Natural Resource perspectives

Number 7, March 1996

THE EROSION OF CROP GENETIC DIVERSITY: CHALLENGES, STRATEGIES AND UNCERTAINTIES

Robert Tripp and Wieneke van der Heide

Within the past decade the concept of biodiversity has passed from the domain of academic specialists to the widespread attention of the popular press. The general public and policy makers are increasingly aware of the scope and seriousness of the disappearance of the earths genetic heritage. Although much of the debate focuses on animals and wild plant species, there is growing recognition that the diversity of cultivated crop species has vastly diminished, affecting the livelihoods of resource-poor farmers and threatening the future of agricultural development. A number of proposals and policy initiatives are being discussed to address the problem, including preparations for a global plan of action for the conservation and use of plant genetic resources which will be presented at the 4th International Technical Conference on Plant Genetic Resources, to be held under FAO auspices in Leipzig in June 1996. This paper describes the challenges to crop genetic diversity, presents some of the strategies that are being implemented to reverse the erosion of that diversity, outlines several gaps in our knowledge that must be addressed in order to make such strategies more effective, and concludes with some policy implications.

Challenges to Crop Genetic Diversity

Farmers have traditionally depended upon their own skills and resources to develop the crops that they need. The process began with the earliest domestication of wild species and has continued through the careful selection of plant materials adapted to varied (and often changing) growing conditions and preferences. The result has been a complex and continually evolving collection of local crop varieties, often referred to as landraces, that reflects interactions with wild species, adaptations to changing farming conditions, and responses to the economic and cultural factors that shape farmers priorities. (Box 1). The richness and range of the diversity of these landraces is now under threat because of the changing nature of agricultural production. One important factor is the widespread adoption of modern varieties (MVs) that are the products of formal plant breeding. These MVs often provide yield increases and other advantages that result in their being sown over large areas. Technological change, such as the use of fertiliser and irrigation, also lowers the demand for landraces adapted to marginal growing conditions. In addition, farm production is increasingly market- oriented, making farmers less inclined to select for crop characteristics that once were important for local customs and culture.

If the adoption and use of MVs and other agricultural technology brings significant benefits to farmers, why should we be concerned with the loss of landraces and the preservation of crop genetic diversity? There are several important reasons.

First, many advances of modern plant breeding have been possible because of the wide range of genetic source material provided by landraces. The very success of modern plant breeding now threatens the source of genetic diversity on which further progress depends, as farmers find it less rewarding to maintain the diverse mixture of landraces developed by their ancestors.

Second, the widespread use of MVs raises questions about the stability of crop production and the threat of disease or pest attack. The threat to stability does not necessarily derive from the MVs

Box 1: Plant Genetic Diversity in the Peruvian Andes

Farmers in the Andes of southern Peru depend on both potatoes and maize as basic staples. A study in the area of Paucartambo illustrates the complexity of genetic diversity maintenance for these crops and provides examples of the criteria that farmers use to select their varieties. Potatoes are the most important crop in the region. Local potato varieties are classified first by use category , divided among those appropriate for boiling, soup-making or freeze drying. Further subclassification is done on the basis of morphological differences, and nomenclature reflects a rich cultural symbolism. Most farmers manage between 3 and 6 separate potato fields in which a mixture of varieties of a single use category are planted together. Women are in charge of selecting planting material; for any one field, they specifically select only a few of the most important varieties and then make a representative selection of the remaining material to provide the desired diversity. Observations in fields of boiling potatoes revealed a mean of 21.1 varieties, with a standard deviation of only 5.1, indicating a remarkable consistency in maintaining field diversity.

Maize is also classified by the farmers of Paucartambo into use categories, distinguishing among boiling and parching. In contrast to potatoes, subclassification of maize varieties is based more on specific choices for use, yield, and time of planting. Also in contrast to potatoes, maize varieties of different use types may be mixed in the same field. The average number of varieties per field is much lower than for potatoes (2.9), and the women who select the seed for planting make much more precise choices themselves. MVs are more uniform than landraces, which may increase their susceptibility to pests or pathogens, but many MVs owe their acceptance to the fact that they are more resistant than the varieties they replace. The principal threat to yield stability from MV use is the increasing uniformity, and continuous cropping, that their use engenders. Large areas planted to a single variety are potentially a cause of concern, no matter what the source of the variety.

In addition, the preservation and utilisation of crop genetic diversity is of particular importance to the more marginal, diverse agricultural environments where modern plant breeding has had much less success. Farmers in these areas tend to be poorly served by public research and extension systems. These areas are often centres of diversity for many crop species, but increasing poverty is forcing many of these farmers to place more dependence on non-farm sources of income, with consequent reduction in their capacity to grow and maintain the range of local varieties they have been accustomed to manage.

Finally, the maintenance of a wide and evolving range of local crop landraces is threatened by the advent of intellectual property protection for crop varieties, accelerated by the formation of the World Trade Organization. The increasing application of plant breeders rights has several implications for plant genetic diversity. For a new variety to be legally protected, it must be subject to very precise description, including the requirement that it be distinct, uniform and stable (DUS). This is a disincentive to the promotion of intrinsically diverse landraces or of varietal mixtures. An additional debate concerns farmers privilege , the ability of farmers to save seed of a variety, to exchange it with neighbours, and to adapt it to their own growing conditions. These practices could be challenged by seed companies when crop varieties are sold under strict legal protection. It is even possible to envisage situations where varieties that originated in farmers fields may be legally protected and then denied to the farmers responsible for having developed them. Hence the advent of plant variety protection lends added urgency to the search for solutions to the conservation of plant genetic diversity. (Box 2).

Innovations and Initiatives

There are several important strategies that address the conservation of plant genetic diversity.

Genebanks

The conventional solution to the conservation of plant germplasm has been through genebanks. These are based on collections of genetic material, from centres of crop origin and elsewhere, that are stored in controlled conditions and periodically regenerated. Genebanks have been important sources of material for plant breeding programmes and other research activities, and will continue to be a basic element in conservation programmes.

Genebanks are not without their problems, however. Although some of the larger genebanks contain impressive numbers of accessions, the costs of characterising and cataloguing genebank material are considerable. Only a small proportion of genebank material is actually used by plant breeders, in part because of inadequate

Box 2: The Intellectual Property Rights Debate: The Crucible Group

The Crucible Group is a collection of 28 individuals including representatives of grassroots organisations, agricultural researchers, intellectual property specialists, trade negotiators and agricultural policy analysts from South and North which met to discuss the issue of the intellectual property protection of plant genetic resources. Not surprisingly, the group s discussions produced varied points of view, but also developed a consensus on a number of important issues. Some of the group s conclusions include:

- The Crucible Group stresses the primacy of specific national conservation strategies for plant genetic resources that invite the participation of local communities as well as private companies. Holders of ex situ germplasm collections should develop equitable partnerships with indigenous and rural societies and make their collections available to them.
- Under the pressure of possible exclusion from an encompassing global trade agreement, many countries feel pressed to adopt some form of intellectual property protection for plant varieties. The Crucible Group concurs that compulsion is inappropriate and that countries, have every right to protect their environment and the well-being of their peoples if they feel that trade rules threaten their security.

With respect to the status

characterisation of accessions. In addition, farmers usually do not have easy access to the materials they have donated. The control of genebanks is also an issue of debate; there are concerns that a country that hosts an important international collection can deny another country access for political reasons.

These issues of control are beginning to hamper efforts at germplasm collection, as countries are increasingly concerned with the possibility that their local landraces may be collected, utilised commercially, and even legally protected, without any compensation. More resources are needed to support national plant genetic conservation efforts, and more attention needs to be devoted to making these collections relevant to farmers interests and capacities. In some cases, national genebanks are being redirected to encourage more farmer participation in their development and utilisation (Box 3).

In situ conservation

An option that is attracting increasing attention is the possibility of carrying out genetic resource maintenance in the field. This is often referred to as in situ conservation , in contrast to the ex situ alternative of genebanks. Arguments in support of in situ conservation include the importance of recognising the roles of both environmental factors and farmer intervention in landrace development. In areas of high crop genetic diversity, landraces often evolve through crossing with wild or weedy relatives, and farmers play a crucial role in selecting and adapting new material. It is this process of landrace development that in situ conservation attempts to enhance and preserve. It is also argued that in situ conservation programmes would provide more opportunities for community conservation, where farmers would be better able to recognise and utilise the plant genetic resources that are available in the community.

But there are several decisions that must be made in designing in situ conservation projects. First, because landraces are not static entities, decisions have to be taken with regard to the nature of human intervention in the selection process. Whose criteria are to be used in the selection and adaptation of new materials? Are local farmers criteria the only ones to be applied in deciding what is conserved, or should scientists interests also play a role in determining the direction of conservation?

In addition, farmers generally seek germplasm from other sources to complement their own landraces. To what extent should this be allowed or encouraged in an in situ conservation project? To what extent is the objective to build a fence around an area of genetic diversity in order to protect traditional crop development processes from outside influences, and to what extent is the objective closer to that of community development? In the latter instance, resources and information are provided to farming communities to empower them to make more informed decisions about the management of local varieties and the utilisation of MVs.

In situ conservation projects will undoubtedly approach these decisions in a variety of ways. At this stage it is important to encourage a range of in situ programmes and to learn from experience. The International Plant Genetic Resources Institute (IPGRI) in Rome is currently developing a large multi-country collaborative project to test and develop techniques for in situ germplasm conservation.

Farmer-participatory plant breeding

There are also a number of efforts under way to encourage a wider scope for farmer participation in formal plant breeding. Possibilities include greater farmer representation in priority setting for crop breeding programmes, more explicit attention to the crops and varietal characteristics of importance to these farmers, the transfer of significant aspects of plant breeding research to farmers fields, and the enlistment and training of farmers to take a more active part in the variety testing and selection process.

There is a growing literature on methods to encourage farmer participation. The innovations include rapid rural appraisal techniques to understand farmer varietal preferences, the organisation of various types of adaptive on-farm research to test varieties under farmers conditions, the wider use of landraces in formal breeding programmes, and the establishment of mechanisms for contact between farmers and experiment station personnel. Some plant breeders see the possibility of an integrated system that incorporates the strengths of both formal and informal plant breeding techniques (Box 4).

Box 3: Farmer Participation in Gene Banks in Ethiopia

The Plant Genetic Resources Centre/Ethiopia (PGRC/E) is involved in several activities that involve farmer participation in conservation activities.

The Unitarian Service Committee of Canada helps support a PGRC/E project in which materials collected from nearby areas are given to farmers to plant and to carry out simple mass selection to improve their characteristics. Farmers select plant types on the basis of characteristics important to them, including pest or disease resistance or maturity. Farmers receive assistance from plant breeders in this activity, and PGRC/E scientists establish standard descriptor lists for the materials. Farmers evaluate their selections in experimental plots and compare performance and yields with the original seed stock. The plots are also used for on-site maintenance of landraces. In another project, the PGRC/E is collaborating with Debre Zeit Research Centre to maintain indigenous material of tetraploid wheat. Wheat germplasm collected by PGRC/E is tested and multiplied by breeders and then provided to farmers for further multiplication and selection. This allows farmers to experiment with landrace lines while the indigenous populations are maintained in the genebank.

Source: Worede, M. and Mekbib, H. (1993) Linking Genetic Resource Conservation to Farmers in Ethiopia. in de Boef, W., Amanor, K., Wellard, K. with Bebbington, A. (eds), Cultivating Knowledge. London: Intermediate Technology Publications.

Knowledge Gaps

Although there is undeniable evidence of the erosion of crop genetic diversity, and several innovative responses have been developed, there are important gaps in knowledge that limit our capacity to decide among the various alternatives. Some of these gaps involve our technical understanding of the nature of biodiversity, while others are concerned with our understanding of its socio-economic correlates.

Appropriate measures for diversity still need to be developed in order to better characterise the current situation and to evaluate changes in the future. Farmers crop variety classification systems are one place to start, but we do not know how these correspond to actual genetic differences. With few exceptions, there is little research that correlates the variation in folk taxonomy with genetic differences. The capacity to evaluate genetic material in the laboratory is growing rapidly, but these are still expensive techniques, and more robust markers and measures are required to follow the progress of genetic resource conservation.

When better measures of genetic diversity are devised they will contribute to a clearer understanding of what exactly needs to be conserved. Currently, there are only very general ideas about what portion of a plant population needs to be maintained in order to conserve particular genetic traits. This information is crucial to the efficient design of in situ conservation projects, for instance, in order to know if efforts might be limited to a fewfarmers fields, or should instead sample more widely from an agroecosystem.

More study is also required to understand the causes of plant genetic erosion. In some cases, the introduction of MVs has led to the replacement of large numbers of local varieties. On the other hand, several studies of varietal adoption in centres of crop diversity have shown that MVs often complement, rather than replace, local varieties. The availability of inputs and crop management techniques that reduce the need to tailor varieties to difficult growing conditions has also contributed to the demise of many local varieties. The cultural value placed on crop diversity and local selection techniques is also diminishing in many areas, and the skills that have contributed to landrace evolution are consequently disappearing.

As farmer variety selection skill is a threatened resource, there is also a need to understand how to conserve and enhance it. Although farmers deserve credit for landrace development, there is little knowledge of what the genetic consequences of their selection techniques are, or what specific effects these have on enhancing diversity. Farmers select materials for practical reasons that may not always be compatible with the maintenance of genetic diversity. Very little interdisciplinary study has been devoted to understanding the biological outcome of the application of indigenous technical knowledge and skills in variety selection.

There is also little understanding of whether attempts to improve local selection capacity should focus on individual farmers or on communities. Indeed we know very little about how varieties, and information about them, are exchanged within communities.

Policy Implications

The challenges of crop genetic resource conservation highlight once again the dilemma of balancing between development and conservation. The development contribution of modern plant breeding weakens diversity by replacing many local varieties, and thus threatens the possibilities of further progress. Areas of high genetic diversity, on the other hand, are often distinguished by their poverty and the declining viability of their agriculture, and are desperately in need of innovation and change. The dilemma is evident in choices of conservation strategies as well as in the design of development programmes. The identification of an optimum mix of development and conservation initiatives is one of the most difficult tasks to face policy makers in the next decade, and the necessity to develop location-specific strategies adds to the complexity of the challenge. Much more effort is required to develop adequate analytical tools to enable policy makers to explicitly address the trade-offs and consequences of particular decisions.

Box 4: The Integration of Farmer and Formal Plant Breeding
It should be possible to strengthen farmer breeding efforts by linking them to elements of the formal system. If the tools and methods of formal plant breeding were made available to traditional systems, an integrated plant breeding model could be the result. The capabilities of farmer and formal plant breeding systems are illustrated below.

Technology elements	Farmer Breeding	Formal Breeding
Taxonomy knowledge In situ conservation Ex situ conservation Acquisition of new germplasm Interspecific introgression	Folk taxonomy Yes Some community seed banks Neighbour exchange, other informal seed flow Limited to species that cross naturally	Scientific taxonomy Virtually none Gene banks for short- and long-term storage Worldwide acquisition of germplasm Expanded by special

Introgression of weed races Gene technology Screening and evaluation of germplasm	Common No For local, not wide adaptation	techniques Sometimes used Yes For wide, not local adaptation

Source: Berg, T., Bjoernstad, A., Fowler, C. and Kroeppa, T. (1991) Technology Options and the Gene Struggle. NORAGRIC Occasional Papers Series C.; Development and Environment No. 8. As: Agricultural University of Norway.

The choice of appropriate plant genetic resource conservation strategies also requires clear policy decisions about the appropriate mix of public, commercial and voluntary contributions to variety development and seed distribution. Commercial seed enterprises are now replacing many public or parastatal seed operations, and are also making an increasing contribution to plant breeding and variety development. In many instances, seed companies will be able to respond more effectively to farmers needs than the public sector. But the commercial sector will not be likely to address many of the minor crops or special growing conditions that are important to resource-poor farmers, nor will they be likely to play a prominent role in conservation activities. Adequate legal protection for commercial varieties should be balanced against the assurance of farmers privilege to save and adapt their own seed. Too much current seed policy advice focuses on the negative experience of public sector seed production and ignores the new set of responsibilities that public seed policy and public research will have to assume in order to assure more equitable agricultural development.

As is clear from the discussion on in situ conservation and new approaches to plant breeding, plant genetic resource conservation will increasingly involve farmer participation. This will require innovative interaction among public sector and voluntary or community organisations. Policy makers need to devote more attention to fostering long-term, productive collaboration between public agricultural research and organisations active at the community level.

A particularly challenging feature of conservation programmes is their necessarily long-term nature. Both national policy makers and external donors who wish to support conservation programmes must assure that funding is available for an extended period to include the necessary research, training, and implementation. Piecemeal efforts at genetic resource conservation that do not feature a long-term commitment will accomplish little. This puts a premium on careful planning and coordination among participating agencies, and implies a significant re-orientation to the way that donor funding for agricultural development is currently managed.

Finally, good policy always depends on good information, and this is particularly true for genetic resource conservation. Despite rapid progress, serious gaps in our knowledge are likely to constrain the informed management of plant genetic diversity for at least the next decade. The issues demand interdisciplinary collaboration among social and biological scientists. They also require increasing collaboration between researchers and the members of grassroots development initiatives. Policy must direct national research and academic institutions to give priority to collaborative research on conservation issues, and should take responsibility for establishing appropriate fora where different perspectives can be presented, debated, and synthesised.

ISSN: 1356-9228

Papers in this series can be accessed on ODI s World-Wide Web pages on the Internet at: http://www.oneworld.org/odi/

Design: Peter Gee
Administrative Editor: Alison Saxby
Series Editor: John Farrington

Overseas Development Institute, Portland House, Stag Place, London SW1E 5DP, UK
Telephone +44 (0)171 393 1600 Fax +44 (0)171 393 1699 Email: agren@odi.org.uk

---

Overseas Development Institute Home Page
