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Conservation and utilization of germplasm in East and southern Africa: an overview

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Introduction

The large number of genotypes of plants which has evolved as the culmination of thousands of years of natural evolution, mutations and, to some extent, human manipulation, constitutes an irreplaceable pool of diversity from which breeders tap the raw material for their crop improvement programmes.

Africa has for long been a source of germplasm of great importance to the world's agriculture. Many of the crops domesticated in Africa have spread widely around the world. This, for example, is the case with sorghum *(Sorghum bicolor)*, cowpea (*Vigna unguiculata*), coffee (*Coffea* spp.) and pearl millet (*Pennisetum americanum*). Some crops such as niger seed (*Guizotia abyssinica*), roselle (*Hibiscus sabdariffa*), okra (*Abelmoschus esculentus*), kenaf (*Hibiscus cannabis*) and castor (*Ricinus communis*) have become important elsewhere while others such as teff (*Eragrostis tef*), fonio (*Digitaria exilis*), yams (*Dioscorea* sp.), bambara groundnut (*Vigna subterranea*) and African rice (*Oryza glaberrima*) have remained important only in Africa.

Several crops introduced some 1000 or more years ago have developed, under various evolutionary pressures, significant genetic diversity which in many cases has made Africa become their secondary centre of diversity.

Africa also possesses scores of under-exploited and unexploited economic plants including forage legumes and grasses, tree species for fuel and timber, medicinal plants, etc.

Genetic Erosion

The wide array of crop plants which has developed in Africa was for long preserved by virtue of the continent's ancient methods of farming. But during the last few decades there has been an alarming deterioration of natural resources and loss of

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genetic diversity. The rapid increase in population in Africa, the clearance of forests for more agricultural land and urban development has generally resulted in intensified exploitation of the environment, very often without long-term planning, or the necessary research background, contributing to genetic erosion.

To solve problems of famine and malnutrition, plant breeders have embarked on the improvement of yields per unit area through a combination of both farming practices and better varieties. This has led to the development of new high yielding crops adapted to existing climatic conditions, with higher production and resistant to various pests and diseases. But while crop yields have been generally increasing, the genetic base of most of the important food crops has been rapidly narrowing. The adoption of high yielding newly developed varieties has resulted in subsistence farmers abandoning traditional varieties, landraces that were rich in genetic diversity. The adoption of modern farming practices as well as bush fires, overgrazing, successive droughts and floods also contribute to genetic erosion.

Germplasm Preservation in East and southern Africa

In order to counteract the loss of genetic diversity, agronomists and plant geneticists have to collect and conserve the germplasm so that plant breeders will have access to the genetic resources necessary for their improvement programmes.

During the early 1960's, the Food and Agriculture Organization of the United Nations (FAO) spearheaded an effort to bring the issue of germplasm conservation to the attention of the world community. The International Board for Plant Genetic Resources (IBPGR), with its headquarters at FAO Rome, was established in 1974 by the Consultative Group for International Agricultural Research (CGIAR) to assist in this effort. IBPGR was re-established in October 1991 as the International Plant Genetic Resources Institute (IPGRI).

In order to increase the efficiency of its action and further assist in capacity building at national level, a regional office was established in Nairobi in 1982, for East and southern Africa. In collaboration with several national, regional and international institutions, the IBPGR has been involved in organizing and financing the collection and conservation of the major crop germplasm of the region.

Collecting Activities

Up to the recent past, and with a few exceptions such as Ethiopia, the conservation and management of genetic material in the region was of poor standard. There were few collecting missions. Most of the countries in the region were keeping some collections, composed mainly of exotic material, a few indigenous species and almost

no wild and weedy relatives. These collections were usually constituted according to the interest of the breeders, their preoccupation at the time and the means at their disposal.

Activities were intensified in Africa especially following the severe drought which occurred in the 1970's and early 1980's. Thus, during the past decade, in close collaboration with some national institutions and programmes, regional and international organizations (ORSTOM, UNEP) and some of the other international agricultural research centres (IARCs) such as ICRISAT, IRRI, WARDA, CIAT, ILCA and IITA, the IBPGR has organized the collecting of endangered crop species with significant genetic variability in the region.

Collecting was based on criteria such as: the risk that genetically diverse material of the species and their wild relatives will be lost in the future; the size, scope and quality of existing collections and recognized requirements of breeders for genetically diverse material.

Following field and herbarium surveys and studies of distribution of diversity, collecting missions which were focusing at an early stage on major species such as sorghum, maize, millets, rice, cowpea, beans, cassava, groundnut and coffee, were extended to vegetable, fibre and sugar crops, medicinal plants and tree species. Sixty-three collecting missions were fielded and 21,349 samples of various species were collected in 20 countries of the region including Namibia recently. Duplicate samples of the material collected were left with the collaborating institutions or the national programmes. Following the recommendations of the 1986 Consultation on Plant Genetic Resources in SADCC, IBPGR stationed a collector in Harare, Zimbabwe, to assist national programmes in the collecting of wild species.

Considering that several important indigenous forage species were under increasing threat of genetic erosion, collecting of forage species became a priority. ILCA started systematic collecting in Ethiopia. Later, together with IBPGR and CIAT, and in collaboration with national programmes, collecting was extended to Tanzania, Kenya, Uganda, Zimbabwe, Rwanda, Burundi, Zambia, Botswana, Lesotho and Malawi. Duplicate samples of forage legumes and grasses collected are maintained at ILCA Headquarters in Addis Ababa. Species collected are mainly *Trifolium*, *Brachiaria*, *Andropogon*, *Panicum*, *Stylosanthes*.

With their own limited resources or with the assistance of some bilateral donors, some national institutions and NGOs in the region have collected and continue to collect specific germplasm useful for the development of their programmes (pigeon pea, vegetable [Gynandropsis], etc). The Kenya forage programme collected and/or introduced more than 20,000 accessions of indigenous and exotic forage species which were maintained at the National Agricultural Research Station, Kitale.

Conservation

Germplasm collected needs to be adequately preserved for present and future utilization. Until recently, several collections in the region were lost mainly because of lack of proper conservation. Collections were kept by breeders in laboratories, offices, cabinet drawers, on shelves, in trays, in paper, plastic or cloth bags. The collections were exposed to all types of storage pests, fungi and rodents. There were however a number of cold storage facilities in the region, but in most cases they were non-functional and still remained in use even after the refrigeration plant had broken down. In the rare case of functioning cold stores, generally there were managerial problems such as the lack of curators, the germplasm was improperly packed and arranged and temperature fluctuations occurred in the stores, etc.

Various conservation situations can be considered for the storage of germplasm:

- Base collection for secure long-term storage at -20° C. Material (seeds) in this category is not for distribution. The seeds are dried to 5 % moisture content and packed in airtight containers in cold stores (also deep freezers).

- Active collection for medium-term storage, multiplication, distribution, characterization and documentation. Seeds are stored between 15° C and 0° C. Field genebanks are also active collections.

- Working collections for conservation by breeders and researchers in conditions that ensure enough longevity for the purpose of their research (evaluation, etc). These could be planted every cropping season. These breeders' collections are part of genetic conservation whenever there are unique materials such as wild species.

- Field genebanks for vegetatively propagated species and species with recalcitrant seeds.

- *In vitro* and *in situ* conservation are currently under research and in pilot stages and should complement the above possibilities taking into consideration comparative advantages.

Active and base collections could be in the same conservation facility and separated by management practices.

In order to ensure that new samples collected and old collections are properly conserved in the region, the IBPGR has been providing assistance to various institutions and national programmes in the region to rehabilitate their conservation facilities or to put up new basic ones. For example:

- Rehabilitation work was done in Kenya at the Plant Quarantine Station (PQS) in Muguga; in Zambia at Mount Makulu Research Station; in Botswana at the Sebele Agricultural Research Centre.

- New conservation structures were established in Sudan at Wad Medani for vegetable germplasm; in Zimbabwe at the Plant Breeding Institute in Harare; in Mauritius at Barkly Station mainly for vegetable germplasm; in Mozambique at the Faculty of Agriculture mainly for groundnut germplasm; in Burundi at IRAZ, Gitega. A conservation centre fully equipped by IBPGR was built at Mahitsy in Madagascar.

- With an IBPGR grant, a modern genebank was established in 1987 at ILCA mainly for the conservation of forage genetic resources.

- Field genebanks were established at Muguga and Matuga in Kenya.

- Conservation equipment ranging from thermohygrographs and aluminium foil seed packets to shelves, deep freezers and standby generators, was provided to several conservation centres in the region (Kenya, Madagascar, Tanzania, Uganda, Sudan, Zimbabwe, Botswana, Zambia, etc.).

Some donor agencies and countries (IDRC, World Bank, USAID, GTZ, the Nordic countries) have also contributed in the establishment of conservation structures in the region.

The Plant Genetic Resources Centre (PGRC/E) was established in Addis Ababa, Ethiopia, by the German government in 1976. With facilities for base and active collections, the centre currently holds more than 50,000 accessions of more than 80 different species such as *Brassica* spp., *Guizotia abyssinica*, *Cicer arietinum*, *Pisum sativum*, *Eragrostis tef*, *Triticum* and *Coffea arabica*. PGRC/E also conserves duplicate collections of *Hordeum*, *Sorghum bicolor* and *Eleusine* which are received from collecting missions all over the world.

GTZ has also built four storage units across Kenya and a modern genebank similar to the one in Ethiopia at Muguga in Kenya. With a World Bank grant, ISAR (Rwanda) has now completed a conservation unit at Butare. Several field genebanks have also been established for the conservation of vegetatively propagated plants in the region in Sudan, Rwanda, Burundi, Zaire and Tanzania. More than 6,000 accessions of *Phaseolus* beans are conserved at the Bunda College of Agriculture in Malawi.

IBPGR and the Nordic Genebank are assisting SACCAR in establishing a regional genebank in Lusaka to serve the SADCC countries. The project is based on strengthening national capabilities by establishing and organizing strong national programmes and providing basic conservation structures. The project is designed for 20 years.

Characterization and Documentation

In most countries of the region, the characterization and documentation of the indigenous germplasm lag way behind the collecting and conservation activities. Characterization of the resources prior to final storage is essential if one considers that the germplasm was collected to be utilized.

Equally important is the documentation. The information collected during the collecting of samples (which will form the passport data) along with the characterization (and later evaluation) data should be put together and be readily available to users for the selection of the desired germplasm.

With the aim of facilitating the retrieval and exchange of standard and uniform information, IBPGR has issued a minimum descriptor list of almost all the major crops at global level and also encourages the use of micro-computers.

Although slow, characterization and preliminary evaluation work has started in the region. It is primarily the responsibility of the national programmes. The IBPGR action has been to help and encourage them to systematically undertake this task. Funds and expertise are also provided whenever possible and necessary. For example:

- In Zimbabwe an IBPGR consultant assisted the Department of Research and Specialist Services in characterizing the sorghum and millet accessions collected between 1982 and early 1985. A catalogue was prepared.

- In Sudan the horticultural division of the Agricultural Research Corporation at Wad Medani is characterizing the vegetable resources of Sudan collected during 1982-84 and early 1985.

- In Madagascar the rice collected in 1983-84 has now been characterized and a catalogue has been published. The same has been done for legume collections.

- In Kenya the characterization of a cassava collection was done at Msabaha Research Station in collaboration with the Commonwealth Institute for Biological Control (CIBC);

- The rice germplasm collected by the Department of Botany of the University of Nairobi was characterized and evaluated in collaboration with the National Irrigation Board (catalogue);

- The characterization of the forage germplasm continues actively at the National Agricultural Research Station in Kitale where documentation is accelerated by the use of a micro-computer and a catalogue has now been issued.

- In Zambia characterization of bambara groundnut was done at the University of Zambia.

- In Mozambique the Faculty of Agriculture of the University of Maputo characterized their groundnut germplasm (catalogue).

- In Botswana cowpea germplasm was evaluated at Sebele Research Station and a catalogue was published.

- In Malawi the evaluation of part of the *Phaseolus* collection was done at the Bunda College of Agriculture.

- In Ethiopia the Plant Genetic Resources Centre has made commendable efforts in the rejuvenation/multiplication and characterization of the various crops conserved at the centre. Every year about 8,000 accessions of various crops conserved are planted in various ecological zones and characterized jointly with the national improvement programmes. Many collections of sorghum, chickpea, *Brassica*, *Eragrostis tef*, barley and wheat have already been characterized.

Use of the Germplasm in Breeding Programmes

Increased food production in the region using stable, high yielding varieties can only be achieved by incorporating the useful adapted indigenous genotypes. Utilization of the germplasm is facilitated mainly by factors such as availability of breeding programmes with defined objectives and strategy; availability of qualified manpower and infrastructure; availability of documented material.

In the past, very limited evaluation and documentation work resulted in limited utilization of the local germplasm in the region. During the colonial era, the presence of expatriate breeders and defined breeding objectives led to the introduction of several resources and the manipulation of limited local materials. Some improved varieties were developed and were spread over the region and some are still in use today. An increase in the utilization of indigenous germplasm was noted during the East African Community period when breeders of the same species were grouped in major stations in the same programme with defined breeding objectives. This led to the development of improved maize varieties at Kitale (Kenya), sorghum and millet varieties at Serere (Uganda), improved cassava varieties at Amani (Tanzania), improved cotton varieties at Namulongi (Uganda), etc.

The major bottleneck in the utilization of local germplasm in the region was the lack of national breeding programmes with qualified personnel, financial support and defined objectives for several crops. The lack of proper equipment for chemical analysis of samples was also a serious problem. The situation is gradually changing. In most countries today major resources such as maize, sorghum, pearl millet, *Phaseolus*

beans, cassava and rice have an established breeding programme with defined objectives such as the screening of germplasm for resistance to insect and disease attack, tolerance to drought or poor soil fertility, high and stable yield components, quality evaluation, etc. But several other crops are still grouped under the same breeding programme, i.e. roots and tubers, forage crops, grain legumes, vegetables, fruits, oil crops, etc.

For obvious reasons, the output of existing breeding programmes varies greatly within country and from country to country in the region. High yielding varieties (composites, hybrids) with tolerance to diseases and great nutritional value were developed in Kenya, Zimbabwe and Zambia. Despite drought and related problems, the increased evaluation and documentation of germplasm has greatly contributed to the utilization of the germplasm in the national breeding programme in Ethiopia. Also high yielding varieties of sorghum resistant to borers were released in Kenya by the International Centre for Insect Physiology and Ecology (ICIPE). Identification of Cassava Mosaic Disease (CMD) resistant material as well as CMD tolerant varieties with high yielding is in progress in the region (Kenya, Uganda, Tanzania, Zaire). Coffee Berry Disease (CBD) resistance was developed in some coffee varieties in Ruiru (Kenya) and also in Ethiopia.

Breeding work at the IARCs which have specific mandate crops is of great benefit to the national breeding programmes with whom new links have been established. Most of the resources collected in the region are being characterized and evaluated at the various centres and advanced material is moved into the national breeding programmes for further testing and release to farmers. High yielding varieties developed in these centres are also sent to the region for release to farmers. This is happening for cowpea, rice, cassava, beans, sorghum, pearl millet, chickpea, groundnut and maize. Scientists at IITA have discovered resistance to cocoyam blight by screening landraces held at the centre's genebank. They have also found cassava varieties which are genetically resistant to mealy bug (*Phenacoccus manihoti*) and green spider mite (*Mononychellus tanajoa*).

In a new development, the Centres are now evaluating the germplasm collected directly in the region together with the national programme breeders (ICRISAT, IITA, CIAT, WARDA, etc.).

The Industrial crops and cash (foreign currency earner) crops are usually under special arrangement whereby a multidisciplinary research programme is established and is operational with sophisticated equipment. This is the case for coffee and tea in Kenya, tobacco in Zimbabwe and sugar cane in Mauritius.

Training

Plant Genetic Resources conservation and utilization is a relatively new field that needs competent manpower. Training is an aspect that is very important for the development of activities in the region.

IBPGR offers scholarships for an M.Sc. course in Conservation and Utilization of Plant Genetic Resources at the University of Birmingham in UK. To date 35 scientists from East and southern Africa have attended this course. Ninety-eight other scientists and technicians attended short courses in management of genetic resources in various research centres and universities in the region and other parts of the world.

A few short courses were organized in the region in Ethiopia and Kenya and recently in Namibia. On-the-job training is offered during collecting missions and regularly at ILCA in Ethiopia. It is hoped that UNZA in Zambia and the Faculty of Agriculture of the University of Nairobi will soon start courses more related to genetic resources management. The former will be as a support to the SRGB initiative. It is also envisaged that Ethiopia will become a more active training centre to serve the African Network on Plant Genetic Resources established by the African Ministerial Conference on Environment (AMCEN).

Problems and Prospects

The catalytic and leadership role played by IBPGR and the assistance provided by the other IARCs, IRAT and ORSTOM as well as the support of UNEP and FAO has increased awareness of the importance of crop genetic resources. There is consequently an increase in the intensity of conservation activities in the emerging. These programmes are faced with several problems such as:

- An acute shortage of manpower. The success of the preservation and utilization of germplasm lies in well trained and dedicated scientists. Today only Ethiopia, Kenya and SRGB have a full team of scientists solely involved in germplasm conservation and development. Sudan has a team but only for horticultural crops. Tanzania, Malawi, Swaziland, Botswana and Zambia have smaller teams for plant genetic resources. Despite the opportunities offered by IBPGR and other institutions, only 98 researchers and technicians have been trained in this region. Many of them are no longer involved in plant genetic resources activities.

- The lack of proper budget. Although many countries in the region have recognized the importance of conservation activities, very few have made provision in their budget for such activities. This is one of the main reasons why trained manpower can not stay in this field, there is no recognition in the system of their usefulness.

- The lack of adequate facilities.

- The lack of collaboration from other research programmes in the national system.

Considering that the risk of erosion today is higher than ever, that more resources are threatened with extinction and that there are more people to feed, these difficulties must be resolved.

- Important gaps in collections must be filled. Remote areas need to be explored. Many of our indigenous resources including wild and weedy species, so-called under-exploited species, fruit trees, medicinal plants, vegetable, etc. are still uncollected.

- The management of collections, seed drying and packaging in particular, needs to be drastically improved and more adequate conservation structures should be established. A few more long-term storage centres similar to PGRC/E and the National Genebank of Kenya must be established in the region in addition to the SADCC Regional Genebank (SRGB).

- Many collections must be rejuvenated and the conservation of clonally propagated crops should be rationalized and systematized. Research on tissue culture should be intensified.

- Evaluation and documentation work is still far behind the collecting and conservation activities. This situtation should change. All existing collections (old and newly constituted) should be systematically evaluated and well documented.

- Young breeders should be encouraged to utilize the indigenous resources.

- National universities should be more actively involved in germplasm development and training of competent personnel.

There is need for better organization at national level. The establishment and strengthening of national programmes with the necessary budget and infrastructure must be accelerated. In many countries of the region, more than one institution is involved in various aspects of germplasm conservation and development. To avoid duplication and waste of limited funds, a national committee for the co-ordination of crop genetic resources activities should also be constituted in all countries.

This committee should define priorities of action, stimulate technical assistance and ensure that the national agricultural research system, which is the main user of genetic diversity, closely assists the national conservation programme in evaluating and documenting the germplasm. The national coordinating committee could also seek financial assistance from the government and from any other internal or external sources.

However, no matter how well organized the national programmes are, it will be difficult for each country of the region to set up and maintain a modern genebank. The running of sophisticated conservation and testing laboratories in each country will neither be economical nor useful. This is where regional cooperation in most aspects of crop genetic conservation and utilization is very important. Base collection centres should be established in a few countries. They will conserve the resources at regional level whereas each country could hold an active collection. A regional committee constituted by representatives of national committees will set up priorities at regional level, stimulate exchange of germplasm, documentation and experience. Responsibilities of regional centres will be defined and will include regular training of conservation personnel. Crop committees should be established and collaborate at regional level.

Conclusion

Today developments in biotechnology are emphasizing the importance of genebanks. This is because scientists studying gene synthesis and the recombining of DNA require naturally occurring genes to serve as models and working material. Germplasm collections need to be much more extensively evaluated and documented and given the enormous benefit that can be derived from plant breeding programmes, conservation facilities are clearly a sound investment deserving the support of governments, universities and even the private sector (Plucknet *et al.*, 1983).

The key to successful preservation of the numerous valuable crop genetic resources of the region and one way to ensure crop improvement today and tomorrow, lies in our ability to organize and strengthen national programmes in order to maximize all possible technical and financial assistance.

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