

Field days

The project team carried out field days in October and November in all the villages where the solar dryers had been installed and were being operated. The objective of these field days were to introduce the dryers to other farmers, explain the operation and working of the dryers to them, offer them the opportunity to ask questions about the technology and allow the case study farmers to share ideas and experiences with their colleague farmers. The need for blanching or steaming to destroy the enzymes of browning and discoloration, to fix the colour and speed up the rate of drying were stressed. The spreading of all products being dried to the correct bed thickness/density for good air circulation and fast drying rate leading to good quality products was also emphasised. Attendance at all the field days was quite good; numbers ranged from 10 to 40 people per field day.

Construction of Private Dryers:
By the end of August 1998, 2 Legon Box Cabinet, 3 Legon single layer dryers and 6 Improved Traditional drying racks (Sunyani District) and 4 Legon Box Cabinet dryers and 5 Improved Traditional Drying racks (Tano District) had been constructed and were being used by individuals with the technical advice and assistance of the project team.

End-of-trial workshop
A one day end-of-trial workshop was organized at the GTZ/MOFA Post-harvest

Demonstration plot at Sunyani in April 1998 for all the case study farmers/processors who took part in the On-Farm Solar Drying Trials and some invited staff of NGOs, Ministry of Food and Agriculture and a group of farmers who were being introduced to solar dryers from the Wenchi district. The purpose of the workshop was to give the opportunity to the case study farmers/processors to share experience, exchange ideas and learn from each other. Each farmer/processor was given the chance to express his/her views on the solar dryers particularly what he/she found useful, what he/she disliked or thought was not useful and should be changed or modified and other issues arising from the field. The main areas mentioned are summarized below.

Efficiency of the Solar Dryers

All the farmers who used the Improved Traditional Drying Rack, single layer Legon Box and one of the NRI/Kawanda Solar Dryers spoke very well of their high efficiency. They mentioned that they were able to do their drying without any hitches whatsoever. Even the lower trays of those dryers, which did not work very efficiently, were better than the traditional open-air sun drying.

Quality of products

The farmers/processors expressed their happiness about the high quality of the dried chilli pepper in terms of bright and shiny uniform colour, low moisture content, whole fruits, no or few discoloured or brown and rotten fruits. They could therefore sell better quality products, as there were no rejects.

Increased Rate of Drying

All the farmers/processors also mentioned the increased rate of drying, even in the humid months, as another good quality of the dryers. This, they said, allowed them to dry more products during the season, as there were few rejects.

Saving of Time and Labour

The farmers highlighted the relatively waterproof nature of the solar dryers. It allowed them to leave the drying products unattended to during wet weather and overnight. The ability to leave the dryers unattended to during drying, especially in the rainy season, became the major attraction for the farmers in the early months of the introduction of the technology.

Storage

The farmers/processors were highly impressed by the good storage properties of the solar dried products. They did not change colour, deteriorate, fade or change shape during storage as compared to the traditional open-air sun dried products.

Sales

The case study farmers/processors also mentioned that compared to the traditional open air sun dried chilli pepper, the solar dried products sold faster and in some cases at a higher price, both on the markets and at the villages and homes. The buyers preferred them due to their high quality. They added that anytime they had sent dried chilli pepper to the market, the solar dried products had been bought first before all others. That saved them a lot of time. Most farmers also mentioned that traders asked of them first whenever they came round their villages to buy dried chilli pepper.

Marketing

All the farmers expressed concern about the marketing of dried chilli pepper in the in the region and Ghana. At present, domestic marketing is the major channel for dried chilli pepper producers in the Brong Ahafo Region. Women traders buy the dried product from producers in villages, homes and local markets and sell in the urban markets. The size and stability of the market including pricing was the major concern expressed by all the producers as indicated by the current prices (1998 season). The price for the dried chilli pepper has been very low this year as compared to 1997. A black rubber (bucket) full sold for between 7,000 to 12,000 Cedis as against 20,000 to 40,000 Cedis the same period in April in 1997. Find attached price data for traditional open-air sun dried and solar dried chilli pepper for the period September 1997 to March 1998.

The case study farmers and processors wanted the Project and MoFA to look for market avenues for them.

Maintenance and Repairs of Solar Dryers

The other concern expressed by the farmers/processors was the tearing and deterioration of the polythene sheet covering the solar dryers by winds, especially after the dry season. It was explained that the polythene sheet degenerates because of the high temperatures and the effects of ultra-violet light, and requires periodic replacement. However, since the price of the polythene sheet was not too high, they could replace them readily whenever the need arises. They were also advised to keep the dryers under shade when not in use.

General Opinion

All the farmers/processors were of the opinion that since the benefits of the solar dryers far outweigh the shortfalls, they would continue to use the dryers so long as they continue to dry chilli pepper. They were unanimous that the solar dryers were far better than the traditional open-air sun drying. They wished the On-Farm solar Drying Trials could continue for another year and if possible to include more people and villages. Most of them also expressed the desire to build their own solar dryers in addition to the project's dryers. Overall, the workshop was very successful and all the participants comprising of farmers/processors, staff from MoFA and NGOs were highly impressed and wished such sessions could be a regular feature in the project.

CONCLUSIONS:

Generally, the results from the first year of the On-Farm Farmer Participatory Solar Drying Research in the Sunyani and Tano districts involving 19 farmers/processors has been very successful despite the few problems encountered.

The dried chilli pepper was of the highest quality in terms of colour, moisture content, shape, storage potential, marketing and pricing. The increased drying rate which allowed farmers to dry and sell more chilli pepper than the previous years, better quality products, labour and time saving were the major attractions, especially in the rainy season. Solar dried chilli pepper also sold faster and in certain instances at a higher price than the traditional open-air sun dried products

The number of people seeking information on solar dryers has increased since April 1 1997 when the training of people on solar dryers and especially the On- farm trials began

in the region. Indications are that there is wide interest in further work on dryers for vegetable processing.

The Improved Traditional drying Rack has proved to be easy to use and of low constructional cost. This dryer is ideal for the small-scale low-income farmer/processor who can easily invest in it, operate and manage it. Larger producers would, however, require higher capacity and have to build the NRI/Kawanda Dryers

The likely beneficiaries of initiatives to further promote solar drying work in the Brong Ahafo Region are individual women and women's groups in rural areas since almost all chilli pepper drying is done by women.

However, the major constraint, which could affect the solar drying technology take up in the region, is the marketing of the product. If the current low prices continue, most farmers/processors may be discouraged from either continuing to produce or enter the production and hence invest in solar dryers. The prices of between 20,000 to 40 000 Cedis for a black rubber encountered at local markets between October 1996 and May 1997, and which brought about the initiation of the Solar Dryer Trials, are not being maintained in 1998. However, from the discussions held with farmers/processors and other groups, e.g. NGOs and churches, solar dryers have a very bright future in the Brong Ahafo Region for processing vegetables, especially chilli pepper.

Recommendations and follow-up.

1. The Improved Traditional Drying Rack is given top priority because of its low cost, ease of construction, usage, maintenance but high efficiency and readily acceptance by farmers/processors on the field as indicated by the number of private constructions.

2. Continuation of the On-Farm Solar Drying Trials for another year for more understanding of the technology by farmers/processors and its application without any supervision.

3. Workshops should be organized in areas where there are established dryers and other areas where there is perceived potential for take up of the adapted technologies.

4. There is a clear need for the provision of appropriate extension leaflets to disseminate appropriate processing drying technologies. It is recommended that an initial draft leaflet should be produced and draft copies sent out to various end-users, in-country institutions and NGOs for review prior to distribution.

THE AGRONOMY COMPONENT OF THE INTEGRATED FOOD CROP SYSTEMS PROJECT: 1. INTRODUCTION

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Purpose

The project aims to work with farmers to evaluate, in a series of on-station and on-farm trails, different amounts and mixtures of animal manures, and a range of different green manures for their effect on subsequent vegetable growth. Collaborating institutions and farmers are involved in the design, assessment and testing of on-station technologies and in the adaptation and assessment of promising technologies.

Background-origins

The agronomy component is the "newest" component within the IFCSP, starting in January 1997, and was developed in response to findings from the other components. These had found that problems associated with post-harvest handling and storage of fruit, also with pest and disease incidence, to be linked to soil health and productivity factors.

Specifically, the design of the project has been based on recommendations from the following studies conducted under the IFCSP.

1. A survey of small-holder vegetable production in the Brong Ahafo region, which provided information on types of vegetables grown, types of vegetable farms/farmers, methods of cultivation, use and sale of produce, socio-economic importance of vegetable production, and main constraints to production (Sherington and Suglo, 1994).

2. A more detailed study of the socio-economic factors that affect vegetable production and marketing systems in selected areas of Brong Ahafo region, which provided insight into the different types of vegetable producers, costs of production, marketing systems, farmers' perceptions of vegetable varietal characteristics, and pests and diseases, and other relevant socio-economic issues (Warburton and Lyon, 1995)

3. A study of soil and water management of dry season vegetable production in four selected case study areas in Brong Ahafo (Holland and Boadi, 1995). The study brings together available information from secondary sources on soil and water quality and current soil/water management practices in the region. More detailed information on these aspects were then collected from the case study areas, including fertiliser use and relevant socio-economic issues. The report's recommendations for potential interventions and discussion of findings have formed the basis for consideration of intervention options for the Agronomy component.

Funding: - Department for International Development (DFID)
Funding for the Agronomy component is provided by the Department for International Development (DFID), formally the Overseas Development Agency (ODA), under the forest/agriculture interface production system of the Natural Resources Systems

Programme (NRSP). The NRSP is one Programme, alongside the Crop Protection and the Crop Post-Harvest Programmes, that fund strategic research into the sustainable use of natural resources under DFID's Renewable Natural Resources Research Strategy.

Objectives: Proposed outputs from the Agronomy component

Improved green manure and mulching technologies suited to dry season vegetable production systems in seasonally flooded and drier areas.

Recommended quantity and suitable mixtures of animal manures required to replace, or supplement inorganic chemical fertilisers for sustainable production of dry season vegetables.

Assessment of the costs and benefits of the new technologies in terms of labour use, replacement of inorganic fertiliser, water inputs, and crop productivity.

Manual outlining the concepts of soil productivity management and most promising improved technologies for use by the extension service and non-government organisations involved in agricultural extension activities
Immediate assistance to collaborating farmers, their villages and the extension staff in the area in the introduction, testing and dissemination of new technologies.

Approach
The project, having developed in concept from findings from the field, has sought to keep in close contact with representative groups of farmers in major vegetable production areas. The first PRA survey identified suitable areas and groupings of farmers to work with in four village areas, Dwomo, Manso, Bepoyase and Akrobi. The survey, through village meetings and individual farmer interviews, generated interest in the proposed technologies and several farmers volunteered to try out the technologies they were interested in on their land. In this way, the project has been able to initiate on-farm trials as well as on-station trials, right from the start. On-going assessment of on-farm trials is conducted by the farmer in aural reports and, for the literate, by notebook. Assessment is also conducted by the AEA in collaboration with the farmer. Researcher visits are made at important times of the year. Technologies taken straight to the field are those that have been developed by CRI (i.e. various varieties of green manures) tried in other areas of Ghana, or well-established technologies in other countries (i.e. the various types of animal manure). More innovative, or risk-prone trials have been located on-station for assessment in the first place.

Methodologies
The project has sought to bring together knowledge from the social sciences as well as the technical sciences to address the problem of declining soil health and productivity. In addition to the original PRA, a second survey was conducted to look at the range of social, economic and practical issues that are likely to affect different farmer's adoption of techniques. This included social profiling and identification of what criteria different farmers use to assess new techniques. Farmers' concerns and criteria have been incorporated into the project monitoring process (as mentioned above) in order to ensure, as far as is possible, that techniques are adapted to suit farmers' conditions and needs. Where the present selection of farmers conducting on-farm trials have been found to be

not fully representative of the range of dry season cultivators, efforts will be made as opportunities arise, to include more characteristic farmers. It is hoped that by including a range of farmers in the trials, technologies will be adapted to suit a range of conditions and needs. Thus, rather than a single "best practice", the project will identify a number of appropriate technologies suited to households with different resource backgrounds and production needs.

THE AGRONOMY COMPONENT OF THE INTEGRATED FOOD CROP SYSTEMS PROJECT: 2. ON-FARM TRIAL REPORT FOR AKROBI, BEPOYEASE, KOFORIDUA and DWOMO DRY-SEASON 1997-1998

Liz Kiff, NRI

The on-farm trials looked at two alternative technologies, the use of various animal manures and the use of green manures, for soil fertility and water-holding capacity improvement in dry-season tomato cultivation.

Objectives of the Trials

1. Animal manure trials (cow, sheep, poultry):

- to assess the performance of various animal manures in comparison to farmers' normal practice in the cultivation of dry-season tomatoes;
- to identify farmers' criteria, and how these may differ, in assessing the performance of animal manures for tomato production.

2. Green manure (*Canavalia ensiformis* and white- and mottled-*seeded Mucuna pruriens*):

- to assess the growth performance of different species of green manure and the subsequent performance of a tomato crops grown after incorporation of the green manure;
- to identify farmers' criteria for assessing the performance of the green manures during the dry season.

Background to the on-farm sites

The on-farm trials are located in two different agro-ecological zones. Akrobi and Bepoyease are found in the transitional zone in the Wenchi District and Koforidua and Dwomo are located in the forest zone in the Tano District of the Brong Ahafo Region.

All four villages are predominantly farming communities and rely largely on vegetable production for their livelihoods.

Dry season vegetable cultivation, mainly of tomatoes, is particularly extensive in Dwomo and Koforidua. In these areas, most farmers use chemical fertilisers and pest control measures during the dry season and it is more common for the cultivator to hire land than own it themselves. Farmers consequently are putting a high level of inputs, both capital and labour inputs, into dry-season vegetable cultivation. While both men and women are involved in vegetable production, more men are involved in dry-season tomato production then women.

A range of vegetables, okro, egg plant, chilli and tomatoes are grown in Akrobi and

Bepoyease, with okro as the main commercial crop. In these areas farmers most commonly cultivate there own or family land and the majority do not use any chemical fertilisers or crop protection products. Cultivation in these areas is less input-intensive. Approximately equal numbers of men and women are involved in dry-season vegetable production.

Trial results

Each farmer was asked to give an overall ranking of the different treatments he/she had used. Farmers used a number of different criteria in assessing the trials.

Criteria used by 11 farmers in assessing their trials:

Criteria	**Number of farmers using given criteria**
Size of tomato fruits	5
Amount of fruits	3
Vigour and health of the tomato plants	2
Rate of growth of the green manure and its weed suppressing ability	2
Resistance to disease	1
Earliness of fruiting	1
Survival of transplanted tomato seedlings	1
Firmness of fruit	1
Amount of watering required	1
Criteria used by farmers where harvest did not, or has not yet, occurred	
Health and vigour of the tomato plants	2
Number of fruits that appear to be forming	1

The general appearance of plants in terms of health and vigour, amount of fruit and size of fruit were the most frequently mentioned criteria. Size of fruit was in fact mentioned more frequently by farmers than number of fruits. The farmers said that this is a particularly important factor in term of quality (amount of flesh contained by the fruit) and in the price obtained for the crop (the ability of the crop to fill crates) for sale.

Overall rankings of treatments (1 = best) given by the remaining 11 farmers is given below:

	DWOMO	KOFORIDUA				AKROBI				BEPOYEASE			
Canavalia	2	1	1	1	1					2	2	2	
Mucuna (white seed)	1									1	1	1	
Mucuna (mottled seed)		2	2		2								
Cow		4	3					2		5	5		
Poultry		6	6			1	2	3		3	3		
Cow/poultry		5	5					1		4	4		
Sheep						3	1						
Sheep/poultry						2							
Control (no fertiliser added)						4	4	4		6	6	3	
Control = fertiliser 15:15:15 at 5g per plant							3						
Control = fertiliser half rate*		3											
Control = fertiliser full rate**			4	2	3								

* half rate use of fertiliser = 1 milk tin (130g) 15:15:15 in 9 litres of water
** full rate use of fertiliser = 2 milk tins (260g) 15:15:15 in 9 litres of water

Analysis of the data indicates that for all the farmers who tested the green manures, both Canavalia and Mucuna were ranked higher than the control in all cases, whether this included the use of chemical fertilisers, or not.

All farmers in Koforidua preferred the Canavalia to the Mucuna (mottled seed variety), where as the reverse was true in Bepoyease, where the white seeded variety of Mucuna was used. The one farmer who successfully grew the green manures in Dwomo preferred the Mucuna (white seeded variety) to Canavalia. This suggests that the white-seeded variety of Mucuna is better suited to local conditions, both around Wenchi and in the Sunyani area, than the mottled variety. (This needs further verification as based on a relatively small selection of farmers and two of the farmers in Koforidua experienced problems with rodents eating the Mucuna seeds)

For five of the seven farmers who tested different animal manures, all the animal manure plots did better than the control. However, for the two farmers in Koforidua who tested animal manures, their control plots did better than most of the animal manure plots. These farmers in Koforidua used chemical fertiliser on their control plots, whereas none of the five farmers in Bepoyease and Akrobi had applied fertiliser to their control plots. This suggests the need to look at higher rates of animal manure application and the use of a combination of animal manure with a reduced rate of chemical fertiliser.

No clear patterns emerge at this stage regarding preferences between the different animal

manure treatments - there is a great deal of variation between farmers as to their rankings of the different types and mixtures of manures. However, one interesting feature is that, whereas the poultry manure treatment was ranked last by both farmers in Koforidua, the two farmers in Bepoyease ranked it as the best of the animal manures. This suggests that some form of interaction is taking place. This may be between the animal manures and the soil type, watering regime, and/or other cultivation practices. The project plans to arrange soil analyses of collaborating farmers' land. Possible interactions between watering regime and manure type will be further investigated through comparison of farmer's diary records of watering regime.

The future

Despite trial abandonment by a number of the farmers due to insufficient water, farmers are enthusiastic to continue with the trials.

A third green manure, Crotalaria sp., which has shown promising performance in on-station trials, will be assessed by interested farmers.

Collaborating farmers have selected the technologies that they consider most appropriate to their situation for trials this year. They have suggested improvements in terms of the timing of sowing of the green manures and incorporation of the animal manures.

A total of 19 farmers are involved in trials this year.

Some farmers were particularly interested in assessing the new technologies in terms of reducing costs of production. Costs of production and the price received on harvest will be recorded by farmers in their diaries this year.

An adapted methodology for non-literate farmers to record activities is being developed.

Support for seed multiplication by farmers of the green manures will be started this year.

POST-HARVEST HANDLING AND MARKETING OF VEGETABLES

J. E. Orchard, F. Lyon, H Warburton and E. K. J. Suglo

Background

Vegetables are an important part of the Ghanaian diet amounting to 9.6% of total food expenditure with tomatoes accounting for 38.0% of vegetable expenditure (4.9% of total expenditure) on average across the country. (GLSS, 1995). Tomatoes are used in most Ghanaian dishes and the only substitutes for fresh tomato are tinned puree and powder. Studies on the average annual per capita cash expenditure on tomatoes is given in the table below.

Table 1. Average annual per capita cash expenditure on fresh and processed tomatoes at 1991-1992 prices

	Urban	Rural	Ghana
Fresh Tomato	3,389	1,679	2,248
Tomato Puree (canned)	158	93	114
Total Vegetables	8,448	4,660	5,920
Total food and beverages	82,924	51, 093	61,691

Source: Ghana Living Standards Survey (1995)

Methodology

The study area falls in the transitional zone (guinea Savannah) and the forest zone (semi-deciduous) although in many areas the division between the zones is unclear, with invasion of Savannah species due to degradation of the forest areas. There is production throughout the year where there is access to water for irrigation. The rainy season in forest areas is between March and November, with a break for a short time in July to August. In the transitional zone, the rains start later and finish earlier and may not have a pronounced gap.

Data for market studies was collected using semi-structured interviews with a wide range of farmers and traders. This was complemented by a weekly monitoring of farmers who were harvesting.

The weekly monitoring was done between June and August 1996 using a prepared format that was pilot tested thoroughly before the study started. The data was collected once a week by trained staff of the Policy Planning Monitoring and Evaluation Department of the Ministry of Food and Agriculture. Details were collected on prices at the farmgate and Accra and Kumasi markets.

This report also presents results from a weekly monitoring study following tomato farmers through their harvest period. The farmers were selected taking into consideration the size of the farm, their age and crop grown. The research was only done with the larger scale farmers as the others were not using uniform units. The size of the farm was used to give an indication of the amount that the farmer could invest in production.

The monitoring was done in two villages, chosen to represent the transitional and forest zones and different levels of accessibility. Manso is on the main trunk road to Tamale, and Dwomo is on a secondary road. The villages are both of medium size (4-5000 people).

Detailed interviews were done with representatives of each of the main farmers' associations and also their members. Research in the market was during regular visits.

The research was done with key informants at first as well as other farmers chosen at random while on the farms or walking in the village. Observation of harvesting, transport and marketing was very important for the collection of data both in the village and in the market.

Details of the market prices were collected by the PPMED staff in each of the markets. They were asked to write out the daily prices rather than taking the weekly average.

Studies on the post-harvest handling chain were undertaken using hazard and critical control point methodology to follow tomato consignments from the time of harvesting through the transport system up to the point of sale.

Farmer Profile

Tomatoes have been an important and expanding cash crop for the farmers of Brong Ahafo Region for the past 20 years. Before 1970, most vegetable production was done by women, often intercropping within other crops and using most for home consumption, while selling any surplus in near by markets. More men became involved as the access to markets increased, especially in the irrigated areas. There was a large increase in vegetable production after the 1983 bush fires that destroyed the main cash crop of cocoa. The numbers of vegetable producers has continued to increase as many young men start farming due to unemployment.

The importance of commercial vegetable production was highlighted by a survey of farmers in the Brong Ahafo Region which found that 62% of women and 58% of men in the households of respondents who were sampled, were growing vegetables 'commercially' (Sherington and Suglo, 1994). The survey also found that 42% of respondents had vegetables as their main source of income and 85% had it as their main or second source of income.

Table 2. Importance of different sources of income (Percentage of respondents)

Source of income	Main priority	2nd priority	Lower priority
Staples	43%	42%	9%
Vegetables	42%	43%	8%
Other crops	4%	4%	4%
Trading	6%	2%	5%
Other	5%	3%	9%
Total	100%	93%	35%

Source: Sherington and Suglo (1994).

Further research identified two main groups of farmers; the consumption and local market oriented farmers, and the urban market oriented farmers. Characteristics of these two groups are shown in Table 3.

Table 3. Types of Vegetable Producers in Brong Ahafo

	Urban market-oriented	**Consumption & local market**
Scale	sacks or crate	Baskets
	up to 3 acres, often about 1 acre	usually small and scattered plots
Farm type	more monocrop with some intercrops	more intercrops with other vegetables or staple crops
	in lines	irregular spacing
Inputs	use of chemicals & fertiliser, hired labour	little use of fertiliser & chemicals or hired labour except for clearing
Crops	often one main crop, generally few different crops or varieties	many different crops and varieties, including leafy vegetables
Seasons	often dry season, plus other season	usually major & minor seasons
Land tenure	often hired, especially in dry season	usually family land
Disposal of produce	farm gate sales to traders serving long distance urban centres	home consumption & headload to local market
Disposal of income	invested back into farming and other enterprises (women may use it for household requirements)	used for household requirements, school fees etc.
People	mainly young men; women farmers tend to be older	most women in village

Source: Warburton and Lyon, 1995.

The consumption and local market farmers are women who grow on a smaller scale for home consumption and sell locally any that they have left over. The commercial market does not have a major influence on their farming practices. They concentrate their production in the rainy season as they do no have the resources or physical strength to do the manual watering of irrigated production. They often intercrop the vegetables with staple crops or other vegetables and use very little fertiliser, fungicide or pesticide.

The urban market oriented farmers tend to be older women and younger men. There is greater use of agrochemicals and monocropping.

There is a wide range of farmers within the category of the urban market oriented with differences based on capital, farm size and access to other resources. There are also gender differences with women having smaller farms than men. This due to the other responsibilities women have such as domestic duties and their reliance on men's labour (family or hired) to clear the land.

Access to markets

The farmers' access to markets depends on the physical location of the farm and roads, links to traders and the availability of transport and the access to capital. The choice of crop is important so that the farmer can ensure good market access for the harvested product. For most farmers the choice can be limited as areas or villages become well known for certain crops being produced at certain times. Therefore, a large number of traders arrive at the usual harvest period, assured of finding produce to buy and do not have to spend time looking for buyers. Traders stated that there needs to be a large supply of produce, or critical mass, to entice them to visit a new area. Abesim is an example of a famous garden egg producing area in the dry season and farmers have found it hard to change to other crops because of this. This has serious implications for the sustainability of the farming system, which, under this trading system cannot rotate crops and prevent soil degradation and build up of pests and diseases.

Location of the farm

Traders prefer to go to those areas that are readily accessible or where sufficient farmers are producing in close proximity. This allows the trader to save time and costs. Therefore farmers often hire land near the road, even if they have access to good land that is further away.

When the farms are small and scattered, then it is the responsibility of farmers to get the produce to the pickup point or market. The head-loading of baskets and bowls of produce is done by women, either family or hired labour. Heavier boxes of tomatoes, weighing between 70 and 90 kg, are carried by male labourers, from the north of Ghana, who are paid per box carried.

Being far from the main producing areas makes it harder to get boxes as the traders may not know when the harvest is ready and the farmers may not know if a trader has arrived. In times of scarcity, traders may walk to the remoter farms, but in times of surplus, they will prefer to buy from farms near the roadside.

Links to traders and availability of transport.

Most of the produce being marketed in the study area is sold to rural or urban-based itinerant traders who will buy from the farmers at the farm gate. The farmers will play no role in the provision of transport. Vegetables harvested in the morning or afternoon one day will be in the market by the next morning and most will have been sold to consumers by that evening. An efficient transport system has developed around this need and allows the traders to travel over very long distances. The transport used ranges from trucks and 'mammy wagons' to smaller vans and even taxis or passenger cars when taking smaller quantities to local markets. Larger vehicles are usually shared between traders.

Access to urban markets

There are differences in the extent to which there are restrictions on who can sell in markets. In certain markets, those not registered in the association are not allowed to sell, in others those from outside have to sell through commission agents and in others, they have to accept lower prices for their product. These barriers to entry are justified on the

grounds that it reduces excessive fluctuations in price and the bankruptcy of traders from sudden falls in price. Restricted access to markets may have negative impacts on the farmers as they may not be able to bring in their own produce. Furthermore, there may be fewer buyers and therefore lower prices at certain times due to lack of competition.

Access to capital

To produce vegetables on a commercial scale and get access to the market, it is necessary to have access to a considerable amount of capital, particularly for labour, fertiliser and pesticide. Much of the work is very difficult so women and older men have a greater need for capital as they have to hire labour.

Capital can come from a variety of sources. Farmers may get credit from the banks but this is very limited. It is much more common for small amounts of credit, in the form of cash or inputs, to be given to the farmers by traders with whom they have built up a 'customer' relationship. This is repaid at harvest time. In certain circumstances, there is a share cropping agreement, especially if the farmer does not own appropriate land. However, it was found that most farmers are not willing to reinvest profits in farming if they had any other alternative.

Marketing Participants and Organisation

The urban marketing system for vegetables is handled by the private sector. The system is characterised by a very large number of small-scale traders who are almost all women. The size of their marketing enterprises is limited by capital and the difficulties encountered in trading vegetables. Traders who do well often move out of vegetable marketing when they have enough capital to invest in other trading businesses that do not require travelling.

Participants

Table 4 below shows the different participants in trading and marketing operations for tomatoes in Ghana.

Table 4. Participants in marketing

Type	Description
Urban market oriented farmers	Older women and young men who sell to itinerant traders. Greater use of agro-chemicals, irrigation and monocropping.
Consumption and local market oriented farmers	Women who grow on a smaller scale for home consumption and sell any left over. Intercropped, use very little inputs.
Urban-based itinerant traders	Buy direct from farmers and local assemblers. Sell in main urban markets.
Rural-based itinerant traders	Buy from local farmers and transfer to urban centres.
Rural local assemblers	Based in villages and rural towns. Buy from farmers, bulk up and sell to itinerant traders/local market retailers.
Rural retailers	Farmers who sell their own produce in a village, rural town or roadside market.
Transporters	Drivers and assistants of lorries and vans that travel to producing areas.

Porters	Unload tomato boxes, carry to selling point and to retailers stalls.
Commission agents and elders (Kumasi)	Sell on behalf of itinerant traders and farmers who are not members of the traders association in that town.
Retailers	Buy from itinerant traders, commission agents. Sell from a stall.
Hawkers	Work with retailers and carry produce around market or around houses.

Urban-based itinerant traders

The urban-based itinerant traders come from the main cities in Ghana and, at times, from Togo and Côte d'Ivoire. The traders take the produce back to their market although some traders register as members in several markets which allows them more selling outlets.

They only go to areas where they can be guaranteed to find adequate supply, buying in bulk or aggregating smaller quantities from farmers, or buying from local rural assemblers. They hire vehicles, often in groups, although those going to nearer towns usually buy smaller quantities and may rely on using passenger cars or taxis. They pay for the transport according to the number of boxes or bags. They will drive over night or arrive in the village the night before and then wait for the farmers to harvest.

Rural-based itinerant traders

These traders live in villages or towns where the vegetables are produced and buy from the farmers to take to the urban markets. There are often restrictions on selling in urban markets imposed by the traders' associations, with the strictest controls in Accra markets. In other markets, they may become part of the association after paying the necessary fees, although many will still have to sell through commission agents. They have the advantage over the urban-based traders in that they know the farmers well and so are often able to take farmers' produce to the market and pay them on the return, thereby removing the restrictions placed by not having the necessary capital.

There tend to be more rural-based traders in those villages that have been growing vegetables for a long time as they have been able to build up capital, they have acquired knowledge of the marketing systems and they are known in the main urban markets. Traders from villages such as Abesim and Tuobodum were often reported to be buying from the villages around them and then selling in the city. In many cases, they are vegetable growers or wives of vegetable growers.

Rural assemblers

These traders are local women who buy small quantities of produce from farmers and sell to itinerant traders or traders in nearby towns. Many of the farmers who supply these traders are the consumption and local market farmers who do not produce enough to fill a whole box of tomato or bag of garden eggs. They may also specialise in buying the small quantities of lower quality produce that the itinerant traders have rejected. This can be sold in nearby towns.

Rural retailers

Some women farmers who grow for home consumption and local markets may sell their own produce locally. This can be done in the weekly village market, or the daily market if the settlement is large enough. Some retailers will put the produce on a table outside their house or send a young girl to hawk it from house to house. The quality of the produce is very high and the retailers buy it from farmers at a higher price on the condition that they can harvest it themselves and be selective. The quantities sold each day appear to be small.

Transport operators

Transport is arranged by the traders. They may hire a vehicle, driver and driver's mate from the urban area and then drive together to the selling point. There are certain drivers who have experience in dealing with tomatoes and know the producing areas well. The Ghana Private Road-users Trade Union (GPRTU) has a Tomato Cargo Branch in Kumasi and in Accra. They play a role in organising the transport for the tomato traders.

Commission agents

In the main part of Kumasi Central Market, the number of people bringing in produce can be restricted by forcing those who come in to sell through elders of the association who act as commission agents. The commission is varied depending on the person bringing produce into the market. Unregistered traders bringing in large quantities are not wanted as they can affect the supply situation in the market.

The association tries to make the selling as quick as possible for its members. The elders who act as commission agents play a role in this as they sell for some of the itinerant traders. They are always present in the market and so allow the trader to visit the farm again or rest while the produce is being sold. The position of commissioning agent is inherited from mother or grandmother to daughter. Much of the trade to retailers is done on credit with the retailer paying back later that day or occasionally the next day. The commission agent has the important information of the credit worthiness of the retailers and the location of their stalls so that the money can be collected.

Urban retailers and hawkers

Retailers in the urban markets can be stallholders in the market, selling on the ground or hawking produce by carrying it around the market, or around other parts of the town. They will buy from the itinerant traders or the commission agents (found in Kumasi Central Market). Often the hawkers are daughters or relatives of the stall holders. Some of the traders supplying the retailers may also be retailing. Women will usually inherit the right to trade in the market and they will spend time learning how to bargain, the conventions of the market, judging quality and quantity, and getting customers.

Conduct and organisation of the marketing chain

Bargaining

The price-setting procedure between farmers and traders will depend on the quantity of vegetables available and the quantities that traders want to buy. In periods of scarcity, the farmers have a greater role in setting the price and the traders will have to buy as there may not be other places to go to. In periods of glut, the farmers cannot afford to bargain extensively.

Farmers may select two or three farmers, based on their knowledge of marketing and bargaining skills' to represent them. It is usually the bigger farmers who are selling that day as it is thought they have more at stake than the small-scale farmers.

When farmers are forced to go to the urban markets to get traders to come to the village, the bargaining is done in the urban centre and farmers have a very weak bargaining position.

Channels for the spread of information on prices and supply have an important impact on the bargaining position of traders and farmers. The lack of relay markets can lead to fragmented demand and supply information when traders cannot get accurate and timely information. This can increase their risks and therefore their costs.

The information reaching farmers can be limited and they may not know of price trends in the markets. Presently, there are weekly prices of commodities broadcast but these are not used by farmers or traders since they come too late and the market prices are changing every day.

Customer relationships

Farmers who have been growing a certain crop for several years will develop close trading relationships with some traders, preferring to sell to them than other traders. Both the farmers and traders refer to each other as 'customers' and this reflects the two way flow of benefits. Traders value their customers as an important resource in their marketing. Older traders were observed bringing their daughters with them on buying trips so that they could meet the farmers and be able to inherit certain customers.

In times of scarcity, farmers will guarantee to sell some of their produce to their customers, even if the price offered by other traders is higher. The farmer will ensure that the quality is good and can introduce the traders to other farmers who are known for good quality produce.

When there is a glut in the market, the trader will give preferential treatment to their customers in terms of giving boxes or sacks. The prices offered to farmers by customers can be lower as they often give credit or inputs to farmers at the beginning of the season.

The customer relationships are not completely binding and the farmer is not tied to accepting the traders' price irrespective of other offers. If a better price is offered then the farmer can accept it while reserving some of their produce for their regular customer.

In many cases, farmers will let the customer sell the produce and bring the money back after the sale. This is very common among the rural-based traders and the farmers in their village or town. This allows a trader to start trading without a large amount of capital. For this reason, traders value their customer relationships and are keen to keep up a good reputation with the farmers so that they can continue. The price may be set beforehand but the trader can give a lower price on her return if she received a lower price in the market. The farmer may be repaid within a few days or within a week. The rural-based itinerant traders may be in a similar relationship with the commission agents in the market.

Some of the farmer associations have developed close links with the trader associations so that they can get help from the elder traders in following up debts. Traders value the reputation of their association as trustworthy people so the members of an association will put pressure on a trader who has not repaid farmers as it may jeopardise their business.

Trustworthiness is a very important security measure for traders as it can help them build up their capital when they have made a loss. It appears that it is quite common for a trader to make large losses when the market prices drop while they are at the farm-gate buying at the previous prices.

Farmer associations and co-operation in price setting

Many villages in which vegetable production is a major source of income have informal farmer associations that have a primary role in setting prices. The price setting by co-operation can only work in the periods of scarcity when the farmers have more bargaining power. It is not possible to co-ordinate the marketing of prices when there is not a scarcity as some farmers will be forced to sell at any price or else loose all the ripe produce.

Villages such as Awisa and Nchira have associations with wider objectives such as the provision of chemical inputs and organising the use of tractors and motorised chemical sprayers. These associations have had limited impact so far. The farmer groups in the transitional zone tend to be more established and stronger.

The farmer groups ensure that there is a uniform price in the village. There is usually a rule that the farmers cannot take boxes before the price is set with the executives of the association. In Awisa, there is a 'chief' farmer who is always involved in this and he has other farmers to help him. All traders have to discuss the price with him before they go to the harvesting farmers. Once the price is set it is announced to the farmers. The association price is only set for the top quality produce and the over ripe and damaged produce can be sold at any price that the farmer negotiates with the trader. Difficulties can arise if a farmer is under some obligation to a trader as part of a 'customer' relationship linked to the provision of credit at the beginning of the season.

Trader Associations

In the main urban markets, there are trader associations for each commodity. The main functions of the associations are to further the interests of its members and to reduce the costs that may occur through lengthy bargaining and disputes between traders. The

association is led by an ohemma roughly translated as a queen mother or market queen. The queen mother's role is to settle disputes between members and negotiate with outsiders such as local authorities and other markets.

She is chosen on personal qualities such as age, emotional reliability, familiarity with market affairs, financial independence and stability as well as wealth, which is important for ceremonial display. She is selected from amongst the elders who advise and help her. The association and the queen mother's role draws on titles and procedures from both the traditional Akan structures and modern organisations.

The association will also represent the traders in dealings with outside organisations, especially the Municipal or District Assemblies who are responsible for the market and collect revenue from it.

Negotiating prices

The associations are where prices are negotiated between retailers and itinerant traders. In setting the price, the traders have to ensure that the produce is going to be sold that day or the next so they will wait to see the supply entering the market that day. They will also consider the farm-gate price, the marketing costs and the profit margins of the traders bringing the produce in. By setting a price at the beginning of the day, the selling of the produce is easier as there is less bargaining. However, the prices change during the day and there is bargaining over produce of lower quality between individual retailers and itinerant traders.

In the part of the Kumasi market which depends on tomato farmers coming to sell through the commission agents there is no fixed price and there is bargaining every time with the commission agent mediating. The quality in this market is much better as the farmers do more grading themselves.

Retailers and itinerant traders or commission agents have customer relationships similar to those between traders and farmers. In most cases, the retailer will get the produce on credit and pay when they have sold it at the end of the day.

Retail prices are usually fixed for the day for a given quantity but retailers try to attract customers by changing the quality of the produce, the size of the piles and gifts given after the sale has taken place. The size and the quality of the gifts depends on the relationship between the retailers and buyer and the importance in retaining the customer. It is often as much as 50% extra although it may be of lower quality and is taken from a container under the stall so that other potential customers will not see how much is given, and so will not demand a larger quantity when they buy. This creates serious problems for the collection of retail prices.

Access

Associations try to reduce over supply by limiting access to the market. This can stop the prices in the market dropping rapidly and reduce losses in terms of lower value produce being thrown away since there are limited storage facilities in the market. It also allows the produce to be sold quickly to ensure cash flow and avoids congestion from unsold boxes or bags of produce. The justification for having control over the supply is to

protect the traders and reduce the risk of loosing all their capital.

Controlling the supply into the market is done by limiting membership and offering lower prices to those traders or farmers who bring in their own produce. It is also done by restricting the quantity and days that members of the association can bring produce in. The extent of the control over the volume of trade and the fixing of prices in a monopolistic way, differs dramatically between markets.

Market channels

The structure of the marketing channels appears similar to the two level system in that traders link between their rural buying point and their urban market, ensuring that a large proportion of the produce does not pass through any assembly market. This can reduce the time taken to reach the consumers and the risk of having losses. The trader would only have direct knowledge of the supply conditions in any one area and demand conditions in any one town. This is in contrast with the redistributive system where the produce is collected and bulked by assemblers in rural markets before being sold to urban wholesalers at relay markets. At the nodes of this system - the relay markets - buyers and sellers from several supply and consuming centres meet.

The two level system allows perishable products such as vegetables to be taken directly to markets without delays associated with passing through a hierarchy of markets. Thus marketing costs of intermediaries, handling, inspecting, repackaging and physical losses are reduced. However, there is a risk that the demand and supply information may be fragmented, leading to poor spatial price adjustments and therefore an economically inefficient marketing system.

Impact of the market on the post-harvest handling system and product quality

The post-harvest handling and marketing chain were examined though analysis of the hazard and critical points in the pathway. Table 5 provides a summary of the operations undertaken during the post-harvest chain and the problems encountered.

The decision to harvest depends on stage of maturity of the crop and the availability of traders. Farmers may have to wait a few days for the crop to ripen and miss good marketing opportunities. The tomatoes are picked when red ripe although a small number of less ripe ones may be acceptable and are put at the bottom of the crates. Ripe fruit is needed as the produce will reach the market the next morning and will be sold that day ensuring that capital is not tied up for too long, although there is a risk of more spoilage if there is a glut on the market. Low quality produce is often left on the field after being picked, saved for seed extraction, sold locally or used in the household, but it is not considered part of the harvest.

Table 5. Analysis of the critical points in the tomato marketing chain (Risk level: 1 = low; 5 = high)

Time	Fruit Temp.	Delay	Description of operation	Nature of risk	Risk level
08.50	20.1		Fruit picked into small containers	Wait for trader Poor selection	1
9.45		X	Fruit taken to field edge		
9.45			Fruit tipped into trader's box	Rough handling	2
9.50	25.8		Fruit selection - small and firm at bottom, large and ripe at top	Exposure to sun during packing	3
11.00	32.8	X	Packed boxes wait on edge of field	Exposure to sun	4
13.00	36.3	X	Box-headed to roadside - fruit settles in box	Damage to fruit - large or broken slats	3
15.30		X	Trader arrives and inspects fruit		
15.40			Box loaded onto vehicle	Some fruit damaged in stacking	3
19.30		X	Vehicle picks up other boxes and transports overnight to market	Vibration and compression damage	4
Time	Fruit Temp.	Delay	Description of operation	Nature of risk	Risk level
06.00	27.5	X	Boxes unloaded from trader's vehicle and portered to selling place	Wait for purchase by retailer - no shade	3
07.00			Box portered to retailer		
07.15		X	Box waits by stall	No shade	2
08.00			Fruit sorted by retailer into quality types		
08.30	29.7		Sorted fruit put into heaps for display	No shade	4

Harvesting begins in the morning however delays in the arrival of the trader can lead to excessive fruit temperatures since fruit are often left in the sun. By the time fruit are inspected by the trader, their surface temperature can reach between 35 and 40° C. This can hasten the ripening process and loss of firmness. Fruit samples selected at the time of harvest are more firm than those fruits from the same harvest taken from the traders box at the market the next day (figure 1).

Apart from low quality, post-harvest losses can occur when fruit are too small or the quantity available would not fill a box. The amount of post-harvest losses could rise to up to 20 % of the harvest (Table 6).

Table 6. Losses from one tomato farm 3 June - 4 August 1996.

Date	No. of boxes sold to itinerant traders	No. of boxes not sold to itinerant traders	Percentage not sold to itinerant traders
3/6	3	0.5	14%
6/6	7	1	13%
10/6	10	1.5	13%
12/6	9	1.5	13%
16/6	6	1	14%
20/6	2.5	0.25	11%
27/6	3	0.5	14%
4/7	2.5	0.03	1%
8/7	3	0.25	8%
12/7	6	1	14%
18/7	9	1.5	13%
22/7	1.5	0.25	14%
28/7	1	0.25	20%
4/8	0.5	0.125	20%
Total	**64**	**9.655**	**13%**

Tomatoes are collected into crates that are owned by the traders. There are two sizes, the bigger Accra box (70-80 kg) and the smaller Kumasi box (55-60 kg). The larger boxes are the most common despite the difficulty in carrying them the short distances from the farms to pick up points. Traders benefit from having larger boxes as they can fit a larger quantity of tomatoes into a vehicle and there is a reduction in the amount paid on levies per box. These include taxes to district assemblies in the producing area, transport costs, market fees for municipal authorities or district assemblies, fees/commission to market associations or market queens and portering charges. There is potential for post-harvest reduction in quality from the use of big crates as the sides are abrasive and the weight of the produce may crush tomatoes at the bottom.

The above problem is compounded in the marketing chain by the amount of rough handling both before the fruit is loaded onto the transport and during the journey to the market. This can cause a loss in quality of the fruit although this does not necessarily lead to discarding of the fruit since fruit are graded by retailers and even low quality fruit is marketed (table 6).

Table 6. Prices and quality of graded tomatoes in Kumasi Central market

Price	**Quality**
C6000	The very best quality - big, red no damage
C4000	Big, red, very few defects. The usual top quality
C3500	big but cracked
C3500	Hard but small/medium sized
C3000	Soft and medium/small sized
C2000	Rotting and soft
C2000	Less ripe, smaller and pest damaged
C1200	Very unripe

The market demand for fruit of low quality highlights the caution needed in developing improvements to handling systems without studying the impact on different consumers.

WOMEN IN VEGETABLE PRODUCTION AND POST-HARVEST LOSSES

Elizabeth Poyari

GTZ/31st DWM

Introduction

Mr. Chairman, ladies and gentlemen and invited guests, I am happy to be called upon on this occasion to present to you the activities of women in vegetable production and post-harvest losses in the Brong Ahafo region. Brong Ahafo region has a higher than expected number of vegetable producers, predominantly within the areas of Bechem, Drobo, Goaso, Sunyani, Wenchi etc.

The main vegetables grown in the region are garden eggs, okro, pepper and tomatoes.

Production

Vegetables are highly produced in this region and at the time of its peak in the season during the year, marketing becomes a problem. The market women and middle men determine the prices of the various vegetables for the farmers. If the farmer refuses to give in to their prices, they simply refuse to buy them, thereby compelling the farmers to sell at traders stipulated prices. Most of the time, due to low prices given by the market women and middle men, the farmers' products are either left in the farm to rot or left at the market places to be eaten by animals. Mr. Chairman, it is our prayer that the woes of these peasant farmers should be considered in this region.

In Atebubu, the main vegetables grown there are garden eggs, pepper, okro and tomatoes. As the area is in a guinea savannah zone, most of the farming activities are done once in a year unlike the forest areas and some transitional areas where they cultivate in major and minor seasons. Furthermore, vegetables like pepper and garden eggs can be produced for more than one season in the transitional forest zone but not in the savannah zone due to drought.

The land preparation usually starts from February when nursing beds are prepared and the seeds nursed. The nursed seeds are taken care of from the first week to the sixth week before transplanting takes place. However, okro, unlike the other vegetables is directly planted without nursing before transplanting.

Varieties of pepper grown in the Atebubu district are as follows: Misua, lady finger, scented pepper and other types.

Pepper was usually said to be the work of women in every area we visited. In this regard, about 85% of farmers producing pepper are women in the various districts mentioned earlier. About 75% of the pepper is done between April and May. Weeding among the crop is done at about three or more times before harvesting. Harvesting starts from the last week of July through to October, which is the peak of the month of harvesting and drying, until December before the dry season sets in. At Drobo, mixed cropping is practised and it gives the farmers better yield. It has been observed by the farmers that the pepper transplanted on yam mounds produce better than those transplanted on the flat fields. The farmers have also come up with a claim that chemical fertilizers can be applied on garden eggs, okro and tomatoes but not on pepper since it brings about fruit

abortion and does not also allow it to last long on the field. The farmers also choose to farm more of the pepper because the disease and pest problem on pepper is insignificant, hence there is no course for alarm that warrant farmers to use agrochemicals as a control as done to garden eggs, tomato and okro. They dry the pepper under the open sun. They then store them in jute sacks. They then wait for the prices to go high before they dispose of them. Lack of knowledge in the modern techniques of drying and knowledge in preservation and storage causes most of the farm produce to go mouldy before they are disposed of. Open sun drying and preservation of okro and pepper, which is mostly the usual method used by the farmers, is not always successful due to the unpredictable conditions of the weather. Due to the issue of the weather conditions, new technologies have been introduced. Solar drying system has been introduced to the farmers and some of them have acquired some of the solar dryers to aid them in drying their vegetables without interruption by unfavourable weather conditions like rain. This new technology of drying will help farmers produce better quality of vegetables both for good prices and long lasting preservation.

Solar drying

Mr Chairman, there is a clear need for the provision of suitable good quality extension technology to disseminate appropriate processing and drying technologies hence the collaboration between the Integrated Food Crops System Project (IFCSP), Sedentary Farming System Project (SFSP) and the 31st DWM. The overall project purpose is to add value to vegetables through processing and marketing and enhance the livelihood of vegetable farmers. In particular, the livelihood of women and children are expected to improve since most of the vegetable farmers are women.

In pursuance of this broad objective, the on-farm trials which evaluates the use of solar drying of chilli pepper in the Brong Ahafo region under real farming conditions was undertaken.

Objectives: The main purpose is to increase the value of fresh and processed vegetables for farmers.

Why processing: In general, processing takes place in order to:

1. Reduce the moisture contents and lengthen the shelf life and the storage period of the produce.
2. Prevent losses due to deterioration of fresh produce by providing an environment, which is unfavourable to the growth of spoilage organisms.
3. Add value to the crop in relation to seasonal prices.

Addition of value to the vegetables by good drying methods

(A) Speeding up the rate of drying.

(B) Improving the quality of the product by reducing rotten and discoloration during drying

(C) Saving of labour by leaving the products unattended during drying

(D) Provision of an environment in which the product is less likely to be contaminated by dust, insects, birds and rodent droppings.

(E) Drying other products like sliced okro, tomatoes and garden eggs.

Marketing

Mr Chairman, you realise that marketing, post-harvest and processing activities of

vegetables appear to be the main problem of the vegetable farmers. They produce so much and are unable to market them.

Mr Chairman, since this is the plight of these farmers, we the collaborative agents would like to suggest through you to the government to help these farmers to dispose of their vegetables through local marketing agents and through exportation by approved exporting agents of vegetables. This kind gesture will not only motivate the farmers to produce more vegetables, but they will be made to produce vegetables of better quality.

Thank you.

WORKSHOP RECOMMENDATIONS

After a critical review of the Project objectives and the work done up to-date, the workshop identified the following areas as needing further research and extension interventions in the next phase of the project

Processing

Constraints	Activities needed	Justification
Drying		
1. Poor utilization of dryers	1.1 Optimising vegetable drying procedures.	Not much has been done by research in the area of vegetable processing in the country.
2. Insufficient records on quality of dried products	2.1 Nutritional quality and sensory analysis of dry vegetable products	The little that has been done in the area of research has not been adequately transferred to the public.
Paste Production		
1. Inadequate knowledge on the part of farmers and consumers.	1.1 Training and field days for field extension staff and farmers. 1.2 Further work on packaging and shelf-life extension. 1.3 Garden egg paste and pepper and tomato combined in the form of paste to be prepared and evaluated for consumer acceptance.	There is therefore the need to do further research on processing and also intensify technology transfer activities in the identified areas.
2. No simple tools for processing.	2.1. Design simple tools for processing.	
Marketing		
1. Difficulty in selling during bumper harvest.	1.1 Develop products for export, e.g. solar dried pepper. 1.2 Studies on types of packaging and storage of dried products.	
2. Insufficient information on possible sales outlets	2.1 Provide opportunities for dissemination of market information	

Seed and varietal work

Constraints	Activities needed	Justification
1. Limited range of good varieties	1.1 Varietal development, improvement and maintenance breeding.	1.1 To increase the range of varieties to meet various markets and ecological conditions.
2. Lack of good quality seed	2.1. Breeder seed production by research institutes. 2.2 Foundation seed production by Grains Board or private growers. 3. Private involvement in certified seed production with supervision from research, MOFA and GSID.	2.1. Reduce seed borne diseases. 2.2 To ensure seed security. 2.3 To ensure higher yield and good quality product
3. Lack of vegetable seed production guide	3.1 Publicise vegetable seed production guides.	3.1 To ensure production of good quality seeds.
4. Awareness creation	4.1 Educate farmers on essence of good quality and economic seed rates. 4.2 Training in seed marketing for farmers and seed dealers	4.1 To achieve efficient and economic use of seeds.

Post-harvest and marketing

Constraints	Activities needed	Justification
1. Short shelf-life 2. Seasonal fluctuations in supply and prices. 3. Complex marketing systems. 4. Poor packaging and grading. 5. Inadequate training. 6. Lack of credit. 7. Poor transportation and road network 8. Lack of strong farmer associations. 9. Poor farmer and trader perception of quality 10. No diversified markets.	1. Identify opportunities for different marketing systems for fresh and processed vegetables 2. Develop and transfer appropriate processing methods to increase market opportunities. 3. Identify target groups for processing. 4. Varietal selection and development of agronomic practices to address post-harvest quality (marketability and prolonged shelf life) 5. Review production practices that affect chemical residues/contamination in the vegetable production system in relation to regulations. (i.e., determine opportunities for environmentally friendly control systems. 6. Technology transfer	Post-harvest and marketing strategies of vegetables have not adequately been addressed by research and extension outfits in the country. The opportunities therefore still exist for further work in the two areas.

Agronomy, soils and water

Constraints	Activities needed	Justification
1. Irrigation a. quality b. quantity c. system	1. Determine cause, filtration rates and erosion rates. 2. Monitor water table 3. Protect river banks 4. Investigate use of mulch	1. To improve health of farmers. 2. To improve production and quality of vegetables
2. Availability of animal manure. a. transport b. concentration	1. Determine availability and quantity to apply. 2. Determine cost of purchase and transport. 3. Investigate use of sawdust. 4. Identify systems to concentrate ruminant manure.	1. To improve quality of vegetable products.
3. Lack of adoption of known technologies. a. traditional practices (ridges)	1. Conduct surveys to establish criteria of adopters and non-adopters.	1. For successful dissemination of proven technologies.
4. Cultivation	1. Investigate different systems particularly in upland areas.	1. To ensure sustainable land use.
5. Weeds a. spear grass b. Cyperus 6. Soil pests and diseases	1. Determine labour reduction options like mulching, green manuring and use of appropriate herbicides.	
7. Lack of alternative strategy to fallow to maintain soil productivity.	1. Investigate possible rotations.	1. To ensure intensification of vegetable production and also to ensure sustainability.
8. Incentive to maintain hired land.	1. Land owners to be educated on proper land use	
9. Availability of soil nutrients.	1. Training on soil fertility maintenance	1. For efficient cultivation and maintenance of soil fertility

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