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Safeguarding the genetic basis of Africa's traditional crops

PROCEEDINGS OF A CTA/IPGRI/KARI/UNEP SEMINAR, 5-9 OCTOBER 1992, NAIROBI, KENYA

CTA

Technical Centre for Agricultural and Rural Co-operation
International Plant Genetic Resources Institute

IPGRI

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edited by **A. Putter**

Technical Centre for Agricultural and Rural Cooperation, the Netherlands
International Plant Genetic Resources Institute, Italy

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Preface

African subsistence farmers have traditionally relied on diversity to ensure the stability of their food production systems. They have developed diverse landraces and cropping practices adapted to local climatic, edaphic, social and cultural situations. They also harvest food from a wide variety of wild plants. However, national food policies in Africa still tend to be based on a few well-researched, uniform varieties of staple crops, rather than on the utilization of farmers' traditional crops and varieties. This has tended to erode not only the genetic diversity that these represent, but also the knowledge that local people have about this diversity.

In recent years these developments have given rise to growing concern. How can the diversity of traditional African agriculture be protected, so that it can be harnessed for development? This was the theme of the seminar, "Safeguarding the Genetic Basis of Africa's Traditional Crops", held in Nairobi, Kenya from 5 to 9 October, 1992 and co-sponsored by CTA, IBPGR, UNEP and KARI. The participants represented the so-called formal sector of agricultural research and the informal or NGO sector, at both national and international community levels. The invited presentations are brought together in this volume.

After welcoming addresses by representatives of the sponsors and FAO, the seminar was officially opened by the representative of the Hon. Kirugi L. M'Mukindia, Minister of Research, Science and Technology of the Republic of Kenya. In his keynote address, Prof. B.N. Okigbo, Director, UNU Programme on Natural Resources in Africa, gave a broad overview of traditional African agriculture. He stressed its sustainability and called for vigorous efforts to protect the diversity of systems, practices, crops and landraces which make it so.

A set of recommendations was drafted by four working groups following their in-depth deliberation of the key issues arising from the presentation and discussion of 24 papers. After further discussion in a final plenary session the recommendations were adopted by the participants.

The essence of the recommendations for conserving the genetic diversity of Africa's traditional crops is recognition of the need for cooperative action between the formal and informal sectors. The two are complementary: each needs - and needs to know about - the other. It is to be hoped that this volume will encourage the dialogue that is the necessary prelude to such a partnership.

Préface

Les cultivateurs africains pratiquant les cultures de subsistance ont traditionnellement maintenu la diversité pour s'assurer la stabilité de leurs systèmes de production alimentaire. Ils ont développé plusieurs cultivars et des pratiques culturales adaptées aux conditions climatiques, édaphiques et socio-culturelles locales. Ils utilisent également à diverses fins (par exemple en nutrition) des plantes sauvages de plusieurs espèces. Cependant, les politiques nationales alimentaires en Afrique demeurent accrochées à quelques cultures de base de variétés uniformes et bien étudiées, au lieu d'être axées sur l'utilisation des cultures et variétés traditionnelles du cultivateur. Ceci tend non seulement à ignorer la diversité génétique que ces cultures traditionnelles représentent mais également la connaissance que les populations locales ont de cette diversité.

Ces dernières années, ces évolutions ont éveillé la conscience des gens. Comment peut-on préserver la diversité de l'agriculture traditionnelle africaine, de manière à la mettre au service du développement? Ce fut le thème d'un séminaire, " La sauvegarde de la base génétique des cultures traditionnelles africaines", organisé à Nairobi, Kenya, du 5 au 9 octobre 1992 et co-sponsorisé par le CTA, l'IBPGR, le PNUE et le KARI. Les participants étaient les représentants du secteur dit formel de la recherche agricole et du secteur informel ou secteur des ONG, à la fois aux niveaux national et international. Les diverses communications présentées à ce séminaire sont regroupées dans ce volume.

Après les mots de bienvenue prononcés par les représentants des bailleurs et de la FAO, le séminaire fut officiellement déclaré ouvert par le représentant de Monsieur le Ministre Kirugi L. M'MUKINDIA, Ministre de la recherche scientifique et technologique de la République du Kenya. Dans son discours-programme, le Professeur B.N. Okigbo, Directeur du Programme des Nations-Unies pour les ressources naturelles pour l'Afrique, donna un aperçu général de l'agriculture traditionnelle africaine. Il mit l'accent sur sa viabilité et réclama de vigoureux efforts pour la protection de la diversité des systèmes, des pratiques, des cultures et des cultivars qui font la spécificité de l'agriculture traditionnelle africaine.

Un ensemble de recommandations ont été formulées par quatre groupes de travail à la suite de discussions approfondies sur les principaux problèmes engendrés par la présentation et le débat sur les 24 communications. Après d'amples discussions à la dernière session plénière, des recommandations ont été adoptées par les participants.

L'essence de ces recommandations sur la conservation de la diversité génétique des cultures traditionnelles africaines est la reconnaissance de la nécessité d'action coopérative entre les secteurs formel et informel. Les deux sont complémentaires, chaque secteur a besoin de et doit connaître l'autre. Nous espérons que ce volume favorisera le dialogue qui est nécessaire pour amorcer un tel partenariat.

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Abbreviations and Acronyms

AA-N	Action Aid-Nepal
AAASA	Association for the Advancement of Agricultural Sciences in Africa
AATG	Action Aid The Gambia
ABS	Agricultural Bank of Sudan
ACORD	Agency for Cooperation and Research in Development
AIC	Agricultural Inputs Corporation (Nepal)
AMCEN	African Ministerial Conference on the Environment
ARD	Associates in Rural Development (US)
ASC	Agricultural Service Centre (Nepal)
ASS	African Seeds of Survival (Ethiopia)
AVRDC	Asian Vegetable Research and Development Centre, China
BARC	Bangladesh Agriculture Research Council
BAU	Bangladesh Agricultural University
CEAO	Communaute Economique de l'Afrique de l'Ouest
CEPGL	Communaute aaeconomique des Pays des Grands Lacs
CESA	Ecuadorian Centre for Agricultural Services
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIC	Centro Internazionale Crocevia
CIDA	Canadian International Development Authority
CILSS	Permanent Interstate Comittee for Drought Control in the Sahel
CIP	International Potato Centre
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora (IUCN), Washington D.C.
CLADES	Latin American Consortium for Agroecology and Development
CSB	Community Seed Bank (Philippines)
CSSTD	Central Seed Science and Technology Division (Nepal)
DAR	Department of Agricultural Research (The Gambia)
DAS	Department of Agricultural Services (The Gambia)
DOA	Department of Agriculture (Nepal)
EC	European Community
ECOWAS	Economic Community of West African States
ELC	Environmental Liaison Centre International
EMI	Embu-Meru-Isiolo project (Kenya)
ENDA	Environment and Development Activities, Zimbabwe
ENS	Empresa Nacional de Sementes (Mozambique)
ESC	Ethiopia Seed Corporation
FAO	UN Food and Agriculture Organization
F1	First filial generation hybrid
FFHC	Freedom From Hunger Campaign
FV	Farmers' variety
GATT	General Agreement on Tariffs and Trade
GCU	The Gambia Cooperative Union
GDP	Gross Domestic Product
GEMS	Global Environment Monitoring System

GIS	Geographic Information System
GNP	Gross National Product
GPMB	Gambia Produce Marketing Board
GPSN	Niassa Seed Production Board (Mozambique)
GRAIN	Genetic Resources Action International
GRID	Global Resource Information Database
GSM	Good Seed Mission (The Gambia)
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
HYV	High Yielding Variety
IARC	International Agricultural Research Centre
ICDA	International Coalition for Development Action
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDESSA	Institut des Savanes
IDRC	International Development Research Centre, Canada
IFOAM	International Federation of Organic Agricultural Movements
IITA	International Institute of Tropical Agriculture (Nigeria)
IJO	International Jute Organization
ILCA	International Livestock Centre for Africa
INIAP	National Agricultural Research Institute (Ecuador)
IRAT	Institute for Research in Tropical Agriculture and Food Crops (France)
IRAZ	Institut de Recherche Agronomique et Zootechnique de la CEPGL
IRRI	International Rice Research Institute (The Philippines)
ISTA	International Seed Testing Association
IUCN	World Conservation Union (formerly International Union for the Conservation of Nature and Natural Resources)
IVO	Development Research Centre (The Netherlands)
JICA	Japan International Cooperation Agency
KHAP	Koshi Hills Agriculture Project (Nepal)
KMP	Peasant Movement of The Philippines
KSHP	Kebkabiya Smallholders' Project (Sudan)
LEC	Livelihood Enhancement Committee (The Philippines)
MASIPAG	Farmers-Scientists Partnership for Agricultural Development (The Philippines)
MCC	Mennonite Central Committee
MIND	Mindoro Institute for Development Inc (The Philippines)
MNC	Multi-National Corporation
MONAP	Mozambique Nordic Agriculture Programme
MV	Modern Variety
NARC	National Agricultural Research Centre
NACGRAB	National Centre for Genetic Resources and Biotechnology
NEF	Near East Foundation
NGO	Non-Governmental Organization
NIHORT	National Horticultural Research Institute of Nigeria
NPK	Nitrogen-Phosphorous-Potassium fertilizer
NRI	Natural Resources Institute (UK)
NSA	National Seed Administration (Sudan)

NSB	National Seed Board (Bangladesh)
ODA	Overseas Development Administration (UK)
ODI	Overseas Development Institute (UK)
OECD	Organization for Economic Cooperation and Development
OFSP	On-Farm Seed Production Project (The Gambia and Senegal)
OP	Open-pollinated variety
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer (France)
PAC	Pakhribas Agricultural Centre (Nepal)
PAI	Paran Agronomy Institute (Brazil)
PARE	Partnership in Agricultural Research and Extension (Bangladesh)
PBR	Plant Breeders' Rights
PGR	Plant Genetic Resources
PGRC/E	Plant Genetic Resources Centre/Ethiopia
PPS	Private Producer-Sellers Project (Nepal)
RAFI	Rural Advancement Foundation International
RENAMO	Mozambique National Resistance
RSS	Research and Specialist Services
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference
SAM	Sahabat Alam Malaysia
SCF	Save the Children Federation (US)
SEAN	Seed Entrepreneurs Association of Nepal
SEARICE	South East Asia Regional Institute for Community Education
SEMOC	Sementes de Mozambique Lda.
SIBAT	Spring of Science and Technology (The Philippines)
SPG	Seed Producer Group (Nepal)
SRGB	SADC Regional Genebank
STIP	Seed Technology and Improvement Program (Nepal)
STU	Seed Technology Unit (The Gambia)
UN	United Nations
UNCED	UN Conference in Environment and Development
UNESCO	UN Educational, Scientific and Cultural Organization
UPLB	University of The Philippines at Los Banos
USAID	United States Agency for International Development
USC	Unitarian Service Committee (Canada)
VRC	Village Relief Committee (Sudan)
WCMC	World Conservation Monitoring Centre
WIPO	World Intellectual Property Organization
WRI	World Resources Institute
WWF	Worldwide Fund for Nature

Recommendations

Recommendations of the seminar were made through group discussions and ratified in a plenary session. The discussion topics on which the recommendations were based were agreed upon as follows:

1.0 Management of documentation and dissemination of knowledge

1.1 Types of information

It was recognized that there are multitudes of types of information systems, operating at different levels among different groups of actors, that are potentially useful in working to safeguard Africa's traditional crops. Within the context of the farmer and other users of information, it was thought that the inter-relationships between these types could be described as a web of information. Each component of this web could be an information system that, potentially, is inter-related with other information systems.

Three general categories of information types were defined. It was recommended that the categories be used to identify areas of concern to action-oriented projects. These categories are:

1.1.1 Information specific to a germplasm sample. This includes a description of plant accession or species. Such data are very detailed and include agronomic, botanical and morphological characters as well as a description of the plant's environmental origin.

1.1.2 People's knowledge and practice systems. These include farming practices and systems that are used by both indigenous and formal sector germplasm users, and the social and cultural setting in which these systems are embedded.

1.1.3 Agro-ecological systems. Information here will include that which is necessary to understand agronomic and ecological interactions that may be perceived to exist within or across geographical regions.

1.2 Management, treatment and storage of information

1.2.1 Enhancing local knowledge
It was recommended that several specific areas be targeted to enhance knowledge at the local level:

1.2.1.1 Incorporating into school curricula, local knowledge related to plant genetic resources. Areas to consider would include the involvement of older people in teaching, the use of experiential approaches, the production of teaching materials by NGOs, teacher

associations and in-service training of teachers regarding awareness of local knowledge of plant genetic resources. Functional literacy programmes should also be encouraged.

1.2.1.2 The restructuring of the extension system to change the attitudes of national and local extension systems such that they are sensitive to the value of local knowledge and practices concerning plant genetic resources management.

1.2.1.3 Encouraging a change in national government attitudes or policies that will officially recognize local associations such as traditional groups and healers, etc., and promote the use of local languages and cultural practices.

1.2.2 Recording, documenting and storing information
It was recommended that many approaches should be investigated in terms of their applicability in recording and storing information. These include:

1.2.2.1 The use of video and other technologies as they become more accessible at the village level.

1.2.2.2 Training that will assist people in systematically ordering and recording their knowledge.

1.2.2.3 The development of oral media approaches to plant genetic resources information documentation, e.g. music, drama, etc.

1.2.2.4 The encouragement and use of various existing institutions that will play a role in the storage of information related to plant genetic resources. Such institutions may include national genebanks, herbaria, museums and cultural archives. It was recommended that these be promoted collectively with non-governmental and governmental assistance and continued governmental support.

1.2.3 Using a multi-disciplinary approach in the collection of information and development of improved methodologies. An example of an innovative and participatory method is the involvement of school children in the collection of information.

1.2.4 Developing guidelines to ensure that information is collected and disseminated in an ethical manner. This is necessary because there

are a number of ethical questions to be considered in the accession of information, especially information which is considered to be secret.

1.3 Dissemination and utilization of information

It was recommended that:

1.3.1 Information flow be encouraged in all directions, e.g. from the formal to the informal sector and vice versa, and also within each sector. The most appropriate mechanism for a particular situation should be used to disseminate information. This may include high technologies such as computers, video, CD-ROM and other multi-media approaches for community viewing. It was recognized that the control and maintenance of this equipment may be a concern.

1.3.2 Other innovative and practical methodologies for the dissemination of information be employed. These may include dissemination of information through advertising on media such as fertilizer bags, bread packages, matchboxes, etc.

1.3.3 An analysis be conducted of how information that is generated from the formal sector could best be made accessible to local communities. Innovative mechanisms need to be developed. It was also suggested that certain international standards may be necessary for reporting the formal sector's findings, to encourage their use at the local level.

1.3.4 The question of intellectual property rights for information be investigated with organizations such as WIPO (World Intellectual Property Organization) and the UNESCO Folklore Convention. Intellectual integrity should be respected and the ethics of research workers, in practice, held to high standard i.e. information collected in the course of research should be fed back to the origin of the research materials.

1.3.5 The role of, and the collaboration between, CTA and IBPGR in dissemination of knowledge should be emphasized.

1.3.6 Information from genebanks should be circulated to farmers.

2.0 On-farm conservation and use of traditional crops in Africa and linkage to formal institutions (technical implications, integration of conservation strategies, management options and training)

Recommendations:

2.1 The formal system needs to recognize the informal system. The latter is a

valid system of knowledge, warranting research funding, support and marketing opportunities. National breeding programme objectives need to recognize the informal system when setting research objectives.

2.2 Interactions among the NARs, IBPGR and NGOs should be strengthened and streamlined to maximize cooperation in the conservation of biodiversity through national capacity building and training. This should lead to the promotion of safe, rational planning of conservation and use of genetic resources, and harmonization of conservation with sustainable use and management.

2.3 With funding and institutional support from international organizations, national research programmes need to look at the following aspects:

2.3.1 Evaluation and documentation of the resources management strategies of farmers, (for example, multi- and intercropping systems).

2.3.2 The selection criteria and maintenance of crop genepools by small-scale farmers; breeding systems and genetic diversity of crop species; and comparative taxonomic studies of landraces and their weedy and wild relatives.

2.3.3 Research on home gardens and back yards. Emphasis should be placed on women farmers. So far, they have been neglected by the formal sector.

2.3.4 Research on under-utilized crops and indigenous vegetables, medicinal plants and minor crop plants.

2.3.5 Seed supply and seed production systems.

2.4 A consultative forum consisting of representatives from farmers (organizations), researchers and policy makers, needs to be established at the international level to coordinate policy making at national level. This would allow governments to make policies supportive of farmers' needs and priorities.

2.5 Coordination of community based genetic resources conservation needs to be integrated at the regional, national and sub-national levels to make full and efficient use of available manpower, funding and existing infrastructures.

3.0 Policy issues

3.1 Access and control of genetic resources was discussed at three levels: local, national and international. It was recommended that:

Local level

3.1.1 When necessary, farmers should have access to their genetic material in genebanks. More information should be given to the farmers before and after the gene collection exercise, including the purpose, destination, characterization and evaluation results of the collections.

3.1.2 There be cooperation between formal and informal sectors in collection, multiplication and storage of local seed varieties.

3.1.3 Biotechnology be introduced within national genebanks to halt genetic erosion at the local level, i.e. tissue culture, DNA probes etc.

3.1.4 Where the farmers' collections have yielded commercial benefits, the farmers should also benefit through an appropriate mechanism.

National level

3.1.5 National sovereignty be respected with regard to genetic resources.

3.1.6 Breeders and policy makers take into account farmers' preferences.

3.1.7 Collaboration be promoted, between NGOs, farmers and genebanks, through national germplasm programmes.

3.1.8 All parties be involved in the development of the proposed plan of action on PGR, i.e. that FAO, in collaboration with IBPGR and other organizations, organize a technical conference on conservation and utilization of PGR, in 1995. The plan of action resulting from the conference should be the product of all parties involved in PGR.

3.1.9 More genebanks assist national programmes in the multiplication of genetic material through allocation of financial support.

3.2 Intellectual property rights and farmers' rights

It was recommended that:

3.2.1 More work be done to identify mechanisms of recognizing farmers' rights.

3.2.2 National regulations on property rights, be set up.

3.2.3 Mechanisms be set up to increase public awareness of the implications of intellectual property rights.

3.2.4 Developing countries set up a bargaining mechanism to protect their genetic material from exploitation by powerful institutions in the North.

3.2.5 A vigorous campaign be launched to secure international funds to support national PGR programmes in developing countries.

3.2.6 The biodiversity network be involved in the international debate of intellectual property rights.

3.3 Biotechnology

The group recommended the following:

3.3.1 Developing countries should have access to biotechnology through training and infrastructural investment which supports biotechnology activities.

3.3.2 Regional cooperation in the application of biotechnology should be promoted to maximize resource use and reduce costs.

3.4 Biodiversity Convention

The group recommended that:

3.4.1 More work be done on the Convention, with respect to the following:

- Legal aspects of the convention. These are still confusing.
- Genetic material in northern genebanks and research institutes. The Convention does not cover this.
- Mechanisms for implementing the convention. These are as yet undefined.

3.4.2 The Convention be clearer on whether or not, under its provisions, genetic resources now in genebanks are excluded. The group recommends that these genetic resources be covered by the Convention (Ref. Article 15 of the Convention).

3.4.3 The mechanisms for implementing the provisions of the Convention be made clearer.

3.5 Ethics of distribution of genetically engineered material

The group recommended the following:

3.5.1 National commissions should be set up to study the ethics of the introduction of genetically engineered material, i.e. the commissions already set up in Nigeria and Cameroon.

3.5.2 International institutions involved in genetics material work (e.g. IBPGR and NGOs) should be involved in the study and formulation of the ethics of distribution of genetically engineered plants or crops.

3.5.3 Biosafety measures, formulated by consumer bodies, NGOs, producers and governments, should be set up at national and international levels.

3.5.4 FAO's draft code of conduct on biotechnology activities should be finalized as soon as possible and circulated to all member countries.

3.5.5 Whatever is adopted by national governments, in respect of this issue should have justice, peace and integrity of living beings, as the underlying principles.

3.6 Access and control

The working group recognized that FAO's draft code of conduct on germplasm collecting, could prove to be a useful guide, allowing local communities and national governments to facilitate the flow of germplasm among themselves.

It was recommended that:

3.6.1 Each country submit to IBPGR, a PGR strategy programme that includes information on factors leading to genetic erosion.

3.6.2 Each country have access to the necessary PGR conservation facilities while the regional genebank's approach should be encouraged in order to maximize resources use and cost-effectiveness.

3.6.3 Information on, and access to, PGR held by international genebanks be made available.

3.7 Intellectual property

The working group noted that some developed countries, party to the GATT negotiations, are attempting to force developing countries to adopt intellectual property laws giving private companies exclusive rights.

It was recommended that:

3.7.1 No external pressure be used to force national governments to adopt the GATT formulation of IPR.

3.7.2 The issue of ownership of PGR held in international genebanks be made clear. [See 3.4.2].

4.0 Training

Recommendations were as follows:

4.1 Each country should evaluate its requirements for short- and long-term training in view of the need to build on and emphasize national and regional strengths in plant genetic resources. Evaluation of both formal and informal training requirements should, for comparative purposes, be done at national, subregional and regional levels.

4.2 Each country should evaluate its budgetary requirements for short- and long-term training.

Major international organizations, such as IBPGR and FAO, should take the initiative in encouraging and assisting governments in evaluating their training and budgetary requirements. This would strengthen national capacities to handle plant genetic resources.

4.3 Exchange of information should be stepped up through the use of mass media, documentation, scientific and popular literature, meetings etc., to create and enhance awareness. This exchange of information should take account of the appropriate language for each target group.

4.4 A policy decision should be taken by large donors, e.g. EC, FAO and UNDP, to create a small-grants facility to fund on-going training and other activities related to plant genetic resources.

4.5 In order to strengthen national capacity, specific attention should be paid to professional level training in technology transfer.

4.6 Because of the importance of women in conservation and utilization of traditional crops in Africa, major emphasis should be placed on gender issues at the design and implementation level of training programmes. In dealing with gender sensitive issues, it will be necessary to sensitize trainers.

4.7 Since training is a continuous process, effort and resources must be invested in continuous evaluation activities and in-service training.

4.8 Researchers in PGR at international and national levels must make a commitment to facilitate the feeding back of information from research into training programmes.

4.8 Researchers in PGR at international and national levels must make a commitment to facilitate the feeding back of information from research into training programmes.

Récommendations

Les recommandations ont été formulées à la suite de discussions de groupe et ont été ratifiées en session plénière.

1. **La gestion de documentation et de diffusion du savoir**

1.1 Les types d'informations

Il a été reconnu qu'il existe une multitude de systèmes d'informations opérationnels à différents niveaux entre les divers groupes d'agents qui sont potentiellement utiles dans l'oeuvre de sauvegarde des cultures traditionnelles africaines. Dans le contexte du cultivateur et d'autres utilisateurs de l'information, il a été observé que les liens existant entre ces types pouvaient être décrits comme un réseau d'informations, chaque composante de ce réseau pouvant être considérée comme un système d'informations qui a des liens potentiels avec les autres systèmes d'informations.

Trois catégories générales de types d'informations ont été identifiées. Une recommandation a été formulée pour l'utilisation de cette classification dans l'identification des sujets d'intérêt connus, devant produire des résultats précis. les trois catégories identifiées sont les suivantes:

1.1.1 La première est l'information spécifique correspondant à un génome particulier et qui englobe la description du spécimen et de l'espèce. Une telle donnée est bien détaillée et comprend les caractéristiques agronomiques, botaniques et morphologiques, de même qu'une description de l'origine écologique de la plante.

1.1.2 La deuxième catégorie est celle de la connaissance des populations et des pratiques culturales. Elle englobe les pratiques et les systèmes utilisés à la fois par les utilisateurs locaux et ceux du secteur formel du génome, et du contexte socio-culturel duquel ces systèmes tirent leur source.

1.1.3 La dernière catégorie est celle des systèmes agro-écologiques. Elle comprend tout ce qui permet de comprendre les liens agronomiques et écologiques qui existent à l'intérieur ou au-delà des régions géographiques.

1.2 La gestion, le traitement et le stockage de l'information

1.2.1 L'approfondissement du savoir local
Il a été recommandé de cibler plusieurs domaines spécifiques afin d'approfondir le savoir au niveau local.

1.2.1.1 des études sur l'intégration du savoir local lié aux ressources génétiques végétales dans les programmes scolaires, y compris la participation des personnes du troisième âge and les équipes de formation, l'utilisation des méthodes expérimentales, la production de matériel didactique par les ONG, les associations d'enseignants et les stages de formation pour les enseignants actifs pour valoriser le savoir local des ressources génétiques des plantes. L'on devrait également encourager les programmes d'alphabétisation fonctionnels.

1.2.1.2 un changement décisif dans les attitudes concernant les systèmes locaux d'encadrement de façon à les sensibiliser à la valeur du savoir et des pratiques locales relatives à la gestion des ressources génétiques végétales. Ceci peut inclure une restructuration du système d'encadrement.

1.2.1.3 d'encourager un changement dans les attitudes et politiques des gouvernements nationaux afin qu'ils reconnaissent officiellement des associations locales comme celles des guérisseurs traditionnels et de promouvoir l'utilisation des langues et des pratiques culturales locales.

1.2.2 L'enregistrement, la documentation et le stockage de l'information
Il a été recommandé que plusieurs approches soient étudiées pour leur applicabilité dans l'enregistrement et le stockage des informations. Celles-ci incluent:

1.2.2.1 l utilisation de la vidéo et autres technologies lorsqu'elles sont plus accessibles aux villageois.

1.2.2.2 la formation qui aidera les populations à adopter une attitude systématique dans la classification et l'enregistrement de leur savoir.

1.2.2.3 des études sur les possibilités de développer les approches de la connaissance des problèmes liés à la conservation des ressources génétiques des plantes par des médias oraux, par exemple la musique et les pièces de théâtre.

1.2.2.4 l'encouragement et l'utilisation potentielle des diverses institutions existantes qui joueront un rôle dans le stockage d'informations liées aux ressources génétiques végétales. Parmi ces institutions on peut citer les banques nationales de gènes, les herbiers, les musées et les

archives culturelles. La promotion collective de ces institutions par l'assistance gouvernementale et non-gouvernementale, et un soutien gouvernemental continu a été recommandée.

1.2.3 Il a été recommandé d'utiliser une méthode multidisciplinaire dans la collecte de l'information et l'on a insisté sur la nécessite de mettre au point des méthodologies améliorées. Un exemple de cette méthode novatrice et participative est l'apport des écoliers dans la collecte de l'information.

1.2.4 L'étude d'un certain nombre de questions déontologiques relatives à l'accès à l'information, notamment l'information qui est considérée secrète, a été recommandée. Par conséquent, les directives doivent être mises au point pour assurer la collecte et la diffusion de l'information d'une manière déontologique.

1.3 La diffusion et l'utilisation de l'information

Les recommandations suivantes ont été effectuées:

1.3.1 la promotion de la circulation de l'information dans toutes les directions, par exemple du secteur formel à l'informel et vice-versa et à l'intérieur de chaque situation devrait être utilisé pour la diffusion de l'information. Cela peut inclure l'utilisation de hautes technologies comme les ordinateurs, la vidéo, le CD-ROM et tout autre moyen audio-visuel. Il a été reconnue que le contrôle et la maintenance de cet équipement peuvent poser un problème.

1.3.2 que soient utilisées d'autres méthodologies pratiques et novatrices de diffusion de l'information. Celles-ci peuvent comprendre la diffusion de l'information par des moyens tels que les sacs d'engrais, les emballages de pain, les boîtes d'allumettes, etc.

1.3.3 la réalisation d'une étude sur le meilleur moyen de rendre accessible aux communautés locales l'information qui provient du secteur formel et l'élaboration de mécanismes novateurs. Il a été également recommandé que certaines normes internationales puissent être nécessaires dans la publication des résultats des recherches du secteur formel pour favoriser leur utilisation par les populations locales.

1.3.4 l'examen du problème des droits d'auteurs en matière d'information avec des organisations telles que l'Organisation mondiale de la propriété intellectuelle et la Convention sur le Folklore de l'UNESCO. L'intégrité intellectuelle doit être respectée et dans le même sens, la déontologie des chercheurs doit être scrupuleusement respectée dans

la pratique. Par exemple, l'information recueillie au cours de la recherche doit être renvoyée là où le matériel provient.

1.3.5 le renforcement du rôle joue par le CTA et l'IBPGR et leur collaboration dans la diffusion du savoir.

1.3.6 la diffusion au bénéfice des cultivateurs, des informations provenant des banques de gènes.

2. De la conservation des champs et l'usage des cultures traditionnelles en Afrique en liaison avec les institutions formelles (les implications techniques, l'intégration des stratégies de conservation, les options de gestion et la formation)

Recommandations:

2.1 Il est nécessaire de favoriser la reconnaissance du système informel par le système formel. Le secteur informel constitue un système valable de connaissance nécessitant un financement de recherche, un soutien et des perspectives commerciales. Les objectifs des programmes nationaux d'amélioration doivent reconnaître le système informel lorsqu'ils fixent leurs objectifs de recherche.

2.2 La collaboration du NARS, de l'IBPGR et des ONG devrait être renforcée et rationalisée afin de maximaliser la coopération et la conservation de la biodiversité en tenant compte de la capacité nationale. Ceci devrait conduire à la promotion d'une planification sûre et rationnelle et à l'utilisation des ressources génétiques ainsi qu'à l'harmonisation de la conservation grâce à une gestion et à une utilisation durables.

2.3 Grâce au financement et au soutien institutionnel des organisations internationales, les programmes nationaux de recherche doivent examiner les aspects suivants:

2.3.1 l'évaluation et la documentation des stratégies de gestion des ressources des cultivateurs, comme par exemple les systèmes de multiculture et de cultures associées.

2.3.2 les critères de sélection, l'entretien des pools génétiques des cultures par les petits cultivateurs, les systèmes d'amélioration et de diversité génétique des espèces et des études taxonomiques comparatives des cultivars traditionnels et de leurs parents herbeux et sauvages.

2.3.3 les recherches sur les potagers avec un accent sur les cultivatrices qui ont été jusqu'à présent négligées par le secteur formel.

2.3.4 les recherches sur les cultures et les légumes locaux sous-utilisés, les plantes médicinales et les plantes culturales de faible importance.

2.3.5 des systèmes de fourniture et de production de semences.

2.4 L'établissement au niveau international d'un forum consultatif composé des représentants (des organisations) de cultivateurs, de chercheurs et des décideurs pour la coordination des conceptions des politiques au niveau national. Ceci permettra aux gouvernements de concevoir des politiques qui tiennent compte des besoins des cultivateurs et des priorités nationales.

2.5 La coordination de la conservation des ressources génétiques provenant de la communauté doit être intégrée aux niveaux régional, national et provincial pour une utilisation pleine et efficace de la main d'oeuvre disponible, du financement et des infrastructures existantes.

3. Politiques à adopter

3.1 La discussion sur l'accès et le contrôle des ressources génétiques s'est portée sur trois axes: local, national et international. Il a été recommandé que sur:

L'axe local

3.1.1 les cultivateurs devraient avoir accès au patrimoine génétique des banques de gènes, chaque fois qu'il est nécessaire. Plus d'informations devraient être fournies aux cultivateurs avant et après la collecte des gènes en insistant sur les points suivants: le but des récoltes, la destination, les caractéristiques et l'évaluation des résultats.

3.1.2 il devrait y avoir une coopération entre les secteurs formel et informel pendant la récolte, la multiplications et le stockage des semences des variétés locales.

3.1.3 la biotechnologie devrait être introduite dans les banques nationales de gènes afin d'arrêter l'érosion génétique au niveau local, par exemple la culture de tissus, les sondes à ADN, etc.

3.1.4 la où les récoltes de cultivateurs ont généré des gains commerciaux, ceux-ci devraient également en profiter grâce à la mise sur pied d'un mécanisme approprié.

L'axe national

3.1.5 la souveraineté nationale devrait être respectée en ce qui concerne les ressources génétiques.

3.1.6 les éleveurs et les décideurs devraient tenir compte des choix des cultivateurs.

3.1.7 une collaboration devrait être créée et renforcée avec les ONG, les cultivateurs et les banques grâce à des programmes nationaux de génomes.

3.1.8 toutes les parties devraient participer dans l'élaboration du plan d'action proposé sur les PGR [plant genetic resources], par exemple la FAO en collaboration avec l'IBPGR et d'autres organismes pour la tenue d'une conférence technique sur la conservation et l'utilisation des PGR en 1995. le plan d'action qui émanerait de cette conférence devrait être une oeuvre de toutes les parties qui traitent des PGR.

3.1.9 davantage de banques de gènes devraient être établies aux niveaux national et régional.

3.1.10 les banques internationale de gènes devraient assister les programmes nationaux dans la multiplication du matériel génétique par l'octroi d'une assistance financière.

3.2 Les droits d'auteurs et les droits des cultivateurs.

Il a été recommandé que:

3.2.1 l'on développe davantage l'identification des mécanismes de reconnaissance des droits des cultivateurs.

3.2.2 l'on établisse des règlements nationaux sur les droits d'auteurs.

3.2.3 la méconnaissance des implications des droits d'auteurs exige la mise sur pied de mécanismes favorisant la prise de conscience du public.

3.2.4 les pays en développement devraient mettre sur pied un mécanisme de négociation destiné à protéger leur matériel génétique contre les puissantes institutions du Nord.

3.2.5 une campagne active afin d'obtenir des financements internationaux pour soutenir les programmes nationaux de PGR dans les pays en développement soit lancée.

3.2.6 le réseau de biodiversité devrait être impliqué dans le débat international des droits d'auteurs.

3.3 La biotechnologie

Sur ce point, le groupe a formulé les recommandations suivantes:

3.3.1 les pays en voie de développement devraient avoir accès à la biotechnologie par la formation et l'investissement en infrastructure, soutien des activités biotechnologiques.

3.3.2 La coopération régionale dans les applications biotechnologiques devraient être encouragée pour maximaliser l'utilisation des ressources et la réduction des coûts.

3.4 La Convention sur la Biodiversité

Le groupe a fait les recommandations suivantes:

3.4.1 plus de travail doit être effectué sur la Convention, en égard aux remarques suivantes:

- les aspects juridiques demeurent confus.
- la Convention ne couvre pas le matériel génétique dans les banques de gènes et les instituts de recherche des pays du nord.
- les mécanismes de mise en oeuvre de la Convention ne sont pas encore définis.

3.4.2 la Convention devrait être claire sur le fait de savoir si les ressources génétiques qui sont actuellement dans les banques de gènes sont exclues des dispositions de la Convention. Le groupe recommande que ces ressources génétiques soient couvertes par la Convention (ref. article 15 de la Convention).

3.4.3 le groupe recommande que les mécanismes de la mise en oeuvre des dispositions de la Convention soient plus clairement définis.

3.5 La déontologie en matériel de distribution de matériel issu des manipulations génétiques

Le groupe a formulé les recommandations suivantes:

3.5.1 des commissions nationales comme celles déjà mises sur pied au Nigéria et au Cameroun devraient être créées pour examiner si l'introduction de matériel issu des manipulations génétiques est conforme à la déontologie.

3.5.2 les institutions internationales travaillant dans le domaine du matériel génétique comme l'IBPGR et les ONG devraient être impliquées dans le débat sur la déontologie en matière de distribution de matériel issue de manipulation génétique.

3.5.3 l'on doit prendre les mesures de sécurité biologique formulées par les associations de consommateurs, les ONG, les producteurs et les gouvernements, aux niveaux national et international.

3.5.4 le code de conduite sur les activités biotechnologiques produit par la FAO devrait être largement répandu dans tous les pays membres.

3.5.5 la solution qui sera retenue par les gouvernements nationaux sur ce sujet devrait avoir comme principes sous-jacents les principes de justice, de paix et d'intégrité des êtres vivants.

3.6 L'accès et le contrôle

Le groupe de travail a reconnu que le projet de code de conduite de la FAO sur la collecte de plasme germinatif pouvait être un guide utile permettant aux communautés locales et aux gouvernements nationaux de faciliter le flux de génomes entre eux. Le groupe recommande que la FAO finalise le plus tôt possible et fasse largement circuler un code de conduite.

Il a été recommandé que:

3.6.1 chaque pays devrait remettre un programme de stratégie en PGR à l'IBPGR comprenant des informations sur les facteurs responsables de l'érosion génétique.

3.6.2 chaque pays devrait avoir accès aux installations de conservation de PGR qui sont jugées lui être nécessaires quoique l'approche des banques régionales de gènes devrait être encouragée afin de maximaliser l'utilisation des ressources et la rentabilité.

3.6.3 l'information et l'accès aux PGR conservées par les banques internationales ide gènes doivent être rendus disponibles.

3.6.4 le projet de code de conduite des collecteurs de la FAO devrait être conclu et distribué.

3.7 La propriété intellectuelle

Le groupe de travail a observé que certains pays développés qui participent aux négociations du GATT essaient de forcer les pays en développement à adopter des lois en matière de propriété intellectuelle qui accordent aux sociétés privées des droits exclusifs.

3.7.1 Le groupe pense qu'aucune pression externe ne devrait être exercée pour forcer les gouvernements nationaux à adopter la formulation du GATT sur le droit de propriété intellectuelle.

3.7.2 Le problème de la propriété des PGR conservées dans les banques internationales de gènes devrait être clarifié.

4.0 La formation

Les recommandations suivantes ont été formulées:

4.1 Chaque pays devrait évaluer ses besoins en matière de formation a court et à long terme en vue de mettre l'accent sur les efforts régionaux et nationaux pour la conservation des ressources génétiques végétales. L'évaluation des besoins de formation devrait être effectuée non seulement au niveau national mais également aux niveaux régional et sous-régional dans un but comparatif à la fois pour la formation formelle et informelle.

4.2 Chaque pays devrait évaluer ses besoins budgétaires pour les formations à court et à long terme.

Il a été recommandé que:

Les grandes organisations internationales telles que l'IBPGR et la FAO devraient encourager et assister les gouvernements dans l'évaluation de leurs besoins budgétaires et de formation comme un moyen de renforcer leur capacité nationale à s'occuper des ressources génétiques végétales.

4.3 L'échange d'informations devrait être renforcée grâce aux mass-media, à la documentation, aux publications populaires et scientifiques, aux rencontres, etc. afin de susciter et de promouvoir la prise de conscience. Cet échange d'informations devrait tenir compte du choix linguistique adéquat pour chaque cible.

4.4 Une décision politique devrait être prise par les grands bailleurs de fonds tels que la CEE, la FAO et le PNUD dans la création d'un programme de petites allocations d'études pour financer les formations en cours et autres activités ayant trait aux ressources génétiques végétales.

4.5 Afin de renforcer la capacité nationale, une attention particulière doit être accordée à la formation pour les transferts de technologies au niveau professionnel.

4.6 Comme conséquence de l'importance du rôle de la femme dans la conservation et l'utilisation des cultures traditionnelles en Afrique, un grand accent devrait être mis sur les problèmes de représentativité des femmes aux stades de conception et d'exécution des programmes de formation. Pour traiter ces problèmes de répartition des tâches, il est nécessaire de sensibiliser les formateurs à ce sujet.

4.7 Dans la mesure où la formation est un processus continu, des efforts et des ressources doivent être investis dans les activités d'évaluation des programmes.

4.8 Les chercheurs de PGR aux niveaux national et international doivent s'engager à faire circuler les informations dans le cadre des programmes de formation.

Address on behalf of the United Nations Environment Programme

J. Hurturbia, *Coordinator of Environmental Management, UNEP, Kenya*

Mr. Chairman, Distinguished Delegates,

It is a great pleasure for me to represent the United Nations Environment Programme (UNEP) at, and to welcome you to, this seminar Due to pressing commitments outside Kenya, Dr. M.K. Tolba, the Executive Director of UNEP, is unable to be here with you. I have the honour to convey to you his greetings and his best wishes for a successful meeting.

On behalf of UNEP, I would like to express our profound appreciation to the International Board for Plant Genetic Resources (IBPGR), the Technical Centre for Agricultural and Rural Cooperation (CTA) and the Kenya Agricultural Research Institute (KARI) for co-sponsoring and organizing this meeting in our headquarters in Nairobi.

We meet here at a time when Southern Africa is suffering the worst drought of this century. This is also the time when thousands of refugees have come to Kenya to escape drought, insecurity, inhospitable environment, political strife and civic turmoil. Hunger, disease and death are pervasive in the refugee camps. This reinforces the need for safeguarding the genetic basis of Africa's traditional crops.

We consider that the role of IBPGR in the conservation and sustainable use of genetic resources, both for the development of viable agricultural systems in Africa (as in the rest of the Third World) and for the continued growth of the bioindustry, is of paramount significance.

The improvement or adaptation of plant varieties to changing environments and demands is at the very heart of traditional crop farming systems. For example, when new diseases emerge plant breeders need to look into the pool of existing genetic resources to find traits of resistance in order to breed them into crops that can subsequently withstand such onslaughts by pests, pathogens and parasites. Farmers benefit but so do the consumers. Rarely do we realize how much we depend on genetic diversity to help provide us with new food products with the desired characteristics.

Most of that genetic diversity originated in the Third World. It was in Africa, in Latin America, and in South East Asia, that plants evolved into a huge biological treasure chest and where peasants domesticated food crops. For thousands of years farmers in Africa and other Third World countries have been breeding and maintaining the genetic diversity upon which a large part of agriculture and world food security depend.

Unfortunately, we are presently witnessing a rapid destruction of this patrimony and we are still unable to reflect this loss in our national resources accounts. As traditional plant varieties get replaced by modern, "high-tech" ones we continue to lose the genes that the former carry as well as access to those genes. We also lose any form of firm control over them. This "genetic erosion", which is really an economic loss, is already hitting small farmers in the Third World, and in Africa in particular, harder than anyone else.

The problems associated with genetic erosion and the difficulties in conserving plant and other genetic resources at the global level have sparked off heated but healthy political debates. The debates hinge upon the question: Can Third World countries be expected to attain scientific and technological self-reliance for food security, based on sustainable

farming systems, when the very materials they require for plant and livestock breeding are disappearing and those remaining might be controlled elsewhere far in the North and in the boardrooms and genebanks of their Trans-National corporations?

At the heart of the problem of conservation and sustainable use of biodiversity components is the equitable sharing of benefits derivable therefrom through expansion of the biotechnology industry worldwide. But, we may ask: What kind of biotechnology development is feasible in the South? How can grassroots initiatives that conserve and use local plant varieties be supported and strengthened? In essence, how can Africa's small farmers and their communities regain control over the now threatened crop varieties and domestic animal breeds their ancestors developed? Can this be achieved without a firm biotechnology base?

The Convention on Biological Diversity, signed at the Earth Summit in Rio de Janeiro in June, 1992, by 157 countries and the European Community, can be considered as a major practical and political breakthrough on how to slow down, to arrest, and, perhaps, reverse the massive genetic erosion rate now caused by adverse human activity. It is a comprehensive and systematic instrument that aims to ensure effective conservation and sustainable use of the full array of biodiversity components, together with the technologies and financial resources by which the biological diversity can be best appreciated ecologically and economically, in perpetuity, for the benefit of humanity and the biosphere.

Genetic erosion and control over genetic resources have become major political as well as ecological, technological, legal and economic issues of global dimensions. This was evident throughout the negotiations for the Convention on Biological Diversity and it was also so in Rio. The hottest battlefield of the war against biodiversity loss is in respect of conservation and sustainable use of *plant* genetic resources, for these, in their various manifestations, provide essential ingredients for man's survival and for the continued functioning of the biosphere. One of the reasons for the geopolitical controversy on plant genetic resources in particular is the fact that breeders in the North have secured patent protection on crop varieties derived from genetic materials donated by Third World Countries. The North has accumulated the genetic resources and mobilized the necessary expertise while the South has been giving away genetic material freely only to buy back the patented, finished product at rather high cost.

It is now 18 years since the establishment of IBPGR and eight years since the African Ministerial Conference on the Environment (AMCEN) launched an African Network for the conservation and management of genetic resources. Can we togeiher take stock of our achievements over the past eight or eighteen years and justifiably pronounce our satisfaction or otherwise? Much water has passed under the bridge over these years; the critical question is, what gullies of genetic erosion have been occasioned by the flow of time and tide in the course of this brief period, which in many ways has been a momentous period?

A few years ago, in 1988, Dr. M.K. Tolba stood before another joint IBPGR/UNEP workshop held right here at UNEP. He posed the question: If Charles Darwin were alive today, what would he choose as a title for a sequel to his book "Origin of Species"? He volunteered the answer that he thought Darwin might call it "An Obituary of Species"! Again, much water has passed under the bridge between then and now. It has been a briefer and yet more momentous and historic period. There have emerged, during this period, a series of documents and legal instruments plus, capping it all, the Rio Earth Summit; an event of global significance to the survival of species and the well-being of planet Earth itself. I particularly refer to the following documents:

- Caring for the Earth: A strategy for sustainable living by the World Conservation Union (IUCN), UNEP and the Worldwide Fund for Nature (WWF);
- The global Biodiversity Strategy by the World Resources Institute (WRI), UNEP and IUCN;
- Global Biodiversity Status Report by the World Conservation Monitoring Centre (WCMC), UNEP. WRI, IUCN; and
- Agenda 21 (an 800-page volume of the Rio Earth Summit).

Also the following international legal instruments:

- The Convention on Biological Diversity; and
- The Convention on Climate Change.

As scientists and specialists playing an increasingly crucial role in defining, tackling and resolving global environmental issues and questions affecting biodiversity encompassing life support systems of the entire biosphere, it is incumbent upon each one of us to harness, to harmonize and to assure the full application of the actions and strategies proclaimed in the above documents and legal instruments.

"Biotechnology" is a word that somewhat conjures a picture of a mystical world to a lot of people including scientists! It raises a lot of expectations, hopes, fears, doubts, controversy and, often, plain confusion. *Even among distinguished academicians, it defies definition and does not even exist in their minds as a single entity; for biotechnology, as you all know, is really an integration of a range of many scientific disciplines and techniques that are applied, as it were, to manipulate living substances and processes.*

Genetic engineering, for example, became possible when many separate scientific disciplines came together. Molecular biology, enzymology, cellular biology, molecular chemistry, and so on, can conspire and change genetic information in almost any desired direction. However, biotechnology is much more than the cutting and splicing of genes. Tissue culture, which provides the possibility for regenerating entire plants from single cells of tissues, is a cluster of powerful biotechnology techniques. Enzyme technology is another crucial part of biotechnology, while the classic and modern fermentation technology is important for the industrial mass production of complex substances produced by novel genetically engineered microorganisms.

The Global Biodiversity Strategy addresses this issue and calls for action to strengthen crop and livestock genetic resources and to fill major gaps in the protection of plant genetic resources. The status of several thousand plant species including lesser known crops, fruits, nuts, vegetables, root and tuber crops, oil and fibre plants, herbs and spices, beverage and forage plants, needs to be assessed; surveys undertaken; and those at risk of extinction or severe genetic erosion should be collected and rescued off-site (*ex situ*) or incorporated into special *in situ* conservation programmes.

The resultant economic, ecological and other benefits to the farmer and to the communal and global village must be given sound safety valves. I take note that it is widely believed in developing countries that progress in agrotechnology will provide the impetus for continuing growth in agricultural productivity leading to food security and self-sufficiency in fibre and pharmaceutical products (among others), if not immediately, at least soon. Post-Rio signals suggest at least a firming up of the foundations so that sustainable improvements gained in IBPGR programmes over the past 18 years can be consolidated in select sectors for sustainable use by Third World Countries. Moreover, like all major

institutional changes, the application of modern biotechnology in IBPGR programmes whether or not for traditional crop agriculture in developing countries, will have differential impacts between adopters and non-adopters, between early and late adopters, between exporters and importers and, ultimately, between producers and consumers.

Modern biotechnology in the field of plant genetic resources need not be seen only in terms of competitive advantage for others. Many other potential applications such as adaptation of traditional and other relevant crops to marginal environments, control of tropical diseases, more efficient biological nitrogen fixation and biological control agents which eliminate the need for chemical pesticides, are more scale-neutral and egalitarian and would undoubtedly benefit resource-poor farmers and disadvantaged people in the developing countries of Africa.

Key policy consideration for developing countries in this regard will be the degree to which they hope to be self-sufficient in biotechnology or, in contrast, the degree to which they envisage the establishment of innovative mechanisms that allow them to become active members in joint ventures involving commercial and scientific collaboration, with fair, mutually beneficial linkages to other institutions and to the world of international industrial complexes. A distinctive and perhaps survival instinct of the new creature called biotechnology is that it thrives only in so far as it is truly multi-disciplinary, multi-sectoral, inter-institutional, transparent, international, public and private. What a complex, interlocking web but, at the same time, what an attractive and important challenge! Every developing country that chooses this course, namely, integrated cooperation and collaboration involving public/private sector interactions, must have in place policies and practices that protect its self-interests without unduly interfering with its capacity, productively, to establish useful external collaboration and cooperation.

Critical policy directions and options to be determined may be those regarding intellectual property protection for biological entities and processes. Protection of proprietary genes, plant parts and crop varieties will be of critical importance for both public and private institutions worldwide, in future years. The nature of policies in the field of intellectual property management will determine whether individual countries are isolated, are taken advantage of, or join the work as full partners of genetic improvement of crop plants and all other genetic resources in the future.

A nation's ability to characterize its plant genetic resources at molecular level, for instance, will make their germplasm collections more valuable. Biotechnologies, when used to locate traits of importance to breeders or commercial application, would enable each nation and its centres of excellence to benefit from its own genetic resource base and collections. Continued investment by the IBPGR by way of strengthening the capacities of National Agricultural Research Centres (NARCs) and cooperation with its sisters the International Agricultural Research Centres (IARCs) in *ex situ* conservation and development of plant genetic resources through, among others, germplasm-related technologies, is consistent with each national and international centre's objectives in the field of plant genetic resources.

In conclusion, Ladies and Gentlemen, I wish to make the following observation: Developing countries have no choice but to acquire the skills to generate and access or borrow, adapt and assimilate modern biotechnology for their national purposes. The first task is organizing, through national policies, strategies and action plans, or as appropriate, their national research systems and priorities for application of modern biotechnological breakthroughs.

With the support and active guidance of IBPGR and in the spirit of the Convention of Biological Diversity, the future of plant genetic resources of Africa and of other regions of the world may be assured.

I thank you all.

Welcome Address on behalf of the Technical Centre for Agricultural and Rural Cooperation

A. C. Jackson, *Technical Adviser, CTA*

Distinguished Guests, Ladies and Gentlemen,

It is my very pleasant privilege this morning to extend a most sincere welcome to all of you to this joint CTA seminar on ways of safeguarding the genetic basis of Africa's traditional crops. I welcome you on my own behalf and on behalf of Mr. Assoumou, CTA's Director and also on behalf of our Deputy Director, Dr. Treitz, who had hoped to join us but who now has other commitments which prevent his coming to Nairobi.

I have set three objectives for my address to you this morning. The first is to welcome you to our meeting; the second is to tell you a little about CTA and my third objective is to recapitulate the context and purpose of our meeting.

Today some of you may be encountering CTA for the first time. Because we offer a range of information services for people in the African, Caribbean and Pacific (ACP) countries and, as most of you can benefit as you are from those countries, I would like to spend a few minutes explaining who we are and what it is that we do when we are not sponsoring meetings of this kind.

CTA is an institute at the service of others. All our activities focus on the mandate given to us by the Lomé Convention: to improve access to technical information for agricultural development in the ACP States. All our pursuits are carried out in the context of the Lomé Convention, which is a cooperation agreement between the 12 member states of the European Community (the EC) and the 69 African, Caribbean and Pacific States who are co-signatories to the Convention. CTA is an institute of the Convention and is entirely funded by the Commission of the European Communities. The Centre's headquarters at Ede, near the Agricultural University of Wageningen in the Netherlands, were officially inaugurated in 1985. Our working languages are English and French, although we do occasionally publish in Portuguese.

CTA provides a range of services customized to the needs of individuals and institutions in ACP countries. I will briefly explain what these are:

Firstly, we convene and pay for technical meetings, or seminars, of which this week's meeting is an example. We support the attendance of ACP nationals at other conferences and have recently commenced a programme of study visits. Our CTA publications and co-publications services are very substantial. Those of you who already know CTA, probably know us through reading our publication "Spore", which appears in English and French every two months. We publish the proceedings of our seminars and we commission and publish studies, bibliographies and directories. Through our co-publications service we purchase books at preferential rates; we jointly fund the production costs, which may include paying for translations, of joint publications. We also pay the not-inconsiderable costs of distributing these publications to ACP countries.

A major feature of CTA's work has been the establishment of a Question-Answer Service. In addition to responding to specific technical enquiries, this service distributes CTA publications on request and delivers primary documents. We provide support services to rural broadcasters and offer our own short training courses for documentalists and those

involved in scientific communication. All these services are available free-of-charge to ACP countries.

In order to provide these services CTA maintains an Administrative Division and a Technical Division, which includes a Documentation Unit. There are, at present, some thirty-two staff at CTA's Headquarters in the Netherlands. Most of our work, however, is contracted out to specialized organizations. We maintain Regional Branch Offices in the Caribbean and the Pacific and are developing National Focal Points in ACP countries. We also have a small Branch Office in Brussels. A computerized mailing-list and database is maintained at our headquarters.

I have taken time to outline the services we offer because it may be that they can be of use to many of you in your work. Throughout the week I will be available to anyone who wishes to discuss these services with me.

I would like now to say a little more about CTA's technical meetings, of which this is one. These meetings are relatively small seminars which generally focus not so much on science itself but on the application of science to development issues. Each year as a service to ACP countries we sponsor about six meetings similar to the one we are attending this week. We always implement these seminars in collaboration with appropriately specialized organizations. These meetings are attended by experts from ACP countries, the EC and elsewhere. The Proceedings are always published and the conclusions are given wide publicity through "Spore" and other media.

I now want to return to the subject of this week's meeting and to begin by reminding you of the objectives we have set ourselves. Our intention is to examine the management of plant genetic resources by African farmers, as well as the present status of landraces and other traditional crops and food plants in African agriculture. We shall be examining the technical implications of promoting conservation and breeding at the grassroots level so as to restore and maintain farmers' control over their own production systems. We shall also consider the acquisition, storage and dissemination of technical information in this context. Information handling is important to CTA, and the development of geographic information handling systems for genetic conservation is a particularly formidable challenge. Our meeting will provide an opportunity to discuss and evaluate the status of conservation and utilization of landraces and food plants in African traditional agriculture. It will, we trust, identify the constraints associated with the conservation and use of landraces at the farm level. It will identify research priorities and will also assess the needs for appropriate integrated conservation technologies for the management of these resources, while incorporating other sources of useful genes into traditional African agriculture.

I have stated our objectives in the rather stark terminology which is appropriate to technical discussions. A couple of weeks ago I was reading a comment on the European unity debate from Professor Adam Roberts of Balliol College, Oxford, UK. Speaking of the present difficulties in that area, Prof. Roberts wrote: "It is partly the European Community's fault for being such a boring institution, concerned with things like agriculture rather than with things that catch the imagination like human rights". I am sorry if Oxford professors find agriculture boring and I suspect that few people in this room would be comfortable with Professor Roberts' sentiments. Perhaps he does have a point. As we have prepared for this seminar it has become increasingly obvious to me that many of the issues linked to the conservation of crop plants do catch the imagination. I suspect this may be because they involve fundamental principles relating to the equitable distribution of the world's natural resources, matters which the international community does not find boring at all. Furthermore, the fluctuating populations of plant genetic resources in farmers' fields

which underpin our basic food security are deliberate artefacts of man which indicate the intimate relationship which exists between plant genetic resources and society.

Whilst I have no wish to encourage a disregard for the utopian and romantic facets of life, I have to stress that the objective of our meeting here in Nairobi is to focus on technical matters and not to be drawn towards the more emotive issues. The international scientific community has a responsibility to give ACP countries the most soundly-based technical advice it can offer to help them tackle the complex challenges of countering the threats currently being posed to the genetic resources of African crops. This meeting is intended as a contribution towards that goal.

Most African countries are thought of as having very limited resources with which to counter genetic erosion and it is generally agreed that these resources need to be used very efficiently. And yet there is a sense in which that perception is not entirely true. We often overvalue the importance of the scientific progress and institutional developments of the last hundred years or so. We forget that before the modern era crop development was carried out by farmers - and that most of these developments were complete even before the Pharaohs ceased ruling Egypt. African farmers invented complex and elegant systems for growing their traditional crops in sequences and mixtures. They later incorporated new crops from America and Asia into their systems. All this was done using resources and methods within their command. Until recently, we were oblivious to the fact that African farmers today are continuing this tradition. We now know better, and that is what makes the topic we are discussing this week so exciting. In the recent IT Publications book "Growing Diversity" the point is made that farmers' approaches to conserving, using and improving plant genetic resources should be supported by the formal system, not impeded by it. Our meeting will have made an important contribution if it can help to define how this might best be achieved from a technical perspective.

I know that we are going to have a lively and stimulating meeting and that we will all benefit professionally from the opportunity to see problems from different perspectives, to develop new ideas and to share views throughout the week. Equally important is the opportunity to build lasting professional relationships with fellow scientists from within and beyond our own countries. Finally, I hope that each and every one of you will find your week with us to be an enjoyable and memorable experience.

I would like to thank you all very much for your attention and, once again to warmly welcome all of you to our seminar. Thank you all very much indeed.

Address on behalf of the Food and Agriculture Organization of the United Nations

H. L. Norton, *FAO Representative in Kenya*

Mr. Chairman, Director of Research MSTR, Director of IBPGR, Deputy Director of CTA, Chief of UNEP Division, Honoured Guests, Distinguished Colleagues, Ladies and Gentlemen,

As the FAO Representative, I am pleased to be here today to convey to you the wishes of Mr. Edouard Saouma, Director-General and the Agriculture Department of FAO, for a successful seminar.

I want to thank the organizers for taking the initiative to organize this seminar which covers a critical area that needs the inputs and support of many organizations and people. Let me start, therefore, by expressing how pleased I am that FAO is associated with this important CTA/IBPGR/KARI Seminar on Safeguarding the Genetic Basis of Africa's Traditional Crops. The future of most developing countries and the world to feed its rapidly growing population will depend on innovative actions taken to find the mechanisms and ways that will allow the food and agriculture sections to use traditional and new findings to increase production.

Thus, FAO recognizes the importance of genetics as a tool for research and the speeding up of development to meet the goals and needs of the world. FAO also feels that modern genetics should be used to complement, but not substitute, conventional technologies in problem-solving. To this end, it is important to provide the proper environment for the promotion of linkages between disciplines and implementation. The adoption of genetic policies for developing countries is critical and requires a proper definition of the strategies.

As I understand, the seminar will attempt to examine the status of conservation and utilization of landraces and food plants by farmers and research scientists in the African traditional agriculture. FAO seeks to facilitate the transfer of technology and assist in the planning, programming and priority settings as well as advising and supporting the formulation of these strategies.

FAO will, naturally, continue to cooperate with other agencies and organizations as well as with NGOs and others in assisting developing countries to elaborate pertinent strategies for their policies.

This can only be done if the transfer of plant and animal genetics to the farmer can make the great leap forward to improve yields and production to meet the rapidly growing challenges of population and land pressures.

It has also been indicated that plant genetic erosion can negatively affect the economic sectors of the developing countries, because the access to more competitive markets is being gradually limited and agricultural industrialization will inevitably restrict the access of the less developed countries. There are also further risks, the consequences of which are still pending.

The management of plant genetic resources is often beyond the existing capabilities of many developing countries who have few trained people to operate this kind of system. Also,

most African countries do not have the financial resources to establish and, more importantly, maintain these significant systems. How do we help? We feel that one of the approaches is the sharing and transfer of genetic knowledge to developing countries. More recently, the international centres have been actively participating in the transfer of genetic developments to their counterparts - the national programmes - for practical application.

FAO recognizes that proper management of genetic resources can help speed up development. FAO also feels that modern technologies should be used as complementary approaches but not as substitutes for conventional technologies. To this end it is important to create the proper environment for the promotion of linkages between these disciplines. The adoption of new technologies in developing countries requires a proper definition of strategies. FAO feels there is a need to assist developing countries in the planning, programming and formulation of strategies.

Finally, FAO believes there is an important need to assist the African countries to manage plant genetic resources and to develop national strategies and policies to ensure the stability of their food production system to meet the serious challenges of today and, more importantly, for tomorrow.

I wish you all success in your deliberations.

Welcoming Address on behalf of the International Board for Plant Genetic Resources

G. Hawtin, *Director, IBPGR*

The term "biodiversity" encompasses the virtually infinite diversity of genetic information in living individuals expressed in an estimated 30 million species of plants, animals and micro-organisms. These species, in turn, form the basis of delicate life-supporting ecosystems. The third level of biodiversity, namely within-species diversity, is the key to the survival of species in nature in the long-term and the main concern of plant genetic resources programmes.

The need to protect and conserve genetic resources was apparent to a few far-sighted scientists as far back as the 1920s, yet it was not until the late 1960s that the dangers of genetic erosion were widely understood by the scientific community; by that time it had reached alarming proportions. Wild strains of agricultural plants, which carry genetic properties needed to breed more productive new strains, disappeared as development destroyed their habitats. In the field, farmers abandoned traditional varieties in favour of new high-yielding types.

The Consultative Group on International Agricultural Research (CGIAR) created the International Board for Plant Genetic Resources (IBPGR) in 1974 in response to calls for international action to stem the loss of these irreplaceable plant genetic resources. Since that time, IBPGR has been in the forefront of global efforts to collect, analyse and store traditional and wild plant genetic resources.

The world has changed greatly in the past few decades and, with it, the priorities and needs of the genetic resources community. In 1974 there were fewer than ten fully functioning national genetic resources programmes; now there are more than 120 and the number is growing every year. The number of regional and international programmes and non-governmental organizations involved in genetic resources activities has increased rapidly as well.

The involvement of so many new players in the field of genetic resources has had a significant impact on the scope of genetic resources activities world-wide. There is now a fundamental recognition of the importance of building strong national genetic resources programmes and ensuring collaboration among them.

IBPGR has long held this position, working for many years in partnership with other institutes. As a result, IBPGR has grown into an institute with the capability to provide a wide range of services in support of national, regional and international efforts to conserve plant genetic resources. This has led to the decision to establish the International Plant Genetic Resources Institute (IPGRI) as an independent centre of the CGIAR; (since its inception, IBPGR has been administered as a trust fund of the Food and Agriculture Organization of the United Nations).

In October 1991, representatives of five governments, including that of Kenya, signed an agreement to establish the institute and it is anticipated that IPGRI will take over the duties of IBPGR early in 1993.

The Strategic Plan of the new institute - "Diversity for Development" - explicitly recognizes the crucial role of the "informal sector" in the conservation and use of plant

genetic resources and identifies collaboration and support for non-governmental and farmers' organizations as fundamental to the institute's strategic objectives.

An important part of the genetic diversity of useful plants is conserved by farming communities. The methods used by these communities are not, generally, well-studied or documented. They have much to teach us about maintaining landraces and local cultivars, whether in the field or in genebanks. IPGRI will collaborate with partners to develop integrated conservation strategies using the most appropriate mix of methods for the genepool concerned.

For many species, *in situ* conservation in protected areas may be the most appropriate method of conserving the genepool. To what extent these methods will prove effective for long-term conservation of genetic resources has still to be established. For a conservation effort to be sustainable, the long-term security of the germplasm must be assured as well as its availability and adequate information to make it useful. IPGRI, while maintaining its interest in *ex situ* conservation, will expand the scope of its activities to include *in situ* and on-farm conservation. IPGRI will focus especially on scientific studies to determine how best to conserve the genetic diversity of wild crop relatives and forest species *in situ*. Other aspects of *in situ* work requiring urgent attention are the identification of areas containing significant genetic diversity, the optimum size and location of sites for *in situ* conservation and the development of sound practices for managing *in situ* reserves.

The conservation and use of plant genetic resources has a human dimension that IPGRI will make part of its agenda for the future. As the institute increases research and other activities concerning *in situ* and farm- or community-level conservation, social factors such as decision-making patterns and social organization must be taken into account. An understanding of gender variables will be critical to any such studies. The use of gender analysis to incorporate social variables into projects has great potential for improving results and will be introduced on a systematic basis into project development.

It is of growing concern that indigenous knowledge about cultivated and wild species is being lost rapidly. Local knowledge about plants and the innovation systems of individuals and communities are an invaluable resource in the search for new ways of conserving and using plants. Such knowledge provides a critically important adjunct to the normal passport, characterization and evaluation data.

IPGRI will initiate research on indigenous knowledge in partnership with national and other organizations, and will seek to develop appropriate strategies for conserving and making such knowledge available. A large share of this information is held by women and much of it is not in the public domain. For this reason, IPGRI will be careful to respect the rights of ownership of this critical resource.

While a tremendous effort is already underway to conserve the world's plant genetic resources, for this effort to be truly successful, action is needed at all levels - local, national, regional and international. IPGRI is committed to working in partnership with other organizations sharing the same goal: the protection and sustainable use of the Earth's genetic heritage.

Official Opening Address

The Hon. Kirugi L. M'Mukindia, *Minister of Research, Science and Technology, Kenya*

Mr. Chairman, Ladies and Gentlemen,

It gives me great pleasure to be with you today at the official opening of the CTA/IBPGR/KARI/UNEP Seminar on "Safeguarding the Genetic Basis of Africa's Traditional Crops". This seminar is important because it brings together scientists, policy makers and international and local non-governmental organizations from within and beyond Africa to discuss the various ways to protect, conserve and utilize indigenous plant germplasm for food production, with emphasis on farmers' participation.

Africa is endowed with a great diversity of plants. Among these are the cultivated landraces, their wild and weedy relatives as well as scores of other under-utilized or neglected species. Their contribution to agriculture, medicine, industry and the environment, worldwide, amounts to billions of dollars each year. Even if uses are not well known for some of these resources, they play an important role in many other ways, including stabilizing the climate, cycling of nutrients or controlling soil erosion and desertification.

The African traditional farmers have relied on the genetic diversity of landraces to ensure the stability of their food production systems. They have developed diverse cropping practices adapted to their local ecological, social and cultural situations. They also harvest from the wild and from various plants which are used directly as sources of food. Traditional farmers in Africa are, therefore, the first to feel the impact of the loss of the indigenous crop genetic resources.

Unfortunately, the African continent is today witnessing a serious loss of these useful food plants due to the erosion of "farming culture" and change of traditional feeding habits due to the introduction and adoption of new exotic and high-yielding crop varieties. This has been worsened by the change in land use systems and the loss of natural habitats and ecosystems. The loss of genetic diversity has an adverse effect because it limits future options for crop improvement programmes.

National food policies for self-sufficiency in feeding the rapidly increasing population still tend to be based on a few well-researched, uniform varieties of staple food crops rather than on the utilization of the rich genetic diversity to be found among farmers' traditional varieties. This has tended to displace indigenous knowledge and the availability of traditional crops. In recent years these developments have given rise to growing scientific and public concern.

These issues have been addressed through several international and regional fora. For example, in 1985 the first African Ministerial Conference on Environment held in Cairo, decided to establish a regional network on plant genetic resources in order to strengthen regional cooperation and accelerate the conservation and wise use of these valuable resources. This was followed by a workshop on Crop Genetic Resources of Africa held in Nairobi in this same venue in 1988. The UNCED Earth Summit, held in Brazil in June this year, further underscored the importance of genetic resources through the Biodiversity Convention and Agenda 21.

This seminar, therefore, serves as suitable and timely proof of further commitments to address the issues, especially the conservation of African traditional germplasm at the farm level. It is my hope that it will provide an opportunity to discuss and evaluate the status of conservation, utilization of landraces and food plants in African traditional agriculture and that it will identify the constraints associated with the conservation and use of landraces at the farm level. It will perhaps be necessary to assess the needs for appropriate integrated conservation technologies for the management of these resources, while incorporating other sources of useful genes into traditional African agriculture.

The enormous task of conserving Africa's landraces will require an integrated approach involving the scientists, policy makers, economic planners and the farming communities in the development of appropriate conservation strategies for increased food production and economic growth.

At this juncture, I wish to commend the efforts made by CTA, KARI, UNEP and IBPGR in organizing this seminar and, even more so, their contributions in prompting national, regional and international efforts for the conservation of plant genetic resources.

Finally, on behalf of the Government of Kenya, I wish to welcome you all to Nairobi and to thank the organizers for choosing Nairobi as the venue for the seminar.

I now have the pleasure of declaring this international seminar on "Safeguarding the Genetic Basis of Africa's Traditional Crops" officially open.

Keynote Address

Conservation and Use of Plant Germplasm in African Traditional Agriculture and Land Use Systems

B. N. Okigbo *Director, UNU Programme on Natural Resources in Africa, Kenya*

Hereditary material consists of various numbers of units of deoxyribonucleic acid (DNA) designated as genes which, for all practical purposes, are units of hereditary information. These genes, during the development of each organism, specify the nature of each characteristic possessed by the organism and the vital metabolic processes that are necessary for survival. In fact, there is a hypothesis that each gene is equivalent to one enzyme and each enzyme is responsible for regulating reactions for the development of a specific trait of an organism or member of an individual species. The *germplasm*, as originally defined by De Vries, consists of a full complement of genes in the reproductive structures that produce gametes or germ cells of an organism, as opposed to the *somatoplasm* or body cells of the organism. Based on this concept, the plant germplasm consists of the reproductive structures of plants through which genes are transmitted from one generation to another and may include pollen, anthers or ovules. In this age of biotechnology, however, especially with respect to the advances in tissue culture techniques in which practically new plants can be regenerated from any part of the plant, differentiation between germplasm and somatoplasm, especially in plants, does not make much difference.

The germplasm of all organisms manifests differing degrees of variability in the characteristics or traits that they possess as a result of heritable changes called mutations. These changes may occur in germ cells or in body cells. Usually, it is only the heritable changes in the germ cells that are phenotypically expressed. Expression of the changes depends on whether the genes are dominant or recessive, the nature of the allelic pairs, the degree of their interaction with genes in other loci and the extent of environmental influence. In plants, bud sports arise from somatic or body cell mutations which may result in new varieties. Similarly, certain traits are transmitted through the cytoplasm. In general, however, it is the heritable changes that are transmitted from parents to offspring, that cause variability. It is this variability that is designated as biodiversity. All the biodiversity that exists in all organisms is the cumulative effect of 400 million years of evolution [WWF, 1989]. The variability exists or occurs at molecular, cell, organ, organism, species and ecosystem levels [Solbrig, 1991]. Biodiversity is a fundamental property of life and, without it, no evolutionary changes are possible [Solbrig, 1991]. Without evolutionary changes in living things, there would have been no adaptation to changing environmental conditions and no natural selection could have occurred. In fact, without variability in living things, plant or animal breeding would be ineffective. Herein lies the importance given to the conservation of biodiversity.

There are two main reasons advanced for the conservation of biodiversity. The first is a moral or ethical one while the second is related to the uses and diverse contributions they make to the well-being of man [WWF, 1989; Stuart *et al*, 1990].

1. Ethical and moral reasons arise from the facts that:

   - All species have an inherent right to exist and the ecological processes that support the diverse species of organisms and the integrity of the biosphere,

landscapes and habitats, have to be maintained; this can only be done when the various organisms that interact to bring about these processes, can survive in their various forms.

- We live in an interdependent world in which the well-being and health of any one part depends on the well-being and health of all the other parts.

- Mankind is part of nature and is, in fact, one member of the animal kingdom subject to the immutable ecological laws of nature, as are all other species on earth. Because of the dependence of all life on the uninterrupted functioning of the natural systems of energy and nutrient cycles or supplies, it is the responsibility of all peoples to ensure survival, equity and security of all ecological communities worldwide. Human culture should be built on a profound respect for nature.

- Development activities should not be aimed, solely, at attaining limits of human endeavour but at keeping within the ecological limits that ensure that all human activities sustain environmental stability and diversity.

- The well-being of future generations should be the social responsibility of the present generation [WWF, 1989].

2. Contributions to our well-being that are derived from conserved biodiversity, relate to:

   - The maintenance of ecological stability by ensuring the continuing functioning of cycles of water, energy and nutrients, photosynthetic fixation of energy from the sun by green plants and its transfer to all components of ecosystems; regulation of climate at all levels; control of erosion of land, etc.; and

   - The supply of all our consumptive needs for wood and other sources of energy, food from plants and animals, structural materials, etc., [Stuart *et al.*, 1990].

It is, therefore, not surprising that conservation of biodiversity is one of the vital components of sustainable development which must be borne in mind, not only in agricultural development, but in all other sectors on which our well-being and economic growth depend. This paper gives due consideration to the status of biodiversity in Africa with emphasis on plant biodiversity and discusses the problems of conservation of plant germplasm in relation to the prevailing agricultural and land use systems in Africa. Finally, recommendations are made for actions to be taken, sooner rather than later, to ensure that conservation of plant genetic resources achieves the basic contribution it is expected to make to sustainable development in Africa and elsewhere.

Conservation as a concept and mode of action

The word conservation used to be interpreted as being synonymous with preserving and protecting things from harm and for posterity, as is done in museums of old. The idea of conservation of this kind is unacceptable or revolting to developers, whose main interest is in converting resources to monetary gain or into forms that can be utilized to satisfy human needs, sometimes irrespective of the consequences of the activities involved in accomplishing these objectives. The United Nation's definition of conservation, based on concepts advanced by UNESCO and FAO, is that conservation means "the rational use of the earth's resources to achieve highest quality of living for mankind" [Dasmann *et al.*, 1973]. This definition does not minimize the conflict between *developers* and *conservationists* as to the interpretation of what "rational use" or "quality of living" is,

because it varies from one culture to another. These phrases can still be interpreted to support either group's point of view. The most important aspect of an acceptable definition of conservation in this age of sustainable development is that it should involve management of resources to ensure that:

- human needs are satisfied without jeopardizing the ability of future generations to satisfy their needs; and
- the resource base, or environment, suffers no adverse effects in our utilizing natural resources in the development process.

According to Jacobs [1988], the most appropriate definition of conservation is as an indispensable part of a broad field or discipline of "the wise utilization of natural resources aimed at utilization *ad infinitum*" in such a way that it involves the three cardinal components of the IUCN [1980] World Conservation Strategy, namely:

1. maintaining essential ecological processes and life support systems;
2. preserving genetic diversity; and
3. ensuring the sustainable utilization of species and ecosystems.

Jacobs [1988] maintains that conservation, broadly speaking, encompasses the idea of preservation, consisting of (1) and (2) above and management, which entails (1) and (3). Thus it involves management of biological resources and environmental management of their ecosystems. Consequently, as an applied science, conservation entails the application of our knowledge of ecology, animals and plants and their ways of life in various ecosystems including aspects of human geography, sociology and environmental legislation [Jacobs, 1988]. In this paper we regard conservation as involving elements of protective, preservative, usable and sustainable management of plant genetic resources that satisfy, with increasing efficiency and more or less in perpetuity, current and future needs of mankind and other organisms.

Status of biodiversity in Africa

The highest degree of biodiversity in the world is found in the humid tropics. In general, however, the degree of biodiversity in different organisms varies among regions and within each major geographical region. There are many more species of fresh water fish in the tropics than in temperate countries [Pomeroy and Service, 1986]. It has also been reported that there are more species of breeding birds in Nigeria than in the whole of Europe which has ten times the area of Nigeria. Within the continent of Africa, the highest species diversity occurs in the equatorial areas because species diversity, just as with primary production, is highly correlated with annual rainfall. Of course, within each area there are other modifying factors such as the landscape, drainage, vegetation and soil type [Stuart *et al.*, 1990]. Environmental heterogeneity, in space and time, usually increases biodiversity. Consequently, within the continent of Africa, even among countries close to the equator, differences in biodiversity may be accounted for by variations in topography and other environmental factors which are responsible for habitat and ecosystem differences. As far as overall species difference is concerned, in the continent of Africa, very high levels of biodiversity are found in such countries as Zaire, not only because they are located astride the equator, but they also cover large areas of tropical rain forest, northern and southern savannas, wetlands, lakes and mountains [Stuart *et al.*, 1990]. Overall, in order of decreasing levels of biodiversity, especially in the numbers of species

of plants, the 12 countries with highest levels of diversity in the continent are South Africa, (21,988 species), Zaire (13243 species), Tanzania (12,633 species), Madagascar (11,771 species), Cameroon (10,184 species), Kenya (9,370 species), Gabon (8,032 species), Ethiopia (6,986 species), Uganda (6,631 species), Angola (6,442 species), Zambia (5,974 species), and Nigeria (5,949 species). It should be noted that, as far as species diversity in plants on the continent is concerned, variation in topography contributes a lot to the degree of biodiversity. One interesting aspect of this phenomenon is the level of concentration of species which are not found anywhere else, or what is designated as the level of *endemicity*. Madagascar, for example, is not very rich in species but is very rich in endemic species, as are other islands such as the Comoros, Mauritius, Sao Tome and Principe and the Seychelles. On the mainland, countries rich in endemic species include those with lowland forests such as Ivory Coast, Liberia, Nigeria, Cameroon and Gabon, in addition to the escarpment forests of Angola and the lowland and montane forests of eastern Zaire, western Uganda, Rwanda and the coastal areas of Kenya and Tanzania [Stuart *et al.*, 1990]. The wetlands of the Inner Niger Delta of Mali, seasonally flooded western Central African Republic, southern Chad, the Sudd region of the Sudan, Lake Kyoga in Uganda, parts of Zambia, the Okavango area of Botswana and the lakes of East and Central Africa, are very rich in fish. In the arid areas, major centres of endemicity include Somalia, Ethiopia and Namibia.

As far as plant diversity is concerned, which is the interest of this paper, African forests are regarded as floristically poorer than those of tropical America and Indo-Malaysia [Figure 1]. Within Africa itself there is a higher species diversity in Zaire and Cameroon than in West Africa [Tables 1a and 1b].

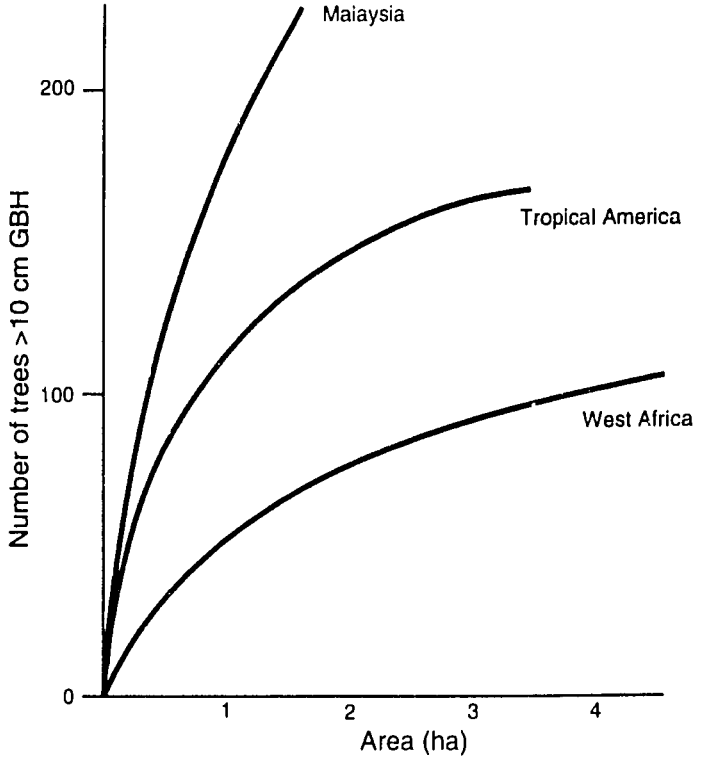

Figure 1. Species/area curves comparing West African forests with those outside Africa. African forests contain relatively few species compared with forests in tropical America and Malaysia. [From J. Bernhard-Reversat, *et al.*, 1978].

Source: Pomeroy and Service, 1986.

Table 1a. The number of species of flowering plants recorded in tropical rainforests in four African countries

Country	No. of species	No. of genera	No. of families
Ivory Coast	600 (trees>10 cm GBH* only)	275	60
Nigeria	4 500	-	-
Cameroon	8 000	1 800	220
Zaire	11 000	-	-

* GBH = girth measured at breast height

Source: Anon., 1978

Table 1b. The number of species and notes on the equitability of communities in smaller study areas in tropical rainforests in three African countries.

Country	Area of study	No. of species	Notes on equitability
Nigeria	18 ha	170(trees > 10 cm GBH)	18 species each contained > 100 individuals; 90 species each contained < 10 individuals
Cameroon	1 are	230 (trees)	1 species contained 150 individuals; 125 species contained 1 individual
Gabon	8 ares	122 (shrubs and trees > 3m in height)	26 species of lines were recorded amongst 96 individual plants

Source: Anon., 1978

It has also been observed that the loci of species richness and endemism for birds, mammals, reptiles, amphibians, butterflies and flowering plants often coincide in areas which have remained tropical rain forest for long periods of time, even during glacial times. These are designated as Pleistocene refuges [Whitmore, 1990]. In Africa, these are in Upper Guinea, Cameroon and neighbouring areas in Gabon and the eastern rim of the Zaire basin [Whitmore, 1990; Figure 2].

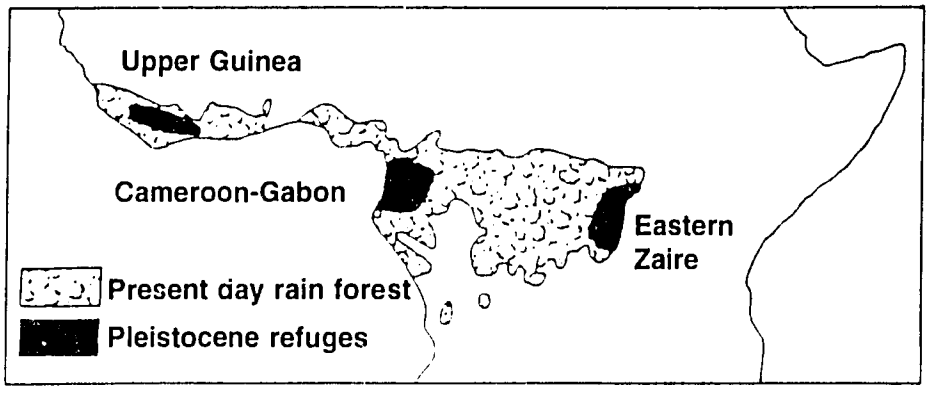

Figure 2. Present-day extent of tropical rain forest in Africa. Areas of high species richness and endemism, which are postulated locations of pleistocene forest refuges, also shown [after Mayr and O'Hara, 1986]

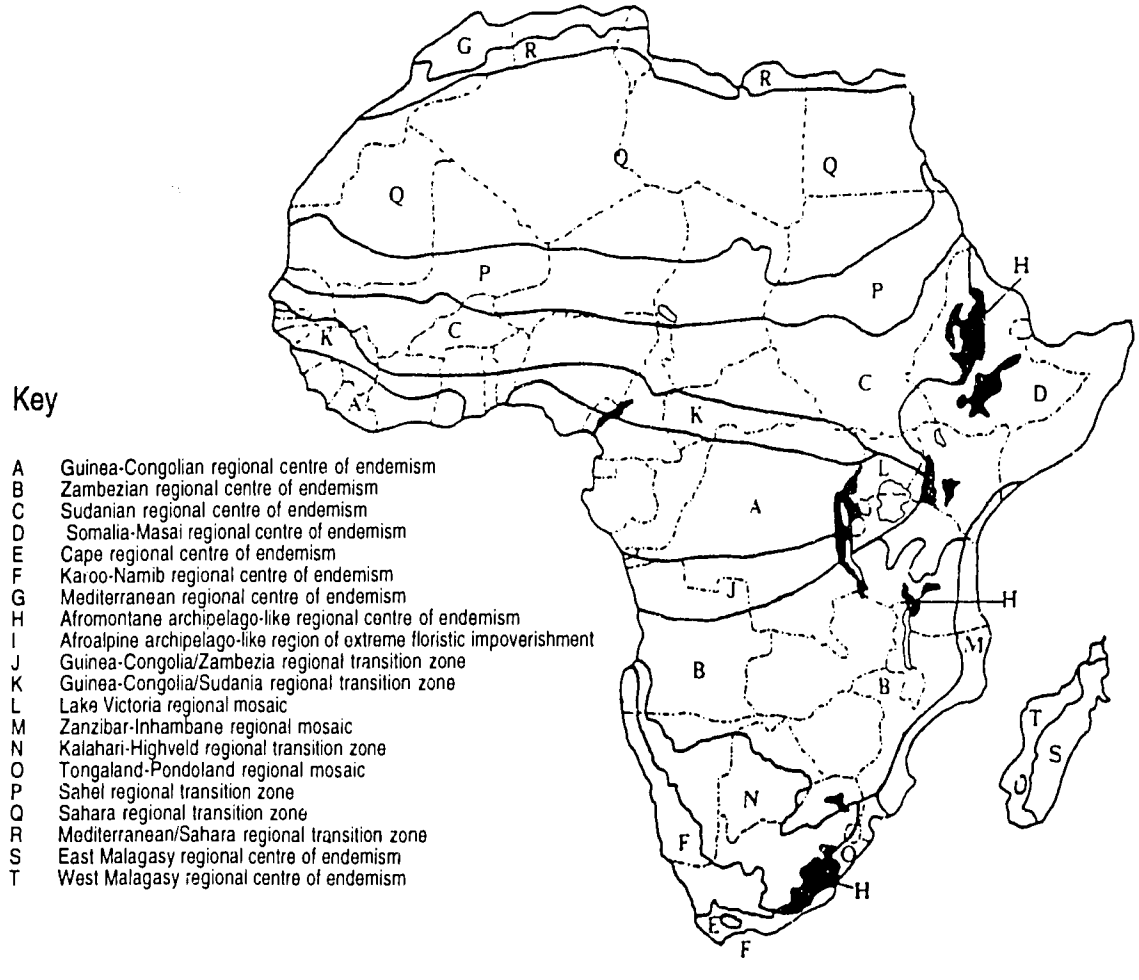

Figure 3. The phytochoria of Africa (biogeographic units based on plant distribution).
Source: Stuart *et al.*, 1990

The Cameroon refuge is reported to have 138 species on several 0.64 ha. sample plots at Korup, compared with less than 100 species per hectare for non-refugial sites in the African rain forest. Areas with concentrations of endemic species should be given high priority in conservation, but, since the African rain forest is relatively poorer in plant species diversity than the other tropical regions, as much as possible should be done to conserve the fewer species that are present. Figure 3 shows areas of Africa that have similar and different phytochoria. These give us a good idea of those areas with similarity in species composition. For example, the tropical rain forests in West Africa and Zaire, share similarities in flora.

Threats to biodiversity in Africa

Biodiversity has been decreasing at different rates in all parts of Africa and this has contributed to differences among countries and areas within countries. Although not all existing species in different countries have been identified to facilitate quantitative determination of the exact rate of decline, it is well known that some identified species have either become extinct or have drastically decreased in number. Stuart *et al.*, [1990] have identified the following causes of the decline in biodiversity:

1. Population pressure: Human population pressure accentuated by improvements in health, sanitation and standards of living has resulted in increasing pressure on resources for many development activities.

2. Food production practices: Food production methods and practices involving technologies and slash-and-burn fallow systems that depend on expansion of area under cultivation for increasing agricultural productivity; overgrazing in savanna areas has resulted in land degradation and desertification.

3. Commercial land use methods: Deforestation and drastic ecosystem disturbance for the timber trade, cash crop production, mining, oil extraction and related activities have, in some cases, irreversibly destroyed the resource base, e.g. wetlands, forests and coral reefs, with concomitant reduced numbers of species that depend on these ecosystems.

4. Foreign debt servicing activities: With mean foreign debts averaging 58% of the GNP, many countries have adopted various agricultural and industrial practices that involve harvesting or mining of resources at unsustainable rates with devastating consequences on the resource base.

5. Over-harvesting: Harvesting of wildlife beyond their rate of natural increase has, for example, reduced the black rhino, in 20 years, from a population estimated at 70,000 to about 35,000. Over-grazing is causing environmental degradation, erosion and desertification in drier areas and over-harvesting of economically valuable species by illegal means, often for the benefit of foreigners, is also of increasing concern.

6. Inviable populations of species: Numbers of some species have been reduced to such an extent that they lack the genetic diversity necessary for long-term survival. Very small populations are often in danger of suffering severe losses due to the risk of fires, disease, natural disasters, etc. that have devastated the fauna of the Sahelian zone in the last 20 years. Some of the species that have become extinct, or nearly so, are those that play vital roles in the pollination, dispersal or germination of some plants.

7. **Climatic changes:** Some areas, as in the Sahel, have experienced prolonged periods of drought, for which no appropriate responsive changes in land use or production systems have been introduced to minimize consequential environmental degradation.

8. **Introduction of alien species:** The introduction of such animal species as cats, goats, rats, deer and many plants, especially in island habitats, constitutes a major threat to biodiversity since these upset, permanently, the ecological balance and extinction of some species has occurred in Reunion, Mauritius and Rodrigues. Examples of introductions of alien species do not only involve introductions from outside Africa. For example, the introduction of the Nile Perch into Lake Victoria has resulted in the danger of extinction of over 100 species of fish.

   With regard to the biodiversity of crops, new varieties have displaced landraces and/or their production systems. This replacement of traditional, mixed or intercropping systems with monoculture constitutes a major threat to biodiversity. Related activities with damaging effects are:

   - the increasing use of pesticides and herbicides which kill non-target organisms that play vital roles in the life cycles of some crops or their wild relatives;
   - tillage systems which lay large areas bare;
   - the introduction of weed species which displace wild relatives of crops and cause changes in ecosystems; and
   - changes in food habits with the result that people are abandoning the harvesting of semi-wild or wild species to such an extent that the younger generation, increasingly, are becoming ignorant of them and may not even include such wild species in conservation programmes. This is because priority is very likely to be given to those species that are known to be useful and "edible".

9. **Fire risk:** A major threat to biodiversity, especially in the savanna areas, is inadequate fire management. Fires can result where there is a lot of dry material late in the dry season. Severe fires change ecosystem species composition and cause soil degradation.

African plant and crop biodiversity

Of the 275,000 - 400,000 higher plant species that are estimated to exist, 10 - 15% are believed not to have been discovered and identified. Only 73,900 species of the lower plants and 36,000 species of micro-organisms are known but total numbers of each are unknown [Wolf, 1987]. Houerou [1991] estimates that there are a minimum of 63,000 higher plants in Africa of which about 20,000 species are consumed by large wild herbivores and livestock. Of these 20,000, only 3,500 play major roles in such feeding. Further, 1,500 of these are grasses and 600 are legumes while 400 are browse plants in addition to the remaining 1,000 other species of pasture plants or forbs. African species of forage plants have contributed 70 - 75% of pasture and fodder grasses and 25 - 30% of legumes to the world fodder and pasture genepool. African flora are known to have contributed immensely to the forage grass genepools of Latin America and Australia. What is interesting in this regard is that while Africa has made highly significant contributions to the world pasture and forage species' genepools and many of these are undergoing genetic improvement, with the exceptions of Ethiopia, where ILCA is engaged in substantial breeding and conservation work, and South Africa, very little is being done in national programmes.

Table 2a. List of indigenous African food plants [Okigbo, 1983]

A. Cereals

Digitaria exilis	Fonio millet	Savanna	W. Africa
Digitaria iburua	Black fonio	Savanna	W. Africa
Brachiaria deflexa	Animal millet	Savanna	W. Africa
Eragrostis tef	Teff	Highland Tropics	Ethiopia
Eleusine coracana	Finger millet	Savanna	W/E./C. Africa
Pennisetum americanum	Candle millet	Savanna	Trop. Africa
Oryza glaberrima	African rice	TRF/Savanna	Trop. Africa
Sorghum bicolor	Guinea corn	Savanna	Trop. Africa

B. Grain legumes and other legumes

Kerstingiella geocarpa	Kersting's groundnut	Forest/Sav.	W. Africa
Cajanus cajan	Pigeon pea	Forest/Sav.	Trop. Africa
Vigna unguiculata	Cowpea	Forest/Sav.	Trop. Africa
Vigna subterranea	Bambara groundnut	Forest	W/E. Africa
Sphenostylis stenocarpa	African yambean	TRF/Savanna	Trop. Africa
Mucuna sloanei	Horse eye bean	Trop. Forest	Trop. Africa
Mucuna pruriens var. *edulis*	Velvet bean	Trop. Forest	Trop. Africa

C. Cucurbits

Citrullus lanatus	Watermelon	Savanna	Trop. Africa
Colocynthes vulgaris	Egusi melon	TRF/Savanna	W. Africa
Cucumeropsis edulis	Egusi melon	Savanna	W. Africa
Cucumis melo	Melon	Savanna	W. Africa
Cucumis anguria	W. Indian Gherkin	Savanna	Trop. Africa
Lagenaria siceraria	Gourd	TRF/Savanna	Trop. Africa
Telfairia occidentalis	Fluted pumpkin	TRF	W. Africa
Telfairia pedata	Oyster nut	Savanna	E. Africa
Trichosanthes cucurmeria	Snake gourd	TRF/Savanna	W/E. Africa

D. Oil crops (seeds)

Sesamum indicum	Sesame	Savanna	Trop. Africa
Guizotia abyssinica	Niger seed	Highland	Ethiopia
Elaeis guineensis	Oil palm	TRF	W. Africa
Vitellaria paradoxa	Shea butter	Savanna	W. Africa
Brassica juncea	Indian mustard	Highland	Ethiopia
Hyptis spicigera	Black sesame	Sav/highland	Trop. Africa
Polygala butyracea		Highland	Trop. Africa
Ricinus communis	Castor bean	TRF/Savanna	Trop. Africa
Tetracarpedium conophorum	Conophor	TRF	W. Africa
Pentaclethra macrophylla	Oil bean	TRF	W. Africa

E. Vegetables

Amaranthus viridis	African spinach	TRF	Trop. Africa
Celosia argentia		TRF	Trop. Africa
Hibiscus sabdariffa	Roselle	Savanna	Trop. Africa
Abelmuschus esculentus	Okra	TRF/Savanna	Trop. Africa
Ocimium viride	Fever plant		W. Africa
Pterocarpus soyauxii	Camwood	TRF	W. Africa
Pterocarpus spp	Camwood	TRF/S	W. Africa
Afzelia bella var. *bella*	Camwood	TRF/S	W. Africa
Gongronema latifolium		TRF	W. Africa
Bombax buonopezence	Silk cotton	TRF	W. Africa
Corchorus olitous	Veg. Juice	TRF/Savanna	W. Africa
Pennisetum purpureum	Elephant grass	TRF	W. Africa
Solanum marcrocarpum		TRF/Savanna	W. Africa
Solanum aethiopicum		TRF/Savanna	W. Africa
Vernonia amygdalina	Bitter leaf	TRF/Savanna	W. Africa
Vitex spp.		TRF	W. Africa
Adansonia digitata	Baobab	Savanna	Trop. Africa
Piper guineense	Guinea pepper	TRF	Trop. Africa
Piper umbellatum		TRF	W. Africa
Myrianthus arborea		TRF	W. Africa
Gnetum africanum		TRF	W. Africa
Heinsia crenata		TRF	W. Africa

Table 2a. (contd)

F. Roots and tubers

Dioscorea cayenensis	Yellow yam	TRF	W. Africa
Dioscorea bulbifera	Aerial yam	TRF	W. Africa
D. dumetorum	Cluster yam	TRF	W. Africa
D. praehensilis	Forest yam	TRF/Savanna	W. Africa
D. rotundata	White Guinea yam	TRF/Savanna	W. Africa
Plectranthus esculentus	Risga	FSM/Sav.	Trop. Africa
Solenostemon rotundifolius	Hausea potato	FSM/Sav.	Trop. Africa
Sphenostylis stenocarpa	African yam bean	TRF/Savanna	W. Africa
Amorphophallus campanulatus	Elephant yam	TRF/Savanna	Trop Africa

G. Beverages

Cola acuminata	Abata cola	TRF	
C. nitida	Gbanja cola	TRF	
C verticillata			
Coffea liberica	Liberian coffee	TRF	W. Africa
Coffea stenophylla			W. Africa
C. canephora	Robusta coffee	TRF	C. Africa
C. arabica	Arabica coffee	Highlands	Ethiopia
Raphia vinifera	Wine palm	TRF	
Raphia spp.	Wine palm	TRF/FSM	

H. Spices and condiments

Aframomum melegueta	Grain of paradise	TRF	W. Africa
Dennettia tripetala		TRF	W. Africa
Piper guineense	Guinea black pepper	TRF	W. Africa
Xylopia aethiopicam	Guinea pepper	TRF	W. Africa
Parkia clappertoniana	Locust bean	FSM/Sav.	Trop. Africa
Parkia biglobosa	Musk tree	TRF	W. Africa
Buchholzia coriacea	African nutmeg	TRF	W. Africa
Monodora myristica			

I. Miscellaneous tree crops, fruits and seeds

Afzelia africana		TRF/FSM	W. Africa
Canarium schweinfurthii	Elemi	TRF	Trop. Africa
Chrysophyllum spp	Star apple	TRF	W. Africa
Detarium microcarpum		TRF/FSM	W. Africa
Cola spp		TRF	W. Africa
Brachystegia spp		TRF	Trop. Africa
Garcinia cola	Bitter cola	TRF/Savanna	W. Africa
Landolphia spp	Rubber vine	TRF	Trop. Africa
Irvingia gabonensis	African mango	TRF	W. Africa
Dacryodes edulis	African pear	TRF	Trop. Africa
Treculia africana	African breadfruit	TRF	W. Africa
Pachystela breviceps		TRF	W. Africa
Synsepalum dulcificum	Miraculous fruit	TRF	W. Africa
Ensete ventricosa	Ensete	Highland	Ethiopia
Dioscoreopyllum cuminsii	Miraculous berry	TRF	W. Africa
Marantachloa spp	Yoruba soft cane	TRF	W. Africa
Spondias mombin	yellow plum	TRF/FSM	Trop. Africa
Dialium guineense	Velvet tamarind	TRF	W. Africa
Tamarindus indica	Tamarind	FSM/Sav.	Trop. Africa
Diospyros spp		TRF/Sav.	
Ziziphus spp		TRF/Sav.	Trop. Africa
Blighia sapiba	Akee apple	TRF	W. Africa
Myrianthus arborea		TRF	W. Africa
Mammea africana	Mammy	TRF	Trop. Africa
Cola gigantea		TRF	W. Africa
Cola hispida		TRF	W. Africa
Funtumia elastica	Lagos rubber	TRF	W. Africa
Acacia spp	Gum arabic	Sav./desert	Trop. Africa

TRF = Tropical rain forest FSM = Forest savanna mosaic

Sources: Dalziel (1937), Harlan *et al.* (1976), Kokwaro (1976), Okafor (1979), Okigbo (1975, 1980, 1983), Okolo (1979), Oliver (1960), Sofowora (1982) and Vickery and Vickery (1979)

With regard to the 150 food crops consumed by man, indigenous African food crops [listed in Table 2a] consist of 115 species out of which, of those that contribute significantly (at least locally) to the subsistence requirements, there are five cereals, four legumes, three cucurbits, five oil seeds, twelve vegetables, four roots and tubers and 5 - 10 fruits or miscellaneous seeds. Of the major staples we consume, species such as wheat, maize, sugarcane, banana/plantain, beans, cassava, Irish potato, cocoyams and sweet-potato, all are exotics [Tables 2b and 2c]. Most of these are undergoing significant genetic improvement either in Africa or outside it. Of the African food crops, only sorghum, *Pennisetum* millet, cowpeas and yams are undergoing routine breeding and/or research of sufficient scope. Generally, serious attention is given to their germplasm conservation and also to that of their wild relatives.

Table 2b. Some crops grown in Africa of Asian origin

Scientific name	Common name	Family	Probable country of origin and route
Introduced before 1500 A.D.			
Triticum dicoccum Schubl.	Emmer wheat	Gramineae	S.W. Asia early to Ethiopia
T. durum Desf.	Durum wheat	Gramineae	S.W. Asia early to Ethiopia
T. aestivum L.	Bread wheat	Gramineae	S.W. Asia later to Ethiopia
Hordeum vulgare L.	Barley	Gramineae	S.W. Asia early to Ethiopia
Pisum sativum L.	Pea	Leguminosae	S.W. Asia to Ethiopia
Musa cvs AA, AAA, AAB	Bananas	Musaceae	Malaysia to Madagascar and Africa
Cocos nucifera L.	Coconut	Palmae	Pacific to E. Africa
Saccharum cvs	Sugarcane	Graminae	S.E. Asia to E. Africa
Colocasia esculenta Schott	Dasheen	Araceae	S.E.Asia to most of Africa
Citrus spp.	Orange, lemon etc.	Rutaceae	S.E. Asia to E. Africa
Mangifera indica L.	Mango	Anacardiaceae	India to E. Africa
Solanum melongena L.	Eggplant	Solanaceae	S.E. Asia to E. Africa
Cannabis sativa L.	Hemp	Cannabinaceae	S.W. Asia to E. Africa
Oryza sativa L.	Rice	Gramineae	Asia to E. Africa
Areca catechu L.	Betel nut	Palmae	India to Zanzibar
Piper betle	Betel pepper	Piperaceae	India to E. African coast
Zingiber officinale Rosc.	Ginger	Zingiberaceae	S.E. Asia to E. Africa
Curcuma domestica Val.	Turmeric	Zingiberaceae	S.E. Asia to E. and W. Africa
Allium cepa L.	Onion	Alliaceae	S.W. Asia to tropical. Africa
Dioscorea alata L.	Greater yam	Dioscoreaceae	S.E. Asia via Madagascar
Carthamus tinctorius L.	Safflower	Compositae	S.W. Asia to Ethiopia
Cicer arietinum L.	Chick pea	Leguminosae	S.W. Asia to Ethiopia
Lens esculenta Moench	Lentil	Leguminosae	S.W. Asia to Ethiopia
Some later introductions			
Eugenia caryophyllus (Sprengel) Bullock & Harrison	Clove	Myrtaceae	Moluccas to Zanzibar via Réunion
Camellia sinensis (L.) O. Kuntze	Tea	Theaceae	S.E. Asia to E. Africa
Aleurites montana (lour.) Wils.	Tung	Euphorbiaceae	S. China to Malawi
Glycine max (L.) Merr.	Soya bean	Leguminosae	China to E. Africa

Source: Harlan *et al.*, 1976

Table 2c. Some crops grown in Africa of New World origin: introduced after 1500 A.D.

Scientific name	Common name	Family	Probable country of origin and route
Mainly early colonial (mainly Portuguese)			
Zea mays L.	Maize	Gramineae	Mexico to most of Africa
Arachis hypogaea L.	Groundnut	Leguminosae	S. America; early to W. Africa
Phaseolus vulgaris L.	Common bean	Leguminosae	C. America to most of Africa
P. lunatus L.	Lima bean	Leguminosae	C. & S. America to W. Africa
Ipomoea batatas (L.) Lam.	Sweet potato	Convolvulaceae	Mexico to most of Africa
Manihot esculenta Crantz	Cassava	Euphorbiacea	S. America; early to W. Africa
Capsicum annuum L.	Chillies and sweet pepper	Solanaceae	C. America; early to W. Africa
C. fructens	Bird pepper	Solanaceae	C. America to tropical Africa
Cucurbita spp.	Pumpkins	Cucurbitaceae	C. America to most of Africa
Nicotiana tabacum L.	Tobacco	Solanaceae	S. America to most of Africa
Anacardium occidentale L.	Cashew	Anacardiaceae	Brazil via India
Ananas comosus (L.) Merr.	Pineapple	Bromeliaceae	S. America to tropical Africa
Psidium guajava L.	Guava	Myrtaceae	Tropical America to tropical Africa
Carica papaya L.	Papaya	Caricaceae	C. America to tropical Africa
Mostly late colonial			
Xanthosoma sagittifolium (L.) Schott	Tannia	Araceae	Tropical America to W. Africa
Solanum tuberosum L.	Potato	Solanaceae	S. America to E. Africa
Persea americana Mill.	Avocado	Lauraceae	C. America to tropical Africa
Theobroma cacao L.	Cocoa	Sterculiaceae	S. America, first to W. Africa
Passiflora edulis Sims.	Passion fruit	Passifloraceae	Brazil to most of Africa
Lycopersicon esculentum Mill.	Tomato	Solanaceae	S. America to most of Africa
Gossypium hirsutum L.	Upland cotton	Malvaceae	N. America to tropical Africa
G. barbadense L.	Sea Island cotton	Malvaceae	N. America to Sudan & Egypt

Source: Harlan *et al.*, 1976

African land use and traditional agricultural production systems in relation to the conservation of plant germplasm resources

I have been requested to discuss plant conservation in Africa in relation to prevailing land use and agricultural systems, but I do not find the current FAO and World Resources Institute land use classification systems suitable for doing this. The categories used by them [Table 3] are as follows:

1. **Cropland.** The arable and permanently cropped land, at any one time, may be carrying: permanent crops which are usually woody species and are not planted, harvested and replanted every year; annual or related field crops which are to be harvested sometime during the year; and/or remnants of crops in areas where harvesting has taken place. Conservation on such land usually involves the farmer or farm family members selecting and saving seed, for next year's planting, according to traditional practice. Permanent crops which may be dotted about the field are usually protected even on communal land. Very often, tree crops on such land consist of some purposefully planted ones growing side-by-side with volunteers Except for limited areas of smallholder plantations of one to three or more hectares of such crops as coffee and cocoa, not many improved varieties are grown.

2. **Permanent pasture.** This land is only found in the savanna areas where most permanent pasture land is over-grazed and burned annually. Not much effort has been made by national programmes to make an inventory of, or to collect, study, categorize, evaluate and document information on pasture species. A major effort in conserving pasture species is currently being spearheaded by ICLA and national programmes networking with them. Losses in biodiversity are usually high except, to some extent, in reserves of various types if they are very securely protected.

3. **Forest and woodland.** In the humid and subhumid areas, most of the land is usually under fallow or forest and woodland.

4. **Other land** may be grouped with forest and woodland where mainly wild species abound.

Table 3. Land area and land use in Africa in 1987-1989

Land use	Area (million ha.)	Percentage of total land
Crop land	186.39	6.3
Permanent pasture	890.90	30.1
Forest and woodland	686.28	23.1
Other land	1,200.57	40.5
Total land area	2,964.14	100.0

Agricultural systems and land use

There is no generally accepted topology for classification of agricultural systems in Africa. I hope that participants in this conference will bear with me for using a classification of farming systems which Dr. D.J. Greenland and I developed in 1976 based on a review of several classification systems that have been used worldwide including Africa [Table 4]. This system recognizes two main systems, namely, traditional and transitional systems and "modern" systems and their local adaptations.

Table 4. Farming systems in tropical Africa.

A. Traditional and transitional systems

1. (a) nomadic herding
   (b) shifting cultivation Phase I (L>10)*
2. Bush fallowing or land rotation: shifting cultivation Phase II (L=5-10)
3. Rudimentary sedentary agriculture: shifting cultivation Phase III (L=2-4)
4. Compound farming and extensive subsistence agriculture: shifting cultivation Phase IV (L<2)
   (a) highland agriculture (unterraced)
   (b) terrace farming
5. Floodland or valley- bottom agriculture

B. Modern farming systems and their local adaptations

1. Mixed farming
2. Livestock ranching
3. Intensive livestock production (poultry, pigs, dairying)
4. Large-scale farms and plantations
   (a) large-scale tree crop plantations
   (b) irrigation projects involving crop production
   (c) natural rainfall
5. Specialized horticulture
   (a) market gardening
   (b) truck gardening and fruit plantations
   (c) commercial fruit and vegetable production for processing.

* L=C+F/C where C= cropping period, F= Fallow period and L= land use factors.
Source: Okigbo and Greenland (1978)

A. Traditional and transitional systems

1a. **Nomadic herding.** This is an extensive system in which pastoralists use natural pastures and browse plants to feed their animals. The pastoralists usually migrate with the rains in search of fodder. Very rarely are improved pastures grazed and no genetically improved species of grasses or legumes are sown. Herders may burn pastures in the dry season in order to encourage uniform growth of fresh forage. The burning, unless controlled, may cause damage to vegetation and result in erosion and land degradation with loss of genetic diversity.

1b. **Shifting cultivation.** This usually involves shifting of homesteads by farmers as they abandon cultivated areas when crop yields decline after 2-3 years of cultivation. In this system, seeds of landraces of cultivated crops are saved during harvesting and carried away by the farm family for planting on newly cleared land. Genetically improved crop varieties are usually not grown by the farm household. Many semi-wild or protected fruit trees and useful trees and shrubs are usually left dotted about the cultivated patches of farmland. With the exception of collecting seeds of the perennial trees and shrubs for planting on other locations close to the new homestead or in permanent home gardens, no regular germplasm conservation of tree crops in large quantities is practiced by these farmers. Moreover, with the exception of a few stands of improved seedlings of such tree crops as oil palm and cocoa, no improved varieties are usually grown by the farmer.

2. **Bush fallowing or land rotation.** Here we encounter, for the first time, the most important change in the evolution of traditional and transitional farming systems in the tropics of Africa. Farmers began to settle down on a more permanent basis and rotate cultivation from one area to another from a more or less permanent homestead or home garden.

3. **Rudimentary sedentary agriculture.** With a sedentary way of life, the traditional African farming system came to revolve around the homestead which is more or less at the centre from where paths lead to fields or cultivated plots of various sizes and at different distances. The homestead and its compound, which may be fenced or walled, is the location of a mixed farming system where crops (annual, perennial and horticultural) are grown and animals are kept. This is the centre of diversity. Such diversity is, as indicated before, highest in the humid tropical rain forest zone and lowest in the Sahelian countries where elaborate home gardens are absent and nomadic pastoralism is dominant. Figures 4 a and 4b are diagrams of a typical home garden where food crops, vegetables, fruit trees, condiments, nuts, drug plants, etc., are grown and animals are kept. Plants or crops at different levels of domestication are grown in the various field systems. Table 5, which is based on surveys in south-eastern Nigeria, an area of high population density, indicates that the species diversity encountered may range from 6 - 62 in the humid tropical belt and from 0 - 65 in the drier savanna zone, inland.

The home gardens grow crops which range from a few stands of improved varieties and several typical more or less ancient traditional landraces to wild plants that are informally, experimentally planted. From the home garden to outlying fields, the following trends are observed:

- number of species decreases with distance from the homestead;
- crops become limited to a few major staples on cultivated plots farthest away from the home garden;
- production systems become more extensive;
- more wild trees and plants which are protected, are associated with crops than domesticated cultivated ones;
- more of the vegetatively propagated crops are grown in the home garden than in the outlying fields;

- animals are less associated with the crops on outlying fields other than after harvest when the stubble left in the fields may be grazed by livestock, especially in savanna areas;

- animals in the more humid areas are fed on crop residues or on forage collected from the wild . In the savanna areas few animals are kept in the home garden but where some are kept they are fed on crop residues or on pastures surrounding the home garden;

- usually, there is a halo effect due to more intense grazing and/or cropping of the zone surrounding the home garden than further away [see Figures 4a and 4b]. The degraded area forming the halo around the homestead has low species diversity and only cultivars adapted to lower soil fertility or showing signs of stress growing side by side with forms of wild plants grow there.

The home garden becomes a regular feature in the traditional farming systems in the categories Nos. A3, A4a, A4b and A5 [Table 4]. It is the most widespread feature in farming systems in tropical Africa. It is also in this component of traditional and transitional farming systems that there is regular selection and saving of seeds of annual crops. *In situ* germplasm conservation is regularly practiced, in that farmers bring wild species into the home garden, on an experimental basis. Moreover, new local cultivars or exotic species from neighbouring farmers' homes or fields are also grown in home gardens. In some home gardens, browse species such as *Ricinodendron heudelotii, Baphia nitido* and *Ficus* species may be brought in from the wild and grown for feeding goats in the dry season. Outside the home garden *in situ* conservation is practiced by farmers through protection of perennial tree crops and shrubs growing in the fields. Usually, however, the number of species of trees and shrubs protected or growing in fields away from home gardens is not as diverse as in the home garden, except in the intensively farmed parklands of the savanna areas. The parkland species, which vary from one ecological zone to another, consist of *Parkia* sp., *Ficus* sp., shea butter and *Daniellia oliveri* in the southern Guinea savanna; shea butter, *Parkia* sp., *Ficus graphalocarpa* and *Ceiba pentandra* in the northern Guinea savanna; *Faihderbia* (*Acacia*) *albida*, baobab and the fan palm, (*Borassus aethepicum*), in the Sudan savanna; and *Acacia tortilis, Balanites degyptiaca* and the doum palm (*Hyphaene thebaic*) in the Sahel (Pullan, 1974).

There is usually a threat to loss of genetic diversity in the home gardens when well-to-do, or affluent people decide to build their homes in rural villages and destroy fruit trees and other vegetation to build houses and concrete whole compounds allowing only a few fruit trees to grow near the homestead. In many situations only a few ornamentals or flowers are grown near homes and in small spaces allocated for gardening.

In general, it should be noted that a high level of genetic variation exists among individual perennial trees, shrubs and crops grown by farmers in sub-Saharan Africa. This is because most tree crops are grown from seed and there is no guarantee that a seedling will develop to be genetically similar to the parent, as compared with vegetatively propagated plants. The extent of heterozygosity among the individual crop plants depends on whether the individual species of crops are cross- or self-pollinated. Thus, especially in tree crops grown from sexual seed, each plant is potentially a different variety or could be used to develop a new variety. Conservation of germplasm of such species of crops will involve collection of several more individual plant seeds than in improved varieties of narrow genetic bases.

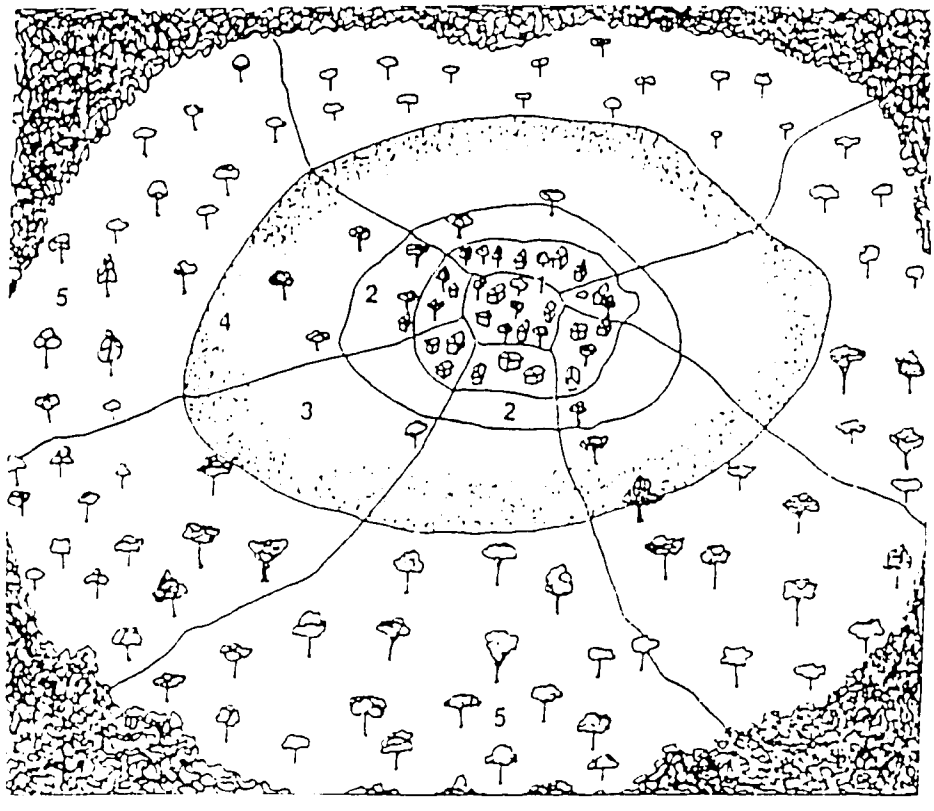

Figure 4a. Spatial organization of land use in N'Gayene, Senegal [from Pellssler, 1966]
1. Houses and gardens; 2. permanent cultivation; 3. semi-permanent cultivation; 4. intensive shifting cultivation; 5. bush and extensive shifting cultivation [after Ruttenberg, 1971].

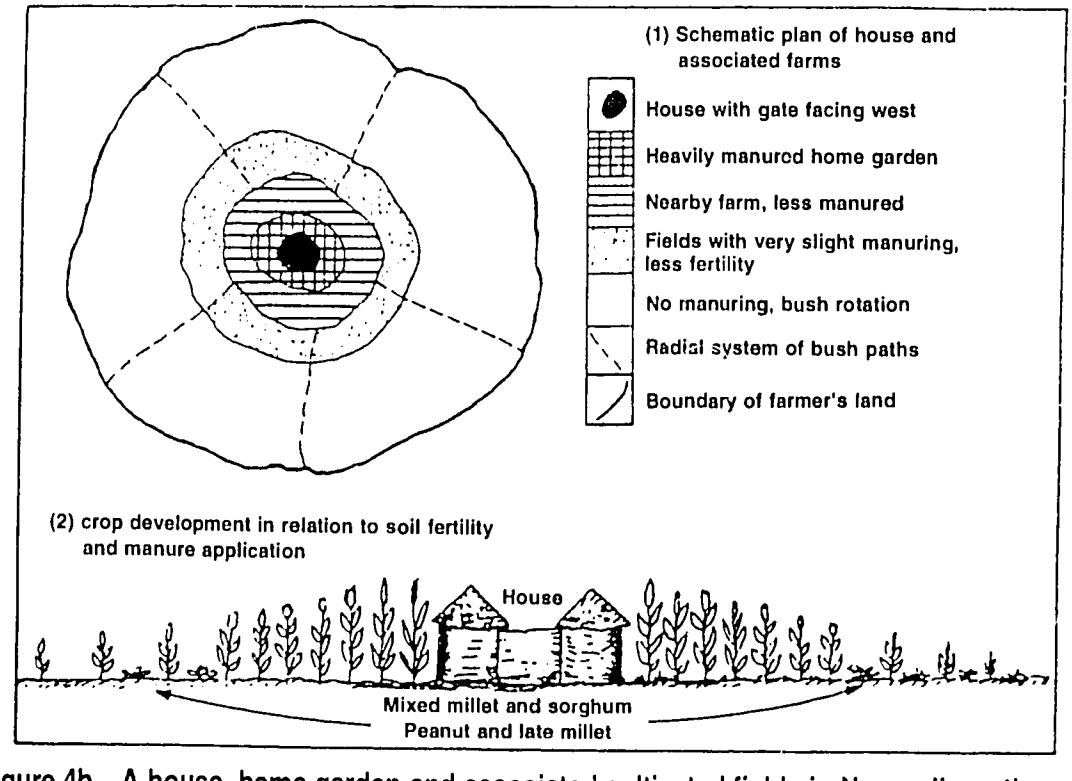

Figure 4b. A house, home garden and associated cultivated fields in Nangodi, northern Ghana [after Hunter, 1975]. Source: Okigbo, 1991

Table 5. Food and other useful plants found in crop mixtures in compound and outlying farms in southeastern Nigeria

	Area of sample										
	Derived savanna 0.003-0.45 Ha		Transition zone/ derived savanna/ oil palm bush 0.04 Ha		Oil palm bush/ high population density 0.04-0.4 Ha		Oil palm bush/ medium-high popn. density 0.05-0.5 Ha		Oil palm bush/ high population density 0.04-0.5 Ha		Mean percentage
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	frequency
Roots & tubers	1-12	5	4-6	5	5-8	7	1-8	4	7-9	8	47
Cereals & other starchy staples	0-3	1	1-2	1	2-3	2	0-4	2	2-3	2	38
Leafy vegetables	3-7	4	0-4	2	4-8	6	0-11	6	2-8	5	27
Fruit vegetables	4-6	4	1-3	2	5-6	5	0-6	2	0-3	3	44
Legumes	1-5	3	0-4	2	2-4	2	0-3	1	0-3	2	33
Fruits, nuts & oil plants	1-14	5	0-1	1	10-11	10	2-15	7	5-12	9	20
Spices & beverages	0-3	1	0-1	1	206	4	0-9	4	1-7	4	18
Miscellaneous useful plants	0-7	2	0-1	0	10-14	13	1-29	11	4-18	12	11
Range in total no. of spp. or cultivars	0-65		4-19		40-18		6-62		25-52		

B. Modern farming systems and their local adaptations

The general practice in these systems is either to obtain seeds of improved varieties that are locally produced each season or to order them from relevant seed companies. Such companies sell seeds that have been tested and shown to be adapted and able to do well in certain areas of Africa. Where seeds are from hybrid varieties, saving seeds from them does not result in sustainable levels of productivity. Animal producers under these "modern" systems usually plant selected pasture species on their farms and, with the exception of some legumes, not much local production of seeds is routinely practiced by farmers. In most situations grasses such as *Panicum maximum* and star grasses (*Cynodon* spp.) are propagated vegetatively. Considerable variation exists among cultivars grown because varietal registration and purity are not ensured by legislation. In the market gardens, horticulturists often save and produce seeds of some species such as papaya and local vegetables but regular supply and conservation of seed is not assured except on research stations and, to some extent, on government parastatal farms.

It is obvious from the above that whether we are practicing African traditional/transitional production systems or modern farming systems, conservation of germplasm remains a serious problem. We face a greater danger of loss of biodiversity in indigenous food and useful crop plants for which there are no seed companies. Germplasm conservation is mainly practiced by IARCs for a few species of major importance. It is therefore necessary that steps are taken, in all African countries, to train enough personnel in plant germplasm conservation and to develop facilities that will promote long term conservation of biodiversity of both major staples and traditional landraces of only regional or local importance.

Status of domestication of indigenous crops

Indigenous African food crops vary considerably in their level of domestication which levels may, for convenience, be categorized as follows:

- fully domesticated, genetically improved varieties of such crops as sorghum, millet, oil palms, okra and cowpeas. These are only found on a small proportion of the farms and have narrow genetic bases;

- domesticated landraces, having wider genetic bases of such crops as sorghum, yams, millets, oil palm, *Pennisetum*, *Telfairia* spp., *Eleusine* spp., *Digitaria* spp., teff, African pear (*Dacryodes edulis*) okra and Bambara groundnut (*Voandzeia subterranea*);

- semi-wild or protected species such as the African breadfruit (*Treculia africana*), African mango (*Irvingia* spp.) and the oil bean (*Pentaclethra* spp.,) in the humid tropics and shea butter (*Butyrospermum paradoxum*) and baobab (*Adansonia digitata*) in the savanna zone; and

- wild species, for example, shea butter, *Balanites* spp., elephant grass (*Pennisetum* spp.), Lagos rubber (*Landolphin* spp.), *Pterocarpus* spp., etc.

In general, it should be emphasized that introduced varieties have relegated indigenous African crops to the background and, with the exception of cowpeas, sorghum, coffee, oil palm, *Pennisetum* millets and water melon, most crops grown by farmers are not undergoing intensive, or routine, genetic improvement nor subjected to serious germplasm conservation activities (collection, evaluation, documentation, storage, etc.). More of the species of our

indigenous edible crops are grown as semi-wild or wild crops than as regular domesticated landraces. About 70% of Africa's crop production is reported to be of American or Asian origin [Wood, 1988; Toll, 1991]. These introduced crops are getting more attention and allocation of trained staff and research funds than many of the indigenous minor crops of secondary and local importance.

The problems of conservation of the latter are related to the fact that one is more likely to find greater variation in home gardens where both dominant and recessive characters are manifested under artificial selection for economically and ecologically adaptive variation, than in other fields far from the home garden. It is mainly in the home garden that sexual seed producing varieties are used as the basis for selection each year or season and vegetatively propagated varieties are under observation and bud sports can be isolated. With the exception of a few experts in germplasm conservation, I do not think that, in collecting seeds for conservation, due consideration is given to the structure of the local farming system and the pattern of the genetic variability that may exist in the traditional farm.

It may be concluded that:

- with the exception of those indigenous African crops that the IBPGR and the IARCs are working on or conserving, there is no serious long-term programme for the conservation of indigenous African crops;
- limited research on some of these crops, which was being conducted a decade or so ago, has recently declined due to unfavourable economic conditions, not least of which are the heavy debt burdens and adverse effects of structural adjustment programmes;
- many African graduates cannot identify, with certainty, those food crops that are indigenous to Africa, or separate indigenous food and useful crop plants from the introduced ones;
- African countries do not exchange information about indigenous food plants, useful plants and plant materials or their utilization;
- conservation of indigenous African plants is left to the farmers or to the herbalists. The latter grow a few plant species or varieties in hidden areas of their back yards and rely on the bush for most of the supplies of wild species for fear of exposing their secrets;
- pasture species of African origin are receiving more attention, in genetic improvement, outside Africa than within it;
- African food and useful plants are thus under serious threat of genetic erosion, since most of them remain neglected and underutilized.

Suggestions to conserve, broaden and intensify research and utilization of germplasm of African plants

Since most of the indigenous African food crops and useful plants are still semi-wild or wild and sometimes protected species, the various protected areas listed in Table 6 may constitute a sound basis for conserving them. Recommendations for using them as a basis for conservation must be explained to local people who must be properly oriented to participate in using these protected areas for the benefit of all concerned, while adhering to well established guidelines for achieving stipulated objectives.

It is imperative that, in all sectoral development plans and strategies, those responsible for implementing them should be made aware of measures to be taken to minimize the loss of both plant genetic diversity and the genetic diversity of organisms that ensure survival of the species that are of direct interest to us. It should not be left to the trained experts alone There should be serious enlightenment programmes, not only for the general public, but especially for policy makers, political leaders and planners so that conservation of plant resources receives the attention it deserves in policies, plans, strategies, research and development activities for sustainable development.

Table 6 IUCN management categories and objectives for protected areas. While all protected areas control human occupancy or use of resources to some extent, considerable latitude is available in the degree of such control. The following categories are arranged in ascending order of degree of human use permitted in the area.

Scientific reserves/ strict nature reserves	To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring and education, and for the maintenance of genetic resources in a dynamic and evolutionary state.
National park	To protect relatively large natural and scenic areas of national or international significance for scientific, educational and recreational use under management by the highest competent authority of a nation.
Natural monument/ natural landmark	To protect and preserve nationally significant natural features because of their special interest or unique characteristics
Managed nature reserve/ wildlife sanctuary	To ensure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment when these require specific human manipulation for their perpetuation.
Protected landscapes	To maintain nationally significant natural landscapes characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal life-style and economic activity of these areas.
Resource reserves	To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives based on appropriate knowledge and planning.
Natural biotic area/anthropological reserve	To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology.
Multiple-use management area/ managed resource area	To provide for the sustained production of water, timber, wildlife, pasture and outdoor recreation, with the conservation of nature primarily oriented to the support of the economic activities (although specific zones also can be designed within these areas to achieve specific conservation objectives).

Source: Stuart *et al.*, 1990, p.4

Specific recommendations that I deem necessary include the following:

1. Categories of protected areas for conservation of biodiversity should be adopted by every country in Africa, not just on paper, but also in resource allocation, monitoring, evaluation and law enforcement in agriculture, removal of fuelwood, etc.

2. Among the protected areas should be included the sacred forests found in many communities at which people are gradually nibbling from various directions.

3. Home gardens in many ecological zones constitute agricultural and land use systems with the highest biodiversity but increasing affluence and urbanization are causing these agro-ecosystems to disappear or be drastically disrupted.

4. Of all protected areas or reserves, the biosphere reserve concept which allows local people to use designated areas, should be encouraged because these areas can be used for research and training of the younger generation who are becoming increasingly ignorant of traditional uses of local plants. Biosphere reserves are not located in all countries. Many reserve areas with research, training and demonstration facilities need to be developed.

5. Special programmes should be developed for improving the curriculum at all educational levels so that students are made aware of the uses and roles of plants in the various ecosystems, including their roles in ensuring circulation of energy and materials and ensuring environmental quality.

6. Every country should develop an integrated land use plan that caters for all the multiple land use requirements of various sectors including special facilities for conservation of African plants, reserves for wildlife, tourism, etc.

7. Every country should designate one institution for the development of indigenous capabilities for making plant and/or natural resource inventories at regular intervals as resources permit and maintaining facilities for germplasm conservation. Such an institution should act as a coordinating institution and should be involved in agricultural research and development. Learning institutions should collaborate in training plant taxonomists.

8. There should be an Africa-wide network of national institutions involved in plant germplasm conservation and exchange of information on the study and uses of local plants. This network should collaborate with IBPGR.

9. There should be more effective conservation of the germplasm of indigenous African food plants by means of evaluating, selecting and encouraging the domestication and greater utilization of several under-utilized or wild edible plants that are of local or regional importance in various parts of Africa.

The United Nations University Programme on Natural Resources in Africa (UNU/INRA Programme) is giving high priority to studies and research aimed at conservation, genetic improvement, increased production and more widespread use of indigenous African food and useful plants, in addition to the study and improvement of home gardens and their productivity. As the Programme develops, UNU/INRA will collaborate with IBPGR, UNESCO and other institutions engaged in plant germplasm conservation, training and related institutional capability building.

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Presented Papers

The Convention on Biological Diversity

P. Chabeda

Background

The final text of the Convention on Biological Diversity, as approved at the Earth Summit in Rio de Janeiro, Brazil (June, 1992) was the result of several years of negotiation and conceptual work on biodiversity. The United Nations Environment Programme (UNEP) country studies, *Caring for the Earth* and the process which led to the publication of the *Global Biodiversity Strategy* all contributed to the vision of what is involved in biodiversity conservation. The concepts included in the Biodiversity Convention well reflect this vision. In a sense, the Convention marks a major change in the way governments wish to address the management of their biological resources. They now wish to make the issue much more comprehensive and place the conservation of biodiversity high on the international agenda.

In an unprecedented show of international solidarity and unanimity, the Biodiversity Convention has been signed by 157 governments and the European Community (E.C.), making it the most widely supported international legal instrument in the history of mankind. It provides a framework which will enable each government to decide how best to conserve its country's biodiversity.

In signing the Convention, governments affirm that they have sovereign rights over their own biological resources but are responsible for conserving biodiversity and for using their biological resources in a sustainable manner. Governments agree that it is vital to address the causes of biodiversity loss at the sources and that *in situ* maintenance of ecosystems and habitats is the foundation for conserving biodiversity. While recognizing the importance of information and research, they do not accept scientific uncertainty as an excuse for postponing measures to reduce threats to biodiversity. Further, the Convention recognizes the traditional dependence of many indigenous and local communities on biological resources and the desirability of enabling local communities to share equitably in the benefits arising from the use of indigenous knowledge.

The Convention commits governments to promote more intergovernmental cooperation as well as cooperation with the non-governmental organization (NGO) sector and with private corporations. Importantly, the Convention recognizes that more money is needed to conserve biodiversity and that increased investment will bring considerable environmental, economic and social benefits at local, national and global levels.

New legal commitments on conservation, finance access, technology transfer and benefit sharing have been established by the Convention. These commitments are likely to be extremely important in the conservation of biological diversity in the years ahead. Both conservation and development objectives are embraced and the strong link between the needs of people and conservation with sustainable use is recognized.

It is a "framework" convention: To be fully effective, its principles will need elaboration by future meetings of the Conference of the Parties or by protocols, annexes, etc. It will enter into force 90 days after ratification by 30 countries, ten of which must be from the developed/industrialized category. With the unanimity and great solidarity already shown in Nairobi in May, 1992 and at the Earth Summit in Rio de Janeiro in June, 1992 and,

if I may also add, with a little bit of luck, the outcome of the former might be in force some time in 1993.

At the Nairobi conference in May, 1992, governments resolved to establish interim arrangements to prepare for the Convention's entry into force. They invited the UNEP Governing Council to consider requesting the Executive Director to convene an Intergovernmental Committee on the Convention on Biological Diversity (ICBD), which would begin meeting in 1993. The ICBD would be supported by the UNEP secretariat, in full cooperation with FAO, UNESCO, IUCN, CGIAR and secretariats of related treaties, e.g. CITES, CMS, RAMSAR and World Heritage.

The proposed ICBD may also consider possible institutional arrangements for scientific cooperation among governments to help with early implementation of the Convention's provisions. Furthermore, during the period before the Convention enters into force the proposed ICBD is to develop policy guidance, strategy and programme priorities for the designated interim funding mechanism, i.e. the restructured Global Environment Facility (GEF), as well as detailed criteria and guidelines regarding eligibility for financial resources. The ICBD is also charged with monitoring and evaluating the use of these resources. Once in force, the Convention calls for the establishment of a multidisciplinary subsidiary body of government representatives to provide scientific cooperation among governments to help with early implementation of the Convention.

It is most important that developed countries (if you like, technically advanced countries, e.g. the E.C. members and Japan) ratify soon. This will allow funding and technology transfer provisions to be negotiated and implemented. It would also ensure that the other side of the coin, that is, access to genetic resources, is maintained and that conservation obligations can be met by the countries of origin.

Agenda 21 and the Convention

The UN Conference on Environment and Development (UNCED) will be remembered, in part, for its adoption in Rio de Janeiro of Agenda 21, a dynamic action plan for sustainable development well into the 21st century. Of its 40 chapters, number 15 covers the conservation of biological diversity and chapter 16, the environmentally sound management of biotechnology. Virtually every chapter, however, touches on some aspect of biodiversity, including the factors that affect it, how to assess and study it and the means to achieve its conservation. Chapters 15 and 16, the two Agenda 21 chapters on biodiversity and biotechnology respectively, were deliberately modified to complement and supplement relevant provisions on the Biodiversity convention.

Global Biodiversity Strategy and the Convention

The Global Biodiversity Strategy is also closely linked to the Convention. It was produced jointly by the World Resources Institute (WRI), the World Conservation Union (IUCN) and the UNEP, in consultation with the UN Food and Agriculture Organization (FAO) and the UN Educational, Scientific and Cultural Organization (UNESCO). It was developed through a process of research and consultation beginning in 1989 and involved six regional consultations, six workshops and more than 500 individuals worldwide. It contains 85 specific proposals for action, offered to complement the negotiation process and eventual implementation of the Biodiversity Convention. The strategy outlines the diverse initiatives that governments and non-governmental actors will need to take, parallel to, or

within, the framework of the Convention. The consultative process of the Strategy featured technical workshops, regional dialogues and systematic exchange of written drafts and materials from and among government administrators, scientists, as well as representatives from the biological resource-using industry, conservation and development non-governmental organizations, local communities, indigenous groups and women's organizations.

Caring for the Earth (CFE) and the Convention

A successor to the World Conservation Strategy of the 1980-1990 decade, CFE has a challenging approach that defines broad lines for the advancement towards a world that must live within the carrying capacities of its life-supporting ecosystems, ecological processes and planetary services. The strategy outlines nine principles and lists 132 specific actions required to establish a sustainable society. It sets targets for those actions as a means both of focusing the actions towards concrete goals and of evaluating the results. A critical mass of actions through local communities, governments and the global village, is considered crucial. To measure progress towards a sustainable society, the strategy calls for, and suggests some, indicators of sustainability in respect of quality of life and of ecological/biosphere sustainability.

GEF and the issue of funding under the Convention

One of the most controversial issues during the negotiations of the Convention was, not so much the enormous funding levels required under the Convention, but the issue of an appropriate financing mechanism for the Convention. The phrase "meeting the full incremental costs" was used frequently by governments though the concept has some significant inherent difficulties for economists and lay people alike. The actions called for in the Convention are in the enlightened self-interests of the governments involved, or at least should be so. If funding were to be available only for "incremental costs", then governments may be tempted to promote only those actions which would increase the amount of funding which might be provided to them.

The optimistic hope of some developing countries that substantial untied funds would be made available through the Convention has yet to be realized. Indeed much remains to be done in trying to determine exactly who pays how much for what. Many countries were understandably concerned about the perceived top-down approach which seems to have characterized the GEF to date, preferring criteria for funding to be established by the countries involved.

The interim funding mechanism is thus still subject to further negotiations. At the first meeting of the parties or signatories to the Convention, detailed criteria and guidelines of eligibility for access and utilization of the financial resources will be considered.

The Convention secretariat

An interim secretariat has been established at UNEP. Kenya, Switzerland and Spain have pronounced their desire to house the permanent secretariat. The exact form remains to be agreed upon among the parties ratifying the Convention. This will, presumably, take place at the first meeting of the signatories (which can take place any time before entry into force); or at the first meeting of the Conference of the Parties (which will take place within a year after the 30th country has ratified the Convention).

The Convention also calls for a subsidiary body to provide scientific and technical advice. It would provide scientific and technical assessments of the status of biodiversity; advise on the effects of the measures proposed; recommend appropriate technologies (including biotechnology) for conserving biodiversity and for using it sustainably; provide specific advice on scientific programmes and international cooperation in research and development (R and D) related to biodiversity; and provide other scientific and technical advice as might be required.

The Convention on Biological Diversity in a nutshell

The Convention on Biological Diversity was adopted at UNEP headquarters in Nairobi on 22 May, 1992 and opened for signature at the Earth Summit in Rio de Janeiro on 4 June, 1992. It was developed during a five-year process initiated in 1987 by the UNEP Governing Council. The wording of the Convention reflects the complex world of diplomacy at work during the negotiation process, with obligations being qualified by elastic (perhaps elusive?) phrases such as "as far as possible" and "as appropriate".

The preamble contains many important principles, including innovations such as recognizing the "vital role that women play in the conservation of biological diversity"; asserting "the intrinsic value of biological diversity"; and entrenching "the desirability of sharing, equitably, benefits arising from the use of traditional knowledge, innovations and practices (of indigenous and local communities)".

Reflecting the concern of many countries, especially developing countries, that the convention should not give the international community any unbridled rights over the management of a nation's biological resources, the preamble affirms that conservation of biological diversity is a common concern - but not a common heritage - of mankind; that states have sovereign rights over their own biological resources; and that states are responsible for using their biological resources sustainably.

The preamble also reflects the consensus that *in situ* conservation is fundamental for the conservation of biological diversity, with *ex situ* measures having important complementary roles to play.

The overall objective (Article 1) of the Convention is a three-tier affair, namely: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Achievement of the third tier is to be by "appropriate" access to genetic resources, "appropriate" transfer of "relevant" technologies and by "appropriate" funding.

Major actions called for under the Convention

The Convention text covers the full range of issues affecting biodiversity but the major activities can be grouped under five broad headings, as follows:

1. Strategic planning and policy

- Preparing national strategies, plans and programmes for the conservation and sustainable use of biodiversity.
- Ensuring that conservation and sustainable use of biological resources is made part of national decision-making.

- Integrating biodiversity concerns into relevant sectoral or cross-sectoral programmes.

- Providing appropriate economic and social incentives for conserving biodiversity and appropriate reflections of collapse in biodiversity status and value in the national system of accounts.

2. *In situ* conservation

- Establishing systems of protected areas, based on guidelines for the selection, establishment and management of protected areas.

- Ensuring the conservation and sustainable use of biological resources important for the conservation of biodiversity, whether inside or outside protected areas.

- Promoting environmentally sound and sustainable development around protected areas as a means of furthering their protection .

- Rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species.

- Preventing the introduction of exotic species and managing their impacts where they have been introduced.

3. Biological diversity science and *ex situ* facilities

- Developing *ex situ* conservation measures as a supplement to the *in situ* measures listed above.

- Identifying and monitoring important components of biodiversity.

- Introducing environmental impact assessment procedures for all activities, programmes and policies that are likely to have significant adverse impacts on biodiversity.

- Establishing and maintaining programmes for scientific and technical education and training in measures for the identification, conservation and sustainable use of biodiversity and its components.

- Encouraging research which contributes to conserving biodiversity and to sustainable use.

4. Local communities and ethno-knowledge

- Conserving traditional knowledge by local people and promoting the application of this knowledge with the full involvement of, and reward to, the local people.

- Encouraging customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation and sustainable use.

- Promoting public participation, education and awareness concerning biodiversity issues.

5. International cooperation and joint ventures

- Informing other governments of any threats to biodiversity which, to be addressed, require international cooperation.
- Creating conditions to facilitate access to genetic resources for appropriate uses, notwithstanding national sovereignty over them.
- Facilitating the exchange of information relevant to conserving biodiversity, including technologies, training, inventories, specialized knowledge and indigenous knowledge.
- Mutually agreed terms for the joint ventures.

The International Board for Plant Genetic Resources (IBPGR)

The role of the IBPGR in the conservation and sustainable use of genetic resources, both for the development of viable agricultural systems in Africa (as in the rest of the Third World) and for the continued growth of the bio-industry, is of paramount significance. These genetic resources, physically embodied in the germplasm, code for characteristics of plants, such as height, potential yield, nutritional quality and resistance to pests or extreme weather. They are not only the first links in the food chain, but are the very building blocks of life itself.

In other words, when loss of biodiversity occurs, it is not only an environmental issue; it is also a development concern, affecting agriculture, forestry, industry, health and, literally, all other sectors. It is a matter of life or death. All cultivated plants and domestic animals originate from wild species so it is imperative to protect their wild relatives as the basis for continuing genetic selection and improvement for food, fibre, fodder, forestry, fisheries, pharmaceuticals and other products. The genetic material contained in domesticated varieties of crop plants, trees and animals and their wild relatives is essential for breeding programmes by which genes are incorporated into commercial lines for the continued improvement in yields, nutritional quality, flavour, pest and disease resistance and responsiveness to different regimes of soils and climates.

Furthermore, many undiscovered or undescribed species may be of significant value as sources of food, fibre, drugs, chemicals or other materials. It is noteworthy that, of all useful plant-derived drugs, only ten or so are synthesized in the laboratory and the rest are still extracted from plants, animals and microbes whose best home is not in the man-made laboratories but on Mother Nature's lap out there in the wild. In the same breath, I must hasten to state that the emergence of biotechnology clearly adds to, rather than diminishes, the need to maintain the richest possible pool of wild genes.

We have been told in this seminar, and I quote ".....as scientists and specialists playing an increasingly crucial role in defining, tackling and resolving global environmental issues and questions affecting biodiversity encompassing life-support systems of the entire biosphere, it is incumbent upon each one of us to harness and harmonize the messages and actions and strategies proclaimed in the above documents and legal instruments". The documents referred to are the GBS, CFE, Agenda 21 and the GBSR. In my view, the harmonization, the harnessing and synthesis of the messages, actions, strategies, etc., can best be done at country level through the country study process.

During the past 14 months or so, a Biodiversity Country Study exercise was initiated under the auspices of UNEP in support of the negotiation process for the Convention on Biological Diversity. The aim was to shed light on the status of national biodiversity and on the needs of governments worldwide regarding the global costs, benefits and unmet needs associated with their effective conservation and sustainable use of natural resources.

The country studies, carried out within national programme frameworks and through provision of funds and technical assistance, as appropriate, are coordinated at national level by country-driven, government-designated, National Biodiversity Units (NBUs). The outputs from these country studies are tailored to achieve both global and national objectives and to propose fundable and implementable measures within the framework of the Convention on Biological Diversity. At the national level, the biodiversity country studies aim to provide information on both the status of biodiversity and priorities for investments and funding needs for *in situ* as well as *ex situ* conservation and sustainable use of biodiversity components. The studies are expected to identify where resources are needed most, define the best options upon which to take action and help the countries concerned in the preparation of their national strategies and action plans for the effective conservation of biological diversity. At the international level, they will contribute to the achievement of a global system of representative protected areas and *ex situ* conservation measures and the adoption of a financing mechanism for the implementation of the Convention on Biodiversity and its future protocols. They are also important for facilitating the sharing of information and for revealing difficulties a country may be having in biodiversity monitoring, data gathering, management, environmental impact assessment and economic evaluation of biodiversity components. The country study exercise is part of UNEP's sub-programme on biological diversity.

UNEP's sub-programme on biological diversity

The *purpose* of the UNEP sub-programme is to assure the continuous implementation of national, regional and global programmes and strategies for the conservation of biological diversity and sustainable use of biological resources.

The *policy* is to develop integrated methodologies based on scientific knowledge for meshing conservation and sustainable utilization issues with economic, social, technological and ecological factors. In this context the following actions to support national efforts have been identified: biodiversity country studies; formulation of national biodiversity strategies, action plans and programmes; national conservation strategies; preparation of regular global biodiversity status reports; ascribing values to biological resources; networks for exchange of data and information; support to relevant international/regional instruments, actions plans and programmes; and institutional and human resources development.

The *impact* of the implementation of Agenda 21 will reinforce linkages with afforestation, desertification, GEMS, GRID, environmental economics, natural resources accounting, technology transfer and environmental law. The country studies exercise will be used as a tool for assisting the countries in the implementation of the recommendations of CFE, Global Biodiversity Strategy, chapters 16 and 17 of Agenda 21, the Biodiversity Convention as well as relevant agreements and global/regional programmes (Biosphere Reserves, AMCEN, LAC Action Plan, etc.) Cooperation between FAO, UNESCO, IUCN, WRI and WWF and the interim Secretariat of the Convention on Biological Diversity will enhance and strengthen the implementation of the sub-programme.

Conclusions

I wish to make four observations for your consideration regarding the IBPGR initiatives in support of some crucial aspects for effective implementation of the Convention:

1. The research priorities of IBPGR-linked IARCs/NARCs should continue to ensure that the external research and development industries do not: tend towards discriminating policies against developing country interests; tend to emphasize substitution of products exported by developing countries; nor tend to focus on the problems of the agricultural sectors of the industrialized countries and thereby enhance their capacity to penetrate international markets. They should, in the main, address developing country agriculture-based production and associated ecological and environmental problems. Many of those are common to both the North and South axes.

   The above tendencies are bound to be exerted, as borne out by recent OECD (1989) studies on the trade impacts of biotechnology and I quote: "The developing countries lie mainly at the receiving end of clearly perceptible trade impacts....trade impacts which are nearly all for reducing the overall demand for primary products from developing countries".

2. Opportunities should be explored for establishing commercial relations by way of joint ventures with the IARCs and, more importantly, with NARCs, so that revenues and royalties generated could provide an additional source of funding, particularly to the national centres. This could operate in a manner similar to mechanisms established at universities or institutes for the receipt of royalty payments. It should be recognized that industrialized countries may become increasingly or somewhat uneasy about allowing bilateral development agencies to provide support for such centre-based research on major commodities if it is perceived that this constitutes a form of subsidy that competes with, or impedes, their export capabilities.

3. Biodiversity country studies should incorporate a national biodiversity strategy and action plan based on a classification of national agricultural research programmes according to their current capacity to use various applications of biotechnology. This would assist both NARCs and IARCs in determining the needs and abilities of their programme partners and ensure the transfer of high-priority technologies. In addition, it would help define the national and international outreach responsibilities attached to each new technology.

4. In keeping with the spirit of the Convention on Biological Diversity, the transfer of technology for the conservation and sustainable use of plant genetic resources in support of Third World agriculture should begin to shift more heavily towards mutually beneficial, joint ventures. In developing countries, the public research institutions at universities, institutes and NARCs, which are the traditional conduits of information and technology transfer, will have to collaborate through new approaches and technologies to facilitate and regulate the flows of relevant technologies, genetic resource information and germplasm to serve national purposes.

Conservation and Sustainable Use of Plant Genetic Resources: FAO Programme

N. M. Anishetty

Introduction

Plant genetic diversity is a key ingredient for sustainable agricultural development. Modern plant breeders and biotechnologists rely on genetic variation in landraces, primitive cultivars and wild forms to produce better-adapted and higher-yielding crop varieties. It is vital, therefore, that a wider range of germplasm be conserved, both *ex situ* and *in situ*, for future use in adapting crops to new and changing environmental conditions and to sustain agricultural production and development.

Sub-Saharan Africa

Tropical and sub-tropical Africa is a centre of diversity for a range of crops such as millet, sorghum, African rice, fonio, cowpea, bambarra groundnut, African oil palm, coffee, yam, okra, roselle and watermelon. The diversity of its ecologies and of its cultural practices has given rise to the use of a wide range of species and a variety of landraces in the cultivated species. For a long time this diversity has been naturally preserved by virtue of the region's traditional agriculture. However, the destruction of natural environments and resources and the shift to monoculture and more uniform varieties over the last few decades as the region has strived to accommodate and feed its increasing population and frequent famine and drought, has led to erosion of this genetic diversity and biological resources in general. There is an urgent need to preserve this diversity, so vital to future efforts to provide sustainable increases in agricultural production.

Many of the countries of sub-Saharan Africa rank among the poorest in the world. Population growth, rated at 2-3% per year, is among the highest in the world. Moreover, the agricultural production is not keeping pace with the population explosion; boosting production by bringing new land under cultivation cannot continue. The destruction of the tropical forest and degradation of the Savanna and Sahel is already at drastic and unsustainable levels. Loss of plant cover implies loss of species and genetic diversity. The pressure to increase food production can no longer be considered in isolation from the need to preserve this diversity. Increased productivity must be sought from existing farmlands and this draws heavily on genetic diversity for alternative farming systems, including crop diversification.

The region is ecologically, agriculturally, culturally and climatically diverse. Rainfall ranges from zero in the Sahara desert to 300 mm, in the forest belt and in the coastal regions. Sub-Saharan Africa can be divided into three major agro-ecological zones:

- the Sahel with its livestock and crop livestock systems, the latter based on millet or sorghum;
- the savanna zone with mixed livestock and cropping, cultivating maize, sorghum, rice, groundnut, cowpea, cassava, yam, cotton, etc.; and
- the humid forest zone where importance is given to root and tuber crops and tree crops.

Sub-Saharan Africa presents a special challenge for agricultural research that in turn makes great demands on its genetic resources. Its ecologies are many and complex and the national agricultural research systems have a crucial role to play in developing and adapting new technologies, including biotechnologies, to fit their particular environments and the special needs of their farmers. Central to their activities are the national genetic resources programmes which provide the scientist with diverse genotypes of species and genes that can be manipulated to improve the region's many and different production systems.

For the most part, the national research and development programmes in Africa are small. In an early stage of evolution following their colonial history, they had limited manpower and financial resources. Although, in relative terms, some countries have made substantial investments in research, in general, national agricultural research systems in these countries are inadequately funded. In several of the countries of Africa support activities, such as collection, preservation and use of plant genetic resources, are fragmented between programmes with inadequate staffing and finances, organizationally and, sometimes institutionally, apart from the crop improvement programmes.

The international agricultural research centres of the CGIAR have an important part to play in strengthening national expertise and efforts in germplasm conservation. The genetic resources units of IITA, WARDA, ICRISAT and ILCA undertake germplasm conservation and utilization work in Africa. IBPGR, since 1981, has established regional offices in Africa to promote and coordinate genetic resources work in Africa. This has resulted in the strengthening of some national programmes. However, the IARC's genetic resources programmes are serving, primarily, the needs of their own breeders' programmes. Therefore, opportunities for providing assistance and guidance to the national genetic resources programmes, cannot always be realized.

FAO Programme

FAO is the United Nations' specialized agency for food and agriculture. As part of its constitution, FAO has always promoted and recommended national, regional and international action, with respect to agricultural research; such action to be aimed at the improvement of agricultural production and the conservation of natural resources, including plant genetic resources. An active concern for the conservation and utilization of crop, pasture, forestry, as well as animal genetic resources has, therefore, been part of FAO programmes since its founding in 1945.

The first FAO Technical Meeting on Plant Exploration and Introduction was held in 1961 and Technical Conferences were subsequently held in 1967, 1973 and 1981. The FAO Expert Panel on Plant Exploration and Introduction was established in 1965 and held six meetings up to 1974, when IBPGR was established. The panel set priorities for exploration, drafted proposals for an international network of genetic resource centres and drafted guidelines for international cooperation in seed conservation. FAO established its Crop Ecology and Genetic Resources Unit in 1968. In the same year, the organization strengthened its forestry genetic resources programme by establishing a panel of experts on Forest Gene Resources. This panel has had seven meetings to date.

Over the past four decades FAO has carried out a series of activities related to the conservation and sustainable use of genetic diversity, especially from threatened areas. Special attention has been given to crops not covered by the IARCs of the CGIAR. FAO holds the view that the development of modern biotechnologies will have a great impact on the conservation, use and availability of biological/genetic diversity. Biological

diversity and biotechnology are interdependent and the latter will enhance the conservation and use of genetic diversity. FAO has been assisting member nations, in particular developing countries, in the application of appropriate technologies for sustainable agricultural production.

Programme Focus

The philosophy of the FAO programme on crop genetic resources is based on a "farmers to farmers" approach which starts with the collection of landraces and primitive cultivars, progresses through domestication, genetic improvement and seed production and ends up with the distribution, to farmers, of newly-developed and improved varieties. A strength of the FAO activities in plant genetic resources is that they are integrated into a broader framework of programmes to address the needs of member countries for research and sustainable agricultural development.

FAO recognizes that conserved germplasm is mainly useful for those countries and institutions which have the technical, economic and human capability to utilize it and new biotechnologies for plant breeding and seed production. Conservation without utilization could become a burden, especially for developing countries. It is therefore a basic objective of FAO to strengthen these capabilities and capacities in less-developed member nations. In order to achieve this, FAO has been collaborating, as appropriate, with other organizations. Cooperating institutions include: IBPGR for *ex situ* conservation; IARCs for germplasm management and utilization for development activities on crop and pasture species; and UNEP, UNESCO and IUCN in work related to *in situ* conservation, biological diversity and ecosystem management.

Global System for Conservation and Utilization of Plant Genetic Resources

FAO, since 1983, has been developing a Global System for Conservation and Utilization of Plant Genetic Resources, covering both agriculture and forestry, to coordinate actions that promote safe conservation (both *ex situ* and *in situ*), sustainable use and unrestricted availability of genetic diversity, for present and future generations. To achieve these objectives a flexible framework has been provided in the International Undertaking on Plant Genetic Resources and an inter-governmental forum in the Commission on Plant Genetic Resources.

To date, the Global System comprises of 131 countries of which 113 have become members of the Commission on PGR and 107 countries have adhered to the International Undertaking on PGR (see Annex I). During the past nine years the Commission on PGR and its Working Group held four and six meetings respectively. These successive meetings have contributed to building the Global System and have facilitated its operation by developing a broader inter-governmental consensus on PGR.

Elements of the Global System that are being developed actively, include:

- preparation of the codes of conduct on germplasm collecting and transfer, and on biotechnology;
- farmers' rights and their realization;
- establishment of *ex situ* and *in situ* networks;

- development of global information and early warning system on PGR;
- access to genetic resources, information and technologies; and
- strengthening of national capacities.

Fourth International Technical Conference on PGR (ICPGR)

In view of FAO's major role as compiler, analyser and disseminator of information on world agriculture, the third session of the Commission on PGR (April 1989) requested FAO to prepare periodic reports on the State of the World's PGR (SW/PGR) with the cooperation of other bodies concerned.

The fourth session of the Commission on PGR (April 1991) recommended the convening of the Fourth International Technical Conference on the Conservation and Utilization of PGR to be organized by FAO and which should concentrate on two main subjects:

- the State of the World's PGR; and
- a Global Plan of Action for PGR (GPA/PGR), taking into account the decisions reached by UNCED on this subject.

Being a technical conference, it is appropriate that the scientific and technological state of the art of conservation and utilization of PGR also be included in its agenda.

The recommendations of the Commission were subsequently endorsed by the FAO Council and Conference (1991). The Fourth International Technical Conference on Conservation and Sustainable Utilization of PGR (ICPGR) will be convened in mid-1995 and, currently, FAO is in the process of approaching the donors for extra-budgetary resources for both the ICPGR preparatory process and the convening of the conference itself. As on the previous occasions, it will be convened in cooperation with other organizations, especially, IBPGR

Objectives

1. to describe, through the SW/PGR report, the current situation of PGR, identify gaps and needs, and propose priorities for action;
2. to secure agreement on a GPA/PGR which will complement SW/PGR and build on the outline plan of action of Agenda 21; and
3. to make available to the international community an up-to-date scientific and technological report, namely, the State of the Art of Conservation and Utilization of PGR (SA/PGR).

The prerequisite for concerted action by individual nations and by the international community on the conservation and utilization of plant genetic resources, is the availability of authoritative information on the state of genetic resources collection, the safety of stored germplasm and the usefulness of collections. This knowledge is needed by country, by region and by crop. There are three other critical issues which call for special attention:

- The growing importance of germplasm for the development of biotechnology know-how and the concomitant transfer of germplasm and technology between developing and developed countries within the context of an agreed mechanism.

- The socio-economic implications for PGR conservation and utilization. The crux of the matter here is the extent to which locally-developed varieties may be able to enhance the sustainability of plant genetic resources.

- The realization of the farmers' rights. This needs to be developed further in the light of the Convention on Biodiversity.

The main products of the Conference will be the three reports mentioned above.

State of the World's Plant Genetic Resources (SW/PGR)

The SW/PGR report will describe the current situation of PGR and identify gaps and emergencies. In particular it will:

- assess, by country and by sub-region, the present state of genetic diversity, the degree of genetic erosion and the current coverage and status of *in situ* and *ex situ* conservation and utilization of plant genetic resources for food and sustainable agriculture (PGRFA);

- identify major constraints to PGR conservation, utilization and exchange;

- assess national and regional capabilities for the conservation and utilization of PGRFA in terms of human resources, institutional structures, policies and methodologies pursued; and

- identify appropriate technologies in meeting the special needs of the developing countries and assess the current state and pattern of technology transfer in PGR.

The scope of SW/PGR will not be restricted to agricultural plants but will cover all useful plants, including forest species. It will give balanced attention to new, as well as, traditional and indigenous technologies. A static "inventory" approach will be avoided by emphasizing actions which need to be carried out at national, regional and global levels.

The first SW/PGR report will provide much needed knowledge for assessing priority needs and recommending national and regional actions to meet such needs. It will provide an authoritative analysis and interpretation of major issues in the global management of plant genetic resources. Future reports on the state of the world s PGR will be produced at appropriate intervals to meet the requirements of the Commission with respect to future policy and strategy.

Global Plan of Action on Plant Genetic Resources (GPA/PGR)

The GPA/PGR will complement and draw on SW/PGR and have the aims of:

1. arresting the continued erosion of plant genetic diversity;

2. enhancing the safe conservation and sustainable utilization of plant germplasm for present and future generations under an international mechanism acceptable to both donors and users of germplasm; and

3. ensuring the monitoring of plant genetic resources on a global scale.

Building on the skeleton programme of action in Agenda 21, it will:

- propose policies and strategies for conservation and utilization of PGR at the national, regional and global levels;

- provide a framework for the elaboration of plans or programmes of priority action for conservation activities at the national level;

- strengthen national capabilities for utilization of PGRFA, plant breeding and seed production capabilities;

- propose appropriate and feasible measures which will make the Global System for PGR more effective; and

- provide guidelines for the promotion, management, monitoring and supervision of funds for the conservation and utilization of plant genetic resources.

The GPA/PGR will be a rolling plan of action and will be periodically updated; the mechanisms for this will be spelled out in the Global Plan of Action.

Report on the Scientific and Technological State of the Art of Conservation and utilization of PGR

This report will examine areas of special interest to PGRFA such as new biotechnologies, local technologies and other issues such as on-farm conservation.

Methodologies and the Preparatory Process of the ICPGR

All available country-based information will be utilized. It will be collated, in part, from a questionnaire requesting:

- facts about the national germplasm collections and their use, including institutions involved, storage facilities, crop improvement programmes, etc.; and

- information about each country's most crucial needs and priorities.

Besides the questionnaire, the countries will be requested to prepare country reports based on guidelines provided by the FAO Secretariat. These reports will be available at sub-regional meetings which will be organized to review the country reports and to consolidate them into sub-regional studies. These meetings will involve scientists, relevant policy-makers and representatives of the private sector and NGOs. Well-defined criteria, including geographic distribution and genetic diversity, will be used in the constitution of the sub-regions.

Building on these inputs, the State of the World and the State of the Art reports will be compiled. Thereafter the Global Plan of Action will be drafted based on the dialogue in these meetings and the information in the above reports. This Plan of Action will be reviewed and debated at the International Technical Conference before being considered by a session of the Commission on PGR which will be held immediately after the Fourth International Technical Conference on PGR.

Annex 1. Members of the FAO Commission on Plant Genetic Resources and/or Countries which have adhered to the International Undertaking on Plant Genetic Resources

Africa	Asia & SW Pacific	Europe	Latin America & Caribbean	Near East	North America
Benin 1/2	Australia 1/2	Austria 1/2	Antigua & Barbuda 2/	Afghanistan 1/	Canada 1/
Botswana 1/	Bangladesh 1/2	Belgium 1/2	Argentina 1/2	Bahrain 2/	USA 1/
Burkina Faso 1/2	Fiji 2/	Bulgaria 1/2	Barbados 1/2	Egypt 1/2	
Cameroon 1/2	India 1/2	Cyprus 1/2	Belize 1/2	Iran Islamic Rep. of 1/2	
Cape Verde 1/2	Indonesia 1/	Czechoslo-vakia 1/2	Bolivia 1/2	Iraq 1/2	
Centr. Afr. Rep. 1/2	Japan 1/	Denmark 1/2	Brazil 1/	Jordan 1/	
Chad 1/2	Korea, Dem. People's Rep 1/2	Finland 1/2	Chile 1/2	Kuwait 2/	
Congo 1/2	Korea, rep. of 1/2	France 1/2	Colombia 1/2	Lebanon 1/2	
Cote d'Ivoire 2/	Myanmar 1/	Germany 1/2	Costa Rica 1/2	Libya 1/2	
Eq. Guinea 1/2	Nepal 2/	Greece 1/2	Cuba 1/2	Oman 2/	
Ethiopia 1/2	New Zealand 2/	Hungary 1/2	Dominica 1/2	Syria 1/2	
Gabon 2/	Pakistan 1/	Iceland 1/2	Dominican Rep. 1/2	Tunisia 1/2	
Gambia 1/	Philippines 1/2	Ireland 1/2	Ecuador 1/2	Yemen 1/2	
Ghana 1/2	Samoa 1/2	Israel 1/2	El Salvador 1/2		
Guinea 1/2	Solomon Is. 2/	Italy 1/2	Grenada 1/2		
Guinea-Bissau 1/	Sri Lanka 1/2	Liechtenstein 2/	Guatemala 1/		
Kenya 1/2	Thailand 1/	Netherlands 1/2	Guyana 1/		
Liberia 1/2	Tonga 2/	Norway 1/2	Haiti 1/2		
Madagascar 1/2	Vanuatu 1/	Poland 1/2	Honduras 1/2		
Malawi 2/		Portugal 1/2	Jamaica 2/		
Mali 1/2		Romania 1/2	Mexico 1/2		
Mauritania 1/2		Spain 1/2	Nicaragua 1/2		
Mauritius 1/2		Sweden 1/2	Panama 1/2		
Morocco 1/2		Switzerland 1/2	Paraguay 2/		
Mozambique 2/		Turkey 1/2	Peru 1/2		
Niger 1/2		UK 1/2	St. Christopher & Nevis 1/		
Rwanda 1/2		USSR 2/	St. Lucia 1/		
Senegal 1/2		Yugoslavia 1/2	St. Vincent & the Grenadines 1/		
Sierra Leone 1/2			Surinam 1/		
South Africa 2/			Trinidad & Tobago 1/2		
Sudan 1/2			Uruguay 1/		
Tanzania 1/2			Venezuela 1/		
Togo 1/2					
Uganda 1/					
Zaire 1/					
Zambia 1/2					
Zimbabwe 1/2					

Notes:
1 Members of the Commission (113 countries).
2 Countries which have adhered to the International Undertaking (107 countries).

Total number of countries involved with either the Commission or the International Undertaking, or both = 131

Recensement, Identification et Répartition Biogéographique des Espèces Alimentaires Couramment Employées dans l'Agriculture Traditionnelle en Afrique de l'Ouest[1]

L. Ake Assi

Le recensement que nous avons effectué, concernant les plantes cultivées de l'Ouest- africain, nous a permis de dénombrer 83 taxons couramment employés dans l'Agriculture traditionnelle. En tant que plantes alimentaires, elles sont réparties en 54 genres que regroupent 34 familles, provenant principalement des régions tropicales.

Les représentants africains, plus nombreux, sont au nombre de 34, soit 40,96%. Suivent, ensuite, par ordre décroissant, les espèces pluricontinentales, d'abord les pantropicales, 11 (13,25%); les sud-américaines, 11 (13,25%); les paléotropicales 9 (10,84%); les plantes d'Asie du Sud-Est, 8 (9,63%). Les autres taxons, afro-malgaches, afro- néotropicaux, cosmopolites, des Iles Mascareignes et de la Polynésie, sont au nombre de 4 à 1 par catégorie chorologique.

Les familles fournissant le plus de plantes cultivées sont, par ordre décroissant: Solanaceae, 11 espèces, soit 13,25%; Papilionaceae, 9 (10,83%); Poaceae, 8 (9,63%); Dioscoreaceae, 7 (8,43 %). Les autres familles comportent de 4 à 1 représentants.

On trouvera, dans les pages qui suivent, un tableau résumant cet inventaire.

Dans ce tableau, les abréviations précédant les noms des espèces indiquent, sur la colonne de gauche:

A	Taxon africain (Afrique intertropicale)
AM	Taxon commun à l'Afrique et à Madagascar (Afro-Malgache)
AN	Taxon commun à l'Afrique et à l'Amérique tropicale (Afro-Néotropical)
As	Taxon asiatique ou quelquefois commun à l'Afrique et à l'Asie tropicale
Cosm	Taxon cosmopolite
Mc	Taxon commun à l'Afrique et aux Iles Mascareignes
N	Taxon originaire d'Amérique (Néotropical)
Pol	Taxon originaire de la Polynésie
PT	Taxon paléotropical: commun à l'ancien monde tropical (Afrique, Asie, Australie, Iles du Pacifique)
pt	Taxon pantropical: commun à tous les pays tropicaux du monde

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1 **Inventory and distribution of landraces in West African traditional agriculture: some case studies and taxonomic issues.**

Sur la colonne de droite, concernant les Organes comestibles de la plante, les abréviations désignent:

b	bulbille
Bb	bulbe
c	calice
f	feuille
Fr	fruit
gr	graine
rh	rhizome
t	tubercule
tg	tige (Canne)

Tableau Résumant le Recensement

Affinité chorologique	Famille Genre Espèce	Organe comestible
	Amaranthaceae	
Cosm	*Amaranthus cruentus* Linn.	f
PT	*Celosia argentea* Linn.	f
	Araceae	
PT	*Colocasia esculenta* (Linn.) Schott var. esculenta	rh
PT	*Colocasia esculenta* var. antiquorum (Schott) Hubbard et Rehder	rh
N	*Xanthosoma sagittifolium* (Linn.) Schott	rh
	Arecaceae	
POL	*Cocos nucifera* Linn.	Fr
A	*Elaeis guineensis* Jacq.	Fr
	Asteracees	
A	*Crassocephalum biafrae* (Oliv. et Hiern) S. Moore	f
A	*Vernonia amygdalina* Del.	f
A	*Vernonia colorata* (Willd.) Drake	f
A	*Vernonia richardiana* (O. Ktze.) P. Sermolli	f
	Basellacees	
pt	*Basella alba* Linn.	f
	Bromeliaceae	
N	*Ananas comosus* Merr.	f
	Caricaceae	
N	*Carica papaya* Linn.	f

Affinité chorologique	Famille Genre Espèce	Organe comestible
	Chenopodiaceae	
Cosm	*Chenopodium ambrosioides* Linn.	f
	Convolvulaceae	
N	*Ipomoea batatas* (Linn.) Lam.	t
	Crassulaceae	
A	*Kalanchoe crenata* (Andr.) Haw.	f
	Cucurbitaceae	
PT	*Citrullus lanatus* (Chunb.) Mats. et Nakai	gr
A	*Cucumeropsis mannii* Naud.	gr
A	*Cucumis metuliferus* Naud.	Fr
A	*Telfairia occidentalis* Hook. f.	gr
	Cyperaceae	
pt	*Cyperus esculentus* Linn.	rh
	Dioscoreaceae	
As	*Dioscorea alata* Linn.	t
pt	*Dioscorea bulbifera* Linn.	b
A	*Dioscorea burkilliana* J. Miège	t
AN	*Dioscorea cayenensis* Lam.	t
A	*Dioscorea dumetorum* (Kunth) Pax	t
As	*Dioscorea esculenta* (Lour.) Burkill	t
A	*Dioscorea praehensilis* Benth.	t
	Euphorbiaceae	
N	*Manihot esculenta* Crantz	t
	Lamiaceae	
As	*Ocimum basilicum* Linn.	f
A	*Solenostemon rotundifolius* (Poir.) Morton	t
	Liliaceae	
As	*Allium ascalonicum* Linn.	Bb
As	*Allium cepa* Linn.	Bb
	Malvaceae	
pt	*Hibiscus cannabinus* Linn.	f
PT	*Hibiscus esculentus* Linn.	f, Fr
PT	*Hibiscus sabdariffa* Linn.	f, c, gr
	Musaceae	
As	*Musa cavendishii* Lamb.	Fr
As	*Musa paradisiaca* Linn.	Fr
As	*Musa sapientum* Linn.	Fr

Affinité chorologique	Famille Genre Espèce	Organe comestible
	Papilionaceae	
N	*Arachis hypogaea* Linn.	gr
As	*Cajanus cajan* (Linn.) Mill sp.	gr
N	*Canavalia ensiformis* (Linn.) DC.	gr
A	*Kerstingiellia geocarpa* Harms	gr
pt	*Lablab niger* Medic.	gr
pt	*Phaseolus lunatus* Linn.	gr
A	*Sphenostylis stenocarpa* (Hochst. ex A. Rich.) Harms	t
pt	*Vigna unguiculata* (Linn.) Walp.	gr
Am	*Voandzeia subterranea* Thouars	gr
	Pedaliaceae	
A	*Ceratotheca sesamoides* Endl.	f
A	*Linariopsis prostrata* Welw.	f
A	*Sesamum alatum* Thonn.	f, gr
pt	*Sesamum indicum* Linn.	f, gr
pt	*Sesamum radiatum* Schum. et Thonn.	f, gr
	Phytolaccaceae	
AM	*Phytolacca dodecandra* L'Hérit.	f
	Poaceae	
A	*Digitaria exilis* (Kippist) Stapf	gr
As	*Eleusine coracana* (Linn.) Gaertn.	gr
A	*Oryza barthii* A. Chev.	gr
A	*Oryza glaberrima* Steud.	gr
As	*Pennisetum americanum* (Linn.) K. Schum.	gr
A	*Saccharum officinarum* Linn.	tg
PT	*Sorghum bicolor* (Linn.) Moench	gr
N	*zea mays* Linn.	gr
	Polygalaceae	
A	*Polygala butyracea* Heckel	gr
	Portulacaceae	
PT	*Talinum portulacifolium* (Forsk.) Asch. et Schweinf.	f
AN	*Talinum triangulare* (Jacq.) Willd.	f
	Solanaceae	
N	*Capsicum annuum* Linn.	Fr
pt	*Capsicum frutescens* Linn.	Fr
A	*Solanum aethiopicum* Linn.	f, Fr
A	*Solanum dasyphyllum* Schum. et Thonn.	Fr
N	*Solanum gilo* Raddi var. Gilo	Fr
A	*Solanum indicum* subsp. distichum (Thonn.) Bitter var. distichum	Fr

Affinité chorologique	Famille Genre Espèce	Organe comestible
	Solanaceae	
Cosm	*Solanum lycopersicum* var. cerasiforme (Dunal) A. Voss	Fr
Mc	*Solanum macrocarpon* Linn.	f, Fr
A	*Solanum melongena* Linn. var. melongena	Fr
Cosm	*Solanum nigrum* Linn.	f
N	*Solanum scabrum* Vahl	f, Fr
	Tiliaceae	
A	*Corchorus lobatus* De Wild.	f
pt	*Corchorus olitorius* Linn.	f
	Zingiberaceae	
A	*Aframomum exscapum* (Sims) Hepper	f
A	*Aframomum melegueta* K. Schum.	gr
PT	*Curcuma domestica* Valeton	rh
As	*Zingiber officinale* Rosc.	rh

On constate que depuis près d'un quart de siècle, plusieurs espèces de plantes alimentaires de cueillette sont à l'abandon et en voie de disparition au profit de plantes plus performantes, d'introduction récente.

Afin de remédier à cette perte de souches génétiques importantes, nous avons initié un vaste projet d'inventaire et de publication relatif à ce patrimoine dont on trouvera le modèle dans les pages qui suivent.

Malheureusement, faute de financement, ce travail se trouve momentanément suspendu, en attendant des jours meilleurs.

Gnetaceae

Gnetum africanum Welw., Trans. Linn. Soc. 27: 73; F.W.T.A. ed. 2: 33 (1954).

Description: Liane grêle, atteignant 6m de longueur. Feuilles opposées, ovales-oblongues.

Habitat: Plante de sous-bois de forêt.

Répartition géographique: Espèce répandue du Cameroun au Zaïre et à l'Angola.

Utilisation: Les jeunes feuilles, hachées, servent à confectionner des sauces.

Observation: Surexploitée, cette plante de cueillette risque de disparaître si l'on n'envisage pas, dès à présent, sa domestication.

Nymphaeaceae

- *Nymphaea lotus* Linn., Sp. Pl. 729 (1753); Keay, F.W.T.A. ed. 2, 1: 66 (1954).

  Plante à rhizome tubéreux. Feuilles orbiculaires, à bords dentés, à long pétiole lacuneux. Fleurs blanches; étamines à connectif des anthères non prolongé au sommet. Fruits globuleux-déprimés, charnus, verts. Graines nombreuses, entourées d'un arille charnu.

  Plante aquatique cosmopolite. On la trouve dans toute l'Afrique intertropicale.

  Utilisation alimentaire: Le rhizome et les graines séchées se mangent cuits à l'eau.

- *Nymphaea rufescens* Guill. et Perr., Fl. Seneg. 15 (1830); A. Chev., Fl. Viv. de l'Afr. Occid. Fr. 92 (1938); Keay, F.W.T.A. ed. 2, 1: 66 (1954).

  Fleurs bleues ou quelquefois blanches.

  Plante aquatique, poussant dans les mares en région soudano-sahélienne.

  Utilisation: Le rhizome et les graines se consomment cuits à l'eau.

Capparidaceae

Gynandropsis gynandra (Linn.) Briq., Ann. Conserv. Jard. Bot. Genèv. 17; 382 (1914); Keay, F.W.T.A. ed. 2, 1: 88 (1954).

Herbe atteignant 60cm de hauteur. Feuilles à 5 folioles. Fleurs blanches.
Espèce originaire d'Asie, cette plante est actuellement répandue dans tous les pays tropicaux. En Afrique intertropicale elle est devenue subspontanée ou quelquefois cultivée.

Utilisation alimentaire: Les feuilles, cuites à l'eau, se mangent en sauce ou en épinards.

Moringaceae

Moringa oleifera Lam., Encycl. 1: 398 (1785); Keay, F.W.T.A. ed. 2, 1: 96 (1954).

Arbuste atteignant 8m de hauteur. Feuilles composées-bipennées. Fleurs blanches, en panicules.

Originaire du Nord de l'Inde, la plante est largement répandue près des villages dans les régions tropicales sèches.

En Afrique intertropicale, surtout en région soudano-sahélienne, elle est souvent cultivée, mais quelquefois subspontanée.

Utilisation alimentaire: Les feuilles et jeunes pousses, cuites à l'eau, servent à confectionner des sauces ou se consomment en épinards.

Des graines, on extrait une huile fine, blanche, appelée huile de Ben, comestible.

Observation: Dans certaines régions, l'usage de cette plante tend à disparaître au profit d'autres plantes plus modernes, facilement accessibles.

Brassicaceae

Brassica intergrifolia (West) Rupecht; Keay, F.W.T.A. ed. 2, 1: 97 (1954).

Herbe glauque atteignant 60cm de hauteur. Fleurs jaunes.

Plante assez répandue en Amérique et Asie tropicales. On la trouve en Afrique intertropicale, en région de montagne, où elle parait subspontanée. Guinée, Sierra Leone, Côte d'Ivoire.

Utilisation alimentaire: Les feuilles, cuites à l'eau, se consomment en sauce et en épinards.

Observation: Etant donné la destruction généralisée actuelle du couvert végétal de l'Afrique tropicale, la plante est en voie d'extinction.

Phytolaccaceae

Phytolacca dodecandra l'Hérit., Stirp. 143, + 69; Baker et Wright, F.T.A. 6, 1: 97 (1909); Keay, F.W.T.A. ed. 2, 1: 143 (1954).

Plante sarmenteuse, dioïque. Inflorescences en racèmes spiciformes plus longues que les feuilles. Fleurs mâles blanches ou jaunes verdâtre. Fruits rouges, à maturité.

Espèce se rencontrant en Afrique du Sud et à Madagascar; et aussi on la trouve en Guinée, en Sierra leone, en Côte d'Ivoire, au Ghana, au Nigéria, au Cameroun et au Congo.

Utilisation alimentaire: Les jeunes feuilles, cuites à l'eau, se mangent en sauce ou en épinards, après plusieurs séries du cuisson.

Observation: La plante qui poussait autrefois en abondance dans les décombres ne se rencontre, à présent, que rarement.

Répartition géographique: Afrique du Sud-Madagascar. Afrique intertropicale: Guinée, Sierra Leone, Côte d'Ivoire, Ghana, Nigeria, Cameroun, Congo.

Dilleniaceae

Tetracera potatoria Afz. ex G. Don, Gen. Syst. 1: 69 (1881); Keay, F.W.T.A. ed. 2, 1: 180 (1954).

Liane atteignant 20cm de hauteur. Feuilles obovales, coriaces. Fleurs blanches, en panicules.

Ecologie: Forêt dense humide.

Répartition géographique: Espèce répandue dans toute la région guineo-congolaise, depuis le Sénégal jusqu'à l'Ouganda.

Utilisation alimentaire: Les portions de tige fraîches, d'environ 60cm de longueur et de 6-7cm de diamètre, laissent s'écouler un liquide abondant, limpide, potable, qui sert pour se désaltérer en forêt lorsque l'on manque d'eau, en saison sèche par exemple.

Conservation of Plant Genetic Resources in Sub-Saharan Africa

A. F. Attere

Introduction

Africa south of the Sahara is a source of genetic diversity of importance to the world's agriculture. A wide range of plant species has evolved as a result of the interaction of diverse climatic, ecological and edaphic factors and the culmination of thousands of years of natural evolution, mutation and, to some extent, human manipulation. Today, these species constitute, a pool of diversity from which plant scientists tap the raw material they need for their crop improvement programmes.

The genetic diversity of crops in Africa was, for a long time, naturally preserved by virtue of the continent's traditional agriculture. However, during recent decades, there has been a rapid deterioration of natural resources resulting in loss of genetic diversity. The rapid increase in population has resulted in an ever increasing pressure on the environment and the destruction of natural habitats. To feed this growing population, new high-yielding and disease-resistant plant varieties have been introduced. This has led to the abandonment of the traditional varieties, rich in genetic diversity, and to significant changes in traditional farming practices with the adoption of monoculture. In addition, large areas of forest have been cleared in order to provide land for new farms and for urban development. This has also resulted in loss of genetic diversity of wild species. Overgrazing of most grasslands, an increase in both the number and frequency of bush fires and the spread of soil erosion have all played a major part in the reduction of the continent's genetic resources.

In the early 1970s sub-Saharan Africa, especially the Sahel, was affected by a devastating and prolonged drought which inevitably brought increased pressure on land use and heightened the perception that the genetic diversity, so necessary for sustainable agriculture, was being severely and rapidly eroded.

Established in 1974 by the CGIAR and based at FAO in Rome, the IBPGR has played, and continues to play, a major role in stimulating the action needed to sustain continued interest in the conservation of genetic resources in sub-Saharan Africa.

Germplasm collection

Before and during the 1970s very few collecting expeditions, with the primary goal of conservation of germplasm, took place in sub-Saharan Africa. Most countries were keeping some collections that comprised mainly exotic material and a few indigenous crop cultivars; there were few, if any, wild or weedy relatives in the collections. The composition of collections tended to reflect the interest of the breeders, their preoccupation at the time and the financial resources at their disposal [Attere, 1988]. During the 1970s, most expeditions were rescue missions targeted at endangered species and the collecting of specific crop species of major priority; mostly cereals and grain legumes.

In 1979, a meeting of the international agricultural research centres (IARCs) involved in sub-Saharan Africa and other regional organizations was convened to plan collaborative action on the plant genetic resources of the continent. Following this meeting, IBPGR assumed more responsibility for coordinating and acting as a catalyst for the various plant

genetic resources activities. As a result, regional offices were set up in Niamey (Niger) and Nairobi (Kenya). During the 1980s, the priorities for collection were revised to include species such as forage legumes, grasses and vegetables [Table 1].

If during the 1970s, most collecting missions were made mainly in close collaboration with ORSTOM/IRAT, UNEP and some of the major IARCs in Africa, namely IITA, ICRISAT and IRRI, the eighties saw the involvement of more national research institutions and the establishment of national plant genetic resources programmes.

Table 1. Regional collecting priorities

Region	Priority	Crops
Ethiopia (Priority 1)	1	coffee, millets, sorghum, wheat
	2	banana, chickpea, cotton, cowpea
	3	*Brassica* spp., barley, *Pisum* spp., *Vicia faba*
	4	teff
West Africa (Priority 2)	1	pearl millet, rice, sorghum
	2	cassava, cotton, cowpea, groundnut
	3	maize, yam, African oil palm
East Africa (Priority 3)	1	millets, *Phaseolus* spp., sorghum
	2	banana, cassava, cotton, rice, groundnut
	3	maize, pigeonpea, yam
	4	*Dolichos* spp., *Lablab* spp.

Some major collecting missions

During the 1970s and 1980s, considerable progress was made in germplasm collecting. Emphasis was placed on acquiring crop landraces and primitive cultivars. Some significant collections were made. Examples are the representative collections of sorghum and pearl millet from West and East Africa, the bean collection at Bunda College of Agriculture in Malawi and the yam collection in Cote d'Ivoire. Duplicate samples of the collected material were left with the collaborating institutions. Tables 2, 3, 4 and 5 show the material (major species) that has been collected in collaboration with IBPGR during 1974 - 1991 in West, Central, East and southern Africa and in Ethiopia.

In 1976, FAO sub-contracted ORSTOM, using UNEP funds, to collect sorghum in the Sahel; this work was later taken over by IBPGR and ICRISAT. Numerous missions visited different countries in Africa until 1981 when the IBPGR/ICRISAT Committee revised its priorities. Thereafter, explorations continued in yet more countries, with increasing emphasis on wild and weedy species. In 1984, IBPGR published a summary of the genetic resources in sorghum and reported that significant collections were held by ORSTOM and ICRISAT, [IBPGR, 1984a], but, on the basis of the 1981 priorities, sorghum still has to be obtained from Angola, Chad, Madagascar and Sierra Leone.

As with sorghum, the successive droughts in Africa have led to a considerable loss of pearl millet diversity. In 1985, IBPGR collaborated with the IUCN/WWF, ORSTOM and the national research organizations in surveying and collecting wild species of *Pennisetum* (and sorghum) in Mali and Niger and, later, in top priority countries requiring urgent attention namely, Burkina Faso, Niger and Sudan. Rice germplasm has been collected extensively in Africa by IBPGR, ORSTOM/IRAT/IDESSA, WARDA and IITA, often in collaboration with national programmes and universities. IBPGR has funded a substantial part of these activities. Rice has now been collected from 23 countries in Africa but many remote regions within these countries have not been visited. IBPGR has recently carried out ecogeographically-based missions to obtain wild and weedy species of rice from the inland delta of the Niger river.

Missions, collaborative with IITA, collected cowpea germplasm between 1976 and 1983 in Burkina Faso, Ethiopia, Mali, Mozambique, Niger, Sudan, Tanzania, Kenya, Zaire, Benin, Togo, Guinea, Nigeria, Botswana, Malawi, Zambia and Zimbabwe. Many forage legumes are indigenous to Africa and, with IBPGR support, ILCA has systematically collected *Trifolium* species in the Ethiopian highlands. Among the numerous forage missions supported by IBPGR in conjunction with scientists from international centres are two of particular note: an IBPGR-funded mission of ILCA and CIAT, in association with national scientists, to collect forage legumes and grasses in Tanzania in 1985; and IBPGR support for a CIAT collector, working in collaboration with the national institutes, to collect grass and legume samples in Burundi and Rwanda.

Table 2. Crop samples from West Africa (1974-91)

Cereals		Legumes		Forages	
Millets	5228	*Vigna*	2923	Grass	293
Rice	4897	*Arachis*	328	Legume	291
Sorghum	8660	*Phaseolus*	893	Other	17
Maize	971				
Roots		**Industrial**		**Vegetables**	
Dioscorea	1955	Coffee	160	*Solanum*	907
Ipomoea	117			*Abelmoschus*	1696
Cassava	100				

Table 3. Germplasm conserved at IITA (1991)

Vigna unguiculate	16 000
Vigna spp. (sauvage)	1 400
V. subterranea	2 000
Oryza sativa	9 500
O. glaberrima	2 500
Oryza spp. (sauvage)	385
Zea mays	1 200
Macrotyloma geocarpa	7

Table 4. Samples collected in East Africa (1980-91)

	Species	CEPGL	NE Quadrant	SADC	Islands
Major cereals	Maize	90	66	264	13
	Sorghum	451	1281	1623	
	Eleusine	12	969	857	
	Rice	27	586	357	
	Pennisetum	12	2	290	
	Others		88	169	
Major food legumes	*Phaseolus*	376	1	581	24
	Vigna	46	123	1686	13
	Groundnuts	81	4	1121	
	Others	146	16	416	
Major vegetables	Okra	1	178	269	17
	Cucurbits	47	275	1023	57
	Amaranthus	3	3	167	6
	Brassica spp.	52	104	21	
	Capsicum		122		24
	Others		434	301	176
Roots and tuber crops	Cassava	133		12	
	Sweet potato	40			
	Mixtures	121			
Forages	Grasses	310	242	620	
	Legumes	148	462	713	
Industrial crops	Fibre crops	732	418		
	Oil crops	73	60	17	
Fruits		18	18	18	
Other		104	86		
	Total	2109	6871	11505	876
	Grand total = 21349				

Table 5. Germplasm conserved at the Ethiopian Plant Genetic Resources Centre

Crop	Short-term storage	Long-term storage
Cereals		
Barley	3822	7402
Maize	211	0
Millets	575	714
Sorghum	2751	5865
Teff	1810	961
Wheat	5948	
Pulses		
Beans	531	20
Chickpea	418	373
Faba bean	1199	61
Field pea	845	239
Grasspea	130	127
Lentils	316	229
Oil crops		
Castor bean	382	50
Linseed	1425	1395
Noog	527	682
Rape seed	353	845
Safflower	141	0
Sesame	252	320
Sunflower	14	7
Other crops		
(61 different species)	1252	194
Total	20 059	25 432

Other collaborative collecting missions with IBPGR include:

- *Sesbania* species were collected in 1987 in collaboration with ILCA and IDRC in Tanzania and Kenya and, in 1991, in Malawi.
- In 1987 forage and wild sorghum were collected in Ethiopia, Sudan and Kenya in collaboration with NBPGR (India).
- Jute, kenaf and other fibre crops were collected in Kenya and Tanzania with the assistance of IJO.

- Between 1982 and 1984 more than 1200 samples of horticultural species were collected in Sudan.
- Sorghum and millet were collected in Namibia in 1991.

During the past decade alone, more than 100 collecting missions have been undertaken in sub-Saharan Africa in collaboration with national institutions. National institutions have been almost entirely responsible for proposing and implementing some 74 collecting missions. Emerging and existing national programmes in Africa will clearly play a far greater role, in the future, in the initiation and organization of collecting missions. The trend in recent years towards specialized collecting and the acquisition of the wild relatives of crop species will continue as plant breeding techniques become more advanced and the value of these wild relatives is increasingly recognized. Also, while many of the early priorities were dictated by emergency situations, attention is increasingly being focused on a regional or country basis. This approach has several advantages: the need for collecting can be more easily assessed; professional links can be developed with a range of national organizations; and local scientists are becoming more involved in the entire process.

Germplasm conservation

Conservation is the vital link between the acquisition and utilization of plant genetic resources and includes all the ways in which plant germplasm is stored and preserved. The needs of conservation and the resources devoted to it vary widely with the crop. Germplasm can be conserved as seed, as vegetative material, as tissue cultures or as living plants *in situ* or *ex situ*. One or more of these methods may be used for any crop [IBPGR, 1985 and 1986]. An integrated approach is recommended.

The standards and strategies of conservation vary greatly between countries and institutions in sub-Saharan Africa, from those of high quality such as IITA, ILCA, PGRC/Ethiopia and GBK, to non-existent. Until recently, most germplasm was kept under extremely poor conditions. Indeed, many of the existing African cold stores for seeds have not worked and, often, management of the germplasm has been inadequate.

IBPGR has put major emphasis, especially during the past decade, on providing facilities and appropriate equipment such as dryers and freezers for seed storage. It has assisted many countries in establishing basic cold stores for seeds. Recipient countries include Botswana, Burkina Faso, Burundi, Cote d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Mauritania, Mozambique, Niger, Nigeria, Senegal, Sudan, Tanzania, Togo, Zaire, Zambia and Zimbabwe. The Genetic Resources Unit of IITA was established in 1975 with initial financial assistance from IBPGR. ILCA and PGRC/E have also received IBPGR support for their conservation efforts.

There are currently too few well-equipped and adequately funded long-term storage facilities in Africa. However, some progress has been made, with assistance from IBPGR and other organizations, as shown by the following recent developments:

Burundi, Rwanda, Zaire	A genetic resources programme has been established with IRAZ and there are now long-term storage facilities in Burundi.

Cote d'Ivoire

A genetic resources centre has been established in Bouake at IDESSA.

Kenya

With the assistance of Germany, the Genebank of Kenya (GBK) is now fully operational. The bank has a mandate for conservation and documentation of a wide range of crop species. It is the focal point of the national programme on plant genetic resources.

Nigeria

A new institute for dealing with crop genetic resources, NAGRABC, has recently been established in Nigeria with assistance from IBPGR and UNDP. Its establishment follows several years of cooperation between IBPGR, FAO and NIHORT (which was the IBPGR regional centre for vegetables such as okra, *Amaranthus* species and *Celosia argentea*). The institute's new mandate covers a wide range of crops.

SADC

The Nordic Genebank and IBPGR are assisting in the establishment of a regional genebank in Lusaka, Zambia, to serve the SADC countries. The objective of the project is to strengthen national capabilities by establishing strong national programmes and basic conservation structures. The project will extend over a 20-year period and the Nordic countries have already pledged $US 10 million. The Southern Regional Genebank (SRGB) is complete and has begun operation.

Senegal

At present, genetic resources work in Senegal is located at several different places: Bambey (millet, groundnut, cowpea and sorghum); Djibelor (rice), Nioro (maize), Kaolack (cotton) and Camborene (horticultural crops). Plans are being drawn up to develop a centralized genetic resources centre, probably in Bambey.

Zimbabwe

A conservation unit has been established at the Crop Breeding Institute (RSS), Harare.

PGRC/Ethiopia

Table 4 shows the germplasm conserved here.

Sudan

IBPGR assisted the Agricultural Research Corporation of the Sudan Agricultural Research Centre to establish a genebank for the conservation of vegetable genetic resources. Modern equipment was provided for running the bank.

Several donor and development agencies, such as those of the Nordic countries, GTZ, USAID, the World Bank, JICA and NGOs have contributed to the development of conservation facilities in sub-Saharan Africa. With a World Bank grant, ISAR in Rwanda has completed a modern conservation unit in Butere.

Characterization and documentation

Characterization of the collected resources, prior to storage, is essential for further utilization. Thus the potential of all accessions needs to be assessed. Equally important is the information (passport data) that is collected during the collecting of the germplasm.

In most of the sub-Saharan countries, characterization and documentation of indigenous germplasm has lagged way behind the collecting exercise. Early collections had no, or very little, passport data. The use of the IBPGR descriptor lists and collecting forms during collecting missions and the distribution of these forms to all collecting institutions and collectors has helped to standardize and initiate systematic characterization and documentation. Some other forms that seem convenient to our collaborators have been designed, with the main idea being to ensure that relevant information is collected during the collecting exercise. In many cases characterization was undertaken during the regeneration of old collections which were in a poor state due to the then lack of good conservation facilities. It is also sometimes initiated during the multiplication of small-sized samples before their storage.

In the past, documentation was mainly done manually but with the increasing availability of micro-computers this practice is being replaced gradually by computerized databases.

Characterization and documentation are primarily the responsibility of national programmes. IBPGR action has been to help and encourage the national programmes to systematically undertake these tasks. Funds and personnel are sometimes provided to further encourage and sustain the action. Although slow, some work was initiated and accomplished by the various national programmes of Kenya, Sudan, Cote d'Ivoire, Nigeria, Togo, Burundi, Zimbabwe, Madagascar, Burkina Faso, Niger and Botswana.

Use of germplasm in breeding programmes

Increased food production in the region using stable, high-yielding varieties can be achieved best by incorporating the useful adapted indigenous genotypes. In cases where the germplasm is well characterized and documented, further evaluation leads to its use in breeding programmes.

In the past, the lack of properly managed indigenous germplasm collections, limited characterization and documentation, lack of breeding programmes with qualified personnel and lack of financial support, resulted in limited utilization of the local germplasm in the region. This is slowly changing, especially since most countries have now established breeding programmes for some major crops, e.g. sorghum, millet, maize, cassava, beans, cowpea and coffee. However, for the reasons mentioned earlier, the capacity to use indigenous germplasm still varies greatly from one breeding programme to another

Screening of germplasm for resistance to insect attacks and tolerance to various stresses such as drought or poor soil fertility, is now becoming a routine undertaking by some national breeding programmes in the region. Identification of cassava mosaic disease (CMD)-resistant material, as well as CMD-tolerant varieties with high yield, is in progress in Kenya, Uganda, Tanzania, Nigeria and Zaire. Also, some high-yielding hybrids of maize which are tolerant to diseases and have great nutritional value were developed in Kenya, Nigeria, Zambia and Zimbabwe. Despite drought and other problems, the increased evaluation and documentation of germplasm has greatly contributed to the use of wheat, sorghum, chickpea, lentil and *guizotia* in the national breeding programmes of Ethiopia.

Breeding work at the IARCs is of great benefit to the national programmes, especially since they, together with national programmes, have started to evaluate the germplasm collected in the regions of origin (e.g. sorghum and millet with ICRISAT, forage with ILCA, bean with CIAT and sweet potato with CIP).

Training

Training of manpower is a major component of the IBPGR overall programme because it is essential for the smooth development of plant genetic resources activities. Training opportunities include a one year, specialized M.Sc. training course on conservation and utilization of plant genetic resources, and various short courses, in the UK. IBPGR has organized several short courses in sub-Saharan Africa during the past ten years. The IRACs and some universities across the world also offer specialized short courses on plant genetic resources (PGR) from time to time. IBPGR assists national scientists in obtaining sponsorship to attend most of these courses. Since 1974 more than 225 scientists and technicians from sub-Saharan Africa have attended various training courses.

Constraints to PGR activities in sub-Saharan Africa

The main problems, with respect to plant germplasm conservation and utilization are:

- **Availability of funds.** Several countries still have no special budget from their government for PGR and there is a general tendency to rely solely on international organizations. Others have insufficient funding from their governments.

- **Manpower.** Most countries have few people trained in germplasm conservation. In many countries there are no full-time curators, and few technicians. There are also frequent changes of personnel in the ministries. Training opportunities are lacking.

- **Equipment and storage facilities.** In many of the African countries there is a shortage of facilities and equipment needed for conservation work. This is perhaps because many of the plant genetic resources genebanks or units have been set up only within the past five years and are thus still acquiring the necessary resources. The lack of vehicles and seed dryers is particularly noticeable. In some institutions, there is no electricity and water is not always available.

- **Security-sensitive areas/war zones.** Political problems in some countries have resulted in security-sensitive areas where collecting can be risky.

- **Descriptor lists.** Some countries have had problems because there are no descriptor lists available in their language.

- **Pests and diseases.** These problems have led to considerable loss of PGR.

- **National conservation policies.** Most countries lack national policies on plant germplasm exploration, collection, characterization and documentation.

- **Perception of the need for conservation.** Unawareness of the need for PGR conservation.

- **Proper organization at national level.** This is lacking in most African countries.

New developments and prospects

IBPGR has played a vital catalytic and coordinating role in Africa. In addition to its offices in West and East Africa, a germplasm collector for SADC has been stationed in Harare, Zimbabwe; interns in Ethiopia have been responsible for the development and testing of simple tissue cultural techniques for collecting; and another intern was in Togo to assist the national programme with characterization and documentation activities.

Various studies such as ecogeographical studies and distribution of diversity were initiated to assist in the understanding of genepools of major species (*Vigna, Eleusines, Corchorus* and *Hibiscus, Solanum*, etc.). A feasibility study of monitoring genetic erosion on a systematic basis was also undertaken. The use of GIS in collaboration with UNEP's GEMS section has been initiated. The information generated is incorporated in the collecting database. This database on germplasm collected with IBPGR support was updated and reorganized and is being supplemented by a literature survey and distribution maps.

Early PGR work in sub-Saharan Africa was conducted mainly through regional and international institutions. This has gradually changed and more and more national agricultural research centres (NARCs) are becoming involved in these activities. In the past, the acute lack of trained manpower and the lack of organization at national level prevented their full participation.

IBPGR has been very active in initiating the development of national PGR programmes in sub-Saharan Africa by assisting NARCs in defining a focal point and obtaining basic conservation and seed processing facilities. Several national PGR programmes are now emerging. In its new strategy IBPGR is putting special emphasis on the development and strengthening of national programmes which will take into consideration the priorities of the countries. IBPGR intends, together with the United Nations' University and UNEP, to increase the training opportunities for sub-Saharan African scientists by initiating and supporting PGR training in the region. Some universities in southern, East and West Africa have been selected to offer post-graduate courses and short, specialized courses in PGR in collaboration with various genebanks in the region (PGRC/E, GBK, SRGB and NAGRABC).

It will be difficult to set up and maintain a modern genebank, fully staffed and operational, in every country of sub-Saharan Africa. The running of sophisticated conservation and testing laboratories in each country may not be economical and efficient. Regional cooperation in aspects of crop genetic conservation and utilization is very important. The development of national PGR programmes will be complemented, whenever possible, with regional integration. Regional networks such as the one in the CEPGL countries or in SADC will be encouraged. In southern Africa the regional genebank (SRGB) in Lusaka, Zambia is the focal point for long term conservation, documentation and training. It might also be cost-effective to establish a few base collections in a limited number of countries and organize them on a regional basis, while each country holds an active collection.

Recently, the AMCEN network for PGR activity was proposed and will comprise all African countries. PCRC/E has been designated as the regional coordinating unit (RCU) and its primary job will be the establishment of databases on the status of PGR activities in Africa. IBPGR has offered to assist the RCU in this very important task.

The CILSS and CEAO countries of West Africa, in consultation with FAO and IBPGR, have initiated a study which will lead to the establishment of a large network in West Africa, probably including all the ECOWAS countries in the future. The involvement of non-government and grassroots organizations (close to farming communities) can play a crucial role in accelerating the conservation of endangered species as well as in the promotion of

the use of traditional resources and the indigenous knowledge associated with them. UNCED and the Convention on Biodiversity have highlighted the lack of policies on conservation issues in most sub-Saharan African countries. This appears to be a serious handicap that needs to be addressed urgently. The level of awareness has increased considerably but it may not be at the level that will ensure serious mobilization of resources for speedy action at national level.

Conclusion

A great deal has been accomplished during the past two decades particularly in the collection and preservation of landraces and primitive cultivars of major crops. However, more needs to be done. Particular emphasis should continue to be placed on wild relatives of crops as well as on the so-called minor, non-CG centre or under-utilized crops which often are of high priority for the NARCs.

In the wake of UNCED and Agenda 21 there seems to be the rediscovery of an old partner; the poor, forgotten or neglected peasant farmer of the developing world, long time custodian of these precious genetic resources. New partners have also emerged, offering opportunities in what could be a very challenging new era. I hope this era will be marked by the use of genetic diversity for sustainable development in a sound, clean, healthy and friendly environment for all.

Le Devenir des Cultures Traditionnelles en Afrique: Le Cas de l'Igname (*Dioscorea*)[2]

P. Hamon, R. Dumont et J. Zoundjihekpon

Selon des données de la FAO, des 1200 espèces végétales cultivées dans le monde, seulement une trentaine constituent l'essentiel de la consommation mondiale. Le blé, le riz, le maïs et la pomme de terre sont les plus importantes, puis viennent l'orge, la patate douce et le manioc.

Cette restriction dans l'utilisation concerne non seulement le nombre d'espèces utilisées à des fins alimentaires, mais aussi le nombre de variétés cultivées par espèce.

Ainsi, pour le blé, l'essentiel de la production mondiale repose sur 4 à 5 variétés sélectionnées.

L'érosion très importante de la diversité génétique de nombreuses espèces cultivées (à la fois inter et intravariétale) est due aux stratégies de sélection végétale, à la généralisation des méthodes de culture intensive, et aux bouleversements écologiques [Pernès, 1984].

La culture intensive ne concerne que les pays développés, le phénomène inverse s'observant dans les pays en développement.

Pour les cultivateurs traditionnels, la recherche et le maintien d'une diversité en culture ont de tout temps été une nécessité pour:

- assurer une production minimale malgré des aléas climatiques;
- accroître dans le temps les disponibilités en étalant la production et la conservation;
- permettre des utilisations culinaires et autres très variées;
- obtenir une meilleur gestion de l'espace en procédant à des associations culturales.

Aujourd'hui, les cultures traditionnelles sont menacées. Les déforestations massives en Amazonie, en Afrique (dans 30 ans, les forêts de Côte d'Ivoire et du Nigéria auront sans doute disparu, [Nouaille, 1990]) perturbent profondément les écosystèmes et menacent de très nombreuses espèces sauvages. Or, chez l'igname, 14 sur 17 espèces sauvages recensées en Afrique de l'Ouest et du Centre sont forestières [Hamon *et al.*, soumis à l'IBPGR].

La modification des agrosystèmes traditionnels et les nouvelles contraintes économiques et sociales (concurrence très forte de cultures commerciales et de produits alimentaires nouveaux) peuvent nuire à certaines cultures traditionnelles.

En Côte d'Ivoire, la diffusion depuis près de 15 à 20 ans d'un clone d'igname, le florido, appartenant à l'espèce *D. alata* (d'origine asiatique) est responsable de l'abandon dans de nombreux villages des variétés locales tardives, qu'elles soient *D. cayenensis-rotundata* ou *D. alata* [Hamon, 1987; Zoundjihekpon, 1990].

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[2] **Traditional Crops in Subsistence Agriculture.**

Il est donc nécessaire de comprendre le fonctionnement des cultures traditionnelles (leur évolution, leur gestion, etc.), d'appréhender leurs richesses potentielles pour mieux les promouvoir.

Nous prendrons l'exemple de l'igname, plante à tubercule, essentiellement cultivée dans les régions intertropicales, et nous nous attacherons à décrire la situation observée en Afrique de l'Ouest.

Les caractéristiques de la culture d'igname

Aliment de base pour les populations des régions intertropicales, l'igname devient une culture de rente de plus en plus importante pour répondre à la demande croissante du milieu urbain.

Cinq espèces sont essentiellement cultivées: 3 originaires d'Afrique et 2 d'Asie du Sud-Est. Dans la plupart des cas, c'est en conditions traditionnelles, une culture plurispécifique (en culture pure ou associée) et plurivariétale [Hamon et Ahoussou, 1988]. La prédominance de telle ou telle espèce varie selon la région et le pays. En Côted'Ivoire, de 2 à 12 variétés sont co-cultivées par village [Hamon, 1987]. Comme culture de rente, elle est naturellement monovariétale.

Le passage à la culture de rente conduit à des modifications allant jusqu'à l'abandon des cultures traditionnelles. Il s'ensuit une très forte érosion génétique.

Dans le cadre de la culture traditionnelle inféodée à l'agriculture itinérante et aux associations culturales, la sélection traditionnelle de l'igname a favorisé les variétés à gros rendement par butte mais à faible rendement à l'hectare (3 000 à 5 000 buttes par ha en culture itinérante contre 10 000 à 12 000 buttes par ha en culture sédentarisée). Actuellement, malgré quelques tentatives faites pour améliorer le matériel végétal [cf. Degras, 1986, pour revue], on ne dispose pas réellement de matériel adapté à l'agriculture modernisée.

Les formes sauvages jouent un rôle important dans l'évolution des formes cultivées. La domestication des espèces sauvages se poursuit toujours et a été observée dans différents pays [Hladik *et al.*, 1984; Hamon et Touré, 1990; Dumont *et al.*, soumis; Zoundjihekpon, 1991]. De plus l'évolution des formes sauvages est fortement liée à la diversité des formes mises en culture [Dumont 1977, 1978; Hamon *et al.*, 1992]. Cependant, peu de centres de recherches disposent de formes sauvages en collection et les intègrent dans des programmes nationaux d'amélioration variétale. Trop peu de travaux, exception faite des descriptions botaniques, les concernent [Hamon, 1987; Hamon et Touré, 1988; Hamon *et al.*, 1992].

La gestion traditionnelle des ressources génétiques

D'une manière générale, le système traditionnel de gestion répond à trois règles essentielles:

- beaucoup de variétés ont une valeur culturelle chez les africains, et sont maintenues à ce titre en culture;
- l'étalement de la production (qui peut aller de Juillet à Février) est réalisé en tenant compte à la fois des possibilités de production mais aussi de conservation des différentes variétés;

- la demande commerciale favorise la prédominance de certaines variétés dans l'agriculture.

Le cultivateur africain fait preuve d'une grande curiosité, comme tous les cultivateurs et, concernant l'igname, on constate que toute innovation l'intéresse à priori.

Auparavant, les variétés traditionnelles étaient parfaitement identifiées par le cultivateur et reconduites d'année en année. Aujourd'hui, on constate que les paysans considèrent des ensembles de variétés plutôt que les variétés individuellement. Ceci accroît certainement l'érosion génétique à court terme.

D'autre part, des formes sauvages sont régulièrement prélevées et amenées progressivement à la culture. Les introductions régulières de matériel cultivé depuis une époque récente concourent à de nouveaux brassages génétiques avec les formes sauvages et créent une certaine variabilité qui peut être par la suite exploitée.

Les actions à mener

La diversification de l'agriculture est une stratégie nécessaire pour faire face aux besoins alimentaires que le développement démographique va susciter. Il importe donc de voir se manifester une volonté politique de façon à ce que soient maintenues et développées toutes les cultures pouvant apporter une solution au problème de l'alimentation humaine.

La conservation et la gestion du matériel végétal relèvent d'un domaine très spécialisé, et nécessitent la mise en place de structures bien définies.

Dans une première étape, il est nécessaire d'organiser un réseau, ayant pour mission la coordination des activités dirigées vers l'inventaire, l'évaluation et la conservation des ressources génétiques.

La majorité des pays d'Afrique de l'Ouest et du Centre ont disposé, ou disposent, de collections représentatives essentiellement du territoire national. Mais jusqu'à présent, on n'a pas une vue d'ensemble des ressources génétiques disponibles. De plus, il n'existe pas de structure pour conserver le matériel végétal à l'échelon régional. Les prospections doivent donc reprendre et mettre l'accent sur les zones de culture marginales, là où il y a le plus de chances de trouver des formes reliques et/ou originales. Une attention particulière devra être apportée à "l'histoire" du matériel collecté, afin de situer son origine dans l'espace et le temps.

Pour de nombreuses plantes, les collectes ont longtemps concerné les formes cultivées et dédaigné les formes sauvages. Les collections mondiales de gombo à l'USDA et de sorgho à l'ICRISAT sont révélatrices de cette tendance. Ceci est également vrai chez l'igname, bien que des efforts de collecte aient été réalisés par la Côte d'Ivoire avec la collaboration de l'IBPGR et de la CEE [Hamon et Ahoussou, 1988; Zoundjihekpon, 1990]. Il est donc impératif d'organiser la collecte des différentes espèces sauvages en mettant tout d'abord l'accent sur les espèces ayant des affinités avec les formes cultivées. Cependant, les collectes seules sont inutiles si elles ne sont pas immédiatement associées à des projets de conservation puis d'évaluation. En effet, les collections maintenues *in vivo* annuellement sont soumises à des pertes énormes, 5 à 40% de pertes chaque année pour la collection de la Côte d'Ivoire. Il en est probablement de même pour l'importante collection constituée au Togo récemment. De plus, ces collections sont très coûteuses en entretien, espace et temps. Pour faire face à ces contraintes, depuis près d'une quinzaine d'années, divers instituts utilisent le

microbouturage *in vitro* pour la préservation de leur collection de travail. Bien que ce procédé paraisse satisfaisant à priori, deux problèmes importants doivent être soulevés:

- pendant combien de temps (combien de repiquages) une igname peut-elle être conservée *in vitro* sans risque de variation génétique? Ce risque est important chez le fraisier. Chez l'igname on peut penser qu'il est réduit car cette plante se multiplie naturellement par voie végétative. Elle n'est donc nullement "forcée" *in vitro*. Des études réalisées sur la collection maintenue à l'ORSTOM ont montré que les caractéristiques enzymatiques (données non publiées) et les niveaux de ploïdie d'échantillons *in vivo* et *in vitro* (après une vingtaine de repiquages) sont comparables [Hamon *et al.*, 1992]. Le risque de variation génétique chez cette plante, bien qu'apparemment faible, reste cependant non évalué;

- en général, la conservation est intégrée dans des programmes de recherches ou dans des financements à durée limitée et, lorsque ceux-ci s'achèvent, se pose le problème du devenir de ces collection. Sans le programme de recherches, pendant combien de temps encore survivra la collection *in vitro* maintenue à l'ORSTOM, Montpellier? Sans crédits spécifiques, combien de temps pourra tenir la collection FAST à Abidjan (Côte d'Ivoire)?

Enfin, récemment, une expérience intéressante de conservation pérenne *in situ* a été mise en place en Côte d'Ivoire, de manière à conserver à faible coût les formes cultivées et sauvages introduites dans la région, et à suivre l'évolution phénotypique des différentes formes.

Depuis peu, dans un but de conservation des ressources génétiques à long terme, les techniques de cryoconservation sont développées chez un certain nombre de plantes [cf. Englemann, 1991, pour revue]. L'application de ces techniques à l'igname permettrait de prendre le relais des collections *in vitro* afin de minimiser les opérations de manipulations et l'espace nécessaire à la conservation. Signalons que la cryoconservation de suspensions cellulaires a déjà été utilisée chez *Dioscorea deltoidea* [Butenko *et al.*, 1984]. Chez l'igname, on a peu d'information sur les caractéristiques des graines, en dehors du fait qu'il y a une dormance. Est-elle de même durée pour toutes les espèces? Quelle est la durée de conservation et dans quelles conditions doit se réaliser la conservation?

L'évaluation est une question également importante, car une collection sans étiquette n'a aucune valeur. Elle devrait permettre l'élimination des duplicatas et la constitution de "core collection" plus facile à gérer et à utiliser dans les programmes de sélection variétale.

Différentes méthodes d'évaluation agronomiques [Lyonga, 1976, 1983], faisant appel à des descripteurs morphologiques, enzymatiques, cytologiques par comptage direct des chromosomes et évaluation des teneurs en ADN par cytométrie en flux [Hamon et Touré, 1990 a, b; Zoundjihekpon *et al.*, 1990; Hamon *et al.*, 1992], ont déjà été utilisées chez l'igname. D'autre nécessitent une formation et des équipements spécialisés. Les techniques d'analyse du polymorphisme de longueur des fragments de restriction (RFLP) sont des outils puissants pour l'etude de la diversité génétique, l'identification des génotype et l'élaboration de cartographies du génome [Beckmann and Soller, 1983, 1986]. Chez l'igname, ces techniques ont été appliquées pour des études de phylogénies par Terauchi *et al.* [1989, 1992].

En **conclusion**, les trois points suivants nous paraissent essentiels:

1. une prise de conscience au niveau politique est nécessaire et indispensable afin de favoriser les actions à entreprendre pour assurer la sauvegarde des ressources génétiques;

2. devant l'importante érosion génétique observée chez l'igname, il est nécessaire de mettre en uvre tous les moyens utiles à la préservation des ressources génétiques encore existantes;

3. la mise en place d'un réseau fonctionnel apparaît comme une évidence et une nécessité pour organiser la gestion et l'utilisation rationnelle des ressources génétiques.

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Rice Biodiversity Conservation and Plant Improvement in Sierra Leone

S. S. Monde and P. Richards

Introduction

Sierra Leone lies at the heart of the West African Rice Zone - that part of the West African littoral (Senegal to Cote d'Ivoire) where rice is the principal subsistence crop. African rice (*Oryza glaberrima*) is an ancient domesticate of local wild rices and the basis for the emergence of settled society in this part of Africa, perhaps up to 2000 years ago. Today, most small-scale producers in Sierra Leone are still directly dependent on rice agriculture for a major part of their livelihood, though growing mainly *O. sativa* types (introduced within the last 500 years). Per capita consumption of rice (c. 120 kg/person/year) is one of the highest in Africa, accounting for 50 per cent of all energy in the national diet. The rice price is a focal point of national political debate and family life. Because no hospitality or social ritual is complete without rice, consumers resist a switch to foods such as cassava in a country where (except for its basic staple) "quality of life" is rated, by UNDP, as among the lowest in the world. Security of the rice harvest and food security in Sierra Leone are synonymous.

In 1987, sample surveys in all major rice ecologies [Lipton, Pain and Richards, 1992], indicated that c. 150-200 local rice types (grouped in several major landraces according to cultivation practice) accounted for c. 80-85 per cent of all rice planted by small-scale producers. The balance was supplied by a number of research varieties, released by the national Rice Research Station at Rokupr over various periods from the early 1960s. Principal varieties were CP4, ROK 3, ROK 5, ROK 10, ROK 16 and ROK 17 (formerly LAC 23), but the older varieties Nachin 11, BD2 and SR 26 were also released. These varieties continue to make progress, and it may now be the case (five years later) that up to 25 per cent, or more, of the national rice hectarage is planted to research varieties. Further expansion can be expected with the recent release of varieties ROK 17 to ROK 32. It would be reasonable to assume that within ten years half or more of all rice planted in Sierra Leone will derive from research station releases.

This anticipated spread of research varieties implies a possible narrowing of the gene pool and the potential loss of rice germplasm biodiversity as farmers begin to place more reliance on research varieties. Breeders are well aware that without special attention to biodiversity conservation they could be cutting the ground, for further improvement, from under their feet. The point is especially well-understood at Rokupr where two of the most successful ROK-series releases, ROK 3 and ROK16 (the latter is a success in Cote d'Ivoire and Ghana as well as Sierra Leone), are pure-line selections from local materials. Among recent releases ROK 27 and ROK 33 are local selections, and other Rokupr varieties are crosses embodying some local parentage (e.g. local selection *pa Wellington* x SR 26 yielded ROK 4, 5, 8, 9 and BD2).

Experience at Rokupr over several decades has shown that varieties incorporating local germplasm are often especially successful in adverse conditions (e.g. on upland soils of low or declining fertility). This is why recent work has placed more emphasis on collection and screening of local germplasm [Monde *et al.*, 1988; RRSAR, 1985; 1986]. Currently, particular attention is being paid to *O. glaberrima* [Jusu and Monde, 1990]. Rokupr accessions of this indigenous West African species frequently show promise both in soils with low available phosphorus, often the limiting factor in highly-leached forest-zone upland soils in Sierra Leone and adjacent areas [RRSAR, 1989; Monde *et al.*, 1991)], and when screened for

tolerance to blast, a major pathogen in upland rice farming in West Africa, [Table 1]. Since *O. glaberrima* accounted for only 5 per cent of all rice types in the 1987 survey there is particular concern to conserve available biodiversity in this species. It is not found outside West Africa.

A further urgent reason why special attention should now be paid to the conservation of native rice germplasm reserves in Sierra Leone is the situation prevailing in the eastern and southern parts of the country following the invasion of rebels from Liberia in March, 1991. Led by Burkinabe and Liberian mercenaries linked to Charles Taylor's National Patriotic Front of Liberia, these rebels took over Kailahun and large parts of the Kenema and Pujehun Districts during the early part of the farming season in 1991. They were beaten back towards the Liberian border by government troops during the latter part of the year. The majority of the rural population in these districts was displaced either by the initial invasion or in subsequent fighting. Farming was at a standstill for six months or more and seed rice stocks were looted or lost.

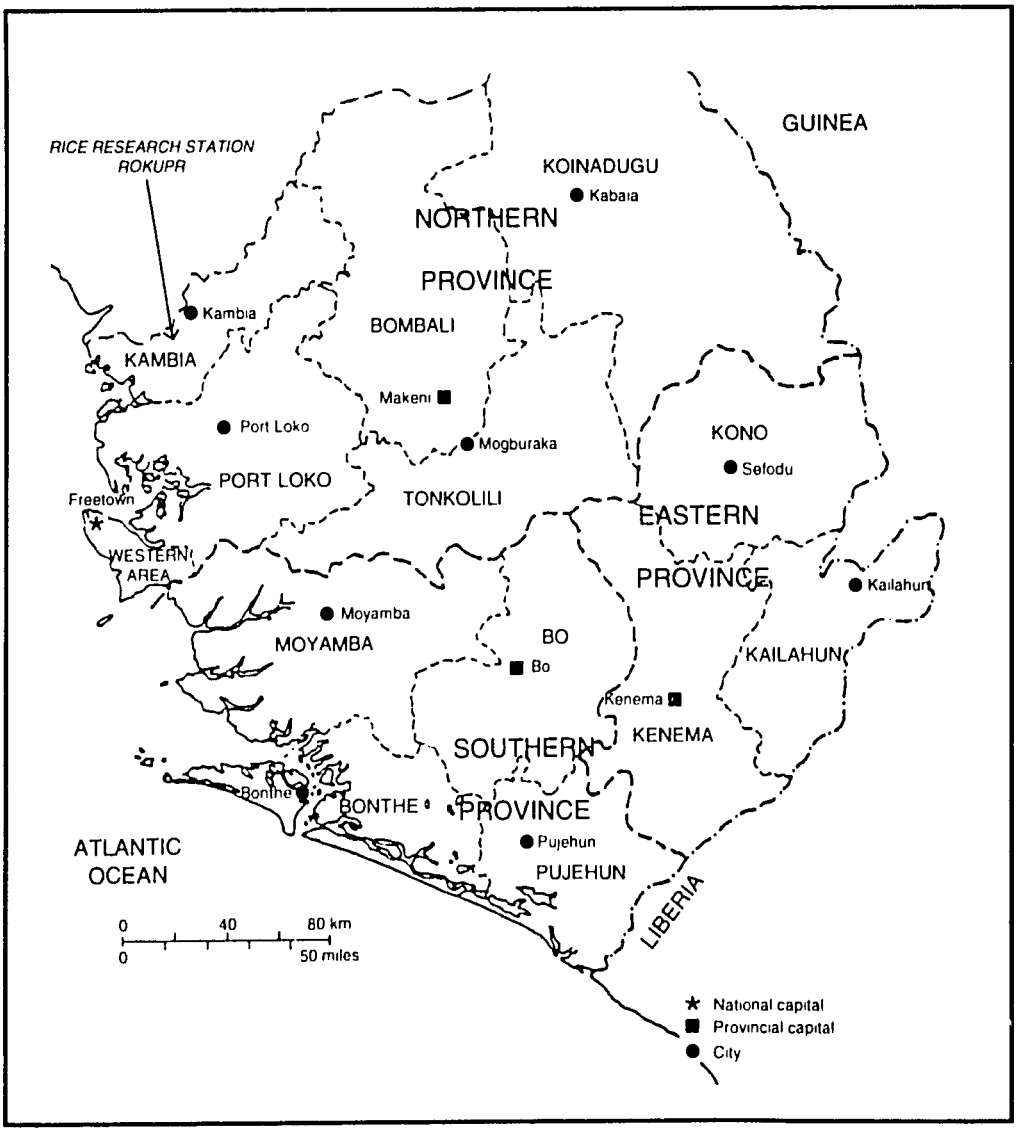

Figure 1. District and provincial boundaries of Sierra Leone

Although the farming populations of the Kenema and Pujehun Districts are now largely resettled, a recent assessment of rehabilitation work in the war-affected zone [Richards, 1992a] estimates that the rice area in 1992 is at least 50 per cent down on a normal year; the major limiting constraint is shortage of seed rice. Farmers are largely dependent on seed stocks supplied by the relief agencies, and these are mainly research varieties available through government seed multiplication sources. In every community visited recovery of lost local planting materials was a priority and, despite limited resources, some farmers had travelled up to fifty miles (often on foot) to beg or borrow the types they had lost. The situation in Kailahun is especially serious, since much of this district remains under rebel occupation and farming has been disrupted for a second consecutive season; displaced villagers are camped at Segbwema and Daru (in Sierra Leone) and across the international border, in Guinea. The northern part of Kailahun District is noted for rice biodiversity, especially forest-zone upland cultivars (e.g. the source for Rokupr pure-line selections ROK 3 and ROK 16, now among the most important upland releases country-wide). The likelihood of accelerated erosion of rice germplasm resources under the conditions just described is high.

The rice germplasm collection record in Sierra Leone

Periodic attempts to collect and categorize rice germplasm in Sierra Leone began with the establishment of the Department of Agriculture's headquarters at Njala in 1912 [Richards, 1986]. From 1934 responsibility for this work was transferred to Rokupr. Collection was irregular and, in the period up until the 1960s, more emphasis was placed on screening, selection and, latterly, breeding from exotic material. In part, this was because Rokupr's early mandate specified work relevant to the mangrove zone where rice cultivation had developed to meet the food needs of Freetown in the colonial period. Many of the rices cultivated in the coastal mangrove zone were introductions through informal channels in the early 20th century. Only later was Rokupr's mandate extended to cover the uplands, inland valley swamps and other wetland environments where the bulk of the subsistence crop was (and is) grown using largely traditional methods and long-established selections.

From time to time, Rokupr staff assemble working collections of potentially interesting material for selection and breeding purposes. For example, G.S. Banya acquired germplasm, later released as ROK 3 and ROK 16, while visiting the farm of a kinsman in Luawa Chiefdom, Kailahun District [Lipton *et al.*, 1992]. A nation-wide rice germplasm survey exercise was undertaken (by IITA staff) in the 1970s, resulting in the deposition of about 400 distinct types in collections in Ibadan and Rokupr. Political disturbances at the station in 1980 resulted in the looting of cold room equipment and the Rokupr collection was lost. Since then staff at the station have continued to collect where and when they could but, hampered by lack of proper conservation facilities, accessions have to be planted out each year in observation plots, thus strictly limiting the amount of material than can be handled.

In 1984, Rokupr made 235 accessions (*O. sativa*, 179; *O. glaberrima*, 56) or (upland, 79; lowland 156) from germplasm collection activities in northern Sierra Leone. Promising types are now at an advanced stage in the screening process [RRSAR, 1985-1989]. Upland types were found to earlier ripening. Reaction of 212 accessions to diseases is recorded in Table 1. Upland (32) and lowland (148) types were also evaluated for reaction to Rice Yellow Mottle Virus (RYMV) and 5 were resistant, 41 moderately resistant and the rest susceptible.

Table 1. Disease reactions of 212 local rice cultivars from northern Sierra Leone

Reaction/Disease	leaf blast	neck blast	brown spot	scald
resistant	113	53	0	3
moderately resistant	79	2	22	22
moderately susceptible	18	77	174	175
susceptible	0	52	12	8
no score	2	28	4	4
Total	212	212	212	212

In the course of a national sample survey of rice types, from October 1987 to February 1988, 225 lowland and 343 upland samples belonging to about 150 distinct types according to farmers' categorizations were collected from all major ecologies in both forest and savanna transition zones (eight sites). They were deposited at Rokupr for evaluation under uniform conditions [Lipton, *et al.*, 1992]. In an associated exercise in early 1988, Rokupr staff collected a further 129 lowland and 201 upland samples from areas (including the riverine grasslands) not covered in the Lipton survey[3]. Data from observation plots at Rokupr are discussed below [see Figs. 2-5]. Some of the more interesting accessions have been evaluated for soil stress and diseases and promising types have been entered into preliminary yield trials [Monde *et al.*, 1991; RRSAR, 1988; 1989]. Lack of facilities at Rokupr means that any material not carried on within the trials programme has to be discarded. A more comprehensive approach to conservation of rice biodiversity in Sierra Leone will depend on the rehabilitation of the station's germplasm conservation unit. This (we argue in this paper) should be done within the context of a wider initiative to understand the nature of the resource (the national heritage of rice germplasm) and the processes and pressures conducive to the maintenance, amplification or erosion of this resource.

[3] In the last 12 years the WARDA unit based at Rokupr has collected 754 traditional mangrove swamp cultivars in West Africa, the majority of which were from Sierra Leone.

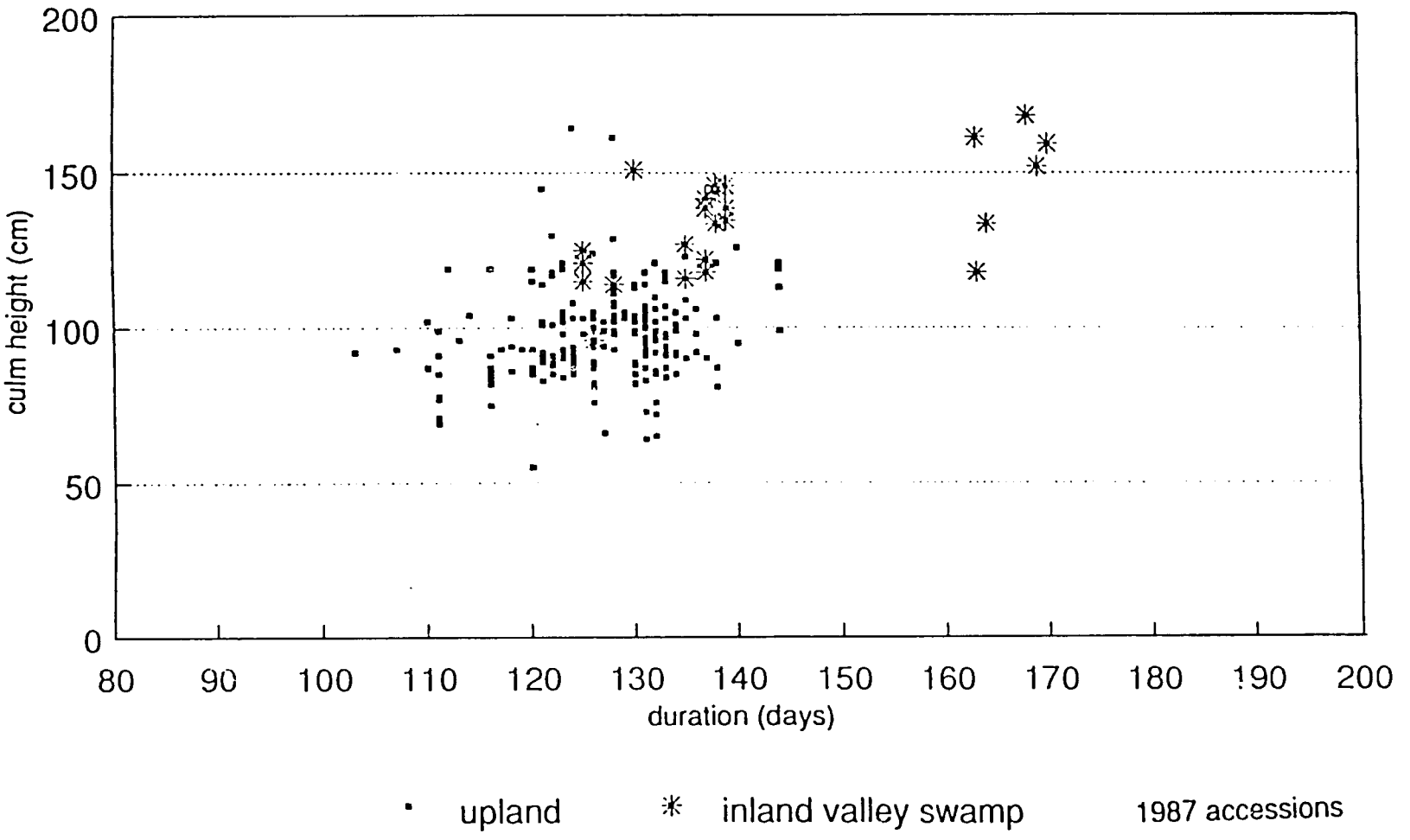

Figure 2. **Upland and inland swamp types: height and duration**

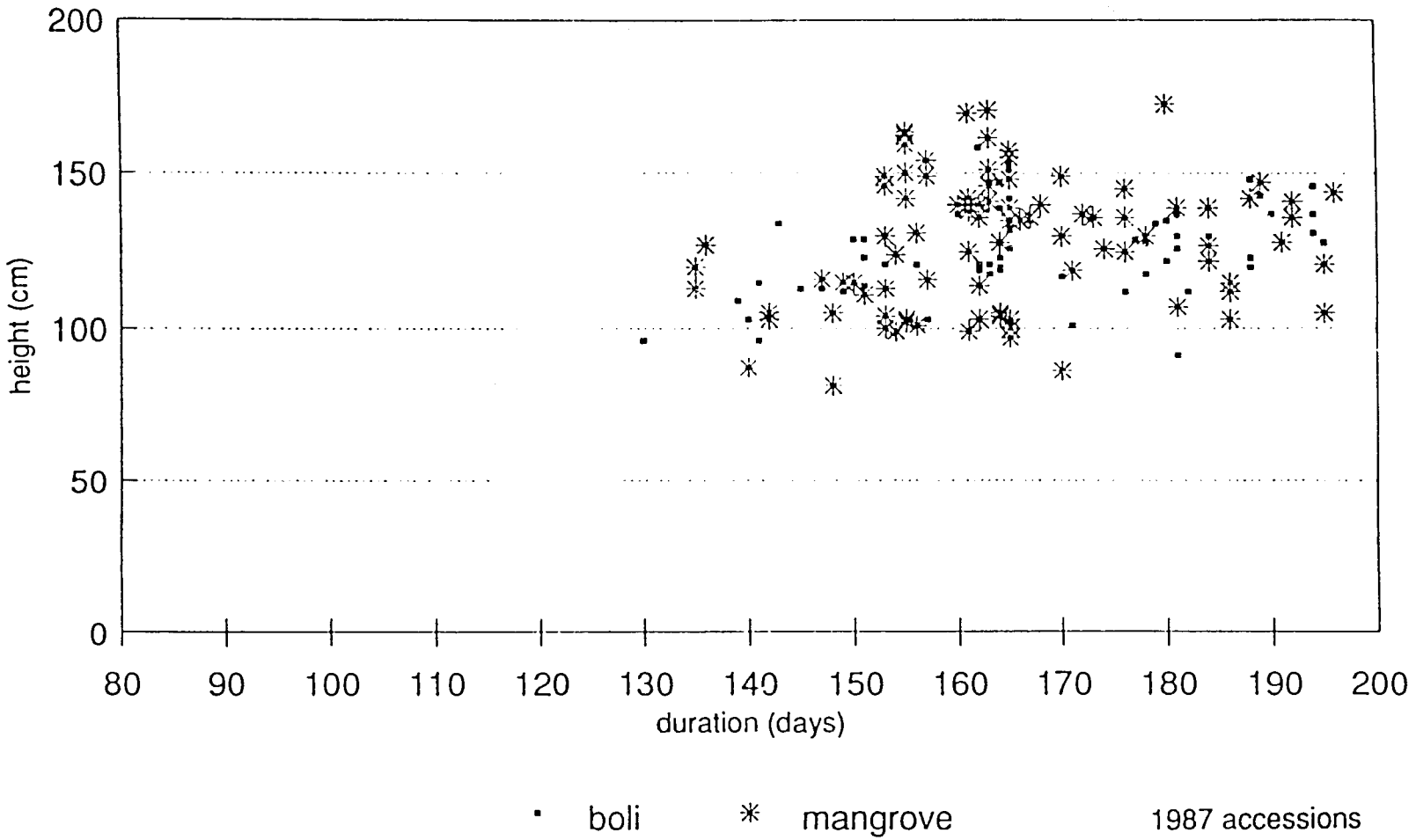

Figure 3. **Boliland and mangrove types: height and duration**

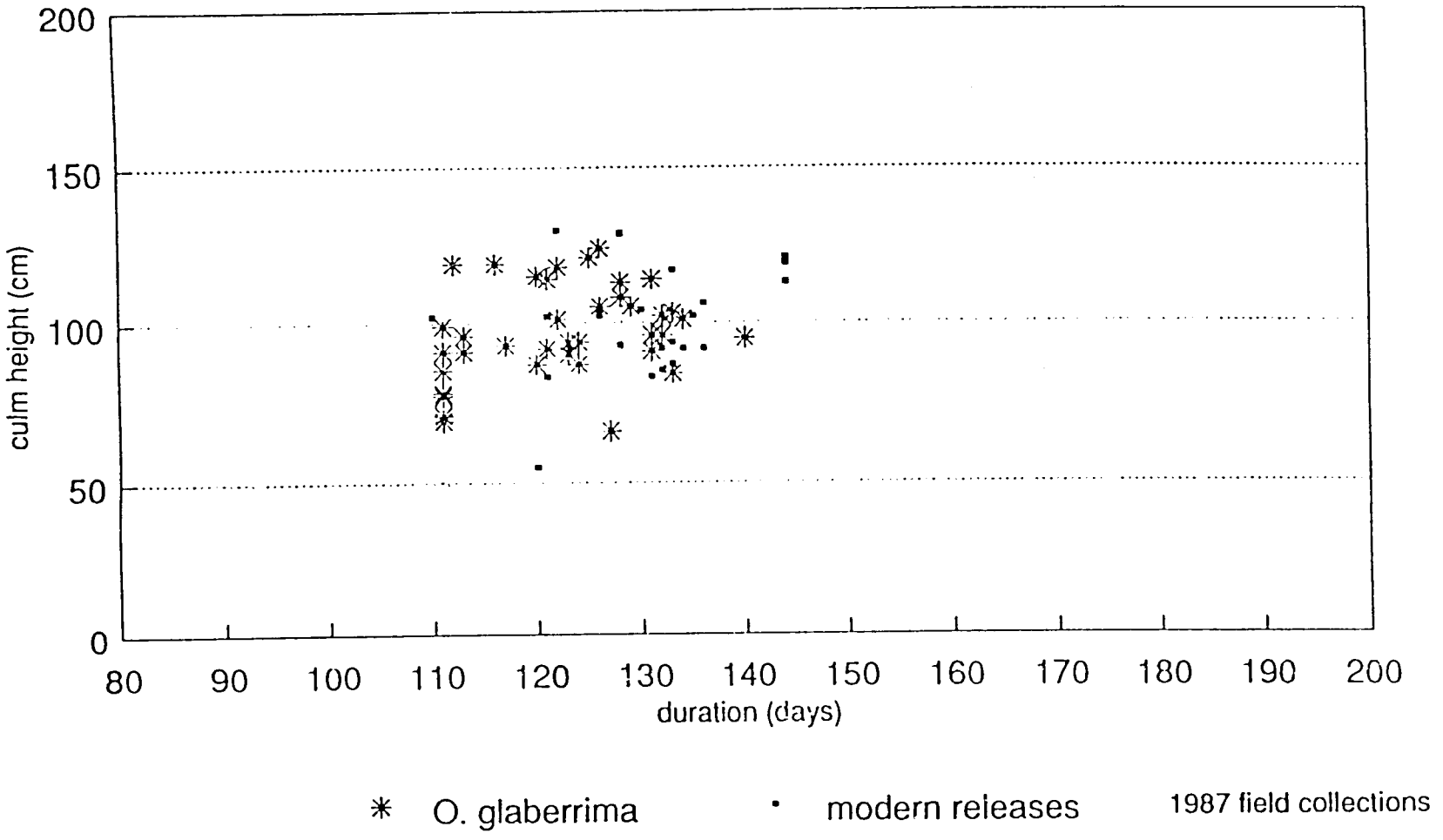

Figure 4. ***O. glaberrima*** **and modern types: height and duration**

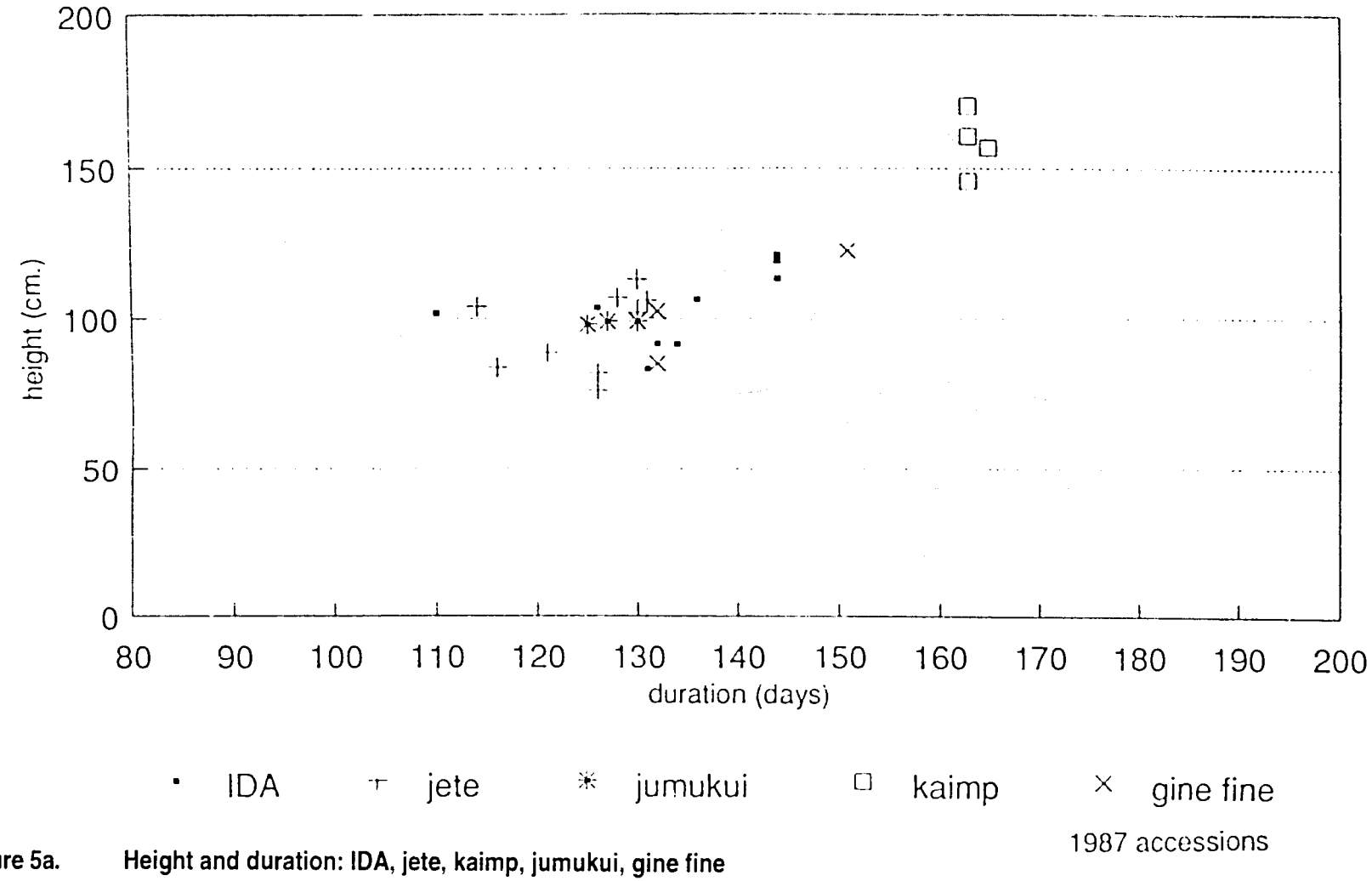

Figure 5a. **Height and duration: IDA, jete, kaimp, jumukui, gine fine**

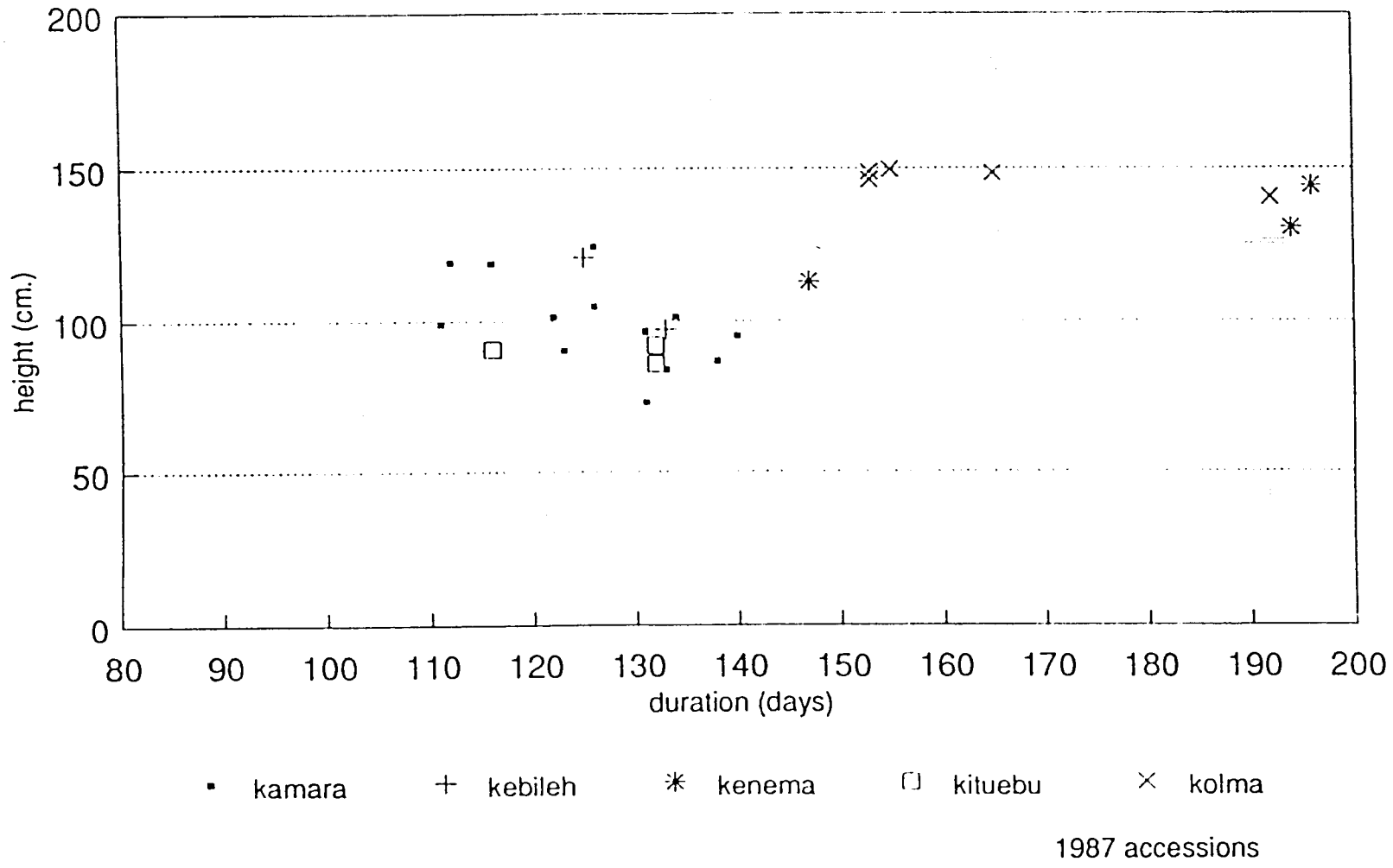

Figure 5b. Height and duration: kamara, kebileh, kenema, kituebu, kolma

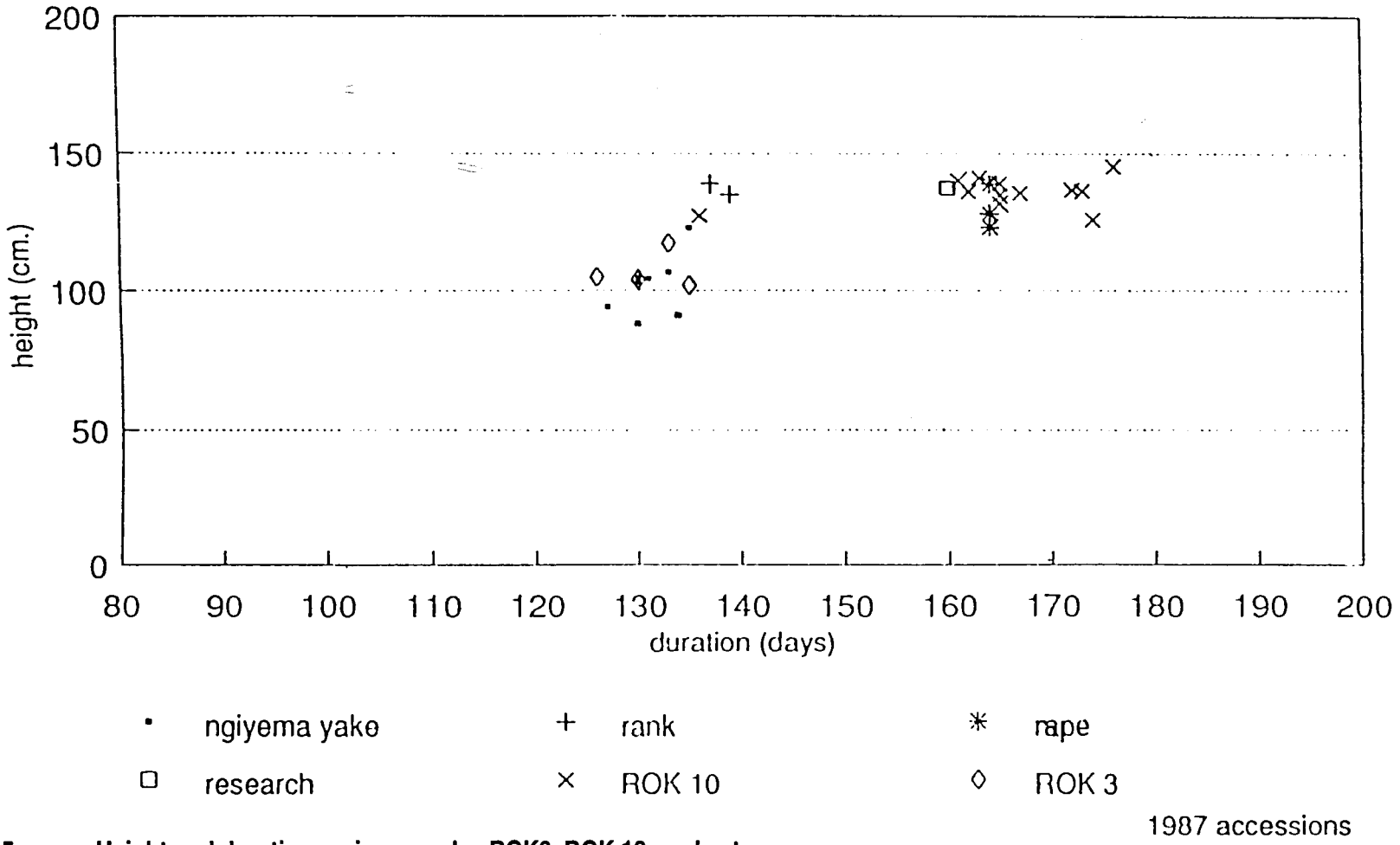

Figure 5c. **Height and duration: ngiyema yake, ROK3, ROK 10, rank, etc.**

Crop biodiversity in Africa: the need for social science inputs

Traditional agriculture has its own built-in conservation principles - according to Grist [1954, citing Kikkawa, 1912], Japanese farmers grew dwarf varieties for the "sake of curiosity" rather than for any practical value, long before breeders made systematic attempts to embody genes for dwarfing into high-yield, Green Revolution releases. Richards [1986] reports a Mende farmer in Sierra Leone continuing to grow an impractically small-grained variety, *kpengee* (literally, "something very small") because "it made him laugh". That material of potential use in scientific breeding programmes survives through farmers' curiosity and sense of the absurd, is a pointer to the importance of a systematic understanding of the role played by cultural and socio-economic factors in the on-farm management of local germplasm resources. The planning of crop germplasm biodiversity conservation in African countries, as yet only lightly affected by processes of agricultural modernization, requires a research partnership between biological and social scientists [Hodgkin and Ramanatha Rao, 1992]. In the particular case of Sierra Leone, where rice is a crop of ancient lineage and deeply interwoven with all aspects of rural social life, a systematic account of rice farming practices cannot be usefully separated from a fuller account of local material culture and social organization [Richards, 1986]. Such a situation is tailor-made, we would argue, for partnership between plant-breeders/agronomists and anthropologists. The present research aims to be a model instance of such collaboration.

Rice types and farming systems in Sierra Leone

A main method for growing rice on small-holdings throughout Sierra Leone is to make use of a range of soil moisture conditions to spread out labour requirements; labour shortage is the single most pressing constraint faced by small-scale rice cultivators. Many farmers group their rices into three major categories by duration: short (90-120 day), medium (130-150 day), and long duration (160-200 day) types. Typically, short-duration types are planted first on moisture-retentive (silty) soils in low-lying places (often river terraces) and are ready for harvest in the hungry season (July-September). Medium duration varieties are mainly planted on free-draining uplands when the rains are well set, and harvested October-November. Long-duration types (mainly flood-tolerant wetland types) are planted in water courses and inland valley swamps from July onwards and harvested December-February. Household dependents (married women and young men) have a particular affinity for the cultivation of these long-duration wetland types (the work is fitted in between other duties on the household farm) and much of the harvest, owned individually, is sold for cash. In some cases separate plots will be cultivated for rices in each of these three categories; in other cases households will seek to combine all their activities on a single piece of land stretching from hill crest to valley floor and combining moisture-retentive, free-draining and hydromorphic soils in catenary sequence. Typically, on a "traditional" farm about 10-15 per cent of land will be given over to short-duration rice grown for household subsistence and only ever sold under duress; 75-80 per cent will allocated to medium-duration rices, some to be reserved for household subsistence and some to be sold; and 5-10 per cent used for long-duration wetland types (known in Mende as *yaka*, lit. "handful", i.e. gleaning [?]) the bulk of which will be sold.

This pattern of cultivation has a documented history reaching back to the 17th century [Richards, 1992b] and still today provides the framework within which farmers group and classify their germplasm resources. The precise balance of emphasis between the three major categories of rice types, however, changes from place to place according to topography, population pressure and penetration of market forces. Farmers in the zone of ancient riverine deposits (below the main escarpment that divides Sierra Leone NW-SE) have much greater expanses of moisture-retentive soils suited to the reliable cultivation of

short-duration rices than elsewhere in the country, and centres such as Bumpe Chiefdom (Bo District) are noted for the diversity of their germplasm resources in this respect. In parts of the north-west of the country where uplands are degraded through heavy over-use and invasion of savanna grasses, and in parts of the south and east where cocoa, coffee and oil palm have begun to take up much of the better dryland soils, there has been a steady expansion over the last fifty years in the amount of rice grown in inland valley swamps. In most cases the main rices in inland valley swamps are long-duration tall types (including the Rokupr release, CP4, perhaps the most widely adopted research variety in Sierra Leone), grown with a minimum of water control. However, in areas along roads and close to towns some short-duration, short-straw, high-yielding varieties of the Green Revolution type are now grown in water-controlled paddies developed by a number of development agencies since about 1970.

The major exceptions to the pattern just described are the three specialist ecologies in Sierra Leone where rice has been developed as a cash crop (in areas where land is unsuited to any other forms of cultivation). These are the estuaries around Rokupr, where rice is grown on mangrove soils prone to acidification upon drying but kept moist by daily tidal incursions; the area behind Turner's peninsula, where floating rices are cultivated in deep-flooding riverine grasslands; and the bolilands, an area of impoverished and seasonally-flooded grassland soils at the foot of the northern half of the main Sierra Leone escarpment. Each of these areas has been opened up to extensive rice cultivation only within the last 50-100 years, and locally-adapted germplasm (often associated with special cultivation techniques, e.g. ultra-short duration rices grown on the rising flood in the riverine grasslands) mingles with specialized exotics dating from the colonial period (e.g. salt-tolerant varieties in the mangrove zone and floating rices in the riverine grasslands). Even in these three specialized rice-growing environments, however, small-scale farmers struggle to secure a repertoire of adapted varieties of different durations to spread their labour burdens. This is an alternative, in the boliland and riverine grasslands, to the expensive and unreliable mechanization otherwise necessary to cope with intractable soils and a very short cultivation season.

Patterns of rice germplasm use in 1987

A 1987 national sample study [Lipton *et al.*, 1992] attempted to discover:

- the main varieties in use on c. 600 farms in all major rice growing ecologies in Sierra Leone;
- how these varieties were used (e.g. whether they were planted early or late, and on which soils);
- what role was played by research releases; and
- the extent to which research varieties were displacing local selections.

The main types encountered were collected and grown in observation plots at Rokupr, in 1988, to determine principal growth characteristics. They have now been provisionally grouped and classified according to species (based on judgements about ligule, panicle form and grain type), duration (from germination to 50 per cent flowering) and culm length. All samples were grown under uniform conditions in one of two observation plots according to whether farmers considered them wetland or dryland types (about 10 per cent were wrongly classed and failed to mature). Farmers also supplied information about the source, date of first adoption of their current varieties and reasons for abandoning types grown previously.

In addition to this sample survey, detailed germplasm inventories were taken in two villages where the "standard" upland-catenary farming systems prevailed; one, Mogbuama (Kamajei Chiefdom) on the forest-savanna transition and the other Lalehun (Gaura Chiefdom) a forest-edge settlement on the Liberian border (since affected by the rebel invasion). The Mogbuama inventory was part of a longitudinal study of farming practices and social organization begun in 1983 [Richards, 1986; 1992b].

Most farming households planted between two and six types of rice, chosen according to duration and suitability for specific soil or topographic conditions. Judging by local names assigned to farmers' types alone, a typical medium-size village of approximately 400-500 people divided into 80-90 farming households makes use of a total of 20 to 40 distinct types. Morphological inspection of grain characteristics suggests some (but not much) overlap in identity (i.e. single types bearing two or more names).

The regional picture is less easy to discern. Names remain fairly constant from village to village, at least within language provinces as most household members sampled had, as a mother-tongue, either Temne or Mende, the two most-widely spoken languages in the provinces of Sierra Leone. However, results from the observation collection show that height and duration sometimes varies quite significantly among samples of a single named type collected from different farms and in different villages (cf. Figs 5a-c). This confirms that farmers' selections in Sierra Leone are better thought of as phenotypic expressions (certain regularly recurring types) within broad landrace groupings than as approximations to true varieties. The issue of how such landrace groupings emerge, and whether landraces are being maintained or diffused, are questions for future research [see below, cf. Hodgkin and Ramanatha Rao, 1992].

The duration and culm height data do, however, broadly confirm what farmers told us about varieties and their use. The samples fall into the three broad duration categories discussed above (though the quickest rices are under-represented because the collection exercise was timed to coincide with the peak harvest season, October-February). The majority of wetland rices tend to be tall long-duration types [Figs 2 and 3]. *O. glaberrima* types tend to be a little quicker than the average modern upland releases. Hungry-season rices in the mangrove zone ripened in c. 150-60 days, as opposed to 175-200 days for other mangrove types, and so on. There were some clear cases of mis-identification by farmers, especially among research varieties (*CP4* and *ROK 3* are sometimes used as generic labels for any recently introduced variety) and in one case a single label, "IDA" (in honour of the World Bank, sponsor of the Northern Area IADP) was applied to two (or more) research varieties [Fig 5a].

In all, the 1987 accessions appear to comprise about 150 distinct types. Among the upland rices it is possible to distinguish a "Temne" group of rices from a "Mende" group: *O. glaberrima* types are more frequent and important in the Temne group, for example. The data to hand give little grounds for suspecting any major overlap between these two groups, except in cases where the name in question was an obvious transliteration or corruption of its Mende or Temne original. The selective pressures tending to group rice germplasm into landraces will be different in the heavily-forested south and east of the country and in the more heavily populated and drier northern and western parts of the country. Farmers close to the border between the two linguistic areas (e.g. Mogbuama) draw readily upon rices from both groups, but are apt to categorize them as "Mende" or "Temne" rice. Rokupr's success with pure-line selections ROK 3 and ROK 16 based on germplasm from Kailahun District (ROK 3 is the most widely used upland research release in Temne-speaking communities NW Sierra Leone) indicates that there may still be potential to accelerate the exchange of potentially useful varieties between these two apparently somewhat distinct germplasm provinces in Sierra Leone.

Farmers mainly acquire varieties through informal channels (from friends and kin locally, or in neighbouring villages) and typically (according to the results of the longitudinal study in Mogbuama) retain each selection for about five years (i.e. the turnover rate for varieties is about 20%/p.a., cf. Fig 6). Accidents, failures, change in circumstances (e.g. a change in farm site under shifting cultivation) and the desire to try something better are important among reasons for changing types. Most farmers experiment in a small way before committing themselves to a new and unfamiliar selection. Some farmers seek out new types by collecting adventitious introductions (e.g. varieties spread by birds or in animal droppings) or selecting off-types at harvest for further observation and experiment [Richards, 1986; 1992b].

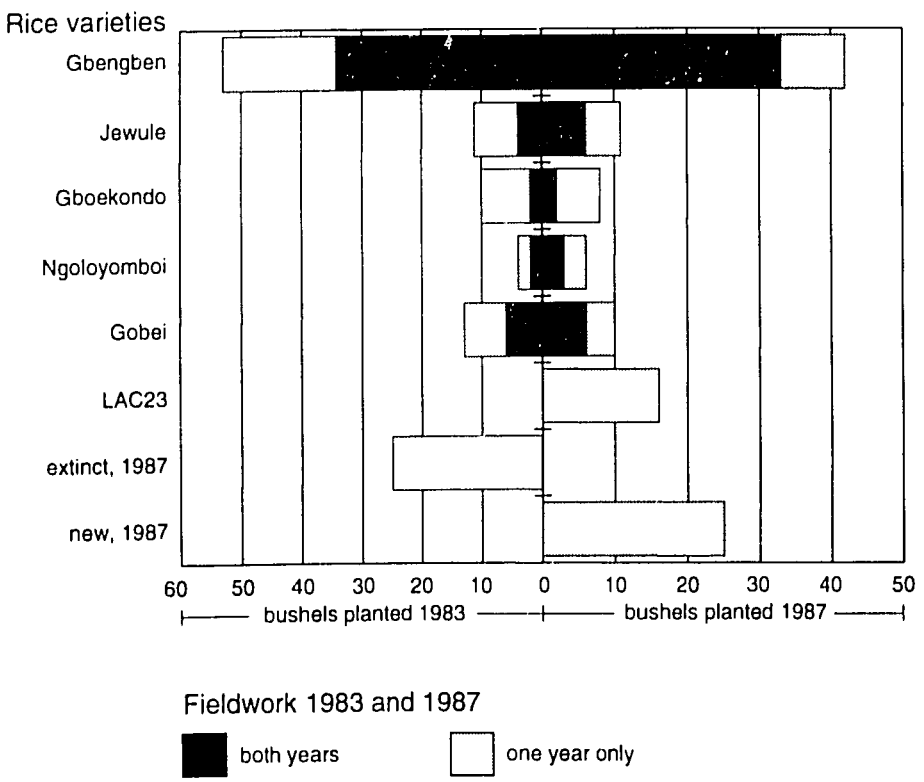

Figure 6 Turnover of rice types, Mogbuama: 52 farmers working in 1983 and 1987

Local opinion stresses the importance of maintaining a wide range of distinct types with different maturation periods suited to specific micro-environments. The need to spread labour requirements, secure food in the hungry season, motivate dependents and minimize risks, are among the main reasons given to justify such a wide range of choice. Some farmers set out deliberately to increase their options in particular directions. Mogbuama farmers have selected for a reduction of maturation period among the hungry-season rices planted on moisture retentive soils. The use of local varieties in the 125-day range has declined in the last ten years in favour of other local selections ripening in 115-120 days.

Research varieties are most common in specialized ecologies (e.g. the boliland zone) or on-road villages where development agencies have been active, but rarely do they account for more than a third of the total area planted in any given village [Lipton *et al.*, 1992]. Farmers readily add research varieties to their repertoire of planting choices but are reluctant to discard older selections. In part this is because the yield advantage of research varieties over local types is not great in the absence of regular and affordable supplies of

fertilizer. But it also reflects a perception on the part of poor households that there is strength in diversity. Despite high rainfall, farming conditions vary markedly from year to year (untimely rainfall often handicaps farmers in wetter areas and the late rains are increasingly unreliable in those parts of the country experiencing savanna incursions). Furthermore, rotational fallow farming involves moving to a regular succession of different sites and farmers retain a strong sense of the diversity of land types they will encounter from year to year. Experience teaches the value of keeping a large number of adapted types in play, to cover these contingencies.

Farmers rarely seek to conserve more seed types than are necessary to cover their immediate planting needs. When it becomes apparent that a specially adapted type might be advantageous, they rely upon being able to secure their choice through informal seed exchanges or by securing a loan in kind through family or friends. By custom, this involves repaying two bushels at harvest for every bushel borrowed in the planting season. This is not a commercial transaction since it barely covers the price swing between hungry season and harvest, or what the lenders might hope to make if they planted the rice themselves. It is best regarded as an element in the pre-market "moral economy" of village life [Richards, 1986].

The effectiveness and efficiency of these informal processes for keeping a range of adapted planting materials (including research varieties) in play at the local level is an important issue in urgent need of further investigation [see below].

Rice germplasm resources in Sierra Leone: a new approach

The 1987 germplasm survey was undertaken primarily to provide evidence on the adoption and impact of Rokupr releases. A new and more comprehensive study is now needed, building on some of the insights of this earlier study, in order to achieve four main objectives:

- identify trends in the national rice germplasm resource base;
- formulate a national rice germplasm biodiversity management and conservation strategy;
- assemble and conserve rare and threatened material (especially *O. glaberrima*, short-duration *O. sativa* types, and "hungry rice" [*Digitaria exilis*], a botanically unrelated species often used as an alternative to short-duration types in harsher environments); and
- assemble and evaluate farmer selections with potential for incorporation in a selection and breeding programme aimed at the needs of small-scale farmers in adverse or deteriorating conditions.

The first of these objectives (discussed in more detail below) is the key to the remainder, since it will involve a comprehensive attempt to characterize the rice germplasm resource base of Sierra Leone, to identify trends within it, and to analyse and understand the biological, environmental, socio-economic and cultural forces responsible for these tendencies. Geologists have long since assayed the gold and diamond resources of Sierra Leone. Similar attention has not been paid to the rice germplasm resource base. Yet it can be argued that rice is (at least) as important as minerals to the long-term well-being of the country.

The final objective also requires some further comment. The station intends to emphasize the needs of small-scale low-resource farmers in future breeding work in order to complement an historical (and continuing) emphasis at Rokupr on specialized environments of potential commercial importance. Emphasis in this proposed new breeding programme will be placed both on varieties that are tolerant of diseases (such as blast) and are capable of performing adequately under low fertility, and on strategic enhancement of the low-resource farmer's repertoire of planting choices (by, for example, releasing short-duration hunger-breaker varieties, or non-labour-intensive varieties suited to cultivation in women's swamps). This new programme is intended, of course, to complement, not replace, existing programmes for higher-resource environments. It consolidates on an innovative interest at Rokupr in recent years in, for example, screening for horizontal resistance to blast and studies to understand the comparative advantage of *O. glaberrima* types in low-fertility conditions [Monde *et al.*, 1991]. The assembly and evaluation of hardy farmer-selections from within Sierra Leone is a natural first step of proven value (e.g. earlier release of ROK 3 and 16 and current work on hardy and quick-ripening types identified from the 1984 and 1987-87 collections) in any such programme. As a more general point, we would emphasize our belief that, for a small under-resourced national research programme, conservation interests will be best served when breeders can see a direct and strategic link between germplasm collection activities and their own interests. Otherwise there is the danger that with *ex situ* conservation, "out of sight is out of mind".

It is also essential, here, to stress that the proposed study envisages an innovative combination of plant-science and anthropological/social-science fieldwork approaches. Conservation biologists have long recognized the important role of farmer selective pressure (under cultural and socio-economic constraints) in shaping, conserving or dissipating germplasm resources of cultivated plants, but major examples of research using the full range of modern social-science fieldwork methods and concepts of cultural analysis are hard to find, especially in Africa [Hodgkin and Ramanatha Rao, 1992]. This is a reflection of institutional constraints. The natural, comparative advantage for work of this kind lies with national agricultural research systems, where biological scientists often draw usefully upon participant knowledge of the local cultural setting. To fully capitalize on any such advantage there is need for formal training and expertise in cultural analysis. Where social scientists have been recruited by agricultural research stations, they have tended to be economists, or have tended to work within a universalist, socio-economic paradigm that treats local cultural factors as "externalities" incapable of coherent analysis. Also, socio-economists tend to be highly mobile internationally. Rokupr has found it difficult to recruit and retain such social scientists. It wishes to use the present possibility to rebuild socio-cultural analytic capacity among staff and associates, in order to service the needs of proposed programmes of on-farm, with-farmer research and other feedback and monitoring activities that assess the impact of its research innovations. The intention is to draw on the possibilities of a research link connecting staff at Rokupr, the Department of Anthropology at UCL (London) and the Danish Centre for Development Studies (Copenhagen).

Proposed research activities

1. Document and analyse farmer selective pressure on the national rice germplasm resource base. (Basic question: what kinds of natural and cultural selective pressures shape and group bodies of rice germplasm in Sierra Leone?). The work will include the following areas of analysis:

    - village-based case studies of planting and harvesting practices (including assessment of seed purity at planting and the extent to which panicle selection is

practised at harvest). Case studies will be chosen from "Temne" (NW, forest-savanna transition) and "Mende" (SE, high forest) germplasm provinces in SL, and compare communities where sickle- and knife-harvesting methods prevail. Data will be related to socio-cultural and socio-economic background.

- studies of the impact on the national germplasm resource base of seed storage and multiplication procedures, and changing formal and informal seed distribution processes. At what rate do farmers "lose" local types, for what reasons, and what are the consequences of such losses where the phenotypes belong to complex landrace clusters? How do we estimate what is being lost? What kinds of cultural factors (e.g. kinship links) are conducive or not to the *in situ* conservation of landrace materials?

2. Determine trends in the national germplasm resource base by means of:

   - repeating the 1987 survey (using the same basic methodology) to assess rates of change 1987-93/4 (e.g. rates of continued adoption of research varieties); and

   - analysing, specifically, the impact of war on germplasm resources in Sierra Leone; this will be based on surveys in war-zones, special investigations in Kailahun (if possible]), and a comparative re-survey of village germplasm case-studies (Mogbuama 1983, 1987 and 1993/4; and Lalehun 1989; 1993/4]).

3. Collect strategic germplasm (it is proposed to use volunteers from Earthwatch to cover collection bottlenecks). The work will involve the following:

   - assembling and analysing strategic germplasm resources, aggregated according to a "model" derived from the above analyses;

   - collecting germplasm in threatened environments and other salient or underexplored localities (e.g. scarp-foot zone around Bumpe; remote areas of Koinadugu District); and

   - paying special attention to cultivars identified by farmers as being especially useful in harsh and stressful conditions (e.g. short-duration types of *O. sativa*, *O. glaberrima* types; cultivars of *Digitaria exilis*).

4. Evaluate germplasm in laboratory or on research station. This will be done to:

   - incorporate new field collections in current screening programmes for low fertility, diseases (e.g. RYMV), iron toxicity, weed suppression ability, and to draw on accessions with valuable properties in subsequent breeding activities aimed at the needs of small-holder farm households in low-resource environments; and

   - follow up on recent advances in the classification of rice germplasm using techniques of molecular genetics (isozyme; restrictor DNA analysis). These techniques have not yet been used to test bodies of material aggregated according to predictions based on models incorporating relevant historical and socio-cultural analysis of seed selection and seed stock management. By so doing we hope to throw light on the character of rice "landraces" in West Africa and to develop a rational conservation strategy for West African landraces based on a firmer understanding of

how selective pressures from farmers, socio-economic trends (further spread of research varieties) and contingencies such as war, are currently impacting upon the region's germplasm inheritance.

Outputs

- a national rice germplasm conservation strategy;
- valuable accessions for the low-resource breeding programme at Rokupr; and
- an implemented germplasm bank at Rokupr.

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Ex Situ Conservation of African Crop Germplasm

E. N. Seme, P. W. Chahira and J. K. Kemel

Introduction

Rapid changes in land use, modernization of agricultural practices, adoption of new varieties possessing a narrow genetic base, and deforestation, etc., have led to the rapid disappearance of many landraces of cultivated crops and their wild relatives. Natural disasters such as desertification, drought and floods also contribute to genetic erosion. As a result of these pressures on the environment many plant cultivars have been threatened with extinction.

In view of the above, there is an urgent need to collect and conserve germplasm for use in crop improvement programmes in the years to come. *Ex situ* conservation is one of the ways of addressing this need. It refers to methods of conservation that entail the removal of germplasm resources (seed, pollen or the whole plant) from their original habitats or natural environments and preserving them in other environments in order to ensure their safety.

Ex situ conservation can include the use of botanic gardens, arboreta, genebanks etc. Botanic gardens and arboreta conserve living plants in their natural forms. Genebanks conserve seeds, pollen, parts of plants under conditions of modified temperature and humidity (tissue culture); or whole, live plants in field genebanks. Conservation at commodity level involves local communities maintaining samples of local cultivars at the farm level in gardens and stores.

The traditional African crops include grains (cereals and pulses), roots and tubers, vegetables, fruits, beverages, oils, fibres and forage or fodder crops. For each crop, different conservation methods are used at both the genebank and farm levels. Many of these crops are threatened with extinction because of one or a combination of various genetic erosion factors. Consequently, conservation priorities differ with each crop and locality.

Cereals and pulses

Many of the millets and sorghums are traditional African staple foods. They are threatened because, in many areas, people's eating habits have changed in favour of other crops, including introduced high-priced cash crops and improved cultivars. This places millet and sorghums as high priority for conservation. Many of the traditional cultivars need to be collected and conserved under long-term storage conditions in genebanks. At farm level, farmers need to be educated about the importance of genetic resources and encouraged to maintain viable stocks of seed of every cultivar available in each locality.

Pulses include field beans, pigeon peas, cowpeas, Lima beans, grams, etc. Their conservation methods are similar to those of the grains.

Root and tuber crops

Many of these crops, such as cassava, sweet potato and yam, are propagated either as tuber or root cuttings. They have to be maintained as living plants in field genebanks or small

plantations at farm level. These crops are regarded, in many communities, as "hard time" crops in that they are grown when conditions are unfavourable for other crops. They tend to be displaced in high potential areas by introduced, high-priced and high-yielding crops. Because of population pressure in high potential areas there is human movement from those areas to marginal lands. Root and tuber crops play a major role in human diet. It is therefore important to collect and conserve them for use, especially in marginal lands where they thrive better than do high-input, introduced crops.

Traditional vegetables

The use of traditional vegetables varies from one locality to another. The majority can be conserved as seed, in genebanks or on farms. In many communities traditional vegetables, such as pumpkin, are grown in kitchen gardens and can be preserved by continuous planting. Also, a substantial number of species grow in the wild as weeds (e.g. black night shade, *Amaranthus*); they need to be collected and conserved in genebanks.

Fruits

Many African fruits grow wild or are partially domesticated (e.g. gooseberries) while many introduced tropical and temperate fruits have become localized and can be considered as landraces. Examples of the latter include mango, citrus, papaya, plum and pear. The wild species are threatened by deforestation, changes in land use and changes in the way of life of many communities. Some fruits have recalcitrant seeds and cannot be conserved under cold storage conditions. Such fruit trees can be conserved in field genebanks or under *in vitro* conservation conditions. Fruits bearing orthodox seed can be conserved as seeds in genebanks or at farm level. The growing of fruit trees in orchards could also serve as a conservation method.

Oil and fibre crops

Some oil crop plants, e.g. *Vernonia galamensis*, have not been domesticated and many indigenous fibre plants are only partially domesticated, e.g. *Urena lobata*, *Hibiscus cannabinus*. All need to be collected and conserved. Of the introduced fibre and oil crops, many have adapted fairly well to our local conditions, e.g. cotton, sunflower and sisal. The majority of these crops are conserved in genebanks.

Beverages

Coffee is of African origin, while tea and cocoa are introductions which have adapted well in some regions in Africa. In this country, coffee and tea genetic resources are maintained in field genebanks Wild relatives of coffee need to be collected and conserved.

Forage and fodder crops

Kenya is a centre of diversity of many forage grasses and legumes. However, most of these plants have not been collected. The few that have been collected have played a major role in the improvement of forage biomass production in both the Americas and Australia. Unless collecting efforts are stepped up to save the genepool that is still in the wild, we are

likely to lose the materials. The majority of the forage germplasm is conserved in genebanks as seeds.

Constraints in conservation

Genebanks are central points where germplasm is conserved. They are always prone to calamities such as fires, earthquakes, floods and acts of war. Breakdown of equipment and lack of spare parts increase the risks to the conserved germplasm. Also, financial constraints limit genebank activities such as collection and the number of conserved species in field genebanks. Limited expertise and human resources reduce the effectiveness of a genebank.

Conservation at farm level has also shown weaknesses in some parts of this country. If, for example, farmers in higher potential areas were asked to spare some areas for conservation purposes they would find it extremely difficult to do so, for socio-economic reasons, without some type of compensation. Also some sectors that are highly knowledgeable, such as the scientific communities, often unconsciously play a major role in the loss of our genetic resources. We have in mind end users, including breeders, who evaluate certain accessions of germplasm for a certain trade and if these accessions do not measure up to the expectation of the end user, the accessions, more often than not, are discarded. This is a loss of germplasm that could otherwise be very important and useful. It is the responsibility of genebanks in developing countries to make sure that conservation of germplasm is stepped up. It is not possible for the few end users to identify the total usefulness of any given accession.

Conclusion

Many of the African traditional crops are disappearing at a very fast rate both under cultivation and in the wild. Efforts, to collect and conserve these, need to be stepped up. Also, duplicate accessions need to be maintained in other locations by the genebanks. There is need to educate farmers and the extension agents of the need to conserve germplasm at farm level. Coordination of germplasm-conserving agents needs to be strengthened at all levels to avoid duplication of efforts.

Potential for Agronomic Improvement of Indigenous Plant Germplasm in African Agriculture - A Case Study of Indigenous Vegetables in Kenya

J. Chweya

Introduction

Agricultural development and cultivation in much of sub-Saharan Africa was, until recently, based upon two foundations. The first, had an emphasis on subsistence crops and edible weedy species and the second, on the cultivation or utilization of a wide diversity of food crops whose total number of species is among the largest in any region of the world [Martin, 1984; Leaky and Wills, 1977; Tindall, 1977]. With colonization and settling of the Europeans, a third foundation was added: one based on cash crops (for raw materials that would be exported to Europe) and exotic crops (for consumption by the settlers).

The emphasis on subsistence agriculture in much of Africa requires that all families grow or collect almost all of their food needs. For this type of agricultural system to be successful the stability of total crop yield is a must. This was achieved in Africa by developing a wide diversity of food crops, including both cultivated and weedy species, grown in mixed cropping systems. The mixed cropping agricultural system with many crops growing in the same fields, supplemented by the harvesting of weedy species, provides a higher degree of stability than does cultivating only a few food crops. In a mixed- or multi-crop subsistence system, each crop species has different growing requirements at different times of the growing season thus buffering any environmental stresses. This agricultural system has also been shown to reduce soil erosion and improve soil fertility [Martin, 1984]. The wide diversity of crops used includes, depending on the locality, several important cereals, roots and tubers, legumes and many vegetable crops [Harlan *et al.*, 1976; Martin, 1984; Tindall, 1977; Prescott-Allen and Prescott-allen, 1990].

Indigenous vegetables

Vegetables, especially leafy types, play an important role in African agricultural and nutritional systems [Keller *et al.*, 1969]. Okigbo [1983] lists over 160 endemic vegetables used in one small area in West Africa and Chweya [1985] and Juma [1989] list several leafy vegetables used in Kenya. Table 1 gives a list of some commonly used Kenyan leafy vegetables. These vegetables play an essential role in maintaining the nutritional well being of local rural populations [Keller *et al.*, 1969; Abe and Imbamba, 1977; Gomez, 1981; Chweya, 1985]. These vegetables supply much, if not most, of the population's required vitamins (especially A, B's and C), minerals fibres, carbohydrates and proteins [Ruberto, 1984; Martin, 1984; Okigbo, 1983; Chweya, 1985; Platt, 1965; Imbamba, 1973a; Schmidt, 1971]. To date, however, the limited agronomic research on subsistence crops has usually concentrated on determining the major starch source (grains and tubers) and/or legumes and has ignored the other vegetables [Hawkes, 1983; Dunbar, 1969; Brush, 1986, 1989; Prescott-Allen, 1990].

Table 1. Some of the commonly used Kenyan leafy vegetables

Species	Family
Gynandropsis gynandra	Capparidaceae
Crotalaria brevidens	Leguminosae
Corchorus olitorius	Tiliaceae
Amaranthus spp.	Amaranthaceae
Solanum nigrum	Solanaceae
Asystasia schimperi	Acathaceae
Vigna spp	Leguminosae
Cucurbita spp.	Cucurbitaceae
Basella alba	Basellaceae
Oxygonum sinuatum	Polygonaceae
Commelina spp.	Commelinaceae
Brassica spp.	Cruciferae
Erucastrum arabicum	Cruciferae
Chenopodium album	Chenopodiaceae
Erythrococca bongensis	Euphorbiaceae
Triumfetta annual	Tiliaceae
Lagenaria vulgaris	Cucurbitaceae
Portulaca quadrifida	Portulacaceae
Tribulus terrestris	Zygopphyllaceae
Bidens pilosa	Compositae
Galinsoga parviflora	Compositae
Launaea cornuta	Compositae
Oxalis latifolia	Oxalidaceae
Cucumis spp.	Cucurbitaceae

Sources: Imbamba, 1973a; Keller *et al.*, 1969; Terry and Michieka. 1987; Juma, 1989; Chweya, 1990; Opole *et al.*, 1991.

Agronomic development

Conventionally, the relative importance of a crop is assessed by its total recorded yield or total sales. Unfortunately, the value of a crop, with respect to the nutritional contribution that it makes to a population, is usually ignored. Therefore subsistence crops, especially vegetables, which almost always lack documentation on their total yield and are rarely sold in the markets, are almost always classified as "worldwide minor" crops. Subsequently, these species have been given a low priority in most agronomic research and development programmes [Brush, 1989; Prescott-Allen and Prescott-Allen, 1990; Altieri and Merrick, 1987; Brown, 1983; Ruberto, 1984]. Very little is known about many of these vegetables in terms of indigenous knowledge of utilization, let alone appropriate cultivation techniques, the extent and structure of genetic variation and potential for crop improvement via selection or breeding. Very few systematic studies in any area have been conducted on these species and few, if any, systematic germplasm collections have been made [Martin, 1984; Tindall, 1977].

People in a traditional African community have a unique understanding and interpretation of their surroundings. This includes an understanding of the crops and weeds that are used

for food and medicine and their relationship to the environment. This unique understanding and interpretation has led to the ability of these people to cope in a harsh and unpredictable environment. Elders, in these communities, are the "banks" of information on identification, utilization, beliefs, growing habits, cultivation requirements, harvesting, nutritional value, fruiting and other information on edible indigenous plants. The indigenous knowledge has traditionally been passed on from the elders to their children. Unfortunately, with the present process of modernization, this information is slowly disappearing. It should be collected and scientifically evaluated for its national and global exploitation.

The major agricultural problem faced by most African countries is that of integrating and balancing the need to feed their populations with the need to develop commercial crops for domestic and export markets. Current conventional methods of increasing food production in Africa follow one or other of two approaches. Firstly, cultivating high yielding varieties of cereals or other starch sources in a monoculture system, often with many and costly inputs. Secondly, by expanding the area under cultivation. Both approaches have proved, under certain conditions, to be extremely successful but at times have led to major ecological and/or economic problems. The second approach often leads to cultivation of virgin marginal lands of low fertility or destruction of the wild and/or weedy habitats surrounding farms [Hawkes, 1983].

A complementary approach for increasing productivity and improving nutrition, is to improve the productivity per unit area of land of the traditional subsistence crops. This has recently been applied in some areas where subsistence farming is very important [Altieri and Merrick, 1987; Oldfield and Alcorn, 1987; Brush, 1986]. It has been shown that these crops, especially the leafy species, when grown under appropriate agromanagement can effectively provide, often at low input levels, the minimum nutritional balance needed by the local populations [Hawkes, 1983; Schmidt, 1971; Prescott-Allen and Prescott-Allen, 1990].

Agronomic potential (Kenya)

One of the most efficient methods of improving the yield and nutritional value of subsistence crops is to improve the landraces or weedy species being grown, through selection and/or breeding. This should be combined with developing more efficient agromanagement systems with minimum, but appropriate, input application. In order to accomplish this, genetic stocks must be available for evaluation and analyses and basic biological, ethnobotanical and agronomic information, should be known. Unfortunately, no systematic genetic collections have been made in indigenous vegetable crops and very little research on their agronomic potential has been conducted. In addition, due to the dynamics of African development, combined with increased population size, serious genetic erosion is occurring in these crops and potentially valuable germplasm may be permanently lost [Mendlinger *et al.*, 1992]. The importance of plant genetic resources from primitive landraces and weedy crops cannot be under-emphasized in safeguarding and maintaining the need for increased crop production. Genes that are important for breeding to improve yield and quality parameters have been found repeatedly in landraces and weedy types [Harlan *et al.*, 1976].

Work done in Kenya [Opole *et al.*, 1991] has shown that most indigenous plants are normally adapted to local environmental conditions. The plants may be tolerant/resistant to pests and diseases and since they are found in the wild and/or growing as weeds, they could be intercropped easily. Traditionally, indigenous vegetables are known and popular. Therefore, promoting their consumption in the rural areas may be easier than promoting use

of exotic types which are expensive to grow or buy as they require advanced agrotechniques. At present, mainly exotic vegetables are found both in rural and urban markets. Because they are expensive, most rural populations are not consuming green leafy vegetables. Opole *et al.*, [1991] have observed that indigenous vegetables may require minimal labour and management and very little land for domestic cultivation. For example, a home garden of about $6m^2$ is adequate for producing vegetables for a household's consumption.

Preliminary study by the author has shown that leaf yields of indigenous green leafy vegetable plants could be as high as, or compare well with, exotic types [Table 2]. Most of the indigenous species, especially *Solanum nigrum*, *Amaranthus* spp. and *Corchorus olitorius*, may be harvested severally, as required, for up to four months, while a plant like *Basella alba* is perennial.

Table 2. Fresh leaf yields of some Kenyan leafy vegetables

Species	Yield (Tonnes/ha)
Indigenous:	
Gynandropsis gynandra	10
Solanum nigrum	30
Amaranthus spp.	45
Corchorus olitorius	7
Basella alba	50
Exotic:	
Beta vulgaris	10
Latuca sativa	10
Brassica oleracea var. acephala	20
Brassica oleracea var. capitata	26

The same study has shown that indigenous vegetables are as nutritious, or more so, than exotic ones [Table 3]. The vegetables can supply enough of the vitamins and minerals required for good human nutrition. Table 4 shows the contribution (as a percentage) to recommended daily allowances (RDA) of vitamins A and C, calcium and iron, for adult males or females, from some of the vegetables under study. The vegetables can supply more than the required amounts of vitamins A and C. However, the vegetables are cooked before consumption and this may reduce the percentage of the RDA substantially. For example, cooking of most of the vegetables reduces the percentage of the RDA for vitamin C by 60% [Imungi, 1989]. Indigenous vegetables may contribute greatly as sources of protein. The protein is high in lysine content [Table 5]. Although the vegetables are good sources of micro-nutrients, they commonly contain anti-nutrients such as phenolic compounds, nitrates and oxalates. In *Solanum nigrum* and *Amaranthus* spp. the levels of nitrates have been reported to range from 156-4 000 mcg/100g fresh weight and 84-98 mcg/100g fresh weight, respectively; levels of tannins for the same species have been reported to range from 40-50 mcg/100g fresh weight and 10-17 mg/100g fresh weight, respectively [Imungi, 1989].

Table 3. Nutrient contents of some Kenyan leafy vegetables (per 100g edible portion)

Species	Protein (g)	Vitamin A (mg carotene)	Vitamin C (mg)	Calcium (mg)	Iron (mg)
Gynandropsis gynandra	5.4-7.7	6.7-18.9	127-177	434	11
Solanum nigrum	3.2-4.6	2.7-7.9	37-141	215	4
Amaranthus spp.	4.0-4.3	5.3-8.7	92-159	800	4
Crotalaria brevidens	4.2-4.9	2.9-8.7	115-129	270	4
Corchorus olitorius	4.5-5.5	3.9-5.4	170-204	270	8
Brassica spp.	3.6-3.8	3.7-5.7	102-142	520	6
Cucurbita spp.	3.1-4.2	2.4-5.3	170-172	40	2
Spinacia oleracea	2.3-3.1	2.8-7.4	1-59	60-595	1-5
Brassica oleracea var. capitata	1.4-3.3	Tr-4.8	20-220	30-204	1-2
Latuca sativa	0.8-1.6	0.2-7.8	3.33	17	1.4

Source: Imungi [1989].

Table 4. Percent contribution to recommended dietary allowance (RDA) of vitamins A and C, minerals, calcium and iron from consumption of 100g of leaves of some indigenous leafy vegetables by a normal adult male or female

Vegetable	% RDA (raw leaves)			
	Vitamin A	Vitamin C	Calcium	Iron
Gynandropsis gynandra	196	437	56	80
Solanum nigrum	122	210	27	34
Amaranthus spp.	170	320	100	34
Crotalaria brevidens	131	420	32	28
Corchorus olitorius	113	521	32	56
Cucurbita spp.	110	467	5	17
Vigna spp.	150	260	110	35

Source: Imungi [1989].

Table 5. Lysine content of some Kenyan leafy vegetables

Species	Lysine content (mg/g N)
Crotalaria brevidens	262
Corchorus olitorius	168
Amaranthus lividus	330
Gynandropsis gynandra	245
Cucurbita spp.	204
Vigna spp.	273
Solanum nigrum	258

Source: Imbamba, [1973b].

In collaboration with the Genebank of Kenya, the author has systematically collected over one hundred accessions of pumpkins (*Cucurbita moschata*) from several parts of Kenya. Preliminary evaluation of fruit weight and constituents has shown that there is great variability between the accessions [Table 6]. This implies that there is scope for selecting for higher yields and better fruit quality.

Conclusion

Indigenous vegetables have a direct role to play in improving the nutrition and diets of rural populations in Africa. These people are usually the last to receive food supplementation and aid during times of food scarcity. It is, therefore, important that programmes are implemented to increase yields and the nutritional quality of those traditional crops that are used at the present time by the rural people.

Such programmes would widen and buffer the food base for rural populations and help ensure a stable and nutritional food source. It is imperative that the germplasm of these crops be systematically collected and evaluated for agronomic and nutritional traits.

Table 6. Fruit constituents in 33 accession lines of pumpkins collected in Kenya, (n=5 in most lines).

Accession line	Fresh wt. (kg.)	Dry wt. (% fr. wt.)S	TSS (%)	Reducing sugars (mg/g fr.wt.)
6112	2.40	13.1	7.5	6.1
6111	1.48	12.5	8.1	8.6
6114	1.38	12.7	5.9	5.1
6115	1.66	13.5	5.9	4.9
6143	1.33	13.0	5.7	4.1
6145	1.44	17.9	6.6	4.1
6495	2.99	13.4	10.3	11.4
6123	1.48	12.7	8.7	10.8
6124	1.60	12.0	4.0	3.1
6125	1.83	12.5	4.8	4.2
6126	1.84	12.0	4.3	4.0
6116	2.02	11.9	4.4	3.9
6128	3.79	15.4	6.8	7.6
6130	1.95	15.0	8.0	8.3
6131	1.17	14.3	5.2	4.9
6136	0.94	14.8	6.7	7.3
6137	1.52	12.9	8.1	8.9
6132	0.84	13.5	8.0	8.1
6140	1.81	13.0	7.3	8.9
0036	1.46	20.0	9.0	10.4
0037	1.90	18.8	12.4	10.8
6101	9.20	2.1	9.2	9.0
6096	10.20	1.92	10.2	10.3
6098	6.30	1.61	6.3	3.9
6091	5.30	1.15	5.3	3.4
6165	5.40	2.25	5.4	5.0
6149	8.10	1.07	8.1	9.7
6150	8.00	2.22	8.0	9.7
6151	8.70	1.47	8.7	10.0
6161	13.70	3.49	13.7	14.5
6160	9.40	2.26	9.4	11.8
6157	10.40	0.87	10.4	11.1
6159	7.70	1.97	7.7	9.1
LSD	0.75	2.2	2.4	3.7

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Local Management and Use of Plant Genetic Resources

J. J. Hardon and W. S. de Boef

Introduction

Plant genetic resources

Plant genetic resources (PGR), in the context of this paper, are that part of the overall biodiversity of present and potential relevance to the improvement of plants useful for socioeconomic development [Hardon *et al.*, 1992]. Hence, conservation of PGR is complementary to activities aimed at conserving overall biodiversity and includes all agricultural crops, fruit, nut and forest trees, medicinal, aromatic and ornamental plants, unexploited plants of potential value and their wild and weedy relatives.

In the classification of the FAO International Undertaking on PGR the following types of material are recognized as part of PGR:

1. commercial varieties (cultivars);
2. obsolete, current and newly developed varieties;
3. elite and breeder lines, as available;
4. landraces (traditional or "folk" varieties);
5. wild and weedy species; and
6. special genetic stocks.

The loss (i.e. extinction) of PGR is caused by a multitude of factors, the most notable being the replacement of farmers' locally adapted varieties (landraces) by the more uniform so-called "high-yielding" (HYV) or "modern" (MV) varieties produced by public and private sector breeding programmes. Concern over genetic erosion has led to the establishment of *ex situ* genebank programmes with the objective to conserve, not only materials of direct relevance to ongoing breeding, but to maintain in long-term storage a reasonable sample of all available plant or crop genetic diversity. Especially the first four above-mentioned types of material (1-4), are conserved in genebanks. At the same time, local initiatives to save and maintain valuable genetic diversity have been launched by non-governmental organizations and private individuals throughout the world. Wild and weedy species related to crops (6) can be conserved in a system of *in situ* management of PGR in their natural or original habitat.

In many areas of the tropics and subtropics, especially in areas with marginal conditions and resource-poor farmers (RPFs), landraces still are an integral part of the farming system. The local PGR are maintained in a dynamic system with continuous human (farmers') selection and environmental adaptation. This is in contrast to the *ex situ* conservation effort in which PGR are maintained in a static system where human selection and environmental adaptation are reduced as much as possible. However, RPF families and communities are the custodians of pools of important germplasm of many crops, especially those of local importance, in the dynamic system which we introduce as "conservation-through-utilization". The primary goal of RPFs is food production in a risk-reducing

sustainable manner. Local diversity is an integral part of that strategy, though the conservation of that diversity is not the principal aim.

PGR and biodiversity

There is a growing realization that, where diversity in agriculture is concerned, human activities contribute considerably to the growth in genetic diversity through recombination and selection [Brush, 1982; Altieri and Merrick, 1987]. Man created environments where plants evolved under selective pressures that differed from those occurring in environments only marginally-, or un-disturbed by people. Farmers develop different approaches to agriculture for different environments, adding to variation in selective pressure [Richards, 1985].

Plant genetic resources are a critical portion of global biodiversity. Single well-known mammals (e.g. panda's) and species-rich ecosystems (e.g. tropical rainforests) under threat of extinction or destruction are more evident in the public debate on biodiversity than is loss of plant genetic diversity. The survival of a species receives more attention than does the protection of diversity within species. In the long term, however, the diversity within species is the key to their survival in nature. Within species diversity is a major concern in PGR programmes for crop species.

Threats to PGR

The WRI/IUCN/UNEP (1992) global strategy on biodiversity lists six fundamental causes for the loss of biodiversity:

- the high rate of human population growth and unsustainable natural resource consumption;
- legal and institutional systems that promote unsustainable exploitation;
- the steadily narrowing spectrum of traded products from agriculture, forestry, and fisheries;
- economic systems and policies that fail to value the environment and its resources;
- inequity in the ownership, management and flow of benefits from both the use and conservation of biological resources; and
- deficiencies in knowledge and its application.

The threats to the security of crop genetic resources have increased dramatically in the last two decades. Four issues directly relevant to programmes dealing with biodiversity, particularly PGR, are:

1. Demographic pressure has started to take its toll on ecosystems diversity. Population leveis have forced the transformation of relatively undisturbed areas, into agricultural land. This is especially threatening to the diversity in the centres of origin of various crops. Often *in situ* conservation efforts are perceived by local communities as being in conflict with their economic survival. This emphasizes the critical importance of developing partnerships with the people living in the centres of biological diversity. *In situ* and community-level conservation efforts,

therefore, should be linked with peoples' - and rural development [Altieri and Merrick, 1987; Brush, 1991].

2. Disease and pest epidemics in monoculture areas with the same genetic origin of crops have indicated that genetic vulnerability to biotic and abiotic stress is significant in monoculture and can best be overcome through genetic diversity of plants. This threat was illustrated dramatically by the southern corn leaf blight epidemic in the United States in 1969-1970 [Adams, *et al.*, 1971].

3. Participation of a continuously growing number of farmers in the global exchange economy transforms local agricultural systems because it forces farmers' families to become competitive with others. Encouragement of the application of external inputs to modern agriculture eliminates any remaining regional difference in selective pressure [Norgaard, 1988]. Economic forces push the farmers towards environmentally less sound and less adapted modes of agricultural production, including fewer regionally-adapted crops. They thereby force the farmers in a direction which has direct consequences for the genetic, species and ecosystem components of biodiversity.

4. Future prospects for maintaining global and regional food security are undermined by the degradation of the environment and the potential changes of climate. A response to this requires advances in crop productivity while developing ecologically sustainable agricultural systems. Agricultural research can neither sustain the food security systems at the global and regional levels nor respond to climatic change and rises in sea levels if the international community fails to conserve PGR and utilize them effectively [SAREC, 1992].

PGR conservation strategies

Within the last two decades, attempts have been made to develop a global plant genetic resources system on four levels: local, national, regional and global. PGR conservation efforts can be carried out in various ways [Keystone Centre Report, 1991]:

- *ex situ* conservation in genebanks (as seed, tissue, or pollen), in field genebanks, or in other live collections;
- *in situ* conservation in natural or original habitat; and
- local/community conservation.

Ex situ conservation

This conservation strategy involves collection, storage, regeneration, documentation and information systems, evaluation and enhancement. It has been set up at the national (NARS) and international (IARC) levels. Genebanks are part of an agricultural research system primarily focused on the development of better crops, with an emphasis on increasing yield. Maintaining sustainable production and adaptation to specific environments have, so far, received less attention [Plucknett *et al.*, 1983]. The individual genebanks are part of an international network coordinated by the IBPGR. Germplasm accessions, varying from cultivars to landraces and wild relatives of major crops, are collected from their native habitats and the seed or vegetative material is stored in genebanks, or placed in

breeding collections, for evaluation and potential use. *Ex situ* conservation has facilitated the availability and use of germplasm for the improvement of a variety of crops [Frankel and Bennett, 1970]. It does not provide a panacea for conserving natural sources of crop genetic resources [Oldfield, 1984] since it extracts the genetic diversity component from the other levels of biodiversity (species, ecosystems and human cultural). A major problem of *ex situ* conservation is that seed storage freezes the evolutionary process by preventing the evolution of new types or levels of adaptations or resistance [Simmonds, 1982], and even places the conserved germplasm, during regeneration out of the original cultural-ecological context, under a selective pressure of the foreign environment [Nabham, 1985]. However, *ex situ* conservation is certainly an essential element of the total strategy of conservation of PGR [Keystone Centre Report, 1991].

In situ conservation

In situ conservation links conservation at the species level of biodiversity with the ecosystem level. A number of scientists have emphasized the need for *in situ* conservation of crop genetic resources and the environments in which they occur, since it allows for the continued, dynamic adaptation of plants to the environment [Nabham, 1985; Prescott-Allen and Prescott-Allen, 1982; Wilkes, 1983]. This conservation strategy may be particularly important in areas farmed by traditional methods, where crops are often enriched by gene exchange with wild or weed relatives [Harlan, 1965]. On the negative side it is argued that, in the absence of controlled monitoring, security is low. Natural habitats are lost and replacement of landraces, by other landraces and modern varieties, takes place as a normal part of cropping systems. Several approaches to *in situ* conservation have been suggested. Nabham [1985] suggested large systems of village-level landrace custodians whose purpose would be the continued cultivation of a limited sample of endangered landraces originating from that region. Wilkes [1983] suggested that governments set aside carefully chosen 5-by-20 kilometre strips, at as few as 100 sites around the world, where native agriculture would still be practiced; areas where both indigenous crops and their close wild relatives interbreed periodically. The idea of setting aside parks for crop relatives and landraces is a luxury in countries where farmland is already insufficient and disappearing. However, *in situ* conservation of landraces would require a return to, or the preservation of, primitive agricultural systems. Many scientists, conservationists and development workers would find this an unacceptable and non-workable proposition [Ingram and Williams, 1984]. Therefore, support has risen to link conservation and management of PGR, at the local level, with development actions [Altieri and Merrick, 1988; Brush, 1991]. This has been recognized as the third strategy at the local level [Keystone Centre Report, 1991]. It is proposed that this strategy be supported in the Biodiversity Programme; conservation through use, complementing, but not replacing, the need for *ex situ* conservation.

Local/community conservation

Community and farmers' efforts in the management of PGR have been recognized, only recently, by the formal sector. Plant genetic resources managers are starting to realize that farmers are consciously trying to maintain diversity in various ways. An informal sector of PGR conservation is also becoming an active component in research on local farming systems, that is aimed at sustainable forms of agriculture (LEISA). Local crops and other sources of native germplasm are (and should

continue to be) incorporated in the design of LEISA, thereby ensuring the maintenance and availability of local diversity to the farmers. Community level conservation should include aspects of collection, storage, regeneration, appropriate documentation and information systems, evaluation, monitoring, research, training, and advocacy [Keystone Centre Report, 1991].

Several NGOs are already active at this level of conservation. They offer training and education tailored to community level conservation and utilization. NGOs foster public awareness of the importance of genetic diversity. An important element of community level conservation and training programmes is making farmers aware that reciprocal exchanges of seeds with genebanks are possible and that they have unconditional access to seeds held in genebanks. They can tap this source if they lose their seeds [Cooper *et al.*, 1992].

Organization of crop improvement

The Keystone Dialogue Series on Plant Genetic Resources, involved participants from international and intergovernmental organizations, national government organizations, non-governmental organizations, corporations and research institutions from developed and developing countries (92 participants from 30 countries). The participants addressed at considerable length, the issue of local conservation and use of plant genetic resources. It was concluded that essentially two types of organization of crop improvement and conservation operate side by side, with little interaction [Keystone Centre Report, 1991]:

1. A formal *institutional system* linking *ex situ* genebanks with institutional and private industry breeding, seed production and, ultimately, distribution to farmers. Such farmers thus benefit from genetic diversity in a linear mode of transfer.

   Modern varieties are adopted mainly in the more favourable production environments and generally require, for full exploitation of their improved yield potential, the use of external inputs such as fertilizers and additional control of biotic and abiotic stress factors. Hence, in most developing countries, the benefits of this system are restricted to only a minority of the more resource-rich farmers.

2. A non-institutional *informal system* using local landraces and integrating conservation and utilization in a dynamic system of local crop improvement and seed production.

   This system is responsible for maintaining a large source of yet available genetic diversity of direct importance to the institutional system and covers the majority of farmers in developing countries. Nevertheless it does not benefit in any manner from advances in plant breeding or from *ex situ* institutional genebanks.

   While the role of local landraces under specific circumstances is acknowledged, institutional plant breeding efforts are directed, almost exclusively, at replacing such landraces with modern improved varieties in continuous almost hit-and-(sometimes)-miss activities. A major problem appears to be a lack of systematic information on the informal system. What information there is, is limited largely to anecdotal descriptions of local practices. The Keystone Dialogue members concluded that local crop improvement should be recognized as an alternative to institutional plant breeding and as having a comparative advantage under a range of environmental and socio-economic conditions. There are numerous examples of

minor crops and even major crops for more marginal and extremely diverse environments that for economic reasons will never justify costly separate institutional breeding programmes. Under such conditions farmers will continue to rely on local crop improvement and seed production. It is for these reasons that we want to stress the need for a more systematic study of local crop improvement systems and suggest ways in which these systems can better take advantage of the formal institutional system.

Rationale

Local management of plant genetic resources

- Custody over and access to PGR are being transferred from farmers to institutions (both national and international) through the introduction of modern technology. At the same time, Intellectual Property Rights regimes favour control, over specific gene-plant combinations, by industrial companies. Both trends limit access of such PGR to the original holders who are often RPFs, especially in centres of diversity.

- The role that farmers and farming communities play, in conserving plant genetic resources and their involvement in a dynamic process of evolutionary crop improvement, is poorly understood and inadequately recognized.

- Linkages between the institutional conservation of PGR and plant breeding, on the one hand and local management of PGR and evolutionary breeding of landraces on the other, are poorly developed and can be improved to the advantage of both systems.

Local crop improvement

- Environmental diversity in tropical and subtropical regions tends to be higher than in temperate zones. Formal plant breeding has been successful in the (sub)tropics for a number of major food crops (e.g. irrigated rice, wheat, corn and major grain legumes) and cash crops (oil-palm, soybean, sugarcane). Its spin-off has been limited to the more uniform and favourable environments (tropical irrigated lowland or upland plains) and, predominantly, to resource-rich farmers with access to external inputs (fertilizers, pesticides, irrigation).

- Agricultural research has reached a point where future prospects for maintaining food security are being undermined by the increasing population and the degradation of the environment. A response to this requires significant advances in agricultural productivity in a sustainable mode; productivity developed through farmer participatory research (FPR). Agricultural research, including plant breeding, should allocate a larger part of its resources to sustainable agricultural development, managing natural resources to enhance adaptation to the extremely variable environmental conditions of RPFs living in marginal areas of developing countries.

- The non-adoption of modern varieties and continued use of traditional landraces by RPFs is often explained by agricultural scientists as being due to the conservative attitude of RPFs, and their inability to obtain improved material and external inputs. However, in specific instances landraces may, in a variety of cropping systems, provide better adaptation and more sustainable yield security than do

modern varieties. The value of landraces within those cropping systems and their value as a basis for adapting breeding material, is rarely acknowledged by agricultural scientists.

- Modern institutional plant breeding is limited in its potential to address all crops and other plants useful to man, especially those grown in marginal and often diverse production environments by RPFs in LEISA. Environmental adaptation tends to be more complex in those marginal environments. The genetic basis of the level of adaptation of local material is not well understood thus complicating improvement through formal plant breeding. Agricultural research is rarely able to focus on minor crops which may be of local importance for the people. Minor crops may also have an important function in the agro-ecological system or in the diet of the local people.

The absence of reliable systematic knowledge of the local management of PGR and crop improvement systems leads to considerable misunderstanding and even to conflicts between institutional conservation and breeding efforts and community development programmes. The former continue to push for the adoption of modern varieties in packages of technology. The latter may reject such a technology push and stress the conservation of existing systems. They argue that existing systems are important in risk avoidance and both environmental and socio-economic sustainability.

Gaps in knowledge

It is evident that, at several levels, there are gaps in the knowledge of the local system of management and use of PGR. Data are essential to fill those gaps. Such information may provide new options for conservation of PGR and for plant breeding. It may also lead to new approaches that provide better support and improve the management of PGR and crop improvement systems at the farm-level while maintaining the inherent characteristics of the traditional or local systems, including socio-economic and environmental sustainability.

Performance landraces versus modern varieties

There is little objective information available that compares the performance of modern varieties with local landraces or plant material under farmers' conditions in LEISA systems. Hence, the reason why farmers in LEISA systems often prefer local plant material, is poorly understood.

Landraces and environments

Systematic information on the extent of genetic diversity in and between landraces within identified environments is also scarce. How variable are they? Is inbreeding a problem? What is the role of introgression from wild or weedy related species or from modern varieties?

There is a serious lack of knowledge of the importance of local specificity or the value of local adaptation of landraces (genotype x environment interaction). Generally, there is little systematic knowledge of the nature of diversity (between and within crops) in farmers' fields, the reasons and importance of such diversity, rates and levels of exchange between farmers and farmer communities, rate of turn-over, etc.

Farmers' knowledge

How do farmers select plant material for next years crop? What are their selection criteria and objectives? What is their taxonomic system? Do farmers encourage introgression and hybridization? Do they make selections and with what criteria and objectives (yield, taste, appearance, cooking quality, marketing aspects)? Do farmers employ field tests, record data, and name their varieties? What is the local knowledge of the maintenance of crop diversity, seed production and post-harvest technology?

Interactions between landraces, farmers' knowledge and environment

Because landraces and local knowledge on PGR are integral parts of environmental management, systematic knowledge of the various factors that influence this complex, is required.

Abiotic and biotic stress factors

Landraces are cultivated by farmers in resource-poor and, often, risk-prone environments, with various constraints limiting production. Little information is available on the local knowledge of, and local methods for dealing with, abiotic and biotic stress factors. The interactions with stress factors are the links between landraces and indigenous methods of (integrated) pest and disease management.

Cropping and farming system

Knowledge is lacking of interactions between cropping systems and landraces versus modern varieties. In modern agriculture, varieties are seen as an external input whereas, in the concept of LEISA, the landraces are seen more as an integral part of the cropping system. Interactions between local diversity and the other crops and activities (animal husbandry, local industry) are to be studied [Reijntjes *et al.*, 1992].

Crop origin

Local diversity in the plant material of a crop largely depends on whether the crop originates from the region (centre of origin, centre of diversity) or whether it has been introduced. In the former situation, local landraces often reflect a broad range of diversity. Landraces may be grown in environments with related weed or wild species. Introgression may play a role in the local crop improvement. In the latter situation, the diversity within and between local landraces may be limited. Actions concerning introduction or conservation of genetic resources are influenced by these factors. Methods of local crop conservation and crop improvement will be developed at sites representing both situations.

Minor crops

Agricultural research has been focused mainly on major food- and cash crops. Scarcely any research is done on region-specific minor and so-called under-utilized crops (vegetables, legumes, fruits, trees and medicinal plants) which may have very specific functions in the farming system, nutrition and culture of the farmers. Farmers' knowledge of these minor

crops will be important in developing strategies for conservation and improvement of those crops.

Seed production systems

Local conservation and improvement is linked to systems of seed production. Links between conservation, improvement and seed production systems have to be studied. Furthermore, the influence of local landraces on the organization of seed production at farm, village and regional levels has to investigated. Economic data on the importance of local systems of seed production are scarce.

Gender related issues

In many regions of the world, the women farmers are most knowledgeable about local landraces and crop improvement. In many regions women are the major labour force. Seed selection and storage often are the duties of women. The consequences of this must be considered in the actions and methods developed. Any change in the farming systems may affect the position of the women in agriculture. Further, links between agricultural production and household economy are important in the management of the farm.

Production factors

Land, labour and capital are the production factors of agriculture. There is little knowledge available about the links between these factors and local systems of seed production, crop improvement and conservation.

Nutrition

Local food crops may play an essential role in the diet of resource-poor farmers. Local staple crops, as additional food crops (vegetables and fruits), are also important. Little systematic knowledge is available on the nutritional aspects of local crops and landraces.

Discussion

There is a need to recognize local crop improvement together with the use of landraces as a form of crop improvement which, under specific conditions, provides an alternative to, and complements, institutional plant breeding and seed production.

This raises a number of questions which need to be answered. For example:

- Under what conditions and circumstances does local crop improvement provide a comparative advantage over institutional plant breeding?
- What are the real or perceived advantages of landraces over modern varieties under a diversity of conditions?

Present information on these issues is largely anecdotal and requires more systematic and comparative information. In essence this means the integration of genetic and technical

knowledge with local knowledge systems. This, in turn, often requires the application of social science methodologies.

Agricultural research has tried to better analyse, at various levels, the situations of RPFs (among others, farming systems research), in order to improve the setting of priorities for on-station agricultural technology development [Harwood, 1979]. This was followed by the adaptation of agricultural technology to farming conditions in local trials. However, the agricultural scientists were yet the ones setting priorities and managing the research [Tripp, 1982]. RPFs rarely are encouraged to experiment themselves and, in general, scientists still ignore the essential knowledge of these farmers. Various approaches of farmers' participatory research (FPR) and participatory technology development (PTD) have been developed with an increased participation of farmers in the planning, design, implementation and evaluation of trials [Rhoades and Booth, 1982; Chambers and Ghildyal, 1985; Chambers and Jiggins, 1985; Chambers, Pacey and Thrupp, 1989; Farrington and Martin, 1990; Haverkort *et al.*, 1991]. These types of approaches have been applied in the development of various forms of agricultural technology, but the local knowledge of RPFs still is largely ignored at the level of crop improvement and management of PGR. RPFs are seldom involved in the development of crop varieties. This ignoring of RPFs' local knowledge and their capabilities is based primarily on the exclusively scientific basis of plant breeding, its institutional setting and the organizational and political bases thereof.

The objective of such research, however, is not to integrate local crop improvement but rather to widen the suitability of modern varieties to replace such systems. This statement is not meant as a criticism. In the final analysis, farmers need to be provided with a choice and to select the material that is most appropriate for their conditions. The argument put forward here is that local crop improvement has an additional role to play and provides alternatives to institutional plant breeding that can and must be optimized [Cooper *et al.*, 1992]. Hence, local crop improvement needs to be provided with a scientific basis. In addition, the formal institutional system should, where appropriate, assist in strengthening that system, both technically and structurally. It may provide a new catalyst to plant breeding and conservation of PGR in the interests of large numbers of farmers that, so far, have not benefited from modern research and developments.

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Seed Diffusion and Utilization Mechanisms: Lessons for Africa

E. Cromwell[4]

The context of farmer seed systems

In Africa some 60 million farmers, or 50% of the total farming population, live and work in areas of comparatively low agricultural potential [Mellor, 1988]; areas that Chambers [1989] classifies as "complex, diverse and risky (CDR)". These areas are characterized as being relatively remote from market centres, with no ready market for farmers' surplus production, nor with easy access to external farm inputs. They tend to have relatively infertile soils, lower and more variable rainfall and they are often outside the plains and valley bottoms, so are prone to problems related to cultivation on steep and unstable slopes. Traditionally, they have received little attention from formal sector agricultural research institutions, as have the crops grown in them, because the potential returns to research are low in these areas; because it is difficult to produce results for them using formal sector agricultural research methods; and it is difficult to reach the large number of small farmers living scattered throughout these areas with any suitable innovations that have been developed. Accordingly, farmers in CDR areas have developed highly diverse farming systems to cope with these constraints. They have tended to rely on their social relations within the local community and their family links, for credit, agricultural information and access to new technologies such as new varieties of seed.

These farmers often have limited land; where they have access to large areas in absolute terms, almost invariably the land is of low potential. They usually have limited capital resources too; much farm production does not enter monetorized market systems and what cash there is from crop sales has to be used for other households needs. Many farmers are ineligible for credit, because they do not have title to their land and/or because they cannot repay loans in cash and/or because they do not want the modern production packages of which institutional agricultural credit generally consists. In addition, this kind of credit is often available only from distant offices with cumbersome procedures. Credit may be available from local money-lenders but, usually, at very high rates of interest so it is used only for emergency consumption needs.

Thus, the only resource over which farmers have some control is labour. Even this may be in short supply for on-farm agricultural production. There is often a higher return to the household's most productive labour resources (mobile, adult males) in off-farm employment in towns or as migrant labour, so only the children, the old people and the women are left to work on the farm. The women, in particular, face conflicting demands on their time from domestic chores such as water and fuelwood collection, child care and food preparation.

As a result of this, the agricultural production system of farmers in these areas is geared, primarily, to meeting domestic consumption needs for food and other natural resource products (roofing and fencing materials, animal fodder, etc.). It is still strongly influenced

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by the social relations of production operating within the wider community. However, the production system typically includes commercially-oriented activities such as some production of cash crops. Often, some commercial transactions take place as a by-product of food production activities (e.g. sale of surplus food crops, beer-brewing, etc.). Accordingly, the farming system has to be highly diverse to meet these needs.

To re-cap, the majority of farmers in Africa have few domestic and external resources to allocate to on-farm production, so their aim is to secure a minimum level of food production. They achieve this by means of a highly complex farming system in which there are a diverse number of land uses and considerable diversity within each (particularly in terms of the number of cultivars of each crop grown). The farming system has to be highly dynamic; constantly changing in response to changes in internal (family life-cycle) and external conditions (climate, off-farm wage rates, new developments in agriculture, etc.). Related to this, there is also considerable variation within communities, between households at different stages in the family life-cycle and with different resource endowments.

Farmers' seed needs[5]

Under the above conditions, farmers require seed for a large number of different crops. They also want seed of numerous different cultivars of each crop, to allow for:

- the varied physical environments in which they plant each crop (valley bottom and hillside; different soil types; interplanted, stagger planted and pure stand; main season and off-season, etc.);
- the numerous end uses of each crop (human consumption of the grain and of the leaves and roots; beer-brewing; straw and stovers for animal fodder, roofing and fencing; storage as an emergency food stock; selling for cash); and
- coping with the uncertainty of the seasons in CDR areas without the use of external inputs, by growing different cultivars (e.g. early-maturing, late-maturing, those able to withstand dry spells). Varieties with a high degree of intra-varietal variation can be very important for this purpose; if there is some variation in the characteristics of different plants within one crop stand the chances of producing some harvest, whatever the season, will be increased.

The cultivars used must yield without large applications of external inputs and characteristics, other than high potential grain yield, are also important. Depending on the crop and the situation, these can include: taste; processing and cooking qualities; storability; and yield of non-grain biomass (leaves, stalks, etc.).

Finally, farmers need to be able to maintain their seed stocks on-farm for some years (unless climatic conditions prevent this, physiologically), without facing a dramatic deterioration in the genetic potential of the seed; they need cultivars which breed true to type, so far as this is allowed by the breeding system of the crop. Thus, for example, composite varieties of maize are more useful for this purpose than are F_1 hybrids.

It is important to consider the specific seed needs of women farmers. In many areas, female-headed households form a significant proportion of the community. Typically, relative to other households, they are short of labour and cash and, therefore, make only limited use

5 This section is based on Cromwell, Friis-Hansen and Turner, 1992.

of seed provided by the formal sector. Women within male-headed households are usually responsible for attending to the domestic food needs of the household and they are particularly concerned with the storage, processing, cooking and organoleptic qualities of cultivars used by the household. These requirements are often relatively neglected by formal sector plant breeders who interface, primarily, with the male members of farming communities. Accordingly, new varieties generated by the formal sector can damage, considerably, the position of women. This was the case, for example, with the first hybrid maize varieties introduced in Malawi. The men took over these new varieties to produce a cash crop for sale, leaving the women to provide for food needs using the traditional, lower-yielding, local maize cultivars. The first hybrids were bred from soft-kernelled material which, unlike the harder local maizes, was prone to pest attack in storage (exacerbated by their incomplete sheathing) and crumbled badly when processed by traditional methods. These problems have been largely overcome now, with the release of two flinty hybrids, *MH17* and *MH18*.

The situation of women farmers does vary, of course, from place to place. In Swaziland, for example, fertilizer is readily available and female-headed households find that using hybrid maize varieties and applying fertilizer are useful means of increasing yields without the need for extra labour [Low, 1986].

To summarize, it is difficult for formal sector plant breeders to provide the kind of seeds wanted by the majority of farmers in Africa. This is because the formal sector is geared to generating a limited number of varieties each of which, is distinct, uniform and stable (DUS), displays wide environmental adaptability, and has potential in terms of high grain yield if grown with applications of external inputs. Variation is dealt with by releasing a stream of new varieties over time, each to replace the previous, rather than by generating a large range of varieties at any one time, between which farmers can choose. Furthermore, the formal sector has tended to concentrate on the limited number of crops that can be manipulated successfully using scientific plant breeding methods, the best known examples being the rices and wheats which produced the Green Revolution in Asia.

It is less profitable for seed companies to distribute the kind of seeds wanted by farmers in CDR areas. The ideal crops from the seed companies' point of view are those that can be hybridized and/or have a rapid rate of genetic deterioration (for example, open-pollinated maize, sorghum and millet), as these secure recurrent seed sales. Other profitable crops are those with a high sowing rate, such as wheat and rice (because farmers have to buy more to plant a given area); and those with a high multiplication factor, such as maize (as this enables the company to produce more seed per sowing). Lastly, there can be a profitable niche in producing seed that for some reason cannot be maintained successfully on-farm. This includes temperate vegetable crops that do not set seed when grown under tropical conditions; and crops, such as soyabeans, for which seed cannot be stored successfully in hot, humid conditions.

Thus, in many circumstances, it is seed kept locally by farmers that is more suited to their needs than are the modern varieties (MVs) produced by the formal seed sector. Overall, some 80% of the cropped area in developing countries is covered by seed which has not passed through any marketing channel [Delouche, 1982; Bal and Douglas, 1992]. This can be seed of landraces (although few true landraces are still in use in most areas) or it can be farmers' varieties (FVs). The latter can take various forms:

- selections from landraces made by farmers on the basis of visible characteristics (plant height and architecture, grain size and colour, etc.); an example of this is the "Balanka" wheat variety discovered recently being widely grown by farmers in eastern Nepal [Ashley and Khatiwada, 1992];

- past releases from the formal sector's agricultural research system, such as the "Bingo" maize variety (an adapted form of the 1960s' *LH11* hybrid maize release) in common use in many areas in Malawi; and

- other exotic material which has found its way into the farming system and has been maintained, on-farm, and incorporated into the farming system (typical examples include seed brought back by travellers and grains saved from distributions of food aid). In Malawi, the maize variety "Asikari" is an example of this, having been maintained by farmers from the seed handed out to soldiers on de-mobilization at the end of World War II.

There can be an important role for MVs in certain circumstances, however, as where environmental change is forcing farmers to modify traditional farming systems. The use of early-maturing MVs can be a valuable method for coping with declining rainfall, for example.

Seed diffusion mechanisms in small-farm areas[6]

What is the most economical and convenient method for farmers to obtain fresh seed when they require it? There is an important distinction between the acquisition of fresh seed of cultivars already in use and that of seed of new varieties.

New varieties, by definition, require an initial infusion of seed from outside. For varieties produced by the formal sector, this is usually as packages of inputs distributed by the extension or agricultural credit services, or via sales from local seed company depots or their appointed dealers. The seed can be provided free, on credit or for cash; the full cost of production may be charged for it, but usually the price of MVs produced by the formal sector is subsidized to some extent.

In practice, only a very small proportion of farmers are ever provided with new varieties by the above means. This is because of the limited capacity of these systems. Only a limited number of farmers go to the effort of establishing links with formal sector agricultural services, can pay cash for seed and are willing to try out new varieties before they are widely proven locally; they are usually the farmers with relatively more land and more formal education and they are often people with a traditional leadership role in the community.

So, the majority of farmers in CDR areas obtain new varieties, at second hand, from the initial adopters within the community. In the Punjab area of Pakistan, for example, two thirds of the farmers that obtain new varieties of wheat seed do so by approaching neighbouring farmers rather than by going to the local Punjab Seed Corporation depot [Tetlay *et al.*, 1990]. Farmers may obtain seed as a gift, as a loan to be re-paid, in-kind, at harvest, in return for labouring, or, less commonly, they may pay cash. The advantages for them of this system are that they can get very small quantities if they wish, they do not have to pay cash, they can see the seed growing and they can get hold of the seed in good time for planting (the nearness of farmer sources is not such an important issue; farmers in most areas seem to be willing to travel considerable distances to get good seed). Where the cultivar is a FV, an additional consideration is that, in any case, it will not be stocked by formal sector seed sources.

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6 This section is based on Cromwell, 1990 and Cromwell and Wiggins with Wentzel, 1992

For farmers wanting to obtain fresh seed of cultivars already in use in the area, rather than seed of new varieties, the above considerations apply even more forcibly. For example, in Malawi two thirds of all bean seed used is obtained from neighbours, relatives and other local sources [Cromwell and Zambezi, 1992]; and in the Great Lakes region of East Africa 75-85% of bean seed is originally obtained from relatives [Sperling *et al.*, 1992].

Aside from the variety considerations discussed in the previous section, seed systems for the majority of farmers in Africa must, therefore, provide the following services:

Quantity Small quantities of each cultivar are required. This is because each farmer grows many different cultivars, often plants at lower than recommended densities and replaces seed less frequently than recommended. Thus, only a handful of fresh seed may be required each year, rather than the amounts provided by seed companies in their standard sized packs which, typically, contain sufficient to plant a whole hectare at recommended sowing rates.

Quality Optimum rather than maximum physiological quality is required. Farmers in CDR areas do not require that seed meets all the standards that ISTA-based certification systems provide; while the physical purity of seed and reasonable germination percentages are valued, uniform seed size, the genetic purity of varieties and their conformity to DUS conditions, are often irrelevant. Furthermore, farmers are generally unwilling to pay for the additional cost of packed seed (packaging of seed is an integral component of formal sector seed certification schemes) and, in any case, standard packs often are split up between relatives and neighbours. Instead, for supplies of fresh seed of cultivars already in use, farmers will happily use seed from crops they have seen growing on neighbours' land. Thus they substitute visible "neighbour certification" for the invisible benefits of formal seed certification. Formal certification does not guarantee seed quality because, often, seed is stored in poor conditions after leaving the processing plant.

Timeliness Delivery of seed in good time for planting is critical for farmers in CDR areas, for two reasons. Firstly, because delayed planting has a much greater impact on eventual yield in these areas than in higher potential areas [Edwards *et al.*, 1988] and secondly, because when farmers in CDR areas have cash they cannot afford to tie it up in buying stocks of seed far in advance of the planting season. Seed companies in the formal sector, especially parastatals with bureaucratic procedures for the allocation of vehicles, often perform particularly badly with respect to timely deliveries. In addition, the task is more difficult in CDR areas which are usually remote and without good roads [Allen, 1968].

Price Farmers are often unwilling to pay for seed, for a number of reasons. Firstly, because they cannot see its superior quality, they are often unwilling to pay a premium over grain prices for certified seed. This premium can be very high where grain prices are kept artificially low by government.

Secondly, farmers see the cost of purchased seed as too large a proportion of their total production costs, as they rarely consider the

shadow cost of their own labour inputs. Including labour costs, seed costs are, in fact, only 2-5% of the total production costs for most crops [Ruigu, 1988; Cromwell and Zambezi, 1992].

Thirdly, they see seed saved on-farm as an obvious substitute for purchased seed; they do not take into account the opportunity cost of saving seed in terms of reduced food availability and/or lower income from crop sales.

Fourthly, as we saw earlier even when there appear to be advantages to purchasing seed from the formal sector, farmers may not have the cash to pay for seed.

Finally, because demand for seed is a derived demand for its ultimate benefits (primarily, increased or more secure production), where the available varieties cannot provide these benefits, they will not be bought. This is often the case on farms in CDR areas. The constraints on allocating household labour to on-farm production can have an important influence on the demand for MVs; to yield well, many of these require extra labour for careful planting, extra weeding and harvesting, particularly if they are not fertilized [Allen, 1968]. In areas with high formal sector wage rates, or with a high proportion of female-headed households, this extra labour may not be available.

The minimum grain : seed price ratios for different crops that provide commercial seed companies with a fair return are given in Table 1. These ratios can be considerably reduced when seed is produced under local multiplication schemes (transport is usually the single biggest cost of seed produced by the formal sector). However, in practice MVs produced by the formal seed sector are often artificially promoted by subsidizing the price at which they are sold to farmers and this results in an overblown reduction in the use of FVs and other more genetically diverse material.

Table 1. Minimum grain : seed price ratios for different crops

Crop	Ratio
Single cross maize hybrid	1:5
Three-way cross maize hybrid	1:3
Double cross maize hybrid	1:2
Groundnuts	1:2
Wheat	1:2
Rice	1:2

Note: Factory gate cost (i.e. processed and packed) ratios in developed countries are often higher.

Source: Cromwell, Friis-Hansen and Turner, 1992

While the above points are valid as generalizations, the variation in the seed needs of different households within individual farming communities can be substantial and is an important factor to take into consideration. Evidence from Malawi suggests that there are four distinct categories of seed users within communities in CDR areas, although the proportion of households in each category varies from place to place and households can be in different categories for different crops. The categories are:

- households that are *seed secure* and never obtain seed off-farm;
- those that obtain seed off-farm from time to time *by choice*, in order to get fresh stocks of seed or new varieties to try;
- those that obtain seed off-farm from time to time because of a domestic *crisis* (harvest failure, death or illness in the family, etc.); and
- those that have a *chronically insecure* seed supply, (most commonly due to shortage of labour) and consistently have to source seed off-farm [Cromwell and Zambezi, 1992].

Research into the channels used by farmers in Rwanda and Burundi to obtain bean seed provides similar evidence of this intra-household variation [Sperling *et al*, 1992].

To conclude, it is not surprising that the vast majority of farmers in Africa still use community seed diffusion systems for most of their off-farm seed needs, because these provide seed in a manner which is accessible to small farmers:

- they deal with most *varieties* of seed - local farmers' varieties as well as adaptations of MVs;
- the individual *quantities* of seed exchanged are often very small;
- the *quality* of the seed provided does not meet formal sector certification standards but, except in environments where seed-borne diseases or off-season storage is a particular problem, it is appropriate for farmers' needs;
- a wide range of *exchange mechanisms* are used to transfer seed between individuals and households, including barter and transfers based on social obligations;
- they are *informal* in their organization, changing between locations and over time are and not subject to the same rigidities as formal sector organizations;
- they operate mainly at the *community level*, although lines of supply may extend over a relatively wide geographical area; and
- they are *traditional*; not necessarily static over time in the way they operate but well-established and often elaborate structures based on, and developing out of, the traditional channels of information and exchange that exist within the community.

Conclusions: implications for safeguarding Africa's plant genetic base

How African farmers' seed systems match with current thinking on the desirable plant genetic resource base in the sub-continent and what strategies are needed to ensure a better match, need to be assessed by those who are fully *au fait* with the technical aspects of the

current plant genetic resources debates. Nonetheless, what has emerged clearly from the socio-economic approach used in this paper is that there is a strong correlation between safeguarding the genetic base of Africa's traditional crops and providing for small farmers' plant genetic resources needs. Three points, in particular, stand out and these are flagged for consideration:

- the economic circumstances of the majority of small farm households in Africa dictate an important role in farmers' variety portfolios for MVs as well as for FVs and other traditional planting material;
- there needs to be greater willingness to accept that many of the current generation of MVs are inappropriate for small farmers' needs, because of the plant breeding methods used in their development; and
- at the same time, there needs to be more recognition of the value of community seed diffusion mechanisms in supplying farmers' seed needs and, therefore, of the value of supporting the structural aspects of seed diffusion as well as genetic resources conservation.

These points can be illustrated with reference to Figure 1. This figure shows the various combinations of planting material and seed supply systems that are compatible with strengthening the sustainability of farming systems in CDR areas (and also those that have been tried but, in practice, are usually incompatible, for the reasons outlined in this paper). In terms of Figure 1, the key task is, therefore, to set up policy, programme and project initiatives which will fill the blank boxes. What sort of initiatives will be required for this to be achieved?

Plant genetic resources conservation

The single most important implication of this examination of farmer seed systems for the plant genetic resources debate, is that farmers in CDR areas want access to MVs, FVs and the range of genetic material in between. This fact is sometimes forgotten in the rush to conserve indigenous germplasm. It is important to avoid substituting one plant genetics straight-jacket with another (i.e. promoting FVs rather than MVs). This has dangerous externality effects for farmers in CDR areas because of the nature of plant genetic resource conservation activities being for the public good (in any case, *in situ* conservation of FVs and landraces is, of course, not the only method of preserving genetic diversity). While conserving genetic diversity is important for the long-term sustainability of global agriculture, in the short-term, it could be considerably non-beneficial (in terms of reduced production, etc.), for individual farmers to use only indigenous germplasm.

To encourage farmers in CDR areas to use a diverse plant genetic base and to make it worth their while to increase diversity in their current production systems, requires macro-economic price policy intervention. At the very least, it requires an end to the common practice of subsidizing the cost of MV seed. More radically, it is possible to make a sound economic case for compensating farmers for maintaining the less productive landraces and FVs. The Convention on Biological Diversity signed at the 1992 UN Conference on the Environment and Development has already gone some way towards recognizing this case, particularly in its Articles 8 and 11.

Seed system/ variety	Farmers' varieties	Enhanced FVs	Locally adapted MVs	Modern varieties Self-poll/OP	F_1 hybrid
Emergency seed distribution	Concern, Sudan Afghanaid, Afhganistan			Concern, Sudan	
Community seed banks	ACORD, Mali Oxfam, Sudan NEF/Oxfam, Mali			ACORD, Sudan	
Farmer-saved seed and community seed exchange	**COMPATIBLE FARMING**	**WITH SYSTEMS IN**	**STRENGTHENING CDR AREAS**		
Local seed multiplication and distribution	ASS, Ethiopia MIND, Philippines Z-San Zimbabwe	(SCF, Gambia) CESA, Ecuador FFHC, Gambia GSM, Gambia (MCC, Bangladesh) (KHAP, Nepal) AA, Nepal	CIC, Mozambique CIAT, Great Lakes	SCF, Gambia CESA, Ecuador AA, Gambia GSM, Gambia MCC, Bangladesh FFHC, Gambia PPS, Nepal KHAP, Nepal AA, Nepal PAI, Brazil CIAT, Colombia	
Government/MNC seed companies				AIC, Nepal PSC, Pakistan	NSCM, Malawi Zamseed, Zambia

Figure 1. Seed systems in CDR areas

Note: FV = farmers' variety; OP = open-pollinated;
MV = modern variety; MNC = multi-national company

Combination of seed varieties and seed systems
= incompatible = compatible
with strengthening farming systems in CDR areas

Source: ODI records

Plant breeding

There must be more exploration of the potential of indigenous germplasm to provide varieties with attributes wanted by farmers in CDR areas. This, for example, is already being done with considerable success by the Plant Genetic Resources Centre in Ethiopia.
At the same time, plant breeders must pay more attention to generating MVs modified to suit farmers' needs, to improving existing FVs and to the whole range of genetic material in between. Breeders need to produce a large number of varieties, both MVs and FVs, including some displaying a degree of intra-varietal variation ('unfinished' varieties). This would make available portfolios of large numbers of different varieties to fit in with both the complex mixes of cultivars in use at any one time in CDR areas and with the constant change in cultivar mixes over time. Such provision becomes increasingly important in response to the climatic changes affecting farming systems in an increasing number of CDR areas.

Plant breeders also need to give greater weight in their breeding objectives to the non-yield characteristics (taste, storability, etc.). Though valued by small farmers they are rarely given much importance by formal sector plant breeders.

These changes in the orientation and products of plant breeding programmes will require changes in both the breeding objectives and the scientific methods used by the formal sector. For example, plant breeders could capitalize on farmers' considerable plant breeding expertise by providing a range of material, including unfinished varieties, for the farmers themselves to manipulate. This would bring further benefits by reducing plant breeding costs and speeding up the release of material. It is the stabilizing of varieties, once they have been generated, that is often the lengthy part of formal sector plant breeding.

The introduction of these kinds of changes is entirely dependent on the free movement of germplasm which, in turn, requires the absence of intellectual property rights on plant genetic resources, particularly patents of the type under discussion in the current round of the General Agreement of Tariffs and Trade (GATT) talks. A relaxation of variety release procedures and seed standards, by permitting FVs and other non-MV and non-formally certified types of seed to be traded as seed, would also help.

Seed supply systems

Another implication which is worth emphasizing is that it may not always be seed of new varieties that farmers most want or need. Rather, it may be access to improved, on-farm seed care techniques and technologies (drying, storage structures and dressings; and pre-planting selection techniques). As with plant breeding, the need here is again to capitalize on indigenous knowledge rather than to try to replicate techniques and technologies used by the formal seed sector.

Alternatively, farmers may want better access to off-farm sources of fresh seed of cultivars already in use. Possible initiatives here include distributing seed produced by the formal sector through traditional community seed diffusion mechanisms rather than through cash-based company dealerships and seed and fertilizer packages that may not be relevant for farmers' needs in either content or size. This is already being tried on a limited scale, but with some success, by a number of non-governmental organizations. Figure 1 gives examples.

If local multiplication of seed can also be encouraged, this often has additional advantages in terms of reducing seed production costs, not least because transport is one of the largest cost elements in most formal sector seed supply systems.

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The Role of Farmers in the Domestication, Maintenance and Use of Traditional Crops

Susan K. Nzou

Traditional staple crops

The traditional Akamba farmer grew crops that included millet, sorghum, cowpea, maize, sweet-potato, cassava, banana, finger millet, sugar-cane and pumpkin. With no farming tools to clear the farm, he used fire to destroy tree trunks and strong, sharpened poles to remove the stumps.

Harvesting would start in February when the crops were dry. Thereafter, the crops were stored in traditional stores called *Ikumbi* to wait for the dry season in August. During the dry period the millet and sorghum would be crushed to separate the grain from the chaff (*syiia aya mwee*). After mixing the grain with ash, for preservation, it was stored in another traditional type of store called *Kiinga*. Maize kernels for eating were removed from the cobs, mixed with ash and then stored in a guard. Seed maize cobs would be tied together to the king post at the centre of the living hut, over the fireplace, to be preserved by smoke.

Millet, sorghum, maize and finger millet were used to make an African dish called *musandi* porridge. Maize kernels were mixed with cowpeas and cooked to make *muthele* or *githeri*, or crushed using a mortar and pestle and cooked in other ways. Cowpeas were generally crushed into small pieces before being cooked; the leaves were used as vegetables. Sweet-potatoes, cassava and bananas are two-three season crops. When mature, they were taken home, cooked and eaten. Bananas could be stored for some days while ripening. Sugar cane was chewed raw or made into African beer called *kaluvu*.

Indigenous vegetables

Vegetable crops grown by traditional farmers included *kitelele*, *kikowe*, green leaves of cassava, *musee*, *ndulu*, *mathookwe*. The leaves were collected, cooked and consumed with *musandi*.

Indigenous fruits

These include *matoo*, *maungoa maua*, *ngala*, *muu*, *matote*, *makuyu*, *nthumula* and *kiamba*. These fruits were vital to the people especially in times of drought and famine.

Indigenous medicinal plants

Some indigenous plants were used medicinally. Examples are: *kitongu* which was used to treat abdominal pain; *nthumula*, the syrup of which was used to treat pneumonia; *muteta* was used to treat fever; *mutungati* was used to treat wounds; *kilului* was used to treat chest pains; *kikolokolo* fibres were chewed to treat coughs; and *mukuli* was used to treat colds.

Conclusions and recommendations

1. The use of indigenous plants for medicinal purposes is dying.

2. Some indigenous plants can be a source of money to the farmer, e.g. *nthumula* and *muu*.

Farmers have seen the value of indigenous plants and have collected their seeds for planting. These farmers should be provided with more mechanical knowledge on how to grow indigenous plants.

Public education is needed because the younger generation is ignorant of the importance and use of indigenous plants.

The Role of Ethnobotany and Customary Knowledge in the Conservation and Use of Plants.

A. B. Cunningham

Introduction

There is an encouraging awareness among individuals and organizations represented at this seminar of the need for effective action to conserve useful wild plant species and crop plant variety. The issues and a conservation strategy have been well documented [Davis *et al.*, 1986; WRI, 1992]. We are also aware, however, of the shortage of money and manpower for this task, particularly at national and/or regional levels in Africa. Existing coverage of *ex situ* genebank conservation falls well short of the targets set for the next five year period [Table 1]. Ethnobotanical research and customary knowledge of African farmers and resource users (the majority of whom are women) provide important means of addressing this problem.

Table 1. Targets for genebank coverage [from WRI, 1992]

	Current number	Target in 5 years
Crop genepools	2 million	3.0 million
Forest species	few thousands	1.5 million
Domesticated animals	few thousands	0.5 million ?
Medicinal plants	almost 0	0.5 million
Ecosystem rehabilitation	almost 0	0.5 million
Locally important plants	few hundred	1.0 million
Microorganisms	500 000	1.0 million

The value of folk taxonomy has long been recognized by academics [Berlin, 1992] and, often, has been adopted into Linnaean taxonomic classification (such as the African medicinal plant *Mondia whitei* after the Zulu specific name *omondi* or the South American crop *Arracaccia xanthorrhiza* after the local name *arracacha*). However, both folk taxonomy and customary knowledge of important plant species remain underutilized in conservation strategies for both wild and crop plants.

Customary knowledge[7], collecting and conservation

More effective use of customary knowledge of wild plants and landraces can be a major part of a more effective plant conservation strategy. For example, its value has been recognized and applied in developing a conservation strategy for medicinal plants in a complex situation dealing with over 400 indigenous and over 20 exotic medicinal plant species [Cunningham, 1990a, 1991]. The same complexity can apply to landraces of crop plants, whether in Africa or elsewhere. In the Andean mountains of South America, for example, farmers have selected thousands of Andean potato (*Solanum*) varieties over approximately 8 000 years of cultivation, with up to 200 varieties grown in a single field [Vietmeyer, 1989]. Similarly, in West Africa, innovative work by Richards [1985] and colleagues [Monde and Richards, pers. comm.] has shown the value of using farmers' knowledge in rice breeding and germplasm conservation.

In some cases, folk taxonomy takes a very different approach to that of Linnaean taxonomy. In the Zambezi valley in Zimbabwe, for example, all five cultivated races of sorghum occur (caffra, *caudatum*, durra, bicolor and guinea) and Linnaean taxonomists distinguish between them most easily by their distinctive spikelets. Local peasant farmers do not recognize such divisions, however. They recognize varieties on the basis of a combination of morphology, ecological requirements and usage [van Oosterhout, 1990]. Similarly, African herbalists use bulb, root, bark or sap characters, as well as taste and smell, more frequently than flower, fruit or leaf characteristics [Cunningham, 1990b]. This can result in differing local names for a single species at a "variety" level, based on plant age or form. An example of this is the classification by Zulu and Tembe-Thonga speaking herbalists of large, older individuals of the African medicinal plant *Schlecterina mitrostemmatoides* (Passifloraceae) as "ihlalanyosi-obomvu", referring to the thicker red roots, while smaller plants, with thinner, paler roots are named "ihlalanyosi-omhlope".

Rather than opposing one another, folk and Linnaean taxonomic systems need to be seen as complementary tools in making *in situ* and *ex situ* plant conservation more effective. There are many advantages in this approach, not the least of which is that working with local specialists, whether herbalists or expert farmers, is an instructive process for the formally trained researcher who is thus able to learn the use of plant taxonomic characters that are rarely, if ever, used in Linnaean taxonomy because taxonomists usually base their work on flower, leaf or fruit characters from dried material.

In all cases, these folk taxonomy characters can be evaluated and used in plant classification, such as in the development of a key to bulbous medicinal plants (exclusive of leaf, flower or fruit characters) for use by medical doctors dealing with cases of overdosage and poisoning with herbal medicine, or conservation staff in identifying threatened species [Tait and Cunningham, 1989]. Similarly, a key to tuberous crop plants could be developed using a combination of leaf and tuber characters or tuber characters alone. In Kigezi, western Uganda, for example, Bakiga farmers recognize at least nine different sweet potato (*Ipomoea batatas*) varieties [Table 2].

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7 The term customary knowledge is deliberately used as a more suitable alternative to the more commonly used terms "traditional" or "indigenous" knowledge. Local knowledge is dynamic and changing; it develops to accomodate new crops and non-indigenous species as well as in response to cultural change, becoming customary knowledge with time. Both "traditional" and "indigenous" unfortunately imply a static approach to what is a dynamic, inventive and experimental process of observation and experimentation by people with plants.

Table 2. Classification of sweet potato varieties in western Uganda

Local name	Characteristics
enderera	large tubers, pale skin, and pale inner tuber
kyebandera	red skin, pale inner tuber
mukazi	red skin, pale inner tuber, different leaf shape to "kyebandera"
kanyasi	smaller tubers than "enderera", pale "white" skin and inner tuber, small leaves
rushalita	yellow skin which is bitter tasting, pale inner tuber, large leaves
nora	yellow skin, pale inner tuber, narrow leaves
magabali	yellow skin, yellow inner tuber, has many "eyes"; is good to eat raw
senga	red skin, white or red inner tuber
sunday	yellow skin, yellow inner tuber, which does not grow as large as "nora"

In the same area, farmers recognize and have local names for different varieties of other introduced crops such as cassava (*Manihot utilissima*), e.g. "kakoba" (white tubers and a hard eating consistency) and "pologoma", (reddish tubers); and for indigenous African crops like *Eleusine coracana*.

At a time when unemployment is high and qualified personnel are sorely needed to develop the national and/or regional capacities for germplasm collection, it is a matter of urgency that the expertise of farmers and the value of local knowledge is recognized and incorporated to a greater degree in collecting programmes in eastern and southern Africa.

Examples of folk taxonomic classification

In order to illustrate the wealth of local knowledge, held by peasant farmers, with respect to important crop plants, I give two examples from climatically, culturally and biologically different parts of southern and eastern Africa. The first is watermelon (*Citrullus lanatus*), an indigenous crop plant with wild relatives in southern Africa; and the second, the banana, which has its centre of origin in South-East Asia, and was introduced into East Africa by Indo-Malayan immigrants and Arab traders [Swennen and Vuylsteke, 1991].

1. *Citrullus lanatus* (Cucurbitaceae)

Indigenous knowledge of variation within a single useful plant species, in terms of fruit yield, fruiting times or fruit quality, can be an important and cost-effective guide to collection of plant genetic material and selection for desirable characters in the development of cultivars. KwaNyama-speaking farmers in Namibia distinguish between, and can name, seven different varieties of *Citrullus lanatus* [Table 3] based on qualities of fruit size, taste, skin colour, seed colour or whether or not the seed margins are ridged. This folk taxonomy often reflects how the crop is used [Rodin, 1985].

It is likely that an equally detailed knowledge is held by gatherers of *Cucumis* and *Citrullus* species and possibly even *Acanthosicyos* in other parts of Namibia. The first two genera have been identified by SADCC as priorities for Botswana [SIDA, 1989] and the

same should apply to Namibia. Appropriate recognition should be given to traditional knowledge and it should be used more extensively as a guide to collecting a broad range of genotypes of these genera. This is to be the focus of a study by G. Maggs (National Herbarium, Windhoek).

2. Matooke and other bananas (*Musa* species)

Bananas are a major crop in the highlands of East Africa. The per capita consumption of bananas in this region is higher than anywhere else in the world [FAO, 1985]. Unlike commercial banana production in southern Africa, which is based mainly on the Cavendish variety, a rich diversity of banana types are grown by East African peasant farmers; an estimated 45 to 70 clones are cultivated in the highlands of Rwanda, Burundi, eastern Zaire, Uganda, western Tanzania and Kenya [Swennen and Vuylsteke, 1991].

Table 3. Classification of watermelon by some farmers in Namibia

Local name	Characteristics
etanga leliua	a large, elongated, dark green fruit which is eaten cooked;
etanga lomungengo	a small, round fruit, with a mottled green-and-yellow skin; because taste is bland the melons are fed to pigs but seeds are eaten raw;
etanga lepuputa	similar fruit to "etanga lomungengo"; a sour taste, white seeds and a melon that is eaten cooked;
ekanuma	an oblong, light green melon with dark green stripes, white or red flesh and reddish seeds; is eaten raw;
omumbada	a soft, green, oblong fruit which is baked before flesh is eaten; white seeds that are eaten raw or fried;
domaliua	has white flesh with seeds eaten raw;
enuua	with yellow flesh and seeds that can be eaten raw.

In south-western Uganda, for example, the three major categories, namely, cooking bananas or plantains (commonly called "matooke"), bananas used for making beer and sweet or desert bananas, are divided into at least 20 different varieties, each with a local name.

Examples of Bakiga names for these three categories of bananas are:

matooke cooking banana/plantain varieties:	enjagata, mbwaziruma, empinda, marambi, enzerabahima, kyitika, the large enkurura plantain and the ngonja bananas, which are normally roasted, with the skin on, next to a fire;
beer (tonto) making varieties:	embiri, subi, musa, and endizi;
desert or sweet bananas:	kabaragara, mbogoya, mujuba and the spectacular red skinned ekyijungu variety.

This is an excellent illustration of the dynamic nature of local knowledge, which far from being "traditional" in the sense of being fixed in time, has developed a folk taxonomy for this relatively new crop to Africa.

Most farmers cultivate 10 - 12 varieties in a single field, interplanted and producing bananas at different times of the year. They are able to distinguish different varieties on the basis of leaf, stem and fruit characters. At a time when black Sigatoka leaf spot disease is a major threat to food security in East Africa and an economic problem, the expertise, acute observation and interest of farmers could play a major role in breeding and selection programmes for disease resistance.

Conclusion

In Africa, a narrowing of the genetic base of crop plants with its concomitant threat to food security together with the threat to the presently or potentially important wild species, valued for medicinal or other purposes, will be an increasing problem in the foreseeable future. Not only are specialist plant users, such as herbalists or craft workers, and peasant farmers custodians of this diversity, but they can play a major role at the "cutting edge" of plant conservation efforts. To be most effective, the common current practice of swift "collecting missions" often carried out by collectors from Europe, Japan or North America must be modified to place a greater emphasis on longer field trips which involve peasant farmers as research and plant conservation partners. The many advantages they offer must be recognized: great knowledge of local varieties, acute observation of plant and ecological characters, and the opportunity to collect and observe early and late producing varieties in a world where professional international staff are often too rushed.

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The Role of Traditional Knowledge in Germplasm Collecting

K. Hammer and D. N. Mbewe

Introduction

A number of crops have originated or have been domesticated in Africa. These include sorghum, pearl- and finger-millets, coffee, cowpea, African rice, *Digitaria* spp., Bambara groundnut, sesame, castor, oil palm, yam, watermelon, *Gossypium herbaceum*, okra, roselle [Simmonds, 1979; Anishetty and Perret, 1981; Mooney, 1983; Paroda and Arora, 1991]. In addition, the continent is also a centre of diversity of crops, including durum wheat (*Triticum durum*) and barley (*Hordeum vulgare*). It therefore has a wealth of crop genetic diversity, both in terms of cultivated and wild forms. The genetic diversity is enhanced further by the presence of landraces of some of the introduced crop species, such as maize.

The main "custodians" of this genetic diversity are the rural farmers [Mooney, 1983]. Among other uses, the peasant farmer has, over the years, used this material to produce food, fibre and medicines and as a source of fuel. Knowledge about crops, such as types, uses, cropping systems, cultivation methods, etc., has been handed down from generation to generation, mainly through local languages.

Traditional crops are well adapted to the environment but suffer, in most cases, from the fact that they produce lower yields. As a result, more and more peasant farmers the world over have turned, and are still turning, to improved varieties with high yields but a narrower genetic base. This has lead to a significant number of peasant farmers abandoning the traditional crops, which action eventually contributes to loss of genetic diversity. It should be pointed out, however, that the extent of the loss of genetic diversity as a result of the increased use of improved varieties, depends in part, on the cropping systems in use [Brush, 1991; Esquivel and Hammer, 1992]. In recent years, the rate of loss of genetic diversity in Africa through the adoption of improved varieties has been accelerated by the drive for food self-sufficiency. In a number of countries, government policies were deliberately aimed at the increased production of one staple crop (e.g. maize, at the expense of others such as sorghum, millets and cassava).

As more and more farmers adopt the improved varieties, not only does the crop diversity diminish [Laghetti *et al.*, 1990)] but the knowledge about them also gets lost. This makes collection even more difficult. The situation is made worse by the increasing migration of young people from the rural to urban areas resulting in lower numbers of farmers and consequently loss of traditional knowledge. It is imperative, therefore, that this knowledge be utilized as quickly as possible in collecting germplasm, not only in Africa but in any other parts of the world, where applicable. A quote from the Keystone International Dialogue [1991] report is appropriate: "To be successful, the Global Initiative set forth in the report will require the joint efforts and involvement of all affected parties and institutions from all levels and from all parts of the world - including those who are contributors of germplasms, information, technology, funds and systems of information".

This paper discusses how traditional knowledge (information) can be used in enhancing the crop genetic base, which in turn will contribute to the Global Initiative in so far as the collection of germplasm is concerned.

Type of knowledge

Normally, a germplasm collection strategy involves, among other things, the acquisition of information from country reports, regional/provincial documents, botanical maps and academic research publications [Arora, 1991]. These give knowledge on climate, ecology, vegetation and agriculture. The contribution of the respective reports to this knowledge depends on their availability and, to some extent, the state of development of a particular country. The secondary information thus obtained, is supplemented by knowledge from local people in the rural areas and peasant farmers. In most developing countries, e.g. those in Africa, where the written knowledge is scarce or sometimes non-existent, traditional knowledge assumes even greater significance.

The type of traditional knowledge that can be useful in collecting germplasm is varied, but it includes information on the type of plant, use(s), role in the people's nutrition, the state of the plant (i.e. cultivated or completely wild) the importance placed on the crop by the local people, cropping systems, agronomic practices [Esquivel *et al.*, 1990; Blixt, pers. comm.], adaptation and quality. Such knowledge will not only give an idea of the best ways of maintaining the crop's genetic diversity, but also the potential utilization in breeding programmes. Information on multiple uses of a particular plant may explain the developmental pattern or introgressive development, e.g. beans which are used either as a vegetable or as grain; while information on the state of the plant may assist in placing collection priorities. For example, depending on the environmental threat, low priority can be placed on those plants that are completely wild. This will not only save time, but also the costs of collecting. Some collectors have utilized traditional knowledge to identify crops [Esquivel and Hammer, 1988; IBPGR, 1990].

Traditional knowledge can take many forms; it can be in the form of verbal communication, local names, folk names or old ethnobotanical records [Laghetti *et al.*, 1990]. Collecting in Georgia, Beridze *et al.*, [1984] utilized folk names for their collection, while Hammer *et al.*, [1985] used information about *Triticum dicoccon* gathered from the local people during the collection mission in Italy. Many such examples are readily available in the literature.

As pointed out earlier, the extent of the knowledge is a function of its availability. Apart from the negative effects of other factors causing genetic diversity loss, as more people of the older generation die, the less the knowledge that will be available. This calls for steps to rescue the traditional knowledge through such projects as the "memory bank" project in the Philippines that is being conducted by the International Potato Centre (CIP) in conjunction with User's Perspective with Agricultural Research and Development (UPWARD) [IBPGR, 1991]. Memory banks parallel the genebanks but, instead of preserving the germplasm *per se*, they preserve the traditional knowledge that can be helpful in future collection.

Traditional knowledge and the use of indicator crops in germplasm collecting

Collecting missions can be either specific or broad based [Arora, 1991]. In specific missions, the objective might be to collect material with defined characteristics, while broad based ones are mainly aimed at collecting multi-crop accessions. In the case of the latter, the use of indicator crops has been found to be quite useful [Hammer *et al.*, 1981; 1985; Hammer *et al.*, 1990; Beridze *et al.*, 1982]. Traditional knowledge of such crops has been used to collect germplasm; for example, Beridze *et al.*, [1982] were able to use knowledge of species regarded as indicators of landrace populations e.g. *Bromus secalinus*, *Lolium temulentum* and *Agrostemma githago* in Georgia, while Hammer *et al.*, [1990] used knowledge, gained

from the farmers, on *Triticum dicoccon*, to collect not only *T. dicoccon* itself, but also *T. monococcum*, *T. turgidum*, and landraces of *T. aestivum*, *T. durum* and *Secale cereale* in southern Italy, as well as pulses and vegetables. Using this method, it is possible to cover a wider area; a useful approach when there is need to carry out rescue missions [Hammer *et al.*, 1991].

In Africa, a number of general collecting missions have been undertaken, but the fast changing environment (as a result of global warming, for example:) will necessitate more rescue missions, especially in desert areas [Moss, 1990]. In such cases, prior knowledge of some indicator crops would be very beneficial. Apart from the desert areas, other collections should be undertaken in areas which have not, or have only partially, been covered. Funding and time permitting, subsequent collecting missions can be more specific. Some scientists believe that collections in any particular area should be done at intervals of 10 years [V. Dragavtsev, as quoted by IBPGR, 1990], but this would depend on the degree of evolutionary pressure as exerted by various factors, such as agricultural system and climate.

Source of traditional knowledge

The main sources of traditional knowledge, apart from the literature, are peasant farmers themselves. The farmers are the ones who practice traditional agriculture and, as such, they are the custodians of the knowledge about the plants they grow [Esquivel *et al.*, 1990]. In most parts of Africa (as well other Third World areas), some farmers have continued to grow their own seeds as a safeguard against the disaster-prone, high-yielding varieties [Mooney, 1983].

Farmers maintain their crops, not only in the normal field gardens, but also in home gardens or *conucos* [Esquivel and Hammer, 1988; Esquivel *et al.*, *1988*; Padoch and de Jong, 1991]. Many of these *conucos* contain a number of old plant cultivars and have developed a high level of plant diversity; they also vary in size, appearance and species combinations [Padoch and de Jong, 1991]. In a detailed study of the home gardens or *conucos* in Cuba, Esquivel and Hammer [1988] found a wide variation in the type and size of gardens (small, medium, large) and genetic diversity knowledge which could be used for the collection of crop germplasm. To demonstrate the wealth of genetic diversity in such gardens, the authors reported 80 taxa in the cases investigated, consisting of ornamental plants (20), fruits (15), vegetables and spices (12), medicinal plants (8), grains (7), starchy plants (7), pulses (5) and others (6). In Africa, such home gardens or *shambas* are common in East Africa, for example. It is clear, therefore, that more studies of this nature would be extremely useful in collecting missions.

Over and above the source of information, the question that follows is, who, the men or the women, generally, have the monopoly of this traditional knowledge [see Anderson, 1952; and Heiser, 1973]? It is not possible to give a definite, affirmative response in favour of either. The answer is influenced by the society's social traditions, the type of crops and the type of gardens cultivated. Some studies on the distribution of labour in crop farming systems seem to indicate that women do more work than do men (60% of all farm work), thus suggesting that women would have more traditional knowledge, hence women would be a good source of both genetic and cultural information [IBPGR, 1990]. However, in some societies, the type of crop cultivated influences this aspect. In the case of vegetables and spices for example, women are more or less responsible for their cultivation; they would, therefore, be expected to have more knowledge on such crop plants; the reverse is largely true when it comes to most field crops [P. Hanelt; M. Esquivel, personal communication]. With respect to gardens, the smaller and nearer to the house the garden is, the more likely

it is that the woman is responsible and would thus have more knowledge of the diversity of the plants cultivated. The reverse may be true for larger and further away gardens.

The above discussion suggests that would-be collectors would do well to have an idea of such information before embarking on a collecting mission.

Influence of cultural history

Some developmental patterns of plants, as indicated by traditional knowledge, may be a reflection of cultural or ethnic influence [Esquivel and Hammer, 1992]. This influence may be reflected in the form of the plant which developed, e.g. in *Brassica oleracea* var. *palmifolia* (kale), there are some that are palm-leafed, while others are leaf types [Hammer *et al.*, 1991]. Such information can reflect the cultural background of the users, i. e. whether European, Asiatic, Indoamerican or African. Historical, linguistic and ethnobotanical information on Cuban plants revealed that about 30% of cultivated plants and their wild relatives in Cuba were of American origin [Esquivel and Hammer, 1987] while about 11% may have originated in Africa [Esquivel and Hammer, 1988]. Such information could explain some of the introgressive evolution or selection of some of the plants; this could enhance the plant germplasm collecting missions and hence is an important tool in meaningful germplasm collection in Africa and elsewhere.

Ethnobotany and the use of checklists

The preceding discussion has highlighted aspects of traditional knowledge and their uses. Some examples were given to illustrate these uses. The information constitutes part of the area of ethnobotany or the relationship between plants and man [Wickens, 1990]. It can be stated, therefore, that ethnobotany formalizes this plant-man relationship as reflected, in part, by the information obtained from the local people, which is then used in the collection of plant material.

A recent development in the process of formalizing the utilization of ethnobotanical (traditional) knowledge in identifying and collecting germplasm, is the use of checklists [Hammer, 1990; 1991]. The need for checklists has been exemplified mainly by the limited knowledge of plants, particularly their taxonomy [Anderson, 1952]. This has been stated already by Darwin [1879]. With notable exceptions. e.g. De Candolle [1886] and Vavilov [1951], there was, only recently, a major breakthrough in the form of a book, edited by Schultze-Motel [1986], which contains information on 4800 cultivated species (excluding ornamentals and forestry plants). However, the input for some areas is limited. For this reason, a method was developed to make better use of the traditional knowledge of the farmers.

Berlin, [1992], after compiling the results of various field studies, stated that traditional cultivators know more plants on the generic level (mean = 520) than do noncultivators (mean = 197). The number cited for cultivators refers also to cultivated plants. A high number of species under cultivation can be expected. To prove this hypothesis, a method was developed using checklists containing folk names, uses and other information on cultivated plant species. In this way it was possible, during collecting missions to effectively update the knowledge concerning the flora of cultivated plants in some areas. The first results from the work with these checklists gave an idea of the richness of cultivated plant species in particular areas, i.e. 1029 species in Cuba, 522 species in southern Italy, 515 species in Korea and 279 species in Libya [Esquivel *et al.*, 1992]. For more information see Tables 1, 2 and 3.

Table 1. Summary of contents of the Gatersleben database for Cuba, Italy and Korea

	Cuba	Italy	Korea	Total of different taxa etc.
Taxa	1045	541	473	1648
Species	1029	522	456	1597
Genera	531	300	314	781
Families	117	86	99	158
Synonyms	727	347	358	1242
Vernacular names	1671	2833	530	5034
Literature references	197	306	4	507

Note: taxa = species and intraspecific categories; the figures for Korea are not complete yet.

Source: Knüpffer, 1992

Table 2. Plant families with the largest numbers of species in the Gatersleben database for Cuba, Italy and Korea (total > 20 species)

Family	Number of Species			
	Total of different spp	Cuba	Italy	Korea
Leguminosae	232	164	72	46
Gramineae	148	95	54	31
Compositae	75	44	32	32
Rosaceae	74	11	41	39
Rutaceae	63	55	18	13
Labiatae	51	26	27	18
Solanaceae	43	35	18	16
Myrtaceae	41	41	7	0
Liliaceae	48	17	16	21
Euphorbiaceae	35	33	1	4
Umbelliferae	32	14	16	22
Cucurbitaceae	25	22	12	12
Malvaceae	25	22	6	8
Moraceae	25	20	6	6
Cruciferae	24	11	20	10

Source: Knüpffer, 1992

Table 3. Summary of the plant uses in the Gatersleben database for Cuba, Italy and Korea (number of taxa for which a particular use is reported, and percentages calculated on the basis of the total number of taxa)

Use	Cuba		Italy		Korea	
	No.	%	No.	%	No.	%
M. (medicinal)	432	41.3	120	22.2	338	71.5
Fr. (fruits)	262	25.0	106	19.6	48	10.1
Fo. (forage)	173	16.5	87	16.1	60	12.7
V. (vegetable)	99	9.5	119	22.0	79	16.7
Sp. (spice and condiment)	60	5.7	59	10.9	16	3.4
Fi. (fibre)	44	4.2	8	1.5	21	4.4
I. (industrial)	41	3.9	49	9.1	17	3.6
St. (starch)	31	3.0	7	1.3	4	0.8
Oi. (oil)	24	2.3	14	2.6	29	6.1
C. (cereals)	9	0.9	21	3.9	15	3.2
Total	1046		541		473	

Source: Knüpffer, 1992

Several of these species have not been reported in the global compilation of cultivated plants [Schultze-Motel, 1986]. In this way the use of the traditional knowledge has led to the detection of new cultivated plant species from the category of underdeveloped and perspective crops. The folk name plays an important role for the collector because it enables him to ask the right questions. In Korea, for example, some rare crops or races were found by using the folk names [Baik *et al.*, 1986; K. Hammer, *et al.*, 1990]. New information can also be obtained from the use (and used parts) of the plant, e.g. a vegetable race of *Cucumis melo* from southern Italy as being a relic of former widespread cultivation [Hammer *et al.*, 1986]. Useful traditional information can be also included into, and obtained from, the distribution of the species in a certain area and from remarks on other noteworthy characteristics, e.g. variation or selection procedures.

Checklists have, therefore, been shown to be very useful in identifying and collecting germplasm. Currently, there are known checklists for Cuba, southern Italy, Korea and Libya. Using these checklists, especially those from Libya, [Hammer *et al.*, 1988] as a starting point, similar lists could be developed for the rest of Africa on a regional or country basis.

Summary

Traditional knowledge plays an important role in germplasm collecting. Methods and principles of ethnobotany should be used. As a complete ethnobotanical approach cannot be

achieved during collecting missions, a concentrated version has been developed by using checklists in exploring plant genetic resources. Checklists include the most relevant data and provide information about the wealth of plant genetic resources in the area covered. Examples from Europe, Asia, northern Africa and Latin America are cited which can be seen as models for projects in Africa.

Conclusion

With respect to plant genetic resources, a complete investigation of traditional knowledge of traditional agriculture needs to be studied comprehensively using the manyfold methods of ethnobotany (see, for example, Jain [1991]). Only elements of ethnobotanical research can be used on collecting missions which have their own dynamics. The use of checklists, which allow the effective inclusion of several items in relation to traditional knowledge, is advocated. By using this method, examples from Europe, Asia, northern Africa and Latin America can serve as models for ongoing research and collecting work in Africa.

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The Role of NGOs in the Conservation and Increased Use of Landraces; or: The Farmers First....

A. Onorati and A. Gaifani

Let us assume that this meeting, joining government institutions, international institutions and NGOs around the same table, is one further step in recognition of the search for a new direction to orientate future scientific investigations with regard to rural development.

The scientific background upon which the Green Revolution was based, considered the farmer as a passive consumer of external technologies and inputs. Within that peculiar framework it was impossible to think of them as active subjects, participating in a research process aimed at the re-activation of local farming systems. Fortunately, this kind of approach is continuously losing its supposed credibility, and it is more and more widely accepted that the local communities must have a say in managing their own development and in the setting of priorities.

It is not a matter of pushing back the course of history in order to re-establish some old agricultural systems that have since disappeared; rather, we can modify the productive system that is presently imposed on peasant farmers. More specifically, we can keep those systems which are based on a rural environment. There is no way, however, that this can be managed without the proper involvement of the farmers themselves, of the community-based organizations, the farmers' associations and unions, and the NGOs.

Unfortunately, one of the main outputs of the Green Revolution has been the destruction of traditional local knowledge, techniques and habits. This caused disruption of the very sophisticated biological links connecting the natural environment to those traditional agricultural techniques which constituted the basis of any sustainability. Sampling of the local knowledge and genetic resources of the farming communities, and the subsequent storing of all such information and materials in the genebanks and the research laboratories, expropriated the farmers' control over their own productive system. Today, it is difficult to go back. However, it is acknowledged widely that these are the reasons for the biodiversity as we find it now. It has taken years of confrontation, discussion and negotiation to reach a formal recognition of the farmer's rights due to their contribution to preserving, keeping and making available, plant genetic resources. Farmers, who through their work and at risk to their own lives supplied an important contribution to the constitution of improved seed varieties and hybrids, are now compelled to buy back products of which the very price reflects the value of their work.

As an NGO, Crocevia is very much concerned with measures which originate from the farmers needs and grant them an effective way of controlling and self-managing their own system. This "informal" sector should be provided with the necessary means and decisional powers to maintain and improve their actions in order to save their culture through their environment and the maintenance of the biodiversity which allowed them to evolve so many different ways of life.

The strengthening of the informal rural sector, the guarantees regarding their right to self-representation and the concern for their inalienable right to self-determination, are high priorities which need to be integrated in the strategies of the CGIAR system. The farmers' organizations should participate at management level in the orientation of research guidelines towards a differentiation of production, conservation, use and evaluation of genetic diversity. They are the only ones who could supply sustainability and economic reliability to these otherwise theoretical concepts.

In order for this to be realized, appropriate means are needed to provide the necessary training for decentralized, on-farm, conservation; appropriate technologies are required to support the production and distribution of seed on a local basis; and government support is required, at least, to prevent those development activities that are menacing the genetic resources which the farmers need to preserve.

With this particular perspective we believe that preservation is not to be considered as a final objective but only as a means for making it possible for someone to use the knowledge, seed or technique.

Together with a number of partners in different countries of the world, Crocevia has been looking for funding for field projects that give support to the farmers' control over the two most important agricultural assets: land and genetic resources. Given that access to land remains the first pre-requisite for any rural activity, control over genetic resources follows immediately in importance.

The very different situations proper to various rural environments taught us that no one example can be taken for granted in the implementation of another project. Considering that the main focus of this seminar is on Africa, we would like to present, briefly, the experience of two contrasting situations:

1. At Lichinga, in the Niassa region of northern Mozambique, the National Seed Company was supposed to build up a local production unit under the control of the central headquarters. After the onset of the civil war in that country, access to Lichinga became difficult and the technicians, under contract to a private firm, were retrenched. Further, because it is no longer possible to depend on supplies from the Indian Ocean ports of Beira and Nacala, there is, at present, a desperate need for seed in the region.

   An agreement has been made between the National Directorate for Agriculture and Crocevia to take over the existing infrastructure and to elaborate a joint plan for seed production together with the relevant authorities in the region. The basic assumption of the negotiations with the agricultural research station and the regional government was that the use of hybrid seed was inadvisable as supplies of the necessary inputs and transport could not be relied upon.

   The final draft of the general framework for operations depicted the activation of a seed chain from the scientific research institution to a commercial network for seed distribution. The main concept was the establishment of a social enterprise to coordinate seed production activities and act as a link between the formal scientific research and the end-users. This new Board was intended to be an autonomous, self-reliant, economically viable institution, set up through a specific project. In its third year of operation, the *Gabinete de Produção de Sementes do Niassa* was able to pay the salaries of its own technicians and field workers.

   The basic seed requirement was obtained, in part, from its own farm, and the remainder from the agricultural research station. It was distributed to contract growers who were given technical assistance and priority in the allocation of inputs. During the growing period, the technicians followed procedures for the production of fully certified seed though this was not, at the time, officially recognized. After harvesting, collected seed was transported to the treatment plant where the final processing and selection was made manually and mechanically, culminating in packaging and storage.

Though this seed production enterprise started because of the pressing need for seed supplies in an emergency situation, it was always clear that the second objective was to establish an economically viable and socially appropriate unit. The emergency supply was made possible because the funds allocated by the project were never used for the running costs (except for a partial contribution in the first couple of years) or for personnel expenses but only as an investment fund for improving the infrastructure.

The second objective had two different aspects to be taken into consideration: an economic one and one with an eye to local knowledge and genetic resources. The actual establishment of a proper society has not yet happened due to the severe deterioration in the Mozambican economy, but it has been agreed that the society is to be under the shared control of the local government, the National Seed Company and local farmers, including the actual workers. At the same time, the field of 14 hectares, owned by the society, is being used partly as an experiment field to test local varieties, minor crops and local techniques, while the rest is under the direct management of the workers for providing their own crops.

During the second year, the *Gabinete* was able to sell maize seed at a lower price than the advised national price. The production of 180 tons of maize seed is sufficient for 9 000 hectares.

Though it is not possible here to give more detailed accounts of the main problems that are being faced, it is worthwhile pointing out that the most dangerous threat to the continued existence of the *Gabinete* comes from the free distribution of imported seed through uncontrolled, self-defined "aid agencies".

2. In quite the opposite way, in the Yatenga region of Burkina Faso close to the border with Mali, a seed production project is managed by Crocevia together with the Regional Directorate for Agriculture. The project involves a large number of small farmers in several villages.

   Burkina Faso has no national seed production facility. Thus the country relies on imported seed and that produced by local farmers themselves. FAO tried to set up a seed production project in the Yatenga region but it was abandoned after the first year with the only result being the fencing of an 11 hectares area to be used for seed multiplication.

   Crocevia then set up a new project in Yatenga in cooperation with the National Seed Service and the remaining local technicians. The agreement that we found useful for this situation was, after an intense effort to technically educate farmers identified by the village groups, to rely on village-level multiplication. The Regional Directorate and Crocevia have the responsibility of managing a small area for field tests, multiplying basic seed and collecting local varieties.

   In Yatenga, the need for improved seeds is a result of the trend, in the last approximately twenty years, of reduced rainy seasons. In certain years, this has resulted in a mere 47 days of rain. Thus, varieties reaching maturity in a 75 days cycle are needed to ensure food security for the household. Apparently, existing local varieties are not adapted to this pattern of quick changes in climate, so it has been necessary to look in other areas for very short-cycled material.

   The seed produced on the project farm is distributed to selected farmers in the villages. They are assisted during the very short rainy season to multiply the seeds to supply

other farmers in the village with seed for the following season. Considering that the farmers are used to reproducing the seed they need themselves, project seed will be introduced in the villages only once every couple of years. The seed farm will be used as a strategic reserve in case the relatively common situation arises in which crops fail because of the erratic rains. Crops involved in this production and dissemination scheme are the major food crops of the area, namely, sorghum, pearl millet, maize, groundnut and sesame; a total quantity of 10 tons of seed is produced.

A different plan will be used for the horticultural crops. A farmers' cooperative, which is also running a small irrigation scheme, will directly manage the production of seed. Still to be faced is the difficulty in reproducing certain exotic crops, given that they need a minimum period of cold temperatures to flower, prevent bolting or to fill the pods. For the time being, priority is being focused on onions, okra, cowpeas and tomatoes.

Conclusion

We believe that the world economic crisis, which is making access to credit more and more difficult for the peasant farmers, makes it necessary to reduce the running costs of agriculture. The farmers are being pushed toward local self-sufficiency and they are forced to reduce the introduction of external inputs such as HYVs. The stagnation of the world agricultural markets and the prices which are barely remunerative exacerbate this situation.

The strengthening of this informal sector must be supported, and acknowledgement of the farmers' rights over collected germplasm is one possible supportive measure. In this regard, the permanent lobbying and monitoring of the international system (FAO, CGIAR, World Bank, etc.) by NGOs and their networks, is to be stressed.

It must be recognized that rural societies have the right to choose their own autonomous way of development. There needs to be restitution of the means to keep and enhance their own way of dealing with agricultural systems, based on the full use of the available resources in a sustainable way.

We stress the right of rural populations to be rewarded for their capacity to modify and innovate the farming systems, beginning with the fair settlement of access to land: the ancestral land for the marginalized minorities of indigenous people. This, in turn, would benefit other sectors of the populations.

Technical Issues in the Conservation of Landraces

A. T. Obilana

Introduction

In the broad sense, indigenous (landrace) conservation involves *in situ* (in natural or original environments), *ex situ* (in genebanks as live collections) and on-farm (farmers fields) protection and safe-keeping of the resources. It is widely accepted that *in situ* conservation is complementary to *ex situ* while *in vitro* collections (tissue culture accessions) would be an addition to *ex situ* conservation, especially for those crops that are difficult to store under long term cold storage conditions. The components of *ex situ* conservation, including collection, storage, documentation, evaluation, regeneration and enhancement, together with the complications of cold storage of live collections in genebanks, constitute technical issues of significant concern.

In general, conservation techniques, be they based on high level scientific technology or at the level of the farmer, are for the continued maintenance of available landrace resources. The intention is to guard against erosion, whether genetic or environmental, biotic or abiotic. It should be noted, however, that the farmer, while maintaining his landrace, also enhances it by selection. This raises the questions: conservation for what; where and how; and by and for whom?

This paper reviews the several approaches to conserving landraces and identifies the technical issues, questions and concerns that arise. Ways of addressing these issues are highlighted and, where possible, some solutions to problematic areas are proposed.

Approaches to landrace conservation issues

Technical issues pertaining to conservation of landraces have been looked at from several perspectives, including:

Organizational approach

- genetic diversity
- population genetics
- conservation/preservation strategies - *in vitro* and *in vivo*
- germplasm health
- germplasm documentation, characterization and evolution
- propagules: seeds, cuttings, tissues, embryos
- research liaison in genetic resources conservation.

Data collection approach

1. Germplasm acquisition and storage:

- inventory (documentation)
- wild and weedy species
- traditional cultivars (landraces)
- breeders materials
  - special genetic stock
  - old/obsolete cultivars
  - current/new cultivars

- backup accessions
- backup systems and long term facilities
- degree of access to new genetic resources/landraces
- degree of access to information about germplasm.

2. Safety of landraces:

   - knowledge of locations where landraces and weedy/wild species exist or are declining
   - extinction problems that endanger landraces due to internal and social pressures
   - identification/knowledge of declining species and their numbers.

3. Preservation of germplasm:

   - viability of accessions: upon receipt and in storage
   - regeneration procedures and standards used concerning: growing out, germination testing procedures and maintenance/adequacy of integrity of accessions.

4. Description of accessions:

   - type of descriptive information available to germplasm users and conservators
   - farmer perception and description of landraces
   - evaluation and characterization data available, its type and usefulness.

5. Utilization and enhancement of accessions:

   - type and value of research and breeding activities on landraces
   - type and degree of emphasis on collecting and preserving landraces in conjunction with research and improvement/breeding
   - degree and level of interaction among collectors, breeders, conservationists and farmers as related to the demand for cultivars and improved landraces.

6. Size of genetic base:

   - amount of diversity and variability in existing collections as related to improved current cultivars
   - effect of developing genepools for specific traits
   - reproductive pattern and implications for maintenance of landrace commodity groups.

Answers to some of the issues raised in the data collection approach can be found in the report on plant germplasm: the United States GAO/PEMD-91-5B [1990]. Other perspectives to answers on technical issues are presented in the papers of this meeting.

Biological diversity approach

The "Convention on Biological Diversity" [UNEP, 1992], a document negotiated and signed in Rio de Janeiro by world member countries during the United Nations Conference on the Environment and Development (UNCED), included generalized definitions and approaches to conservation of genetic resources. There was agreement for an action programme on technical issues including:

- *in situ* and *ex situ* conservation (the latter complementing *in situ* measures)

- suitable use of components of biological diversity involving integration of its conservation into the national decision-making process

- research and training taking into account the special needs of developing countries (including Africa which possesses several crop landrace species)

- impact assessment and minimizing adverse impacts through implementing procedures that monitor environmental consequences and promote reciprocity in notification, exchange of information and consultation on activities that affect (positively or negatively) biological diversity

- access to genetic resources and transfer of technology

- technical and scientific cooperation

- identification and monitoring of: ecosystems and habitats of threatened species communities; wild relatives of domesticated or cultivated species; medicinal, agricultural and other economically valuable plants; plants of social, scientific or cultural importance

- research into indicator species which have importance in the conservation and sustainable use of biological diversity, or described genomes, genes and genotypes.

Other technical issues

The Final Consensus Report of the Keystone International Dialogue [1991] identified the following issues that also require special attention:

- Monitoring and early warning of genetic erosion through adequate information systems from which one can access information on the existing range of genetic diversity and timely warnings of events that may affect such diversity.

- Sustainability. It is in the development of techniques for sustainable advances in productivity that plant genetic resources play a pivotal role. It is possible to reduce the use of chemical pesticides and fertilizers if naturally occurring genetic variability and diversity in landraces are appropriately and effectively used to develop new crop strains which carry a wide range of genes from the landraces.

- Research and training. It was concluded that a better scientific understanding is required to solve the problems that hamper plant genetic resources conservation. This can be achieved by intensification of integrated and systematic research on technical and socio-economic issues concerning plant genetic resources conservation. It is realized that an expanded and more effective conservation system will require additional and better trained staff to implement plant genetic resources research and conservation.

- Public education and awareness about plant genetic resources conservation and its implications and consequences.

The several approaches to viewing the conservation of landraces (plant genetic resources) have some themes in common. Such themes are conceptual in nature, concern methodologies for improving old and establishing new strategies and involve institutional or

organizational changes. A combination of the several approaches with the identified themes arising as a consequence of the approaches, result in five broadly defined technical issues which are:

1. Conservation strategies
2. Genetic issues
3. Biodiversity and the environment
4. New technologies
5. Training and education

Several questions arise from discussing these issues, some of which are brought out below and some are highlighted in other papers of this seminar.

1. Conservation strategies

Landrace conservation can be done in three basic ways:

- *in situ* in natural or original habitat or in geneparks;
- *ex situ* in genebanks as live collections in several forms; and
- on-farm conservation.

In situ conservation is now being seen and recognized as a complementary strategy to *ex situ* conservation. These two strategies may be backed by *in vitro* (tissue culture) techniques wherever and whenever required. This applies especially for those plants/crops, like many shrub species and vegetatively propagated crops, which cannot be preserved in long-term cold storage. According to the Keystone International Dialogue Report [1991] approximately 150,000 accessions of such species are presently stored in field collections (field genebanks) with about 2000 accessions in *in vitro* collections. They estimate that 10% of total future accessions in holdings will be under such storage conditions. How do we tackle the logistics and technical implications of such potentially huge activity? How much will it cost? How easy will it be for all users, including farmers, to access them?

Many existing storage, maintenance and regeneration strategies and facilities are inadequate. There are several instances where accessions from genebanks have been found to be non-viable with zero germination. How do we guarantee longevity and viability of collections in genebanks? How secure are the *in situ*, *ex situ* and even the *in vitro* conservation efforts? Also, how secure would be the field genebanks and on-farm/community conserved material? For all these situations, consider both biotic and abiotic disasters (such as drought, floods and fires) including man's intervention. We may not, at present, be able to quantify and appreciate how many plant genetic resources have been and are being lost due to wars in Mozambique, Angola, Sudan and Somalia.

How do we maintain and regenerate accessions in genebanks? Several crop groups are difficult to handle and do not respond to conventional methods for maintenance/regeneration purposes. Do we use random-mating (isolation planting) as for cereals, controlled pollination as for some legumes, or tissue fusion as for species stored *in vitro*?

More collection expeditions are required for weedy and wild relatives of landraces. Minor crops or relatively under-exploited and under-utilized crops have been neglected and are in serious need of further collection. It should be emphasized that re-collection exercises are necessary for landraces in arid and semi-arid tropical and sub-tropical Africa where natural disasters like droughts and fires often occur. This would prevent loss of such potentially useful genetic resources. More targeted collections and re-collection exercises also can help to prevent or disturb the process of evolution which could be a long term problem for plant genetic resources stored in genebanks.

Additional descriptors such as nutrient uptake capacities, end-use quality and those that incorporate local knowledge and farmers' perceptions (socio-cultural and cosmovisional) may need to be included in current descriptor lists of IBPGR and cooperating institutions. Such a move would address positively the issues of changing priorities and the emphasis on sustainable agriculture, and also improve the linkage between local knowledge and agricultural research.

Characterization at biochemical and molecular level can be undertaken in a limited number of useful lines, to augment the normal agronomic level evaluation. Many programmes lack the ability or resources to evaluate or enhance the accessions they are conserving. Most national programmes also lack proper documentation. This does not augur well for adequate use of available plant genetic resources, especially the under-utilized and minor crops. Assistance from the International Agricultural Research Centres (IARC's), regional genebanks (such as the SRGB-SADC regional genebank) and mentor institutions (such as the CPRO-DLO Centre for Genetic Resources, Wageningen, Netherlands and the Plant Genetic Resources Centre, Addis Ababa, Ethiopia) is urgently required for training and empirical work in documentation and information dissemination (especially for characterization and evaluation information).

Multilocational evaluation and data collection and analyses are important preludes to enhancement of plant genetic resources. In some centres, the carrying out of these particularly valuable characterization exercises seems to be increasingly frequent and their quality can be continuously upgraded. Such exercises, aimed towards the effective enhancement of plant genetic resources, including basic research on the genetics of resistance to difficult diseases and pests (e.g. downy mildew and ergot of pearl millet and seedling rot in groundnut) require collaboration between genetic resources scientists, plant breeders, biotechnologists and other biological scientists in a cooperative programme. The management of the information on biotic problems from farmers in the diverse areas where these occur, could be useful and might involve social scientists and socio-agrologists. It is sometimes erroneously assumed that certain blocks of characters or races of some species in comparable environments are similar. The nature of the basic migrant populations in the comparable areas and selective and diversifying forces at play could have been responsible for fixing such blocks of characters (e.g. in the Guinea and Durra Guinea races of sorghum in Africa and Central America).

2. Genetic issues

Plant population structures (and changes in those structural patterns) could be determinants in the conservation strategies used for different groups of crops. Major groups of crops in Africa, include the cereals, legumes, oil crops, fibre and horticultural crops. In order to determine appropriately what conservation strategies to use for these commodity groups, one would need to consider genetic structure and genetic changes together with the genetic x environmental effects which affect the population structure of the plant genetic resources [Obilana 1992a and 1992b]. Figure 1 shows the linkage between plant genetic resources and

population structure in most crop plants, and how diversifying forces would affect both natural and breeders' populations which are components of indigenous and enhanced germplasm, respectively.

Both biotic (farmers, scientists and pests) and abiotic (drought, floods, chemical pollution and physical development or destruction of the environment) factors influence the genetic make-up and population structure of genetic resources. Obviously, therefore, what is required is an integrated approach to conservation strategies; one that involves all actors in conservation activities from farmer level to scientist level.

3. Biodiversity and environment

Of concern is the interrelationship between human, plant and other biological species and the micro- or macro-habitats, in the totality of conserving diversity. This has been the focus of the recently concluded Convention on Biological Diversity which considered both technical and non-technical issues including legal implications. I do not intend to elaborate here on the themes, but I emphasize the implication of access to, and exchange of, genetic resources. Complications in exchange procedures can be political or the result of government policies (which may need looking into); and also due to a lack in the capacity and resources of genebanks to respond to requests. A major problem is that of quarantine (issues and facilities) which needs closer re-consideration, especially with regard to the introduction or spread of new diseases and insect pests into areas where these are hitherto unknown.

4. New technologies

Several laboratory techniques and statistical procedures have been used in the characterization, evaluation and documentation of plant genetic resources. Few of these have been used for indigenous African germplasm in national programmes. There is need to improve on the older methods and make available to conservators, the new ones, including *in vitro* (for crops such as plantain, cassava and yams) and allozyme variation techniques. The use of cluster and component analysis statistical methods need to be more widespread.

Biotechnological approaches can be used for enhancing germplasm resources; gene mapping using RFLP's; genetic management of mapped genes for understanding interrelationships among landraces; and gene hybridization to generate new recombinations.

It seems, however, that not much research has been done on new techniques for collection in the field. New computer software to generate thematic maps that indicate scatter diagrams of collection locations, type and size, and identify uncollected areas, would be useful to decide on collection expedition strategies.

5. Training and education

New and additional training and education strategies have to be worked out and implemented for the new approaches to indigenous genetic resources conservation to be properly and adequately utilized. Cooperation among the several actors involved in conservation is required for such interdisciplinary cooperative research and training in present techniques, and to develop new conservation strategies.

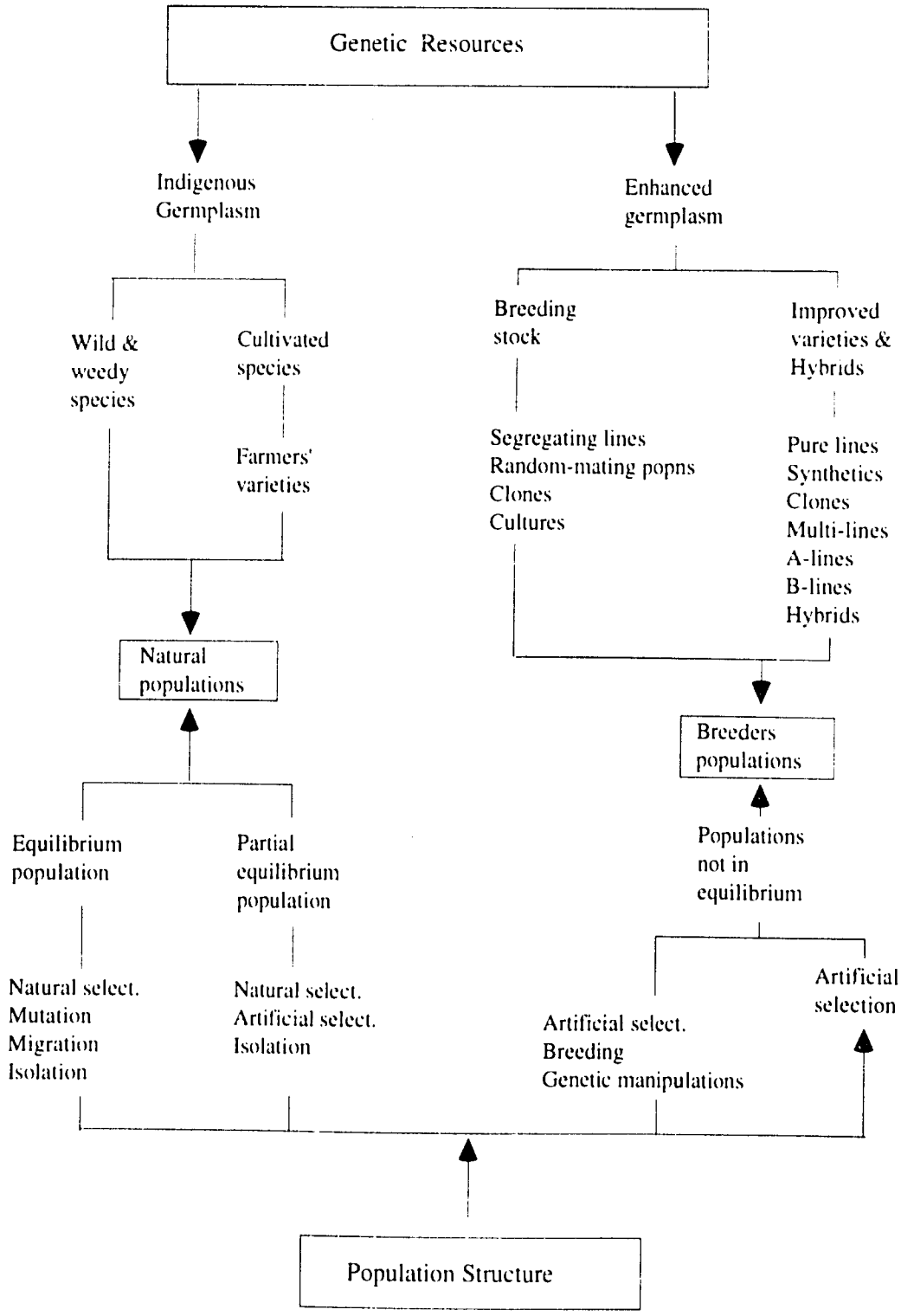

Figure 1. **Linkage between genetic resources and population structure in crop plants**

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Training for Conservation and Use of Plant Genetic Resources at Farm Level: New Perspectives

T. A. Mushita

Introduction

Training for conservation and use of plant genetic resources at farm level needs to be pursued through an agricultural revolution which mobilizes indigenous knowledge and skills. Such an approach would have profound implications for the training of agricultural professionals.

Richards [1985] noted that many scientists interested in cross-cultural studies of "rationality" [c.f. Hollis and Lukes, 1982; Horton, 1967] paid no attention to the issue of indigenous agricultural experimentation when debating the differences and similarities between "traditional" and "modern" systems of thought. He suggested that perhaps the answer was to be found in what Coomaraswamy [1979] called "The Bugbear of Literacy", by which he meant a consistent downgrading of oral and practical skills (as if these were in some way sub-intellectual) by those who make their own living from "scholarship".

The formal system of training is centralized with an established operational framework and mechanism while the informal system is decentralized, uncoordinated and relatively obscure. Agricultural training programmes should be designed with objectives, aspirations and thrust to make scientists aware of, and to facilitate, the technology development process. Also, the programmes should include a study of the linkage mechanism between agricultural research and extension and its role in technology transfer [K.V. Raman, 1989].

Training for conservation and utilization of plant genetic resources at farm level calls for the scientists to understand and appreciate the local farmers' present practices. Scientists should be prepared to understand and learn from the local farmers' agricultural development priorities at village, community and district levels. They need to be exposed to the rural setting in order to understand the training requirements of their clientele, with respect to the use of PGR material. Such an approach would facilitate a broader understanding of the socio-economic constraints affecting the adoption and diffusion of technology at the local level.

One of the limiting factors in understanding local initiatives, practices and dynamics, with respect to conservation and utilization of PGR material, is that of modern science's underlying article of faith which claims the spatial and temporal universality of its laws and theories [Horton and Finnegan, 1973]. Current scientific theories are neither wholly universal nor wholly specific to any society. They are mixtures that vary from field to field. There are increasingly large cultural biases as one moves from a rather abstract physical field, (e.g. economics), to a much larger area of conflicts such as agriculture where specific environments, cultures and values interface [Dahlberg, 1979]. It is therefore important for scientists to understand and build on farmers' knowledge and experiences.

Farmers' knowledge as the first step

Our work at ENDA, Zimbabwe, provided us with the opportunity to understand the evolutionary approach of farmers to their knowledge of the management and utilization of local plant genetic resources. We have been able to realize why farmers are still

cultivating open-pollinated crop varieties despite the extensive introduction, promotion and marketing of hybrids [see Fig. 1]. This is largely because the distribution of the staple food crop cultivars is so closely related to that of the various soil and vegetation types as to allow the definition of corresponding agriculture systems. Currently in Zimbabwe, the commonly practiced sustainable agricultural practices are crop rotation, inter-cropping, winter ploughing, water/soil conservation and organic farming.

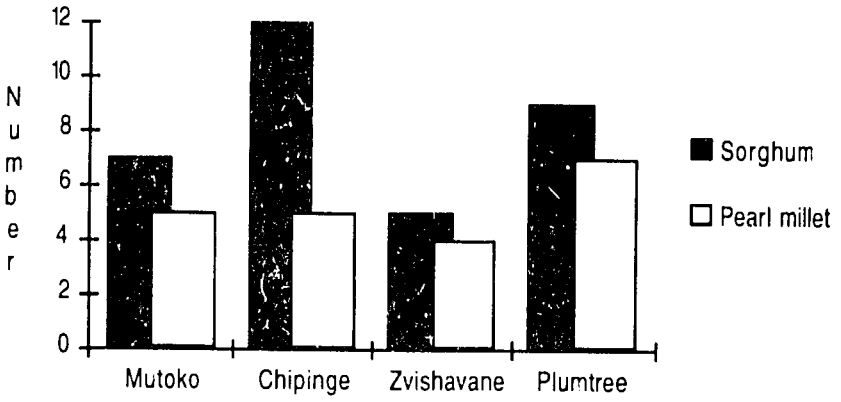

Figure 1. Number of pollinated sorghum and pearl millet varieties cultivated in Mutoko, Chipinge, Zvishavane and Plumtree

In a survey carried out by ENDA in Mutoko, Chipinge, Zvishavane and Plumtree, the above practices were employed by 19, 18, 16 and 13 percent of the farmers, respectively. They identified benefits associated with these practices as being higher yields, risk aversion measures, pest control and soil nutrient improvement. These practices were employed in ideal agro-ecological zones.

Though the extension department has been promoting the adoption of mono-cropping, farmers, to this day, still practice inter-cropping as a risk aversion measure, particularly in drought-stricken areas. These practices are complemented by the cultivation of crops with a wider genetic base. The above information calls for the recognition of the inherent soundness, under natural conditions, of farmers' knowledge and their agricultural practices.

Our comprehensive, village-level studies in the semi-arid tropical areas of Zimbabwe revealed several ways in which local farmers' knowledge on the management of traditional farming systems was applied.

Mixed cropping or inter-cropping, involving a combination of crops with different food values, maturity periods, capacity to withstand calamities and salvage possibilities, represented one of the most important practices that characterized traditional farming systems. Indeed, inter-cropping and crop diversification can minimize crop fluctuations and the number of total crop failures, thereby helping to stabilize income and food supply.

In each of the four areas researched by ENDA (i.e. Mutoko, Chipinge, Zvishavane and Plumtree), farmers cultivated an average of eight sorghum (*Sorghum bicolour*) and five pearl-millet (*Pennisetum typhoides*) local varieties.

The preferred characteristics and attributes of the above crop varieties included, earliness, overall agronomic stability, yield potential, drought tolerance, grain colour, palatability

and storage quality. One or two of the above crop varieties met more than one of the above mentioned attributes in each area. Though we observed that the genetic base is narrowing, we and the farmers agreed that the maintenance of a wider genetic base as a risk aversion measure was, and still is, important.

Farmers in the researched area cultivate a combination of short-, medium- and long-seasoned varieties of sorghum and pearl millet (see Figs 2a and 2b). The proportional distribution of the crops cultivated according to their growth cycle is as follows:

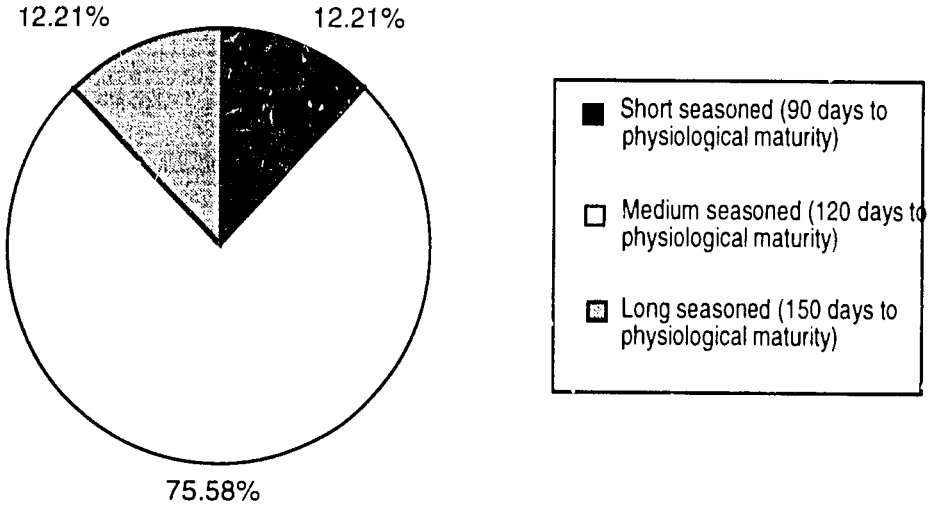

Figure 2a. Growth cycle of sorghum

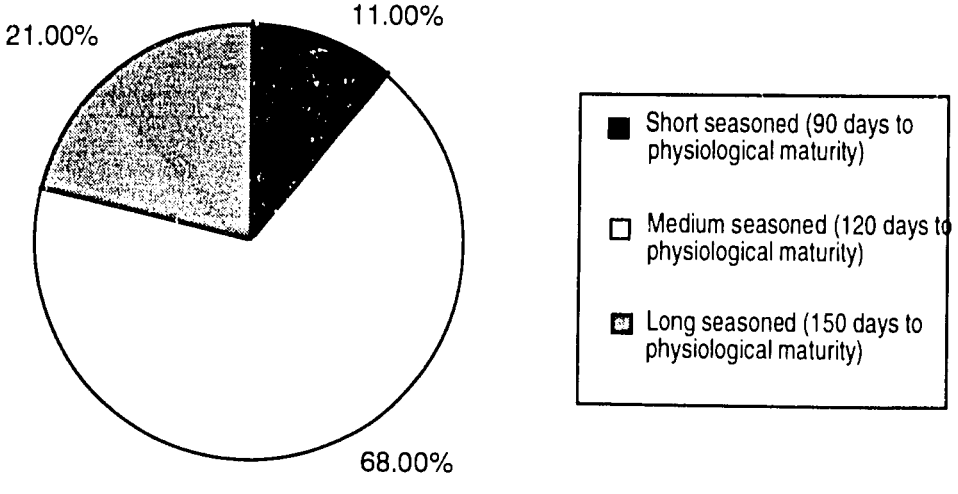

Figure 2b. Growth cycle of pearl millet

Short seasoned varieties are preferred for their earliness in times of drought. However, they are not ideal when rainfall is well distributed throughout the season.

Medium seasoned varieties are preferred by farmers because they comprise of a number of desirable characteristics and traits such as yield potential, grain size, drought tolerance and good storage quality. They have the ability to cope with moderate climatic conditions.

Long seasoned varieties are usually tall crops which are heavy yielders but require favourable rainfall. Their uses include food, construction and animal feed.

The spread of high yielding varieties in low potential areas at the cost of acreage and production of open-pollinated and environmentally adapted crops has resulted in increased vulnerability of farmers to food insecurity and malnutrition. The improvement in maize production, as a result of a plant breeding strategy to increase yields, over-compensated for the possible decline in nutritional well-being of the people from the decline in pulse and other nutritious crop production. Crop improvement programmes during the pre-independence period in Zimbabwe emphasized export crops such as tobacco, tea, coffee, maize and oil seeds [Collins, 1984].

Seed selection

Farmers knowledge and experience with respect to seed selection assumes a gender dimension in which women are the most skilled. Seed selection is carried out either pre- or post-harvest.

Pre-harvest selection

Most farmers in the research areas practice this method. Selection is based on the overall agronomic plant stand and performance, disease incidence level, head shape (true to type), grain size and insect infestations. Desirable plants are marked either by tying a leaf around the head or to tying them to another plant. The plants are harvested separately.

Post-harvest selection

Farmers who employ this method also consider the above characteristics. However, selection is carried out at threshing places. The retained seed is selected from harvested heads.

Selected seed is preserved by various methods and techniques such as:

- mixing of seed with finger-millet ash;
- selected heads are hung in the kitchen and treated with smoke;
- seed is sealed in clay pots;
- selected heads are kept together with millets to avoid infestation;
- mixing of seed with cow dung.

The farmers' methods also allow the creation, maintenance and promotion of crop genetic diversity as most of the materials are cultivated as mixtures. Seed exchange among farmers ensured conservation and utilization of a wider genetic base, by a community conscious of nature's variable limitations.

Usually farmers befriend farmers from different agro-ecological zones as a means to gaining access to crop varieties adapted to similar environments. Such relationships are often based on barter or exchange networks at the grassroots level.

These barter/exchange systems of economy are not based on monetary values. The farmers carry out on-farm characterization and evaluation of the crop cultivars received. In addition, farmers evaluate the overall performance of any improved material in comparison with their own local crop cultivars. While plant breeders and agronomists look for yield *per se*, farmers are interested in a number of factors that are difficult to combine by conventional plant breeding methods. If it were possible, a wonder variety would result; suitable for all agro-ecological zones in the whole country.

Further reasons why farmers' prefer to cultivate crops with a broader genetic base include the following:

- staggered labour demand over various peak periods;
- increased ability to cope with different environmental factors;
- greater provision for different end-utilization i.e. food, beer and storage quality;
- required palatability obtained; and
- broader nutrition base.

Training

Agricultural advancement through crop improvement should be viewed as one element in a farming system. Its success, effectiveness and ability to address the food security equation, depend on its interaction with other elements. For example, the interaction between the promotion of a specific crop type and soil and water conservation are well known but local biodiversity conservation practices are not known. This frequently results in serious degradation of the genetic base.

To ensure the sustainability of the agricultural production there is a need for manpower education and training in all related fields of agriculture - especially local biodiversity conservation practices. An integrated rural development approach and training should be based on an understanding of the framework within which the small farmer lives and works. Improvements should be developed from the characteristics of that framework.

Planning and implementation of any crop improvement programme must be accompanied by a well organized training programme geared to the needs of the farmer and his family as well as to those of the various levels of administration and extension personnel involved. The main problem with scientists is that they have approached agricultural development with the idea that they had all the answers in their briefcases. Due to this attitude, a lot of resources and time have been invested with limited success. Not only are policy changes called for to incorporate farmers' knowledge in agricultural research, but there is also a need for training.

Agricultural technology development

When we talk of "food security" we are talking of productive agriculture. A reversal in agricultural research and extension is required in order to put farm families first, to incorporate their local knowledge in the "food cycle" and to support and involve them in the generation of new technologies. Instead of a "package of practices", research and extension have to generate and offer a basket of choices. Instead of a message, farmers need methods and techniques to handle practical problems in their daily farming. The basket of choices should relate to aspects such as local PGR conservation, seed selection, improvement and storage, and local values of utilization, etc. This calls for the introduction, through the vehicle of research and development, of practicable farming systems which appreciate local farmers' knowledge and farming systems. It entails diversifying in order to produce more. Therefore, for the exercise to succeed, it must have practical relevance to living conditions and be developed with an eye on the value of the systems of the society [Kagogo, 1992].

In a nutshell, agricultural technology development, which is tightly linked to food security, requires an integrated approach which appreciates PGR conservation, utilization practices of the local people and modern crop improvement practices.

Technology transfer

One of the hotly debated subjects today is whether capital-intensive farming systems have been the cure and solution to all ills of food insecurity in our society, particularly the rural communities. Certain basic questions have to be answered in this context. How, if at all, have modern farming systems changed the lifestyles of our rural people? What characteristics distinguish a "good" technology from a "bad" one? What has modern plant breeding and crop improvement achieved? Can capital-intensive farming systems raise the standard of living of our people while maintaining their value systems and the genetic diversity? What are the conditions that are required to be fulfilled before new technologies can become part and parcel of the rural arena of our farming communities?

In my opinion, any technology transfer should be tested for adaptability to the prevailing environmental, socio-economic and cultural conditions and the sustainability thereof.

Conclusion

It is important to note that modern crop improvement training programmes have only managed to assist farmers located in high potential areas with the relevant socio-economic base. There are gaps where minor crops of local importance play a pivotal role in the provision of food security. In these localities, the adoption of modern technologies has been minimal or the effect has been negative. As a result, training and policy have to be changed to accommodate the local people's integrated farming systems and their knowledge of all stages and aspects of crop production and maintenance of the genetic base. There is need, therefore, to understand the importance and value of the local farming systems as they form the basis of local people's survival strategies.

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The Development of Dynamic Conservation Measures for Indigenous Crop Landraces: Limitations Imposed by the Hegemony of Western Science

S. van Oosterhout

Introduction

In this paper I present information about the uses of sorghum landraces by small-scale farmers in Zimbabwe. With these examples I want to illustrate that the traditional way in which scientific methodology has been used has limited our understanding of the dynamics surrounding the conservation of sorghum landraces.

A rich and varied genepool of sorghum landraces has been selected and built-up over the centuries in Zimbabwe. To date, however, breeding efforts have focused mainly on green revolution technologies using imported germplasm [Mushita, pers. comm.] and small-scale farmers have been encouraged to concentrate on a small number of high-yielding varieties (HYV's). As the landraces of indigenous food crops have become increasingly displaced, by HYV's and by maize, the genetic resource base of the landraces has become progressively narrowed.

Recently, serious attention has been given at the international level to the conservation of crop landraces [Keystone Dialogue Report, 1991; SAREC, 1992]. However, it needs to be seen that conservation is a dynamic process which can be fixed neither in a given system of knowledge (epistomologically) nor in time (temporally). Thus three key areas for discussion are identified. These fall into the political, social and agronomic, and the biological arenas.

Political dimensions

Limitations of scientific methodology

Where knowledge is equated with science, the broader implications of knowledge are diminished in that we lose the connection with the political, economic and religious struggles of the people who grow the landraces. I therefore challenge the view that science gives an objective representation of reality. Science is a particular system of knowledge and it therefore supports certain values and interest groups. On the other hand, science is a particular methodology with clearly defined procedures. The basis of this methodology is falsifiability. Thus, rigorous scientific testing can formalize the advantages of a particular management system which is based on indigenous knowledge. However, the discrepancy between the knowledge system of small-scale farmers and the more dominant objectives of breeders has frustrated efforts to build a scientifically falsifiable methodology for the former.

The methodology developed for the green revolution, which is still in use in much of agricultural science today, was based on Newtonian science. Newtonian science has a reductionist and mechanistic approach. It has objectified the farmer. It has isolated the farmer from her crops and her management practices and has isolated the crops from their environment. Germplasm was removed from the fields, breeding experiments were conducted on research stations and in the laboratory and then, *voila*!, the ignorant farmer is presented with improved varieties without any of the farmers' own selection criteria or

management strategies being taken into account. Then we are surprised that new technologies fail and that improved varieties do not produce as expected.

Empowerment of small-scale farmer communities

Small-scale farmers in Zimbabwe experience a severe sense of expropriation and dispossession which relates not only to their removal during colonial times from their ancestral lands and resources [Page and Page, 1991; Carter *et al.*, in press], but also from a lack of acknowledgement and validation of their customary knowledge. This has affected that sense of power which is inherent in people who are able to affect their own destiny and have control over their own future and resources. Empowerment of small-scale farmer communities through *participatory* breeding and conservation efforts is thus seen as the key to more effective and long-term conservation of crop genetic resources.

Gender issues

I would like to speak about the marginalization of women, both as farmers and as researchers. Yes, *some* farmers are indeed *men*!!. A quick analysis of the gender composition of the participants present here has revealed that approximately less than 10% are female. Scientific research, in which gender-based dominance relations have allowed the distortion of content, context, meaning and uses of that knowledge, has failed to address the knowledge of *female* farmers [Keller, 1985; Spender, 1985; Cashman, 1991]. This means that it has been limited both in analysis and in application. In other words, much of it can be termed poor science [Rocheleau, 1991]. This may also partly explain why conservation efforts have failed to reach local communities: the approaches at both the national and international levels have been designed by men and are taught by men for men. Recognition of the role that women farmers play in conservation of resources will lead to better and more effective science.

Social and agronomic dimensions

To enable policy makers to develop an appropriate conservation plan, it is important to understand which strategies farmers employ in their selections of landraces. We may thus ask the following questions:

What do farmers *do*?

Sorghum farmers in Zimbabwe live mainly in those parts of the country where rainfall is variable and unreliable and temperatures are high. Many different sorghum varieties are grown in each of the study areas (Musikavanhu, n = 10; Gokwe, n = 13; Siabuwa, n = 8), [Figure 1]. Individual farmers grow two to four varieties each [Figure 2]. Some of these varieties are grown by around 80% of farmers and may be called *general purpose* varieties. Other varieties are grown by around 20% of farmers and are more *specific* varieties. These differences may be important in breeding for broadly-adapted or site-specific, improved varieties. Electrophoretic studies are currently underway to investigate whether there are genetic differences between these two types of varieties.

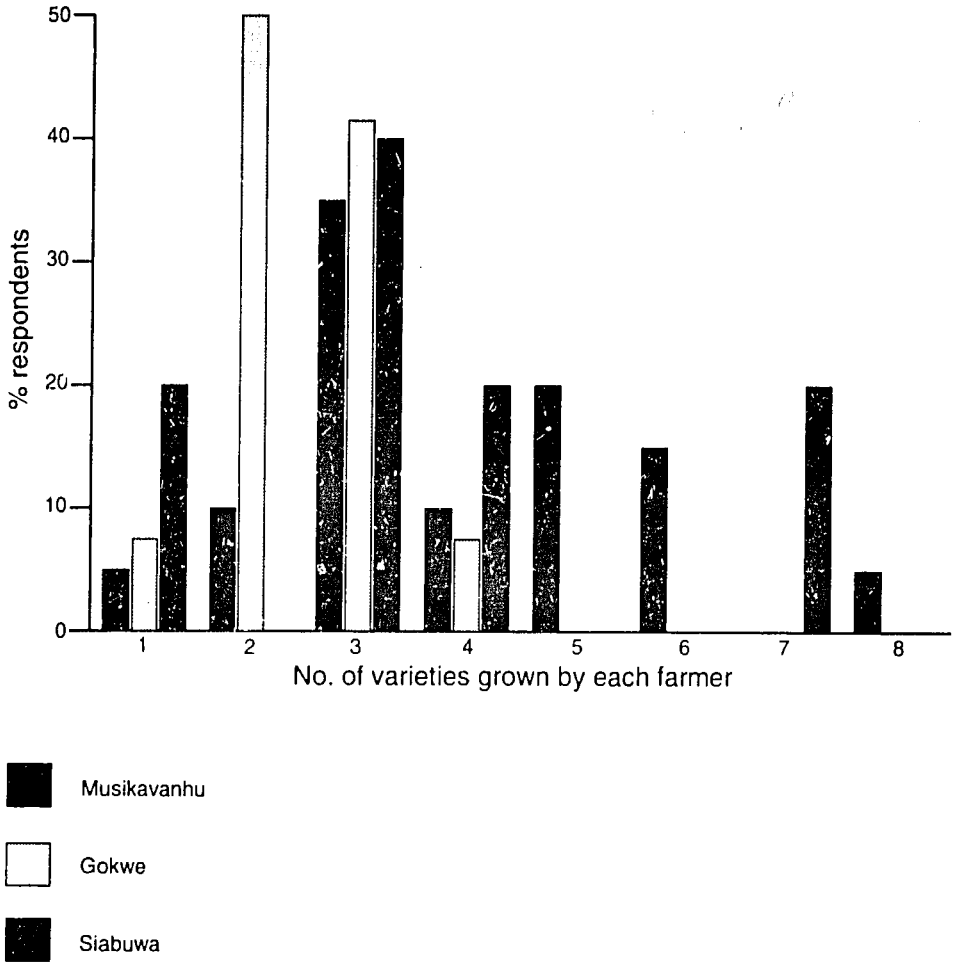

Figure 1. Percentage respondents growing each sorghum variety in Musikavanhu, Gokwe and Siabuwa.

Where do the varieties originate?

Some varieties such as *mutode, mbondo, muchaina, chindindindi, dewe* and *ipwa* have been present in the area for a few generations (i.e. about the turn of the century). However, since the process of germplasm exchange is most probably an old and regular practice, distinctions between 'old' and 'new', 'traditional' and 'modern' varieties are difficult to distinguish. Most farmers who were interviewed asked for varieties from other areas for testing on their own farms.

Which criteria do *farmers* choose?

The criteria used by farmers to describe their varieties were grouped into three classes: agronomic, gastronomic and morphological. Agronomic descriptions included maturity period, soil and water requirements, their tolerance of weeds, insects, pathogens and drought during the growing season and susceptibility to bird damage. Gastronomic descriptions included the following: threshability, ease of winnowing, pounding and

milling, good taste for beer and *sadza* (traditional porridge), colour of resultant food products, time required in cooking, keeping quality of the cooked grain, texture of endosperm and suitability for use in multiple food products and storage quality. Morphological descriptions included yield, plant height, grain and fodder yield and tillering potential.

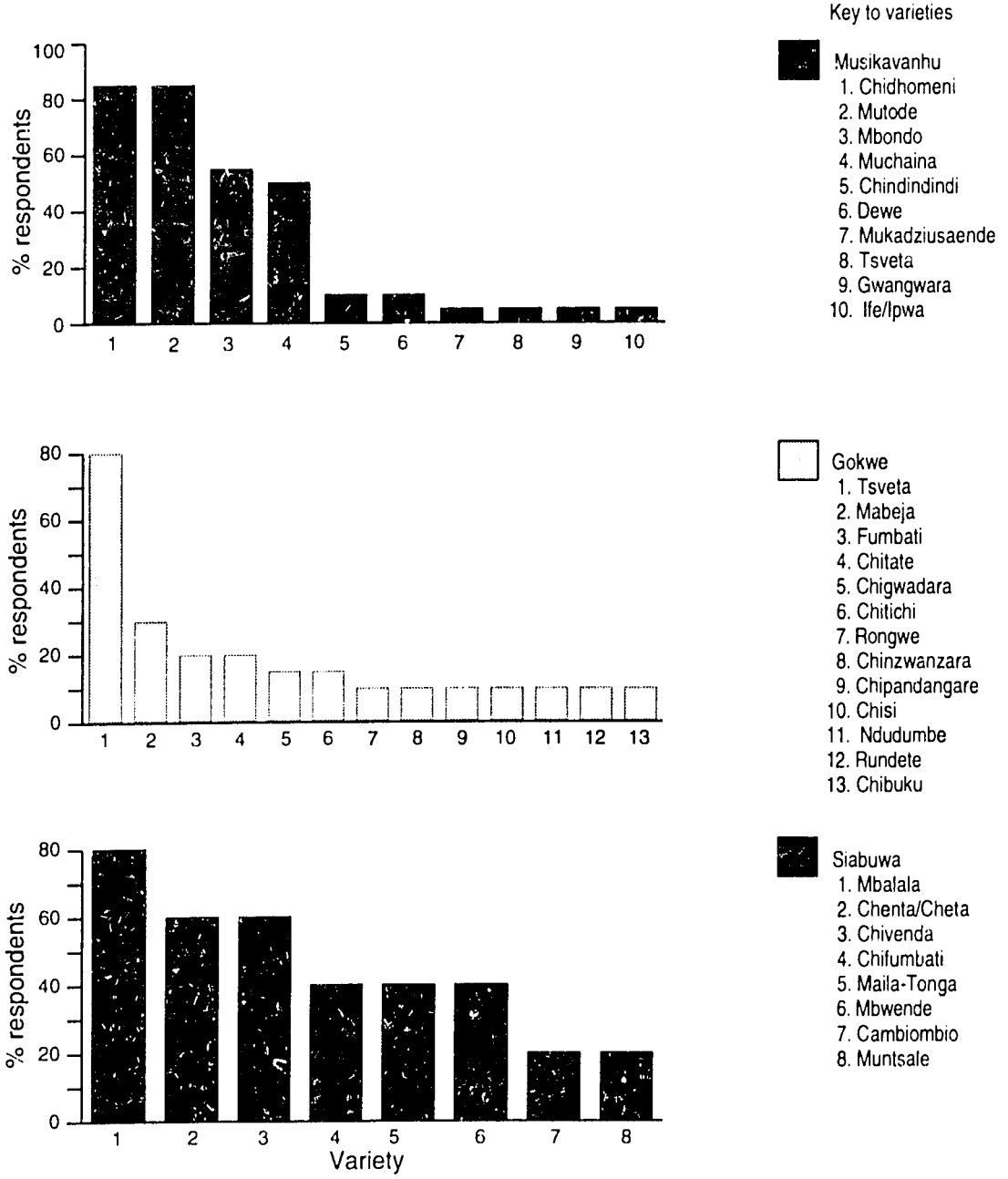

Figure 2. Maximum number of sorghum varieties grown by small-scale farmers in the study areas in Musikavanhu, Gokwe and Siabuwa.

The frequency with which each type of description was used was analysed by direct matrix ranking and is shown in Figure 3. In Musikavanhu, agronomic and gastronomic criteria were considered to be of equal importance while in Gokwe, agronomic criteria were used more frequently than in Musikavanhu. At this stage it is not quite clear why gastronomic criteria were said to be more than twice as important in Musikavanhu than in Gokwe.

The culinary qualities and the taste of sorghum varieties were considered to be the most important gastronomic traits. However, in some varieties, early maturing is tolerated despite poor taste and poor storage qualities. In general, late maturing varieties are grown for their much-desired taste and cooking qualities despite the higher labour inputs which they require in terms of weeding and scaring of birds. Higher prices are paid for beer made from a favourite variety, such as long-season *rongwe* [Billing *et al.*, 1984].

In both areas, morphological criteria were *least* frequently referred to. In contrast, morphological criteria have received the bulk of breeders' attention [House, 1987; Obilana, 1988; ICRISAT, 1990]. In this study, there was no instance of yield being identified by farmers as an important criterion. Extremely poor yields of less than 1.0 t/ha in both study areas may partly account for this. Nevertheless, in general, small-scale farmers consider consistent, reliable and stable yield more important than high yield [Richards, 1985; Conway and Barbier, 1990].

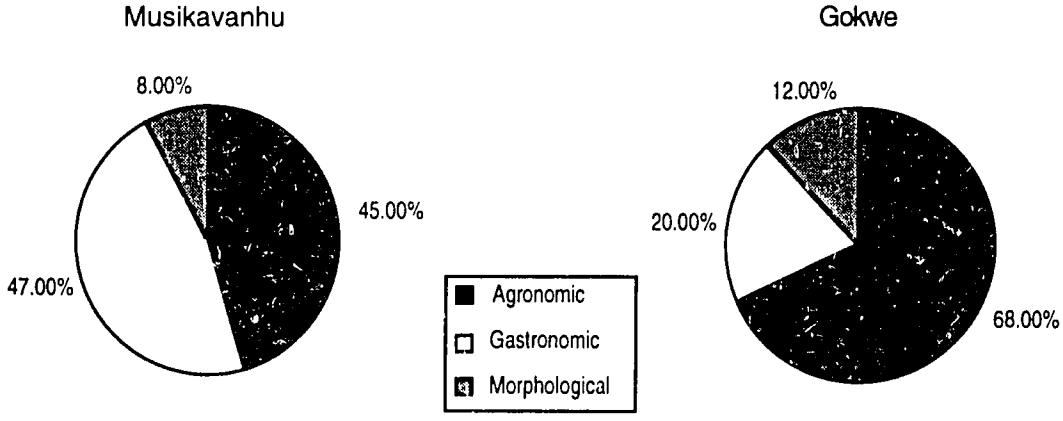

Figure 3. Relative importance of local criteria used for sorghum variety classification in Musikavanhu and Gokwe.

The different varieties were also said to differ in their resistance to storage pests. Some varieties such as *muchaina* (Musikavanhu), *rongwe*, *mabeja* (Gokwe) and *maila-tonga* (Siabuwa) can be stored for up to three years due to their hard, corneous endosperm. In this respect, these varieties offer a measure of food security since they are available for consumption once the soft-endosperm varieties (such as *chidhomeni*, *mbondo*, *chivenda*, and *chibuku*), which do not store well, have been finished.

How do farmers *manage* highly variable rainfall?

Individual farmers generally grow two short-season, one medium and one long-season variety, in different fields [Figure 4]. Taken together, 50% of all varieties grown in Musikavanhu, Gokwe and Siabuwa are short-season and the remainder are either medium or long-season. Planting and harvesting dates vary not only for different varieties with different maturing periods but also for those with similar maturing periods. Planting is spread over the period from mid-October to the beginning of January and harvesting is done from the beginning of March to the end of May. Management of a variable maturation period gives farmers three main advantages. Firstly, it allows farmers who have no cattle

to plant later than those who own cattle [Shumba, 1984; Cousins *et al.*, 1988; Amin, 1989; Stanning, 1989]. Secondly, since the coefficient of variation for annual rainfall in Musikavanhu, Gokwe and Siabuwa is between 30 and 40 percent [Bradley, 1992] and the mean median length of the growing season only 96 days [Hussein, 1987], it allows farmers to manipulate planting and harvesting dates depending on the nature of the season. Thirdly, staggered planting and harvesting times help farmers cope with eventual food shortages, should any one variety have poor yields or experience crop failure. The end result is that farmers have an increased flexibility in the way that they can meet the demands of a heterogeneous environment.

Small-scale farmers are extremely vulnerable to the exigencies of external factors (such as off-farm incomes, environmental conditions and national policies) as well as internal factors (such as the demands of other crops in the farming system, labour availability and availability of animal draught power). Flexibility of farming operations is, therefore, an essential and fundamental component and is partly achieved by growing a number of varieties of differing maturity periods each having different planting and harvesting times.

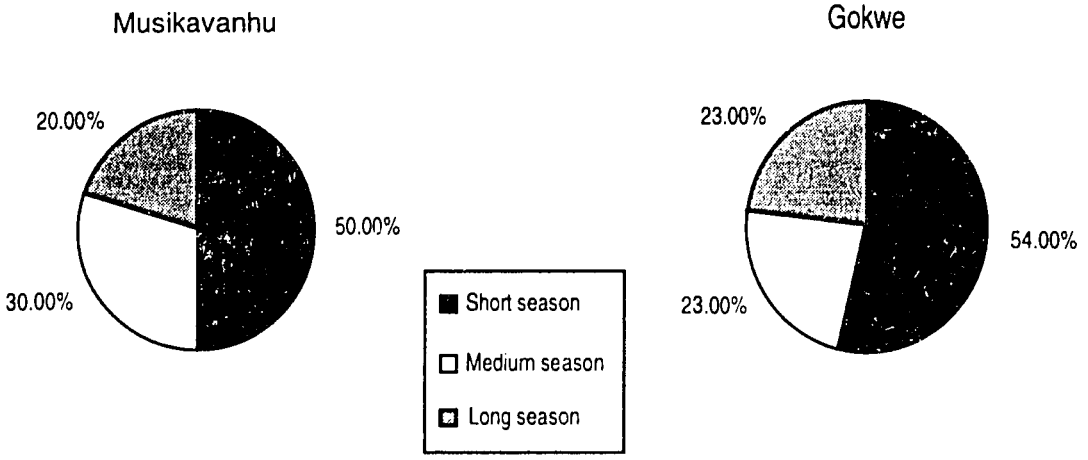

Figure 4. Relative importance of short-, medium- and long-season sorghum varieties grown in Musikavanhu and Gokwe.

Note: short season = c. 90 days to maturity; medium season = c. 120 days to maturity; long season = more than 120 days to maturity

Biological dimensions

Conservation programmes have also failed to a large extent due to the failures of scientific methodology to encompass the complexity of biological systems. I will give two examples here.

1. System complexity: Whereas extension agents have harassed farmers into growing uniform crops in pure stands, weedy and wild sorghum is allowed to mature in the fields of all varieties of cultivated sorghum. Although unverbalized, this practice allows for a persistent, low-level gene exchange between cultivated varieties and

weedy and wild sorghum. The process is controlled to some degree in that obvious 'off-types' are selected *against* by the farmer. The result is that genes which do not markedly affect the phenotype or which agree with the farmer's internalized concept of the 'archetype' of the variety, enter the genepool of the next season's seedstocks. Such genes, providing they do not have pleiotropic effects which affect the phenotype, may confer qualities which have been selected for in the natural habitat. Qualities such as disease resistance and drought tolerance may be incorporated into the cultivated crop in this manner. Evolutionary changes occurring in crop pathogens and crop pests, as well as changes in ecological conditions, which are tracked by the weedy and wild sorghums are thus incorporated in the cultivated crop.

2. Temporal and spatial components: In contrast to the interactive process of gene exchange described above, *ex-situ* genebank collections are isolated temporally and spatially from the very evolutionary processes which produced them. This means that a more dynamic approach incorporating aspects of small-scale farmer management, for example introgression, is needed for the conservation of indigenous sorghum genetic resources.

Implications

Haugerud and Collinson [1990] have pointed out that "in Africa, the IARC's have spent more per head, hectare and tonne of food, with less to show for the effort than elsewhere". The loss of financial returns has been, partly, a result of ecological and economic constraints [Baker and Siebert, 1984; Matlon and Spencer, 1984]. However, the loss is also attributable to a methodological mismatch which has its roots in the 'technological-package-solve-all' approach adopted by green revolution agriculturists. This approach created an artificial divide between the farmers and their management of the farming system and the crop genetic resources themselves.

The success of a breeding programme can be measured by its relevance to farmers' existing management strategies and their everyday experiences [Altieri, 1987; Conway and Barbier, 1990; Haugerud and Collinson, 1990; Nazarea-Sandoval, 1991a and b]. The investigation above of farmers' choices indicates the urgent need for improved communication between farmers and breeders.

A participatory method, appropriate in breeding, is shown as a conceptual model in Figure 5. Essentially it views the small-scale farmer as the central source of crop genetic diversity, complemented and supported by the national or regional genebank and breeding institutions. The method is based on selection of germplasm by breeders, in full consultation with the target farmers, starting with the most popular varieties in an area (such as *chidhomeni, mutode, mbondo* and *muchaina* in Musikavanhu and *tsveta, mabeja, fumbati,* and *chitate* in Gokwe) as the primary building blocks of an improvement programme. Selection criteria are identified by farmers and there is frequent feedback between farmers and breeders via agricultural extension workers. This is followed by the early release of a number of improved varieties for evaluation and selection by farmers under farmers' conditions of management. Finally, the farmers' evaluations are coordinated by agricultural scientists and breeders and the farmer-selected material tested in subsequent trials.

Such a participatory methodology has two major advantages: Firstly, a wider range of farmers can be targeted. Secondly, farmer selection methods allow rapid screening for a wide range of variables under conditions suited to their particular constraints.

Furthermore, as discussed earlier, involvement of the farmers at this level empowers farmers and minimizes their objectification. Thus where breeding is integrated with conservation of indigenous genetic resources, as in the participatory breeding methodology outlined above, farmers remain the *decision makers* in the selection processes, they thereby retain *power* over their own destiny. Recent research in identifying the 'keepers of diversity' in a community has also shown that management of genetic diversity cannot be divorced from the broader issues of *general resource management*. As was pointed out in the paper by Elizabeth Cromwell (this seminar), farmers are interested and willing to experiment with different varieties and this in turn points to the need for a *decentralized seed supply system* where farmers can choose varieties according to their own needs.

While recognition is given to the valuable role played by genebanks in the *ex-situ* conservation of crop genetic resources, the need for attention to *in-situ* conservation is extremely urgent. This of course implies a substantial shift in thinking about genetic conservation and cultural diversity and a *meaningful* commitment from the international scientific community concerned with crop genetic resources.

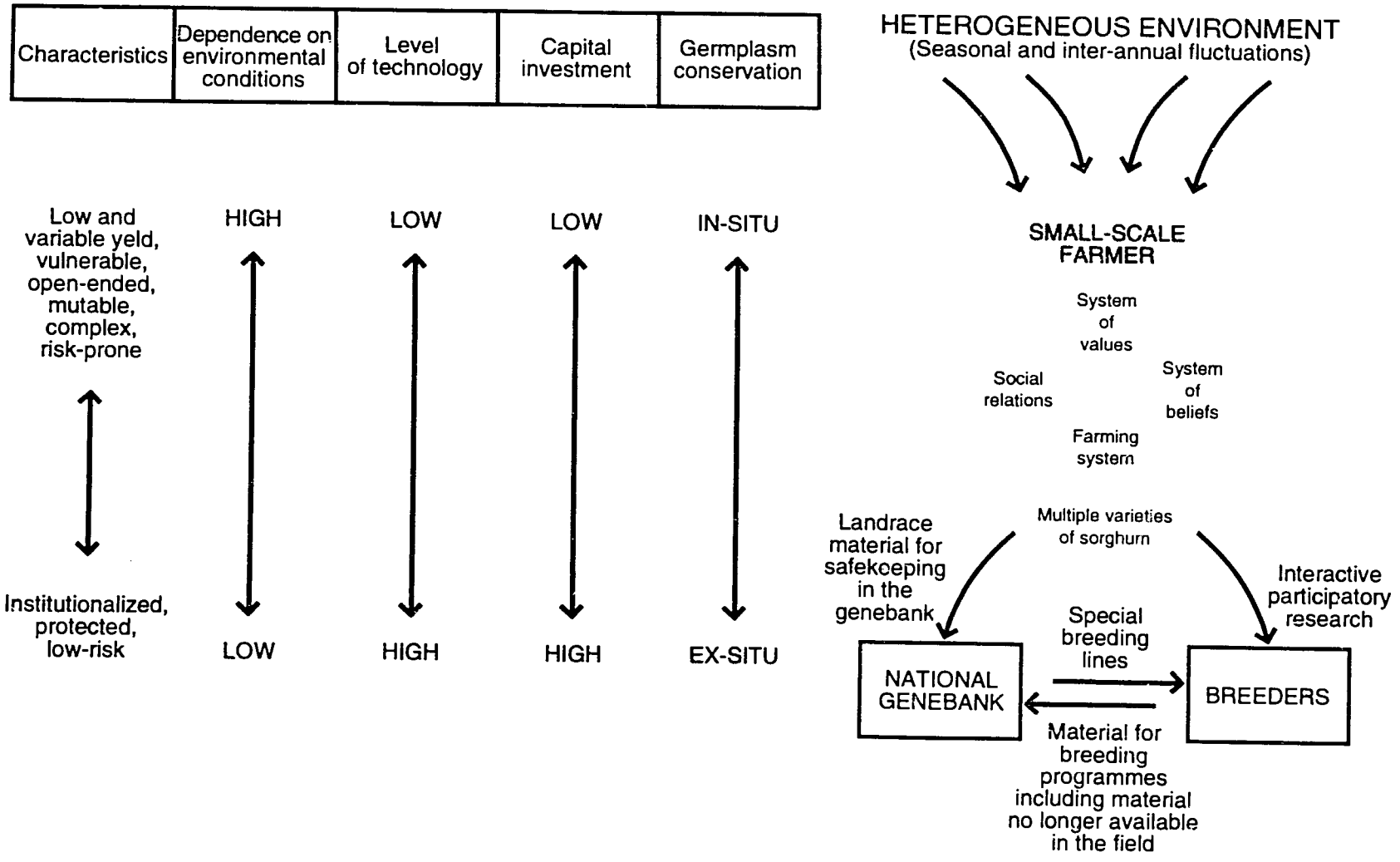

Figure 5. Conceptual model of genetic conservation as an integrated activity of small-scale farmers, breeders and the national genebank.
For the sake of simplicity, only the most important influences and interactions are indicated.

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L'Impact des Nouvelles Technologies sur la Conservation et l'Utilisation des Germeplasmes Végétaux.[8]

J. Ndeberi

Concept de la biodiversité

Dans le cadre de ce séminaire, où nous avons à discuter de la conservation des ressources génétiques des cultures traditionnelles africaines, il convient que nous nous entendions d'abord sur le terme biodiversité, lequel sera abondamment abordé au cours de ce séminaire. Pour nous, la biodiversité est un terme générique qui exprime le degré de variabilité qu'offre la nature, laquelle s'entend:

1° *Au niveau génétique.*

La diversité génétique est exprimée par la variation génétique au sein d'une même espèce, mais la diversité génétique peut également s'exprimer au sein d'une même population.

2° *Au niveau des espèces.*

Présentera une plus grande diversité, une région qui dans la même famille compte le plus grand nombre d'espèces.

3° *Au niveau des écosystèmes.*

Les différents écosystèmes seront habités par des populations différentes en fonction de leur adaptabilité à ces écosystèmes. Il convient donc de prendre en considération l'existence de ce critère dans l'évaluation de la biodiversité dans son ensemble.

4° *Au niveau culturel.*

Cette diversité se retrouve au niveau artistique, au niveau des langues, au niveau religieux, au niveau social et autres. Celle-ci a naturellement un impact direct sur la conception de la biodiversité, la conservation ou la dégradation des écosystèmes. Il convient donc de toujours tenir compte de cette diversité dans toute analyse qui aurait trait à la conservation de la biodiversité pour un développement durable.

La biodiversité ainsi définie constitue la base même de notre existence. Les populations qui n'ont pas su s'adapter n'ont pas survécu. C'est pourquoi notre degré de civilisation, au lieu de nous faire oublier cette triste réalité de la vie, devrait plutôt nous inciter à nous conscientiser sur ce qui est en train de nous arriver.

C'est pourquoi nous ne devons en aucun cas accepter de devenir les wagons de la locomotive du développement, nous devons être et rester les machinistes de cette locomotive. Nous devons rester lucides afin de percevoir de loin l'approche d'un tournant, et ralentir s'il le faut la locomotive pour mieux le négocier.

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[8] **Impact of New Technologies on Conservation and Use of Plant Germplasm**

Le développement mis en cause dans la dégradation de la biodiversité

De tout temps, l'homme a su se maintenir dans le système évolutif dont il n'est qu'un élément. Il a su utiliser ses connaissances pour maintenir la biodiversité. Il a su tirer profit de cette biodiversité pour se soigner, fabriquer les outils dont il avait besoin. Il a su lutter contre les maladies des plantes et contre les prédateurs qui menaçaient ses récoltes, etc. Mais, depuis la "Révolution verte", une certaine fissure s'est faite dans le monde des hommes: l'homme du "Nord" s'est vu propulsé dans un autre monde, dans lequel il essaye d'entraîner l'homme du "Sud". L'homme du Nord a su tirer profit des innovations qui ont eu cours dans les années 50 et 60 et, est resté plus ou moins maître du développement, avant d'en devenir lui-même victime, ce que nous allons voir plus loin. L'homme du Sud, par contre, n'est plus le machiniste de sa locomotive: il est pris dans un engrenage qu'il contrôle de plus en plus difficilement, ne dominant pas tous les tenants et aboutissants du développement dans lequel il est, bon gré - mal gré, obligé de faire parti. Les choses évoluent très vite autour de lui, et souvent il n'est que très peu ou pas associé aux grandes décisions qui le concernent directement en matière d'environnement.

La "Révolution verte" a permis le développement de nouvelles variétés, plus performantes, la mise au point de certains procédés chimiques, qui ont permis l'essor de l'agro-industrie; elle a aussi introduit la mécanisation agricole à outrance.

L'homme du Sud n'a subit que des retombées de ce développement du Nord: vente des semences développés ou manipulées dans le Nord, lesquelles semences nécessitaient l'application d'intrants fabriqués dans le Nord, et que l'homme du Sud ne pouvait financièrement s'offrir. Cette introduction innocente ne pouvait manquer d'avoir des conséquences néfastes sur la biodiversité. L'introduction d'une nouvelle espèce ou variété constitue en soit un enrichissement de la biodiversité, mais qui dit semence sélectionnée dit aussi produit fragile. C'est ainsi que l'on a vu se développer certaines maladies jusque là inconnues dans la région (cassava Mosaïc Virus), certains prédateurs ont fait irruption, un nouvel équilibre et un nouvel écosystème se sont installés. Les nombreuses variétés locales, mises au point au cours des décennies mais moins performantes que les nouvelles variétés, ont dû faire place á ces dernières et ont disparu, exemple de notre mauvais développement. L'explosion démographique dans les pays en voie de développement a forcé les populations à produire plus pour nourrir une population sans cesse croissante. Ne pouvant s'offrir les semences plus performantes et les intrants qui vont avec, ces populations n'avaient d'autres alternatives que de déforester et détruire la biodiversité que renfermaient ces forêts.

L'introduction des pesticides a vu certains insectes disparaître, mais avec eux leurs prédateurs, ce qui a conduit à la modification de l'équilibre biologique existant. Certains pesticides ayant des conséquences réelles et directes sur l'homme et l'environnement.

Le développement a engendré un autre mode de vie et des nouveaux besoins. L'homme déforeste non pas seulement pour ses besoins en bois de chauffe, mais également pour le bois de construction ou d'art. L'homme chasse et massacre les éléphants, les rhinocéros pour leur ivoire, l'homme tue les crocodiles, les iguanes ou les pythons pour leurs peaux recherchées dans la maroquinerie.

Les pluies acides sont aussi des manifestations d'un développement pas toujours maîtrisé. Le dernier produit de notre développement est l'industrie du nucléaire, dont il n'est pas toujours facile de débarrasser les déchets. Le développement de l'industrie chimique n'est pas non plus innocente dans la dégradation de notre biodiversité. Quelques industriels peu scrupuleux se débarrassent de ces dé hets en pleine mer sans considérer que les mers et les océans regorgent d'une multitude de biodiversités et que quelque part l'homme est en aval de cette pollution.

Il est vrai que le développement est une trajectoire obligée de l'histoire, il est également vrai que le développement a ses avantages et ses inconvénients, c'est pourquoi nous devons rester maître à bord pour contrôler notre environnement, sinon nous serons victimes de notre propre développement, et ce à très brève échéance.

Nous devons mettre à profit nos connaissances pour contrôler la biodiversité, et ainsi asseoir un développement durable, faute de quoi le tout va s'effondrer comme un château de sable.

L'impact des nouvelles technologies sur la conservation et l'utilisation des germeplasmes végétaux.

Toute innovation, dans le domaine des technologies, participe au développement. Il est donc intéressant de voir en quoi l'humanité, et principalement les pays en développement, peuvent tirer parti du développement de la science.

Les cultures des tissus permettent un assainissement viral et une multiplication clonale. Ceci veut dire qu'une fois l'espèce clonée, on peut la conserver indéfiniment sous forme de cultures cellulaires ou sous forme de vitroplants. Pour cette raison, une cellule de culture des tissus devrait faire partie intégrante des acquisitions des banques de matériels végétaux. En effet, partout se trouvent des espèces végétales en voie d'instinction et dont la multiplication par graine est relativement difficile. Pour ces végétaux en danger, la micropropagation offre une chance de survie. De même, dans les régions en voie de désertification, certaines espèces naturelles qui apparemment résistent aux changements climatiques peuvent encore une fois être micropropagées et utilisées dans la reforestation de la région en danger.

Hier, Dr P. Hamon a laissé planer un certain doute sur la fiabilité de la stabilité génétique d'un matériel ainsi conservé. Personnellement, nous croyons que nous pouvons avoir confiance en la stabilité de ce matériel génétique. Les variations somaclonales n'étant à craindre que spécialement dans des cultures où l'on doit passer par le stade calls, et là encore, la cartographie génétique nous permet de contrôler nos spécimens.

Actuellement, la biologie moléculaire nous permet d'établir une carte d'identité génétique pour chaque espèce. Cette technique est devenue un outil indispensable pour quiconque doit procéder à la conservation des germesplasmes. En effet, la cartographie génétique permet à tout moment de vérifier si l'espèce en collection, ou qui rentre en collection, est oui ou non identique à une autre déjà en collection. Un plante en multiplication pour la collection peut subir une mutation quelconque difficilement décelable dans l'immédiat car présentant les mêmes caractéristiques morphologiques; la cartographie génétique sera là pour trancher.

Encore une fois, la biologie moléculaire permet d'identifier certains gènes intéressants, leur isolation et leur conservation. La technique dite de transformation permet d'introduire une nouvelle biodiversité génétique. Si la culture des tissus permet la conservation d'espèces soit en culture cellulaires, soit sous forme de vitroplants, la biologie moléculaire nous offre une nouvelle forme de conservation simplifiée sous forme de gènes (ADN).

Voici, brièvement évoqués, les avantages des biotechnologies végétales dans la conservation et dans l'utilisation des germeplasmes végétaux. Ceci est plus facile à dire qu'à faire. En effet, au stade actuel du développement des biotechnologies, en Afrique, les biotechnologies sont encore au stade embryonnaire. Il serait donc très hasardeux de nous lancer dans ce genre d'entreprise la tête baissée, car le chemin est plein d'embûches qu'il convient d'éviter assez rapidement en regardant où nous mettons le pied.

Nécessité d'un ordre biologique nouveau pour un développement durable

Pour que des gens puissent continuer à faire de la recherche, il faut que celle-ci soit rémunératrice. La seule forme de rémunération en vogue est la brevétation. Il est un fait qu'actuellement les seuls chercheurs susceptibles de pouvoir bénéficier d'un brevet sont les chercheurs du Nord. La plupart des organismes sur lesquels ils ont travaillé sont des organismes qui intéressent spécialement les pays en développement. Les discussions actuellement en cours visent à déterminer si un chercheur qui acquiert un matériel génétique du Sud peut, sans autre forme de compassion, procéder à la manipulation génétique de ce matériel et s'en approprier le titre par brevétation, arguant que le matériel génétique du Sud est du domaine de l'"Héritage Commun". Sommes-nous actuellement en droit de revendiquer le rapatriement de notre matériel génétique au même titre que les monuments historiques autrefois emmenés vers les métropoles par nos anciens colonisateurs? La discussion est ouverte.

Peut-être peut-on freiner le temps, mais peut-on arrêter le temps ou l'histoire? Il se fait que nous avons enregistré un très grand retard dans beaucoup de domaines et principalement en biotechnologies, moteur du développement.

Nous savons que l'Afrique, en général, ne vit que de son agriculture (agriculture de rente). Nous savons également que l'Afrique est le continent le plus assisté sur le plan alimentaire, ce qui est paradoxal pour un continent essentiellement agricole. Toutefois, sans entrer dans les détails, en faisant une simple analyse, au train où vont les choses, si nous acceptons le principe de brevétation, nous serons amenés à acheter nos semences dans le Nord au prix auquel le Nord voudra nous les vendre, produire pour le Nord au prix auquel le Nord voudra bien acheter. Devons-nous, pour cette raison, freiner tout développement dans le Nord? Et d'ailleurs sommes-nous capables de l'arrêter? Je ne crois pas. C'est pourquoi je reste persuadé qu'une négociation avec nos partenaires du Nord s'impose, pour chercher les éléments de base de l'établissement d'un ordre biologique nouveau, où tout le monde trouverait son compte.

Information Management in On-Farm Conservation

C. Blake

I should in the first instance state that the topic I am about to introduce falls, generally into two subject areas, one with which I feel quite comfortable and the other in which I cannot even claim even cursory competence. However, because of the pervasiveness of the "information" imperative that stalks all disciplines these days, we are all compelled to take excursions into areas that have organic linkages that hitherto have not been recognized by scholars and researchers. It is against this background that I am going to attempt to introduce the topic "Information Management in On-Farm Conservation.

It is now widely recognized that indigenous knowledge plays a significant role in the day-to-day life of people in the South, notwithstanding the tremendous resources that have been expended by governments and international bodies in their efforts to introduce so-called "modern" knowledge to inhabitants of the southern hemisphere. The knowledge base used for this modernization has, generally, come from the North even though we know that several western scholars did their research in the South and produced "knowledge" and "information" they deemed important to improve the lot of the South.

As we are all aware, not much has been achieved over the last thirty years in many African states. It is perhaps this failure that has prompted the international community to pay attention to those researchers, in the North and South, that have been calling for more in-depth studies of the traditional/indigenous knowledge systems that have guided rural societies for centuries. Among the fields that are now concerned with the importance of indigenous knowledge systems are information sciences and environmental studies. Given the above, it is incumbent on those who are conducting research and/or engaged in pedagogy in the subject matter with which we are dealing, to realize that information on the conservation of plant genetic resources and the local management of such resources, form the bases for our work. If our work is to be meaningful, we have to put information systems *in situ* to help the farmer systematize what s/he already knows and practices, so as to build on this knowledge base and improve on it as necessary.

As it stands currently, we cannot talk about the management of information in on-farm conservation without first establishing an information system. The knowledge that exists among farmers, especially those that cannot read or write, is housed in their heads. It is used repeatedly and transmitted to offspring, clan members and/or others closely related to the immediate community. In order to get at this information, those interested (who generally are researchers or policy makers) have to rely on interviews, either directly with the farmers or through informants. When the information is obtained, it is taken out of the community, analysed, interpreted and published. Research could reveal the extent to which the findings are used. Some may argue that such findings are hardly used beyond their analysis for publication purposes. In essence, the analysed information may be out of reach of its source.

The question now is how does one go about dealing with information management in on-farm conservation? I propose we review the following steps:

1. The aggregation and organization of extant knowledge through methods that the farmers can understand and replicate.

2. In the process of aggregating this knowledge, all attempts should be made to highlight the roles, functions and rituals involved in its practice. This is crucial, particularly for gender and other socio-cultural issues.

3. Promotion of the use of the aggregated knowledge beyond the immediate community so as to improve, modify and/or facilitate access to a wider audience, at any given time.

With regard to step one, the interested researcher/information science specialist would have to work in close collaboration with experts in plant genetic resources in order to ask of the farmers, pertinent questions that would yield information that could be appropriately recorded. It is critical for the farmers to participate in the recording of the information they provide, and for them to understand that others will have access to this information. The reasons for ascertaining such participation are twofold: first of all, the farmers have to maintain their credibility, requiring them to be forthright in providing the information sought. Secondly, they have to be in a position whereby they can aggregate and organize information even after the initial phase that involved "experts" from "outside". In this vein, the farmers have to "manage" the information they provide.

One method that could be considered in developing the information system mentioned above is the use of video cassettes. Several years ago, the United Nations University sponsored a dissemination activity called Village Video Network, implemented by Martha Stuart Communications, New York. The essential feature of this activity was to introduce the video system at the village level by teaching the villagers how to use the machines to capture, on video, successful innovations and other useful development programmes. Activities such as biogas production were recorded. The tapes were transported from village to village, particularly to those that did not produce biogas but could do so, if taught.

Villagers in the various countries in which the project was carried out taught each other through information sharing The biogas project was recorded by Chinese villagers who not only shared this knowledge with fellow Chinese citizens but also with villagers in the Caribbean, thousands of miles away. Skills and knowledge peculiar to other sectors were similarly captured on video by villagers in Mali, Nigeria and other African states, and disseminated to other areas in the world as information that could be used by others.

Groups that had full responsibility for producing and managing the information were formed in the villages. The dissemination of the tapes outside of the villages was managed by Martha Stuart Communications. The essential point, however, is that villagers were taught how to organize their knowledge into a system that could be accessed by them whenever needed, and by others outside of their communities. Most importantly, the groups managed the systems.

It is my firm conviction that by encouraging farmers to participate in the organization and systematization of information on plant genetic resources based on indigenous knowledge, and emphasizing the importance and potential use of this information by members of their communities and others, a management culture could be nurtured to ensure continuity and effectiveness. The acquisition of the management skills required for maintaining such systems could be enhanced as a result of the interactive characteristic feature of the method advocated herein.

The above position is stated because the dominant mode of transmitting agricultural information among illiterate farmers in the South is through apprenticeship. With what I am proffering now, the transmission of agricultural knowledge could be enhanced through

the use of a medium that can reach more people, at a given time, than by apprenticeship alone. Also, those who would have primary access to such knowledge through apprenticeships can refine their knowledge during their leisure periods through community viewing of video cassettes.

Among the kinds of information that could form the basis of such an on-farm managed system would be data on landraces, farmers' knowledge of the selection of plant materials, criteria for selection, pest and disease management, management of environmental stress factors, uses of minor or under-utilized crops, methods of local conservation of crops and equipment/instruments used.

Stemming from the above, we now look briefly at the second step mentioned, that is, the socio-cultural dimension. If the information that we seek to systematize in the on-farm context is to be useful, it should be organized in a holistic manner. That is to say that if, for example, we use the video as a medium, it would be important to capture the rituals that go along with agricultural practices in the localities in which we are interested. The rituals constitute an essential element of the quality of the information we seek to organize. Since the organization of the information is for an intended group of users and not just for exotic purposes, we would fail in servicing the needs of would-be information seekers on issues pertaining to plant genetic resources in a given locale, if we ignored such socio-cultural information.

The same concern for a holistic information system should be manifested in capturing the significant role played by women in the entire agricultural sector, particularly the physical aspects of farming. Added to their physical contribution, to put it bluntly, their labour, is the knowledge they harbour and use in this crucial sector that represents the life-stream of their communities. Since the lot of the African woman in public is to be seen and not heard, even though she works the hardest, the video can bring her contribution into sharper focus than has hitherto been seen.

The third and final step involves the promotion and utilization of the system beyond its immediate environment. The information aggregated and systematized on-farm, should not be perceived as a mere archival exercise, in the old sense of the term. We are not talking about the setting up of a traditional library in the form of a depository, housing what we know as library holdings. The information is meant to be disseminated and applied, hence the importance of its management. Since the approach to its aggregation was user-oriented, promotion of its use should be an aspect of the management of the system. Through such promotion within and outside of the immediate locale, modifications could be made to enhance the quality of the information as a result of new discoveries and other innovations. It is precisely because of the possibilities of such improvements that a system of aggregation and systematization should be one which the ordinary illiterate farmer could use.

There are, of course, risks involved in the promotion and utilization of such information systems outside of their original locale. The risks include modifications to the system that are not conducive to application in a given environmental context. Nonetheless, one cannot expect much use from an information system that is stagnant and not susceptible to modifications that could conceivably improve the quality of information contained in the system.

What I have tried to do in this paper is to introduce my biases with regard to the manner in which information systems on traditional/indigenous resource realms could be set up. I provided only one means of aggregating and organizing such a system. There are other methods that could be considered. Since my concern was with farming populations that are

largely non-reading communities, I chose to adopt a method that does not require reading and writing for people to understand and manage the system. One area that is lacking, perhaps among many others, is the maintenance of the video system - video cassette recorders (VCRs) and monitors. As part of the operation of such a system, consideration should be given to link extension workers with the system. They could then assist in either bringing in video repair personnel or facilitate the training of one or two members of the group responsible for the operation of the information system. The management component would, of necessity, have to be nurtured.

Information Management for *Ex Situ* Genebanks

M. C. Perry

Introduction

Conservation and use of genetic resources have been recognized as important activities needed to sustain and improve production of agricultural and forestry crops. This realization has lead to a considerable expansion in the number and sizes of germplasm collections over the past few decades, and to an increased emphasis on the efficiency of their manner of utilization and management. There has also been a realization that the data related to germplasm samples as well as other similar information are potentially as important as the genetic material itself.

The management of data and information associated with plant genetic resources can be one of the most active functions of a genetic resources centre. Ultimately, this information is referred to in all genetic resources communications. In general, these data are used by the conservation, research and development community within, and associated with, the centre; they may also be used by administration departments for reporting, planning, determining fiscal policy and publicity. On a broader scale, combining data for a crop, from many national germplasm collections, can provide the basis on which to plan international genetic resources activities. This type of cooperation may help to reduce duplication of effort in the areas of conservation, regeneration, multiplication and collecting.

The purpose of this paper is to describe, in general, the management of genetic resources information associated with *ex situ* germplasm collections. An attempt has also been made to describe the types of data that could be associated with *ex situ* genetic resources collections that, currently, are not considered a priority to manage. In addition, there is a short discussion of the problems relating to information management and international data management, that exist at many germplasm collection sites.

Importance of information in genebanks

Information management for *ex situ* genetic resources collections is generally centred around the management of a database of sample-specific data that have been accumulated through the use of crop-specific descriptors. Broadly speaking, a genetic resources database can be described as a collection of data fundamental to a genetic resources collection or system. This definition does not imply the manner in which the data will be maintained, i.e. with either a manual- or a computer-based system. Depending on the type of maintenance, the crops held and the specific objectives of the genebank, there may be a great variation in the data found in genetic resources databases. The need for an organized, easily used database increases proportionally to the number of accessions and the number of parameters that are important for its management.

Databases provide logical means of organizing the information on collections and provide accessible inventories of collections' holdings. Several factors relating to germplasm databases need to be taken into account:

- The size of a germplasm collection may be limited due to financial or physical constraints. Appropriate data and information is needed to decide whether or not to include material.

- The collection curator requires data for monitoring viability, quantity and location of seed or the location of stocks in a germplasm nursery, as well as for determining how the collection should be augmented through further collecting efforts or exchange.

- Decisions will need to be made on the choice of material to use in breeding and research programmes. Such decisions can only be based on the data that is available on the accessions in the collection.

- Efforts to coordinate global genetic resources activities can be successful only if the data on germplasm collections is sufficiently complete to provide a basic understanding of the initial global or regional status.

Data generation in genetic resources

Much of the information generated by a functioning genetic resources collection is of interest and value to some part of the scientific community. Information from specific studies will often be published in reports, catalogues or journals. Some of the information produced during genebank activities may or may not be of interest to other scientists but is of value in genebank management for setting priorities, planning activities and managing resources. Genetic resources data are generated during the following activities:

- *Plant collecting and introduction (registration).* These activities are responsible for accession origination, either in the field (collecting) or as the accession enters a country or institution where it will be maintained (introduction).

- *Characterization and evaluation trials.* These activities are used for describing genetic resources. They assist in the maintenance and use of the genetic material and are the basis for the rationalization of the genetic resources held in collections.

- *Management of collections.* This is essential for maintaining the viability of the genetic resources and their distribution to users. Management activities include, among others, monitoring the condition (viability, amount of stock, etc.) of the genetic resources.

Categories of *ex situ* genetic resources data

A. Descriptors and common categories of genetic resources data

A descriptor is generally defined as an identifiable and measurable trait or character of a plant accession. Examples include a descriptor name, a descriptor definition and possibly a list of descriptor states and codes used for the descriptor states. The selection of descriptors made during the establishment of the database will determine not only the size of the resulting database, but its usefulness. The choice of descriptors and descriptor states will also help to establish a standard type of language for the exchange and use of data. The use of descriptor lists that have been developed by an international group of crop-specific experts will generally effect compatibility of data during exchange. IBPGR has been responsible for publishing over 60 crop-specific descriptor lists, each of which follows a standard format for descriptor categories.

Most descriptors that are used in plant genetic resources databases for *ex situ* cultivated species can be placed in one of the following categories:

- **Passport** descriptors describe characters observed at the time of original field collection or when an accession is bred. Included are the original identity of the accession (scientific name and collector's number), the identifier assigned to the accession after it enters into a collection, provenance and detailed collection site characteristics The last two can help define the adaptation of the genetic material which can guide multiplication, characterization and evaluation trials, as well as utilization. IBPGR descriptor lists include both the accession and collection data sections.

- **Characterization** traits are highly heritable, can be easily seen and are equally expressed in all environments. For many highly inbred species, data for these descriptors can be collected during multiplication trials but, more commonly, they are collected during characterization trials.

- **Preliminary evaluation** traits may not be equally expressed in all environments, may be more difficult to score than characterization descriptors but have been determined for their importance for collection management and use by a consensus of users of the particular crop. Even though non-replicated trial data are environmentally influenced, they are generally used for genetic resources collections.

- **Evaluation** traits are closely linked to breeding programmes. To gain an adequate understanding of the genetic attributes of the accession, replicated trials are needed. Because crop use varies from country to country, these descriptors may or may not be used depending on their importance within a particular country or region.

- **Management** descriptors are used to assist in stock control of *ex situ* (seed stores, *in vitro* and field) collections. They help to determine and assist in the timing and management of multiplication and regeneration trials and in tracking the location, distribution and receipt of samples.

- **General information on collections**. Besides descriptor type information, data on collections of a particular crop are very useful for locating alternative sources of germplasm and for providing a start in locating other people working on the same, or similar, crops. IBPGR has published this type of information in its *Directories of Germplasm Collections*. The information collected includes the complete name, address, contact numbers and a summary of the holdings (genus and species names, geographical distribution of the material, documentation status and quarantine restrictions that might apply).

Due to its recently extended involvement in the documentation of certain woody species, IBPGR has begun to see an expansion and, in some cases, a reclassification in the types of data that need to be maintained by certain genetic resources collections. This has been especially true in the case of coconut and woody species. At a recent meeting on coconut genetic resources data (19-22 May, 1992, Montpellier, France) the types of descriptors that are required for adequate management, use and exchange of genetic resources were shown to not always fit well into the definitions given above.

B. Categories of data used less commonly for *ex situ* collections

As noted above, certain descriptors may be more important for certain crops and/or types of germplasm. For most cultivated vegetative species, the above categories and descriptors are quite commonly used for many collections. However, to maintain as much genetic variability as possible and to carry out successful regeneration of wild relatives of many cultivated species, much more detailed environmental data must be known about the original site of collection.

The specific data requirements, for the genetic resources of many forestry and multipurpose tree (MPT) species that are maintained *ex situ*, also have different priorities. In these cases, the extent of information on the accession's provenance, specifically the climatic and soil conditions, can be used for selection of germplasm, its establishment in another location and regeneration and multiplication. For species that have extremely long juvenile periods, those for which the seed is not easily obtained and for forest species, the provenance and locality data may indicate the area of the *in situ* stand where the germplasm is found and hence may indicate, at a future date, the only source of seed.

Indigenous (traditional, local) knowledge has not always been given the level of importance that it deserves with regard to documentation. Plant collectors have, in many cases, collected data related to the accession's vernacular name, the distribution, appearance, properties, uses and origins, the cultural management practices and environmental conditions with which the accession is associated and how the accession has been affected by changes in farming practices and natural habitats [Guarino, in press]. However, the use of this data has not been widespread due to the small amount of effort that has been put into the overall documentation practices including the thoroughness of data collection and transcription, the inability to readily classify the different types of knowledge obtained and the incorporation of data into computerized information systems. The last point also creates problems for computer storage and retrieval and, therefore, use of the data. Events and publications leading up to, and including, the United Nations Conference on the Environment and Development (UNCED) have promoted the importance of recording and utilizing indigenous knowledge. Hence, the information management aspect of this problem is now getting increased attention [Morin-Labatut and Akhtar, 1992]. IBPGR will also dedicate resources to the information management/technology issues related to this area.

Information management systems

A. Definitions and requirements

After the database is designed and established it is important, particularly for larger databases, to determine the system that will be used to manage it. These can be manual or computer-based. The latter are generally referred to as database management systems (DBMS). Whether the database should be maintained manually or using a computer is determined by the experiences, resources and the size of the database that does, or will, exist. The database and the system that is used to manage it are generally referred to as an information management system. An information system should have, at least, the following design requirements:

- it must take into consideration the overall structure and operating procedures of the organization the system is to serve;

- it must either define, or be designed around, the specific methods that will be used to carry out activities related to data definition, storage, retrieval, auditing, etc.;
- it must take into account the type, quality and quantity of data to be maintained;
- it should provide users with logical, fast and flexible information retrieval and storage mechanisms.

B. Information system compatibility

Consideration must occasionally be given to compatibility of data between information systems that are similar with respect to the subject matter. This can be physical format compatibility or logical compatibility. Physical formats can be changed to accommodate the receiving institute. If incompatibility exists, it is necessary to reformat the data by writing it in an ASCII fixed field format.

Logical compatibility refers to the use of different or inexact descriptor states for the same descriptor. The use of standard descriptor lists assists with the exchange of data between institutes that maintain or are interested in the same crop. Logical data incompatibility exists if descriptors with nonequivalent definitions or non-convertible descriptor states or coding schemes are used. For many plant morphological or agronomic descriptors, the conversion between two descriptor lists that utilize different descriptor states, is generally not possible.

Data incompatibility may also result from the use of different standards. These may include names for countries, taxonomy, institutes, etc. A single standard set of names for these descriptors will probably not be used in the foreseeable future but many different organizations are working in this direction. A possible solution is to communicate with the institute that supplied the data and to create a table of equivalent conversion values that can be used to translate the descriptor values and hence ensure compatibility at the receiving institute.

C. Information systems in use

The relatively low cost and wide availability of computer technology have provided the basis on which to establish information management systems in genebanks in most areas of the world. These vary considerably in operation, complexity and design. The simplest design may utilize a personal computer and a simple text editor or word processor for data management. More complex systems are designed to work for many different germplasm collections in different locations. The resulting databases are complex and require, in many cases, several people to maintain them over and above those that manage the data [Mowder and Stoner, 1989]. Many of the information systems that are designed for small- to medium-sized genebanks have been developed to operate on a single personal computer and utilize a PC-relational database management system (DBMS) software package [IBPGR, 1985]. Computer programs that utilize the DBMS' programming language are usually designed and written to facilitate data management as determined by daily genebank routines.

Problems associated with *ex situ* information management

It has not been possible for many national or local genebanks to develop information management and/or suitable documentation systems that meet their particular needs. This causes delays, inaccuracies and mistakes in data use and may actually lead to a loss in genetic diversity or genetic resources due to incorrectly or poorly managed conservation practices. These problems are usually caused by:

- the lack of, or inability to keep, properly trained documentation staff who are responsible for data management at the genebank. This could be caused by a low level of resources and/or a low level of prestige;
- the inability to acquire funding to purchase the necessary computer technology;
- the lack of organization of genebank procedures and processes that will generate data in a coherent and logical manner; or
- a combination of any of the above points.

Development of sound information practices at a genebank must start with the recognition of the importance of the function. This must be demonstrated by the dedication of resources to provide the function. Also, it is necessary for the genebank management to recognize that the documentation and information functions are vital and integral parts of the operation of the genebank. They alone can help to elevate the prestige of the information management function.

International databases

A. Central crop databases

This general discussion has been focused primarily on genetic resources databases important to a single institute or group of institutes within a particular genetic resources programme and within a particular country. A concerted effort is now being made to establish crop-specific genetic resources networks. The basic idea behind these networks is to develop cooperation and share information between and within all groups that are working on the genetic resources aspects of a particular crop. One of the initial activities of these networks is to plan a research and conservation agenda to set the stage for global activities. This approach stimulates communication and helps to reduce duplication of effort. In the experience of IBPGR, one of the activities started after the first planning meeting is the establishment of a central crop database. This is a database that results from compiling predetermined accession-specific data from all participating germplasm collections of the particular crop. In the past, several of these have been compiled with varying degrees of success. After the launch of IBPGR's crop network concept, the formation of these databases has been considered by the network participants as an important primary activity necessary for directing and identifying the long-range goals of the network.

Databases that are currently under way in conjunction with an IBPGR crop network are: barley, maize, *Beta*, rice, groundnut (wild *Arachis*), okra, *Musa*, coconut and cassava. Other important central crop databases that have been compiled under other projects or arrangements are: wild wheat, *Aegilops*, *Avena*, *Cucumis*, *Cacao* and *Citrus*.

B. Concepts and uses

The rapid advances in computer technology and its increased availability have enabled the use of relatively powerful microcomputers in many remote areas of the world. This has made it even easier to realize the numerous advantages of integrating into one computer database, data on germplasm held in different centres. General concepts behind the compilation of these databases were developed early by IBPGR. These include the criteria that databases should be organized separately for each crop and that they should be located in an internationally recognized "centre of excellence" for the crop. The latter point helps to ensure dedicated support for the database and makes available expertise for the verification of the data. The compilation of the central crop database, for which there are many thousands of accessions and many different collections from locations throughout the world, may be facilitated by setting up and rationalizing several regional databases first and, later, compiling these into a global database. This approach spreads out the overall workload and allows the participants, most familiar with the data to have a close input into its rationalization in conjunction with geographically similar collections where there may be a great deal of initial duplication of material.

Central crop databases have no purpose unless they are going to be used. In the context of a network of collections, they can act as a tool to guide the network activities and as a service to breeders that are either participants in the network or will be users of the data. As a tool for management the database provides a means to:

- assess the current status of conservation and characterization of the genetic resources in all participating collections;
- provide an indication of duplication (including intentional security duplication) of material between collections;
- provide an indication of gaps that may exist in the representation of geographical provenance or phenotypic/genotypic variability among collections as well as study the phenotypic/genotypic variability inherent in the collection; and
- assess the regeneration requirements at an international level.

As a service to breeders, the central crop database can provide current information on the content of specific collections and assist in the selection of germplasm that possesses specific attributes.

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Opportunities and Considerations for Collaboration between Formal and Informal Systems

P. R. Mooney

Opportunities

The opportunities for cooperation between community-based (informal) and institution-based (formal) systems for the conservation and improvement of genetic resources are almost without limit. Each system perfectly mirrors the other in purpose and function and each can enhance the work of the other. There is virtually no part of a national or IBPGR germplasm strategy that cannot benefit from the participation of local communities and NGOs.

It must also be acknowledged that each system needs the other. Neither is perfect unto itself. Farming communities have been conserving and improving agricultural germplasm for more than ten thousand years. Genebanks have been doing the same job for only half a century. Despite the best efforts of the informal system, approximately 70% of the genetic diversity of the world's major food crops has disappeared from the field. Losses in genebanks - again despite the best efforts of curators - have also been severe. Conservation is forever. We are not in the business of conserving agricultural diversity for the foreseeable future. We must conserve genetic resources for the unforseeable future. It is in all of our interests to work to see that the short-term perspective on political issues and undue commercial interests can be laid aside in a common effort to make sure that future generations of farmers have access to a sustainable supply of genetic material for improvement.

Some examples of potential areas of cooperation might help us all appreciate the value of working together.

Together, the two systems could develop an Early Warning System to identify urgent areas for collection of endangered germplasm. NGOs and farmers' associations working in rural areas could cooperate with the national system through a number of uncomplicated and inexpensive mechanisms including through access to a "hot line" phone number (and mailing address) that is widely circulated. Among others, expatriate NGOs and private companies working in rural areas could also be asked to (voluntarily and at their own expense) participate in an annual seminar on national genetic resources management that would give them the opportunity to advise the national programme of any developments that could require additional collection work. In some countries, however, the need to protect the rights of civil society may make it difficult to achieve this level of cooperation.

If the two systems can work together, it is possible to imagine that communities could undertake much of the national collection and documentation work themselves. Local people can collect both the early-maturing and late-maturing samples in a field and can provide much more useful documentation and characterization data for each sample. In these ways, costs could be substantially reduced for the formal system. Collaboration is also possible in improving safety and efficiency in rejuvenating genebank accessions whose germination rates have fallen too low. Seeds could be returned to the original community or, where passport data is missing, to a community with a similar agro-ecological environment where the seeds could be multiplied and samples shared with the genebank.

A number of real policy considerations must be resolved before this cooperation is possible.

Considerations

Despite years of debate and discussion at FAO, the rights of farming communities, or "Farmers' Rights", have not been fully developed or understood. In considering collaborative programmes between the two systems, national and international germplasm committees should bear in mind at least four rights:

- the Farmers' Right to retain their folk varieties within home or community genebanks;
- the Farmers' Right to know what is being done with folk varieties and to have access to information generated from folk varieties;
- the Farmers' Right to innovate and to participate in innovations related to genetic resources;
- the Farmers' Right to benefit from the commercialization of materials derived, partially or wholly, from their genetic resources.

Until there is acceptance of the need to safeguard the intellectual integrity of farmers, it will be difficult to achieve the collaboration for which we all wish. The greatest barrier to acceptance of farmers' integrity is the spread of intellectual property systems that usurp the genius of local communities. This is a critical topic we must all address in meetings like this.

Integrity and trusteeship

Some of the concern in protecting farmers' integrity in the face of intellectual property expropriation relates to the status of international genebanks. RAFI is in the early phases of an evaluation of the trusteeship role of the Consultative Group on International Agricultural Research (CGIAR) and its International Agricultural Research Centres (IARCs) with respect to their *ex situ* collections of genetic material. The trend in policy formulation within CGIAR is to argue that each Centre holds genebank materials "in trust" on behalf of farmers in developing countries. As laudable as this position is, it raises a number of difficult questions:

1. Is the legal status of each genebank clear? Most IARC arrangements suggest that genebanks are an asset of the IARC and, therefore, ultimately the property of the country hosting the IARC.
2. If not an asset but a "trust", who entrusted CGIAR with this responsibility and what are the conditions of the trust? The IARCs are currently negotiating with FAO to be given retroactive "trust" but this is, at least, convoluted since the IARCs seem to want unconditional trust (everlasting love).
3. Most especially, where does genebank material (and, therefore, "trust") end and where do IARC research products begin? Do IARCs have the right to claim ownership over products based on genebank materials? Is there a "trust" element in their ownership?
4. More specifically, can IARCs patent genebank material or trade this material as part of intellectual property or technology transfer deals with private companies?

Most of the accessions in genebanks are so-called "landraces" (folkseeds or farmers' varieties are better terms). These accessions form part of the intellectual integrity of

farming communities. Together with information, funds, technologies and systems, germplasm makes up a genetic resource whose importance to conventional plant breeding and biotechnology increases daily. Genetic resources are quite incorrectly described as "raw material" for biotechnology. They are not. They represent the current intellectual contributions of informal innovators but the resources can only be appropriated by companies if their intellectual content is demeaned.

It should be absolutely clear that there is no evidence (and little likelihood) that any IARC has ever expropriated material held in trust for its own commercial advantage. It seems that IARC thinking, on the parameters of intellectual property ownership questions, is pretty fuzzy. Hope Shand of RAFI has identified some recent situations in which IARCs may have overstepped their (self-appointed) role as trustees and used farmers' material as a bargaining chip in negotiations that are resulting in patents. Five examples that raise doubts, follow:

1. Rice research financed by the Rockerfeller Foundation and involving the co-participation of the International Rice Research Institute (IRRI) in the Philippines and Cornell University, has led to Cornell applying for a series of patents and offering to sell access to their information, to biotech boutiques in the United States.

2. In 1991, the International Potato Centre (CIP) in Peru signed a contract with Plant Genetic Systems (PGS) of Belgium to trade genebank material for access to a transgenic potato (resistant to potato tuber moth) that was derived from that material. PGS has exclusive rights to the germplasm in industrialized countries and CIP has the right to use the material in the South. For the first time, CIP is obliged to refuse requests for this germplasm from the North.

3. A Pepsico subsidiary, Frito-Lay, was allowed to come to CIP to screen genebank accessions for potato chip processing qualities. Frito-Lay took useful germplasm samples back to the United States and is now developing proprietary (patentable) varieties which could be marketed in such countries as Korea and Taiwan where Frito-Lay has large operations. CIP traded access to the genebank for access to (some or all of) Frito-Lay's screening documentation.

4. EscaGenetics, another US agricultural biotechnology boutique, has also obtained germplasm from CIP which it is turning into patentable material. EscaGenetics is testing its new potatoes in a number of developing countries including Colombia, Venezuela, Argentina, Mexico and Egypt.

5. The International Centre for Tropical Agriculture (CIAT), in Colombia, is negotiating intellectual property rights, over two new bean varieties, with a French public sector institution. Royalties will be disposed of by CIAT. Officials concede that one of the varieties is based heavily on a Chilean accession in their genebank and have wondered if they should turn over the profits to Chile.

CIP officials argue that their genebank is their "comparative advantage" in negotiating technology transfers with private companies. Was this in the invisible "trust" agreement with farmers? Have even the governments (from whose sovereign lands the germplasm came) been consulted?

If informal innovators establish working relations with institutes that accept the possibility of patent monopolies over genetic resources, what are the implications for farmers? Will recognition of the informal system simply lead to the expropriation of not only farmers' varieties but also farmers' knowledge about those varieties? How can this be

prevented and/or how can farmers be compensated? These issues also apply to national agricultural research services and universities who are also becoming interested in patenting living materials.

It is difficult to quantify the intellectual contribution of Third World farmers to industrialized countries. Most genebank directors in the North privately (or publicly) acknowledge that the contribution of farmers' varieties is enormous. A great deal of the most commercially usable material flowing to the North passes through International Agricultural Research Centres either directly from their genebanks or as "improved" material for field trials. RAFI is attempting to establish reasonable calculations on the value of farmers' varieties exported in this way.

The best information is available for wheat material obtained by the North through the International Maize and Wheat Improvement Centre (CIMMYT), in Mexico. Our preliminary estimates are based on information from only four industrialized countries and the base figures are drawn from three national research institutes. For the United States, our estimates are based on a 1982 Organization for Economic Cooperation and Development (OECD) report that, somewhat cryptically, estimated the value of Third World wheat germplasm to the United States at US$ 500 million per annum. An internal 1983 study by Canadian and American government wheat breeders came up with a similar figure specifically related to CIMMYT germplasm. RAFI believes these figures are a minimal estimate. Two studies by Dama Dalrymple of USAID (1981 and 1986) show that 21% of the entire US wheat crop was sown to semi-dwarf material derived from CIMMYT. RAFI estimated the value of the CIMMYT contribution at (roughly) US$ 1.8 billion in the mid-eighties.

In a report for The Crawford Fund for International Agricultural Research in Australia, Derek Tribe, in 1991, offered three different calculations for the value of CIMMYT material to that country. The low estimate was about US$ 75 million per annum while the high estimate (based on RAFI's extrapolation of other figures cited by Tribe) was approximately US$ 122 million. Tribe also cites a 1990 New Zealand estimate that CIMMYT's contribution to that country could be valued at NZ$ 338 000 per annum.

In 1992, a study from INTAGRES, a CGIAR documentation and information centre based in Rome, concluded that CIMMYT's annual contribution to the Italian durum wheat crop was not less than US$ 300 million.

The total value of CIMMYT wheat germplasm to the four industrialized countries is not less than US$ 875 million a year, according to governmental or semi-governmental estimates [Fig. 1].

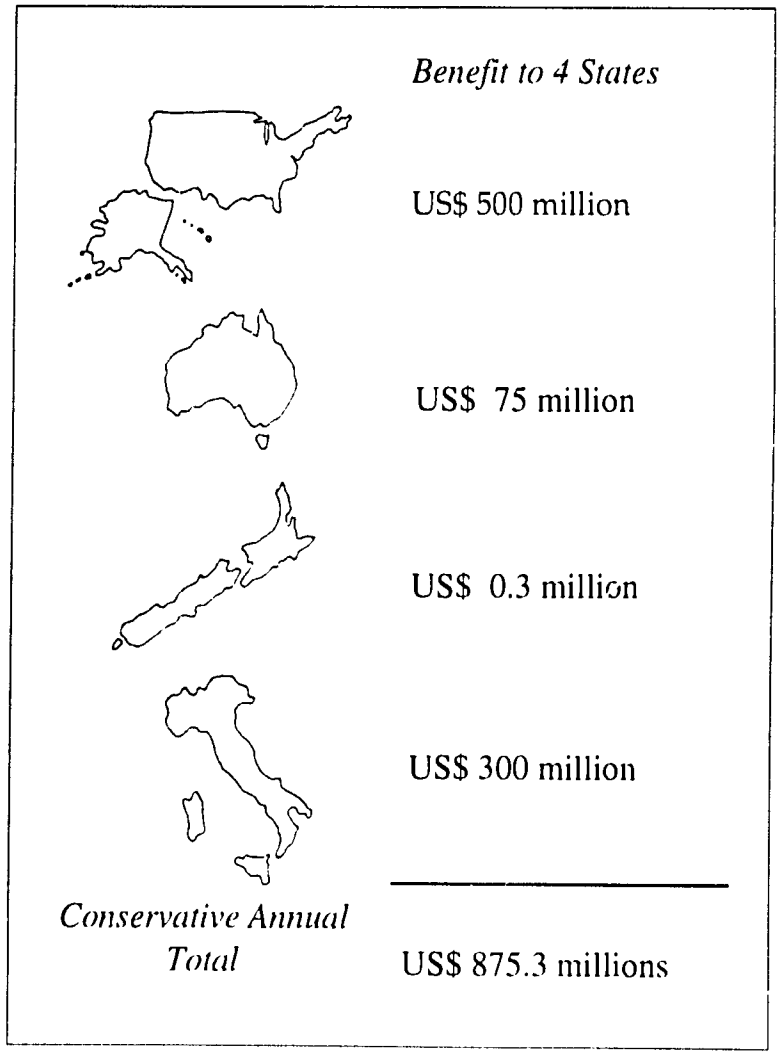

Figure 1. Understanding the IARChy; CIMMYT's Contribution to Wheat

Source: RAFI diskfile: cgbentot Disk: p/hd File: 72

In Table 1 below, RAFI takes each estimate from each of the four countries discussed above and applies them over all industrialized countries on the basis of the percentage of total wheat production in the North. Thus, the United States (which averaged 18% of the North's entire wheat production in an average year over the 1986-90 period) is measured by the US dollar estimates made by the OECD in 1982; by RAFI, based on USAID acreage data in 1986; by Trice's estimates for Australia and New Zealand; and by INTAGRES's estimate for Italy. Each country is measured the same way. The result is a range, estimating the total annual value of CIMMYT material to the North, running from less than US$ 300 million (based on New Zealand's rate) to more than US$ 11.5 billion (based on INTAGRES's Italian rate). The extrapolation of the OECD data and the high end of Tribe's Australian data both come close to US$ 2.7 billion per annum. RAFI thinks this is a reasonable estimate of CIMMYT's real value to the North. CIMMYT's budget, in 1990, was US$ 27.1 million. CIMMYT's return to the North, then, is one hundred fold.

Table 1: CIMMYT and Wheat in the North - Various Estimates of Annual Value

State	Prod. Av. ('86-'90) 1000MT	%W	%N	OECD ($500)	USA (1800)	AUS#1 ($75)	AUS#2 ($122)	Italy ($300)	NZ ($0.3)
World	539448	100							
South	220727	41							
North		59	100	$2 720	$9 780	$1 630	$2 650	$11 540	$300
USA	58697	11	18	$501	$1 801	$300	$488	$2 125	$55
AUS	14565	3	5	$124	$447	$74	$121	$527	$14
Italy	8391	2	3	$72	$257	$43	$70	$304	$8
NZ	249	0	0	$2	$8	$1	$2	$9	$0

Notes:
1. Estimates are based on the extrapolation of national estimates from the four countries described in Table 1, above.
2. Percentages are based on FAO AGROSTAT disks. "%W" indicates the share of world production in thousands of metric tons averaged over the 1986-90 period.
3. All currency figures are in US$ millions.

Operating on the same basis (percentage of annual production in the North), RAFI has also tried to estimate the value of IRRI and CIAT rice material, CIAT beans and CIMMYT maize. Once again, we have to caution that these figures might only offer a very crude "ballpark" understanding of the contribution of informal innovators. In the final analysis, probably the most accurate thing to be said is that Third World farmers are contributing *enormously* to the North.

A 1986 USAID study (by Dana Dalrymple) showed that 73% of the semi-dwarf rice acreage in the United States was based on IRRI material. Semi-dwarfs accounted for about 22% of the entire US rice crop. Extrapolating from this, RAFI estimated that the annual farmgate contribution made by IRRI amounted to about US$ 176 million in 1984. The semi-dwarf share of the American harvest has continued to grow but RAFI has kept the figure at the 1984 level. Since the US crop equals about 26% of the North's total rice production, the total value of IRRI material to the North is extrapolated to be about US$ 677 million per year. In 1990, IRRI's budget was US$ 30.6 million offering the North a 22-fold return on investment per annum.

Yet another US study (by Major Goodman at North Carolina) of maize shows that, in 1985, perhaps only one-tenth of one percent of the value of the American maize crop was based on "tropical" exotic germplasm. In the mid-Eighties, this tiny percentage still equaled US$ 20 million of the annual farmgate value of the crop. Since US maize is equal to about 68% of all maize production in the North, the total value of Third World germplasm to the North is only about US$ 29 million. Were all this material derived from CIMMYT, this would afford Northern donors an even return on their investment. Of course, CIMMYT's US$ 27 million budget is also for wheat, barley and triticale.

Recently, CIMMYT maize breeders reported that about 30% of the requests they receive for farmers' varieties of tropical maize now come from private companies and that this percentage is growing rapidly.

The U S accounts for an average (over the 1986-90 period) of 54% of the North's dry bean production. According to CIAT authorities, CIAT material contributes US$ 60 million to the US agricultural economy every year. Extrapolating this figure, the North gains about US$ 111 million from a CIAT (1990) budget of US$ 28.1 million - a four fold return.

It is worth remembering that these figures are crude estimates for just four crops. CIP's contribution in potatoes is probably enormous. ICRISAT virtually established the Australian chickpea industry based on 16 000 farmers' varieties given to Australian breeders. There are no estimates for barley from CIMMYT and of vegetables from AVRDC, for example.

In one sense, both IARCs and farmers could, and should, take pride in their contribution to global agriculture. In principle, there is no reason why the North should not benefit. The problem arises when there is neither acknowledgement of, nor compensation for, the commercial value flowing North. The situation worsens massively when Northern governments allow the patenting of material wholly or partially derived from farmer's varieties. As private companies move into Third World seed markets, farmers are finding themselves paying for the end product of their own genius. The North is becoming a huge klepto-monopoly taking freely-given germplasm from the South and winning patent monopolies in the North. Informal innovators - and their NGO supporters - need a policy toward this situation and toward institutional research systems that are involved in the flow of material and information.