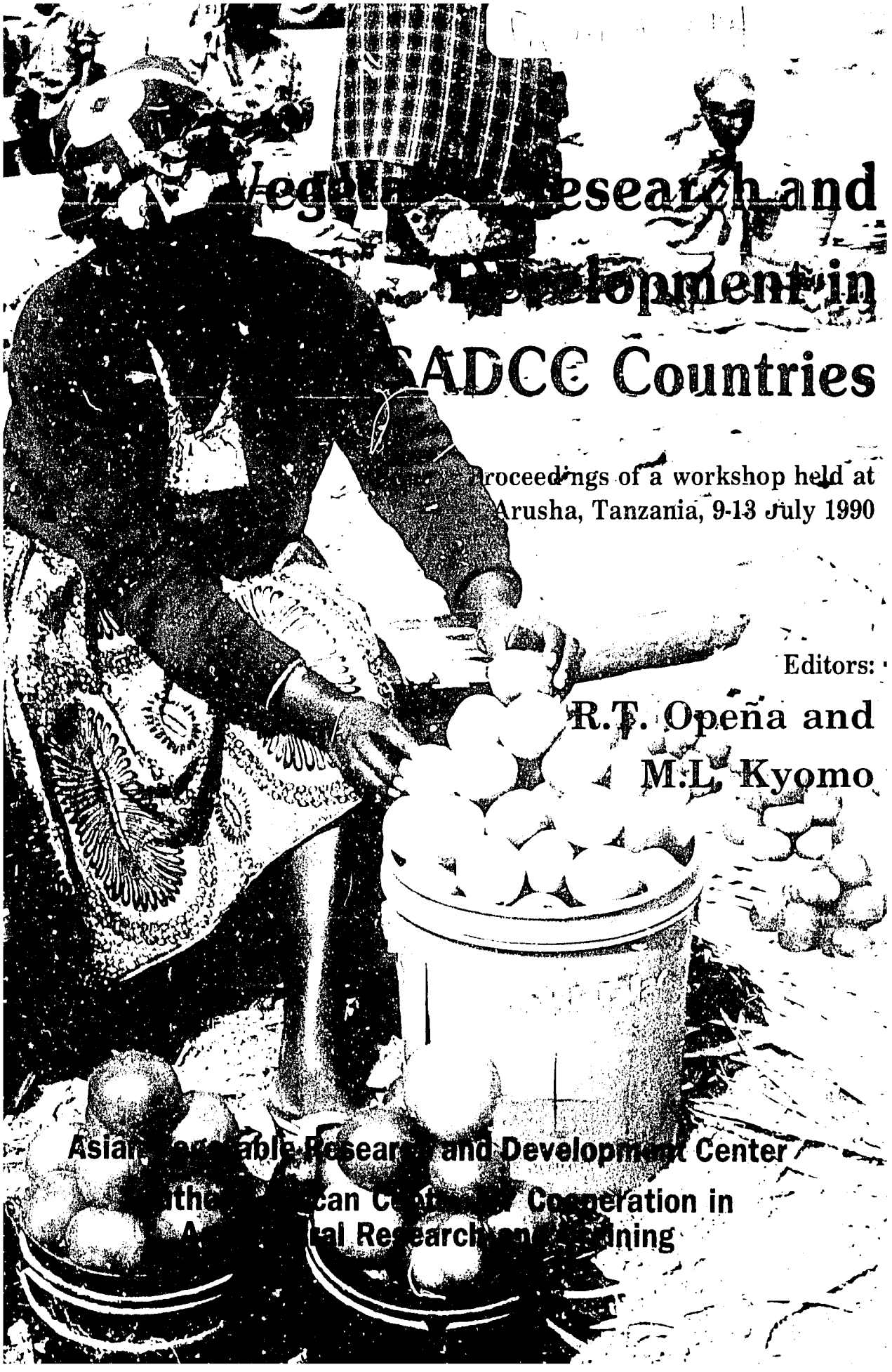

Legume Research and Development in SADCC Countries

Proceedings of a workshop held at Arusha, Tanzania, 9-13 July 1990

Editors:
R.T. Opeña and
M.L. Kyomo

Asian Vegetable Research and Development Center
Southern African Centre for Cooperation in Agricultural Research and Training

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VEGETABLE RESEARCH AND DEVELOPMENT IN SADCC COUNTRIES

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Foreword

AVRDC is proud to have played a role in the original SADCC/SACCAR mission that developed the proposal for the creation of a 'Collaborative Network for Vegetable Research and Development in the SADCC Region'. As a result of the workshop held at Arusha, 'CONVERDS' is now a reality, and we commend the proposal to the international donor community for its support. The detailed proposal is available as a separate document from AVRDC.

This publication contains important information on the status of vegetables in Africa, and in particular the status of research and development efforts in the SADCC countries. Combined with the other invited papers, we believe this publication will serve as a useful benchmark document for some time to come.

I would like to thank Dr. Martin Kyomo, the Director of SACCAR, and all of the local staff who worked tirelessly to ensure a successful workshop.

Emil Q. Javier
Director General
Asian Vegetable Research and Development Center

Acknowledgments

Many people contributed to the success of this international initiative. AVRDC and SACCAR are particularly grateful to the Canadian International Development Agency, the German Agency for Technical Cooperation (GTZ) and the Government of France for providing funds to organize and run the Arusha workshop.

The CGIAR Secretariat has provided ongoing support and encouragement for which we are grateful. A special thanks to the Hon. Augustine Mwingira, Regional Commissioner for Arusha and Member of Parliament, for officially opening the workshop.

We wish to thank all of the participants, the paper presenters and the following people who acted as chairperson or rapporteur: Dr. F.M. Shao, Mr. M. Madisa, Dr. G.B. Chibiliti, Mrs. V.F. Malima, Mr. V. Shongwe, Dr. B.N. Okigbo, Dr. N.A. Mnzava and Dr. G. Faku.

Special thanks go to Mr. R.E. Swai for handling the local arrangements, and to the secretariat staff: Mrs. B. Mgonja, Miss F. Swai, Miss H. Molefi, Mr. E. Kitomary, and Mr. R. Mziray.

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Welcome Address

Martin L. Kyomo
Director, SACCAR

On behalf of the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR) of the Southern African Development Coordination Conference (SADCC), and on behalf of all the workshop participants, I wish to say how greatly honored we are to have the Honorable Regional Commissioner as our guest of honor at the opening of the workshop. We are also grateful to the Tanzanian government for allowing us to hold this workshop in Arusha. Your officials in the Ministry of Agriculture, especially the Division of Research and Training, have worked very hard in preparing for this workshop and we are grateful to all of them for their efforts.

The primary goal of the sector of Food, Agriculture and Natural Resources of SADCC is to achieve food security at household, national and regional levels. Food security is defined as ensuring that all members of a household, nation or region have access to an adequate diet to lead an active and normal life. Its essential elements are food availability through expanded (intensified) production, generation of employment through the creation of agribusinesses, increased cash incomes of farmers through production of food and cash crops, and increased foreign earnings of each member state by growing exportable crops and animal products.

Vegetable production as part of horticulture can, if fully developed, assist SADCC to achieve food security. Their production, packaging, processing and storage are labor-intensive and therefore can provide employment to a large segment of the labor force. It is amenable to the good care of the resource bases of soil and water and therefore can contribute to sustainable production and care of the environment. Vegetable production or horticulture is like a dairy cow that continuously brings in income to the farmer once in production.

In 1987 SADCC accepted the recommendation that SACCAR start two vegetable research centers: one for tropical vegetables and another for temperate vegetables. Funding for these projects is still being sought. In the meantime, the Consultative Group on International Agricultural Research (CGIAR) has been looking for ways and means of promoting vegetable research and development in the developing countries. In 1989 SACCAR, the CGIAR, the Asian Vegetable Research and Development Center and ISNAR worked together to develop a proposal on how a network on vegetable research and development could be initiated in the SADCC region. We are looking forward to SADCC's cooperating partners such as Canada, Germany, France, the World Bank, Japan, USA and others to support our initiative in this field. SACCAR is grateful to the Director General of AVRDC, Dr. Emil Q. Javier, for wanting to share with SADCC's national research systems his Center's long experience in vegetable research and development. Participants have been invited from Botswana, Lesotho, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe. We have resource persons and participants from AVRDC, the UN University, USAID, Zambia Seed Company, Australia, Canada, the International Board for Plant Genetic Resources (IBPGR), and from the SADCC/CIAT Bean Improvement Project.

In 1987, the SADCC agricultural experts who were asked to review the policies and strategies of the sector of Food, Agriculture and Natural Resources observed as follows: 'At present there is neither an adequately resourced horticultural research station nor a graduate programme in horticulture in SADCC region. Moreover, member states find it difficult to obtain plant material or information from other regions of the world. There is need to study how SADCC can catch up with the level of horticultural research and training reached by other parts of the world.'

We have attempted to bring to this meeting as many horticulturists from SADCC and outside as possible. We expect that they will chart out the direction that SADCC should be following in research and development, including human resource development for the vegetable industry. We are looking forward to receiving your guidance on issues that need to be addressed at this workshop.

Welcome Address

Emil Q. Javier
Director General, AVRDC

Allow me to join Dr. Martin Kyomo in his cordial words of welcome to all of you. The Asian Vegetable Research and Development Center which I represent is most pleased to be a cosponsor of this meeting, and we look forward to the opportunity of joining hands with you in the exciting task of conceptualizing, harmonizing, and implementing a program of vegetable research and development in the countries of the SADCC region.

Perhaps the first question in the minds of some of you is what is an Asian institution like AVRDC doing in Southern Africa in the first place. For your information AVRDC was born 19 years ago amid circumstances similar to those prevailing here today. Several countries in Asia saw the need for a regional initiative to improve vegetable production, distribution and consumption through research and personnel training. They resolved to create a research institute along the model of the International Rice Research Institute (IRRI) which was successfully established 10 years earlier in the Philippines. As a location for the new entity, the Asian countries turned to Taiwan, with its ideal environment and long tradition of olericulture, to provide land and serve as host country. They asked Robert Chandler, the founder of IRRI, to organize AVRDC on their behalf.

Although primarily an Asian institution, and in fact drawing much of its support from the countries of Asia, AVRDC from the very beginning shared its improved germplasm, its improved production technologies and information with countries from other parts of the globe. Thus, for example, AVRDC-improved varieties have been released directly or used as breeding parents in many parts of Africa, Latin America and the Near East. We count among the hundreds of participants in our training programs a good number of vegetable specialists from these regions.

Presently our Center is going through a strategic planning exercise for the coming third decade of its existence. After almost 20 years of service in Asia, our Board has decided it is now time to respond to the needs of developing countries in other parts of the world. And thus with the encouragement of the World Bank, several donor countries, and upon the request of countries outside Asia, the AVRDC board has resolved to broaden the Center's geographic scope and assume a more global responsibility for research and training on vegetable crops.

Our presence here at Arusha is the first concrete manifestation of this new expanded global role that AVRDC has imposed on itself in the coming years. In time you shall know us by the initials IVRDC!

Importance of Vegetables

In any case, and with institutional issues aside, the fact is vegetable crops are neglected commodities everywhere in the developing world, including Asia, but more

particularly so in Africa. Most of the research and development efforts hitherto have been directed to cereals, roots and tubers, and some pulses. While these commodities certainly need attention, significant opportunities are being missed in failing to exploit the potential of vegetables.

The role of vegetables in providing essential vitamins and minerals in the diet is often conceded though not applied in practice. Vitamin A deficiency is prevalent in many parts of the SADCC region, a problem which can be readily and inexpensively alleviated through the production and consumption of green leafy vegetables. Less understood and certainly unrecognized is the potential of many vegetables to produce more calories and protein per square meter of land per day than cereals and roots and tubers. Thus in addition to being sources of vitamins and minerals, vegetables can be efficient and cost-effective supplementary providers of calories and proteins.

In Asia where gains in cereal productivity have been impressive, many governments have come to recognize that vegetables generate more farm employment and greater family incomes than cereals and other staples. For example a farmer in Indonesia can easily obtain 5-8 times more income from the same piece of land if he plants tomato or pepper than if he grows rice or maize.

In addition many vegetables have processing potential thus further increasing employment and value-added. Moreover some vegetables can generate foreign exchange as some East and Southern African countries are now doing with exports to Europe.

Purposes of the Workshop

Coming back to the purposes of this workshop, it should be obvious to all that given the constraints in resources in each of the countries, mutual advantage and benefit can be gained in acting in concert, in sharing and in collaboration with each other in trying to advance the production, consumption and distribution of vegetables in the region. After all this is the moving spirit and philosophy behind SADCC and SACCAR.

As additional background to this workshop, we may recall that SACCAR, upon instructions of the SADCC Council of Ministers, has resolved to organize a regional effort on horticultural crops, in particular on vegetables. Coincidentally the Consultative Group on International Agricultural Research (CGIAR) in Washington has seen fit to support regional networks for vegetable research in Africa and other parts of the world, outside Asia. At the same time AVRDC expressed its interest and willingness to collaborate with SACCAR on vegetable research and training.

Thus in mid 1989 the CGIAR Secretariat commissioned a project identification mission involving SACCAR, AVRDC and ISNAR to assess the needs, interest and potential for improved vegetable production in the SADCC region. The mission submitted its recommendations for a regional network and a small group of donors including Germany, France and Canada provided support for a start-up phase pending a formal proposal from interested national research systems in the region for donor support.

The purposes of the workshop are:

(1) To update the state-of-the-art in vegetable research and development in the region;

(2) To gain a comprehensive understanding of priorities in vegetable research and development of the member states of SADCC and of the region as a whole;

(3) To bring together vegetable researchers, extension specialists, educators and policymakers and secure a broad regional consensus on the priorities and mechanisms for collaborative vegetable research and development which will mutually benefit all member states of SADCC; and

(4) To develop a proposal for a regional collaborative effort on vegetable research and development which will merit the support of the national governments and the donor community.

The following questions need to be addressed:

(1) In the first place, do the SADCC countries want to organize and implement a regional initiative on vegetable research and development?

(2) If yes, what should be the major objectives and activities of the *regional initiative*?
   (a) *Research* on which commodities? Which disciplines? Which environments and production systems? Which problems?
   (b) *Training*, at which levels? For whom? For what?
   (c) *Information* for whom? For what?

(3) The regional initiative could take the form of a number of possible institutional arrangements. How should the regional initiative be organized, managed and governed? Which countries, which agencies, individuals? Who will be responsible for policy? For implementation? For monitoring and coordination?

(4) How will the regional initiative be supported? Bilateral and multilateral donors? Contributions in cash or in kind by the participating countries? Role and support by regional and international collaborating institutions?

The formal proposal outlined the kinds of answers and options which the team in their collective professional judgment considered as most relevant, appropriate and timely. I am sure the workshop participants will exercise good judgment in deciding on the issues being addressed. The needs are immense, but resources including people, facilities and funds are limited. Among the many attractive alternatives you must select those that are essential, attainable and sustainable.

Will the activity have the greatest impact on the greatest number of needy people in the highest number of countries (The Equity Principle)? What are the chances of a successful outcome (The Probability Principle)? Will the activity/ar-

rangement, lead to strong, sustainable institutions in the long term (The Sustainability Principle)?

Before I close I wish to thank those who prepared the country reports for the workshop. These reports will be useful sources of base information and serve as standards by which we can measure future progress.

I wish to acknowledge also at this point the resource persons whom the organizers have invited to speak on a number of critical issues which we feel are relevant to the deliberations we will have this week.

Finally I would like to thank our Tanzanian colleagues from the Ministry of Agriculture for their hospitality, and our guest speaker, the Honourable Commissioner Mwingira, for finding time in his busy schedule to welcome us and share his ideas with us on what we might profitably do together.

I wish you all a pleasant stay in Arusha and a professionally interesting and fruitful workshop.

Opening Remarks

Honourable A.C. Mwingira, (MP) Regional Commissioner, Arusha

On behalf of the Government of Tanzania and on my own behalf, I am pleased to welcome all of you to our country and to Arusha in particular. The weather may be rather chilly for some of you but I would like to assure you all that our hearts are warm with your presence. I am almost certain that only a few of you are here for the first time, because Arusha, and the Arusha International Conference Centre in particular, have become a traditional conference venue for many international meetings. I hope, therefore, that the facilities at your disposal will be adequate and up to your expectations. It is thus a great privilege for us to play host to this workshop on vegetable research and development in the SADCC region.

In Tanzania, as in many developing countries, agriculture plays an important role in the national economy, as it is the number one foreign exchange earner and provides the foundation and the base for industrial development. Our agricultural production must expand fast enough to meet our needs, and also as a means of improving the lives of men, women and children in our country.

SADCC wishes each member state to go for increased food security for their citizens, meaning ability to purchase food, raise incomes, contribute to foreign exchange earnings and create employment and increase nutrition of all citizens. Horticulture has potential to contribute to all of the above including care, improvement and sustainability of the natural resource base. It is on this basis, therefore, that we have to transform our traditional agricultural methods and techniques to meet the challenges of our increasing population.

We have to advance in full recognition that we have neither adequate capital nor expertise to do so on our own, and there is much that we in Africa can learn from other parts of the world and from experiences and techniques that have succeeded in different societies. However, we have to stop and think before assuming that a method of increasing output which has succeeded elsewhere will be directly applicable to our situation. The production problems in tropical Africa are different in many ways and greater than those which prevail elsewhere, especially in temperate climates.

The recent crises in many parts of Africa lie in part on national policies that have given little attention to the needs of smallholder agriculture and to the threats posed by rapidly rising populations. In actual fact, aid from donor nations has not only been inadequate in scale but too often it has reflected priorities of nations giving the aid rather than the needs identified by the recipient governments.

Each year, therefore, there are more people who do not get enough food, although our countries have vast potential to grow enough food for all. Still food is not always available where it is needed because the farmers are not sufficiently supported.

The policy in the food, agriculture and natural resources sector of SADCC is to ensure adequate availability of nutritious food to all people in the member countries,

by increasing production of both food and cash crops, thus increasing the cash income of farmers and generating employment.

Horticulture, which deals with production of fruits, vegetables, flowers, etc., has not been given serious consideration in the agricultural programs of our countries as compared to the attention directed to increased production of staple crops, especially cereal grains. The various vegetables, many of which fall under the so-called 'non-traditional crops', will help to diversify both agriculture and diets in our countries. They serve as important sources of vitamins and minerals to the local populations particularly in the growing urban areas. Many of them can form export crops to Europe, America as well as within Africa.

There are many constraints which need to be overcome before we can meet the vast demands for horticultural products in our countries. The diversity of the existing vegetable species is very great and often requires specialized handling and storage facilities. The removal of the various barriers to horticultural development, particularly transportation, storage, marketing and processing which are currently affecting further expansion, needs to be given serious attention.

Although many factors may contribute to a rise in horticultural production, research remains one of the most important areas. Training will also need to be stepped up in order to be able to cope with the high demand for trained personnel for the region.

Ultimately, however, the major goal of our efforts should be directed to the farmer who is the sole beneficiary of the above efforts. It is only recently that the governments of the SADCC member states have begun to recognize the strategic importance of horticulture, especially vegetables and fruits, as an excellent tool in enhancing the nutritional well-being and income of the people. A decision was therefore reached to accord priority to horticultural research and hence the hosting of this workshop. This is indeed a commendable decision because the potential for vegetable cultivation is enormous as evidenced by the many types of vegetable crops which can and do grow in our countries.

The main reasons why SADCC is one of the regions with very low vegetable production and consumption include: lack of research input; nonavailability of seed; lack of organized production, marketing, transport, storage, packaging and market information; lack of horticultural promotion associations; lack of investment in irrigation, both large and small scale; and lack of trained people to carry out all the above.

It is gratifying to note that in 1987 a SACCAR-sponsored workshop recommended the launching of research on tropical and temperate vegetables in SADCC, and this was approved at the ministerial level. It is further commendable that SACCAR has since then worked tirelessly looking for collaborators and donor support. I am also informed that the Consultative Group on International Agricultural Research (CGIAR) has been looking for ways to promote increased research efforts in this neglected field.

The governments of the SADCC member states should take up this challenge and actively promote vegetable production and associated services such as personnel development, research, extension, marketing, infrastructure and market promotion.

In Tanzania, at the moment, as you will see during the field trip to our Horticulture Research and Training Institute at Tengeru some effort has been mounted to undertake research in various areas including vegetable seed production of some of the most important vegetable species like tomato, onions and even some of the indigenous vegetables. This is an important area because although many farmers do grow western types of vegetables like cabbage, carrots, etc. for sale in towns, they often eat local vegetables such as Amaranthus leaves, melon seeds, cassava leaves, cowpea leaves, etc., which require a more concentrated research effort to develop their potential.

A considerable amount of research remains to be done in all the SADCC countries in the control of pests and diseases that attack many vegetables during the growing period. Interested donors and international institutions are welcome to support the activities of a network. Since serious studies have preceded this workshop, the recommendations and findings of these previous missions should enable the network to get established as soon as possible. We hope, therefore, to see in the near future a regional Vegetable Research Institute serving the needs of the SADCC member states. We wish to urge SACCAR to spearhead the initiatives shown thus far by our policymakers and research leaders in the various countries, in spite of the recognized shortage of trained personnel in horticulture existing at the moment. With the help and experience of the CG and AVRDC you will be able to identify crucial areas which can be tackled in the short term.

The scope of your work here will require a wider perspective in order to cover many areas. There might be a need to put together a highly qualified team of scientists to reflect on the realities and propose workable plans.

Let me end up with a spirit of optimism that something of great value to all of us will come out of your discussion, as you join forces to identify common actions for bringing about changes and improvements to the present situation in vegetable crop production.

A strategy will have to be developed around exploiting the existing types, intensifying their cultivation and finally investigating new species which can be adapted to our conditions.

In conclusion, I would like to take this opportunity to thank the organizers of this conference, in particular the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR) for taking the initial step and conducting the previous workshop in March 1987 in Malawi; the CGIAR for supporting the proposal from the beginning, and AVRDC for organizing this conference and their interest shown in contributing to the development of the vegetable industry in Southern Africa. Sincere thanks are due to the various institutions commissioning the joint mission which produced the proposal for the Collaborative Network for Vegetable Research and Development in the SADCC region, which will be the main document guiding your

discussion. And finally special thanks are due to GTZ, the Government of France and the Canadian International Development Agency (CIDA) for funding support and commitments to this workshop.

I wish you all much success with your meeting and I am happy to declare the workshop open.

Summary and Recommendations

This regional consultation workshop provided contributed country papers on national agricultural policies and the current status of vegetable research and development in the national programs of the SADCC (Southern African Development Coordination Conference) region. As well, papers on home gardening, seed production, integrated pest management, and postharvest technology of vegetables were presented to provide an adequate background on substantive issues which affect the development of the vegetable industry. Together, these papers set the tone for the working group discussions and in-depth review of 'CONVERDS', a comprehensive proposal for collaborative vegetable research and development in the SADCC region, and paved the way for developing appropriate recommendations and endorsing in principle the proposed collaborative network.

CONVERDS, which stands for 'Collaborative Network on Vegetable Research and Development in the SADCC Region', was conceived by a joint project identification mission mounted by the CGIAR (Consultative Group on International Agricultural Research), SACCAR (Southern African Centre for Cooperation in Agricultural Research and Training), AVRDC (Asian Vegetable Research and Development Center), and ISNAR (International Service for National Agricultural Research) in August 1989. It is an attempt to band together the national agricultural research systems (NARS) of SADCC into a cohesive and singularly effective group which addresses the strategic research and development needs on vegetables of the region as a whole. Individually, the NARS do not have the critical mass of resources to address the most important problems of their vegetable industry; together with other NARS, however, pooling of resources allows them to give profound attention to a number of research and development issues that are strategically common to all NARS. The CONVERDS proposal was reviewed by a group of donors during the CGIAR meeting in October 1989. Following that review, funds were allocated for the regional consultation workshop by GTZ (the German Agency for Technical Cooperation), by the Government of France and by CIDA (Canadian International Development Agency). The consultation workshop had the following goals: (1) to update the state-of-the-art in vegetable research and development in the SADCC region; (2) to gain a comprehensive understanding of the priorities in vegetable research and development of the member states of SADCC and of the region as a whole; (3) to bring together vegetable researchers, extension specialists, educators and policymakers and secure a broad consensus on the priorities and mechanisms for collaborative research and development which will mutually benefit all member states of SADCC; and (4) to review the indicative proposal to establish CONVERDS, and develop a final proposal for a regional collaborative effort on vegetable research and development that merits the support of the participating national governments and the donor community.

The participants were divided into two working groups. Group I dealt with the issues of national priorities – vegetable species, researchable problem areas, production systems, ecologies/environments for vegetable production, and needs for human resource development and information. Group II tackled the issues of network modalities – objectives, functions or responsibilities, preferred institutional arrangements, mechanisms of collaboration, management functions, linkages with the national vegetable research groups, role and contribution of the participating

NARS, role and contribution of regional and international institutions, needs to deploy a small team of regionally and internationally recruited scientists based at one of the NARS, and other related issues. Below is a combined summary of the recommendations proposed by each working group.

Priority Vegetable Species

The priority vegetables identified by each member country, arranged in order of importance, were as follows:

Botswana	- cabbage, tomato, onion, mustards
Lesotho	- cabbage, tomato, onion, carrot
Malawi	- tomato, onion, cabbage, indigenous vegetables*, mustards
Swaziland	- tomato, onion, carrot, cabbage
Tanzania	- indigenous vegetables, tomato, onion, cabbage
Zambia	- tomato, mustards, onion, cabbage
Zimbabwe	- tomato, onion, cabbage, mustards

(* Indigenous vegetables include mainly native species often growing wild as weeds such as amaranths, *Corchorus*, African eggplant, cat's whiskers (*Cleome*), and others.)

The criteria for determining priority were based on consumption and production by local people. Accordingly, the above species may be arranged as follows in their order of importance in the SADCC region: tomato, cabbage, onion, mustards, and indigenous vegetables. Based on the above exercise, the working groups agreed unanimously on the following:

Recommendation No. 1 - The vegetables or groups of vegetables for research consideration by the network should include: tomato, onion, cabbage and indigenous vegetables.

Recommendation No. 2 - Lead countries for each of the above network commodities are as follows:

Malawi	- cabbage;
Tanzania	- indigenous vegetables;
Zambia	- onion; and
Zimbabwe	- tomato.

Priority Researchable Problems

Discussions on the most appropriate research activities of the network for the priority species led to the identification of two general research areas – (1) Genetic Resources and Enhancement and (2) Production Systems and Component Technologies.

Recommendation No. 3 - The recommended areas of research under each of the general research areas for each of the network commodities are:

	Tomato	Cabbage	Onion	Indigenous Vegetables
I Genetic Resources and Enhancement				
1 Survey/exploration	-	-	-	+
2 Collection*	+	+	+	+
3 Germplasm characterization	-	-	-	+
4 Variety evaluation	+	+	+	+
5 Utilization	-	-	-	+
II Production Systems and Component Technologies				
1 Cultural practices	+	+	+	+
2 Plant protection	+	+	+	-
3 Home gardens	+	+	+	+
4 Seed production	+	+	+	+
5 Postharvest	+	+	+	-
6 Socioeconomics	+	+	+	+

* Includes assembly of local landraces as well as advanced breeding lines and cultivars.

\+ higher priority

\- lower priority (or absence of activity in some cases)

Note: Indigenous vegetables is a diverse group. In view of this, it was further recommended that some prioritization in the species to be handled by the network will have to be done. This could come about after a preliminary survey and assessment of NARS activities on this group, their priorities, production figures, etc.

Priority Production Systems

Recommendation No. 4 - The SADCC NARS unanimously agreed that the vegetable research packages to be generated by the network should focus on home gardens to market gardens. The recommendation could be applicable to any size of farm holdings, i.e. small-scale, medium- and large-scale vegetable farming, although more so to those practiced by the majority of vegetable farmers. The following ecologies/environments were identified by each NARS as important areas to which research should be directed:

Botswana - lowland;
Lesotho - highland;
Malawi - lowland to highland;

Tanzania	- lowland to highland;
Zambia	- lowland to highland; and
Zimbabwe	- lowland to highland.

Training Needs of the SADCC NARS

Human resource development at various levels was identified by each NARS as necessary to enhance their capacities to carry out vegetable research in the years ahead. These needs are as follows:

Botswana	- BSc to PhD;
Lesotho	- Diploma to PhD;
Malawi	- Diploma to PhD;
Swaziland	- Diploma to PhD;
Tanzania	- BSc to PhD;
Zambia	- BSc to PhD; and
Zimbabwe	- BSc to PhD.

The types of training required for the SADCC region are as follows:

(1) Intensive 5–6 month course on vegetable production – This type of training is preferably for general BSc degree holders, but could be open to diploma holders as the needs are identified. The aim of this training course is to enhance the capability of general agriculturists who currently undertake most of the horticultural activities in the region.

Recommendation No. 5 - It was recommended that the training program should be conducted at the location where the team of internationally recruited scientists is to be based by the executing agency. As decided later, this location is HORTI-Tengeru in Tanzania which already has the training infrastructures to carry out a short-term course as proposed above.

(2) Diploma course – This is a 2-year course for general agriculture certificate holders as well as high school graduates. According to the initial proposal, it was agreed that two students per NARS per year will undergo this type of training. For reasons already stated above, this type of training will also be conducted at HORTI-Tengeru.

(3) BSc and MSc in Horticulture – The participants were in favor of BSc Agriculture with major in horticulture to avoid the narrowness of work scope since the graduates normally handle other crops as well in the field. Specialization in the field of horticulture could be undertaken at the MSc level. The participants felt that training should start immediately (for degree courses), and that preparatory activities on training to be initiated by CONVERDS could involve the immediate identification of research staff in the NARS for the intensive course program at AVRDC.

Recommendation No. 6 - The participants unanimously agreed that the professional training in the field of horticulture in the SADCC region should be conducted by the University of Zimbabwe.

Recommendation No. 7 - It was likewise recommended that the above-proposed training programs be open to both the public and private sectors. However, candidates from the latter will have to be nominated by the national research leaders representing the NARS in the network; otherwise they will have to bear the cost of training.

Information Needs of the SADCC NARS

The participants generally agreed that initially a database of vegetable research activities in the region should be compiled by the network secretariat. Later, this database could be expanded to include internationally available research information databases, including those already available at AVRDC. In order to assist in collecting information available in the region, it was agreed that scientists in each country could be commissioned to prepare reviews of all past and present research reports on vegetables for inclusion in the network's database. Bibliographies, abstracts from journals, workshop proceedings, and annual reports and a regular network newsletter are to be published and disseminated by the network scientists to the region's vegetable researchers.

Objectives, Structures, Functions and Governance

All participating countries of SADCC unanimously agreed to participate in the proposed vegetable research network, thus concurring in principle with the third objective of CONVERDS, i.e. 'to establish ways and means for collaborative research partnership among the SADCC country members and to attain a better and efficient use of expertise, technologies and the scarce resources available for vegetable research and development in the region'.

The NARS delegates agreed with the four proposed objectives of CONVERDS, adding only minor clarifications such as 'improved technologies' instead of simply stating 'technologies' in the first objective. The fifth objective was also changed and now reads as follows: 'to develop an information and diffusion network in the SADCC region aimed to facilitate the assembly and dissemination of technical information to and from the region's vegetable research and extension services and eventually to and from vegetable growers'.

There was unanimous agreement on the general functions of the network as earlier proposed. However, the delegates recommended the addition of two more functions, namely:

(1) to provide financial and technical support to the NARS given the lead roles in specific commodity or cross-commodity areas; and

(2) to effectively discharge their enhanced responsibilities, to identify training needs at various levels and set priorities according to the needs of the component NARS.

On planning, programing and budgeting, it was agreed and recommended that the lead NARS should be backed up by a specialist in the particular crop of interest assigned to it.

The networking mode of collaboration among the participating NARS was agreed upon with no alterations.

The functions of the proposed oversight committee of CONVERDS were generally accepted by the delegates with the exception of the second function, 'to review and confirm the selection of the network coordinator and network's expert team by the executing agency', which the delegates agreed to delete. In addition, it was proposed and accepted that the oversight committee name be changed to TAP (Technical Advisory Panel) and the executive and technical entity below it to Steering Committee, in order that CONVERDS will conform with the existing system of SACCAR's regional networks.

It was also recommended and accepted that membership in the Steering Committee be extended to include a representative from the extension service of the host country and invited observers from the seed company as well as training institutions.

There was also general agreement that the Steering Committee should have an open mandate to invite any resource person(s) to its meetings if they are considered important in the conduct of the committee's activities.

The section on 'Network Coordination' in the CONVERDS proposal was generally approved with minor modifications on the first responsibility of the Implementing Units. This should now read 'to provide the leadership and to serve as the focal point for the collaborative research and/or other activities specifically assigned to a country'.

As noted earlier, it was recommended and accepted by the delegates that HORTI-Tengeru of Tanzania should host the expert team to be deployed by AVRDC, the executing agency, and that the 5 month intensive training on vegetable production and the 2 year diploma course in horticulture be conducted at the same site. The host country, Tanzania, was noted by the delegates to have the necessary quarantine facilities for importing and exporting plant materials to and from the member countries of CONVERDS.

The delegates recommended that SACCAR prepare an agreement or memorandum of understanding (MOU) between the NARS hosting the network's secretariat and the executing agency on behalf of the expert team to be deployed there by the latter.

On linkages between the team of experts and the NARS, it was agreed that the national research leaders representing the NARS in CONVERDS should be responsible to the network coordinator.

On other issues, a strong relationship between the network and the SADCC Regional Gene Bank (SRGB) in Zambia was considered important to enable the utilization of SRGB's existing gene bank facilities, to promote the collection, characterization, conservation and utilization of the region's indigenous vegetable genetic resources. The participants unanimously agreed that the region's genetic materials should be sent to and preserved at AVRDC as a backup collection.

OVERVIEW PAPERS

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Vegetables in Tropical Africa

Bede N. Okigbo*

Introduction

The word vegetable is used to designate an edible, mostly herbaceous plant species, or a relatively tender part of it, that is consumed fresh, steamed or boiled, salted or unsalted, alone or in combination with other foodstuffs and sometimes as an ingredient in soups or stews (Thompson 1949; Duckworth 1966; Okigbo 1980). One key characteristic of vegetables is their high water content which usually exceeds 80% (Duckworth 1966). As a result they are highly perishable. Vegetables as a food group are important as sources of minerals, vitamins and some proteins. In the humid tropical areas where starchy roots and tubers are the dominant energy foods, or for vegetarians, vegetables are major sources of cheap plant proteins. In the Sahelian, semi-arid, arid and other parts of the dry savanna areas of Africa, the scarcity of vegetables or their deficiency in the diet is a major cause of vitamin A or carotene deficiency. This causes blindness or xerophthalmia, and even death in young children. Vegetables contain fiber which adds bulk to the food, thereby minimizing the feeling of hunger, in addition to enhancing movement of food through the alimentary canal. The supplies of vegetables at the later part of the planting season, when most starchy staples have been planted, is of nutritional strategic importance, since vegetables contribute significantly to the amount of calories and other nutrients consumed in the so-called little hungry season.

Compared to other major food groups and agricultural commodities, vegetables constitute the fifth largest commodity group produced worldwide, or fourth largest in the Africa region in 1988 in quantitative terms (FAO 1989) (Table 1). In tropical Africa, vegetables are produced as components of prevailing farming systems including traditional shifting cultivation and associated fallow systems, home gardens, various upland and lowland field production systems, market gardening and specialized horticultural enterprises. According to Dema (1965), the amount of vegetables consumed often depends on the prevailing agricultural or farming system and socio-ecological conditions. It was reported that in the intensive terrace farming area of Anambra State in southeastern Nigeria, which is based on growing of cocoyams and vegetables, the amount of vegetables produced and consumed was the largest of all six locations surveyed. The cereal-dominant savanna farming systems of Vodni in the Middle Belt of Nigeria devoted the lowest area of land to vegetables, and consumption of vegetables was among the lowest. Production and consumption of vegetables were intermediate in the cocoa or cocoa food crops producing rainforest farming systems at Igren and Abebeyun in southwestern Nigeria. Food consumption surveys also indicate that socioeconomic factors such as nearness to roads and markets in vegetable-producing areas to some extent influence the amount of vegetables consumed. A classification of the prevailing farming systems in which vegetables may be

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Table 1. Production and yield of vegetables in Africa and globally as compared to those of other food commodities (1988).*

Food commodity	Africa			World		
	Production (million t)	Yield (t/ha)	% production of all commodities	Production (million t)	Yield (t/ha)	% production of all commodities
Cereals	89.0	1.2	25.9	1743.0	2.5	39.5
Roots and tubers	98.0	7.0	28.5	571.0	12.3	12.9
Pulses	6.9	0.61	2.0	55.0	0.80	1.2
Vegetables	30.8	-	9.0	423.4	-	9.6
Fruits	41.6	-	12.1	332.3	-	7.5
Sugar	77.1**	53.1**	22.4	1282.9*	47.5*	29.1
Nuts	0.3	-	<0.01	4.1	-	0.1

* Source: FAO Production Yearbook 1989.

** Average of cane sugar and beet sugar production figures.

Note: With the exception of the sugar production figures, the yields of various food commodities in Africa are below the respective world averages.

produced is presented in Okigbo and Greenland (1976). For details on the extent to which vegetables are produced in the different farming systems of tropical Africa, reference should be made to Okigbo (1980) on which the status of vegetable crops domestication and the diversity of vegetables grown in Africa is based.

Apart from their nutritional importance, vegetables do contribute significantly to the farmer's income when sold locally, and to the foreign exchange of producing countries if they are exported. Vegetables, as minor components of traditional intercropping systems, add diversity to the commodities or foods produced, minimize risk of crop failure, and thereby contribute to stability in the system. Vegetable production systems, especially when they are practiced as components of integrated crops and animal production enterprises, constitute one of the most sustainable production systems in tropical Africa, for example, in home gardens in which they are also components of multi-storied complex agroforestry systems. Vegetable production systems as practiced in market gardens near urban centers constitute one of the most profitable small-scale agricultural production enterprises. With the current economic crisis in many African countries, and increasing reliance on food purchase and food aid to satisfy demand, many workers in urban areas are increasingly growing vegetables as part-time enterprises so as to augment cheaply available food supplies. In urban areas of Nairobi and other large cities, for example, squatters rely on vegetable gardening on roadsides and rights-of-way as a primary source of food.

Classification of Vegetables

Vegetables are often classified according to the part of the plant from which they are obtained. They consist of: (1) leaf vegetables; (2) fruit vegetables; (3) flower

vegetables; (4) root and tuber vegetables, and so on. Vegetables are also classified according to the botanical family of the plant kingdom to which they belong.

Leaf vegetables: These are vegetables that consist of edible leaves of plants such as the African spinach (*Amaranthus hybridus* var. *cruentus*), *Amaranthus viridis*, *Celosia argentia*, vegetable jute (*Corchorus olitorius*), lettuce (*Lactuca sativa*), the bitter-leaf (*Vernonia amygdalina*), the fluted pumpkin (*Telfairia occidentalis*), cabbage (*Brassica oleracea* var. *capitata*) and the camwood or Pandouak (*Pterocarpus soyauxii*). Most leaf vegetables include not just the leaf blade but also their petioles (leaf stalks).

Fruit vegetables: These are plants whose fresh edible parts consist mainly of fruits or similar reproductive structures. Within this group are okra (*Abelmoschus esculentus*), the cucumber (*Cucumis melo*), the pumpkins and squashes (*Cucurbita* sp.), the green or sweet pepper (*Capsicum annuum* var. *frutescens*), the eggplant (*Solanum melongena*), the African eggplant (*Lycopersicum esculentum*) and many others. The edible young pods of several leguminous plants constitute a special group of fruit vegetables; these include vegetable cowpea (*Phaseolus* spp.), the winged bean (*Psophocarpus tetragonolobus*) and the pigeon pea (*Cajanus cajan*).

Flower vegetables: This is a group of vegetables whose flowers or flowering structures constitute the edible part of the plant. Included here are cauliflower (*Brassica oleracea* var. *botrytis*), globe artichoke, broccoli (*Bassica oleracea* var. *italica*) and the cocoyam or eddoe (*Colocasia esculenta*).

Root and tuber vegetables: These consist of plants that produce underground edible swollen storage organs which are either anatomically formed from stems, for example yams (*Dioscorea* spp.), Irish potato (*Ipomoea batatas*), the carrot (*Daucus carota*), the Hausa potato (*Plectranthus esculentus*), and the cocoyams (*Colocasia* and *Xanthosoma* species), or from roots such as cassava (*Manihot esculenta*), beetroot (*Beta vulgaris*) and the sweet potato (*Ipomoea batatas*).

Stem or shoots vegetables: These are vegetables that consist of edible portions of stems, vines or twigs made up of succulent or young leaves, petioles and the tender apical portions of the shoot to which some leaves are attached. Examples of vegetables in this group include asparagus (*Asparagus officinalis*), elephant grass (*Pennisetum purpureum*) and tips of vines of sweet potato, fluted pumpkin and pumpkin.

Other Plant Parts

Other plant parts that are used as vegetables include bulbs as in onions and leeks and petioles as in celery and rhubarb. In many vegetable species, more than one part of the plant may be used as vegetable. In the cowpea, the young pods and leaves are used; in okra, the fruits and young leaves; in peas, the seeds and pods are used as vegetables; in lima beans, it is mainly the young seeds; in onions, the bulb is the main vegetable while in spring onions, the leaves and not much of the bulbs.

Botanical Classification

There are some plant families that have given us many species of plants used as vegetables, and each family may have some characteristic features. For example, the legume family is the source of many pod and seed vegetables that are known for their richness of plant proteins. Another family is the Cruciferae which is the source of *Brassica* spp. of vegetables which include cabbages, kohl-rabi, cauliflower, collard, brussels sprouts, mustards and turnip. Similarly there are vegetables from the carrot

family (Umbelliferae), the pumpkin (Cucurbitaceae), the potato family (Solanaceae) and so on.

Functions and Uses of Some Vegetables

Some vegetable species do not only fulfill their function of supplying nutrients in their own right as vegetables, but they are also used as condiments for flavoring food and improving the appetite. These include vegetables in the onion family (Liliaceae) or in the lily family (Amaryllidaceae), the mint family (Labiateae), the red pepper genus (*Capsicum* spp.), the black pepper family (Piperaceae), etc. It is also interesting to note that some of the vegetable species, when their parts are young, are used as vegetables but when mature and dry, they are regarded as major staples, for example many of the grain legumes. Others, such as roots and tubers, are classified either as vegetables or as starchy staple field or arable crops. Examples of these include Irish potato, sweet potato, and yams.

Antiquity of Vegetable Crops in Africa

There has been a lot of speculation about the origins of agriculture in tropical Africa. A long-term controversy has been raging between proponents of *diffusion* and those of *independent origin*. The former maintain that agriculture originated in the Fertile Crescent of the Middle East or Southwestern Asia from where it spread to Egypt about 12000 years BP. From Egypt's Fayum depression it spread westwards into North Africa and southwards through the Nile valley to Khartoum at about the fourth millennium BC, and later from there to other parts of sub-Saharan Africa. Proponents of independent origin hold that plant domestication in Africa occurred after long periods of experimentation at different locations and times, resulting in the independent ennoblement of local domesticates. Another hypothesis is that of Vavilov who postulated that the main center of origin of plant domestication and diversity in Africa was Ethiopia. Others maintained that domestication of African crops did not take place until after a stimulus from Asian crops which reached Africa after 1000 AD.

There is now considerable evidence (botanical, historical, archaeological, linguistic and geographical) that there were two main origins of agriculture which arose independently in sub-Saharan Africa. These consisted of a *Seed agriculture complex* and a *Vegecultural agriculture complex*. The seed agriculture complex involved the domestication of such seed plants as cereals (e.g. sorghum) and grain legumes (cowpea) grown in fields in the savanna areas north of the equator. The vegecultural agriculture complex involved the domestication of vegetatively propagated plants such as yams, and tree crops such as oil palms, grown in gardens rather than in open fields in the rain forest zone to the south of the savanna (Skinner 1964; Coursey 1976; Harlan et al. 1976; Harris 1976; Porteres 1976; Purseglove 1976; Scudder 1976; Shaw 1976). The two complexes arose about 6000 years BP. Later, around 1100 AD, Asian crops were introduced, such as Asian rice (*Oryza sativa*), bananas and plantains, and then in the 16th century AD, new world crops such as groundnuts, maize and cassava were introduced. Based on Anderson's Plants, Man and Life, most vegetables are nitrophiles which arose in rubbish or refuse heaps from

weedy species and were grown in association with major staples such as yams, maize and sorghum. Although the probable sequence of plant domestication according to Burkill (1962) was cereals followed by pulses (grain legumes), short-lived greens, oilseeds, roots and tubers, herbaceous fruits, tuber plants, trees and industrial crops, the roots and tubers are now believed to have been among the first crops domesticated before vegetables, especially in the humid tropics. Trees are thought to have been domesticated later. Although in tropical Africa some trees such as the African pear, the oil palm and the African bread-fruit were probably domesticated earlier, the use of leaves of such trees as *Pterocarpus soyauxii* and the baobab must have taken place at a much later stage. Due to the more recent use of trees as leaf vegetables, and the fact that many African vegetables are still wild or semi-wild, it is likely that variability among them is limited. With the current rate of deforestation, genetic erosion and probable extinction are serious threats to these indigenous vegetables. Coupled with this is the rapid rate of urbanization and loss of indigenous knowledge about the uses of local vegetables. All these call for higher priority to be given to collection, conservation and genetic improvement of indigenous African vegetables.

Domestication of African Vegetables

Vegetables used in tropical Africa range from those that are regularly cultivated to those that are completely wild. The various categories of domestication or extent of cultivation include:

(1) Wild and harvested in time of food scarcity or famine (e.g. *Vitex doniana*, *Myrianthus arborea*, *Combretum* spp., *Piper quincensis*, *Bidens pilosa* and *Corchorus aestuans*);

(2) Wild, but regularly harvested from the wild and only occasionally planted (e.g. *Gongronema latifolia*, *Gretum buckholzianum* and *G. africanum*);

(3) Semi-wild, partly protected or harvested from fallow land (e.g. water leaf (*Talinum triangulare*), elephant grass (*Pennisetum purpureum*), *Pterocarpus* sp., *Portulaca oleracea*, *Commelina diffusa*, etc.). Most of these are also harvested on farms among major staples during weeding operations since they usually grow as volunteers, as are also other bona fide vegetables such as the vegetable jute and African spinach;

(4) Cultivated in mixtures in traditional and transitional farming systems (e.g. *Amaranthus viride*, *Corchorus olitorus*, vegetable cowpea, okra, *Celosia argentea* and the bitter-leaf). Many of these are also grown in home gardens and associated special microenvironments, such as rubbish heaps; and

(5) Cultivated in market gardens and specialized horticultural enterprises. These consist of most of the introduced or exotic vegetables such as carrot, lettuce, radish, tomato and onions. Many of the popular indigenous African vegetables are increasingly being grown under these systems (e.g. *Amaranthus*, vegetable jute, local eggplant (*Solanum* spp.), bitter-leaf, etc.).

A line drawn from the northernmost tip of Ethiopia on the Red Sea coast to Luanda on the Atlantic coast, broadly speaking separates lowland Africa to the west, from highland Africa to the east. In the highland areas of east and southern Africa, which are generally cooler than lowland areas, most subtropical and some temperate vegetables can be grown. But good seed production of such crops as cabbage, cauliflower, broccoli and carrots is not readily achieved in the warmer areas. There are, of course, some selections of these vegetables that do better in the tropics. Peas perform much better at higher elevations than in the lowland areas. There are also fewer diseases and environmental stresses at moderately higher elevations. In the lowland areas to the west of our dividing line there are a few isolated highland areas such as the Cameroon/Adamawa highlands, the Jos Plateau, and Futa Jalon highlands where subtropical and some temperate vegetables perform as well as in the eastern and central African highlands. A large part of the lowlands of tropical Africa consist of the humid tropics, where many subtropical vegetables do not perform well because of the very high rainfall associated with storms that damage seedlings, and a diversity of bacterial and fungal diseases which cause considerable losses in subtropical vegetables and even also in vegetables of the humid tropics. Here, significant reduction of the damage and losses can be achieved by protecting young seedlings with plastic films. This, however, may be not economical. In the drier savanna areas where night temperatures are lower, some vegetables such as tomatoes, lettuce, cabbages and cauliflower perform better than in the humid tropics, provided that sufficient moisture is made available. Some tropical vegetables such as squash and other cucurbits perform better in the drier environments than in the humid areas, where severe losses may occur as a result of damage caused by viruses, wilt and several leaf diseases.

Classification of Vegetable Crops

A comprehensive list of vegetables in tropical Africa is presented in Tables 2 and 3. Table 2 lists 54 exotic vegetables, and the list is by no means exhaustive. Moreover, certain species, which are not strictly vegetables, but may be grown as vegetables, have been excluded. Among the exotic vegetables are subtropical and temperate biennials, which may not produce seeds in the tropics except at very high elevations. Others produce seeds poorly and some bulb vegetables do not produce seeds although they may produce bulbs. However, most of the exotics that originated from tropical America or Asia perform well in tropical Africa.

Table 3 lists native vegetables and indicates the status of their production, general importance and means of reproduction and conservation. The exotics do not have as many problems as the natives in conservation and improvement. If their cultivars continue to be exploited in tropical Africa, the origin and parents of their parent cultivars that perform well should be safeguarded in temperate countries or at suitable locations in the tropics. Those species that are adapted to the tropics require continued attention if productivity is to be maintained. Genetic improvement of those species that are propagated vegetatively are sometimes not easily achieved as in species with true seed.

Tomatoes, capsicum peppers, cucurbits and other widely grown crops should be given higher priority in collection, evaluation and conservation.

Table 2. Exotic vegetables of tropical Africa.

Scientific name	Common name	Family	Origin	Part utilized and importance	Possibility of seed production in tropics
Allium ascalonicum	Shallot	Amaryllidaceae/ Liliaceae	SW Asia	Bulb**	Seed
A. cepa	Onion	"	SE Asia	Bulb****	Seed
A. fistulosum	Welsh onion	"	E Asia	Bulb**	Seed
A. odorum	Chinese chives	"		Leaves & bulb**	Seed
A. porrum	Leek	"	C Asia	Leaves & bulb***	No seed
A. sativum	Garlic	"	"	Bulb**	No seed
A. schoenoprasum	Chives	"	"	Leaves & bulb**	Seed
Apium graveolens	Celery	Umbelliferae	Eurasia	Petiole, root	No seed
Asparagus officinalis	Asparagus	Liliaceae	Oldworld	Shoot*	Seed
Basella alba	Ind. spinach	Basellaceae	T Asia	Leaves***	Seed, shoot
Basella rubra	Ind. spinach	"	"	Leaves, young shoot**	Seed, shoot
Benincasa cerifera	Wax gourd	Cucurbitaceae	SE Asia	Seed*	Seed
Beta vulgaris	Beetroot	Chenopodeaceae	Eurasia	Tuber, leaves**	No seed
Brassica oleracea cv. *acephala*	Collard	Cruciferae	Europe	Leaves, young shoot*	No seed
B. oleracea cv. *botrytis*	Cauliflower	"	"	Flower***	No seed
B. oleracea cv. *capitata*	Cabbage	"	"	Leaves****	No seed
B. oleracea cv. *gemmifera*	Brussel sprouts	"	"	Sprouts**	No seed
B. oleracea cv. *italica*		"	"	Flower*	No seed
B. caulorapa	Kohl-rabi	"	Asia	Stem, leaves*	No seed
B. chinensis	Chinese cabbage	"	SE Asia	Leaves**	Seed

(Continued)

Table 2. Exotic vegetables of tropical Africa. *(Continued)*

Scientific name	Common name	Family	Origin	Part utilized and importance	Possibility of seed production in tropics
B. juncea	Chinese mustard	"	Africa	Leaves**	Seed
B. rapa	Turnip	"	SE Asia	Tuber**	No seed
*Colocasia esculenta**	Taro	Araceae	SE Asia	Corm, leaves, flower***	No seed
Canavalia ensiformis	Swordbean	Leguminosae	S&C Amer	Pod, seed*	Seed
Capsicum annuum	Chilli pepper	Solanaceae	T Amer	Fruit****	Seed
Capsicum cv. *grossum*	Sweet pepper	"	"	Fruit****	Seed
Capsicum frutescens	Hot pepper	"	"	Fruit****	Seed
Cichorium endiva	Endive	Compositae	W Asia	Leaves**	Seed
Cucumis melo	Sweet melon	Cucurbitaceae	Africa/India	Fruit**	Seed
Cucumis sativus	Cucumber	"	SE Asia	Fruit***	Seed
Cucurbita maxima	Pumpkin	"	S&C Amer	Fruit**	Seed
Daucus carota	Carrot	Umbelliferae	C Asia	Tuber***	No seed
Foeniculum vulgare	Fennel	"	SE Asia	Leaves**	No seed
Helianthus tuberosus	J. artichoke	Compositae	N Amer	Tuber**	Seed
Ipomoea batatas	Sweet potato	Convolvulaceae	S Amer	Tuber****	Tuber, seed
Lablab niger	Hyacinth bean	Leguminosae	T Asia	Pods, leaves**	Seed
Lycopersicum esculentum	Tomato	Solanaceae	S Amer	Fruit****	Seed
Lactuca sativa	Lettuce	Compositae	SW Asia	Leaves****	Seed
Mentha spp.	Mint	Labiateae	SW Asia	Leaves**	Seed
Phaseolus lunatus	Lima bean	Leguminosae	SC Amer	Seed****	Seed
P. vulgaris	French bean	"	"	Pod, seed***	Seed
Petroselinum crispum	Parsley	Umbelliferae	W Asia	Leaves**	Seed

(Continued)

Table 2. Exotic vegetables of tropical Africa. *(Concluded)*

Scientific name	Common name	Family	Origin	Part utilized and importance	Possibility of seed production in tropics
Pisum sativum	Pea	Leguminosae	Europe	Seed**	Seed
Glycine max	Soybean	"	SE Asia	Seed, seedling**	Seed
Psophocarpus tetragonolobus	Winged bean	"	Oceania	Pod, tuber*	Seed
Raphanus sativus	Radish	Cruciferae	W Asia	Tuber**	No seed
Rheum rhaponticum	Rhubarb	Polygonaceae	Russia	Petiole*	No seed
Rorippa nasturtium-aquaticum	Watercress	Cruciferae	Europe	Leaves*	
Sechium edule	Chayote	Cucurbitaceae	S&C Amer	Fruit**	Seed
Solanum melongena	Egg plant	Solanaceae	India	Fruit***	Seed
S. tuberosum	Irish potato	"	S Amer	Tuber****	Tuber, seed
Zea mays cv. *saccharata*	Sweet corn	Gramineae	C Amer	Seed****	Seed
Zingiber officinale	Ginger	Zingiberaceae	SE Asia	Rhizome****	Rhizome

**** Very important and widely grown. *** Of some importance. ** Of limited use in some areas. * Of negligible or potential value.

1. Seeds may be produced at high elevations in the topics. 2. Sources: Janick et al. 1969; Tindall 1968; Purseglove 1968, 1976; Tindall and Sai 1965.

Table 3. Plants more commonly used as vegetables in tropical Africa.

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
Ceratopteris cornuta	-	Pteridophyta (Adiantaceae)				
		Gnetaceae	Leaves	* w	Herb	Spores
Gnetum africanum	Gnetum	"	Leaves/shoots	** w	Vine	Cones
G. buckholzianum	"	"	"	** w	Vine	Cones
		Acanthaceae				
Hygrophila spinosa and *H.* spp.		"	Leaves	* w	Herb	Seed
Justicia insularis		"	"	sm&c	Herb	Seed
Justicia spp.		"	"		Herb	Seed
		Amaranthaceae				
Amaranthus hybridus subsp. *cruentus*	African spinach	"	"	*** c	Herb	Seed
Amaranthus viridis	"	"	"	** c	Herb	Seed
Amaranthus spp.	-	"	"	** sw,w	Herb	Seed
Celosia argentea	-	"	"	*** c	Herb	Seed
C. trgyna	-	"	"	** sw,w	Herb	Seed
		Amaryllidaceae				
Cyrtanthus bicolor		"	"	* w	Herb	Seed
Pancreatum trianthum	-	"	"	* w	Herb	Seed
		Anarcardiaceae				
Lannea microcarpa	-	"	"	**	Tree	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status		Habit	Means of propagation & conservation
L. oleosa	-	"	"	*	w	Tree	Seed
Pseudospondias microcarpa	-	"	"	*	w	Tree	Seed
		Annonaceae					
Cleistopholis patens	-	"	"	*	w	Tree	Seed
Dennettia tripetala	-	"	Leaves, fruit seed	***	c	Shrub	Seed
		Apocynaceae					
Alafia lucida	-	"	Leaves	*	w	Vine	Veg., seed
Isonema smeathmannii	-	"	"	**	w	Herb	Seed
		Araceae					
Amorphophallus spp.	-	"	Corm	*	w	Herb	Corm
Zantedeschia aethiopica	-	"	-		w	-	-
Stylochiton warneckei	-	"	Corm	*	w	Herb	Corm
		Asclepiadaceae					
Brachystelma bingeri	-	"	Tuber	*	w	Vine	Tuber, seed
Congronema latifolium	-	"	Leaves	**	sw,w	Vine	Seed, stem
Glossonema boveanum	-	"	Top fruit	**	w	Vine	Seed
Pergularia deamia	-	-	Leaves	*	w	Vine	Seed, vine
		Begoniaceae					
Begonia hirtella	-	"	Leaves	*	w	Herb	Seed, veg.
B. poggei	-	"	"	*	w	Herb	Seed, veg.

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
		Bombaceae				
Adansonia digitata	Baobab	"	Leaves, fruits	*** sw,c	Tree	Seed
Bombax buonopozense	Silk cotton	"	Leaves	** sw,w	Tree	Seed, veg.
Ceiba pentandra	"	"	"	** sw,w	Tree	Seed
		Campanulaceae				
Lobelia fervens	-	"	"	* w	Herb	Seed
L. filiformis	-	"	"	* w	Herb	Seed
		Capparidaceae				
Boscia senegalensis	-	"	Leaves, berries	** w	Herbs	Seed
Capparis corymbosa	-	"	Leaves, fruit	** w	Shrub	Seed
Cleome hirta	-	"	Leaves	** w	Herb	Seed
Cleome monophylla	-	"	"	* w	Herb	Seed
Gynandropsis pentaphylla	-	"	"	* w	Herb	Seed
Maerua angolensis	-	"	Leaves, fruit	** sw,w	Herb	Seed
		Chenopodiaceae				
Chenopodium murale	-	"	Leaves	** sw,w	Herb	Seed
		Combretaceae				
Combretum spp.	-	"	"	* w	Shrub	Seed
Guiera senegalensis	-	"	"	* w	Shrub	Seed
		Commelinaceae				
Commelina diffusa	-	"	"	* w	Herb	Seed, stem
		Compositeae				

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
Bidens bipinnata	-	"	"	** sw,w	Herb	Seed, stem
Bidens pilosa	-	"	"	** sw,c	Herb	Seed, stem
Crassocephalum biafrae	-	"	"	*** sw,c	Herb	Seed, stem
C. crepidioides	-	"	"	*** sw,c	Herb	Seed, stem
Lactuca taracifolia	-	"	"	* w	Herb	Seed, stem
Struchuim sparganophora	-	"	"	*** c	Shrub	Seed, stem
Vernonia amygdalina	-	"	"	*** c	Shrub	Seed, stem
Vernonia colorata	-	"	"	** w	Shrub	Seed, stem
		Cucurbitaceae				
Colocynthis vulgaris	Bitter lemon	"	Seed	*** c	Vine	Seed, stem
Cucumeropsis edulis	White melon	"	"	*** c	Vine	Seed, stem
Cucumeropsis mannii	"	"	"	*** c	Vine	Seed, stem
Lagenaria siceraria	Gourd	"	"	*** c	Vine	Seed, stem
Telfairia occidentalis	Fluted pumpkin	"	Leaves, seed	*** c	Vine	Seed
T. pedata		"		*** c	Vine	Seed
Trichosanthes cucumerina var. *anguina*	Snake tomato	"	Fruit	** c	Vine	Seed
Luffa cylindrica	Luffa	"	"	** c	Vine	Seed
		Cyperaceae				
Cyperus esculentus	Tiger nut	"	Corm	** w,c	Herb	Corm
		Dillenaceae				
Tetracera alnifolia	-	"	Leaves	** w	Tree	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status		Habit	Means of propagation & conservation
T. potatoria	-	"	"	**	w	Tree	Seed
		Euphorbiaceae					
Claoxylon longifolium	-	"	"	*	w	Tree	Seed
Croton mubange	-	"	"	*	w	Tree	Seed
Erythrococca menyharthii	-	"	"	*	w	Tree	Seed
Hymenocardia acida	-	"	"	*	w	Tree	Seed
Maesobotrya floribunda	-	"	"	*	w	Tree	Seed
Manihot esculenta	Manioc	"	Leaves, root	***	w	Shrub	Seed, stems
Microdesmis mercurialis	-	"	Leaves	*	w	Shrub	Seed
Microdesma puberula	-	"	"	*	w	Shrub	Seed
Ricinus communis	Castor bean	"	Leaves, seed	***	c	Shrub	Sed
Tetracarpedium conophorum	Cocophor	"	Nut, leaves	**	c	Vine	Seed
		Gramineae					
Aristidia sp.	-	"	Leaves	*	w	Herb	Seed
Pennisetum purpureum	Elephant grass	"	Shoot	**	sw,c	Herb	Seed, suckers
Saccharum officinarium	Sugarcane	"	Stem	****	c	Herb	Stem, seed
Zea mays	Maize	"	Seed, cob	****	c	Herb	Seed
		Labiateae					
Aeolanthus frutescens	-	"	Leaves	**	sw,c	Herb	Seed
A. helitropioides	-	"	"	**	sw,c	Herb	Seed
A. pubesceus	-	"	"	**	sw,c	Herb	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
Plectranthus esculentus	Risga	"	Tubers	*** c	Herb	Tuber, seed
Solenostemon rotundifolius	Tumuku	"	Tubers	***	Herb	Tuber, seed
Hyptis pectinana	-	"	Leaf	** w	Herb	Seed
H. spicigera	-	"	Seed	** w,c	Herb	Seed
Ocimum viride	Fever plant	"	Leaves	*** w,c	Herb	Seed
		Leguminosae				
Acacia arabica	-	"	"	** w	Shrub	Seed
Afzelia bella var. *bella*	-	"	"	** w,c	Tree	Seed, stem
A. africana	-	"	Leaves, seed	** w,c	Tree	Seed
Albizia spp.	Rain tree	"	Leaves	** w	Tree	Seed, stem
Bauhinia esculenta	-	"	"	* w	Tree	Seed
Cajanus cajan	Pigeon pea	"	Seed, leaves	*** c	Herb-shrub	Seed
Eriosema scandens	-	"	Leaves	* w	Herb	Seed
Mucuna sloanei	Horse eye bean	"	Seed	** c,w	Vine	Seed
Psophocarpus palustris	Wild wing bean	"	Seed	** w	Herb	Seed
Pterocarpus mildbraedii	Camwood	"	Leaves	** w,sw	Tree	Seed, veg.
P. osun	-	"	"	** w,sw	Tree	Seed, veg.
P. santalinoides	-	"	"	** w,c	Tree	Seed, veg.
P. soyauxii	-	"	"	** w,c	Tree	Seed, veg.
Sesbania aegyptiaca	Egyptian sesban	"	Flower pod	** w,c	Shrub	Seed
Sphenostylis spp.	African yambean	"	Leaves, seed flower, tuber	*** w,c	Vine	Seed, tuber

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status		Habit	Means of propagation & conservation
Vigna unguiculata	Cowpea	"	Pod, seed	***	c	Vine	Seed
Voandzeia subterranea	Bambara groundnut	"	Seed, leaves	***	c	Herb	Seed
Kerstingiella geocarpa	Kerstings groundnut	"	"	***	c	Herb	Seed
		Liliaceae					
Asparagus spp.	Asparagus	"	Shoot	**	w,c	Herb	Seed, rhizome
Dracaena spp.	-	"	Leaves	*	w	Shrub	Stem, seed
		Loranthaceae					
Glohimetula braunii	-	"	Leaves	*	w	Tree	Seed
Loranthus sp.	Children's matches	"	"	*	w	Tree	Seed
		Malvaceae					
Abutilon cabrae	-	"	"	*	w	Shrub	Seed
Abelmoschus esculentus	Okra	"	Fruit, leaves	****	c	Herb-shrub	Seed
H. sabadariffa	Roselle	"	Leaves, calyx	***	c	Herb	Seed
H. rosasinensis	Hibiscus	"	Leaves	**	c	Shrub	Stem
Triplochiton scleroxylon	Obeche	"	"	**	w,c	Tree	Seed
		Marantaceae					
Phrynium confertum	-	"	Leaves, rhizome	*	w	Herb	Rhizome, seed
Sarcophrynium arnoldianum	-	"	Leaves, fruit	*	w	Herb	Rhizome, seed
		Melastomataceae					
Dissotis spp.	-	"	Leaves	*	w	Herb	Seed
Sakersia laurenti	-	"	"	*	w	Shrub	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
		Moraceae				
Cholophora excelsa	Iroko	"	"	** sw,w	Tree	Seed
Ficus spp.	Wild fig	"	"	* sw,w	Tree	Veg., seed
Myrianthus arboreus	-	"	Leaves, fruit	* sw,w	Tree	Seed
		Musaceae				
Ensete ventricosum	Enset	"	Inflorescence, leaves	*** c	Herb	Suckers, seed
		Nyctaginaceae				
Boerhavia diffusa	-	"	Leaves	* w	Herb	Seed
		Passifloraceae				
Adenia cissampeloides		"	"	* w	Vine	Seed
A. venenata	-	"	"	* w	Vine	Seed
		Pedaliaceae				
Ceratotheca sesamioides	-	"	"	** sw,c	Herb	Seed
Sesamum radiatum	-	"	"	** sw,w	Herb	Seed
		Piperceae				
Piper guineense	Guinea pepper	"	Leaves, seed	** sw,w	Vine	Seed, stem
Piper umbellatum	-	"	Leaves	* w	Herb	Seed
		Polygonaceae				
Polygonum spp.		"	Leaves	* w	Herb	Seed, stem
Rumex bequaertii	-	"	"	* w	Herb	Seed
Portulaca oleracea	Purselane	"	"	** w	Herb	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Continued)*

Scientific name	Common name (if any)	Family	Part used	Importance and status	Habit	Means of propagation & conservation
Talinum triangulare	Water leaf	"	Leaves, stems	** sw,w,c	Herb	Seed, veg.
T. paniculatum	-	"	Leaves	* w,w	Herb	Seed, veg.
		Rubiaceae				
Amaralia calycina	-	"	"	* w	Herb	Seed
Canthium monstrosum	-	"	"	* w	Tree	Seed
Fadogia cienkowskii	-	"	"	** w	Herb	Seed
Heinsia crinita	-	"	"	* w	Herb	Seed
Pseudspondias microcarpa	-	"	"	* w	Tree	Seed
Tricalysia longestipulata	-	"	"	* w	Shrub	
		Rutaceae				
Afraegle paniculatum	-	"	Leaves, fruit	* sw,c	Tree	Seed
		Sapindaceae				
Allophylus olnifolius	-	"	Leaves	* w	Tree	Seed
Paullinia pinnata	-	"	Leaves, aril	* w	Woody, vine	Seed
		Solanaceae				
Solanum aethiopicum		"	Leaves, fruit	*** c	Herb	Seed
S. gilo	-	"	Leaves, shoot	*** sw,c	Herb	Seed
S. incanum	-	"	Fruit	*** c	Herb	Seed
S. macrocarpon	-	"	Fruit, leaves	*** c	Herb	Seed
S. nigrum	-	"	Leaves, fruit	** w,c	Herb	Seed
S. nodiflorum	-	"	Leaves, fruit	** w,c	Herb	Seed

(Continued)

Table 3. Plants more commonly used as vegetables in tropical Africa. *(Concluded)*

Scientific name	Common name (if any)	Family	Part used	Importance and status		Habit	Means of propagation & conservation
		Tiliaceae					
Corchorus aestuans	-	"	Leaves	*	w	Herb	Seed
C. tridens	-	"	"	*	w	Herb	Seed
C. olitorus	-	"	"	****	c	Herb	Seed
Glyphaea brevis	-	"	"	*	w	Shrub	Seed, stem
Grewia spp.	-	"	"	*	w	Tree	Seed
		Typhaceae					
Typha sp.	-	"	Leaves, spike, rhizomes	*	w	Herb	Seed, rhizome
		Urticaceae					
Boehmeria platyphylla	-	"	Leaves	*	w	Herb	Seed, rhizome
Urera cameroonensis	-	"	"	*	w	Herb	Seed, rhizome
U. mannii	-	"	"	*	w	Herb	Seed, rhizome
		Verbenaceae					
Vitex doniana	-	"	Leaves, fruit	* sw,w		Tree	Seed, stem
V. ferruginea	-	"	Leaves	* sw,w		Tree	Seed, stem
V. cieukowskii	-	"	Shoots, fruit	** c,w		Tree	Seed, stem
		Vitaceae					
Cissus spp.	-	"	Root, fruit	**	w	Vine	Seed, stem

**** Important and widely grown.
*** Of some importance.
** Of limited or local importance.
* Of negligible importance.

c = cultivated.
sw = semiwild or protected.
w = wild.

Source: Dalziel 1955; Okigbo 1973, 1975; Martin and Ruberte 1975; David 1976; Scudder 1976.

One hundred and sixty species of native African vegetables are listed in Table 3. This may be less than 50% of the potential vegetables of tropical Africa. Since some plants that are poisonous and not in widespread use are reported to be potential vegetables, it is necessary to identify species with the greatest potential value for future improvement and utilization. Nutritional and biochemical studies should make it possible to determine those plants that do not contain toxic principles and are rich in minerals, vitamins, essential amino acids or other dietary constituents.

Genetic Improvement, Improved Husbandry and Conservation

Few tropical native vegetables are grown under improved husbandry. A search of existing literature on these plants and observations on their culture, development and utilization indicates that very little genetic improvement has taken place.

The extent of priority and allocation of resources to the conservation and improvement of species of vegetable crops depends on their overall nutritional importance in addition to commercial value. Some native vegetables are not only important sources of high-quality nutrients during the dry season, but are also sources of commercial timber, dyes, drugs and other products (e.g. *Pterocarpus*).

Furthermore, high priority should be given to vegetable crops that are already cultivated and eaten by millions of people, and cultivated plants of considerable antiquity in domestication which tend to be rich in genetic diversity. More ancient cultivated plants tend to have the greatest potential for improvement per unit of available resources devoted to assembling and utilizing their germplasm. Plants that are wild or more recent in domestication require a lot of effort in evaluation and exploration before plants with desirable characteristics can be isolated.

Plants of high nutritive potential, which thrive in environments where they are seriously threatened by human activities, should be identified for conservation. Perennial vegetable crops, which are being sought out in the wild and harvested for timber or commercial products, are in danger of rapidly losing the genetic diversity so important for their future improvement and utilization. Every year, more and more wild *Pterocarpus* trees are cut down. These trees now exist mainly in compound farms and 'sacred' groves. There are also wild vegetables that are useful in providing cover and protecting the soil under associated trees and shrubs. For example, *Gnetum africanum* occupies an ecological niche under the thick shade of trees. When the trees and shrubs that protect and provide support to it are removed, the ground or soil is then exposed to the elements. More research should be conducted to develop agroforestry systems for such vegetable species.

Conservation of germplasm of plants that produce seeds sexually is less expensive and more feasible than the conservation of vegetatively propagated plants. It is easy to store seeds of plants like *Vernonia amygdalina* whose dry seeds are easily used in propagation. Moreover, *Vernonia*, which is easily propagated vegetatively, becomes more susceptible to diseases and insect pests when continuous vegetative propagation is practiced.

Finally, conservation is easier with herbaceous species than trees that require a lot of space. However, since all herbaceous species may not be suitable substitutes for some tree vegetables, attention should be given to finding methods of conserving and enhancing the use of those tree species that are available in off-season periods when herbaceous vegetables are scarce.

Summary and Recommendations

Vegetables constitute a group of food crops that are of nutritional and economic importance to low-resource farmers in Africa. Apart from their being chief sources of minerals and vitamins, they are also cheap sources of plant protein. They are of major nutritional importance to farmers of the humid tropics who cannot afford to purchase adequate quantities of animal protein and to vegetarians who mainly depend on plant protein. Vegetables feature in different traditional farming systems of tropical Africa and especially in the highly sustainable multi-storied home garden agroforestry systems of the humid and subhumid tropics. They are increasingly grown in the highly lucrative and commercialized market gardens and specialized horticultural production systems. Home gardening as part-time farming close to ur' an centers is becoming a major source of vegetables under the prevailing economic squeeze in many African countries.

Vegetables range from totally wild species harvested only in time of famine and food scarcity through those that are partly wild and partly cultivated to those that were domesticated thousands of years ago. There is a diversity of vegetable crops that are grown in tropical Africa and these include introduced subtropical and some temperate vegetables that are grown in the tropical highlands of eastern and southern Africa. Not enough vegetables are being produced to satisfy demand and to eliminate the scourge of vitamin A deficiency and associated xerophthalmia in the dry areas of tropical Africa. If the full potential of vegetable crops in nutrition, economic development and improvement of human welfare in tropical Africa is to be realized, there should be changes in policies and strategies for increasing the productivity of vegetable crops and enhancing their utilization during all seasons of the year

To realize the potential of vegetables in: (1) sustainable agricultural production systems; (2) satisfying nutritional needs in urban and rural areas; (3) import substitution and foreign exchange generation; and (4) raising farm incomes, the following measures are recommended:

(1) Highest priority should be given to the study of nutritional evaluation, genetic improvement and conservation of indigenous vegetable crops. This should include the collection and study of the botany, mode of reproduction, genetics and methods of utilization of the indigenous African vegetables. The recent advances in biotechnology should not be regarded as a substitute for conventional plant breeding in crop improvement.

(2) Since many indigenous vegetables are not fully domesticated, very little is known of the variation among them and the utilization of this in genetic improvement. Since high rates of deforestation are associated with genetic erosion and loss of species and varieties with a range of desirable characteristics, the faster these

species are studied and conserved the better. The higher the priority given to exotic species that are well known and are well documented in books and periodicals, the more there is a tendency to neglect the less-known traditional species. Consequently, the less-known indigenous species should be studied to ensure that superior species of the less-adapted exotic vegetables are discovered and utilized. For example, the bitter-leaf has to be washed through several changes of water before it is used in soups in west Africa. The washing also results in the loss of some nutrients. But a study of the bitter-leaf has resulted in the identification of more sweet varieties that do not have to be washed more than two times before they can be used in soups and stews.

(3) There is need for the development of improved propagation techniques and improved husbandry for indigenous vegetables. More is known about methods of propagation and husbandry techniques for introduced vegetable species. Lack of such knowledge of native vegetables hampers their production and utilization. For example, the bitter-leaf is easily propagated by cutting. As a result many traditional farmers do not know that the bitter-leaf can be grown from seed. Experiments have indicated that bitter-leaf can be grown from seeds but the seeds do not store for long periods of time. These experiments also indicate that propagation by seed results in plants that give higher leaf yields and are less damaged by stem boring weevils as compared to those that are propagated by cuttings.

Related to the above is the fact that the harvesting of tree vegetables such as the *Pterocarpus* spp. is tedious and hazardous because the tree sometimes attains heights of 10 m or more. By using cuttings to propagate them, shorter plants are produced, and where there is good pruning and training of the stem, it is possible to harvest the plant by standing on the ground instead of climbing with ladders. The study and development of methods of disease and pest management in indigenous vegetable crops should be a part of improved husbandry of vegetable crops.

(4) Some priority should be given to the study, documentation and dissemination of information on the nutritional quality of African vegetables, in addition to methods of their preparation and consumption. This will contribute significantly to more efficient utilization of Africa's vegetable resources, and increase the diversity and spectrum of vegetables consumed. Many vegetables consumed in West Africa are not eaten in other parts of Africa and vice versa. The more the number of vegetable species that can be grown and utilized in a given area the better. This is very likely to improve nutritional status since many of the vegetables complement each other in the diet.

(5) Valley bottoms, flood plains of streams and rivers and to some extent small-scale irrigation projects, provide conditions for dry or off-season production of vegetables. Priority should be given to utilization of these highly productive areas for the growing of vegetables including the elimination of health hazards that may hamper their production in such environmental situations. Related to this is the need to develop production systems that make better use of solid and liquid wastes in vegetable production so as to minimize the environmental pollution that may result where they are allowed to accumulate.

(6) Serious losses in production and quality of vegetables occur as a result of poor handling, use of inadequate containers for handling of vegetables and deficiencies in postharvest technology of highly perishable vegetable crops. It minimizes the extent to which these vegetables are utilized in urban areas and the prices paid for them. There is a possibility that some indigenous vegetable crops could be further developed so as to create demand and new markets in developed countries and in various African countries.

(7) High priority should be given to evaluation of introduced vegetable crops so as to: (1) determine those species whose seeds can be produced in suitable locations in Africa; (2) identify adapted species and varieties of those whose seeds have to be imported and distributed in areas where they are most adapted; and (3) develop the most suitable methods for producing them in the tropics competitively with countries in other parts of the world so as to compete favorably in the export market.

(8) There is need to develop improved processing and preservation techniques of introduced and indigenous vegetables, so as to ensure better conservation of what is produced and their availability throughout the year.

(9) Since many African governments are interested in introducing agriculture into the curriculum of primary and secondary schools, it is recommended that vegetable gardening constitutes a production system that could be used for the practical work component of such courses. It could also be integrated with poultry production. Related to this are programs of the type used by AVRDC in improving nutritional status of students through school vegetable gardening projects.

(10) There is need to study and document the variations in germplasm among and within species with respect to yield, texture, cooking qualities, nutritional quality, toxic factors, keeping quality or storability, local preferences and, above all, adaptation to environmental stresses.

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Conservation and Use of Indigenous Vegetable Resources in the SADCC Region

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Introduction

Vegetables remain the cheapest source of important protein, vitamins, minerals and essential amino acids in the diet of many rural communities in Africa. In their diversity of species, forms and texture, vegetables can supplement the diet with nutrients in a way that cannot be achieved with any other major energy-providing food.

The nutritional value of indigenous vegetables is comparable to that of the exotic vegetables (Chweya 1989). Uses of indigenous vegetable species vary from one community to another. Some vegetables are believed to have some medicinal value and are given to the sick, or to babies.

Indigenous Vegetable Resources in Southern Africa

A considerable variety of vegetable species are indigenous to Africa. These species are more common to most rural populations. Some of the important vegetable species grown in Southern Africa are: *Abelmoschus esculentus*, *Amaranthus* spp., *Basella alba*, *Corchorus* spp., *Crotalaria brevidens*, *Curcurbita* spp., *Commelina* spp., *Vigna* spp., *Gynandropsis gynandra*, *Solanum* spp., *Manihot* spp., *Celosia* spp., *Hibiscus* spp., and *Brassica* spp.

Some indigenous vegetable species in Africa are often considered weeds or wild plants. According to Okigbo (1978), vegetable species in Africa can be classified according to their degree of domestication and usage as follows:

(a) Wild but harvested in times of food scarcity;
(b) Wild but regularly harvested;
(c) Semi-wild or protected on farmland or fallow land;
(d) Cultivated in various traditional and transitional farming or cropping systems; and
(e) Cultivated in market gardens and specialized horticultural projects.

Collecting

There have been very few specialized vegetable-collecting missions in Southern Africa in recent years. The IBPGR-funded missions collected vegetable germplasm during 1978, 1981, 1982 and 1984. By 1984 a total of 1372 accessions of mainly *Cucurbita* spp., *Abelmosclus* spp. and *Amaranthus* spp., were collected (Table 1) in Zambia,

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Zimbabwe, Malawi and Tanzania. In addition *Vigna* and *Manihot* spp. were also collected as vegetable crops (Table 2). Some universities and a few research departments in the region have also collected some vegetable resources (e.g. Tanzania, Swaziland and recently Zambia).

Table 1. Samples of vegetables collected in the SADCC region by 1986.

Vegetable species	Zambia	Zimbabwe	Malawi	Tanzania
Cucurbita spp.	531	446	-	-
Amaranthus spp.	74	16	-	-
Solanum spp.	49	22	-	-
Abelmoschus spp.	108	69	30	27

Table 2. Samples of *Vigna* and cassava collected in the SADCC region by 1986.

Species	Botswana	Malawi	Mozambique	Tanzania	Zambia	Zimbabwe
Vigna spp.	800	216	174	385	264	208
Manihot spp.	148	29	246	36	-	-

Existing Diversity

Cucurbita spp.

A variety of cucurbits are grown in the region. These range from the small spiky cucumber *Cucumis metuliferus* to some indigenous gourds and pumpkins. A wide variability was noticed among the edible gourds and their related wild species. Nonedible gourds are cultivated for making utensils and musical instruments. Such cultivars are disease-free but low fruit yielders. Variability of cultivated and wild/weedy relatives of *Citrullus lanatus* is often found in the region as well as *Cucumis melo* and *Lageria siceraria*.

Abelmoschus spp.

Okra is mostly grown in village gardens, behind huts, and in mixtures with other crops. Considerable variability was found among species collected from Zambia. Three species are recognized in the region: *Abelmoschus moschatus*, *A. esculentus*, and *A. ficulneus*, but local preference was for smooth-skin types.

Hibiscus spp.

Different stages of domestication and evolution of the cultigens from the wild types were observed and two species *Hibiscus sabdariffa* and *H. cannabinus* were collected.

Vigna spp.

Several wild *Vigna* exist in Southern Africa. Collecting started intensively in Botswana in 1982. Leaves of certain *Vigna* spp. are used for vegetable relish in many communities.

Solanum spp.

A variety of nontuberous solanums (cultivated types in farmers' fields with red or green fruits, semi-domesticated and wild types) and of nonthorny, bushy types of the *Melongena* group was collected.

Existing Collections and Their Conservation

Conservation methods for vegetable resources are well established, including long-term storage at -20 or -10°C in hermetically sealed packs (aluminum foils or air-tight container). For active collection, seeds can be kept between 12 and 15°C and at about 40% RH. Field genebanks are set up for cassava and sweet potato. In vitro collection at 20°C is suitable for sweet potatoes and cassava.

Very few collections exist in a good state of conservation in the region. By 1985 the Uyole Centre in Tanzania had lost its vegetable germplasm collections at the Centre. The collections were rejuvenated every year, but due to lack of funds and good storage facilities, most of the accessions lost viability and the collection was lost. Similarly, vegetable collections at the University of Swaziland were gradually reduced in number.

The accessions in Tables 1 and 2 are supposed to be well conserved at Mount Makulu, Zambia, and in Zimbabwe. Loss of viability has already been observed in Zambia due to poor maintenance. In Zimbabwe the collections were multiplied in 1984-85 and were conserved in the module provided by IBPGR at the Department of Research and Specialist Services. Interested breeders in the region still maintain some accessions in paper bags, envelopes, glass bottles, tins, cups, on tops of shelves, and in fridges in offices or laboratories. In Botswana, the *Vigna* collection is well maintained in freezers provided by IBPGR.

Utilization

Existing Information

Some basic information exists on some of the indigenous vegetables. An illustrated handbook on selected traditional vegetables and fruits issued by the Communications Unit of the Rural Information Service of Zambia was distributed. Another compendium by Lewis (1974) is available.

Similarly, the Department of Research and Specialist Services of Zimbabwe has published a guide to arable and edible weeds with some notes on their identification and use.

The University of Dar es Salaam holds a herbarium collection of several indigenous vegetables.

As mentioned earlier, rural populations consume various parts of the indigenous vegetables, the leaf, the seeds, the stem and/or the roots. For example, women and children are effective producers of pumpkins. Leaves and fruits are also in demand in urban areas. Generally pumpkin leaves are gathered (and sometimes sun-dried) for use in the relish. Seeds are also dehulled, pounded and added to the relish. Fruits of edible species are eaten fresh, boiled or dried and stored. It was noted during collection missions that farmers saved their seeds from one or two fruits resulting in possible genetic drift.

Spiky cucumbers are split and sun-dried. *Manihot gotzu*, a wild cassava, is used in Tanzania as a green leafy vegetable; the tubers are not utilized. The plant produces leaves prolifically and appears to be resistant to local diseases of cassava. The leaf is marked and is preferred to that of the cultivated cassava. In some areas this species is domesticated. Its latex is tapped and used in repairing bicycle tires, which accounts for its local name of 'mpira' meaning 'rubber' in Swahili.

Research

In the past research was focused on exotic vegetable types, whereas present research is being carried out on some indigenous vegetables.

Various workers have investigated the nutritive value of some of the vegetable species. The ratio of dry matter to protein, total ash, vitamins A and C content of some vegetable collections are shown in Table 3. The fatty acid composition in seed of cleome (*Gynandropsis gynandra*) is given in Table 4.

Indigenous species are known to contain varying concentrations of nutrients, according to variety, stage of maturity, conditions of storage, methods of processing and sometimes areas of origin.

Some researchers have also compared the nutritive value of indigenous vegetables to those of exotic vegetables (Table 5).

Most indigenous vegetables such as cucurbits and *Solanum nigrum* were found to contain ascorbic acid as high as about 160 mg/100 g and 240 mg/100 g. Some of the exotic vegetables such as kale and spinach have been reported to contain about 190 mg/100 g and 50 mg/100 g, respectively, of ascorbic acid (Awino 1989).

Research on the cultivation of indigenous leafy vegetables is being undertaken at Sokoine University of Agriculture, Morogoro, and at the Horticultural Research and Training Institute, Tengeru. These include grain and leafy *Amaranthus*, *Gynandropsis gynandra* and *Brassica*.

Table 3. Dry matter, protein, total ash, vitamin A and vitamin C content of vegetables.*

Vegetable	Dry matter (%)	Crude protein (%)	Total ash (%)	Vitamin A (mg/100g)	Vitamin C (mg/100g)
Amaranthus spp.	14.2	4.3	3.3	5.3	102
Gynandropsis gynandra	15.3	5.7	2.1	10.8	139
Corchorus olitorius	16.3	4.7	2.6	9.2	125
Vigna unguiculata	12.6	4.6	2.0	5.5	87
Solanum nigrum	13.6	4.4	1.4	4.9	112
Curcurbita spp.	15.3	5.1	2.0	7.1	172
Crotalaria brevidens	13.5	4.9	1.4	4.3	190
African kale	11.7	4.5	1.8	4.6	122

* Data on minerals and crude fibre not yet available.

Table 4. Fatty acid composition (% of total fatty acids) in seeds of cleome (*Gynandropsis gynandra*) selections.

Fatty Acid	Selections				
	Purple stem	NIRS-2	NIRS-3	Green stem	Mean
Palmitic (16:0)	11.5	10.7	11.2	11.7	11.2
Palmitoleic (16:1)	0.3	0.4	0.3	0.3	0.3
Stearic (18:0)	6.4	7.6	6.1	6.1	6.6
Oleic (18:1)	19.6	23.9	21.5	22.2	21.8
Linoleic (18:3)	61.1	56.3	59.7	58.6	58.9
Arachidic (20:0)	0.1	0.2	0.2	0.2	0.2
Eicosenoic (20:1)	0.1	0.1	0.1	0.1	0.1

* Source Mnzava (1990 a,b).

Table 5. Nutrient content of some Kenyan indigenous and exotic vegetables (per 100 g edible portion).

Vegetable (local/English name)	Vitamin A (mg carotene) RDA	Vitamin C (mg) RDA	Protein (g) RDA	Calcium (mg) RDA	Iron (mg) RDA
Gynandropsis (Chisaga, saget)	6.7-18.9	127-177	5.4-7.7	434	11
Solanum nigrum (Osuga, esaga, managu)	2.7-7.9	37-141	3.2-4.6	215	4.2
Amaranthus spp. (Terere, emboga)	5.3-8.7	92-159	4.0-4.3	800	4.1
Crotalaria brevidens (Murenda, Apoth)	2.9-8.7	115-129	4.2-4.9	270	3.8
Corchorus olitorius (Mitoo)	3.9-5.4	170-204	4.5-5.5	270	7.7
Cucurbita spp. (Liserere, Marenge)	2.4-5.3	170-172	3.1-4.2	40	2.1
African Kale (Kanjira)	3.7-5.7	102-142	3.6-3.8	520	6
Spinach	2.8-7.4	1-59	2.3-3.1	60-595	0.8-4.5
Cabbage (white)	Tr.-4.8	20-220	1.4-3.3	30-204	0.5-1.9
Cauliflower	Tr.-0.4	8-114	1.8-3.4	13-43	0.2-1.9
Lettuce	0.15-7.8	3-33	0.8-1.6	17-107	0.5-4.0
French beans	0.02-0.6	5-28	1.1-2.4	30-65	0.5-3.2

Constraints and Prospects

Some of the constraints to vegetable development are lack of finance, lack of strong, well-defined programs, lack of adequate personnel and lack of germplasm collections. The lack of adequate conservation facilities frustrated efforts to build good collections. In addition, information on indigenous vegetables remains scanty and often unavailable to researchers in the region.

Genetic Erosion

There seems to be a decline in quantity and type of major indigenous vegetables produced or found growing naturally in the region. Genetic erosion is due to the replacement of indigenous species by the deliberate introduction of exotic vegetables which are well commercialized and studied. It is also due to the rapid transformation of the ecologies in which they have evolved, and the constraints discussed earlier.

Future Prospects

There is a need for a deliberate effort to collect and conserve the large and diverse germplasm of the indigenous vegetables in Southern Africa. This will enable

researchers to systematically evaluate them for their agronomic and nutritive traits in order to boost their utilization.

Indigenous vegetables are better adapted to their ecology and have few insect and disease problems. There is a need for proper information gathering at the national and regional level. An inventory of all existing accessions (along with the passport and existing evaluation data) is necessary. An assessment of the distribution of the various species is needed. There is a need to set up priorities and start work on the diversity that exists on major priority species. The SADCC Regional Gene Bank (SRGB) project is an asset to the region. With the strengthening of national plant genetic resource centres (NPGRC), rejuvenation and proper storage and duplication of the various species is possible and should be initiated as soon as possible.

This has to be a regional effort for the mobilization and utilization of the indigenous vegetables of the region. Personnel training in conservation and utilization of vegetable species is also essential in the region.

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The Vegetable Industry: A SADCC Regional Perspective

N.A. Mnzava*

Introduction

Horticulture, including vegetable production, has been a largely ignored industry in the SADCC region (Kyomo 1988; Rice and Rice 1988). From their early introduction by traders, missionaries and settlers, production of vegetables was restricted to pockets of favorable climate, and invariably where the major consumers established themselves. Dumont (1966) remarked: 'As far as vegetables are concerned, Africa has always thought in terms of European and 'evolue' tastes...this is because they command high prices...The situation is even worse in the rainy season when plants introduced from Europe grow poorly.' As if prophetic on issues now being considered, Dumont challenges: 'Why not develop production of properly 'tropical' vegetables which have originated in Africa or been introduced from South China?' However, the question is not which vegetables should be grown per se, for this is dictated by marketability, but why there has been a total neglect of the vegetable industry in the SADCC region.

Reasons for Neglect

Vegetables were relegated to the 'Miscellaneous' category of crops while desperate efforts were directed towards increased production of cash crops. Even after countries gained independence, increased vegetable production did not become an immediate goal of national development plans. Limited resources were earmarked for increasing 'belly fillers', particularly the staple grains, and continued production of exportable cash crops. It seems that unless a country becomes self-sufficient in staple food production, the vegetable industry (or horticulture in general) remains a non-starter.

The state of the horticultural industry reflects the standard of living. The very definition of horticulture advanced by Wurster and Jensen (1971), as high investment crop production using resources intensively for a high value end-product, signifies that poor regions may not have the horticultural industry as practiced and understood in developed regions. Crop prioritization, though inevitable, has accounted for the neglect of the vegetable industry which was given very little attention.

Production of vegetables is done in riverine valleys or where guaranteed water is available. However, rainfed cultivation is mostly practiced for species that thrive during the rainy season. Conditions of water scarcity have left otherwise productive land untapped, or heavy rainfalls and high humidity result in poor quality and low yields. In SADCC countries, vegetables are a key component in the daily diet of the majority of the population, and with scarcity of 'relish' in form of meat or grain legumes, vegetables are often the cheaper alternative. Despite this, they have been taken for granted and their development has seemingly been postponed.

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Commodity Factors

Vegetables have inherent characteristics which make them difficult to promote under SADCC conditions.

(1) They comprise many and varied species each one offering something different, thus it has often been difficult to choose species for cultivation;

(2) They are not chief suppliers of calories and are merely regarded as supplements to the 'main' food. Indeed, when considering the state of food in a country, vegetables disappear from mention;

(3) Their production is dependent on often expensive inputs;

(4) They are highly perishable, and their seasonal production results in gluts or scarcity, so farmers regard vegetable production as a risky enterprise; and

(5) As they are produced by scattered small farmers in subsistence backyard gardens, or are simply foraged, production statistics are lacking. It's therefore difficult to convince policymakers to accord vegetables a higher priority. Without convincing data, the industry will remain without strong support at the policymaking level.

Agents for Change

The role of vegetables in nutrition and income generation has been recognized by SADCC member states. This is a result of concerted education of the people by many agents. Publicity through statements like 'Grow Vegetables for Health and Wealth' may have converted more to turn to vegetable growing. Recognized deficiency diseases, notably avitaminose-A and dietary anemia, occur in the SADCC region. As observed by Lapasini (1986), the growing of green leafy vegetables stands as a long-term solution for vitamin A deficiency alleviation, echoing an earlier recommendation in Tanzania (Mnzava 1981), in which an olericultural intervention could solve problems affecting the physiologically vulnerable groups – school-age children and women.

The increase in population, especially of the nonfood-producing wage-earners in urban areas, has been the driving force behind the expanding market-garden green belts in periurban areas. In suitable areas geographically apart from major towns, truck farming (e.g. in Tanzania's Uluguru and the Usambaras) has developed to some degree. Conscious efforts to supply daily quantities of vegetables to an urban center are exemplified by Mozambique's 'casa agraria' model (Tembe 1988) and could be emulated. The development of the vegetable industry in the SADCC countries can be seen as a farmer initiative where pecuniary incentive is the predominant driving force. Seemingly, the urge to earn more overrides the desire to eat better. This answers the earlier remark by Dumont (1966).

In recent years, the governments of SADCC member states have begun to recognize the strategic importance of horticulture, especially vegetables (SADCC

1987; Kyomo 1988). Indeed the varied climate in SADCC favors the cultivation of a diversity of species. With this positive policy direction, it should be possible to exploit the existing comparative advantages in vegetable production in a collaborative manner, so that the industry's full potential can be realized.

Vegetable Production and Consumption

Production is small and farmer-dominated, and is practiced in small backyards characterized by a large mix of species. Vegetables are produced for subsistence and the excess finds its way to nearby markets or makeshift roadside stands. Where fertile land, irrigation and quick transport are available, market gardens exist and intermediaries join the marketing chain. It is estimated that market gardens contribute up to 50% of vegetables consumed in developing countries, foraging adds 10% (though declining), and the rest is from home gardens and some commercial-scale production (Grubben 1978). The situation varies between countries in the SADCC region.

Where commercial scale has been attempted the export market is the target. Export figures are not accurate nor has the effort been sustained in some cases. Growing vegetables for export has been described for some SADCC countries (Verheij 1982 for Tanzania, and Mnzava 1986 for Zambia).

The consumption figures for vegetables in SADCC are not known. Grubben (1977) estimated that developing countries consume only 101 g/head/day compared to 221 g/head/day in developed countries, and in countries of Central and East Africa the quantities are lower. The supply of protein from vegetables in most African countries is less than 2 g protein/head/day (Pirie 1976). Understandably, eating habits are a mixture of what is available, what can be afforded, and what one is used to, with quite an emphasis on the latter.

Vegetable Yields in SADCC

Reliable quantitative and qualitative yield data, per unit area, the area under production, and total production are not available. Marketed quantities could be estimated if they were sold through cooperatives, but the ephemeral nature of production makes it difficult to quantify production. FAO (1988) estimates for yield/hectare for tomato and onions are shown in Table 1(A) and (B). The area occupied by tomato, cabbage and onion in some SADCC countries is shown where available in Table 2(A).

Yields are considerably lower for all vegetables in Africa (Table 2(B)), but better in some countries (e.g. tomato in Swaziland, and onions in Botswana, Zambia and Zimbabwe). Production of onion is highest in Tanzania due to a large area under cultivation, and tomato production is highest in Malawi. Yield figures in Africa for most vegetables are generally lower than in other developing countries, developed countries and in centrally planned countries (FAO 1988).

Table 1. Vegetable production statistics in SADCC.

	Tomato yield (kg/ha)			
A	1979-81	1986	1987	1988
Angola	1500	1500	1500	1500
Malawi	9022	9143	9167	9189
Mozambique	9744	9615	9615	9615
Tanzania	7897	7727	7609	7500
Swaziland	13333	14000	14000	14000
Zambia	11145	11020	11000	10980
Zimbabwe	7012	6812	7059	7222
Africa	10757	10023	10535	9741
Developing Countries	15819	17668	18547	18516
Developed Countries	28211	33387	33037	32104
Centrally Planned	17503	19456	19523	19845
	Onions (dry) yield (kg/ha)			
B	1979-81	1986	1987	1988
Botswana	16667	16667	16667	16667
Malawi	3166	3617	3750	3878
Mozambique	4667	4400	4400	4400
Tanzania	2097	2043	2000	1960
Zambia	19697	16667	16250	15882
Zimbabwe	16797	16500	1700	16667
Africa	12860	12707	12035	11969
Developed Countries	24591	26416	24097	26594
Developing Countries	17137	18991	18172	18248
Centrally Planned	19033	21445	20149	22063

Important Vegetable Species

Tomato, cabbage and onion dominate as important species, however, based on dietary patterns in the SADCC region, other leafy vegetables, many of which are less conspicuous, are very important. Notable among these are kale and rape in Malawi and Zambia, tronchuda in Mozambique, amaranth in Tanzania, and chard and spinach in Botswana, Lesotho and Swaziland. Many others, best referred to as unconventional and indigenous, are invariably utilized and hold considerable promise (Mnzava 1989).

Constraints to Vegetable Production

The low vegetable yields are due to biotic, abiotic and institutional factors. Biotic factors include: unavailability of suitable cultivars; prevalence of pests and

Table 2. Vegetables in SADCC countries in 1988 (FAO 1989).

	Country								
	Angola	Botswana	Lesotho	Malawi	Mozambique	Swaziland	Tanzania	Zambia	Zimbabwe
A. Area ($x10^3$ha)									
Tomato	2	-	-	4	1	-	2	3	2
Cabbage	-	-	-	2	-	-	-	-	-
Onion	-	-	-	5	1	-	25	2	-
B. Production ($x10^3$t)									
Tomato	3	-	-	34	13	4	18	28	13
Cabbage	-	-	-	27	-	-	-	-	-
Onion	-	1	-	19	2	-	49	27	4
Pumpkin	-	-	-	-	1	-	-	-	-
Garlic	-	-	-	-	-	-	1	-	-

diseases; inadequate supply of quality seeds; and lack of appropriate production packages. Abiotic constraints include: unfavorable climate arising from high temperatures, high rainfall, drought which results in seasonality of production; and infertile soils. Institutional constraints include: poor marketing infrastructure, undeveloped seed supply and distribution system, poorly staffed, underfinanced and uncoordinated research and extension systems; lack of credit facilities, and incoherent development plans for the industry. The industry is faced with a complex of problems and solving one or two may not be sufficient to cause noticeable impact. For example, encouraging irrigation for vegetable production without organizing marketing, or producing seed without addressing other linked issues in the industry, may not stimulate growth. Likewise, where there is little horticultural tradition like in many parts of the SADCC region, rigorous training and extension would be essential for a step-wise development of the vegetable industry. Little investment in vegetable processing to absorb excess production has resulted in increased wastage and hence is a deterrent to increased production.

Support Services in SADCC – Why Vegetable Research Has Little Impact

Vegetable producers are avid seekers of new information and varieties. Vegetable research programs in SADCC are handicapped by lack of staff and resources (Mnzava 1988a) and often have little impact. Each program takes a too-broad research strategy leaving resources thinly spread. An example is a six-objective research agenda in Zambia executed by a handful of technicians based at one site addressing no less than 10 species operating in three seasons yearly. The opposite is shown by Tanzania's better staffing and multilocational approach. Their problems would be in programing and coordination. Many programs opt to address commercial producers instead of the many small-scale farmers, and as a consequence little

impact is ultimately visible. Likewise, the small amount of vegetable production technology generated by research cannot reach small-scale farmers because the extension system is weak. The major thrust in each program must be clearly targeted to small-scale farmers with a proper understanding of their needs. In order to fill the staffing gaps, technical assistance failed to recognize differences between vegetable species, cultural practices desired by commercial producers from those which work best in home gardens, and has often resulted in ineffectiveness of some programs (Dumont 1966).

Despite the apparent general weaknesses of national vegetable research programs in the SADCC region, pockets of strengths are perceptible. The recognition of research as a critical element in the vegetable industry in SADCC is seen from the influx of donor-supported programs – seed production in Tanzania and Zambia, tissue culture in Zimbabwe, collaborative efforts with other institutions in Tanzania and Malawi, and research and training in Tanzania.

Vegetable Seeds

Collectively, the SADCC countries can produce most of the vegetable seed needed. Most vegetable producers in the region save their own seeds. About 80% use their own seeds (Linnemann, pers. comm.) with the effect of perpetuating diseases and poor-quality produce. With ample research backing up seed production, seed testing and control, and a marketing institution as exemplified by Zambia, dependence on imports could be avoided. Instead of national seed companies being conduits of seed bred and produced in the temperate zone, local breeder ingenuity could be nurtured to create locally adapted varieties. A collaborative venture in vegetable research could make this possible.

The development of indigenous vegetables deserves some emphasis as the target group – the small-scale farmers – are the beneficiaries. Although widely utilized in the SADCC region, they are virtually forgotten in the research agenda of most countries. Advocates of their development include FAO (1985), Dumont and Cohen (1980) and Pirie (1976).

Apart from the vegetable research and seed supply, key support services, namely market information and infrastructure, development of irrigation, and input supply, should receive emphasis in order to boost the SADCC industry. The equally critical issue of specialist staff development with reference to the SADCC region (Mnzava 1988a) needs to be addressed. In order for a country to benefit from a regional collaborative effort, it must have a program in existence, and the program must be sufficiently strong. However, the challenges of the vegetable industry in the SADCC region are many, but as Hopper (1989) stated: 'Mankind is at the edge of a horticultural revolution.' We in the SADCC region must take part.

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Vegetable Seed Production in the SADCC Region: Status, Problems and Future Prospects

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Introduction

Vegetable production in the SADCC region is a neglected industry. Production, predominately subsistence in nature, is based on small backyard gardens, although there have been increases in market-oriented production in market gardens and commercial-scale production. One of the key elements accounting for the poor performance both in quality and quantity of vegetables produced has been the lack of seed. This is a major problem encountered in the rural areas of most SADCC countries. As the vegetable industry is closely related to the size and development of commercial vegetable farming, the status of the seed industry in SADCC can be described as rudimentary, since commercial vegetable farming is only in its infancy.

Vegetable Seed Sources

In the SADCC region as a whole, where a strong horticultural tradition has not existed, vegetable seed has always been considered as a commodity product and not as a quality product.

Seeds used or sold are unselected by-products of vegetable farming. Most small-scale farmers traditionally save their own seed, often from the unmarketable fruits or virtually without conscious selection (Grubben 1978). Whatever can flower and fruit is used as a seed source. Notable among these are the legumes, cucurbits, the solanacea and some cruciferous vegetables. The indigenous vegetables (amaranthus, etc.) are a special category where seed is exclusively produced by the farms. Market gardeners and the emerging commercial farmers must search for seed that will allow them to produce what the market prefers. Vegetable seed for biennials (e.g. carrot, cabbage, chard, onion, etc.) has to be purchased whenever available.

Vegetable seed importation has been a regular practice in most SADCC countries. Reliable importation figures are difficult to obtain as the vegetable seed trade has not been centralized. Despite regulations governing plant introductions, many unique vegetable cultivars are to be found around home gardens and town markets.

Reliance on importation has its own problems; among them is the introduction of unadaptable varieties previously tried in a country, introduction of pests, and seed-borne diseases, and a continuous drain on scarce foreign exchange (Buttenschon 1985). The current trend of marketing vegetable hybrid seed has been a deterrent in promoting seed sales, because most farmers do not realize their value. Importation of

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hybrid seed creates a dependency on temperate-zone breeder ingenuity, and perpetual importation may not be avoided. Thus the issue of an endogenous vegetable seed supply system in SADCC deserves urgent attention at a time when the industry is at a critical take-off point.

Problems of Vegetable Seed Production

Attempts to produce vegetable seed in some SADCC countries date as far back as two decades (e.g. with haricot beans in Tanzania), and ample descriptions on the needed practices in Zimbabwe have been published. There are a number of problems associated with vegetable seed production which have accounted for the slow development of the industry. Among these are:

(1) The stress placed on seed of staple crops which are relatively easier to handle;

(2) The weather prevailing in some SADCC countries, particularly in areas with bimodal rainfall pattern, does not permit some vegetables to flower and mature seed before the onset of rains. It is only in areas with monomodal rainfall where success can be achieved;

(3) In tropical environments, disease pressure is high and often expensive to control, therefore without proper chemical control even the produce (e.g. fruit) is of poor quality;

(4) Vegetable crops are varied, and there has been a general apathy towards developing them. Government policy on vegetable crops is recent, and has been dictated by the unavailability of resources, both human and fiscal, to venture into the vegetable seed industry;

(5) Without research directly towards seed production, or indeed a weak vegetable research system to screen varieties and recommend and solve production problems, it has not been possible to locally produce vegetable seed in most countries in SADCC;

(6) Although national seed companies are in place in most countries, there has been a tendency to import, repackage (reliable) and resell vegetable seed. There has been more emphasis on those that generate profits;

(7) Production costs for vegetable seed are high, since in most species the seed is a product of the 'crop' itself (e.g. the opportunity cost of selling carrots or onions as produce as opposed to letting them go to seed is high);

(8) There are no specialized seed growers in the region who know the needs of vegetable seed crops.

Vegetable seed production requires that the following precautions be taken during seed multiplication (George 1979).

(1) Cross-pollination, mechanical admixture, disease and pest control, and seed deterioration. The obvious lack of local expertise in vegetable seed production in the region and a weak extension system have contributed to the low state of the vegetable seed industry; and

(2) High temperatures and humidity accelerate vegetable seed deterioration. In the absence of cool storage or insulated packaging, the timely distribution of seed to remote areas without loss of seed viability has been difficult.

The Zambian Initiative

Traditionally, Zambia imported all its vegetable seed requirements. The trend continued after independence and there was no concerted effort towards self-sufficiency of vegetables until 1981. Basic requirements for any meaningful seed production program are the identification of suitable cultivars with local adaptation, high yield, resistance to common diseases and pests as well as capability for seed production under local climatic conditions. Work on variety evaluation began in September 1978 at the National Irrigation Research Station (NIRS), Nega Nega, under the auspices of the Ministry of Agriculture and Water Development (MAWD). Work has continued since them and has prepared the way for local seed production.

With the inception of the Zambia Seed Company Limited in 1981, local seed production of recommended cultivars was initiated. The impetus for this program was provided by SIDA through Svaloef AB of Sweden. Prior to 1981, the production and importation of most seeds was organized by National Agriculture Marketing Board (NAMBOARD), Seed Services, now known as the Seed Control and Certification Institute (SCCI) and the Zambia Seed Producers Association (ZSPA). From the beginning Zamseed proved to be a vigorous young company that had to do a lot of work in order to satisfy the country's crop requirements.

In 1981, Zamseed included the production of vegetable seed. It became fully responsible for the production (through multiplication), procuring (through importation when necessary), processing and storage and national distribution of high-quality seeds. From 1981 to 1989, vegetable seed production was concentrated in a 50-km radius of Lusaka. Besides the availability of good soils and water, the most important factor is dry hot weather during the harvesting of seeds. Lusaka and the surrounding area is almost free of any rains during the period from June to September. The temperature is also higher in September and October (32°C). Relative humidify is lowest in September (39%). This is very conducive to seed crops.

Most vegetable crops therefore are planted from the end of February to mid May. Crops depending on their duration come to harvest during June to October, which are rain-free, low-humidity months.

Components of the Zambia Seed Industry

The Zambia seed industry consists of the following components:

The Seed Company

This group is responsible for the local production of vegetable seeds. Local production of vegetable seeds for those species that can grow in Zambia is done through contracts with selected farmers who grow government-approved seeds, under determined hectarages. Types that cannot be produced locally are produced under contract with other companies abroad, based on predetermined quantities. This is much cheaper than direct importation from seed houses abroad.

Vegetable Crop Research (VCR)

Plant introduction and breeding are the responsibility of this group. They also provide recommendations on varieties on the basis of agricultural environments in the country. VCR is also the source of all parent materials (prebasic seed) to the company, and carries out varietal descriptions of new varieties to be released. The latter function is undertaken by the Research Branch of the Department of Agriculture.

Variety Release Committee

This committee is responsible for the release of all new crop varieties to be grown in the country. The committee is made up of different institutions, and Zamseed, SCCI and ZSPA are members. It is headed by the Director of Agriculture from the Ministry of Agriculture.

Different characteristics for each variety are studied (e.g. yield, disease resistance, etc.) before a variety is approved for release. The committee also recommends the phasing out of obsolete varieties.

Seed Control and Certification Institute

The functions of the institute were separated from those of research and involved quality control and certification. The institute is under the Permanent Secretary, Ministry of Agriculture (as controller of seeds). Seed certification is carried out according to OECD rules whilst ISTA regulations govern sampling procedures and laboratory testing.

Marketing

About 50% of all vegetable seeds are sold at the Zamseed main Marketing Department Sales Shop, and 50% sold through stockists.

Zambia Seed Producers Association

This is the parent body of our seed growers. It is responsible for price negotiations with Zamseed.

Promotional Efforts

Research

The Vegetable Research Program previously concentrated on testing and selections of vegetable species most familiar to settlers (e.g. cauliflower, Brussels sprouts, etc.), in accordance with one of its objectives 'to conduct research so as to develop indigenous vegetable species in Zambia'.

The vegetable research program has carried out studies on *Amaranthus* spp., *Solanum macrocarpon* and local selection of *Brassica carinata*. A small germplasm collection of these and other tropical species, notably *Ipomoea aquatica* and *Basella* spp., has been established.

Extension Branch

A notable promotional effort made was the publication in 1984 of a handbook on local fruits and vegetables and a book on vegetable seed production by Zamseed, which now needs to be expanded and reprinted. The role of the mass media to create a wider awareness needs to be discussed and encouraged.

Zambia Alliance for Women (ZAW)

In 1985, ZAW organized a Workshop that addressed local Zambia vegetables, and the publication of the proceedings (FAO 1985) increased awareness of local vegetables. Since these are crops handled by women, this group is key, and any promotional effort by them would have far-reaching effects.

Indigenous Vegetable Seed Production

Between 1981 and 1984, Zamseed vegetable seed production concentrated on a few crops. By 1985, the company decided to focus on small-scale farmers promoting indigenous vegetables through production and sale of seed.

This was designed to take care of one major production constraint – the unavailability of seed of these species. Thus seeds of *Amaranthus cruetus* ('Unza - A', 'Unza-2'), *Corchorus tridens, Brassica carinata* and *Solanum macrocarpon* are being marketed.

Table 1 gives an account of seed production by Zamseed since 1981. Peak production amounting to over 137 ha under 22 different crops was in 1984. This included indigenous vegetables, producing a total of over 43 ha.

Production thereafter dropped as most crops were in excess stock. By 1989, acreage had stabilized to an annual average of 70–80 ha.

Zamseed, in conjunction with the Ministry of Agriculture, has trained over 30 farmers in vegetable seed production covering a wide range of crops, and has produced relevant literature in this area.

Table 1. Zamseed vegetable seed production, 1981-90 (in hectares).

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Beans 'Contender'	-	5.0	-	14	25	-	-	2	6	33.5
Peas 'Dark Skin Perfection'	-	2.0	9.0	15	25	-	-	6	3.9	20.25
Capsicum 'California Wonder'	0.5	-	-	-	-	-	0.25	-	1.25	1.5
Chillies										
Mufulira Market II	0.5	-	-	2	-	-	-	-	0.25	.25
Eggplant 'Black Beauty'	1.0	-	2.25	6	-	-	2	-	0.25	.25
Tomato 'Money Maker'	-	-	-	-	-	-	-	-	-	-
Tomato 'Heinz 1370'	4.75	15	18	45	-	-	-	-	-	-
Tomato 'Roma'	-	-	-	-	-	-	-	-	1	-
Watermelon 'C Sweet'	1.75	0.25	1.5	5.0	-	-	-	-	-	2
Musk Melon 'Punjab'	-	-	-	0.01		0.25	-	-	-	-
Pumpkin 'Green Boer'	0.05	1.0	9	14	-	-	-	-	-	1
Squash 'Caserta'	-	-	-	-	-	0.50	-	-	-	-
Cucumber 'Palomar DMR'	-	-	-	-	-	10	-	-	-	-
Okra 'Clemson Spineless'	-	-	-	-	9.0	-	-	-	-	-
Lettuce 'Great Lakes'	-	-	-	-	-	1.0	-	0.25	-	-
Rape 'Prior'	-	2.0	24	30	-	-	-	-	-	-
Rape 'Karate'	-	-	-	-	-	1	-	-	3	1
Onion 'TE Grano'	-	-	-	2	0.2	1	-	-	-	-
Onion 'Pusa Red'	-	-	-	0.1	-	-	-	-	-	-
Cabbage 'Chihili'	-	-	-	-	0.4	-	-	-	3	2
Cauliflower	-	-	-	0.1	0.05	-	-	-		-
'Improved Japanese'	-	-	-	0.1	0.05	-	-	-	-	-
Carrot 'Cape Market'	-	-	-	0.5	1.0	-	-	-	4	-

Table 1. Zamseed vegetable seed production, 1981-90 (in hectares). *(Continued)*

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Swiss chard 'SW1'	-	-	-	0.5	0.5	-	-	-	-	-
Amaranthus 'UNZA A1'	-	-	-	2.0	-	-	-	-	0.25	-
Amaranthus 'UNZA A2'	-	-	-	-	-	-	-	-	-	-
Corchorus Local	-	-	-	0.25	0.5	-	-	-	-	-
Solanum Local	-	-	-	0.5	0.5	-	-	0.25	0.25	4.0
Cleome Local	-	-	-	0.5	0.5	-	-	-	0.25	1
Brassica Local	-	-	-	0.25	0.75	-	-	-	0.25	1

Zamseed vegetable seed production, 1981-90 (yield in kg).

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Beans 'Contender'	-	1666	-	8560	21354	-	-	840	3000	10530
Peas 'Dark Skin Perfection'	-	1062	7121	14784	Cancelled	-	-	3760	1660	*
Capsicum 'California Wonder'	20	-	-	-	-	-	8.7	-	29	-
Chillies										
Mufulira Market II	50	-	-	41	-	-	-	-	48	*
Eggplant 'Black Beauty'	4	-	364	386	-	-	156	-	40	*
Tomato 'Money Maker'	-	-	-	-	-	-	-	-	-	-
Tomato 'Heinz 1370'	200	514	685	534	-	-	-	-	-	-
Tomato 'Roma'	-	-	-	-	-	-	-	-	36	*
Watermelon 'C Sweet'	80	55	70	Failed	-	-	-	-	-	-
Musk Melon 'Punjab'	-	-	-	1.0	-	13.3	-	-	-	-
Pumpkin 'Green Boer'	01	185	120	630	-	-	-	-	-	98

(Continued)

Table 1. Zamseed vegetable seed production, 1981-90 (yield in kg). (Concluded)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Squash 'Caserta'	-	-	-	-	-	102.5	-	-	-	-
Cucumber 'Palomar DMR'	-	-	-	-	-	397	-	-	-	-
Okra 'Clemson Spineless'	-	-	-	-	3450	-	-	-	-	*
Lettuce 'Great Lakes'	-	-	-	-	-	41.9	-	8.1	-	-
Rape 'Prior'	-	190	9000	16529	-	-	-	-	-	-
Rape 'Karate'	-	-	-	-	-	43	-	-	236	-
Onion 'TE Grano'	-	-	-	237	8.0	131	-	-	-	*
Onion 'Pusa Red'	-	-	-	Experimental	-	-	-	-	-	-
Cabbage 'Chihili'	-	-	-	-	58	-	-	-	72003	*
Cauliflower	-	-	-	-	0.5	-	-	-	-	-
'Improved Japanese'	-	-	-	-	Nil	-	-	-	-	-
Carrot 'Cape Market'	-	-	-	82	Nil	-	-	-	355	-
Swiss chard 'SW1'	-	-	-	146	77	-	-	-	-	-
Amaranthus 'UNZA A1'	-	-	-	438	-	-	-	-	5	-
Amaranthus 'UNZA A2'	-	-	-	-	-	-	-	-	-	-
Corchorus Local	-	-	-	173	242	-	-	-	-	-
Solanum Local	-	-	-	24	5	-	-	10	20	440
Cleome Local	-	-	-	10	97	-	-	-	80	*
Brassica Local	-	-	-	33	35	-	-	-	20	*

* Crops still in the field.

Future Scope

Zambia is now geared to produce all the requirements of locally producible vegetable seeds. Work, however, should go on in local testing and breeding of cultivars suitable for specific needs of Zambia and neighboring countries. This involves selection and breeding of cultivars capable of growing during the rainy season and with better shelf life. Breeding and improvement of indigenous vegetables remain the exclusive responsibility of Zambian researchers, and there is need for a promotional strategy.

Problems

Parent Seed

At present, we are depending entirely on imported parent seed material except for a few local crops and their cultivars. We have at times received parent materials which are genetically mixed. Such a situation is not conducive to the growth of a vegetable seed production program.

Field Processing Equipment

Unlike field crops and potatoes, vegetable seeds are grown in small- and medium-level farms with limited capital. Mechanical means of harvesting and threshing of dry seeds like peas, beans, rape and the like, and extracting seeds from wet fruits (like tomato, eggfruits, peppers, melons, cucumbers, squash, etc.), are the only means by which we can sustain our present level of production.

Threshing seeds by sticks and extracting wet fruits and seeds by hand is expensive, accounting for almost 60% of the cost of production in some of these crops.

It is not always possible to obtain the required seasonal labor in time, so the present growers are reluctant to take up further seed production of these crops.

Producer Prices

The opportunity cost of selling seed and that of the whole crop fruit is considerable where wet fruits are concerned. Farmers feel that it is more profitable if they sell the whole watermelon or pumpkin fruit than to sell the seeds, thus many refuse to grow these crops for seed.

Future Prospects

Collectively, SADCC countries have the necessary climate to produce most vegetable seed. The highlands around Kilimanjaro and the cool areas in Zimbabwe, Lesotho and Swaziland are examples of regions where cool-season vegetables can flower. Systematic multi-site cultivar evaluation is required to recommend product packages, and we need to create institutions responsible for certification, production and distribution. Production constraints facing the industry, of which the seed issue is only one, need to be addressed.

The key role of sustained and targeted vegetable research needs to be emphasized. At the SADCC regional level, collaboration in research to develop appropriate vegetable seed production technologies and exploit physiographic advantages would encourage development of the industry.

As each country is initiating vegetable production through donor assistance (e.g. FAO/UNDP in Tanzania, SIDA (Svaloef AB) in Zambia, ARDA in Zimbabwe), shared experiences on germplasm exchanges can benefit all.

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COUNTRY PAPERS

Botswana

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Introduction

Botswana imports substantial amounts of vegetables amounting to millions of pula (Botswana Currency; ~4 pula = $US1) per year primarily from the Republic of South Africa. Local production is estimated at about 20% of the total vegetable requirements of the country. Though the government has initiated several programs to qualitatively and quantitatively improve horticulture production, only marginal improvements have taken place. This is partly attributed to lack of horticultural background, production inputs, complexity, and inadequately trained personnel in horticulture.

Background

Botswana is traditionally a livestock and dryland farming country. At independence the agricultural sector contributed about 40% of the country's Gross Domestic Product (GDP). Preliminary 1987-88 GDP estimates put the sector's contribution at about 4%. This dramatic decline for the sector is largely due to the mining sector increasing from almost zero in 1966 to about 45% in 1987-88 (Ministry of Agriculture 1990).

In 1967-68, the agricultural sector contributed 27% (7570) to the total formal sector employment of 28 148, and government came second with about 21%. As a result of dramatic economic transformation in Botswana, estimated formal sector employment in agriculture as at 1987-88 stood at 5600 or 4% of total formal sector employment of 150 200. The government sector employed about 35% of the figure. The mining sector, as expected, is capital-intensive and provided jobs to about 5% of the 1987-88 estimated formal sector employment (Ministry of Agriculture 1990).

Despite the decline in the agricultural sector's contribution to Gross Domestic Product and total formal sector employment, Botswana will for a long time depend on this sector for food, income, employment and investment capital.

Of the estimated 1.3 million people in Botswana, about 76% live in the rural areas and derive their livelihood mainly from agriculture. In agriculture, the major dominant production activity, both in income and employment, is livestock, primarily cattle. However, cattle contribution is heavily skewed with about 40% of the farming households without cattle, while over 60% of the national herd of 2.3 million is owned by fewer than 10% of the farming households (Ministry of Agriculture 1990).

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Botswana is poorly supplied by rain, hence all the vegetable production is under irrigation. The average rainfall varies from 650 to 700 mm in the extreme north, to 150 - 200 mm in the extreme southwest. The extreme variability in seasonal totals, and effectiveness of rainfall, is significant. The high number of hours and intensity of sunshine (lack of cloud) leads to rapid growth, but causes problems of germination of vegetable crops, plus rapid cooling at night. The high diurnal temperature variation is most marked in the south and west of the country.

Arable farming is primarily subsistent and largely constrained by management and very poor weather conditions, both spatially and temporally. In general, the agricultural sector is dominated by mixed farming (livestock and crop production) as a multifaceted strategy to spread risks, particularly the traditional sector.

Botswana agricultural policy objectives (Ministry of Agriculture 1985) are aimed at:

(1) Providing adequate and secure livelihood for those involved in Agriculture;

(2) Increasing agricultural output;

(3) Increasing self-sufficiency;

(4) Conserving agricultural land resources; and

(5) Meeting the employment demands of a growing labor force.

Policy objective (3) above has been changed to Food Security. Given Botswana's physical/climatic conditions, economic and human resources cannot achieve food self-sufficiency, hence the shift towards food security (Ministry of Agriculture 1990). Policy proposals for the entire Ministry of Agriculture are under review.

Review of Horticultural Sector

There is a steadily increasing trend in local vegetable production. This is in the face of unfair competition from producers from South Africa and elsewhere, who flood the market with vegetables while our farmers cannot sell for the following reasons: (i) lack of transport or poor road conditions; (ii) long distance to market sites; (iii) lack of growers' expertise; (iv) high costs of production resulting in disparity in price indices between Botswana and Republic of South Africa which favors the latter; (v) high temperatures especially during summer months (November - January) which hinder growth of certain vegetable types; and (vi) unavailability of marketing facilities at or near places of production.

Incentives

The government of Botswana has adopted a package of incentives that are intended to minimize constraints to horticultural development.

A Financial Assistance Policy was started in 1982 to assist productive businesses, including horticulture, for economic diversification and employment creation. Individual entrepreneurs and limited liability companies venturing into various scales of horticultural production benefit from the Financial Assistance Policy (FAP) that provides up to 80% of the total cost of the project as a grant to the entrepreneur (Horticulture Annual Report 1988-89).

Agricultural Extension Small Projects Programme (AE10, AE11) started in 1978 with funds from United States Agency for International Development (USAID) to assist a group of producers involved in horticultural production. The objectives are to assist small-scale farmers, who work in groups of five members or more (a) to increase horticultural production to achieve food security in horticultural products; and (b) to create rural employment and economic diversification (Horticulture Annual Report 1988-89).

The program provides grants to farmers for infrastructure development to a ceiling of P15 000 and working capital for provision of inputs for a period of 6 months to enable farmers to raise their first crop. The Group's contribution is 10% of the total investment which could either be in kind or cash.

Credit Institutions

Financial and commercial institutions such as National Development Bank (NDB), Barclays, and Standard Chartered Banks provide unsatisfactory services to the farming community by being reluctant to offer credit. The other reason is that most growers do not have anything to offer as security to the financial institutions. Horticulture is a labor- and water-intensive undertaking, but risks involved in failure are high due to insufficient water and market uncertainty within Botswana (Logens and Mrena 1986).

Marketing Facilities

There are proposals pending regarding the construction of better-equipped central market facilities in Gaborone, Francistown and Lobatse. Large, centrally located facilities with adequate storage are expected to improve the marketing channels for local producers, as well as to increase the availability of local produce to traders and individual consumers. The markets would be run on a strictly commercial basis without government assistance except during initial stages.

Import Permit System

The government of Botswana has taken certain actions to assist the marketing for the horticultural industry (Horticulture Annual Report 1988-89). In order to stimulate domestic production, the government has taken steps to reduce competition from growers in the neighboring countries. An import permit has been instituted, whereby traders and licensed dealers are required to have permits to import selected crops that are also grown locally. Vegetable crops requiring import permits include

cabbage, tomatoes, onions and potatoes, and these are priority crops in Botswana. During the season of sufficient local production, importation is limited. Traders are thus encouraged to purchase local produce first before importing.

Technology Development

Personnel

Horticulture like many other sectors has continued to face a critical shortage of qualified personnel (Table 1). Despite the government's concerted efforts during all development plans to increase qualified personnel through training, the supply has not met demand, hence the reliance on expatriates.

Table 1. Current personnel distribution (excluding expatriates).

Institution	Certificate	Diploma	BSc	MSc	PhD
Research	1	2	1	1	-
In-Training	-	-	-	-	-
Extension	5	10	1	-	-
In-Training	-	-	5	1	-
BAC	2	1	-	-	-
In-Training	-	-	1	-	-

Personnel distribution of the three main institutions involved in vegetable research, training and development is shown in Table 1. There are six expatriates, one PhD, one MSc and four BSc, all in horticultural extension.

Training

Botswana Agricultural College (BAC) continues to provide technical skills in general agriculture with certificate and diploma training including the recently introduced degree program (Kemsley 1990). However, only 45 hours is allocated to vegetables in both diploma and degree programs. In addition to the above training programs the college plans to introduce a diploma course in irrigation engineering with the first batch of students in February 1991. The college will also establish in 1991 a center for inservice and continuing education which will be able to offer specialized courses in agriculture (Kemsley 1990).

Specialized training will continue to be pursued both overseas and from within the region.

Research

Agricultural research is an integral part of the Ministry of Agriculture. It contributes to the national development objectives by identifying technologies and opportunities for improving the productivity of the agricultural sector. It addresses

various commodity and factor production problems perceived to be constraints to production.

The Horticultural Research Unit, in the Department of Agricultural Research, is the officially recognized institution doing research in vegetables. However, there are other institutions doing limited research in vegetables, and these include the Botswana Development Corporation (BDC) and Sanitas. BDC is a parastatal organization and produces substantial amounts of locally produced vegetables. Sanitas, which is a privately owned farm, is experimenting with and growing vegetables on concrete benches which use river sand as the medium of growth. The system seems to have potential advantages over the conventional method of vegetable production. However this has yet to be determined. Though the initial costs of the system are high, some of the advantages include low water use and minimum or no tillage required.

The Horticultural Research Unit, which is part of the Department of Agricultural Research, carries out research on fruit and vegetable crops most commonly grown and consumed in Botswana. The aim is to provide recommendations for production of these crops with reference to time of planting, varieties, pest and disease control, and other cultural practices for horticultural producers throughout Botswana.

The Unit is also engaged in a project to evaluate production of vegetables on concrete benches, and a program on indigenous vegetables has been initiated.

Extension

National policy on vegetables can be summarized in the goals of horticultural extension insofar as they relate to vegetable production. They are:

(1) To increase productivity of horticultural estates/projects so as to diversify the economic production base and enrich the nutritional status of the people;

(2) To satisfy the bulk of the horticultural requirements of the people;

(3) To make vegetable production a viable and profitable business, and

(4) To generate productive employment for the fast-growing labor force and food security in the area of vegetable production.

Horticultural training for the grassroots (certificate) to graduate level is available to extension personnel at local colleges, African institutions and overseas institutions. Emphasis is also placed on non-formal, on-the-job training of field staff, through (a) organized study tours to places of vegetable production in other SADCC countries (Zimbabwe 1989, Swaziland for farmers and officers in 1990); (b) teaching seminars; and (c) short courses conducted for farmers at farmer training centers.

Visits to horticultural estates and projects are a regular feature of the activities of the government horticulture extension personnel. Technical advice on all matters

related to vegetable production is offered. On horticultural estates there are resident estate managers with an agricultural background.

In addition, weekly radio broadcasts on the techniques of vegetable production and the related problems and their control have begun. Subjects being treated are seeds, seedling care, cultural operations and agronomic practices, disease, weeds and pest control; irrigation requirements and practices; postharvest care and storage.

Vegetable Production Constraints

Lack of Horticultural Tradition

Batswana have generally been people who gathered wild vegetables (indigenous) and grown some with their field crops. The reservoir of vegetables in the wild has dwindled, so people are now faced with a new task of growing mostly the exotic vegetables to continue the supply. Growing these vegetables (i.e. cabbage) requires practical experience which is traditionally lacking in our people.

Unfavorable Climate

Production of quality vegetables is difficult if climatic conditions are not favorable. In summer, temperatures are usually higher than the optimum temperature requirements for most vegetables. This is also compounded by the heavy occurrence of pests and diseases (Namponya 1988). Farmers are therefore not able to overcome these problems and they shy away from producing vegetables. An ideal time for growing most vegetable crops is winter, but winters in Botswana are severe for some crops like potatoes and tomatoes.

Quality and Quantity of Water

Botswana as a dry country has limited water resources. Crops that are grown in the country have adapted to drought conditions. Water requirements for vegetables are high and one cannot rely on rainfall. To establish a successful horticultural project a reliable water source is required. Most commonly in Botswana reliable water sources are wells/boreholes, and we have no dams for irrigation. Pumping water is very expensive, especially if you compare this with neighboring South Africa and Zimbabwe. The cost of untreated water from the Water Utilities Cooperation in Botswana is much higher than in South Africa or in Zimbabwe (Logens and Mrena 1990).

Similarly, the tariff charges for the use of electricity in irrigation schemes is prohibitively high. In most countries electricity used for irrigation is provided at highly subsidized rates (e.g. energy costs in South Africa and Zimbabwe are about one-third of the price charged in Botswana) (Logens and Mrena 1990).

Horticulture Inputs

Most of the horticultural inputs are available in Botswana, but they usually do not reach rural farming communities. It will be easier for farmers who are near the

major centers. Inputs such as pesticides and irrigation equipment are too expensive for the average farmer.

The insufficient supply of horticultural resources and services raises the price and production risks.

Shortage of Trained Horticultural Personnel

The Ministry of Agriculture provides support services through the Horticultural Unit in the Department of Crop Production and Forestry, and the Research Unit in the Agricultural Research Department. All these units lack adequate staff and facilities to support vegetable production. The few staff in Extension Services are located in Regional Offices. They do not cover the grassroots farmers adequately. The results are that the industry is expanding very slowly.

Market and Marketing Facilities

This is one area requiring improvement. There are no organized markets and marketing facilities. Small farmers do not produce enough for the market (either wholesalers or retailers), so these small farmers should logically pool their produce in designated markets from which wholesalers could buy. Efficient cooling facilities are unavailable especially for the perishable commodities. Farmers must harvest and sell these perishables immediately, before they lose their quality.

Transportation and Communication Facilities

Roads are bad and in some cases are not accessible to production sites or to the markets. As a result some producers like BDC sell their produce in South Africa, because they are nearer that country and it is cost-effective to sell there. In some cases the growers have to choose growing certain durable crops (i.e. cabbage) instead of the perishable crops. Lack of communication facilities makes it difficult for farmers to have contacts with the markets. This results in growers loading the produce into a truck and aimlessly hunting for people to buy the vegetables. The prices that farmers receive are low because the price structure is determined by more efficient and developed South Africa markets. Prices on the main South Africa markets are usually lower than Botswana prices because of cheap irrigation water and economies of scale due to large mechanized production.

Strategies for Future Development

The government is reviewing the agricultural sector policy to diversify the economy from the livestock and diamond-dependent economy, by allocating scarce resources to meet the country's socioeconomic objectives such as employment generation and promoting household food security.

The agricultural sector will under a food security strategy diversify into technically and economically viable enterprises such as fruits and vegetable production, which will efficiently use scarce resources and generate employment.

Although agriculture is the most important life-sustaining industry in Botswana, arable agriculture in general has performed below expectations because of agroclimatic conditions.

Horticulture, being labor- and water-intensive, is expected to contribute significantly to the economy and the agricultural sector after the development of the National Water Master Plan, which will enhance water conservation for irrigation (Logens and Mrena 1990). Already, there are many small as well as medium-sized dams in several parts of the country that provide readily available sources of water for irrigation. More big dams are planned in National Development Plan VII, mainly for irrigation rather than the existing dams which are specifically for domestic and industrial water use. Capital development in irrigation and construction of roads will remain the responsibility of the government and growers will pay water use charges.

The availability of water resources will improve food security at both household and national level and diversify the agricultural production base for more income opportunities.

Marketing

As stated earlier there is a proposal pending regarding the construction of better equipped, central marketing facilities in major population centers. Large centrally located facilities with adequate storage will extend the availability of locally produced vegetables. In some parts of the year, certain crops are over-produced resulting in loss or low return to the grower. The storage facilities will hold produce during such periods, hence extend the supply period. The government of Botswana, specifically the Ministry of Agriculture, will not engage in marketing. The markets will be run on purely commercial basis by the Farmers Marketing Association. It is government policy that marketing of agricultural produce can be more efficiently undertaken by the private sector.

Personnel Development

This is one of the multifaceted strategies to alleviate and facilitate the attainment of the policy objectives of the Ministry of Agriculture. These strategies are going to be emphasized in the National Development Plan VII (1991-96) as submitted by the Ministry of Agriculture.

The government recognizes the role of the private sector in the development of the country. Sometimes the private sector may be constrained by technical and financial resources which in turn could adversely affect its capacity and capability, hence training for the private sector. With the current developments, the government will train for all the sectors with emphasis on all problem areas.

It is hoped that the regional cooperation with organizations such as SADCC and SACCAR will assist Botswana in developing technology for improvement of vegetable production. Already SACCAR offers research and travel grants to scientists in the SADCC region. This facilitates interaction and technology exchange by national scientists.

Acknowledgments

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Lesotho

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Introduction

Lesotho has about 1.1 million ha of arable land, which is about 12% of total land area. The country is well endowed with mineral or other resources, therefore agriculture is the main source of income for most of the population. About 85% of the 1.5 million people live in rural areas, with an average landholding of 0.2 ha/household.

A significantly small proportion of the total arable land is devoted to horticultural crops, mainly in the form of backyard or home gardens, which were estimated at 17 000 ha in 1979. This figure hasn't changed much in recent years, however, at about 11% of the annual gross income, the contribution of vegetables for home consumption to the national income is considerable.

Fruit production is often not accorded its rightful priority in Lesotho, but it is one of the horticultural undertakings with a great deal of potential. Peaches, apples, apricots, pears, etc., all grow very well, and the backyard production of peaches alone has an annual value far greater than any other crop, including maize and sorghum which are the major staples and occupy most of the arable land.

National Policy on R and D

The basic goal of Lesotho agricultural research and development programs is to increase agricultural productivity and efficiency. This goal was defined based on the following factors:

(1) High rural unemployment in the country;

(2) Increasing pressure on arable land due to rapid population growth;

(3) Low level of agricultural productivity; and

(4) Depressed rural incomes due to the low rate of return to agriculture.

To address this broad goal, agricultural research must provide new technologies that will meet the following goals:

(1) Increase farm cash income: by lowering unit costs of production, introducing new high-value crops and varieties, and cultivation practices that are more economical;

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(2) Provide technological inputs and new agronomic practices that can overcome labor constraints; and

(3) Provide technological packages for intensification of production of basic grains and vegetables that protect and enhance the productivity of the natural resource base.

Institutions and Funding for Research

Agricultural research in Lesotho is basically project-driven. Over the last 10 years, funding of research programs and the training of staff has come mainly from donor sources. The Lesotho Government's main contribution has been in the provision of personnel costs and minimal operating costs. A summary of the expenditure on agricultural research during the period 1985-89 is given in Table 1.

Table 1. Agricultural research expenditure (in Maloti – 2.4 Maloti=$US1, mid 1990).

	1985-86	1986-87	1987-88	1988-89
Personal emoluments	543188	515133	515152	726477
Operating costs	138822	75353	122330	146477
Total (Maloti)	682010	590486	639482	872723

The summary in Table 1 is for expenditures through the Agricultural Research Division of the Ministry of Agriculture. It is the main institution charged with research in the country, however, there are up to 50 donor-funded agricultural projects, some of which carry out some research. It should also be noted that the total is for all agricultural research activities, of which vegetable research is a part, and is not budgeted for separately but draws from a common pool of funds.

The basic problem is that there is a very low level of funding by the Government of Lesotho. The agricultural sector contributes about 21% to the GDP, yet the funding for agricultural research is currently at 0.6% of the AGDP. We feel it should be raised to about 1.0% of the AGDP to provide for a modest but sustainable agricultural research program.

Vegetable Research and Personnel

Fruit and vegetable research is one of the five core programs within the Agricultural Research Division, the others being the Cereal Programme, Food Legumes Programme, Livestock Programme and the Natural Resources Management Programme.

The Fruits and Vegetables Programme objective is to focus on the development of technologies for increasing the quantity and quality of fruits and vegetables for

internal consumption and for export. These technologies would include those for intensive production under rainfed, irrigation and other water management regimes, with emphasis on improved crop quality and higher incomes per unit area.

At present there are six local people working with this program (one MSc, two BSc, and three with a Diploma in Agriculture). The goal is to have one PhD heading the program and raise the BSc graduates to the level of MSc.

Malawi

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Introduction

A wide range of exotic and indigenous vegetables are grown in Malawi. These vegetables play a critical role in the nutrition of the people by providing essential minerals and vitamins and in providing some income to smallholder farmers. The exotic vegetables are mostly produced for sale to urban populations and to some extent in the rural areas. Most indigenous vegetables are not cultivated. They grow in crop fields and wastelands, but they are the main source of relish for the rural people. Hence both the exotic and indigenous vegetables are important in promoting good health and generating income.

In recent years, there has been a growing awareness of the significant role vegetables play in combating many health problems associated with vitamin and mineral deficiencies, such as blindness due to Vitamin A deficiency and anemia due to iron deficiency. Furthermore a large percentage of rural women generate their income from vegetable production and marketing; and there is a tremendous potential for the country to earn hard foreign currency through vegetable exports. These factors have prompted the Ministry of Agriculture to attach greater importance to more vigorous research, extension and personnel training in vegetable production.

The principal institution in Malawi responsible for generating new agricultural technology is the Department of Agricultural Research (DAR). DAR consists of more than 100 research scientists supported by more than 200 non-degree research staff. The scientists operate through a system of four main research stations, seven experimental stations, seven substations, and on-farm sites in all the eight Agricultural Development Divisions (ADDs), in order to tailor new technologies to the varied agroecological zones found throughout Malawi. Researchers are organized into seven commodity groups: Cereals, Grain Legumes/Oilseeds/Fibres, Livestock and Pasture, Soils/Land Husbandry/Engineering, Horticulture, Technical Services, and Adaptive Research. Each group is composed of several multidisciplinary research commodity teams; for example, the Horticulture Group consists of the Temperate Fruits, Tropical Fruits and Spices, Tree Nuts, Coffee, Roots and Tubers and Vegetables. The emphasis of the work is to generate technologies suitable for smallholders to adopt in order to increase productivity.

Policy Issues

Although Malawi has made significant improvements in expanding food production since independence in 1964, there remains great potential for using

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science to further increases in field/horticultural crops and animal production. In particular, increases in yields of field and horticultural crops by using improved varieties and improved agronomic practices, irrigation development, and expanded production of horticultural crops have great potential. This underscores the importance of Malawi's participation in the proposed SADCC Vegetable Research and Development Network.

Constraints to increasing the impact of research included weak linkages between researchers/extension/farmers/agroindustries, the lack of smallholder capacity to purchase inputs, and the threat of pests and diseases in the field and in storage. Constraints within the research system include: inadequate funding for agricultural research, a shortage of trained scientists, poor prospects for professional career advancements within the DAR, inadequate reporting, limited research facilities, and a lack of maintenance and repair of scientific and associated equipment.

Closer cooperation should be achieved between the international agricultural research centers (IARCs) and Malawian researchers. Personnel from the IARCs, particularly those who reside and undertake research in Malawi, should more closely cooperate as partners in research with Malawian researchers.

The overall goal of the National Rural Development Programme (NRDP) (as stated in the Statement of Development Policies 1987-96) is to increase the productivity, quality of life and incomes of smallholder farmers through:

(a) Increases in the general level of Malawi smallholder agricultural production for domestic needs, import substitution and export;

(b) Increases in agricultural productivity and, consequently, smallholder incomes and welfare by assuring access to needed inputs and services; and

(c) Preserving Malawi's natural resources by encouraging conservation-linked crop production, developing multiuse conservation programs and developing forestry reserves on customary and estate land.

Horticultural Research Group

Horticultural research teams are focusing on variety improvement through breeding and selection, crop protection, growth and development, crop management and postharvest handling. Horticultural research is coordinated from Bvumbwe Research Station, but trials are sited at all the other stations.

Vegetables

A great deal of research work has been conducted on vegetables. Books on vegetable production have already been made available to the farming community. The success of work on these commodities is evidenced by farmers supplying the cities and the ADMARC Canning factory with vegetables. The horticulturists are also studying indigenous vegetables.

Strategy for Vegetable Production

The strategy for vegetable production is to ensure a continuing expansion of output and an improvement in quality in order to improve nutritional standards and meet the demand from the local markets such as Lilongwe, Blantyre, Zomba and Mzuzu. Supplies to Lilongwe will mainly originate in Mchinji, Ntchisi, Dowa, Dedza and Ntcheu. Similarly, Blantyre supplies will come from Ntcheu, Mwanza and the shire Highlands. Mzuzu and Zomba will also be supplied with vegetables from the surrounding districts.

Vegetable production by smallholder farmers is being supported by assistance to self-help irrigation schemes and by providing credit funds for production for local markets. In the 1987-88 season a pilot credit scheme for vegetable production was initiated in Lilongwe ADD and will, if successful, be expanded to all ADDs. Vegetable production is demonstrated and encouraged at all the irrigation schemes as part of the crop diversification program. An irrigation scheme has been especially developed in Salima ADD for vegetable production by smallholder farmers around Salima Township.

Exploitation of export potential will be tied to the development of direct links to foreign markets, best done with relatively large production runs on specialized estates, and to the establishment of new processing facilities or expansion of existing ones. Export production of vegetables is being developed around the Kamuzu International Airport (KIA) with the technical assistance provided by UNDP/ITC.

Vegetable Seed Production

A project with the intention of producing vegetable seeds has been initiated at Bvumbwe Research Station. The project is sponsored by the Government of Malawi and the Food and Agriculture Organization of the United Nations. The project intends to establish infrastructure including trained personnel, an equipped and functioning vegetable seed production and processing unit with a micropropagation laboratory for production of some basic vegetable seed for tomatoes, sweet pepper, amaranthus, mustard (mpiru), some other indigenous vegetables and disease-indexed seed potatoes. The project is expected to improve the availability and quality of vegetable seeds and potatoes in Malawi. This will subsequently improve the diet of people, especially in rural areas. It is hoped that the project will promote integration of women in agriculture, save foreign exchange due to reduction of seed imports and assist export diversification.

Vegetable Research

Historical Perspective

In Malawi considerable vegetable research has been going on since the mid 1960s. The research focus has been on variety evaluation for yield potential and general adaptability and the development of appropriate agronomic practices for the different types of exotic vegetables and spices (Table 1). However, very little research has been done to develop appropriate technological packages for seed production and

postharvest handling and marketing of these vegetables for use by smallholder farmers.

Research on indigenous vegetables was initiated in 1983 at Bunda College of Agriculture. The emphasis to date has been on germplasm collection and documentation, seed multiplication, agronomic studies and nutritional evaluation of some of the common indigenous vegetables (Table 2). The interest in indigenous vegetables has grown, and research activities are being extended country-wide through collaboration with government agricultural research stations.

Table 1. Some of the exotic vegetable research activities carried out in Malawi from 1960 to 1990.

Scientific Name	Common Name	Research Activity
Lycopersicon esculentum	Tomato	Variety evaluation, plant density, fertilizer rates, planting dates and pesticide screening
Solanum tuberosum	Potato	Variety evaluation and herbicide screening
Capsicum annuum	Green pepper	Fertilizer rates and variety evaluation
Solanum melongena	Eggplant	Variety evaluation
Brassica oleracea var. *capitata*	Cabbage	Variety evaluation, plant density and planting dates, fertilizer and manure rates
Brassica oleracea var. *italica*	Cauliflower	Variety evaluation, fertilizer rates and planting dates
Brassica oleracea var. *botrysis*	Broccoli	Variety evaluation
Brassica juncea	Mustard	Variety evaluation
Brassica chinensis	Chinese cabbage	Variety evaluation and fertilizer rates
Allium cepa	Onion	Variety evaluation and planting dates

(Continued)

Table 1. Some of the exotic vegetable research activities carried out in Malawi from 1960 to 1990. *(Concluded)*

Scientific Name	Common Name	Research Activity
Allium ampleoperasum	Leek	Variety evaluation and fertilizer rates
Daucus carota	Carrot	Variety evaluation
Pisum sativum	Peas	Variety evaluation and planting dates
Phaseolus vulgaris	Green beans	Variety evaluation and planting dates
Cucumis sativus	Cucumber	Variety evaluation, planting dates, fungicide screening
Cucurbita spp.	Pumpkin/squash	Variety evaluation and planting dates
Hibiscus esculentus	Okra	Variety evaluation
Latuca sativa	Lettuce	Variety evaluation and planting dates
Apium graveolens	Celery	Variety evaluation
Asparagus officinalis	Asparagus	Variety evaluation, planting dates and plant density
Zea mays	Sweet corn	Variety evaluation
Capsicum frutescens	Chillies	Variety evaluation
Citrullus vulgaris	Watermelon	Variety evaluation
Glycine max	Soyabean	Variety evaluation

Sources: Bvumbwe Agricultural Research Station Annual Reports for 1968-69, 1970-71, 1971-72, 1972-73, 1978-79, 1980-81, 1986-87; Spurling 1967-71, 1972.

Priority Areas

The vegetable research programs are aimed at addressing critical problems faced by smallholder farmers. These problems include:

(a) Lack of suitable exotic and indigenous vegetable varieties for different agroecological zones;

(b) Lack of appropriate technological packages for producing vegetables during the rainy season when pests and diseases are limiting factors; and during the dry season when water stress and high temperatures are limiting factors;

(c) Unavailability of good quality seed of both the exotic and indigenous vegetables; and

(d) Poor postharvest handling and marketing of vegetables.

Table 2. Selected indigenous vegetable research activities carried out at Bunda College in Malawi, 1983-90.

Scientific Name	Common Name	Research Activity
Amaranthus spp.	Amaranth	Germplasm collection, variety evaluation, plant density and fertilizer/ manure rates evaluation, nutritional evaluation
Gynandropsis gynandra	Cat's whiskers	Germplasm collection and plant density evaluation
Corchorus trilocularis	-	Germplasm collection, plant density and fertilizer rates evaluation
Hibiscus acetosella	White roselle	Germplasm collection and variety evaluation
Hibiscus sabdariffa	Purple roselle	Germplasm collection and variety evaluation
Vigna unguiculata	Cowpea	Variety evaluation for green pod and leaf yield

Sources: Thomo and Kwapata 1984; Kwapata 1989; Kwapata 1990 (unpublished data).

The current research focus is in the following areas:

(a) Variety evaluation of major exotic vegetables (tomato, potato, cabbage, onion, carrots, cucumbers and green peppers) for yield, general adaptability and disease and insect pest reactions;

(b) Germplasm collection, nutritional evaluation and development of suitable agronomic practices for major indigenous vegetables (amaranthus, roselle, cat's whiskers, black jack, sweet potato, cassava and cowpea);

(c) Development of appropriate agronomic practices for the rainy and dry season vegetable production;

(d) Development of appropriate postharvest handling and preservation of vegetables for smallholder farming conditions; and

(e) Development of appropriate technology for vegetable seed production, storage and distribution.

Major Institutions Involved

The major institutions conducting vegetable research are:

(1) Bvumbwe Agricultural Research Station:

This is the main center for horticultural research. It is situated in the southern region of Malawi and its relatively cool weather provides favorable climatic conditions for conducting various vegetable research programs.

(2) Kasinthula Agricultural Research Station:

This is a satellite research station for horticultural research. It is situated in the southern region of Malawi and its warm-to-hot weather provides an ideal environment for evaluating vegetable varieties for heat and drought tolerance.

(3) Chitedze Agricultural Research Station:

This is the main center for agricultural research in Malawi. It is situated in the central region near the international airport. It is a center for sweet potato research.

(4) Lunyangwa Agricultural Research Station:

This is a satellite research station situated in the northern region of Malawi. Both exotic and indigenous vegetable research programs are carried out.

(5) Bunda College of Agriculture:

This is a constituent college of the University of Malawi, which is situated in the central region of Malawi, in Lilongwe district. Various aspects of exotic and indigenous vegetable research are being carried out by both staff and students. Major areas of research focus are germplasm collection, evaluation of yielding potential and nutritional values and development of appropriate agronomic practices of indigenous vegetables. For exotic vegetables, focus is on evaluating varieties and development of cultural practices for the rainy season vegetable production. In addition, suitable postharvest handling and storage methods of vegetables for smallholder farmers are investigated.

Personnel

The current personnel involved in vegetable research are shown in Table 3. The present level of staffing is inadequate for a comprehensive research program in vegetable production, but can provide the basis of a regional vegetable research training and development initiative.

Table 3. Current staff, full-time equivalent, assigned to vegetable research compared to some other horticultural subcommodities in the Department of Agricultural Research.

Horticulture subcommodity	Professional officer	Technical officer	Technical assistant
Vegetables	1.3 (PhD) + 2.0 (MSc)* 0.8 (BSc)	2.3	3.2
Temperate fruits	1.0 (MSc)*	1.4	4.5
Tropical fruits	1.0 (MSc) 0.2 (PhD) +	1.7	5.0
Tree nuts	1.0 (MSc)* 2.0 (MSc) +	2.0	5.0
Vegetable staff as % of total	37	31	18

* One on study leave to work toward a PhD.

\+ Expatriate staff (USAID and Australian government assistance).

NB. At Bunda College there is one professional officer (PhD) and one technical assistant involved in vegetable research. In addition, there are staff in complementary disciplines (in soil science, pathology, nematology, entomology, plant breeding, agronomy and human nutrition) who occasionally participate in joint vegetable research projects.

Facilities and Finances

At each research institution there is ample land for field experimentation. In addition, there are laboratories with equipment for weighing, drying, and conducting simple laboratory studies on seed purity, germination, and vigor. For advanced laboratory studies and expansion of laboratory research activities, however, it would require more and newer equipment and increased laboratory space.

The annual budget for vegetable research in the Department of Agricultural Research in 1990-91 is 45,261 kwacha (2.8 kwacha = $US1).

Training

There are two main institutions offering training in horticulture as part of a curriculum for certificate, diploma and degree programs in general agriculture: Bunda College of Agriculture and the Natural Resources College.

In both institutions, vegetable production courses are part of the curriculum for agriculture and landscape horticulture. As such, little time is available to teach students in detail all aspects of vegetable production. It is hoped that in the future both colleges would offer a separate horticulture program with adequate time allocated to vegetable production courses.

Extension

The extension program for fruits and vegetables is under the responsibility of the Ministry of Agriculture. Training of farmers is done by the extension staff based on recommendations from the Department of Agricultural Research. Farmers are trained through demonstrations of the recommended practices in vegetable demonstration gardens at EPA centers, and by attending training courses at rural training centers. Currently farmer training is done on a small scale, but will be expanded when resources are available.

Information (Library) Services

Under the National Agricultural Research Project (NARP), the DAR Library system has been established, encompassing seven libraries that support research, planning and extension departments in the Ministry of Agriculture. A computerized information retrieval system contains records of documents located in each of the collections in a single database, currently comprised of 1300 records. The database is expected to include an estimated 100 000 records in 10 years and, including the holdings of the Bunda College Library, constitutes a national documentation system for Malawi's agricultural sector.

Another achievement of the DAR library system is perhaps the most advanced application of the compact laser disk (CD-ROM) technology in all of Africa. Using this new technology, large international databases that index agricultural literature

produced worldwide are accessible in the library via a microcomputer and is producing a significant impact on the design, quality and implementation of DAR's research trials. The NARP project has also provided substantial funding for books and other information resources that are being acquired to improve the Ministry's access to external information.

Acknowledgments

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Swaziland

D.M.Gama*, A.N. Kunene, and V.D. Shongwe*****

Introduction

The climate of Swaziland is subtropical with hot summers and dry cool winters. The country is divided into four agroecological zones according to the varying climatic conditions: Highveld, Middleveld, Lowveld and Lubombo, and all regions have a great horticultural production potential.

Both Swazi Nation Land and Title Deed farmers are engaged in the production of fruit and vegetables, with the latter group experiencing greater success in production than the former group for economic reasons. Swazi Nation Land farmers devote 31% of the available land area, producing 14 t/ha of tomatoes whilst Title Deed farmers utilize 24% of the land and produce 20 t/ha (Annual Statistical Bulletin 1984).

This situation, however, has not afforded the country self-sufficiency, since most of the fruit and vegetables still have to be imported from the Republic of South Africa in order to satisfy the ever-increasing demand for these commodities. Local producers face some problems with the production of these crops, particularly with diseases, insects, choice of suitable cultivars, and improved agronomic techniques.

Research on vegetables is concentrated mostly on three aspects of production:

(1) The introduction and evaluation of new cultivars for yield performance and for disease and insect resistance;

(2) The development of production techniques that will improve the yields; and

(3) The solving of farmers' production problems.

Success in achieving the above goals has a bearing on the availability of institutions involved in research, training, personnel and fiscal resources for research and development.

The current status of the institutions involved in vegetable research and development, personnel and fiscal resources and the active research programs are discussed below.

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Institutions Involved

The institutions are:

(1) Agricultural Research Division (ARD), which has the prime responsibility for carrying out research activities in Swaziland. These include screening for new cultivars and solving specific production problems faced by the farmers, especially the small-scale farmers.

(2) University of Swaziland (UNISWA), which deals with training agricultural personnel for both research and extension. As part of its training program UNISWA also conducts some research.

(3) International Fund for Agricultural Development (IFAD) and Agricultural Extension Division (AED). IFAD, which is a public institution, works in collaboration with the Extension Division of the Ministry of Agriculture and Cooperatives. The major activities carried out by these two bodies include setting irrigation schemes for the small scale farmers on the Swazi Nation land, training farmers in vegetable production and identifying potential vegetable markets.

(4) Swaziland Farmers' Development Foundation (SFDF), which is a private institution, trains mainly school leavers and dropouts in agricultural production. It also assists in setting up young farmers' irrigation schemes.

(5) National Agricultural Marketing Board (NAMBOARD), which is a parastatal institution, operates a vegetable wholesale market and also disseminates technology to farmers on postharvest handling of vegetables.

Personnel

The available personnel in the institutions involved in research and development are shown in Table 1. The personnel requirements of each institution, however, could not be ascertained except for the horticulture section in the ARD. This section has a shortage of people since it has only one horticulturist to work on both fruit and vegetable research. Other researchers from other disciplines who work with the horticulturist as a team include a sociologist, an economist, a nutritionist and a plant pathologist. The latter four researchers are also responsible to the other research sections of the ARD. The personnel without degrees are responsible for the implementation and monitoring of experiments under the supervision of the researchers. The shortage in personnel is caused by the absence of posts in the ARD.

Financial Resources

The current allocations of fiscal resources for vegetable research pertain to ARD, where the fiscal resources for all the research sections are placed in a common pool. The amount of money allocated to each section depends on the total requirements of the research programs from all the sections, presented to the Chief Research Officer for approval for implementation. This system so far has not seen programs turned down because of shortages in current fiscal resources. This,

however, does not mean that the ARD has all the facilities it needs for carrying out research. It still needs greenhouses and cold storage facilities.

Table 1. Institutions and personnel involved in vegetable research, training and development in Swaziland.

Institution	Type	Personnel	PhD	MS	BS	Dip	Cert
ARD	public	7	0	4	1	1	1
UNISWA	public	6	3	3	-	-	-
IFAD & AED	public	8	0	0	0	8	0
NAMBOARD	parastatal	4	0	1	2	2	0
SFDF	private	8	0	1	0	0	7

Status of Vegetable Research and Active Programs

Vegetable research is carried out on the research station and on farmers' fields. The implementation and monitoring of the on-farm trials is carried out by research assistants under the supervision of research officers.

The on-farm trials allow interaction between the researchers, extension workers and the farmers, so that pertinent production problems can be discussed or observed in the fields.

The major vegetables grown in Swaziland are cabbages, tomatoes, potatoes and onions. The production of these vegetables is not without constraints, so research is directed towards solving these problems.

Constraints Hindering Vegetable Production

Summer vegetable production is hampered by the presence of diseases such as bacterial wilt (*Pseudomonas solanacearum*) and late blight (*Phytophthora infestans*), which are the most serious diseases infecting the solanaceous crops such as tomatoes and potatoes. As a result of these problems farmers are reluctant to embark on vegetable production in the summer period. NAMBOARD bridges this gap of vegetable scarcity during the summer months by importing vegetables from South Africa. Vegetable prices are very high in summer.

Shortages and high costs of seed supply are limiting production. The seeds that are often in short supply are those for Rodade and Zest tomatoes and Pronto S and Rocket onions. The shortages of the seed supply are caused by the sanctions imposed on South Africa. By being the sole supplier of seed to Swaziland, South Africa dictates prices in the market.

Marketing problems that discourage production are numerous, but the four major ones are: First is the sale of vegetables on consignment rather than on a cash

basis. The consignment deal pays the farmer after the sale of the produce. Farmers want to be paid for their produce on delivery at the market. Second is the market glut which pushes prices down. The glut is caused by farmers growing the same crops at the same time. Third is the lack of transport to deliver the produce in a healthy state to the market. Fourth is the lack of market information with regard to market prices. Forecast market prices can be helpful to farmers in planning their vegetable production and in obtaining better returns for their produce in the market.

Active Research Programs

Trials on the evaluation of Zest and Rodade tomato varieties for tolerance to bacterial wilt were conducted in the 1988-89 summer season on farmers' fields. The two varieties showed similar tolerance to this disease compared to the Karino and Floradade varieties which are commonly grown.

In trying to solve the problem of market glutting, new vegetables such as broccoli and sweet corn are being introduced as alternative crops to the major vegetables such as cabbages and tomatoes. The new vegetables have a demand in the hotel industry. The broccoli varieties are Dandy Early, Green Valiant and Atlantic. The sweetcorn varieties are Commander and Rival.

Another alternative being tried to avoid the market glut is the possibility of growing vegetables for export. The vegetable crop that has been tried for this purpose is cucumber for gherkin production for the European markets. The cucumber variety that has produced the highest yield of 1.6 t/ha of the prime grade (fruits ranging between 8 and 16 mm in diameter) is Explorer.

The problem of seed supply has only been addressed for onions where an exploratory trial on the production of open-pollinated seed has been conducted. The result from this trial was promising because a seed yield of 65 kg/ha was obtained. The variety used was TG502 PRR.

Shongwe (1983) evaluated the relative effectiveness of two fungicides, Daconil and Bravo, on the cultivar Heinz 1370 in controlling early and late blight, and *Septoria* leafspot diseases. The parameters assessed were the same as in Magogwe's (1982) work. Although this trial was conducted in the absence of the more devastating late blight disease, Bravo, a cheaper emulsifiable concentrate formulation of chlorothaconil, proved to be the most economical control as indicated by marketable fruits and reduced infection indices, and was thus recommended.

Mmopelwa (1984) concluded that yield losses were directly proportional to disease intensities and inversely proportional to increasing spray concentrations with Bravo.

Future Research

Although attempts have been made towards disease and root-knot nematode control in fruit and vegetables, most of the results were inconclusive since the work

was done over one season and at times the climate was atypical. There is therefore a need to repeat most of the experiments. It is evident that some research has been done only on tomato, pumpkin, green beans and okra. Other fruit and vegetable crops such as cucumber, eggplant, capsicum peppers, melons, peas, squash, sweet corn and watermelons have received no attention whatsoever. The need to undertake research on these crops therefore cannot be overemphasized. In the research endeavors, particular attention must be paid to cultivar evaluation and selection, crop protection (diseases, insects, weeds), crop rotation and intercropping, crop physiology and growth regulators, and improved cultural/agronomic practices.

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Tanzania

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Introduction

Production of vegetables in Tanzania is not well developed (Table 1), either as food or cash crops, despite weather that is suitable for a wide range of vegetable crops (Swai 1989).

Temperate and subtropical vegetables can be grown successfully in the highlands, and tropical ones in the coastal zone. This potential has not been fully exploited, however.

Factors that have contributed to the low performance of vegetable crops include low priority given to the horticultural subsector of agriculture, and lack of adequate personnel trained in horticulture research, training and extension. Institutions involved in vegetable research and development are also poorly equipped and funded (Minjas 1988; Nyomora 1988; Swai 1988).

Table 1. Vegetable production in Kilimanjaro, Arusha, Iringa and Morogoro Regions in 1986 (in metric tons).

Vegetable	Kilimanjaro	Arusha[a]	Iringa	Morogoro
Tomato	706	-	269	8725
Cabbage	19299	-	-	9000
Onion	11425	-	-	15000
Carrot	707	-	-	132
Eggplant	154	-	-	350
Sweet pepper	158	-	-	-
Potato (round)	35375	-	-	-
Beans	21518	-	4.9	21000
Peas	-	-	-	2530
Indigenous vegetables	779	-	4.3	-

Source: Annual Regional Reports 1986.
[a] Individual crop production records were not available.

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National Policy on Horticultural Production

The importance of horticulture is reflected in the National Agricultural Policy (1982) which states that: There is a great potential for producing fruits, vegetables and flowers, both tropical and temperate varieties, to satisfy domestic needs and for export market. Despite great emphasis on the expansion of production in 'Siasa ni Kilimo', the performance of this subsector has been dismal. The reasons for the poor performance include non-existence of official marketing channels, high perishability of the crop, lack of research and extension services, shortage of seed planting materials, poor transport and storage and minimum effort put into transportation.

In order to realize the full potential in horticulture, the following policy recommendations are proposed:

(1) Production should be enhanced through research extension and irrigation;

(2) Marketing (organized) and processing of horticultural crops should be given high priority;

(3) Location of processing plants should be as close as possible to producing areas to reduce waste and transport costs; and

(4) Private entrepreneurs should be encouraged to organize export enterprises by streamlining the licensing procedures.

The policy covers all aspects of horticultural development including research, production, extension services, promotion, marketing and export of the horticultural produce. However, government priority has not been strong enough to build up the systematic infrastructural base in terms of research extension services, production, promotion and marketing of horticultural crops.

Training

There are only six MSes and about 10 BSes working on horticulture in Tanzania. Most of these are also involved in diploma-level horticultural training. However, the national agricultural policy proposes a strategy to concentrate on developing the existing staff. It also recommends that specialist training should be intensified both on the job and through the services in relevant institutions. Priority areas are land use planning, soil conservation, irrigation, horticulture and in priority crops and disciplines. Research focus on agroecological zones, farming systems research approach, field days and strong research extension linkage have been adopted to ensure technology diffusion.

Resource Allocation for Agricultural Research

The national agricultural policy recommends that 'The share of agricultural budget going to agricultural research should be increased to strengthen the research institutions and cater for increased activities. This has, however, not been possible

due to limited financial resources. In terms of allocation of trained personnel, the national agriculture policy further recommends that staffing should reflect the correct priorities of the needs of the sector.' With limited staff available this becomes difficult. Priority has been given to training and assigning staff to serve the farmers.

Agricultural Credit, Price, Subsidies and Marketing

The national agricultural policy recommends that:

(1) Investment in marketing capacity such as transport, storage, skilled staff and auditing should be regarded as crucial to the proper functioning of any marketing system.

(2) Marketing of export crops should as much as possible be done by auction or tender with physical participation of parastatals and national private companies.

(3) Marketing operations should be separated from production and processing in order to make it and each of the other two more effective.

(4) A system of collecting and circulating marketing information should be established in order to guide marketing agents (whether transporters or those providing storage facilities, etc.) in making prompt and correct decisions. This will also provide policymakers with information required to review their policies.

The marketing of vegetable crops follows very much the above guidelines. This has been possible mainly because the marketing of these crops is in the hands of private dealers.

The policy recommendations for agricultural credit are that:

(1) Direct access to credit institutions should be maintained for large-scale parastatals and private farmers;

(2) Credit institutions should not be involved in physical distribution of inputs; and

(3) Agricultural credit should be operated strictly on commercial principles.

Most of the vegetables are produced by smallholders and in backyards. A majority of these do not seek credit, but for those who wish to get credit for purchases of inputs they can do so. Subsidies are not provided.

Institutions Involved in Vegetable Research and Development

There are three main groups involved in vegetable research and development in Tanzania:

(1) Sokoine University of Agriculture (SUA)

SUA is situated at the foot of Uluguru Mountain slopes in Morogoro Municipality, 200 km from Dar es Salaam. The University has 2376 ha for research and production, of which 380 ha are used for crop research and production. The Horticultural Unit occupies about 3.5 ha of irrigable land. SUA has the largest agricultural library in the country.

(2) Horticultural Research and Training Institute (HORTI) - Tengeru

HORTI-Tengeru is located 14 km southeast of Arusha Municipality along the Arusha - Kilimanjaro International Airport road. The Institute is on the slopes of Meru Mountain, 1250 m above sea level. It enjoys excellent weather with an annual mean temperature of 19.7°C, and total annual rainfall of 730-1000 mm which comes in two parts (October to December - short rains, and March to May - long rains). The Institute has 235 ha with 120 ha under coffee and 95 ha under irrigation. Vegetable research and seed production activities occupy 15 ha of the arable land.

(3) Uyole Agricultural Centre (UAC)

The Centre is located in the South Highlands near Mbeya Municipality, at an elevation of 1705 m, with annual mean temperature of 16.8°C and total rainfall of about 1030 mm. It is 9 km from Mbeya Airport. The Centre serves the southern highland zone comprising Mbeya, Iringa, Rukwa and Ruvuma regions with a substation in each region.

Resources for Vegetable R and D

Personnel

There are only a few trained staff members in horticulture at basic and higher degree levels. Most staff involved in vegetable R and D are either general agriculturists, agronomists or botanists (Table 2).

Table 2. Personnel engaged in vegetable R and D.

Institutions	PhD	MSc	BSc	Diploma	Certificate
SUA	1[a]	2	2[b]	1	1
HORTI-Tengeru		1+5[b]	2+6[b]	7	1
UAC		1[b]	2[b]	2	
Total		3+6[b]	2+10[b]	10	2

[a] On leave of absence.
[b] Personnel trained in General Agriculture, Agronomy and Botany.

Financial Resources

Generally very limited funds are allocated for the support of horticultural R and D programs. This has resulted in scanty vegetable research activities, lacking continuity and coordination.

Physical Resources

Most of the institutions involved in vegetable R and D are not adequately equipped. Basic research facilities like glasshouse, screenhouse, cold rooms, laboratories, etc., are not available in some institutions. Where laboratories exist, they are not well equipped. Lack of farm machinery and transport to support logistics is another important constraint.

Research Programs

A wide range of vegetable crops is grown in Tanzania. However, due to limited resources, research efforts are directed only to major common vegetable crops like amaranthus, tomatoes, onions, cabbage, carrot, okra, pepper *Brassica carinata*, African eggplant, swisschard, cucumber, watermelon and eggplant. The main areas of research are:

Agronomy

The objective is to evaluate vegetable crop varieties suitable for different ecological zones, and develop production technical packages for each crop variety. Many vegetable varieties have been recommended and released for multiplication and for use in different zones (Anon. 1988; Laterrot et al. 1989).

Seed Production

Vegetable seed production is a relatively new undertaking to most research institutions (Anon. 1990). The program has been nationally coordinated from HORTI-Tengeru since 1989, and charged with the following tasks:

(a) Collection, introduction and evaluation of indigenous and exotic vegetable varieties;

(b) Identification of various locations in different agroclimatic zones for producing various kinds of vegetable seeds;

(c) Purification and maintenance of the selected vegetable varieties; and

(d) Development of systematic vegetable seed production (multiplication, processing, packing and marketing, etc.) and seed quality standards.

So far the program has identified varieties of carrots, cabbage, swisschard and onions that can flower and set seeds in both northern and southern highlands. Basic seeds of these vegetables and many other vegetable varieties have been produced.

The program also maintains a total of 240 varieties of indigenous and exotic vegetables.

Plant Protection

Emphasis is placed on screening vegetable varieties and pesticides, and developing schedules for the control of specific pests and diseases of economic importance in the vegetable production areas. Investigations on integrated pest and disease management are also in progress.

Development Programs

Training

Horticultural training is conducted at Sokoine University of Agriculture, HORTI-Tengeru and UAC. At SUA horticulture is taught to students pursuing a BSc in agriculture with option in crop science. Plans are underway, however, to start a 4-year BSc degree in horticulture (Evers and Mattee 1990).

HORTI-Tengeru offers an intensive 2-year diploma course in horticulture. This is the only group of professional personnel trained in horticulture in Tanzania (Swai 1990). UAC offers a 2-year certificate in agriculture where only basics of horticulture are taught.

Personnel development to basic and higher degree levels in horticulture is of immense importance for vegetable R and D, and horticulture in general.

Technology Transfer and Adoption

To facilitate transfer of information and technologies generated from vegetable research institutions, several methods are employed including on-farm research, field days, outreach programs, participation of research personnel in fortnight training (T&V) for extension staff, and through publications (Evers and Mattee 1990; Swai 1990).

Research findings from SUA, HORTI-Tengeru and UAC have made considerable impact on the production of vegetables. There are now more farmers and families engaged in home and commercial gardening of vegetables. Farmers in the northern and southern highlands where land is limited have increased acreage under vegetables at the expense of coffee and food crops.

Conclusion and Recommendations

Tanzania has great potential for production of various types of vegetables. This potential has not been fully exploited due to lack of workable policy, priority and inadequate capacity of the institutions involved in vegetable R and D. There is need therefore to:

(1) Coordinate the work of individuals and institutions involved in vegetable activities; and together with policymakers develop a workable national vegetable policy, network and establish research priorities;

(2) Strengthen the capacity of agricultural institutions involved in vegetable R and D to be able to develop vegetable varieties, seeds of high quality and production technologies suitable for different agroecological zones; and

(3) Develop regional cooperation in vegetable genetic resources, breeding, seed production and personnel development. This will enhance exploitation of the existing potential of vegetable crop production in the region.

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Zambia

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Introduction

Intensified vegetable research in Zambia started in the early 1970s by the Department of Agricultural Research. The vegetable research program has been located and coordinated at the National Irrigation Research Station (NIRS) in the southern province of Mazabuka. In the past, research activities have been more or less geographically confined to NIRS because it was the only area that offered the facilities required to conduct vegetable research. The vegetable program now operates at two other locations, the ZAMSEED Farm and Golden Valley, thereby making results more reliable.

Initial research involved introduction, testing and selection of cultivars of all vegetables, but many of these were typical vegetable species most familiar to, or favored by, settlers (e.g. broccoli, brussels sprouts, cauliflower, etc.). Certain agronomic studies were also carried out, but many of these could not be completed because of staff changes. Another factor that hindered the progress of work was the delay in importation of seed materials from abroad. Studies on the processing of some common vegetables were also undertaken.

National Policies

The agricultural sector has a major role to play in the restructuring of the economy, given its largely undeveloped potential for exports and import substitution, and the relative abundance of labor and land resources. In the Fourth National Development Plan (1989-93) the main development objectives of the agricultural sector are as follows:

(1) To achieve a satisfactory level of self-sufficiency in production of staple foods;

(2) To expand the production of agricultural exports;

(3) To increase the import substitution of agricultural products or inputs; and

(4) To improve rural employment and incomes.

National Long-Term Plan

A first draft of the National Research Action Plan was produced in April 1990 by senior research officers. The background to this has been the concern expressed in

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many quarters over the high degree of fragmentation in the Research Branch. Furthermore the Research Branch of the Department of Agriculture has been a recipient of an increasing amount of donor aid since the economy started declining in 1973. Although it is recognized that donor participation has contributed greatly to the success of a wide range of specific research programs, there is a general lack of overall coordination in the absence of a National Research Plan. As a result, serious difficulties have arisen, including:

(1) Repetition of work by different groups;

(2) A diversity of methodologies in the same field of work;

(3) A tendency to autonomy within projects and loss of influence and control by Zambian authorities;

(4) Sporadic funding arrangements which expand or shrink with changing commitments and priorities of individual donors; and

(5) Reduced morale among Zambian scientists because of differential budgeting between donor- and government-funded projects.

The Research Action Plan, which in principle has been accepted by the government and donor countries, proposes to introduce a more effective organizational structure to meet the real and immediate needs of the traditional and small-scale farmers within the economic and ecological constraints in which they operate. It also suggests a framework for better donor coordination. Some of the means to achieve these will be through adopting an agroecological regional approach to research planning; the creation of a national policymaking body; and the strengthening of the research-extension linkages.

Research will be grouped into three main divisions: (1) crops, (2) livestock and (3) soils/agronomy to facilitate coordination and to ensure high professional standards. Vegetable research, which is regarded as a commodity team on its own, will be under the division of crops. The main vegetables to be addressed are the traditional and exotic crops.

Vegetable research will be conducted in all the three main agroecological zones of Zambia. In terms of personnel development this will be done once the ongoing expertise of staff establishment appraisal is completed. The idea is to establish a critical mass of staff needed to address the agricultural problems in a given ecological zone. All the three agroecological regions will be served by a network of research stations to address the agricultural problems in these areas.

Objectives

Objectives were laid down to guide the vegetable research program. The overall objective has been to increase vegetable production to satisfy dietary needs and achieve self-sufficiency with surplus for export. This was to be achieved through the following:

(a) Cultivar development;

(b) Agronomic research;

(c) Seeds research;

(d) Germplasm maintenance;

(e) Plant protection; and

(f) Indigenous vegetables development.

Other strategies to be undertaken during the current Fourth National Development Plan (1989-93) are:

(a) Improving postharvest handling methods, including preservation methods;

(b) Encouraging contract farming by processors and exporters;

(c) Promoting market gardening near large market centers; and

(d) Improving central wholesale and retail markets for fresh produce.

Review of Research Activities

The vegetable research program is expected to tackle production constraints of a number of crops. The current specific activities are shown in Table 1. However, based on a wider scale of consumption by the Zambian people, the following crops have been high on the priority list: Solanaceae: tomato (*Lycopersicon esculentum*), bulb onions (*Allium cepa*), leafy brassicas (cabbage and rape), indigenous vegetables (amaranth, cleome, corchorus and African eggplant); Malvaceae: okra (*Abelmoschus esculentus*).

Table 1. Vegetable R and D; specific activities during 1990.

Activity	Site	Period
Cultivar trials		
Watermelon	NIRS	summer + rainy season
Tomato	GV + NIRS + ZAMSEED farm	all year-round
Onion	"	"
Beans	"	"
Cabbage	"	"
Okra	"	"
Rape/Mustard	"	"
Tronchuda	"	"

(Continued)

Table 1. Vegetable R and D; specific activities during 1990. ***(Concluded)***

Activity	Site	Period
Potatoes	NIRS+ZAMSEED farm+ Water Valley farms	"
Pumpkin observations	NIRS	rainy season
Peas	"	winter season
Local eggplant	"	summer+rainy season
Carrot	"	end of rainy season
Agronomic trials		
Okra density x N-fertilizer	"	mid rainy
Removal of apical bud in Okra	"	mid rainy
Defoliation of *Brassica*	"	winter
Seed production research		
Carrots, propagation by "stecklings" season	"	end of rainy
Onion, flower formation	"	winter season
Seed multiplication of cabbage, pepper, eggplant, peas, beans, okra	NIRS+GV+ZAMSEED farm	winter season
Plant protection		
Black rot in *Brassica*	NIRS	rainy season
Evaluation of fungicides in tomatoes and potatoes	NIRS+GV+ZAMSEED farm	rainy season
Evaluation of insecticides, including neem, against vegetable pests	"	rainy season
Plant breeding		
Resistance in *Brassica*	Special Research Activity	ongoing
Resistance in peas	"	proposed
Chemical analysis of local vegetables	"	ongoing

Rainy season: trials are field sat during November to February
Winter season: trials are field sat during March to April
Summer season: trials are field sat during August
NIRS: National Irrigation Research Station
GV: Golden Valley Research Site

Targets

The small-scale farmers are the main target of the program. Other categories of farmers are also addressed. The selection of priority crops make it possible to cater to all client groups. The major research thrust on indigenous vegetables is aimed at the small-scale farmers. Cross-commodity studies, for example seed production, agronomy and plant protection, are intended to benefit all farmer categories. The vegetable research program also includes the potato improvement project which is addressing mainly the commercial farmer.

Since the inception of the program, varieties have been evaluated in each of the three distinct seasons (rainy; cool and dry winter; warm and dry summer) and appropriate cultivars have been released. The pest and disease profile in most vegetables has been done for each season. Research efforts on control strategies have been worked out and are on-going. Seed production research has made it possible for large-scale production. Parent stock of nearly all vegetable seeds being produced by the Zambia Seed Company Limited and some cultivation recommendations can be traced to the research program.

Research efforts have been made to better understand and develop indigenous vegetables. Previous research activities include: establishment of a small working germplasm collection of some traditional species, cultivar evaluation in amaranth, corchorus, African eggplant, cleome, Abyssinian rape and pumpkins; agronomy involving fertilizer regimes in African eggplant and Abyssinian rape; preliminary work on chemical analyses in amaranth and Abyssinian rape foliage, seeds of cleome, Abyssinian rape and African eggplant; routine observations for pests and diseases; and a study on production, utilization and marketing of traditional vegetables in selected urban and rural areas.

Development of Capacity

Funding

The vegetable research program is currently financed by SIDA under the Agricultural Sector support program. The financial and technical support commenced in 1982 and is expected to continue during the next 3 years. During 1990, a sum of SEK 1 195 000 (~0.025 = $US1) was approved for the vegetable research program.

Human Resources

The vegetable research program is headed by a team leader who administratively falls under the Officer-in-charge. At the moment the program is composed of two Zambians (MSc professionals - one on PhD training; four diploma holder technical officers - two studying for BSc degrees; three agricultural assistants with general agriculture certificate) and one PhD SIDA employee for plant protection. We hope to recruit more staff in the near future. Until well-trained and experienced personnel are available, there will be a need to involve consultants to supplement local efforts in carrying out certain specialized research activities.

Horticultural staff have received lower priority for training than those involved in cereal and other field crop research. We need to develop a strong personnel development and training program for local horticultural staff. Workshops, seminars, symposia, and visits should be encouraged as part of the training program.

Physical Facilities

Due to limited funds and staff, vegetable research has been in the past more or less geographically confined to NIRS, which is not representative of an agroclimatically and ecologically diverse country. With a single research location, it was difficult to release varieties as multilocational data are required to approve a variety for release. Recently another trial site was developed at Golden Valley, 60 km north of Lusaka. Developmental plans include irrigation and civil works. Two land areas will be developed separately: 6 ha for general trial purposes, and 4 ha for isolation of crops under breeding and seed production. The future scope should be to extend efforts to identified sites in other parts of the country to obtain more representative data. For this to take place sufficient funds, facilities and more trained staff will be required.

Cooperation With Other Organizations

The program has good relations with various international research institutions and seed companies. The program cooperates well with various international and national agrochemical companies. It also cooperates well with some local training institutions and self-help schemes in the country.

Other Vegetable Research, Training and Development

Extension Branch

Training

Over the years, promotional efforts have been done through publication of various pamphlets and handbooks, many of which now need to be updated. The mass media creates awareness through radio programs. The horticultural research extension linkage does, however, require improvement.

Production

There is a great potential for horticultural crops in Zambia. Apart from being an important source of vitamins, vegetables form the bulk of the relish for most people. There are many farmers engaged in vegetable production, both commercial and small-scale. However, most of these vegetables are produced under irrigation during winter when it is cool and dry. Although Zambia is self-sufficient in vegetable production, and even exports vegetables to neighboring and European markets, there are still periods of vegetable supply scarcity during the hot summer.

Marketing

There is no organized marketing system for horticultural crops in general. Vegetables are marketed informally and it is difficult to collect data. There is a need to carry out a detailed survey to collect data which could be used in planning and measuring performance effectively. Attention needs to be paid so as to improve the structure for domestic markets and streamline procedures for those crops with export potential.

The Zambia Seed Company Ltd. (ZAMSEED)

This company has been in the forefront, along with the Research Branch, of development and promotion of vegetables. This has been done through the provision of facilities to support research, and production and sale of seed. During 1988-89, the sales of vegetable seed have been above estimated demand, and ZAMSEED sold 1.5 million small packages of seed showing that vegetables are readily grown provided seed is available.

University of Zambia, School of Agricultural Sciences

Currently vegetable research deals with indigenous vegetables, and several experiments are in progress. These are aimed at finding the response of indigenous vegetables to fertilizers (N,P and K). The indigenous vegetables under study are African eggplant, cleome, amaranthus, corchorus and Abyssinian rape. From previous cultivar trials on amaranthus, two varieties UNZA A1 and UNZA A2 have been released.

National Food and Nutrition Commission (NFNC)

The NFNC has been given the task of monitoring dietary anemia and Vitamin A deficiency, and has conducted household surveys on the utilization of traditional food plants including vegetables in Luapula. A study under FAO assistance was recently commissioned to document the utilization of traditional food plants in Zambia. Recently, the NFNC assisted in a multidisciplinary study on the procurement, utilization, and marketing of traditional vegetables in selected urban and rural areas.

Zimbabwe

J.E. Jackson*, R. Madakadze, E. Manzungu§ and D. Utete§§**

Institutions Involved in Research, Training and Development of Vegetables

Ministry of Lands, Agriculture and Rural Resettlement

This ministry is involved in vegetable research, training and development through two of its constituent departments, the Department of Research and Specialist Services (DRSS) and the Department of Agriculture, Technical and Extension Services (Agritex), through the parastatal Agriculture and Rural Development Authority (Arda) and through Chibero and Gwebi Colleges of Agriculture and Esgodini, Mlezu, Kushinga-Phikelela and Rio Tinto Agricultural Institutes.

DRSS is responsible for horticultural research which is carried out in the Horticultural Research Institute (made up of the horticultural section of Chiredzi Research Station in the lowveld, The Horticultural Research Centre, Marondera, Nyanga Experiment Station, and a unit at the Coffee Research Station, Chipinge) the Plant Protection Research Institute, Harare, and the Chemistry and Soils Research Institute, Harare and Marondera.

Agritex is responsible for extension, including training. It has headquarters and training staff in Harare and horticultural specialist posts, distributed by province, at Marondera (Mashonaland East), Mutare (Manicaland), Bulawayo (Matebeleland), and Gweru (Midlands).

Arda is primarily involved in commercial production but its professionally and technically qualified staff are also involved in both development and training.

The College of Agriculture grants Diplomas in Agriculture, which incorporates horticulture. The Agricultural Institutes offer training in agriculture, incorporating horticulture, to certificate level.

University of Zimbabwe

The university is involved in both teaching and research in horticulture including vegetable crops. Horticulture is one of the options within the BSc(Hons)Agriculture degree and is taught in the Department of Crop Science.

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Harare Polytechnic

Harare Polytechnic offers a Diploma in Horticulture and Certificate courses.

Current Staffing Resources for Vegetable R and D

Public Sector R and D

Research and development on vegetables in the public sector in Zimbabwe are carried out within institutional structures that do not have specific allocations of resources to vegetables as such. Allocation of staff to specifically horticultural activities is given in Table 1.

Table 1. Public sector personnel for horticultural R and D.

	PhD	MS or MSc	BSc	Diploma
DRSS	1	-	10	4
Agritex	1	4	3	-
University	-	2	-	-
Arda	1	1	2	-

The figures in Table 1 include expatriate staff integrated on a full-time basis into these organizations, but exclude science specialists (biotechnology, chemistry and soils, crop protection, etc.) with a mandate wider than horticulture. They also exclude senior administrative scientists responsible for horticulture as well as other crops and technical staff who service horticultural science among other responsibilities. Approximately one-half of the people in Table 1 are devoted to vegetable crops.

Private Sector R and D

The major agrochemical companies (Zimbabwe Fertilizer Company. Windmill, Agricura, Bayer and Sprayquip) employ professionally and technically qualified staff at all levels from recent graduates to the doctorate level. Some are employed as specialist advisers in horticulture, others have a wider mandate which includes horticulture. These firms collaborate closely with DRSS especially in the area of product evaluation. Companies that grow or purchase vegetables for processing, etc. also employ their own horticultural advisors, usually with diploma qualifications (Olivine Industries (Heinz), Lever Brothers, etc.). Producer groups (e.g. Fruit and Vegetable Co-op (FAVCO), Enterprise Co-op and Hortico) also employ qualified horticultural advisers. Zimbabwe's storage engineering firms now have considerable expertise in the design and manufacture of cold stores for vegetables, and some of the marketing organizations are run by professionally qualified people as are private sector seed firms and nurseries. One private sector vegetable nursery has its own tissue culture facility and staff with experience in this technology. Many commercial farmers and horticultural entrepreneurs have degrees or diplomas and employ technically qualified staff, so are competent to do at least some of their own development

work. They include at least one ex-University of Zimbabwe lecturer and one ex-member of DRSS with an MS in horticulture.

There is no register of scientifically qualified personnel in private sector vegetable production, but the total number is probably in excess of those in the public sector.

Donor-Aided Projects

Several donor-assisted projects have their own technically qualified staff employed on horticultural development projects. The effort on vegetables is probably equivalent to about 2 person-years. There is probably the equivalent of 25-30 full-time, technically qualified scientists involved in vegetable R and D.

Current Allocation of Fiscal Resources to Vegetable R and D

Core Funding of Public Sector R and D on Vegetables

Research and development on vegetables is not dealt with as a separate accounting unit within public sector R and D, so the following figures are estimates calculated as an approximate proportion of total expenditure on horticulture in 1989-90. Staff costs are not included. To include them would introduce an element of double accounting, since staff numbers are covered under the heading of personnel, and because salary costs per unit of research output vary so much between national research organizations and between these and international bodies that comparisons of salary expenditures are almost meaningless (Z$2.5 = $US1).

DRSS

Horticulture Research Institute

Running expenses	Z$104 000
Capital expenditure	Z$6 000
New vehicles (CMED)	Z$25 000

Head Office, Biometrics, Plant Protection, Chemistry and Soils and Agritex
Expenditure relevant to vegetable development work is not readily quantified.

University of Zimbabwe
There is no separate vote for horticulture but the total expenditure including salaries is approximately Z$150 000.

Arda

It is very difficult to separate expenditure on development from that on production.

Donor Funding of Public Sector R and D

Donor-funded projects usually last for several years. The total approved expenditure by the donors is given for all current projects together with the duration

of the project. The national (Zimbabwean) contributions are not given because these are allocations of resources already accounted for under the personnel and core fiscal resources headings.

DRSS

World Bank National Extension and Research Project to 1991

Tenders are currently being invited for expenditure on horticultural research within this project. Expected expenditure is approximately:

Tissue-culture laboratory HRC, Marondera	Z$120 000
Other machinery and equipment Horticultural Research Institute	Z$250 000
Houses for five research officers and 29 other staff at HRC, Marondera	Z$1 755 000

Approximately 50% of this expenditure should be set against vegetable research.

World Bank Agricultural Credit and Export Promotion from 1990

Agreement signed March 1990. Agreed expenditure at HRC, Marondera: Postharvest research including building and equipment US$871 800. Approximately 50% of this expenditure should be set against vegetable research.

Danish International Development Agency (DANIDA) Funds for Plant Quarantine Facility

Plant Protection Research Institute, Henderson Research Station. Agreement signed 1989. DANIDA contribution D.Kr.29 million (Z$11 188 271). A very large proportion of the use of this facility will be to support the introduction of horticultural plants free from pests and diseases including viruses, a key aspect of vegetable R and D.

SAREC (Sweden)

Water use and water use efficiency of horticultural crops in dambos. SKr.150 000 (Z$60 000) per year for 2 years with possible continuance. Horticultural Research Centre, Marondera. Allocated entirely to research on vegetables on vleis (dambos) and representing approximately one-third of a SAREC-funded project on dambos (the other aspects, coordinated by University of Zimbabwe Department of Civil Engineering being on dambo water resource mapping). Additionally the project makes a 4-wheel drive vehicle available to HRC, for off-station horticultural research on dambos for 4 months/year.

ODA (United Kingdom) Postharvest Project

One week consultancy on building design, etc. 1989. Further involvement expected.

ODA and NRI (United Kingdom)

Two, 2-week consultancies 1989-90 regarding onion cultivar trials, storage and seed production. Further involvement expected.

Rockefeller Foundation

Funding one student for horticultural science PhD, Davis, California, USA.

British Council

Funding one student for postharvest horticulture MPhil, Silsoe, UK.

FAO/UNDP Project on Horticultural Extension and Training

US$505 103 over 2 years. Assume at least 50% on vegetable extension and training.

University

Donor funding is currently being sought to help set up a University Department of Horticulture.

Private Sector R and D

Most private sector trials on horticultural crops are done on growers' farms with the effective cost being borne by the commercial companies (technical advisors and materials) and farmers (land and management). Indirect fiscal inputs to the private sector development result from the close links which commercial growers have with importers (e.g. in Europe, who provide them with information (e.g. on the growing of mange-tout peas)).

Contacts with sources of information are also made through the Horticultural Promotion Council (HPC) which arranges visits by international experts who talk directly to farmers' meetings (e.g. an American and a British specialist in postharvest R and D on horticultural crops visited Zimbabwe in 1989 under HPC auspices). There is close interaction between this activity and the state sector, the general pattern being similar to that in many developed countries.

There are no estimates of the cost of private sector R and D but its role, especially in technology transfer from developed countries, is very significant.

Donor-Funded Development Projects

Mashonaland East Fruit and Vegetable Project

Total project cost over 4 years Z$6.06 million to which the European Development Fund will contribute Z$5.8 million consisting of Z$4.5 million as a special loan and Z$1.8 million as a technical assistance grant. This program is targeted toward

1200 fruit producers and 4100 vegetable growers in communal lands. Harare City Council will upgrade Mbare Musika market to deal with produce.

Manicaland Smallholder Coffee, Fruit, Nut and Vegetable Project

This scheme will benefit 600 coffee farmers, 840 fruit tree farmers and 400 farmers providing off-season food crops and vegetables as well as establishing 30 self-help irrigation schemes covering 125-150 ha. Project implementation is by Arda and the Government is responsible for running costs and provision of qualified staff. Project financing is through a loan of Z$8.4 million from the EEC.

Taguta Gardens Horticultural Development Project

This is in the Gutu district and its main objective is to improve production of vegetables so as to cover subsistence requirements. The German Agency for Technical Co-operation provides financial and technical assistance.

General Status of Facilities for Vegetable Research

DRSS

DRSS facilities for vegetable research have been strengthened appreciably since January 1988 at the Horticultural Research Centre, Marondera. The number of horticultural research officers has been increased from two BSes to one PhD (expatriate) and five BSes plus one currently taking a postgraduate MPhil course overseas. An additional nursery has been brought into operation and a cold room installed. Major enhancement in terms of laboratories and equipment is scheduled during 1990 and later years as a result of World Bank and SAREC support. Enhancement of facilities at Chiredzi Research Station is also planned. Allocation of two new vehicles by CMED (Zimbabwe) and of a shared 4-wheel drive vehicle (SAREC) has increased the capability for off-station R and D, while the building of houses for staff should help to retain them. The planned expansion of staffing has not yet been completed, and the average level of experience is still very low but the training plan is on schedule.

Staffing at Chiredzi was reduced by departures on courses overseas but new appointees have partially made good the temporary vacancies. Nyanga Experiment Station has increased its involvement in vegetable R and D.

There has been substantial improvement of operating systems in four areas:

(1) Cultivar trials with good links developed with major seed sources in Asia, Europe and the USA and coordinated trials on cabbage and carrots - initiated from Chiredzi and carried out at all three institute sites;

(2) Research on seed production; capability has been enhanced by cooperation with NRI/IHR Wellesbourne (through ODA funding) and by the acquisition of the cold room which has been used for onion vernalization;

(3) Research on vegetable production on vleis (dambos). This now has one full-time research officer with a full-time technical assistant plus field staff and considerable funding from SAREC. Additionally this program is benefiting from close involvement of experienced soil scientists from the nearby Soil Productivity Research Laboratory; and

(4) Off-station trials and extension. The capability for this has been strengthened by:

(1) Stationing one (graduate) Agritex horticultural crop specialist at HRC, Marondera; and

(2) Effective functioning of the horticultural activities organized by the Committee for On-Farm Research and Extension (COFRE) which helps coordinate the work of DRSS and Agritex.

Agritex

Agritex facilities are also greatly strengthened with two graduates returned from overseas postgraduate training, and three others in post as horticultural crop specialists. The average level of experience is still very low but the overall administration is under a much more senior member of Agritex and there are two FAO/UNDP technical experts with special responsibility for training. The structure for effective horticultural extension is therefore largely in place, and the overseas training program for graduates is operating as is the within-Zimbabwe program for training junior field staff and farmers. A general horticultural training handbook has been produced, a nation-wide program of training Agritex field workers in horticulture has completed its schedule, and a horticultural training center is being set up at Dombashawa near Harare.

The system for on-farm trials and demonstrations is still hampered by lack of experienced personnel and shortages of transport.

Arda and Donor-Aided Projects

Arda is relatively well financed with generally adequate transport. The main activity is production-related and the research, extension and training activities are on a relatively ad-hoc basis compared with DRSS and Agritex.

University of Zimbabwe

Although staffing levels have improved, the current emphasis is on expansion in horticultural teaching rather than expansion in horticultural R and D. The present horticultural teaching staff have been in post for less than 2 years. A PhD plant pathologist advises vegetable growers on crop protection problems.

Private Sector

The private sector in Zimbabwe horticulture is dynamic and entrepreneurial. Partly as a consequence of this there is a shortage of salaried professionals, with a tendency for these to move out of paid employment into business on their own.

Therefore, as in DRSS, Agritex and Arda there is a general lack of experience among salaried staff. Many growers and advisors in the private sector have South African qualifications.

Active Programs of Vegetable R and D

DRSS

Cultivar Trials

Zimbabwe has short days throughout the year but otherwise has a very wide range of climate, the local climate being determined by altitude and rainfall. There are large areas of farmland above 1400 m, some below 400 m but most is in the 1000 – 1400 m range. Mean daily maxima are seldom above 30°C in the highveld, and seldom below 20°C, giving excellent conditions for the growth of temperate zone vegetables year-round. In the lowveld temperature maxima in excess of 32°C are common in the summer months, so that vegetables are produced mainly as a winter crop. Cultivar trials are carried out at the representative sites of HRC, Marondera (1620 m) and Nyanga Experiment Station (1850 m) on the highveld and in the Eastern Highlands, at Chiredzi (429 m) in the lowveld and at off-station sites.

Typical North European cultivars, e.g. the tomato 'Moneymaker', are successful year-round on the highveld and in winter on the lowveld. Current trials include cultivars from the main vegetable seed companies of the Netherlands, the United States, Japan, Taiwan, France, Israel, South Africa and Australia. Quarantine regulations result in some seed-producing countries being unable to meet Zimbabwe phytosanitary requirements, and there is an active program in collaboration with the Natural Resources Institute (NRI) and the Horticultural Research Institute (HRI), Wellesbourne (UK), to obtain healthy seed from such sources.

Detailed cultivar evaluation in terms of yield, earliness in cropping, quality characteristics and postharvest storage is carried out at the research centers. Onion cultivar trials were extended to the Matopos site (DRSS) in 1990. In future years the Agritex cultivar demonstration trials will be linked more closely to DRSS programs. As well as being evaluated under conditions of irrigated agriculture, vegetable cultivars are also assessed under vlei (dambo) conditions at HRC, Marondera, and it is planned to extend this to communal area farms in 1990-91.

The main crops dealt with, and outstanding results are:

Amaranth – leaf amaranth cultivars selected earlier are now being tested on communal gardens;
Asparagus – potentially a major export crop. Twenty-seven cultivars are under trial;
Cabbages – suitable cultivars for year-round production at Chiredzi have been identified with marketable yields from 50 to 140 t/ha. Hybrids outperformed open-pollinated cultivars. This was also the case at HRC, Marondera, where Anjar F_1 yielded equivalent to 215 t/ha, with average head weights of 4.9 kg;
Chinese Cabbage – being tested at Chiredzi where yields of most cultivars were around 30 t/ha. Their acceptability to the people has not yet been tested;

Carrots – new cultivars have failed to outperform 'Cape Market' and 'Chantency';
Chilies – seven cultivars are being evaluated for yield and capsaicin content;
Onions – in 1989 twenty cultivars were compared with the local standard 'Texas Grano' as a winter crop at HRC, Marondera. The hybrid 'Rio Bravo' was outstanding with a yield equivalent to 141 t/ha;
Potatoes – evaluation of four cultivars under summer (rainy season) conditions on Marondera vlei ridges showed yields ranging from 17 to 32 t/ha, with the cv. 'Opal' being the highest yielding.
Tomatoes – in trials at Chiredzi of both indeterminate and determinate tomatoes planted so as to crop in all four seasons of the year, marketable yields ranged from 30 to 100 t/ha. 'Amfora' consistently gave the highest yield among indeterminate and 'Heinz 1370' and 'Rodade' among determinates. Cherry tomatoes are being compared with standard cultivars at HRC, Marondera;
Tsenza – cultivar assessment is in progress at Nyanga Experiment Station;
Tsunga – trials comparing farmers' strains with those sold commercially are in progress at HRC, Marondera. Preliminary trials are being carried out on different cultivars of a range of crops, such as red spinach, green spinach, senposai and mungbeans.

Vegetable Seed Production and Nursery Management

Vegetable seeds, especially onion, are in short supply, except to those who have access to foreign exchange and who generally import hybrid seeds. In an effort to improve the prospects for local seed production, at least of open-pollinated cultivars, trials on production of carrot and onion seeds are in progress at HRC, Marondera, with some technical assistance from NRI/IHR Wellesbourne (UK). These are being done in contact with Arda, which plans to diversity into seed production, and with individual seed companies.

Nursery irrigation studies are in progress at Chiredzi.

Postharvest Management of Onions

Large-scale commercial growers store onions through the rainy season in large stores with forced dryers. Communal farmers experience rapid deterioration of their produce. Preliminary trials at HRC, Marondera, using well-ventilated stores of inexpensive construction have given good results, and this line of work will be further developed.

Market Intelligence and Horticultural Surveys

Horticultural crops are numerous, perishable and not controlled by marketing boards in Zimbabwe. Prices vary greatly through the year with off-season products usually being the most profitable despite generally lower yields. Marketing practices and prices are being monitored as one element in research planning.

Vlei (Dambo) Vegetable Production

This is a major research project with attention concentrated on:

(1) Crops and cultivars to fit year-round production systems based on cropping on ridges to avoid waterlogging in summer, and on the use of residual groundwater supplemented by irrigation from shallow wells in winter (the dry season);

(2) Identification and correction of nutrient deficiencies on these acid, seasonably waterlogged, soils;

(3) Investigation of the effects of cropping on soil organic matter content and on the impact of organic composts to maintain and improve soil structure;

(4) Determining the pattern of water resource use, especially in the winter season when the water supply is by lateral seepage and upward capillary movement, and the appropriate irrigation practices using inexpensive hand pumps (micro-scale irrigation);

(5) Developing vegetable production within a sustainable system for overall vlei land use, including erosion prevention measures and the production of fuelwood and cut fodder.

Among the most significant results to date are:

(1) The high yields of potatoes, up to 32 t/ha, as a staple food crop for consumption or sale;

(2) The improvement in yields following liming and correction of nutrient deficiencies;

(3) The large responses in incorporating compost at a rate of 50 t/ha. This led to a three-fold increase in cabbage yield. It was observed that water can move upward for about 1 m from the water table as a result of capillary action, but that the supply rate does not necessarily prevent mid-day wilting in hot weather; and

(4) It was also noted that although the top 30 cm or so of the soil is of relatively high organic content and good structure, below this level it is almost pure sand which has very little structural strength and is easily eroded by water. From this it can be inferred that deep cultivation or the digging of deep drainage ditches would lead to the risk of serious erosion.

Overall DRSS Research Approach

This recognizes that both the large-scale and the small-scale (communal) sectors are strongly market-oriented as far as vegetable production is concerned, but that dietary aspects are also important for the latter. Climatic conditions in much of Zimbabwe are such that cultivars bred for temperate conditions can be very successful, although there are special problems due to the summer rains (which favor leaf diseases) and to high summer temperatures in the lowveld. There is therefore a heavy emphasis on evaluation of cultivars bred overseas, especially, but by no means exclusively, for export markets.

Communal sector producers are, however, limited in their scale of operations, their access to irrigation and their access to other capital resources. The vegetable research program, therefore, pays particular attention to the improvement of productivity under these constraints, but without giving up the objective of developing intensive production systems.

Agritex

The major Agritex activity in horticulture over the last 2 years has been in training field staff. In the first training cycle in 1989 (organized by the FAO/UNDP/Agritex teams) 43 Agritex staff, mainly extension workers plus a few extension supervisors, were given an intensive 2-week vegetable production course. This covered food values, botanical classification, cultivars, seed and seed storage, production systems, market garden economics, site selection and preparation, nursery practices, crop rotation, compost and fertility trenches, fertilizer practice, salinity and sodicity, nematode susceptibility, pests and diseases and their control, irrigation and postharvest handling. The staff were then given field assignments followed by a 1-week workshop to discuss these. There was then a 2-week session on vegetable production to discuss cultural practices of vegetable crops grown in Zimbabwe and a final workshop to discuss the field assignments.

The second training cycle was similar, with 64 participants completing the course. A new cycle, mainly run by the recently appointed graduate horticultural crop specialist with lesser involvement by the FAO/UNDP team, is in progress.

Agritex extension work on vegetables is primarily in the communal sector and emphasizes cultivar trials and demonstrations on tomatoes and leaf vegetables including amaranth. Some of this work is market-oriented (e.g. trials on determinate and indeterminate tomatoes on irrigation schemes). Other work is nutritionally-oriented (e.g. there are a large number of nutrition gardens planned jointly with the Ministry of Health).

Arda

The major current Arda R and D efforts are on market intelligence and marketing, seed production and support of the donor-funded schemes noted earlier.

University of Zimbabwe

Currently the major research activities on vegetable crops are:

(1) Disease identification and advice on disease control for farmers;

(2) Research on production of cabbage seed; and

(3) Research in biotechnology ranging from tissue culture to gene transfer. Sweet potatoes are one of the test crops at present.

National Plan and Strategy for Agricultural Development

Zimbabwe's national development plan includes the objectives of economic expansion, land reform and efficient land utilization, while maintaining a correct balance between the environment and development, raising living standards especially of the peasant population, increasing employment opportunities, developing science and technology and reducing dependence on external resources.

Within this framework horticulture is seen as being of special importance for creation of employment, earning foreign currency, enhancing the nutritional standards of the population and ensuring self-sufficiency in fruit, flower and vegetable products.

Importance of Vegetables

There are no fully reliable data on the total area or output value of vegetable production, but a number of approximations have been made. Horticultural crops account for about 9% of total agricultural output (Agritex 1989) and vegetables account for only a proportion of this.

Much of the communal area production is on vleis (dambos) or the margins of these, and about 20 000 ha of such land is used for vegetable production in small-scale gardens (Central Planning Unit MLARR 1989). Small-scale irrigation schemes have 393 ha producing vegetables. This communal and small-scale production is both for home consumption and for sale. Vegetables are eaten as a 'relish' together with maize porridge (sadza) and provide an important source of minerals and vitamins. Sales both to nearby and distant markets are a very important source of income, and Bell et al. (1987) found that the vegetable garden can provide income up to Z$2000/year.

This source of income is especially important because it can be obtained throughout much of the year and the money is immediately available, in contrast to once-a-year payments for crops sold through marketing boards. The overall importance of vegetable production for both consumption and sale is indicated by the finding in a Agritex survey of communal farmers in regions near Bulawayo, Harare and Mutare that 77% of the respondents grew vegetables.

The main communal area crops are rape, tomatoes, cabbages, onions, beans and pumpkins, but many others are of significant importance.

Farms in the large-scale commercial sector had approximately 2500 ha planted with vegetables in 1987 and the area probably increased subsequently. Cabbages, onions and tomatoes are primarily grown for sale within the country but growing amounts of asparagus, baby corn, baby carrots, French beans, mange-tout peas and other high-value crops are exported.

National Long-Term Program For Horticultural Research

The general aim is to improve the productivity of the communal and small-scale horticultural sectors while maintaining the competitive efficiency of the commercial sectors with regards to export crops.

Research programs specifically relating to the communal sector are directed towards efficient use of scarce water resources and to developing locality-specific horticultural technologies which will maximize sustainable production by resource-limited farmers.

Programs of general national applicability emphasize the introduction, evaluation and selection of improved cultivars from other countries and the breeding of local stocks, seed production, agronomy, nutrition, crop protection, handling, storage and processing.

In prioritizing these programs there is due recognition of the need for food security and a health-giving diet on the one hand for generation of cash incomes, and export income, on the other.

Personnel Development

Government policy is to provide formal horticultural training at certificate, diploma and degree levels and directly to farmers. Certificate and diploma courses at the existing colleges and institutes under the Ministry of Lands, Agriculture and Rural Resettlement will be expanded and their horticultural content increased. A centre for training farmers in horticultural practice is being set up and there is a strong national emphasis on farmer training by Agritex.

Agricultural Credit, Price, Subsidy, Marketing, Export

Growers are responsible for the production and marketing of their own crops. In this, horticulture differs from, for example, cereals and other controlled crops where established Marketing Boards are responsible for marketing. This is likely to continue to be the case because most of the products are highly diversified and perishable and are subject to weekly, even daily, fluctuations in demand and therefore price.

Credit

The perishable nature of the produce and the price variations cause problems in the provision of credit secured against expected returns from the crops. Large-scale commercial producers generally have adequate credit facilities. The government aims, through Agritex, to ensure that small scale/communal horticultural production is sufficiently viable to satisfy the credit requirements of the Agricultural Finance Corporation. It also encourages small-scale producers to form cooperatives and savings clubs in order to reduce the unit cost of borrowing.

Irrigation

The limited availability of water resources is a major constraint on horticultural production and it is government policy to provide irrigation facilities in potentially valuable horticultural growing areas, especially in Masvingo, Midlands and Matebeleland.

Transport

Government provides foreign exchange for the importation of spares for on-farm and off-farm transport to ensure that local-scale and export vegetables move as rapidly as possible to market. Transport, however, remains a severe problem.

The government is assisting the horticultural export industry by the allocation of more airfreight space for horticultural export, this space being provided by Affretair, charter aircraft and passenger airlines.

Processing

To ensure the adequate supplies of fresh produce are available for processing, government policy encourages farmers to diversify further into horticultural production through an export bonus scheme, and to encourage processors by provision of more foreign exchange for the upgrading of existing plants.

Packaging

This is a vital component of the transportation and marketing of horticultural produce. Government will continue to provide foreign exchange for the importation of materials for both local-scale and export packaging. In the long term it will encourage local production of packaging materials.

Information

Government encourages effective use of the news media and Exporters Information Service to disseminate information about local and export markets, market promotion and trends in horticultural sales. It also encourages trade conferences where farmers can meet representatives of other countries on the production and marketing of horticultural products.

Market Access

Government will continue to negotiate for improved access for Zimbabwean horticultural produce into foreign markets and for reduction of tariffs.

Export Incentives

Government has actively provided export incentives in the form of foreign exchange allocations to exporters and will continue to do so.

Horticultural Production Small-Scale Development

It is recognized that seasonally inundated wetlands (or dambos) play a vital role in maintaining the hydrological balance, and also represent the major water resource available to communal farmers for horticultural production. Government is therefore giving particular attention to determining the ways in which intensified horticultural production on vleis can be reconciled with prevention of erosion and maintenance of the hydrological balance.

State Farm Development

State participation in horticultural production marketing is through Arda, which has several major estates producing tomatoes, onions and carrots, and promotes horticultural development in the small farm sector through donor-funded projects. Major policy lines are to strengthen marketing and diversify into seed production, processing and packaging.

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INVITED PAPERS

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Development of an Integrated Pest Management Program for the Control of Diamondback Moth on Cruciferous Vegetables

N.S. Talekar*

Introduction

Diamondback moth (DBM), *Plutella xylostella*, is an oligophagous insect that feeds on such economically important cruciferous plants as common cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*B. oleracea* var. *botrytis*), broccoli (*B. oleracea* var. *italica*), Chinese cabbage (*B. campestris* ssp. *perkinensis*), radish (*Raphanus sativus*) and others. The insect probably originated in the Mediterranean area and now enjoys worldwide distribution (CIE 1981). At the centre of its origin, a complex of natural enemies in the European continent keeps this pest under control. In Romania, for example, up to 28 parasite species were found in cabbage fields in Moldavia (Mustata 1987). Their combined parasitism ranged from 70 to 90%. However, in new areas, with the expansion of crucifer cultivation, this pest has spread rapidly due to the lack of natural enemies. This has resulted in DBM becoming a serious pest of crucifers through much of the world.

The insect larva feeds mainly on the foliage and other above-ground parts of the cruciferous plants. As a result of this damage, the yield and quality of the produce is reduced considerably and, in extreme cases, there is total loss. This insect can breed and develop between 10 and 40°C and adults can remain active up to 50°C. This survival characteristic, coupled with high fecundity, enables survival of this insect under a wide range of climates from the humid tropics to the near arctic.

DBM Problem in Southeast Asia

Crucifers are important vegetables throughout Southeast Asia, including Thailand, Malaysia, Indonesia, Philippines, Taiwan, Laos, Vietnam and Kampuchea. In these countries most of the vegetables are cultivated throughout the year, around big cities and specialized vegetable growing areas which supply the city markets. Farmers in these production areas use intensive cultivation practices to produce high-quality vegetables.

DBM is the most important insect pest of all crucifers in Southeast Asia and farmers use insecticides intensively to combat the pest. With the introduction of synthetic organic insecticides in the early 1950s, effective control of DBM was initially achieved. As a result, alternative control measures were ignored. Inevitably, DBM developed resistance to insecticides. The first case of any field crop insect pest becoming resistant to synthetic organic chemical was reported from Indonesia, where DBM developed resistance to DDT (Ankersmit 1953). Similar instances were report-

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ed soon thereafter from Malaysia (Henderson 1957) and, less formally documented, in other countries of the region. Instead of searching for alternate control measures, trials were conducted in Southeast Asia to introduce newer chemicals to replace the ineffective ones. Soon, the insect developed resistance to the newer chemicals. Availability of host plants throughout the year, and rapid turnover of generations under ideal conditions of the tropics, results in selection of insecticide-resistant biotypes far more quickly in Southeast Asia than elsewhere. Due to the absence of effective alternate control measures, vegetable farmers are now using higher concentrations of existing insecticides, spraying mostly as 'cocktail' mixtures more frequently than in the past. As a result of this indiscriminate use, other insects, such as *Spodoptera* spp., *Croccidolomia binotalis, Hellula undalis* – which were once the minor pests of crucifers – have become major problems because of the destruction of their, along with that of DBMs' natural enemies. As a result, development of insecticides has now become the single most important factor adversely affecting crucifer production in this part of the world. A similar approach to the well-known cotton pest control programs in parts of Central America resulted in the destruction of the cotton industry there (Metcalf 1980).

Research and Development on DBM at AVRDC

In view of the seriousness of the DBM problem in Southeast Asia, research at AVRDC since its founding in 1971 has emphasized the need to develop control measures to reduce dependence on chemical insecticides. The alternative controls that are being explored include: (1) finding crucifer cultivars resistant to this pest; (2) use of insect viruses and the bacteria *Bacillus thuringiensis*; (3) cultural practices that will reduce DBM infestation; (4) biological control with introduced parasites; and (5) use of selective chemical control agents which are toxic to pests but are safer to parasites and predators.

Before initiation of the above research, we studied the seasonality of the DBM. Although the purpose of this exercise was to find a suitable time when we could do most effective research in the field when the DBM population is high, we were aware of the potential use of seasonality information in the implementation of successful control measures both in terms of use of preventive control measures and forecasting of an epidemic. We therefore initiated a detailed insect pest monitoring program for Chinese cabbage and common cabbage, two of the most common crucifers in Taiwan. The results of monitoring from 1976 to 1983 are presented in Talekar et al. (1986). We found that DBM infests the crucifers from October to May, and it was practically absent from June through September. A cool and dry winter is a major crucifer season in Taiwan and host plants, including wild crucifers, are present in the field during this period. The absence of DBM during the summer, despite the availability of host plants in this study, appears to be due more to frequent rains than to high temperature. The larva of DBM is a surface feeder and is frequently washed away or drowned in the cavity created as a result of its peculiar feeding habit in the leaf. Rain is also believed to disrupt the flying of adults and, thus hamper their movement including mating and oviposition. This hypothesis is further supported by the fact in 1980, when Taiwan experienced drought, DBM was present throughout the year (Talekar and Lee 1985). Harcourt (1957) in Canada has also reported rainfall as an important mortality factor in the population dynamics of DBM.

Resistant Cultivar

We screened 506 Chinese cabbage and related *B. campestris* germplasm accessions for resistance to DBM. However, we failed to find any accession that had sufficient resistance to be useful for planting as a DBM-resistant cultivar, or to initiate resistance breeding to transfer the resistance into commercial cultivars. This line of research, therefore, was discontinued. More recently, however, a research group at Cornell University in the United States reported that Plant Introduction (PI) 234599, a dark green glossy-leaved cauliflower, was highly resistant to lepidopterous insect pests (Dickson and Eckenrode 1975; Eckenrode et al. 1986). Utilizing this PI as parent material, the Cornell group bred several insect-resistant common cabbage and cauliflower lines (Dickson and Eckenrode 1980; Dickson et al. 1984, 1986).

Some of these lines were imported to AVRDC to study their resistance to DBM and to possibly transfer the resistance to Chinese cabbage. Six lines of cauliflower and seven of common cabbage, including a local cultivar of each species, were planted in a replicated test in the field and exposed to the ambient population of DBM, which was augmented by the release of laboratory-reared insects. Observations on the number of eggs laid, number of larvae and pupae on the plants and severity of damage were recorded periodically. There was no marked difference in the oviposition; however, significant differences were observed in the number of larvae and pupae found infesting various entries (Table 1). In general, the glossy green foliage lines significantly lower DBM infestation than the nonglossy pale green lines. Cauliflower line NYIR 314 and cabbage lines NYIR 116 and NYIR 118 were significantly less damaged than the other (AVRDC 1989). The DBM-resistant common cabbage has thick waxy dark green leaves; DBM-resistant cauliflower has a similar type of foliage and yellowish curd. Both characters are not readily acceptable to the consumers in Southeast Asia. Besides, both cultivars have yield potential lower than the commonly used cultivars of respective species. They are thus not suitable for commercial cultivation unless their yield and consumer acceptance is improved. However, they represent an important source of resistance to breed DBM-resistant cultivars.

Cultivar Control

Modification of Irrigation

The study of modification of method of irrigation to control DBM was the direct consequence of our DBM population monitoring, which indicated that frequent rains adversely affect the DBM infestation (Talekar and Lee 1985). We studied the utility of modification of irrigation methods to stimulate rainfall in controlling DBM. In one such experiment, sprinkler irrigation was applied in such a way that water was delivered as tiny jets from above the plant via perforated rotating pipe. A drip irrigation system served as the check. The amount of water applied to both check and sprinkler plots was equal. In sprinkler irrigation treatment, water was applied at sunset for 5 min. The purpose of this timing was to get maximum disruption of adults which are active in mating and oviposition at dusk (AVRDC 1989).

The DBM larval and pupal population was monitored at intervals. The number of larvae + pupae was consistently lower in the sprinkler plots than in drip irrigation plots during each observation. The numbers of marketable heads and total yield in

the sprinkler plots (20 t/ha) were significantly greater than in drip irrigation plots (8.3 t/ha). Similar beneficial effects of sprinkler irrigation in reducing DBM infestation of watercress have been reported by Nakahara et al. (1986) in Hawaii.

Table 1. Infestation of selected cauliflower and cabbage breeding lines by DBM in the field.

		No. eggs/ 10 plants	No. of DBM larvae and pupae/10 plants		Damage score[a]	
Lines	Leaf	85/3/12	85/12/17	85/12/23	85/12/18	85/12/24
NY 7802-2(CF)[b]	G[d]	34.33ab	21.33c	6.00c	3.27bc	3.13b
NYIR 127(C)[c]	G	33.00abc	61.00bc	24.33bc	2.37d	2.83bc
NYIR 114(C)	N[e]	27.00abc	132.67a	84.00a	3.83ab	4.30a
NYIR 9150(CF)	N	37.00ab	78.67b	30.00b	4.27a	4.67a
NYIR 9120(CF)	G	19.00abc	31.00c	22.00bc	3.00cd	3.43b
NYIR 115(C)	G	20.33abc	61.00bc	24.33bc	2.03d	2.10c
NYIR 314(CF)	G	18.67abc	19.33c	9.00c	1.73d	1.40d
NYIR 310(CF)	N	35.33ab	72.67b	30.33b	4.37a	5.00a
NYIR 128(C)	G	17.67bc	32.33c	21.67bc	1.67d	1.47cd
NYIR 116(C)	G	20.00abc	33.67c	14.00c	1.73d	1.47c
NYIR 131(C)	N	44.67a	141.00a	84.00a	3.97a	4.23a
Cauliflower local	N	13.33bc	41.67bc	26.67b	3.83ab	4.37a
Cabbage local	N	7.33c	80.00b	47.33b	3.17c	3.47b

a Damage score 1 = <5%, 2 = 5-20%, 3 = 21-40%, 4 = 41-60%, 5 = >60% leaf surfaces destroyed.
b CF = cauliflower.
c C = cabbage.
d G = glossy leaf (dark green).
e N = nonglossy leaf (pale green).
f Data shown are means of three replicates. Mean separation by Duncan's multiple range test ($P = 0.05$).

Experiments were conducted to investigate whether the adult flying activity is also affected by sprinkler irrigation. To achieve this, sex pheromone traps were placed in both drip and sprinkler irrigation fields and irrigation was applied at dusk. The number of male moths in the sex pheromone trap trapped during this period was recorded. DBM adult population was also monitored in the same plots during daytime when irrigation was not applied. Sprinkler irrigation treatment considerably reduced the number of male moths captured compared to the drip irrigation. During the day, when irrigation was not applied, there was practically no difference in DBM adult capture between sprinkler- and drip-irrigated plots. Sprinkler irrigation thus seems to affect the mating-related flying activity of DBM, which at least partly contributes to the reduced larval and pupal population.

Despite the beneficial effect of sprinkler irrigation, its utility in controlling DBM on a large scale seems to be limited due to the cost in fitting such irrigation systems. However, in small-scale home gardens this control practice has potential in controlling DBM.

Intercropping

In a large field experiment, we planted common cabbage between two rows of each of 54 different crops. The DBM infestation of common cabbage was monitored at intervals during the season. Intercropping with barley, dill, garlic, oat, safflower and tomato reduced the insect infestation. Barley, dill, oat and safflower also shaded the crop and reduced yield considerably. In a later confirmatory test, when cabbage was intercropped with only garlic and tomato, the intercropping did not give consistent control of DBM. A survey of the literature also showed inconsistent results on DBM control by intercropping with noncruciferous crops. However, in general, under field situations, the diversified crop community usually reduces the insect pest infestation including that of DBM.

Microbial Control

Granulosis Virus

In 1973 we isolated one granulosis virus (GV) from a diseased DBM larva found in the field. This virus was identified through pathological changes in infected insects and by light phase and electron microscopy techniques. DBM larvae were raised on common cabbage to serve as hosts for the virus multiplication. Larvae were periodically collected and sprayed with virus suspensions. After the larvae died, their cadavers were used to prepare more virus suspension.

In order to determine its suitability for use in the field, laboratory studies were conducted to assess the effect of temperature and sunlight on the pathogenicity of the GV. In the temperature effect study, second instar larvae were fed on cabbage leaves that had been sprayed with a concentration of 2.8×10^{10} granules/l and then placed in growth chambers set at different temperatures. As the temperature increased from 20 to 40°C, the percent infection rapidly decreased from 90 to zero (AVRDC 1975). In the sunlight effect study, the cabbage leaves sprayed with 2.8×10^{9} granules/l were placed in direct sunlight for intervals ranging from 4 to 60 hours. After each exposure the leaves were placed in petri dishes and fed to second instar DBM larvae. The length of exposure to sunlight decreased the pathogenicity of GV to DBM substantially (from close to 100% to 10% in 38 hours – AVRDC 1976). No practical remedies could be used to overcome the effect of high temperature, other than not growing the crucifer in the hot season. In order to minimize the deleterious effects of sunlight, various adjuvants to viral suspension were added in both greenhouse and field tests. In the laboratory test both India ink (1 and 3%) and carbon (3%) effectively prolonged the GV pathogenicity. In the field test, addition of yeast, charcoal, India ink, and red ink to viral suspension all increased effectiveness, but red ink proved to be phytotoxic. India ink provided the best protection and enhancement of virus effectiveness (Kao and Rose 1976). The virus, however, does not start epidemics and needs to be applied weekly if one is to get good control. Virus alone does give ade-

quate control but it can be integrated with other methods such as introduction of parasites.

Bacillus thuringiensis

Because of the safety, excellent compatibility in integrated pest management, and commercial availability, *Bacillus thuringiensis* makes an ideal candidate for DBM control. In this connection, the following 13 strains or formulations of *B. thuringiensis* were tested at AVRDC in our routine insecticide screening trials to control DBM: ABG, ABG6162, Bactospeine, Bag-A-Bug, Biotrol, Dipel, Dipel 2X, H3a3b, H7, a local formulation, SAN415, Thuricide, and Toarow. DBM control due to *B. thuringiensis* varied considerably. However, in general, the lower the temperature the better was the control of DBM. In the laboratory tests, however, *B. thuringiensis* was unaffected by high temperature. Among all *B. thuringiensis* strains, SAN415 was far better than the rest in controlling DBM. Like the GV, *B. thuringiensis* also does not start disease epidemics, and hence it needs to be applied frequently.

Biological Control

Biological control research at AVRDC began with the importation of a larval parasite *Diadegma eucerophaga* from Indonesia. This parasite, which was introduced into that country from New Zealand in 1950 (Vos 1953), is well established in certain highland areas of Java and Sumatra where it is keeping DBM under control (Sastrosiswojo and Sastrodihardjo 1986). The parasite is reared on DBM larvae in the laboratory and pupae are released in the field (Talekar 1988).

Soon after importation, we conducted one field trial where common cabbage was planted in a 40x45 m area which was divided into three 40 m x 15 m parcels enclosed in 1.5 m high nylon net. Three weeks after cabbage transplanting, 250 DBM cocoons were introduced in the first two cages and the third was maintained a DBM-free check. Starting within a week after DBM release, *D. eucerophaga* adults were introduced periodically in one of the two cages where DBM was introduced. Parasitism of DBM larvae was monitored periodically and yield was recorded at harvest.

Diadegma eucerophaga readily infested DBM larvae. The average parasitism which was only 13.1% about a month after the initiation of parasite release, reached 65.4% just before harvest. As a consequence the cabbage yield increased significantly (only DBM released, 7.7 t/ha; DBM + parasite, 14.8 t/ha; no insect release, 30.9 t/ha) (Talekar 1988). Obviously, the parasitism was not high enough to give complete control of DBM.

Based on this preliminary study, attempts were made in the 1985-86 season to introduce the parasites on farmers' fields at three locations in Taiwan. At all locations, DBM had developed resistance to practically all insecticides and it was causing enormous damage to crucifers, mainly cauliflower and cabbage. Among the first of three locations, Luchu is in the lowland area, where crucifers are grown only during cool-dry autumn and winter seasons. The remaining two locations, Yangminshan in the north and Wuling in central Taiwan, are in the highlands where crucifers, mainly cabbage, are grown in summer.

At Luchu we introduced the parasite at three sites. The first site consisted of a 9-ha area owned by 21 farmers; the second, a 1-ha isolated field owned by one farmer, and the third, a 5-ha isolated field owned by one farmer. All farmers were advised to use only *Bacillus thuringiensis* which is not toxic to the parasite but is toxic to DBM and other lepidopterous pest species. Between October 1985 and April 1986, a total of 35 166 cocoons of *D. eucerophaga* were introduced. Due to suspension of chemical insecticide spray, a native parasite *Apanteles plutellae* parasitized DBM larvae. This parasite was therefore collected and reared in the laboratory in an identical manner to *D. eucerophaga*, and released in the field (12 506 pupae) simultaneously with *D. eucerophaga*. A maximum combined parasitism of 27% DBM larvae was achieved. The cauliflower yield was similar to the previous years. However, the insecticide cost was reduced considerably. In each case the cost of insecticide (mainly *B. thuringiensis*) used throughout the season was reduced to one-third of the cost incurred during the previous (1984-85) season. Even including the cost of *B. thuringiensis* that was supplied free, the total cost was less than half of the previous year. In general, the fewer the number of farmers per unit experimental area, the lower the use of insecticides, and the better was the pest control by parasites. Despite intensive efforts in discouraging farmers from using broad-spectrum chemical insecticides, some farmers continue to spray these chemicals which adversely affected the parasitism.

At the second location in the highlands, where common cabbage is grown in the summer, 45 000 parasite cocoons of both species were released on a 17-ha area owned by a cooperative. Within a month after introduction of the first lot of 20 000 parasite pupae, which was done 2 weeks after cabbage transplanting, the parasitism of DBM larvae reached 75%. After this the DBM population was reduced drastically and no further observations could be performed.

There was no difference in the yield obtained during this year and the previous year, but the cost of insecticide was reduced drastically. In 1984 this cooperative used nine different insecticides and incurred an expense of NT$47 000 (US$1300)/ha. The insecticides, often mixtures, were sprayed once every 5–6 days. In 1985 they sprayed seven different chemicals and it cost about NT$42 000/ha. The spraying frequency was similar. In 1986, based on our advice, farmers used only *B. thuringiensis* formulations. The cost was reduced to about NT$17 000/ha and the spraying frequency was reduced to once every 9–10 days.

At Yangminshan during summer 1986, we released 35 600 *D. eucerophaga* and 97 200 *A. plutellae* pupae over a 10-ha area. DBM larval population which was quite high initially (122–154 larvae/15 plants), decreased gradually. The parasitism rate, which was very low soon after parasite release, increased to 52.4% in 4 weeks. From this time onwards pest population remained relatively low dropping to 5 larvae/15 plants which is below the economic threshold of 2 larvae/plant after 10-leaf stage (Chen and Su 1986). Parasitism stabilized between 35 and 40%. At this stage plants had already formed heads and most of the insects were on outer leaves which did not affect the yield. A week before the beginning of the harvest, the insect population increased to 90 larvae/15 plants but it was reduced to 5 larvae/15 plants the following week when parasitism reached 80%. A cyclical pattern between the pest population and parasitism was evident. Most of the parasitism was by *A. plutellae*; only on three occasions did we find *D. eucerophaga*, and its parasitism hovered between 4.5 and 7.6%. None of the farmers used chemical insecticides and only *B. thuringiensis* was

used to control caterpillar pests such as *Trichoplusia ni*, *Pieris rapae*, and *Spodoptera* spp. Large numbers of *S. litura* adult males were trapped in the specific sex pheromone-baited traps. However, this pest still caused some damage especially at the base of cabbage heads, which was visible only when the crop was harvested.

Parasite Establishment

Among the three locations where we released *D. eucerophaga*, the parasite has not yet been established in lowland Luchu and Yangminshan (elevation 700 m). At Wuling (elevation 1700 m), the site of parasite release in 1986, a survey in 1988 revealed that a total of 56.9% DBM population was parasitized by both insects. *Diadegma eucerophaga* parasitism amounted to 45.6% and the remaining 11.3% by *A. plutellae*. At Lishan (elevation 1600-2100 m), 20 km to the south, both parasites were present but the DBM population was too low to judge the extent of parasitism. At Chingchin (elevation 1600-2000 m), 60 km to the south, 68.3% of the population was parasitized. *Diadegma eucerophaga* contributed 46.8% of the parasitism and *A. plutellae*, 21.5%. At Tienhsiang (elevation 1000 m), 30 km to the east, both parasites were present but the DBM population was too low to reliably judge the extent of parasitism. At Nanshan (elevation 1100 m), 50 km to the north, both parasites were found. However, the DBM population was too low to reliably judge the extent of parasitism.

The parasite has now been established in crucifer-growing areas in the highlands of central Taiwan. All farmers report considerably less DBM damage and consequently very little use of insecticides in this area. *Apanteles plutellae* used to occur occasionally in this area but *D. eucerophaga* was introduced by AVRDC, and has been well established and is spreading. The parasite can overwinter and seems to have alternate hosts, possibly some forest insects. Although no firm statistics exist, in excess of 1000 ha is grown to two crops of cabbage in the highlands every year. We were not able to get reliable data on the expenses on insecticides for DBM control before the introduction of parasites. However, a similar highland area, Yangminshan near Taipei, farmers spend NT$5500 for DBM control per hectare per crop. Based on this, the parasite introduction represents savings of over NT$10 million (US$350 000) per year. In addition to direct savings, the reduced insecticide use will reduce the toxicant being washed from the highlands into streams and eventually polluting the river water and coastal areas around Taiwan.

Since the lowland area, where the temperature during winter, when most of the crucifers are grown, is similar to summer temperatures in the highlands, there is potential that *D. eucerophaga* may migrate and spread into the lowlands and reduce DBM damage. We are now studying this possibility.

These studies show that the introduction of DBM parasites has great potential for pest control. However, greater efforts are needed to convince the farmers not to spray chemical insecticides. This is the most formidable limitation to the biological control of DBM in Taiwan and the rest of Southeast Asia.

Selective Insecticides

Recently two benzoyl urea-type insect growth regulators (IGRs), chlorfluazuron and teflubenzuron, have been introduced into Taiwan and certain other parts of Asia

to control DBM and other lepidopterous pests. Both IGRs and *B. thuringiensis* are practically nontoxic to the parasites. Their normal use will not harm the parasites. In areas where these chemicals and *B. thuringiensis* are used in Taiwan, the parasites are occurring in large numbers, reducing the frequency of IGR sprays to once every 3 weeks. This represents a great opportunity for introduction and establishment of parasites before DBM develops resistance to IGRs, and farmers are forced to resort to spraying of insecticide mixtures which will be detrimental to the establishment of the parasites. Introduction of these parasites at this stage will reduce the need for intensive insecticide use. Besides, the DBM control by parasites will supplement the use of IGRs which will prolong the utility of these chemicals. This will be achieved by delaying the time when DBM will become resistant due to low population pressure and reduced chances of selection of resistant strains. Biological control alone may not provide complete DBM control, and supplemental methods such as occasional spraying of *B. thuringiensis* and IGRs will be necessary to control occasional outbreaks of DBM as well as other pests.

Future Plans

In 1988 we imported one egg parasite of *Trichogrammatoidea bactrae* from Thailand. This parasite gives high parasitism of DBM eggs under laboratory conditions, and preliminary field tests at AVRDC also show high parasitism of DBM eggs. Recent reports from Thailand also show high parasitism of DBM eggs by this parasite (P. Keinmasuke, pers. comm.). This parasite is far easier to rear than the two larval parasites. We recently introduced *Thyraeella collaris*, a pupal parasite of DBM from Malaysia. Our future research will emphasize the two new parasites along with the existing two larval parasites, *A. plutellae* and *D. eucerophaga*, for the control of DBM and their synchronized use will enhance the chances of control of DBM without resorting to the use of toxic and costly chemical insecticides.

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Postharvest Handling of Vegetables

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Introduction

The utilization of any product, regardless of whether it is a raw material or manufactured item, goods or services, relies on the successful integration of three stages:

(1) Production (growing the crop; developing a service);

(2) Delivery (transferring the product to the marketplace); and

(3) Sale or consumption (selling to the consumer).

All of the steps are essential and must be carried out effectively if the activity is to be successfully and profitably undertaken. For horticultural crops the successful delivery of good-quality products to the market for sale is dependent on correct postharvest handling and technology.

In horticulture much attention is given to increasing production by research on breeding improved varieties, optimizing fertilizer and crop water requirements, better pest and disease control, and other farm management aspects. Providing farmers with good production techniques and given favorable seasons, the right soils and adequate moisture, we can often ensure that crops of high quality fruits and vegetables are grown. However, much of the resources and energy devoted to production will be wasted if postharvest technology to handle the products and marketing procedures are inadequate. For the enterprise to be profitable the three links in the chain need to be given equal importance and developed together.

When the opportunities for a new horticultural crop are being investigated, we need to carefully examine all three factors in reverse order, looking first at the marketing aspects, available postharvest technology, and finally production areas. Questions which need to be answered include:

(1) Where is the market for the product? What varieties are in demand? What quantities and quality of product are required?

(2) Can the product be delivered to the market in the desired time at the optimum quality?

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(3) Can the desired varieties of the right quality and in the required quantities be grown profitably?

Local Market Versus Exports

The use of the appropriate postharvest technology to target various markets has important implications for horticultural development in Southern Africa. SADCC has stated that among its regional objectives for horticulture are the production of nutritious and short-term cash crops like vegetables, to contribute food supplies for urban areas, to enhance employment opportunities and provide cash income for farmers, and to increase foreign exchange earnings by growing export crops. From the point of view of postharvest technology, we need to distinguish between the need of local and export markets. Similar problems have been addressed in Southeast Asian countries through the ASEAN-Australia cooperation program to establish and organize R and D in postharvest horticulture for that region (Wills and Lee 1989).

Where vegetable crops are being produced for domestic consumption for a population with low incomes, a major consideration will be a low price for commodities. Variable quality may be acceptable, and the marketing chain may be short and direct. In such a situation, only simple low-cost postharvest technology is affordable and justifiable. At the other end of the scale where production is being targeted for more affluent export markets, the most important factors could be the delivery of specific varieties of high quality and with long shelf life, presented in attractive packages and transported without deterioration over long distances. With higher cash returns the use of more costly postharvest handling and transport technology is therefore appropriate.

For any new horticultural project it is necessary to first determine the market target and then design the postharvest technology appropriate for delivering the product to the consumer.

Postharvest Losses of Food

World production of fruits and vegetables is increasing, with most of the increases occurring in developing regions (Table 1). However, according to FAO estimates, product losses between harvest and consumption account for 20-33% of all food produced. The size of losses varies greatly with different commodities, depending on their perishability and handling history, and may reach 100% in some circumstances. Because of postharvest losses much of the effort put into production of good quality food is wasted, with no financial rewards. Even a small reduction in postharvest losses will result in lower financial losses and increased availability of food. All types of loss need to be considered including weight loss, loss of quality and nutritional value, financial loss and loss of marketing opportunities (Wills et al. 1981).

Postharvest Deterioration

The aim of postharvest technology is to prevent undesirable changes between harvest and consumption (Wills et al. 1981). Most of the problems occur because

Table 1. World production of fruits and vegetables in 1970 and 1985.

Region	Production (Million Tonnes) 1970	1985	% increase
World	1010	1296	28
Developed Regions	444	458	3
Developing Regions	567	840	48
Africa	112	165	47
Middle East	34	56	65
Asia and Oceania*	317	492	56
South/Central America	103	127	23

* Excluding Australia and New Zealand.
Source: FAO Production Yearbook, 1980. Vol. 34: Rome (1981);
FAO Production Yearbook, 1985. Vol. 39: Rome (1986).

vegetables are living plant organs both before and after harvest, respiring and converting metabolites into carbon dioxide, and giving off heat energy and water. When vegetables are harvested they continue to carry on their metabolic reactions, but they have been removed from their source of water and nutrition on the parent plant and soon start to deteriorate. Depending on temperature, there may be rapid metabolic changes associated with ripening and senescence such as a greatly increased respiration rate, accelerated softening, water loss and changes in chemical constituents like pectins, starches, sugars and acids. The general effects of rapid senescence and loss of quality in vegetables may be seen as loss of green color and wilting, accompanied by undesirable changes in texture and loss of flavor.

All vegetables have water as a major constituent, ranging from 60% in legumes to 98% in leafy vegetables and melons. In dry atmospheres water continues to evaporate from the surface of the produce and losses can be considerable. Vegetables exposed to tropical temperatures for periods as short as 2 hours may lose 10% of their weight, resulting in loss of quality and economic loss because they are unsaleable. Even a loss of 5% weight may be visible as wilting or shriveling of root crops and reduce the product's value. One way of reducing moisture loss from vegetables is to increase the relative humidity of the air, thus reducing the vapor pressure difference between the produce and the air.

Good postharvest technology aims to reduce the product's metabolic rate and water losses, so that its nutrient reserves last longer and senescence is delayed.

Direct Causes of Losses

(1) Mechanical Damage

Because of their high water content vegetables are very susceptible to damage through rough handling. Injuries which include cuts, bruises, abrasions and

punctures can be classified into four main types: impact, vibration, compression and puncturing. The visible effects of injuries detract from the market appeal of the product but they also significantly affect its physiological breakdown. Damaged plant cells respire more rapidly and provide sites for infection by microorganisms which can result in rots and reduced postharvest life.

(2) **Biological**

Harvested vegetables are susceptible to invasion by a range of bacteria and fungi. Infection may take place either before or after harvest. Many pathogens may remain dormant on or near the surface of the plant tissue in the field. They only develop as rots after harvest when senescence processes have weakened the outer cells or the product has been damaged. Postharvest treatments for vegetables are aimed at preventing such growth and killing the causal organisms. Insect pests can cause problems in stored products after harvest and may necessitate commodity treatments where quarantine barriers restrict trade.

Control of Postharvest Environment

(1) **Temperature**

The rate of all chemical and biochemical reactions is dependent on temperature. By lowering the temperature of the product we can reduce its rate of metabolism (Table 2). The retention of quality and storage life of vegetables can be significantly extended by precooling the crop within a few hours of harvest. The ideal storage temperature for many vegetables is just above their freezing point (-1°C). Cool stores are therefore commonly run at 0°C, so that the product's metabolism and transpiration, as well as the growth of microorganisms, are all reduced. It is important not to freeze fresh produce because it can suffer extensive damage as it thaws.

Table 2. Heat evolved by fresh vegetables in storage.

	Rate of heat evolution (kJ/t per 24 h)		
Vegetable	0°C	4.5°C	21°C
Beans, green	7000	11600	58100
Cabbage	1200	2400	11600
Carrots	3500	5100	14000
Peas, green	9800	17400	69800
Spinach	5200	12800	53500
Sweet potatoes	2800	4000	8700

Source: Lidster et al. 1974.

However, many vegetables, particularly tropical and subtropical kinds, are susceptible to chilling injury at temperatures well above their freezing point. The

degree of injury depends on the length of exposure and the temperature and may be evidenced by pitting, discoloration, decay or changes in flavor and texture. The critical temperature for chilling susceptible vegetables such as green beans, cucumbers, tomatoes and aubergines is usually between 7 and 13°C (Lidster et al. 1974). Recommended storage conditions for a few common vegetables are shown in Table 3.

Table 3. Recommended storage conditions for selected vegetables.

Vegetable	Temperature °C	Relative humidity %	Storage life (weeks)
Beans, green	7	90-95	2-4
Cabbage	0	95-100	4-12
Carrots	0	95-100	4-20
Cucumber	7	90-95	2-3
Onions	0	50-75	4-32
Potatoes	7	85-90	16-24
Sweet potatoes	13	85-90	16-24
Tomatoes	13	85-90	2-4

Source of data: NSW Agriculture & Fisheries, Agfact HI.4.2.

(2) **Humidity**

The rate of water loss from produce is directly proportional to the relative humidity (RH) of the surrounding air. Most vegetables are highly susceptible to moisture loss, with leafy vegetables wilting readily. Unlike fruit, which are often susceptible to increased rots and physiological disorders at high RH, most vegetables stored at high RH are resistant to decay and breakdown (Lidster et al. 1974). A few vegetables such as onions, garlic, squash and pumpkin require low RH.

(3) **Atmosphere**

Postharvest life of some fruits and a few vegetables can be influenced by the gaseous composition of the atmosphere surrounding them. Normal air contains about 78% nitrogen (N_2), 21% oxygen (O_2), 0.03% carbon dioxide (CO_2) and traces of other gases. In controlled atmospheres (CA) or modified atmospheres (MA), O_2 may be reduced to levels as low as 1% and CO_2 increased from 2 to 5%, with beneficial results for some products, depending on the specific requirements of the commodity. Extreme changes in atmospheres may result in abnormal metabolism, damage to the product and development of off-flavors.

Probably of greater significance for the storage of vegetables is the presence of ethylene in the atmosphere. The concentration of ethylene in air is normally only 0.01 ppm, but it accumulates in the storage atmosphere (0.1 – 1 ppm) then it can reduce the postharvest life of vegetables. Many fruits give off ethylene during ripening which can cause yellowing of leafy vegetables, induce bitterness in carrots and sprouting in

potatoes and onions. These products should therefore never be stored or transported together, unless special provisions are made for chemically absorbing the ethylene or ventilating the air.

Harvesting and Handling

Vegetables need careful handling at all stages because mechanical damage can occur at any point between harvest and consumption. It is important to educate all workers to teach them the correct handling practices which must be employed during each phase of the marketing chain. Field staff responsible for harvesting (packers, transport workers, traders and retailers) all need to be made aware of the need to handle fresh produce carefully. They should be provided with the proper equipment for the job, such as picking bags for harvest. Proper packaging can cushion the product to reduce impact damage and better roads and transport will minimize injuries arising from vibrations.

Postharvest Treatments

A range of chemical and physical postharvest treatments has been developed for various vegetable crops, according to specific problems which might arise with a particular commodity. Methods are available for controlling rots, curing, waxing, ripening and inhibition of sprouting. Fungicides and bactericides are commonly used for decay control, but they require careful application to ensure that the correct concentration of chemicals is used. There must be sufficient active ingredient to give adequate control of the pathogen, but using concentrations higher than those recommended will result in excessive pesticide residues which may be toxic to humans.

Physical treatments such as heat, cold and ionizing radiation can also have useful applications and have the advantage that they pose no residue problems. For crops such as potatoes and sweet potatoes it has been found that holding the tubers at relatively high temperatures (25–35°C respectively) and 98% RH will promote curing of harvest wounds and protect against subsequent invasion by storage pathogens (Scott and Atkinson 1989). Similarly, onions can be naturally protected by curing in a dry atmosphere, either in the field or in ventilated stores.

What treatment should be used and when should it be applied? As a general principle, a treatment should only be used if it is necessary to ensure that the quality of the vegetable is retained and it reaches the market in the time required. All treatments take time and increase costs, which must be recovered in the prices received from the consumer.

In the simplest handling systems, harvested vegetables are carried direct to the village market and sold the same day. Postharvest treatments are often not required, especially if a wide range of product quality is acceptable to the market. More distant urban markets may place greater demands on quality and require more sophisticated technology. Successful exports of high-quality vegetable products to distant markets will only be assured if the best techniques are employed. The appropriate technology to use will be determined by the type of deterioration to be prevented in particular

vegetables (e.g. yellowing of leafy vegetables, sprouting of potatoes, bacterial soft rots, etc.). Effective treatments for products from this region will result from appropriate research and development to investigate the individual problems of Southern Africa, and evaluation of their benefits to marketing before introducing the new technology.

Priorities For Postharvest Technology In SADCC

Any postharvest handling system is only as good as the weakest link in the marketing chain. Poor handling or ineffective treatment at any stage could result in loss of product or quality which will be magnified further down the system. For SADCC we believe that the highest R and D priorities for attention in the postharvest treatment of vegetables are *handling practices* and *temperature management*.

Good Handling Practices

The objectives of any good handling system for vegetables should be to minimize mechanical damage so as to reduce the rate of senescence and infection by rot organisms. The technology required is often simple, cheap and easy to apply, and can be utilized for a wide range of vegetable crops.

Workers should be trained to handle the crop carefully and correctly, to raise their awareness of all the steps involved. The operations of the workers need to be supervised to ensure that they follow correct procedures. Providing them with simple equipment will improve worker efficiency. Harvest aids such as well-designed picking bags and sorting tables will reduce product damage.

It may be most efficient to provide an enclosed area or packing house close to the production area. Here a range of possible operations can be carried out, including product receival, sorting, treatment, grading, packing and dispatch. Packing house operations can range from being all manual to completely mechanized, or combinations of these. The degree of investment in equipment must match the needs of the market and the likely cash returns.

Packaging

Most vegetable handling systems utilize containers or packages to transport the crop from farm to market. In many countries indigenous materials are used to manufacture containers locally. For special purposes such as export the use of synthetic materials may be necessary or justified if required by the market.

The functions of packaging are to contain the product so that it is easy and convenient to handle, and can be readily stowed, to protect produce against mechanical damage in handling and transport operations, to reduce contamination, water loss and spoilage. It can also be used to clearly identify the product for advertising and marketing (Schurr 1988).

Improvements in packaging are often promoted as the first step in solving a range of postharvest problems, but it is essential to attack the real deficiencies in the handling system. Packages, especially when made of imported materials, can be costly

and we need to demonstrate a real economic benefit to justify introducing a more expensive package.

Temperature Management

Cooling the produce to remove the field heat is beneficial for all vegetables and can be achieved without expensive refrigeration and cool stores. The simplest step is to protect the harvested crop from the sun immediately after picking which may reduce temperatures by 10-20°C in summer. Vegetables can be placed in the shade of trees or in simple shelters made of local materials such as leaves or grass. Low-cost ventilated stores can be constructed which are evaporatively cooled. They should be positioned so as to take advantage of prevailing winds. Specialized storage sheds have also been designed to utilize cool night air for convection cooling.

The capital expense of a refrigerated store with precise control of temperatures is only justified for high-value vegetables or where long periods of storage will be beneficial. Many cool stores are unprofitable because insufficient product is stored and the space is empty for much of the year.

The ultimate in temperature management is a continuous cold chain in which produce is precooled immediately after harvest, transported in refrigerated trucks or containers to the cool store and from there to the wholesale market and the consumer, but it must be cost effective (Scott and Atkinson 1989).

Storage

Storage of vegetables can be beneficial where it is desirable to extend the marketing period for a crop. Many crops have to be harvested in a relatively short time. If storage is not available then supplies of the produce will be excessive at harvest time, but there will be shortages at other times of the year. At the village level providing a store will make product available for consumption for a longer period after harvest. For commercial trade, storage facilities enable the supply of vegetables to the market place to be regulated so that prices remain stable and sales are more profitable.

The costs of cool storage are usually easier to justify where product is being sold on more profitable urban and export markets, when vegetables need to be held in good conditions while they are being marketed over a period of time. The types of storage areas can range from simple structures to large refrigerated stores, depending on the volume of stored commodity and the likely economic returns. Careful planning and evaluation are necessary before deciding on the most appropriate cool store construction.

Conclusion

(1) Vegetables are often highly perishable. Large losses of product, losses in nutritive value and loss of income can occur if postharvest handling is not carried out correctly and effectively.

(2) Experience in other countries has shown that there is a range of techniques available to overcome postharvest handling problems and that improved technology can produce substantial benefits (Wills and Lee 1989).

(3) It is usually not possible to successfully import a total handling system from another country. What is needed is to conduct local R and D to determine the most appropriate solutions for the indigenous crops and situations and to evaluate these thoroughly before introducing new practices.

Acknowledgments

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Food Production at the Household Level

Frances R. Davidson*

Introduction

Home-based food production is an ancient activity, primarily carried out by women, having an impact on the nutritional status of entire families and communities. The household garden is as old as human civilization and plant cultivation. Agricultural research activities usually ignore utilization issues including those concerned with the nutritional impact of project activities. Because of this focus, home gardening is rarely considered, even in passing, when formulating agriculture projects. This is unfortunate since the support of home gardens could play an important role in future efforts against hunger and malnutrition.

Substantial documentation (Spring 1986; Immink et al. 1981; Due 1987) exists regarding the preeminent role African women play in food production, both large and small scale. Equally well documented is the fact that development agencies and indigenous institutions ignore this fact when implementing new project activities. Extension workers are usually male and interact exclusively with other males in the community (Due 1987), rarely the ones most able to benefit from technical assistance. This serious neglect of women farmers might do more to compromise the productivity of African agriculture than all other factors.

Gardening and Development

In addition to proper recognition of the role women play in agriculture, support for home gardens should be a developmental priority. Nutritional benefits of agricultural and rural development projects and policies are often assumed (Pinstrup-Andersen 1982). However, home gardens actually offer a direct opportunity for equity in food accessibility. Raising the income of households may not result in improved nutritional status for its most vulnerable members. Household spending and consumption patterns may be more a result of control over earnings than concern over health benefits for family members.

Support for household gardens as one part of a development strategy for private and governmental organizations has fluctuated over the years. While individual gardening efforts have been continuous despite uncertain interest from the larger agricultural sector and its supporters, current interest in the role of nutrition and 'natural foods' in assuring good health in the developed world may have a benefit for those engaged in gardening in developing countries.

Household gardens, often referred to as 'horticulture activities', do not, traditionally, compete with larger agricultural activities. In fact they exist in a

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complementary fashion, especially since they often are limited to the production of indigenous vegetables and fruits. Since they are located in close proximity to the home, they can be maintained by anyone residing there. Garden workers are usually women, children and older members. Households involved in gardening, be it a home garden or participation in a community garden (school, clinic, etc.) have more diverse diets than those without gardens. This diversity results in better nutritional status overall and might result in better health and resistance to disease which are important development goals.

African Women Are Farmers

Recognizing the role of women in agriculture, and including them in research and extension activities, will improve the ability of African countries to feed their population and improve their nutritional status and ability to develop. African women play a part in every aspect of the food chain. They prepare the land for cultivation, plant, weed, harvest and process the resulting food. Some aspects of these activities may be performed in order to earn income, others to ensure an affordable food supply and the nutritional well-being of their families (Spring 1986). An FAO (1983) report of a time allocation survey in Ivory Coast found that women who bring in only 17% of total outside cash earnings for their households spend 80% of this money on food purchases. It was also found that the important food items are those mainly produced at home with women cultivating 32-45% of all food grown.

New technologies usually bypass women. Extension advice and loans for mechanization are given to men. In order for programs meant to increase production and food supply to be successful, they must reach the right people. Many such programs are exclusively addressed to male adults when those most responsible are, in fact, the women in the area.

Benefits of Home Gardens

Home production of foods can affect household nutritional status through direct consumption of garden produce. Indirectly the benefits can come through savings due to reduced purchases and increased income from sale of produce. The exact impact of gardens on household food security – the availability and accessibility of adequate nutrition to all family members – depends on information about the inter- and intra-household distribution of foods including barter and gift exchange, often difficult information to obtain. Evaluations of household gardens have been inconclusive in establishing their direct consumption efforts.

Findings reported in the published literature show that gardens have the potential to provide a significant amount of different foods which can improve nutritional status overall, and that of specific micronutrients such as vitamin A in particular.

Some studies have reported improved overall household nutrition, without specific nutritional references. Still others have found a positive correlation between indigenous gardens and provision of significant amounts of specific micronutrients, e.g. vitamin A (Immink et al. 1981).

A study of home gardens in Puerto Rico (Immink et al. 1981) concluded that 'home gardens may have the effect of increasing the total food supply of the household during certain seasons'. The investigators also found that overall, preschool-aged members of the household appeared to derive greater nutritional benefits from home gardens than did homemakers. At the same time, where home gardens were cultivated, homemakers had higher intakes of vitamins A and C. Similarly, studies in southern and eastern Africa (Bittenbender 1985) indicate that reductions in garden area cultivation resulted in fewer vegetables and fruits in the diet, and increased staple grain consumption. Nutritional implications of these changes have all been negative.

The problem of evaluation of home gardens, in order to justify their position in allocation of resources, remains complicated. The lack of statistically significant evidence on the costs and benefits of home gardening has been a considerable obstacle to serious consideration of its role in food production. Confounding of variables such as socioeconomic status of families, which may affect children's nutritional status as much as the foods cultivated, makes quantitative cause and effect relationships elusive. However, Ninez (1984) points out that many decisions for developmental projects are made with equally inconclusive data. The contribution of gardens to home food supply, the importance of women as gardeners, food processors and providers of food and nutrition for their families should be examined with innovative indicators of effectiveness.

The functional benefits of household gardens (Ninez 1987) applicable to all ecological settings include:

(a) production of considerable amounts of food on land areas too small for field agriculture;

(b) gardens require low inputs and do not degrade the environment;

(c) vegetables and fruits cultivated supply nutritional benefits lacking in field agricultural production;

(d) gardens provide a readily accessible nutrient supply;

(e) gardens provide food during times of agricultural disruption;

(f) adaptability to respond to particular needs and resources of households;

(g) gardens fulfill other household needs (e.g. fodder, petty cash from sale, etc.);

(h) gardens act as laboratories for experimentation with new plant and cultivation techniques; and

(i) gardens have a convenient and secure labor source - women, children, and the elderly.

Recommendations

The current neglect of home gardens in agricultural and development projects is out of proportion to their potential benefits in the developing world. The lack of attention to this activity mirrors the lack of attention given, overall, to women's work in agricultural policies and programs. This is especially so in the African context where women play a major role in food production and preparation. Given the tragic state of malnutrition in the world and the high toll it takes on development potential, gardens and their contributions to human development should be given proper recognition and resources. A useful first step would be the linking of agricultural research and production projects to utilization issues. In this way, the nutritional benefits of gardens, rarely included in government statistical reporting, would be given proper recognition.

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Closing Remarks

SACCAR/AVRDC Consultation on Vegetable Production in the SADCC Region

M.L. Kyomo, Director of SACCAR

On behalf of the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR) and the Asian Vegetable Research and Development Center (AVRDC), I want to thank all of you most heartily for attending this workshop. All participants made excellent contributions in the form of lead papers or valuable comments during the plenary sessions. Furthermore, very useful deliberations were made in the working groups. The recommendations in the CG/SACCAR/AVRDC/ISNAR consultancy report have been refined and clarified, and the information will be useful in formulating the project on vegetable research in SADCC.

As usual one of the great benefits of a regional or international workshop is the opportunity the participants have of meeting each other, exchanging views and laying a foundation for long-lasting professional contacts.

The workshop has reemphasized the earlier recommendation namely that horticulture and especially vegetable production is a very useful but neglected field in terms of resource allocations of people and money by our governments. It has been agreed that we urge governments of SADCC member states to give this field greater prominence.

In SADCC we are very fortunate to have a good political will. It is up to us in the technical fields to work together and deliver the goods in terms of generation of technologies.

We wish to extend our thanks to the Director of the Arusha International Conference Centre and his staff for his excellent conference facilities, the Commissioner of Agricultural Research and Training and his staff for their assistance, and the chairpersons and rapporteurs of the various sessions for their inputs. Lastly we want to thank the secretariat of the workshop for the good secretarial services.

I want to end by wishing all of you a safe journey back to your countries.

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