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Plant Genetic Resources Newsletter

Bulletin de Ressources Phytogénétiques

Noticiario de Recursos Fitogenéticos

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Organisation des Nations Unies pour l'alimentation et l'agriculture et l'institut international des ressources phytogénétiques
Organización de las Naciones Unidas para la Agricultura y la Alimentación y el Instituto Internacional de Recursos Fitogenéticos

Plant Genetic Resources Newsletter

Aims and scope

The *Plant Genetic Resources Newsletter* publishes papers in English, French or Spanish, dealing with the genetic resources of useful plants, resulting from new work, historical study, review and criticism in genetic diversity, ethnobotanical and ecogeographical surveying, herbarium studies, collecting, characterization and evaluation, documentation, conservation, and genebank practice.

Management

The *Plant Genetic Resources Newsletter* is published under the joint auspices of the International Plant Genetic Resources Institute (IPGRI) and the Plant Production and Protection Division of the Food and Agriculture Organization of the United Nations (FAO).

Availability

The *Plant Genetic Resources Newsletter* appears as one volume per year, made up of four issues, published in March, June, September and December. *Plant Genetic Resources Newsletter* is available free of charge to interested libraries of genebanks, university and government departments, research institutions, etc. The periodical may also be made available to individuals who can show that they have a need for a personal copy of the publication.

Types of paper

Articles

An article will publish the results of new and original work that makes a significant contribution to the knowledge of the subject area that the article deals with. Articles, which should be of a reasonable length, will be considered by the Editorial Committee for scope and suitability, then assessed by an expert referee for scientific content and validity.

Short communications

A short communication will report results, in an abbreviated form, of work of interest to the plant genetic resources community. Short communications in particular will contain accounts of germplasm acquisition missions.

Other papers

The *Plant Genetic Resources Newsletter* will publish other forms of reports such as discussion papers, critical reviews, and papers discussing current issues within plant genetic resources.

Book reviews will be printed, as well as a News and Notes section. Suggestions for books to review are invited, as are contributions to News and Notes.

Submission

In the first instance papers may be submitted in typescript form or as an Email message. The final version may be submitted as an Email file or as an MS-DOS-readable file on diskette.

Editorial office

Manuscripts submitted for publication and other communications on editorial matters should be addressed to:

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Cover: A wild pineapple (*Ananas* spp.) plant, locally called 'ananas marron' found on a nature reserve in Mauritius (Photo: A.B. Damania).

Bulletin des ressources phytogénétiques

Domaine d'intérêt
Le *Bulletin des ressources phytogénétiques* publie des articles en anglais, en espagnol et en français, sur les ressources génétiques de plantes utiles, fruit de nouvelles recherches, d'études historiques, d'examens et de critiques concernant la diversité génétique, d'études ethnobotaniques et écogéographiques, d'études d'herbiers, d'activités de collecte, de caractérisation et d'évaluation, de documentation, de conservation et les pratiques des banques de gènes.

Parrainage
Le *Bulletin des ressources phytogénétiques* est publié sous les auspices de l'Institut international des ressources phytogénétiques (IPGRI) et de la Division de la production végétale et de la protection des plantes de l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO)

Distribution
Le *Bulletin des ressources phytogénétiques* paraît une fois par an en un volume regroupant quatre numéros publiés en mars, juin, septembre et décembre. Il est distribué gratuitement aux bibliothèques des banques de gènes, universités, services gouvernementaux, institutw de recherche, etc. s'intéressant aux ressources phytogénétiques. Il est aussi envoyé sur demande à tous ceux pouvant démontrer qu'ils ont besoin d'un exemplaire personnel de cette publication.

Types de documents publiés

Articles
Un article contient les résultats de travaux nouveaux et originaux qui apportent une contribution importante à la connaissance du sujet dont traite l'article. Les articles, qui doivent être d'une longueur raisonnable, sont d'abord examinés par le Comité de rédaction qui en évalue la portée et la validité, puis par un expert qui en examine le contenu et l'intérêt scientifiques.

Brèves communications
On entend par brève communication un texte contenant, sous une forme abrégée, les résultats de travaux présentant un intérêt pour tous ceux qui s'occupent de ressources phytogénétiques. Elle contient en particulier des comptes rendus des missions d'acquisition de matériel génétique.

Autres documents
Le *Bulletin des ressources phytogénétiques* publie d'autres types de rapport tels que dew documents de synthèse, des études critiques et des articles commentant des problèmes actuels concernant les ressources phytogénétiques.

Le Bulletin publie une revue de livres ainsi qu'une section intitulée Nouvelles et Notes. Les auteurs sont invités à envoyer leurs suggestions pour les livres à passer en revue ainsi que des contributions aux Nouvelles et Notes.

Présentation
En premier lieu, les documents doivent être soumis dactylographiés ou par courrier électronique. La version définitive doit être présentée en fichier de courrier électronique ou sur disquettes compatibles MS-DOS.

Rédaction
Prière d'adresser les manuscrits présentés pour être publiés et d'autres communications sur des questions de rédaction à:

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Couverture: Un plant d'ananas (*Ananas* spp.), appelé localement 'ananas marron', que l'on trouve dans une réserve naturelle à Maurice (Photo: A.B. Damania).

Noticiario de Recursos Fitogenéticos

Objetivos y temas

El *Noticiario de Recursos Fitogenéticos* publica documentos en inglés, francés y español que tratan de los recursos genéticos de plantas útiles, fruto de nuevos trabajos, estudios históricos, revisiones y análisis críticos relacionados con la diversidad genética, investigaciones etnobotánicas y ecogeográficas, estudios de herbarios, actividades de colección, caracterización y evaluación, documentación, conservación, y prácticas en bancos de germoplasma.

Dirección

El *Noticiario de Recursos Fitogenéticos* se publica bajo los auspicios conjuntos del Instituto Internacional de Recursos Fitogenéticos y la Dirección de Producción y Protección Vegetal de la Organización de las Naciones Unidas para la Agricultura y la Alimentación.

Distribución

El *Noticiario de Recursos Fitogenéticos* aparece como un volumen anual compuesto por cuatro números, que se publican en marzo, junio, septiembre y diciembre. Se distribuye gratuitamente a las bibliotecas de bancos de germoplasma, facultades universitarias y servicios gubernamentales, centros de investigación, etc. que se interesan en los recursos fitogenéticos. También pueden obtener este noticiario las personas que demuestren necesitar una copia personal.

Tipos de documentos

Artículos

Los artículos divulgarán los resultados de trabajos nuevos y originales que contribuyan de modo importante al conocimiento del tema tratado. Dichos artículos, que deberán tener una longitud razonable, serán examinados por el Comité de Redacción en cuanto a su pertinencia e idoneidad y posteriormente un experto juzgará su contenido y validez científicos.

Comunicaciones breves

Las comunicaciones breves informarán de modo conciso sobre los resultados de trabajos de interés para las personas que se ocupan de los recursos fitogenéticos. Las comunicaciones breves incluirán, en particular, resúmenes sobre las misiones de adquisición de germoplasma.

Otros documentos

El *Noticiario de Recursos Fitogenéticos* publicará otros tipos de informes, como documentos de trabajo, análisis críticos, y documentos que examinen cuestiones de actualidad relacionadas con los recursos fitogenéticos.

El Noticiario publicará una reseña de libros así como una sección de Noticias y Notas. Las propuestas de libros para reseñar y las contribuciones a la sección de Noticias y Notas serán bien acogidas.

Presentación

Los documentos deben entregarse, incialmente, en forma de texto mecanografiado o a través del correo electrónico. La versión final debe presentarse como un archivo de correo electrónico o en disquete compatible con el sistema operativo MS-DOS.

Oficina de redacción

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Portada: Planta de piña silvestre (*Ananas* spp.), llamada localmente 'ananas marron', que se encuentra en una reserva natural en Mauricio (Foto: A.B. Damania).

Plant Genetic Resources Newsletter, 1996, No. 107: 1-18

REVIEW
Biodiversity conservation: a review of options complementary to standard *ex situ* methods

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Summary
Ex situ conservation is conservation outside the natural habitat, usually as seeds in genebanks at subzero temperatures. Although *ex situ* methods, such as genebanks and botanical gardens, have contributed to the improvement of certain plants and major food crops through utilization of preserved germplasm, they do not provide a panacea for conserving naturally occurring genetic resources and protecting the habitat in the face of changing environmental conditions. Hence *in situ* methods remain the single most effective means of conserving diversity together with the dynamic environment. These methods apply to crops cultivated on relatively small holdings of subsistence farming in tropical countries and other developing economies. To overcome the limitations of *ex situ* collections, conserving populations of crop wild relatives in their natural habitat is important for the long-term benefit of national programmes and the international community as a whole. Selected examples of *in situ* conservation efforts around the world have been described, e.g. special projects for preserving wild progenitors of crop plants, home gardens, botanical gardens, nature reserves, seed savers programmes, field genebanks, etc. However, there should not be total reliance on *in situ* methods to safeguard our precious genetic resources. *In situ* methods should be provided with back-up from *ex situ* collections as a sort of insurance policy against total loss or extinction. This review attempts to assess some of the alternatives to standard *ex situ* conservation and mentions examples and successes of *in situ* conservation, which not only preserve diversity but also help to keep the earth 'green', acting as a buffer against indiscriminate urbanization and habitat destruction.

Introduction
National and international efforts to collect and conserve crop plant genetic resources during the last four decades have resulted in a very large number of germplasm accessions of cultivated, obsolete/primitive, and wild forms of crop plants being stored *ex situ* at various genetic resources conservation centres around the world. *Ex situ* conservation implies conservation of germplasm outside the natural habitat of the plant concerned. In crops, this is in the form of samples of seeds stored at subzero temperatures in airtight containers, tissue cultures in glass vials, or complete plants in field genebanks where seeds are recalcitrant or cannot be dried and frozen for storing in a genebank, e.g. rubber (*Hevea* spp.) and coconut (*Cocos nucifera*). At present, almost all public funding is directed toward maintaining germplasm *ex situ* at great expense although there is room for cost-saving by reducing duplication of accessions in genebanks. For example, a large proportion of the durum wheat collection of the United States Department of Agriculture (USDA), Aberdeen, Idaho, and the Germplasm Institute, Bari, Italy, is duplicated at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria and the International Maize and Wheat Improvement Center (CIMMYT), Mexico.

In situ conservation, on the other hand, is thm continuing maintenance of a plant population within the ecological community of which it forms a part as well as in the environment to which it is adapted. It is usually applied to wild progenitors of crop plants, forest trees and wild fauna. But it can also include conservation of existing landraces of crops as well as the artificial regeneration of folk varieties or obsolete cultivars, whenever planting is carried out without conscious selection in the same area where the seed was developed by a particular farming community. Thus, *in situ* conservation provides a broad genetic base, maintenance of population structures, stability of population numbers, and opportunities for future adaptive expansion (Chang 1994). However, relatively little international funding has been set aside to encourage this to happen, perhaps because centres of diversity are located in remote areas far from the traditional donor countries, or perhaps since over 75% of the world's *ex situ* genetic resources are under direct or indirect control of the donor countries, they assume that they have enough genetic material for any forseeable future needs.

Threats to destruction of biodiversity in general stem from the very high rate of growth of human population, especially during the latter half of this century. This phenomenon in developing countries has led to over-exploitation of the biotic and physical environment, habitat fragmentation and subsequent loss, pollution, microclimate change, large-scale but unsustainable agriculture and forestry projects (Bajaj and Williams 1995). The depletion of crop plant genetic resources, in particular, in their centres of diversity can be associated with the spread of modern agricultural practices which gained ground mainly after

the Second World War. These include the adoption of agronomically improved, higher yielding, genetically uniform varieties requiring greater fertilizer and other inputs over large areas. This has resulted in the abandonment of the locally adapted, genetically variable, but relatively lower yielding indigenous varieties grown by subsistence farmers in developing countries (Damania and Srivastava 1990). International Agricultural Research Centres (IARCs), supported by private and public funds, encouraged farmers to adopt improved varieties with superior yields under optimal conditions and put aside their own landraces. This has worked well in some cases such as the Sudan and Syria which have become self-sufficient in wheat production for the first time in decades.

However, farmers in some developing countries have allowed themselves to become so dependent on external solutions of their essentially local problems that they have lost confidence in their own ability to help themselves (Fernandez 1994). They see modern, imported, high-tech, or institutionally promoted techniques as superior to their own or those passed on to them by their ancestors. This erroneous perception has, unfortunately, created a communication gap between the youth and the elders in the farming communities which affects the flow of indigenous knowledge related to biodiversity and its utilization in farming systems. However, agricultural crop diversity cannot be preserved *in situ* without simultaneously encouraging the traditional culture of the farm community which fostered it and protecting its rights. There is a need to recognize the equity of developing countries and the rights of their farmers who have nurtured and unselfishly provided to collectors the crop genetic resources, especially the landraces, which make up the bulk of most major *ex situ* collections today.

In situ conservation

Wild populations of crops and their close relatives are found in two broad categories of *in situ* reserves: those designated to maintain optimum conditions and those that permit extraction and even clearing of land for other purposes. National parks, nature reserves and specialized field genebanks fall into the first category, whereas national forests, indigenous peoples' reserves and extractive reserves which permit a range of economic activities, such as harvesting of forest products, fall into the second category (Smith *et al.* 1992). A third category is the possibility of offering incentives to local farmers to act as custodians of traditional varieties and selections nurtured in their fields and backyards (Altieri and Merrick 1987).

In the past, *in situ* conservation was always referred to in the context of wild progenitors and forest species and this form of conservation with respect to the folk varieties or obsolete landraces was largely ignored. Hawkes (1991) has suggested some basic requirements for establishing *in situ* reserves of crop plant wild relatives, and Jana (1993) has touched upon some of the difficulties, constraints, merits and rewards of *in situ* conservation methods. However, a scientific understanding of biodiversity is essential to determine which parts of it should be conserved and how this could be managed. Since natural ecosystems are highly dynamic, a full understanding of biodiversity and conservation of all its components at short notice is an unrealistic goal and hence there is a need to safeguard the entire natural ecosystem for now. Later, as the components become apparent, these can be selectively conserved, making optimum use of available resources.

Several arguments (Brush 1995; Maxted *et al.* 1996) have been put forward supporting *in situ* conservation of landraces and varieties of crop plants since it permits evolutionary processes to continue, as well as assures equitable participation in the long-term benefits of such conservation to accrue to the local people, including farmers. The conservation of crop plant genetic resources and the promotion of biodiversity in their natural habitats is a matter of course among farmers with diversified cropping methods, and different cultural and agricultural practices. The cultural integrity of indigenous people and the conservation of crop genetic resources are inescapably linked (Smith *et al.* 1992).

A high proportion of extant alleles of the major crop plants have been conserved *ex situ*, with the evolutionary processes literally frozen in time, such that new germplasm is not generated. Qualset *et al.* (1996) observed that *ex situ* conservation may have conserved this part of the existing diversity, but it has basically curtailed such adaptation changes as may occur in the usual crop husbandry practices such as changes in biotic and abiotic stress factors. Space and high operating costs will, in the future, limit expansion of *ex situ* genebanks for tropical crops in developing countries.

To overcome limitations and constraints of the *ex situ* collections it is important to protect wild relatives of crops and preserve population samples of folk varieties and landraces in their natural habitat for the long-term benefit of the national programmes' breeding objectives and the international community as a whole (Qualset *et al.* 1996). The germplasm so protected and conserved will be adequate not only for fulfilling current research needs but can also adapt itself to fulfilling those for the future, such as responding to changed climatic conditions due to global warming (the so called 'greenhouse effect'), changing rainfall patterns, acid rain and habitat destruction (Davis 1989) as well as evolving in a manner which develops inbuilt tolerance to biotic stresses.

There is another beneficial spin-off in practising *in situ* conservation of economically important plants, which is the simultaneous conservation of other associated plant and animal life which comprise the ecosystem. Often, when biodiversity is threatened, thm loss of animal life is highlighted first because of its greater visibility and emotional appeal. For instance, the consequences of destruction of mangrove vegetation, due to cutting and industrial pollution, were first noticed by the indigenous fishermen ('kolis') along the coastline near Bombay, India, since their catch had alarmingly reduced. According to the researchers at

the Bombay Natural History Society (BNHS), several species of fish utilized the relative safety of the mangroves to spawn. Subsequently, the port authorities declared a moratorium on further destruction of the mangrove forest and have designated it as an *in situ* conservation area. This move by the Bombay Port Trust, called the Emerald Project, has not only saved the mangrove plant species but also assured that the nesting grounds of many migratory birds from central Asia remain intact. In fact, flamingoes (*Phoenicopterus ruseus*), which had not been seen in the area for the last 40 years, made their re-appearance on the reserve in the winter of 1994, giving the entire Emerald Project wide publicity in the media (Kehimkar 1995).

To fulfill their objectives, *in situ* conservation projects should be politically viable and share broad national development goals, such as increased farm income, besides straightforward conservation. Political viability depends on acceptance of the project by several interest groups other than genetic resources scientists and nature conservationists, i.e. farmers, consumers and government officials (Damania 1994a). The support for conservation of wild relatives of crop plants *in situ* can be difficult to gather, but the stakes for inaction can be high. Through the increase in food production after the beginning of the agricultural revolution the human species has incredibly multiplied its own numbers at the expense of the rest of the world's biota (Damania 1990). However, it is almost impossible to convince authorities in the gene-rich developing countries, struggling under the weight of socioeconomic problems and human population pressures, to set aside relatively large tracts of land for the sake of *in situ* conservation of as yet undefined economic future benefit.

When *in situ* conservation of crop landraces is envisaged, needs and demands of local farmers must be recognized and satisfied in concert with preservation endeavours and developed as an integral part of land-use management. Indeed, the farmers themselves must perceive a commercial advantage in continuing to grow traditional varieties, the conservation of which should be sustainable. However, human population pressures and the demand for increased food production will curb success of strict *in situ* conservation management practices when it is perceived that little or no economic benefits are forthcoming from these efforts (Cohen *et al.* 1991). Hence, it is important to identify where agricultural production and pricing policies are likely to act as disincentives to the continuing cultivation of landraces before implementing *in situ* conservation projects.

Established forms of resource use have long sustained people in fragile environments and, therefore, must be supported unless and until superior and sustainable resource uses are developed and proven in the field. At present, the successful efforts of spontaneous *in situ* conservation of landraces rest more or less on the competitive advantage, mostly in taste, over the improved, genetically uniform germplasm in certain farming systems, e.g. as observed in the case of the tomato (*Lycopersicon esculentum*) crop in Mauritius (Damania 1985) and sweet potatoes (*Ipomoea batatas*) in Indonesia (Widodo 1995).

In situ conservation, in contrast to *ex situ* conservation, not only preserves evolving diversity and protects the interests of the indigenous people but also helps to keep the earth 'green', acting as a buffer zone against indiscriminate urbanization, and discourages an increasing tendency toward consumerism. This review assesses complementary procedures to standard *ex situ* conservation, which has been the principal method of gene preservation until now. Diverse farming practices and some successes of *in situ* and other forms of conservation are discussed.

Conservation in home gardens

Home gardens have been sometimes described as 'living genebanks' where indigenous germplasm in the form of folk varieties or obsolete cultivars, landraces and rare species thrive side by side and are preserved. On their own home gardens provide, in several regions of the world, a considerable amount of species diversity but very little genetic diversity. This may be because most plants, especially perennials, are generally represented by only a few specimens and genotypes in each home garden. However, if we take into consideration a whole community of home gardeners then the resulting genetic diversity thus conserved can be high indeed.

Home gardens are productive not only in developing countries but also in industrialized nations of the West. For example, during the Second World War when imports were disrupted, 40% of the total vegetable production of the United States came from home gardens (Niñez 1986). However, there is much greater diversity of forms and species in a tropical home garden than in one located in the temperate zone.

The considerable potential of traditional agricultural systems as tools for *in situ* conservation has been recognized and reviewed by Maxted *et al.* (1996). For example, the traditional habitation sites of the indigenous people of West Java usually contain 80 to 125 useful plants. Of these plants, about 42% provide material for fuelwood, building houses and other implements, 18% are fruit trees, 14% are used as vegetables, and the remainder constitute medicinal plants, ornamentals, spices, condiments and other cash crops (Christanty *et al.* 1986). Subsistence farming based on Neolithic culture practised by indigenous people of the Mek group in isolated hamlets of the highlands of West New Guinea (Irian Jaya) has preserved diversity in vegetatively propagated crops such as sweet potatoes, taro (*Colocasia esculenta*), bananas (*Musa* spp.), sugarcane (*Saccharum officinarum* and *S. edule*) and some vegetables. *Pandanus* spp. and reed grass (*Eleocharis dulcis*) are two of some of the wild plants from which selections are made for utilization by the native people. This may lead to the eventual complete domestication of these plants (Plarre 1995).

Indigenous agroforestry is an integrated approach to land use that is characterized by the deliberate maintenance of trees and other woody perennials in fields and

pastures (Soemarwoto and Conway 1991). According to one estimate, agroforestry-based farming systems in the tropics typically comprise well over 100 plant species per site, the products of which are used for construction purposes, simple tools, firewood, medicine, livestock feed and human food (Altieri and Merrick 1987). Areas in the vicinity of the dwelling sites of Huastec Indians in Mexico, for instance, are known to contain 80 to 125 useful plant species, mostly of medicinal value.

Medicinal plants deserve special attention because not only are they of immense value in averting or treating common illnesses but their conservation also means retention of the indigenous knowledge associated with their unique properties and correct application. By raising awareness among local people of the value of indigenous medicinal plant biodiversity and by appropriate interventions for conservation and use, sustainable conservation of medicinal plant biodiversity can be achieved at the village level (Bajaj and Williams 1995). On the other hand, it has been suggested that projects aimed at gathering and documenting indigenous knowledge may result in the disempowerment of the local people as the latter might lose control over their plants of medicinal value and their marketable products (Fernandez 1994). However, if efforts are not made to preserve this knowledge immediately, the loss due to inaction may far outweigh any losses due to the feared disempowerment of the local people (Damania 1995).

A comprehensive account of the important role of home gardens in the Cuban economy and their use as *in situ* conservation sites has been given by Esquivel and Hammer (1992). These home gardens, which the Cubans call 'conucos', are modest-sized fields or relatively large gardens, where farmers practise traditional agriculture based principally on local cultivars which have their origins in almost all major Vavilovian centres of diversity. These cultivars were transported to Cuba during colonial times. Several tropical crops, such as mango, banana and sugarcane, which were introduced by Europeans to the Caribbean islands in the 16th century, have reached high economic importance today. Plants of African origin also play a major role in the home gardens of Cuba owing to the connection with that continent through the slave trade. Among others, medicinal plants are also perpetuated in the home gardens. Rural doctors, who freely prescribe them because of the scarcity of allopathic medicines in recent economically difficult times, actively promote their cultivation (Qualset *et al.* 1996).

Professor Miguel mota of the Estaçao Agronómico Nacional, Oeiras, Portugal, related a personal incident (Mota 1987). One day, while he was tidying his library, he came across a small long-lost book belonging to his great grandfather who was a pharmacist by profession. The book, published in 1852, was titled *"Catalogus Plantarum Horti Botanici Medico-Cirurgieae Scholae Olisiponensis Anno MDCCCLII"* (or "Catalog of the Plants in the Botanical Garden of the Lisbon School of Medicine and Surgery"). The book mentions 1803 species of plants being grown in home gardens by pharmacists, among which were ones that have proved to be some of the most useful contributors to modern medicine.

Even to this day people grow a considerable number of aromatic and medicinal plants in their gardens in Portugal (Mota 1987) based on germplasm brought from all corners of the world by the early Portuguese seafarers and explorers, such as Vasco da Gama. For example, people still use leaves and other plant parts of *Rosmarinus officinalis* ('álecrim' in Portuguese) as well as several species of the genus *Lavandula* in wooden chests which house their finest clothes even though plenty of modern synthetic products are available as insect repellents. It is believed these plants not only protect the clothes from moths but also impart a sweet scent to them.

The use of herbs for medicine and homemade teas is still very popular in the urban areas of Portugal. For instance, the yellow pages of the Lisbon telephone directory list 71 'ervanárias' (herbalists or herbal cure shops) where one can buy remedies based on plant products for almost all ailments under the sun. Some of these plants are conserved *in situ* at the Arrábida mountain reserve near Lisbon.

The development of cooperative farms does not necessarily lead to genetic erosion of autochthonous cultivars. After the restructuring of the former USSR, an acute scarcity of fresh produce existed for a number of years. Individuals who had worked previously on cooperative farms took to home gardening, utilizing indigenously produced seeds and bartering the fruits and vegetables grown for other goods. This led to the spread of locally adapted cultivars in the Commonwealth of Independent States (CIS) and a resurgence in the development of community seedbanks. Produce from some of the folk varieties or obsolete cultivars of fruits and vegetables can, in numerous cases, only be found in home gardens.

In the relatively recent history of plant domestication, home gardens may have played a vital role as being the first step in bringing several wild species under cultivation, especially considering the number of wild and semiwild plant species that may be found in home gardens. From the view of crop diversification the role of home gardens as providers of appropriate conditions for change and new crop development can be very important.

Community-based plant conservation

Community-based conservation includes, at one extreme, buffer-zone protection of parks and reserves and, at the other, natural resources use and biodiversity conservation in rural areas. Community-based conservation shifts the focus from Centre-driven conservation activities to the people who bear the costs, i.e. conservation of biodiversity by, for and with the local community. The agenda of local communities usually is to regain control over natural resources and, through conservation practices, seek compensation for their use by outsiders, which improves their economic well-being. Community-based conservation and awareness is growing globally of its own accord despite

multiple obstacles. At this stage what is most needed is recognition of a neglected set of participants and the acknowledgement by more economically favoured urban dwellers of the rural landscape's significance in conservation of biodiversity. At stake is nothing less than the fate of the natural world and its resources (Western and Wright 1994), and hence of humankind itself.

It has been reported that certain Italian farming communities, using traditional agricultural practices, still grow *Triticum monococcum* (einkorn) and *T. dicoccum* (emmer), two obsolete forms of wheat known to be extensively grown during Roman times, but thought to have disappeared from the peninsula (Perrino and Hammer 1982). The glumes in the kernels of both species are persistent and are utilized to supplement the diet of swine as well as poultry. The high biomass of these ancient forms produces a considerable amount of straw which is used to provide roofing to the field huts. However, because of immigration by the younger generation to urban areas for better economic prospects, the Italian farmers were skeptical that their heirs would continue to grow these two relic crops. In the last decade or so *T. dicoccum* cultivation in Italy has become financially profitable because it was publicized that the consumption of flour milled from 'farro' (dicoccum wheat) prevents colon cancer owing to its higher fibre content compared with other wheat flours. Some commercial interests, who are keen to keep its cultivation going because of market demand, are providing subsidies to farmers.

Indigenous farmers have been known to retain folk varieties and continue to grow them even when they experiment with and adopt some modern high-yielding varieties. The reasons for this practice given to plant collectors, who gather data from the farmer, are as diverse as the crops themselves. Some of the most often mentioned are: storage properties, cooking ease, nutritional and processing qualities, and historical and cultural reasons such as dietary diversity, the use of folk varieties in traditional foods or religious ceremonies and the filling of unique market niches (Cleveland *et al.* 1994). Thmre may be agronomic reasons as well, such as greater suitability to traditional intercropping systems, early or late maturity, or greater resistance to local biotic and abiotic stresses. Stability of yield in regions where seasons are unpredictable from year to year may also be a factor in farmers retaining their folk varieties in addition to planting improved germplasm. However, highly bred modern cultivars also have a role to play in developed sustainable farming systems. For example, a highly disease-resistant cultivar reduces the need for pesticide application which results in monetary savings and raises productivity. It is clear that the use of landraces for broad-acre planting would entail substantial yield losses to farmers relative to modern cultivars selected for productivity in specific agroecosystems (Frankel 1995).

Examples of maintenance of landraces by farmers who have also adopted high-input technology, including high-yielding cultivars, have been given by Brush (1995): potatoes (*Solanum* spp.) in the Andes of Peru, maize (*Zea mays*) in southern Mexico, and wheat (*Triticum* spp.) in western Turkey. These examples seem to suggest that on-farm conservation of landraces can be a viable proposition even though modern techniques are applied to boost yield in traditional farming practices.

Factors that promote *in situ* conservation in such farming communities are the fragmentation of land holdings, marginal agricultural conditions associated with hill lands and heterogeneous soils, economic isolation, cultural values and preference for diversity (Qualset *et al.* 1996). The author has also observed landrace cultivation persisting in small pockets in the areas of crop domestication and diversity despite superior introductions. Perhaps these areas generate diversity naturally after a few seasons even when planted with genetically uniform germplasm, as observed in the case of diversity for spike colour among introduced 6-row barley (*Hordeum vulgare*) being cultivated in certain remote provinces of Tibet (Damania 1994b).

In 1990, Soviet scientists took part in a collecting mission organized by ICARDA that retraced Vavilov's route in northeast Syria. At the town of Qamishli (very close to the border with Turkey) a farmer, who had switched over to ice-cream vending, had prominently displayed wheat spikes in a fan-shaped design inside his shop. The team, which included this author, curious to know the origin of the wheat, was informed by the ex-farmer that the spikes belonged to a durum wheat variety no longer grown by his family. The variety, in its heyday, was well known throughout the region for its flat-bread making qualities. The distribution of imported wheat flour subsidized by the Syrian Administration in the past and the recent automation of the flat-bread making process were some of the reasons mentioned for the obsolescence of the traditional varieties in the region, the bread basket of the country. Had some incentives been given or had the valuable contribution that the variety could make to the wheat genepool been made known to the farmer, perhaps the heirloom variety would not have been lost without any attempts at conserving it on at least a small patch in a corner of the field or an experimental station. The farmer, in this case, was not coerced to give up farming but merely wanted to change his way of life from an essentially rural setting to an urban one. But in the final analysis even conservationists have to bow when confronted with economic realities, i.e. there may be more to gain in ice-cream vending than growing traditional varieties of wheat in remote parts of Syria.

The Andes is one of the main areas of domestication and diversification of some important crop plants. The central Andes is the centre of origin and primary centre of diversity for potato (*Solanum tuberosum*). The highland Andean farmers grow seven species and subspecies according to Hawkes (1979), evidence of a dynamic system of cultivation which could accommodate new varieties whenever available. Modern varieties of potatoes, with higher yields and larger tuber size, smooth skin, even shape and light-coloured flesh, were introduced in Peru in the

early 1950s and are now found in almost every village in the highlands (Brush 1992). Nevertheless, native farmers in the Tulumayo and Paucartambo valleys have created subsystems within their farms on which they produce local different types of potatoes. Indigenous varieties are appreciated for their culinary appeal and because they fetch higher market prices. The modern varieties are cultivated for their yield potential and resistance to biotic and abiotic stresses. Farmers in the Andes do not intend to replace their indigenous varieties entirely with exotic ones. In fact their general strategy has been to grow potatoes in a three-tier system: improved varieties are cultivated side by side with selections from the native varieties, which are sold in the market, and mixturew of native varieties are reserved for home consumption (Brush 1991).

It seems from the data from these two valleys in the Peruvian Andes that the farmers there have reached a point where even if they adopt more of the modern varieties, the diversity in the part of their fields devoted to mixtures of native varieties is unlikely to diminish, thus arresting further genetic erosion. This is a development which must be encouraged elsewhere in South America and in other such hot spots of diversity around the world. However, community ownership of the exploitable genetic resources must be maintained.

Almost three dozen races of maize (*Zea mays*) were described from Meso-America, which is its centre of origin, before the advent of the products of crop improvement programmes based primarily in Mexico gained ground. Nevertheless, local farmers still maintain their own races separately, each of which is adapted to their own particular micro-environment. Farmers who adopt improved germplasm obtain them from private seed companies which usually sell sterile hybrids, or they purchase seed on credit from cooperatives. In both cases a dramatic impact on the diversity of local varieties can be expected. But, as in the case of potatoes in the two valleys of Peru, the traditional maize farmers in the southern Mexican state of Chiapas are well aware of the desirability as well as the shortcomings of their native varieties (Qualset *et al.* 1996). However, they choose to maintain diversity in a mixture of seed management practices which allows the conservation of traditional varieties while deriving economic benefits from planting improved germplasm (Brush 1991).

In the Chaing Mai Valley in Thailand, rice (*Oryza sativa*) farmers have also demonstrated that adopting improved germplasm does not necessarily lead to the genetic erosion of the traditional varieties. As in the Peruvian Andes, the indigenous varieties have a special commercial value in addition to being a nutritious food source. Thai rice farmers, who are known to change varieties every 3 or 4 years, seem to select more varieties from the traditional genepool than from the introduced one (Qualset *et al.* 1996).

Research carried out among the Native Americans of the Hopi tribe in Arizona in the USA revealed that they primarily plant local varieties of field crops (Soleri and Cleveland 1993). The Hopi also plant mixtures of folk varieties which are known to produce greater yields in drought seasons. For example, tribesmen retain their blue maize folk varieties because they are adapted to drought and a short growing season and meet cultural requirements; blue maize seed and cobs are important in ritualistic ceremonies (Qualset *et al.* 1996).

The Great Rann (desert) of K}tch is located on the northwest coast of India, an area which forms the border with the neighbouring country, Pakistan. It is a vast expanse which forms a sanctuary for many species of animals and birds, some of them quite rare, who are fleeing the onslaught of rapid increase in human populations and the subsequent urban expansion accompanied by destruction of their habitat. Interestingly, in this unequal battle, nature may have found an ally in humankind itself, for the Vishnoi, a tribal people which occupy some of these parts, have conserved innumerable forms of indigenous crops, flora and fauna for centuries (Tiwari 1993).

The Vishnoi is basically a farming community, who grow mainly traditional folk varieties of cumin (*Cuminum cyminum*) and pearl millet (*Pennisetum typhoides*) among other crops. The cumin is sold for cash whereas the millet is used for food and feed. They also rear herds of the noted indigenous cattle breed called 'Sanchori' which are adapted to the harsh desert-like environment. The Vishnoi dwelling places are exclusively built of locally available material such as clay, cow dung, straw and plant material from dead trees. In 1730 AD the Vishnoi people non-violently resisted the cutting down of khezri (*Prosopis cinerarea*) trees in their domain. The Vishnoi view ownership of their land as collective and communal in contrast to individual titles favoured in market economies. The recent application of urban concepts of ownership to indigenous common systems, developed over centuries, could prove retrogressive to people such as the Vishnoi, hastening perhaps the process of alienation of their society and commercialization of its resources (Tiwari and Damania 1995).

In contrast, the Dani tribesmen of Baliem Valley in Indonesia protect their forests by promoting individual ownership of trees. Such trees are marked by grass bound together at its base, indicating that it is forbidden for people other than the owner to pick the fruits or cut the tree for wood (Wiriadinata 1995).

At the Fiddler's Green Farm located in the Capay Valley, north of Woodland in California, subscribers pay a fee in advance to share the farm produce of fresh organically grown old cultivars of vegetables such as bok choy, red chard, lettuce, kale, carrots, potatoes, tomatoes, etc., which are not usually found on the shelves of supermarket chains. The cultivars grown have enough variation to appeal to all tastes, e.g. 15 types of tomatoes are grown. The movement mutually benefits consumers who gain access to a diverse and fresh source of vegetables and small-farm owners who struggle to survive competition from large-scale commercial growers supplying a non-organically grown standard variety to supermarket chains.

The community-supported agricultural enterprises or subscription farms, described above, are on the increase (no doubt owing to their economic viability and

sustainability) in states like California where health-conscious supporters of an ecologically favourable lifestyle subsidize small-farm owners through payment at regular intervals and encourage them to grow diversity. This helps to preserve genetic resources even though they may be far from their centres of origin. Such incentives and concepts could be used in developing countries for promoting community-based conservation and ready markets found for the produce. Other incentives for locally based conservation have been discussed by Qualset *et al.* (1996).

Farmer community maintenance of folk varieties *in situ* depicted by these examples as part of the local farming systems may be difficult to sustain in the future. Hence, it would follow that for the conservation of this type of germplasm, safety-duplication using *ex situ* methods may be desirable. There has been little research done on indigenous seed supply networks or seed conservation at the local community level. As these communities become more assimilated into the mainstream of industrial society, traditional markets or indigenous germplasm exchange networks may lose their importance, making it less easy to find folk variety seeds, especially for the next generation of young people who wish to continue farming in the traditional manner (Qualset *et al.* 1996). In Ethiopia, the recent widespread famine and political unrest has had a devastating effect on indigenous germplasm because of crop failures, abandonment of fields with standing crops, and consumption of seed stocks meant for next season's plantings to placate hunger. When traditional systems of *in situ* conservation of folk varieties collapse, local *ex situ* conservation in community genebanks may be desirable. Thus, in some cases *ex situ* collections can also help in re-establishing indigenous cultivars which have been lost due to man-made or natural disasters.

Community-based conservation in combination with home gardens can be used as a seed resource for generating locally adapted materials and enhancement of landraces. These can also serve as germplasm repositories. Improved indigenous storage skills could be employed to ensure a sustainable supply of plant material to the *ex situ* genebank from time to time for supplementing its stocks.

Botanical gardens and field genebanks

Species that do not readily produce seed and those with recalcitrant seeds are best conserved in what are known as 'field genebanks' maintained by research stations and farmers (Qualset *et al.* 1996). These genebanks are usually located in designated areas of land within whose boundaries a collection of certain species of plants is assembled. Ideally, field genebanks should be located within the boundaries of the centres of diversity of the particular crop and close to the ongoing breeding effort. For instance, a very comprehensive field genebank of pomegranate (*Punica granatum*) with a collection of over 760 unique varieties exists at the Agricultural Research Station on the outskirts of the Iranian city of Yazd (Fig. 1). The pomegranate plant, a native of central Iran, has great significance for the Iranians as it is deeply embedded in their religious rituals, folklore, culture and pharmacopeia.

Fig. 1. A field genebank which conserves 760 varieties of pomegranate (*Punica granatum*) at Yazd Agricultural Research Station, Iran. A substantial number of accessions in this collection are unique (Photo: A.B. Damania).

Some field genebanks are included in botanical gardens, arboreta and plantations, where germplasm is maintained as a permanent living collection. Field genebanks are also established to maintain working collections of living plants for experimental and research purposes in addition to basic conservation. Some of the world's oldest botanical gardens were created in Europe during the 16th century and offer a key component to biodiversity conservation of non-crop plants (Du Puy and Jackson 1995). Europeans later went on to establish botanic gardens in their colonies, many of which still survive, despite lack of solid funding.

Botanical gardens have also played a key role in the spread of crop plants far from their areas of origin. A single coffee (*Coffea* spp.) plant shipped by Dutch plant explorers to Amsterdam from the East Indies in 1706 was nurtured in the botanical garden of that city (Jacob 1935). Some of the seedlings from this single plant migrated via France to the Caribbean island of Martinique and from there to South America around 1730. A few plants were collected by the French from Yemen (coffee originated in Arabia) and transported to the Indian Ocean Island of Réunion in 1717. From here they were transported to the Caribbean and subsequently introduced to South America. The French, during colonial times, also introduced coffee to Ceylon (now Sri Lanka) where some of the clones are still preserved at the botanic gardens, Hakgala (Fig. 2). In 1869 the coffee rust, *Hemileia vastatrix*, invaded Ceylon (Jacob 1935). The Ceylonese coffee plants had very little resistance owing to their narrow genetic base, and the losses were so devastating that the industry could not recover. The expatriate coffee plantation owners soon turned to growing tea (*Camellia sinensis*) instead. Latin America remained free of this disease until 1970 when it suddenly made its appearance in southern Brazil. Recently, resistant hybrids have been obtained by crossing cultivated coffee, *Coffea arabica* with *C. robusta* (syn. *C. canephora*), a semi-wild form still to be found in the jungles of Uganda and conserved on a nature reserve in Mauritius (Fig. 3).

Fig. 2. The Botanic Gardens at Hakgala, Sri Lanka (formerly Ceylon) where some of the original coffee clones brought by the French are preserved (Photo: A.B. Damania).

Fig. 3. *Coffea robusta* (syn. *C. canephora*), a semi-wild form with useful genes for disease resistance conserved on a nature reserve in Mauritius (Photo: A.B. Damania).

Established in 1936, the California Native Plant Collection (CNPC) at the University Arboretum at University of California at Davis (UC Davis) comprises 336 plant species and 38 named cultivars conserved in an attractive landscape. Nineteen species are listed as rare and endangered and 13 as rare but not endangered. The plants native to California at the site on the banks of the Putah Creek include the following genera: *Acer, Distichlis, Elymus, Fraximus, Juglans, Marah, Nicotiana, Equisetum, Platanus, Populus, Quercus, Rubus, Salix, Sambucus* and *Rosa*. Of particular significance are the site's valley oaks (*Quercus lobata*) which are a commanding element of the campus landscape. The collections of the University Arboretum serve as a vast outdoor living laboratory for the faculty, researchers and students at UC Davis and other colleges in the vicinity.

The collection at UC Davis Department of Pomology comprises samples of several fruit and nut species, including *Actinidia, Dispyros, Prunus, Juglans, Pistacia, Ficus, Malus, Citrus* and other edible fruits which are used for teaching and research. The seeds of all these nuts and fruits are recalcitrant and cannot be stored conventionally in a cold room and hence collections of these species have been established at the Wolfskill Experimental Orchard at Winters (near Davis, California).

A field genebank for horticultural crops found in Israel since its inception has been set up in Upper Galilee. Between 1987 and 1993 a survey was conducted and information on local populations of various interesting unimproved types of fruit trees was gathered. A sample tree was removed from the local habitat and transferred to the field genebank nursery. Between 1992 and 1994 genetic material was planted over an area of 12 km^2 buffered on all sides by the larger area of about 38 km^2 of the conservation park. The number of various fruit species found with potentially valuable genetic material and transferred to the field genebank is given in Table 1.

Also, under the 'Peace Campus' project initiated by the European Union, a Biblical Fruit Tree National Park is being established near Neve Ya'ar in Israel (Porceddu 1995). Some scientists involved in breeding work believe that many of the region's oldest domesticated fruit varieties, which have been cultivated by traditional farmers since Biblical times, have the potential to dramatically increase the crop's adaptability to the region's unique climate, soils, plant diseases and pests. These include 75 fig (*Ficus carica*) cultivars, 40 grape (*Vitis* spp., 35 pomegranate (*Punica granatum*), apple (*Malus* spp.), *Prunus* spp. and others. For example, the local

Table 1. Summary of genetic material of fruit trees conserved *ex situ* in a field genebank in Upper Galilee, Israel (A. Levy, pers. comm., February 1995)

Common name	Botanical name	Trees planted
Apple	*Malus* spp.	16
Pear	*Pyrus communis*	16
	Crataegus spp.	1
Grapevine	*Vitis vinifera*	29
Fig	*Ficus carica*	38
Pomegranate	*Punica granatum*	19
Plum	*Prunus domestica/P. salicina*	6
Apricot	*Prunus ameniaca*	19
Almond	*Prunus amygdalus*	14
Total		159

Hashabi apple has developed resistance to diseases which would affect almost all exotic cultivars. The rootstock of the Hashabi apple has been used to transfer this resistance to other local and imported cultivars with great success, with the added benefits of increased vigour, early and heavier fruit bearing, and enhanced fruit quality. This gene park intends to be largely self-supporting financially by uniquely combining genetic conservation activities with revenue from tourism which is bound to multiply as a result of the peace process in the region.

A field genebank also has been set up near Manaus in Brazil which specifically conserves valuable germplasm of the South American peach palm *Bactris gasipaes* (Hoyt 1988). Similarly, as part of the national coffee (*Coffea* spp.) conservation programme, a special effort is being made in Ethiopia to safeguard semicultivated coffee species on peasant farms in areas such as Kefa, Ilubabor and part of Welega, where the coffee plants are found growing spontaneously in the forests. Backyard or kitchen garden conservation of coffee plants is also being carried out by farmers in Harer, Sidamo and Welega regions of Ethiopia (Worede 1993).

However, field genebanks do take up many times the space of a conventional seedbank with cold rooms. But it is uncertain if they can cover the full range of genetic diversity of a species or maintain it in the absence of environmental conditions of its native habitat. Also, such collections are difficult to protect against natural disasters such as flooding and forest fires, and may be susceptible to various diseases which attack the plants from time to time. Despite these drawbacks, functional field genebanks have been established in several countries around the world and they continue to provide a means for combining conservation with education and research as seen at UC Davis. For example, some of the most valuable collections of commercial crops such as bananas, plantains, oil palm, coconut palm, chilli peppers and coffee are those established many decadew ago in field genebanks.

Seed savers programmes

In several countries, no doubt as a result of increasing awareness of genetic erosion of biodiversity, informal groups of small farmers, hobbyists, gardeners and like-minded persons have come together to form what are collectively called 'seed savers'. Such grassroots groups share resources, information, seeds and plant materials for mutual benefit. The International Plant Genetic Resources Institute (IPGRI) formerly the International Board for Plant Genetic Resources (IBPGR), based in Rome, Italy, can be credited to a large extent for initially promoting this awareness which has now begun to bear fruit.

The Seed Savers Exchange (SSE) is one of the largest and most active non-governmental organizations (NGO) that conserves plant genetic resources in North America. It is based on a small farm in rural Iowa and depends on individuals who maintain seeds of numerous obsolete heirloom varieties of subtropical vegetables and other crops. The SSE maintains a large collection of about 16 500 entries, forms networks of gardeners and like-minded persons around the country, sets up displays at agricultural and garden shows, trains curators and regularly publishes catalogues of its holdings as well as all nonhybrid seeds offered for sale by seed companies in North America as a Garden Seed Inventory. The SSE itemizes cultivars that are decreasing in availability and encourages interested persons to conserve them in their gardens, thus reintroducing 'lost types' to their native habitat.

The Seeds of Diversity Canada (formerly Heritage Seed Program) based in Ontario, Canada, has similar aims and activities to the SSE and regularly publishes a newsletter which contains information on seed saving, gene conservation, heritage gardens, historical sites, seed companies which sell heirloom varieties, and provides an annual listing of all seeds which are offered to the public by its 1800 members at nominal cost. Some of its members also multiply seeds for Plant Gene Resources of Canada (PGRC), the national genetic resources conservation programme, which has recently undergone drastic restructuring in order to promote efficient utilization of the national collections.

In addition to clonal collections of potatoes and garlic (*Allium sativum*), the Seeds of Diversity Canada maintains three conservation orchards in the province of British Columbia (BC). one of these, on Salt Spring Island named Tsolum River Fruit Trees, has 350 varieties of obsolete apple varieties derived from scions from an old nursery in Merville, BC. The varieties include 'Roxbury Russet', an American dessert apple that originated in the 17th century, 'Orleans Reinettel' dating back to 1776, and 'Lady', a dessert apple that once grew in the garden of King Louis XIII of France. The nursery has recently been taken over by a seed company which will exploit its commercial aspects and use part of the profits for the conservation of the collection. The scion wood and other forms of germplasm from the nursery will continue to be available to the public (Geffken 1996).

Native Seeds/Southwestern Endangered Aridland Resource Clearing House (SEARCH) based in Tuscon, Arizona, USA, is a seed conservation organization focusing on the traditional native crops, and their wild relatives, of the US and Mexico. They seek to integrate cultural and biological resources in an effort to encourage continued use of these plants in their native habitats through *in situ* and *ex situ* conservation activities. Newsletters and seed catalogues are periodically published and seeds are distributed at cost.

Thomas Jefferson Center for Historic Plants based in Charlottesville, Virginia, USA, was established at Monticello in 1987. It collects, preserves and distributes historic plant varieties and strives to promote greater appreciation of the origins of garden plants. The programme, which also promotes conservation of garden and horticultural plants through publications, centres on Thomas Jefferson's own horticultural interests, but also includes varieties and plants from the early 20th century and those connected with American culture.

The North American Fruit Explorers brings together people interested in conserving antique and heirloom fruit and nut trees. Such groups are not part of the national plant germplasm system, but nevertheless hold valuable germplasm not readily found in other collections. The heirloom seed movement is considered highly efficient and low-cost, it uses minimal inputs, and forms a flexible complement to government and private sector germplasm conservation and utilization efforts.

Many wild plants known since prehistoric times to the native Americans have been domesticated and widely consumed this century; some of these are blueberries (*Vaccinium corymbosum*), pecans (*Carya illinoiensis*), cranberries (*Vaccinium macrocarpon*) and wild rice (*Zizania palustris*). Hence if current human population trends continue, new crops will be needed to avoid famine in the future. New crops can only come from germplasm which is conserved today. For example, Texas wild rice (*Zizania texana*) is a relatively rare plant but has substantial agricultural potential all over the world. However, it has been neglected by conservationists so far. The plant is endemic to a single stream in Texas, USA, where it is vulnerable to aquifer depletion and consumption by introduced rodents (Phillips and Meilleur 1995).

There is, however, another aspect to seed savers programmes, especially those based in areas other than the centres of diversity. For example, programmes based in North America do conserve rare forms, but most of these are introductions from developing countries. With aggressive marketing techniques the seed savers programmes have managed to capture a specific niche of the market in North America for their produce. However, if some method of preserving the produce during transportation can be found, these same varieties could be grown in their countries of origin where benefits would accrue to the poor subsistence farmers. Furthermore, the genetic diversity would have a chance of being maintained in areas where it originated and could continue its evolution.

In situ conservation of cereal wild progenitors in West Asia

The 'fertile crescent', which traverses Jordan, Israel, Palestine, Syria, Lebanon, Iraq and parts of southern Turkey, is one of the main centres of crop biodiversity in the world where naturally occurring populations of the wild progenitors and relatives of some of our most important crop plants, such as wheat, barley, oats, lentils, pea and vetch, can still be found (Damania 1994a). The ecological amplitude of wild relatives may exceed those of the crops derived from or related to them, a feature plant breeders exploit to enhance resistance to biotic or abiotic stresses, thereby increasing the adaptive range of the crop concerned (Altieri and Merrick 1987).

West Asia, and particularly Syria, has not only been a cradle of human civilization but also includes areas where domestication of wild plants may have first occurred about 10 000 years ago (van Zeist and Bakker-Heeres 1984). The region includes two of the most important Vavilovian centres of origin of food crops: the Near East and the Mediterranean (Vavilov 1951). These two regions fall within the pattern of global genetic diversit} also described by Harlan (1970, 1971). In the past, the 'green revolution' which positively affected the grain production in many countries of the tropics did not have much impact in West Asia and North Africa (WANA). However, the rich regional biodiversity in crop plants and their wild relatives in WANA is now threatened by rapid urbanization, overgrazing by small ruminants as flocks multiply to satisfy demand from the oil-rich gulf states, and agricultural development which is based on the introduction of improved varieties with a narrow genetic base, accompanied by modern agricultural technologies which are less labour-intensive.

Carbonized plant remains of wheat, which morphologically resemble wild progenitors, have been recovered from a number of archaeological sites in the 'fertile crescent', but it is very difficult to determine whether they were cultivated there or gathered from the surrounding areas. These wild progenitors retain three basic characteristics: dormancy, uneven ripening and natural dispersal at maturity due to a shattering rachis (Willcox 1992).

Recent pilot studies carried out by Valkoun and Damania (1992) at ICARDA in Syria and elsewhere (Jana 1993) have demonstrated extensive genetic diversity in the original populations of the wild genepool in the natural habitat which is impossible to conserve by the standard *ex situ* collection procedures. Also, it is generally accepted that during field collection usually only about 50 to 150 plants per site are sampled and many genotypes may be left out. On the other hand, under *in situ* conservation a much larger and continuously evolving genetic diversity is preserved.

Indirect evidence from studies carried out so far indicates that *in situ* methods should be effective for the conservation of genetic diversity in populations of both cultivated and wild species. During their long history of propagation in crop fields in the centres of origin and primary diversity, landrace populations of major crop speciew were in close association with their wild and weedy relatives. They occasionally exchanged genes, usually at the borders of cultivation, and mutually enriched their genetic diversity. They co-evolved, during which time they were exposed to a multitude of biotic and abiotic stress selection pressures to which they have adapted themselves as seen in bread wheat (*Triticum aestivum*) fields in Iran (Damania *et al.* 1993).

From biological considerations, the relative merit of the *in situ* method for conserving biodiversity within a cultivated species may be best evaluated in comparison with its wild evolutionary progenitor. Although several comparative studies on diversity in wild and cultivated barley have been reported (Jana 1993), comparable investigations are rare in wheat. In a preliminary assessment of genetic variation in populations of durum wheat (*Triticum durum*) and its wild progenitor (*T. dicoccoides*) from Turkey, the results showed that there was no difference in overall genetic diversity between the two.

Germplasm could be repeatedly collected from *in situ* conservation sites for off-site evaluations from time to time. The sites should be exposed to limited grazing periodically in order to maintain soil fertility and prevent it becoming a forest again. An ongoing experiment spanning 5 years is underway at ICARDA to establish well-defined populations of wild relatives of cereals and legumes conserved *in situ* and thereby determine the main factors which affect survival and competitive ability, and to evaluate colonizing ability and regeneration capacity in populations of the target species: *Hordeum spontaneum, Triticum urartu, T. boeoticum, T. dicoccoides, Lens orientalis, L. odemensis* and two annual *Medicago* species and their mixtures. Sheep are allowed to lightly graze the experiments so as to simulate as far as possible the actual disturbance factors involved in this type of conservation effort (Fig. 4).

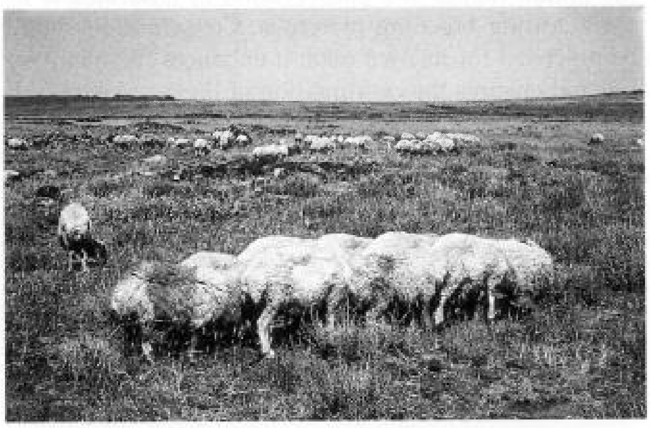

Fig. 4. Sheep lightly graze the experiments at Tel Hadya (near Aleppo), so as to simulate the actual disturbance factors involved in *in situ* conservation of wild progenitors of cultivated crops.

In wild cereals such as *T. boeoticum, T. dicoccoides* and *H. spontaneum*, selection for a non-brittle rachis led to their domestication. Both wild diploid wheats and wild barley show great climatic tolerance in terms of their natural distribution. Their natural habitats range widely in latitude and altitude. Wild einkorn (*T. boeoticum*), for example, can be found growing from sea level in Macedonia to 2000 m above mean sea level in Iran and Iraq. The most dense stand encountered so far has been in southeastern Turkey at altitudes between 900 and 1500 m (Willcox 1992). Wild emmer, *T. dicoccoides*, has been reported from 100 m below sea level in the Jordan valley and at 1500 m on the slopes of Mt. Hermon in Palestine (Zohary 1969). Several of these habitats could qualify for consideration as *in situ* conservation sites.

Populations of *H. spontaneum, T. urartu, T. boeoticum* and *T. dicoccoides* collected from the southern provinces of Sweida and Damascus, the Anti-Lebanon mountains, and the northern province of Aleppo during 1991, 1992 and 1993 were analyzed for genetic diversity through the study of seed storage protein (gliadin) polymorphism. Extremely high genetic diversity was found in populations collected from the high plateau in the province of Sweida, while populations found in valleys of the Anti-Lebanon mountains showed lower diversity (Valkoun and Damania 1992). The discovery of *T. urartu* growing in close proximity with *T. dicoccoides* and *H. spontaneum* in the middle of the Hauran plain forms a link between the *T. urartu* populations found on the slopes of Mt. Hermon and the Jebel Al Arab mountains of the Sweida province in Syria. This may also indicate that the Hauran plain used to be the natural habitat of the two wheat ancestors and that *T. urartu* was the wild progenitor of cultivated barley before the area came under cultivation and was intensively grazed by sheep and other small ruminants.

Long-term monitoring of biodiversity is essential to develop an understanding of its value for conservation and sustainable use (Bajaj and Williams 1995). During 1993 a monitoring trip was conducted jointly with the National Agricultural Research System (NARS) scientists of Syria with the objective of gathering information on these sites (land use, farming system and socioeconomic background, botanical composition of the associated vegetation, etc.), and the target species populations (phenology, reproductive ability, vigour and health). It was observed that the populations of wild progenitors of cereals are relatively well protected during the vegetative phase when they are growing on non-arable habitats among the basaltic rocks. They are not grazed before the harvest of durum wheat by which time the spikes have matured and shattered on the ground, averting damage from grazing sheep (Fig. 5). However, when the ownership of the land is not in private hands, flocks belonging to wandering bedouins graze continuously with deleterious effect on the plants. Only highly unpalatable spiny weeds survive this form of grazing and not a single plant of wild *Triticum* spp. is left standing (Damania 1994a).

During these missions *T. urartu* populations were also sampled from the Anti-Lebanon mountains, close to the town of Bloudan, at an elevation of 1800 m asl, the highest collection site reported for this species so far (ICARDA

Fig. 5. *Triticum dicoccoides*, the wild progenitor of wheat, growing naturally among basaltic rocks in Sweida Province, south of Damascus, in Syria.

1995). Results of these studies will be used to identify the most suitable populations and sites and to develop a sustainable strategy, together with the appropriate land management system, for *in situ* conservation of the indigenous wild wheat progenitors in Syria and the neighbouring countries.

A similar project for *in situ* conservation of *T. dicoccoides* populations has been underway in Eastern Galilee in Israel for almost a decade, with initial support from USDA. The 1-ha site is located 1 km west of Kibbutz Ammiad, in a hilly tract that is the southern extension of the Mt. Kenaan ridge. The objective is to establish an *in situ* conservation site that would protect and maintain the entire genepool of the selected populations. The climate is typically Mediterranean with an average rainfall of 580 mm which falls during the winter months. As in Syria, the survival of these populations of wild wheat progenitors is now increasingly threatened by human population pressures and intensified mechanical agricultural practices (Anikster and Noy-Meir 1991). During 1984 to 1989, individual plants were monitored at closely spaced, permanent sampling points along with four topographically diverse transects. Single spike collections were made annually from these plants and seed from progenies was sent for *ex situ* conservation.

The results of the Ammiad experiments have managed to highlight some of the problem areas of *in situ* conservation of wild species. One of the most difficult decisions in the establishment of such reserves is to determine the size of its area. The minimum viable population size will be greater than the minimum effective population size of individuals that can contribute to the next generation. Dur(ng the last 4 years, the wild wheat study using the Ammiad methods of sampling and progeny testing has been extended to other populations, particularly in two nature reserves in Yahudiya in the disputed Golan Heights and Har Meiron in Upper Galilee.

In situ conservation of wild wheat relatives at the Erebuni Nature Reserve, northeast of Yerevan in Armenia, has met with some success. Vavilov (1951) first recommended protection of this site because of its unique richness of the wider *Triticum* genepool. *T. urartu* was discovered there in 1935 and later this species was fully described by Gandilyan (1972). Other wild wheat species, such as *T. boeoticum* and *T. araraticum*, grow in the protected area together with *Aegilops* species. *Amblyopyrum muticum*, a species considered to be taxonomically intermediate between *Aegilops* and *Agropyron*, was also found near this nature reserve. Hence, this site in Armenia is the only site outside Turkey where the uncommon species of the Anatolian highlandw are found. The actual size of the reserve is about 100 ha but protection of a much wider area, about 400 ha, is needed in order to include rare populations of other species growing on the periphery of the protected area as well as to provide a buffer zone for protection of the core area.

Damania *et al.* (1993) observed, during explorations in Iran, that the limited presence of wild *Triticum* taxa in their centre of diversity is worrisome, not only from the conservation point of view, but also as a useful genetic resource since it has been reported that they may provide valuable traits, such as disease resistance, for wheat improvement. They recommend that certain sites in Iran be considered for immediate *in situ* conservation to preserve the few remaining populations of wild *Triticum* spp. Later, selected genotypes from these populations can be re-introduced in areas where they have disappeared.

In situ methods of conservation of landraces and wild progenitors are, understandably, looked at with skepticism by plant breeders. As long as genetic conservation and crop improvement are directly linked, any form of conservation will be judged by its short-term benefits to breeders, and *in situ* methods will attract considerable opposition (Brush 1991). However, on-site conservation is more plausible if these two goals are decoupled, making biodiversity conservation an end in its own right. In fact, Jana (1993) has said that we should get away from the notion that *in situ* conservation of landraces is for safeguarding breeding materials. Conservation should be practised for its own sake; it enhances the quality of life and ensures the continuation of the ecosystem.

Several scientists have advocated the need for resorting to *in situ* conservation of landraces in the communities in which they occur (Altieri and Merrick 1987; Brush 1995) and where they may be threatened by replacement by high-input, better-yielding cultivars. However, Qualset *et al.* (1996) caution that it is a challenge to undertake *in situ* conservation of cultivated crops and their wild relatives without a return to or preservation of obsolete agricultural practices which may be unacceptable or impracticable under sociopolitical systems in areas where diversity abounds. In the case of recalcitrant seeds or plant life which cannot be conserved *ex situ* there does not seem to be much other choice. Besides, conservation of germplasm of an economically important crop *in situ* would most probably also result in the conservation of subsidiary or associated species occurring naturally in the same ecosystem. Moreover, *in situ* conservation permits natural evolution to continue, an extremely important option for the preservation of genes for abiotic and biotic stress resistance, as species co-evolve with their pathogens and changing environment.

The discussion, up to this point, has focused almost exclusively on edible plants and their wild relatives, the former being under human control, and the latter surviving in nature because of unpalatability or other defence mechanisms which make them unsuitable for human consumption. Let us turn finally to conservation on a wider scale which appeals to a broad spectrum of citizens and not just the conservationists. It includes preservation of an entire ecosystem which may also contain plants and animals useful to humankind.

National parks and nature/biosphere reserves

One of the more traditional solutions from the past for safeguarding biological life has been to preserve it in spe-

cial areas such as national parks and nature reserves, where it is protected from human disturbance. However, this method of conservation has certain limitations. For example, if the reserved space is not large enough, inbreeding reduces the genetic diversity of the target populations. The concept of biosphere reserves as a method of sustainable conservation and development was launched in the early 1970s by the UNESCO-sponsored Man and the Biosphere programme (MAB). In contrast to national parks and other nature reserves, the biosphere reserve concept permits human habitation within a reserve. Rather than isolating natural areas and protecting them from humans, biosphere reserves carefully incorporate limited and sustainable human activities into the planning and management of the areas under protection. The ideal biosphere reserve contains an undisturbed core area surrounded by peripheral zones which permit interaction with human settlements. National parks and biosphere reserves conserve not only the targeted plant and animal species but also the entire ecosystem. However, this spin-off may be more or less obligatory in the case of certain species, for as scientists have discovered, these plants and animals can hardly be conserved *ex situ* and/or in isolation.

Although most national parks have been established in the last two decades, various societies have been consciously protecting ecosystems for hundreds of years. For example, South and Southeast Asian farmers have traditionally honoured sacred groves of trees, which they believe to be abodes of powerful deities. The Kuna and Emberá-Chocó Indian tribes of Panama preserve patches of old-growth forests as supernatural parks, a sanctuary for both wildlife and the spirits (Ryan 1992).

The largest of Costa Rica's reserves, Talamanca Biosphere Reserve, is a mosaic of more than 500 000 ha which includes three national and international (with Panama) parks, five Indian reservations and two large forest reserves. Talamanca, which contains some of the richest biodiversity of plant and animal life in all of Central America, is part of the MAB.

Convinced that if effective biodiversity conservation is to succeed it must be economically rewarding to the rural people, nonprofit groups, NGOs and green-minded entrepreneurs are bringing new food fads, cosmetics, medicines, soaps and dental hygiene products from the world's subtropical and tropical forests to the shelves of stores in developed countries. The range of items whose basic ingredients come from hidden forests, reefs and other ecosystems is a powerful argument for their conservation. For example, less than 1% of the plants of Madagascar's forests, where products from medicinal plants are a major export as well as the basis of local health care, have been analyzed and their medicinal and other properties ascertained (Ryan 1992).

The National Park and Conservation Service under the Ministry of Agriculture and Natural Resources of Mauritius, one of the Mascarene Islands in the Indian Ocean, established the Perrier Nature Reserve in the 1970s. The reserve is located near the Mare aux Vacoas reservoir on the central plateau and is protected by a barbed-wire fence and normally not open to the public. This is a relatively small reserve of only 2 ha but contains the only remaining transitional native forest of the island largely dominated by *Sideroxylon puberulum* (mangier rouge). Other important trees (local names in parentheses) in this reserve include *Pandanus eydouxia* (vacoas), *Aphloia* (fandamane), *Memecylon trinerve* (bois de canne), *Trochetia blackburniana* (bouche d'oreille), *Colea colei* (bois margoze) and others. Some extremely rare plants are also preserved *in situ* in this reserve: *Xylopia amplexicaulis, Gaertnera longifolia, Chionanthus boutonii* and *Euodia obtusifolia* var. *gigas*. In 1986 conservation management areas were established which were incorporated into the Black River Gorges National Park in 1994. Certain designated areas of this 6574-ha reserve are open to the public. Samples of wild forms of some of the island's fruits observed by Damania (1985), such as passion fruit (*Passiflora edulis* f. *flavicarpa*), pineapple (*Ananas* spp.) (Fig. 6), guava (*Psidium guajava*) and semi-wild coffee (*Coffea canephora*), are to be found in this park.

Fig. 6. A wild pineapple (*Ananas* spp.) plant, locally called 'ananas marron' found on a nature reserve in Mauritius (Photo: A.B. Damania).

The dominant vegetation in this park is composed of *Labourdonnaisia glauca* (bois de natte), *Syzygium* spp. (bois de pomme), *Mimusops* spp. (makaks), *Diospyros tesselaria* (black ebony), *Coffea macrocarpa* (wild coffee) and *Canarium paniculatum* (colophane), among others. The reserve has an added advantage in that it also attracts rare and endangered bird life. In addition to plant life, the park is home to most of the endemic bird life of the island such as the Mauritius kestrel, the pink pigeon, and the rare and endemic Mauritius parakeet (the national bird). The endemic Mauritian fruit bat is another example of wildlife found in the park. Numerous species of the endemic reptile of the genus *Phelsuma* as well as some rare molluscs also inhabit this park. The nature reserves occupy 3.5% of the land area of the island which has at least one extinct volcano. There are field genebanks on the island of Rodrigues (Mauritius) also (Fig. 7). Such examples of government-sponsored *in situ* conservation need to be emulated by other countries with a rich treasure trove of biodiversity.

Fig. 7. A field collection of chilli peppers (*Capsicum* spp.) and coconuts (*Cocos nucifera*) on Rodrigues island (Mauritius) (Photo: A.B. Damania).

Among the Seychelles group of the Mascarene Islands mention must be made of the Vallée de Mai Reserve on Praslin Island which has the only known natural grove of the double coconut or coco-de-mer (*Lodoicea maldivica*, syn. *L. seychellarum*) palms (Fig. 8) and the few remaining specimens of a subspecies of the extremely rare and endemic black parrot (*Coracopsis nigra* subsp. *barklyi*). There does not seem to be any close association between the parrots and the double coconut palm trees though the birds do nest in decayed stumps, but fruit of another palm, *Verschafeltia splendida*, prevalent in the reserve, is a favoured food. Past records suggest that these birds were more widespread but habitat destruction due to a boom in tourism, forest fires and competition for nesting space from the aggressive Indian mynah, *Acridotheres tristis*, have reduced their numbers to only 58 to 100 individuals, exact numbers being difficult to determine (Forshaw 1989). The present population seems to have remained stable for the past decade or so. Of positive conservation significance are the strict legal protection given to the endangered species by the Seychelles Government and a caring attitude on the part of the local people of Praslin Island to safeguard their parrots. The Vallée de Mai Reserve has been declared a World Heritage Site. The cooperation and enthusiasm of the indigenous inhabitants in contributing to the success of *in situ* conservation projects is once again emphasized.

One of the more successful nature reserves in Malaysia is the Pason Nature Reserve, located on just 50 ha, where 820 species including 76 species of edible fruits and their wild relatives are conserved *in situ*. Some of the most important genetic resources conserved on this reserve are 12 types of *Mangifera* spp., 13 *Garcinia* spp., 10 *Artocarpus* and 5 *Nephelium* spp. (Saw *et al.* 1991). Some of the species density is less than one tree per ha. Most of the wild species have yet to be characterized and evaluated but the potential value of these resources is estimated by horticulturists to be enormous.

In Taiwan, nature reserves have been established recently for each of the following rare plant species: *Cycas formosana*, *Pleione taiwaniana*, *Kandelia mangrove*, *Keteleeria davidiana*, *Amentotaxus formosana* and a hydrophyte, *Isoeles taiwanensis*. Each of the reserves is bounded in a 50 to 100-ha zone which is heavily protected. The endemic wild pear *Pyrus koehnei* has shown resistance to diseases such as fireblight, leaf spot, pear root aphid and waterlogged soil. These traits have been easily transferred to cultivated *Pyrus* spp. (Westwood and Lambard 1977).

Fig. 8. The double coconut or coco-de-mer (*Lodoicea maldivica*) palm at the Vallée de Mai Reserve on Praslin Island, Seychelles: a World Heritage Site (Photo: A.B. Damania).

In 1977, a botany student at the University of Guadalajara in Mexico, while searching for wild maize, rediscovered a perennial species, *Zea perennis*, which was thought to have been extinct since the early 1920s. However, this species had 40 chromosomes and was genetically incompatible with cultivated maize (*Z. mays*), which has 20 chromosomes. The rediscovery, nevertheless, subsequently led Mexican and US researchers to an ecological niche up the same mountain (Sierra de Manantlán), where they found another population of teosinte (wild maize) with 20 chromosomes. This wild maize, also a perennial, was named *Z. diploperennis*. On evaluation this species was found to be resistant to seven of the nine tropical viruses affecting maize (Hoyt 1988). It also provided tolerance to poorly drained soils, greater stalk and root strength, and multiple ears on each plant. The crosses with cultivated maize have so far not been very promising from the agronomic point of view, but hopes of a disease-free supercorn with high

yields cannot be ruled out as experiments with backcrosses continue to utilize desirable traits from the wild species at CIMMYT, Mexico. In 1987 Brazilian authorities declared the site and the area surrounding it a nature reserve which also provides refuge for the wild perennial forms of the runner bean, *Phaseolus coccineus*, among other plant and animal life.

Another example of the importance of conserving forests is the threatened caoba tree (*Caryodaphnopsis theobromifolia*) from Ecuador, a wild relative of cultivated avocado (*Persea americans*), which is a source of resistance to blight disease. Farmers in California have benefitted greatly from the genes of blight resistance which were successfully transferred from the wild caoba tree to avocado. When the caoba tree was found in Ecuador only 12 specimens remained in a small forested area (Hoyt 1988). Today, almost all the remaining lowland forest in Ecuador has disappeared. Although a small country area-wise with 275 800 km^2, Ecuador has about 20 000 plant species, and new areas earmarked for nature reserves are being studied and new species discovered within them (Gentry 1976).

There are some islands in the Mediterranean sea which are strategic to the defence of the Italian mainland. These islands are out-of-bounds for all except personnel of the Italian navy who visit them sporadically to check for trespassers. It has been suggested that these islands be used to establish nature reserve parks where it would be easy for *in situ* conservation to proceed undisturbed by human factors (Porceddu and Srivastava 1990). Also, there would be no import or export of genes to and from such islands and a degree of equilibrium in the genetic structure of the target species could become established over time.

However, *in situ* conservation projects, such as those described here, require a high degree of technical expertise and persuasion skills to monitor and manage the community structure. They also require the fullest cooperation from the local residents in protecting the targeted species, especially when the *in situ* sites are in remote areas (Chang 1994). Poachers, loggers, smugglers and bandits can ravage a forest ecosystem and usurp its resources for personal gain in the absence of a well-developed guard and monitoring system, as has been seen in the sandalwood (*Santalum album*) forests of southern India.

However, most of the original proponents of the 'closed fencing for protection' of the parks and biosphere reserves have been moving away from that concept and the importance of human/community involvement in the efforts to conserve biodiversity is being recognized. In recent years there have been several ongoing debates on the state of national parks, sanctuaries and biosphere reserves, and whether the human populations living in and around these protected areas should be involved in their management or not.

Some examples of successful locally based *ex situ* and *in situ* conservation projects around the world are given in Table 2.

Table 2. Some examples of successful diversity preservation projects in the field, including *in situ* conservation, using methods other than standard *ex situ* genebank procedures

Name of reserves/parks	Location	Description of main activity
ASIA		
Vishnoi Community	Vishnoi-ke-Dhani, Rajasthan, India	Folk varieties of cumin and millet, khezri trees, and black buck antelope
M.S. Swaminathan Research Foundation	Madras, India	Conservation of mangrove forests
Black River Gorges National Park	Mauritius, Indian Ocean	Native forest and bird life as well as wild fruits and coffee
Vallée de Mai Reserve	Praslin Island, Seychelles	Double coconut and black parrot
Pason Nature Reserve	Malaysia	Fruits and their wild relatives
LATIN AMERICA		
Field Genebank	Manaus, Brazil	Peach palm and wild coffee
Talamanca Biosphere Reserve	Costa Rica, Central America	Native forests and animal life
Tulumayo and Paucartambo Valleys	Peru, Central America	*In situ* conservation of native varieties of potatoes
Sierra de Manantlan Reserve	Guadalajara, Mexico	Wild maize and runner bean
NEAR EAST		
Erebuni Nature Reserve	near Yerevan, Armenia	Wild wheat relatives
Field Genebank for Horticultural Crops	Upper Galilee, Israel	Mediterranean fruit trees
Sweida Province (proposed)	Sweida, Syria	Wild wheat progenitors
Field Genebank	ARC, Yazd, Iran	Pomegranate varieties
EUROPE		
Arrábida Mountain Reserve	near Lisbon, Portugal	Traditional medicinal plants
Castelfranco in Miscano	Benevento, Italy	*In situ* conservation of einkorn and emmer landraces by local farmers
NORTH AMERICA		
California Native Plant Collection	University Arboretum, Davis, California, USA	Endangered and rare plants of California
Hopi Indian Reserve	Arizona, USA	Folk varieties of maize (corn) with blue cobs
Seed Savers Exchange	Decorah, Iowa, USA	Mexican and Native American crop folk varieties
Seeds of Diversity Canada	Ontario, Canada	North American traditional and heirloom varieties of fruits and vegetables
Native Seeds/SEARCH	Tuscon, Arizona, USA	Traditional native crops of the USA and Mexico, and their wild relatives
Thomas Jefferson Center for Historic Plants	Charlottesville, Virginia, USA	Collects and preserves historic varieties and garden plants

Conclusions

Renewable resources used to fuel engines of multinational economic growth can survive only if plant genetic resources are safeguarded and their use regulated and put on a sustainable basis. The issue is just beginning to receive the global attention and funding which was sorely lacking in the past. Although most traditional agro-ecosystems are undergoing modernization to some degree in different parts of the world, conservation of plant genetic resources can still be integrated with agricultural development. This is especially true in regions where rural improvement projects include a component of preserving the vegetational diversity of agro-ecosystems anchored in the traditional farmers' rationale to utilize local resources together with their intimate knowledge of the environment. To be sustainable, agroforestry-based farming systems should first satisfy the basic human needs for food and fuel. Forest protection measures cannot be enforced unless rising standards of living curb uncontrolled population growth. Some of the major crops originating in tropical forests of Latin America, Asia and Africa and their genetic resources conservation have been critically discussed by Smith *et al.* (1992).

Although *ex situ* methods of conservation, such as genebanks and botanical gardens, have contributed to the improvement of certain plants and the spread of major food crops through utilization of preserved germplasm, they do not provide a panacea for conserving naturally occurring genetic resources and protection of the habitat, and hence *in situ* methods remain the single most effective means of conserving diversity for future use.

Despite several successes there exists a strong possibility that farmer maintenance of indigenous germplasm may succumb to the pressures of population growth, migration to urban areas and a shift toward consumerism. Only concerted national and international efforts to support *in situ* conservation can guarantee its continuation in the foreseeable future. These efforts should focus on providing incentives in the form of awards (rather than plain cash subsidy), holding farmer's fairs, resurrecting local markets where indigenous varieties can fetch good prices, educating communities on the value of *in situ* conservation, assisting the communities by identifying their immediate other needs such as electrical energy supply, medical assistance, etc.

The loss of traditional knowledge, habitats and plant species may prevent evolution and development of new crops which are needed to feed the billions that will inhabit the earth in the coming decades. Several plants that were known only from the wild in the past are today enjoying popularity as their domesticated varieties are consumed with relish. The potential use of wild plants, especially in terms of new germplasm resources for improvement of crop species in the future, is much greater than perceived at present. In fact, if rare plant conservation is an insurance policy for the future survival of humankind it would appear to offer exceptional value for the investment in time, money and efforts (Phillips and Meilleur 1995).

The objective of an applied conservation activity should be to demonstrate that the preferred enterprise of the local people in a given area is consistent with the profits from that area's economically important biological diversity. The indigenous knowledge and practices of the small subsistence farmers are key inputs in the continuing evolution of farming and resource management systems. The knowledge base of farming cultures which have managed intricate collections of diversity of crop varieties, especially in the developing nations, is a very valuable resource not only to the genetic resources scientists but also to the farmers themselves.

Traditional farming systems preserve experience of interaction of plants with the environment accumulated over centuries without access to scientific information, external inputs, modern banking credit facilities and guaranteed market for the produce. These systems represent a strategy which promotes diversity of food intake and income, efficient use of available labour, and optimum inputs for production utilizing low levels of technological skills. It has been estimated that as much as 15 to 20% of the world's per capita food supply still comes from traditional and multiple cropping systems (Francis 1985). But these figures may be on the decline as even traditional farmers today tend to use hybrid varieties for higher market acceptance and the consequent financial rewards. Also, with each passing year, local farming communities are becoming more and more fragmented and absorbed into the mainstream of consumerism encouraged in most industrialized societies. As a result, it is feared that indigenous germplasm exchange networks and traditional markets may lose their importance, thus making it difficult for plant collectors to locate true landrace germplasm, as was the experience of the Soviet ICARDA team in northeast Syria in 1990. Hence, *ex situ* conservation of landraces and/or folk varieties should be strengthened to play a complementary role to long-term *in situ* conservation projects. After all, agriculture has survived the last 10 000 years without long-term genebanks but not without some efforts on the farmer's part to conserve seed for the next season and beyond.

Given the great difficulties in protecting whole ecosystems, people representing a wide range of interests have called for solutions less demanding than the defence of wilderness defined as very large, roadless, lightly managed, minimally polluted ecosystems. Conservationists have come to realize that change and disturbance due to fire, windstorms and practices of the indigenous peoples play an important role in fostering biological diversity. Foresters, among others, are beginning to custom-design production systems that duplicate these processes.

Efforts at documenting indigenous knowledge in conjunction with *in situ* conservation, especially that of plants of medicinal value, should be augmented even if danger of the local people losing control over the commercial exploitation of this knowledge is perceived. This has become necessary because the loss of the local people themselves has become far more imminent in recent years, e.g. in the Amazon basin among other places in Africa and Asia. Each time an aged 'shaman' or medi-

cine man/woman dies it is as if an entire library of encyclopedias has gone up in flames (Wolf 1993).

Although the diversity of species, cultivars and cultural practices within natural and agricultural habitats may contribute to sustained productivity and help buffer ecosystems against shocks and stresses, the long-term benefits of *in situ* plant conservation, however substantial, are not necessarily sufficient returns on investments targeted at meeting the immediate needs of agrarian populations in developing economies. In other words, economically compelling reasons for conserving genetic resources must be established as the basis for sound land-use planning in the case of *in situ* conservation.

In situ conservation is not just for crop or economically important plants but for the entire ecosystems. If the utilization of biodiversity from *in situ* reserves is to be sustainable, it must be conserved as a renewable resource. It is, therefore, essential to investigate the association of ecological and environmental variables with genetic diversity. The distribution pattern of the genetic diversity and human activities at or near the site will in turn determine optimal condmtions in suitable locations for *in situ* conservation of the target species. There may be multiple obstacles to overcome in practising locally based conservation, but an array of strategies and methodology is now available that are multidisciplinary and can be applied as appropriate. A strategy applicable at one site may not work at another. In certain cases *in situ* conservation may actually be less expensive and more desirable than *ex situ* maintenance of seed and clonal collections in genebanks, especially if methods other than direct financial subsidies to farmers are implemented.

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Résumé

***Conservation de la diversité biologique: examen des options pouvant compléter les méthodes classiques de conservation* ex situ**

La conservation *ex situ* est une conservation hors du milieu naturel, habituellement sous la forme de semences dans des banques de gènes à des températures inférieures à 0°C. Quoique les méthodes de conservation *ex situ*, par exemple dans des banques de gènes ou des jardins botaniques, aient contribué à l'amélioration de certains végétaux et des principales cultures vivrières moyennant l'utilisation de matériel génétique conservé, elles ne représentent pas la solution pour conserver des ressources génétiques présentes naturellement ou protéger l'habitat des changements dans l'environnement. Par conséquent, les méthodes de conservation *in situ* restent le moyen le plus efficace de conserver la diversité en même temps que l'environnement qui ne cesse de changer. Ces méthodes s'appliquent à des plantes cultivées sur des exploitations relativement petites consacrées à l'agriculture de subsistance dans des pays tropicaux et d'autres pays en développement. Pour remédier aux limites des collections conservées *ex situ*, il est important de conserver des populations de plantes sauvages apparentées aux espèces cultivées dans leur milieu naturel au profit, à long terme, des programmes nationaux et de la communauté internationale dans son ensemble. Quelques exemples de conservation *in situ* dans le monde ont été décrits, par exemple des projets spéciaux de conservation de géniteurs sauvages de plantes cultivées, des potagers familiaux, des jardins botaniques, des réserves naturelles, des programmes de récupération de semences, des banques de gènes de terrain, etc. Toutefois, il ne faudrait pas s'en remettre entièrement aux méthodes de conservation *in situ* pour sauvegarder nos précieuses ressources génétiques. Les méthodes *in situ* devraient être soutenues par des collections conservées *ex situ* comme une sorte de police d'assurance contre le risque de perte totale ou d'extinction. Le présent article tente d'évaluer certaines des options pouvant compléter la conservation *ex situ* et donne des exemples de réussite de conservation *in situ* qui non seulement protège la diversité mais aussi aide à conserver la terre 'verte', faisant fonction de bouclier face à l'urbanisation aveugle et à la destruction de l'habitat.

Resumen

***Conservación de la biodiversidad: examen de las opciones complementarias de los métodos normalizados* ex situ**

La conservación *ex situ* significa conservación fuera del habitat natural, generalmente en forma de semillas en los bancos de germoplasma a temperaturas bajo cero. Aunque los métodos *ex situ*, como los bancos de germoplasma o los jardines botánicos, han contribuido al mejoramiento de ciertas plantas y de algunos de los cultivos alimenticios más importantes mediante la utilización de germoplasma conservado, no representan una panacea para conservar los recursos genéticos que se producen en forma natural ni para proteger el habitat frente a condiciones ambientales mutables. Por consiguiente, los métodos *in situ* siguen siendo el único medio más efectivo de conservación de la diversidad junto con un medio ambiente dinámico. Estos métodos se aplican en cultivos que se producen en tierras relativamente pequeñas de agricultura de subsistencia en países tropicales y en otras economías en desarrollo. Para hacer frente a las limitaciones de las colecciones *ex situ*, es importante la conservación, en su habitat natural, de las poblaciones de parientes silvestres de las plantas cultivadas en su habitat natural en pro de un beneficio a largo plazo de los programas nacionales y de toda la comunidad internacional. Se describen algunos ejemplos de esfuerzos de conservación *in situ* en el mundo, por ejemplo, proyectos especiales para conservar los progenitores silvestres de plantas cultivadas, huertos, jardines botánicos, reservas naturales, programas de recuperación de semillas, bancos de germoplasma en el campo, etc. No debe haber, sin embargo, una dependencia total de los métodos *in situ* para salvaguardar nuestros valiosos recursos genéticos. Los métodos *in situ* deberían estar respaldados por colecciones *ex situ* a manera de póliza de seguro contra pérdidas totales o extinción. En este examen se trata de evaluar algunas de las alternativas a la conservación *ex situ* y se presentan ejemplos y éxitos de la conservación *in situ*, que no sólo conservan la diversidad sino que ayudan también a mantener una tierra 'verde', actuando como elemento regulador contra la urbanización indiscriminada y la destrucción del habitat.

Complementary approaches to the collecting of plant genetic resources by national programmes

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Summary
This paper discusses the reasons why a national genebank may want to consider the active participation of different kinds of partners – specifically, locally based individuals and structures such as government extension services and NGOs – in its collecting programme. Ways in which this kind of collaboration may be organized are described, and its implications for the overall role of the genebank discussed. In particular, it is suggested that national genebanks can play an important training role.

There is an increased awareness of genetic erosion of crops and their wild relatives, and of the potential benefit that can accrue from the systematic exploitation of such disappearing genetic resources. In response to this realization, many countries are establishing or strengthening national programmes for the conservation of plant genetic resources, often coordinated by a national genebank based within a government research institute. It is increasingly recognized that for such programmes to be viable and sustainable, they should encompass a wide range of partners within the country, including different government institutes and services, non-governmental organizations (NGOs), universities and private companies. Strong collaborative links are also needed regionally and internationally with agricultural research organizations and crop networks. Taking germplasm collecting in particular, this paper will discuss in detail the reasons why a national genebank may want to consider the active participation of different kinds of partners – specifically, locally based individuals and structures – in some of its activities, the ways in which this may be organized, and its implications for the overall role of the genebank.

Involving locally based structures in germplasm collecting: why?

Why should national genebanks want to consider fostering more direct and active involvement by locally based people in their collecting programmes? Collectors who live and work within a genebank's target region have several features to recommend them, from both a logistical and scientific perspective. Local collectors will have extensive local ecogeographic, biological and cultural knowledge. They will be well placed to judge the most appropriate times and places for collecting specific crops. They will know road conditions, local market days and relevant local customs and language(s). They will be attuned to the ways in which genetic and other natural resources are used and conserved locally, and will be well placed to elicit such indigenous knowledge with sensitivity and to document it accurately.

More prosaically, they will also not have to travel very far to do their collecting. Shortages of funds, staff time or equipment, especially vehicles, are often blamed if geographical gaps persist in national collections of many crops. After all, national genebanks must move fully equipped and trained collecting teams of several professionals to a perhaps distant and probably not easily accessible target region even before they can begin to gather target germplasm, and then bring them back to base. Often, only one suitable vehicle will be available, which means that only one collecting team can be in the field at any one time. Once in the target region, time in the field may be limited by insufficient funds and perhaps the reluctance of team members to spend long periods away from their families.

Even where genebank staff time and funds are not a serious constraint, it may well prove logistically difficult to squeeze more than one mission into the period of time during which collecting can most efficiently take place from farmers' fields. Local collectors, on the other hand, will be ideally placed to collect throughout the fruiting season(s), and also in successive seasons. Visiting each collecting location briefly, and only once, means that landraces (and genotypes within landraces) that are late- or early-maturing relative to the date of the visit may be missed. The problem will be especially acute where there is considerable variation in harvesting time within a relatively restricted area, as is the case in mountainous areas. Important micro-environments within complex agricultural systems may be overlooked. The kind of repeat visits which locally based collectors would be eminently suited to make are also necessary to monitor genetic erosion. Finally, local collectors can also be very flexible, enabling the national programme to rapidly meet any demand for germplasm or respond to the threat of genetic erosion.

Involving locally based structures in germplasm collecting: how?

If people living and working in target collecting areas can carry out crop collecting to the appropriate standards, it may well be advantageous in particular cases for a national genebank to devolve some of its collecting responsibilities onto them, integrating them fully as active partici-

pants in the national collecting programme. Who are these potential collectors? Several groups may be considered:

1. Many countries, especially large and agro-ecologically diverse ones, have a **regional agricultural research infrastructure** which could be used to collect crop genetic resources. It is already standard practice for national genebank collecting teams in many countries to include staff of regional research stations because of their local expertise. They could also in some cases be entrusted to undertake the collecting on their own, and then forward conservation materials (passport data, seed, vegetative plants, voucher specimens, etc.) to the national genebank.
2. **Government support services** are also organized in a decentralized manner. Perhaps the most obvious examples are the agricultural extension and forestry services. A province may have a chief extension officer responsible for a network of extension officers with more local responsibilities in turn. An extension worker will typically make regular visits to farmers throughout his/her area, often getting to know both the area and the people fairly well. Often they have been successfully involved as guides and intermediaries in genebank collecting teams. They could, however, also carry out collecting themselves on a regular basis, as an integral part of their normal routine of farmer visits. Again, samples and associated data could then be dispatched to the national genebank. Many countriew have university campuses spread through the provinces. Interested researchers at provincial universities, colleges and polytechnics could also be organized by the national genebank into a network of locally based germplasm collectors. Schools are also an important reservoir of potential collectors.
3. **Local professional NGOs** have also proved effective agents of collecting and conservation. These range in size from relatively large, national organizations, which may have projects and outposted staff in various areas of the country, to small, community-based groups. They represent a ready-made network of locally based potential collectors that the national genebank can point in the right direction as to priority target species and areas. They are also "well placed to monitor development projects that may have negative impact on the environment," for example by causing genetic erosion (Muchiru 1985).
4. Increased public awareness of conservation issues has led to public demand for 'better' conservation from the general public. In many countries, this has been expressed in the form of voluntary funding for conservation and the formation of **amateur conservation NGOs**. In practice the funds raised may be limited, but the public educational effect should not be underestimated.
5. **Local communities** themselves could also be integrated more fully into *ex situ* conservation as active participants in the process, not just donors but also collectors of germplasm. One way might be through the various types of structures into which farmers have organized themselves: local grassroots organizations, federations or networks, and national farmers' associations (ISNAR 1994). Another way might be through traditional institutions such as elders' councils. The media are another vehicle for reaching farmers. Possibilities include posters, newspapers and journals, radio and television.

Some experiments along these lines have already started. For example, competitions to collect seeds of semi-wild fruit trees have been organized among schoolchildren by local NGOs in Botswana (Frank Taylor, pers. comm.). A series of articles was published in newspapers and popular gardeners' journals in the former East Germany in the 1970s by the national genebank asking for samples of relic crops and rare cultivars. Radio has been used in Cameroon to obtain germplasm of 'plus' trees of forestry species (Zac Tchoundjeu, pers. comm.). The National Clonal Germplasm Repository of the USA has even used the Internet to solicit wild strawberry material from local people: a biodive-l posting gives instructions on sampling strategy, fruit handling in the field, seed cleaning and dispatch, and documentation. School teachers and their charges were singled out in the posting as potential collectors. National tree seed centres, for example in Africa, commonly procure seed from particular high-value provenances for conservation and distribution by commissioning local NGOs and communities to do the collecting. Some genebanks, for example in Ethiopia, have begun training extension officers as collectors, especially in areas where genetic erosion is an imminent threat. In 1991 IBPGR (now IPGRI) and the SADC Regional Gene Bank (now the SADC Plant Genetic Resources Centre) collaborated with the just-established Namibian national programme to train extension staff in the northern region of Ovambo in collecting strategies and methods. The Swaziland national programme is looking into the possibility of using traditional chieftaincies as the foci of both collecting and *in situ* conservation activities.

Some national genebanks themselves have locally based staff, for example housed at regional agricultural research stations. A national genebank may even have its own regional stations, which may specialize in the conservation of particular crops. This is common for crops which are conserved in field genebanks. Some national genebanks actually started out as fairly decentralized programmes, with regional agricultural research stations housing regional collections of locally important crops, which were then brought together under one roof. Increasing the involvement of locally based professionals in collecting could simply be a case of going back to the way things used to be done, with the important difference that it would be easier now to have comparable methodologies and standards for collecting across the country, adequate duplication and better dissemination of information.

A training and supervisory role for national genebank staff

If a national genebank is to involve local people more directly and more actively in germplasm collecting, it will

have to re-evaluate its use of time and financial resources. In particular, genebank staff will necessarily be involved in more training and supervisory activities. They will need to identify, sensitize, motivate, train and supervise potential local collaborators, who may have limited previous exposure to plant genetic resources conservation.

The training role would be particularly important. Training in five basic aspects of collecting and conservation would have to be provided:

1. **General introduction to plant genetic resources conservation.** Collaborators, whether professional or amateur, cannot be expected to assist the national programme efficiently unless they are given an overview of the subject and of how their contribution will fit into the national effort.
2. **Population identification.** Collaborators will need to be able to recognize the target species in the field and identify which populations are likely to represent new or otherwise interesting genetic diversity.
3. **Field sampling procedures**, including: distribution of sites in the target region; number of sites in the target region; delineation of the site; distribution of plants sampled within site; number of plants at a site; number of seeds per plant.
4. **Documentation of samples**, including the accurate recording of passport data and the gathering of ancillary specimens (herbarium vouchers, microsymbionts, soil, etc.) as necessary.
5. **Handling of germplasm samples**, so that orthodox seeds, recalcitrant seeds and vegetative material are each processed appropriately in the field and dispatched to the national genebank in a timely and efficient manner, maximizing quality at reception.

Such training could take place in a series of province-level workshops, bringing together potential local collectors and national genebank staff. Training could also be provided on-the-job, i.e. during the course of collecting missions involving national genebank staff and potential local collectors. Trained local collectors could then pass on the skills they acquire to other local people, resulting in the building of a network of local resident collectors throughout a region. A possible model might be for the national genebank to plan to carry out coarse-grid collecting throughout the country, with on-the-job training of extension workers and other potential local collectors wherever possible. This could then be followed up by fine-grid collecting by both the national genebank in some areas, and the local collectors in others.

The efficiency of training could be enhanced by the supply of relevant training materials. Careful thought would need to be devoted to developing training aids of the appropriate level. Owing to the technical problems of locating and identifying wild species, it seems likely that it will be in crop collecting that the direct involvement of locally based people will be of most relevance. It may be difficult to convince extension workers of the benefits of collecting the wild relatives of crops, many of which are 'weeds'. The technical training required to ensure that local collectors have all the appropriate skills to recognize, distinguish and name target wild species would appear unlikely to be justified, and best left to specialists. However, the experience of Costa Rica's InBio with 'parataxonomists' clearly demonstrates that it is possible to teach interested lay persons enough scientific taxonomy in a relatively short period to allow them to function efficiently as biodiversity collectors (Janzen *et al.* 1993). Modern identification aids, using novel approaches such as multimedia, may well make an increasingly important contribution in this field in the future. It should also be remembered that local people use, and have considerable knowledge of, many of the plants growing around them, often using folk classifications which are often remarkably congruent with the results of scientific taxonomy.

The support of the national genebank to its network of local collectors would not be limited to training. Staff would be required to give guidance to local collectors and supervise their efforts. They may also need to supply some materials and equipment, such as collecting bags, perhaps silica gel and air-tight containers for samples of orthodox seeds, maps, pH kits and collecting forms. It might also be necessary in some cases to provide some limited financial support, for example for the dispatch of samples to the national genebank.

Conclusion

This discussion should not be interpreted as implying that a national genebank can or should completely abdicate its responsibility for collecting in favour of local delegates, professional or otherwise, restricting itself entirely to motivating and training them. There are always likely to be regions where no suitable locally based collectors can be identified. Also, no matter how interested and trained, local collaborators will have other duties and responsibilities competing for their time and so may not in practice be able to devote the necessary effort to the extra task of collecting. The active involvement of locally based people in germplasm collecting would, however, allow national genebank staff to concentrate their fieldwork on activities requiring their specialist technical expertise. Examples include relatively rare or obscure taxonomic groups and cases where more than the basic passport data are required by the prospective users of the material. Even if little germplasm is in the end acquired through local collectors, there are obvious adavantages in public awareness to a national genebank encouraging a network of key locally based people sensitized and trained in plant genetic resources conservation – resident 'paraconservationists'. An approach to the collecting of plant genetic resources which considers the advantages of the active involvement of various categories of locally based people clearly has great potential value in helping national programmes meet their goals when staff and financial shortages are coupled with rising public expectations for more effective conservation.

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Résumé

Un plus pour la collecte de ressources phytogénétiques par les programmes nationaux

Le présent article passe en revue les raisons pour lesquelles une banque de gènes nationale pourrait vouloir envisager la participation active de différents types de partenaires - individus ou structures travaillant sur place telles que services de vulgarisation gouvernementaux et les ONG - à son programme de collecte. Il décrit les façons d'organiser ce type de collaboration et ses répercussions sur le rôle global de la banque de gènes en question. On suggère en particulier que les banques de gènes nationales peuvent jouer un rôle important au niveau de la formation.

Resumen

Criterios complementarios para la recolección de recursos fitogenéticos en los programas nacionales

Este artículo se ocupa de las razones por las que un banco nacional de genes puede tomar en consideración, en su programa de recolección, la participación activa de diferentes tipos de interlocutores, especialmente personas que se encuentren en el lugar y estructuras locales como los servicios gubernamentales de extensión y las ONG. Se describen las maneras en que puede organizarse este tipo de colaboración y se consideran sus repercusiones en la función global de los bancos de genes. Se indica, en particular, que los bancos de genes nacionales pueden desempeñar una importante función de capacitación.

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Identification key to Brazilian populations of wild peanut, *Arachis sylvestris* (A.Chev.) A.Chev.

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Summary
A key organized with organographical and agricultural information from laboratory and field conditions, with 17 populations of one species of peanut (*Arachis sylvestris* (A.Chev.) A.Chev.), is presented. The key is subjected to modifications as data from new populations become available. It starts with general characteristics of the species and follows through to those found in each population. The key is intended for research purposes, to be used by active germplasm banks, curators of *Arachis* and by researchers working on populations of this species.

Introduction
Arachis sylvestris has the largest geographical distribution in the peanut genus, which facilitates its use in population studies.

This paper describes both the general features that are common for all populations and the detailed population-specific characters. This information is most useful for peanut researchers as well as the curators of active germplasm banks of *Arachis* species for better management of the accessions.

Material and methods
Seventeen Brazilian populations were chosen (Fig. 1), including distant and adjacent groups. After 4 years of laboratory and field observations the data gathered were used for the identification key of *A. sylvestris* populations (Chevalier 1929, 1933). The key has a sequential alphanumerical code for each item, and is arranged dicotomically. Both morphological and agricultural data are included in the key for general and specific characters.

The field observations were made at the Instituto Agronômico de Campinas SP, Brazil, located outside the geographical area of distribution of *A. sylvestris* (Fig. 1). Cultivated lines containing 10 plants of each original population were used (IBPGR 1990; Krapovickas and Gregory 1994). The laboratory data were obtained at the National Germplasm Center (Centro Nacional de Pesquisa de Recursos Genéticos e Biotecnologia/Empresa Brasileira de Pesquisa Agropecuária, CENARGEN/EMBRAPA) in Brasilia DF, Brazil, and at the Genetics Department of the Universidade Estadual Paulista (UNESP) University campus of Botucatu, State of São Paulo, Brazil. The measurements are reported in centimetres, other data used are from the list of descriptors (IBPGR and ICRISAT 1992; Veiga 1994).

Results

I. General characters
Data obtained from 17 populations showed annual plants, main root axial, without tubercles and roots in the branches. Prostrate or decumbent cotyledonary lateral branch, plant height with 5.0-41.1 cm in length, plant spread 46.8-208.8 cm. Cotyledonary lateral branch 0.3-0.8 cm thick, and main stem 0.4-1.1 cm thick. Alternate branching 2:2:2 or 1:2:1. Concatenate fruits, indehiscent, maximum of 2 segments separated by isthmus, one seed each, smooth peg hairy only at the base, pegs 11-66 x 0.1-0.2 cm, segment of pod oval-rounded but with variable forms, with short or absent beak, without reticulation, with longitudinal veins slightly salient, with dense hair before the maturation, pods 1.0-1.4 x 0.4-0.7 cm. Seeds with tan colour, beaked, 0.5-1.1 x 0.3-0.6 cm. Leaflets with hairs on the lower face and with or without them on the upper face, with or without bristles on the lower face, mucronate on the apex, border hairy, marginal vein visible, 1.4-4.6 x 0.8-0.20 cm. Petiole 1.2-2.8 cm long, rachis 0.5-1.8 cm long and petiolule 0.1-0.2 cm long. Stipule filiform, smooth marginal with hair, the free part of stipule 0.8-1.5 cm and 0.5-1.2 cm adnate. Flowers papilionate, with purplish lines on the back face of the standard, wings yellowish 0.59-0.72 x 0.38-0.49 cm, standard orange 0.77-1.18 x 1.13-1.44 cm, calyx lobulate with 4 teeth, calyx tube green or purplish 2.08-6.38 cm long, hairy, with little complete flowers sometimes open others possibly cleistogamous, inflorescence with 0.1-1.0 cm long.

Native plant of Brazil, with the largest geographical distribution area in the genus *A. sylvestris*.

II. Specific characters

1. Leaflet hairy on both faces, number of days to maturity: short (<270 days), medium (271-330 days) or long (>331 days): .... **1a-1b**.

1a. Leaflets lower face, with bristles, branches purplish or greenish, segment of pod diameter narrow (<0.5 cm), medium (0.5-0.6 cm) or large (> 0.6 cm), leaflet length medium (2.5-3.5 cm) or large (>3.5 cm): .... **1a1-1a4**.

1a1. Plant height very long (>20.1 cm), with or without (n+1) branches on the main stem apex, branches purplish or greenish, segment of pod of medium length (1.1-1.3 cm), and width medium or large, main stem thickness medium (0.6-0.7 cm) and cotyledonary lateral branch thickness medium (0.4-0.5 cm), the number of days to maturity cycle

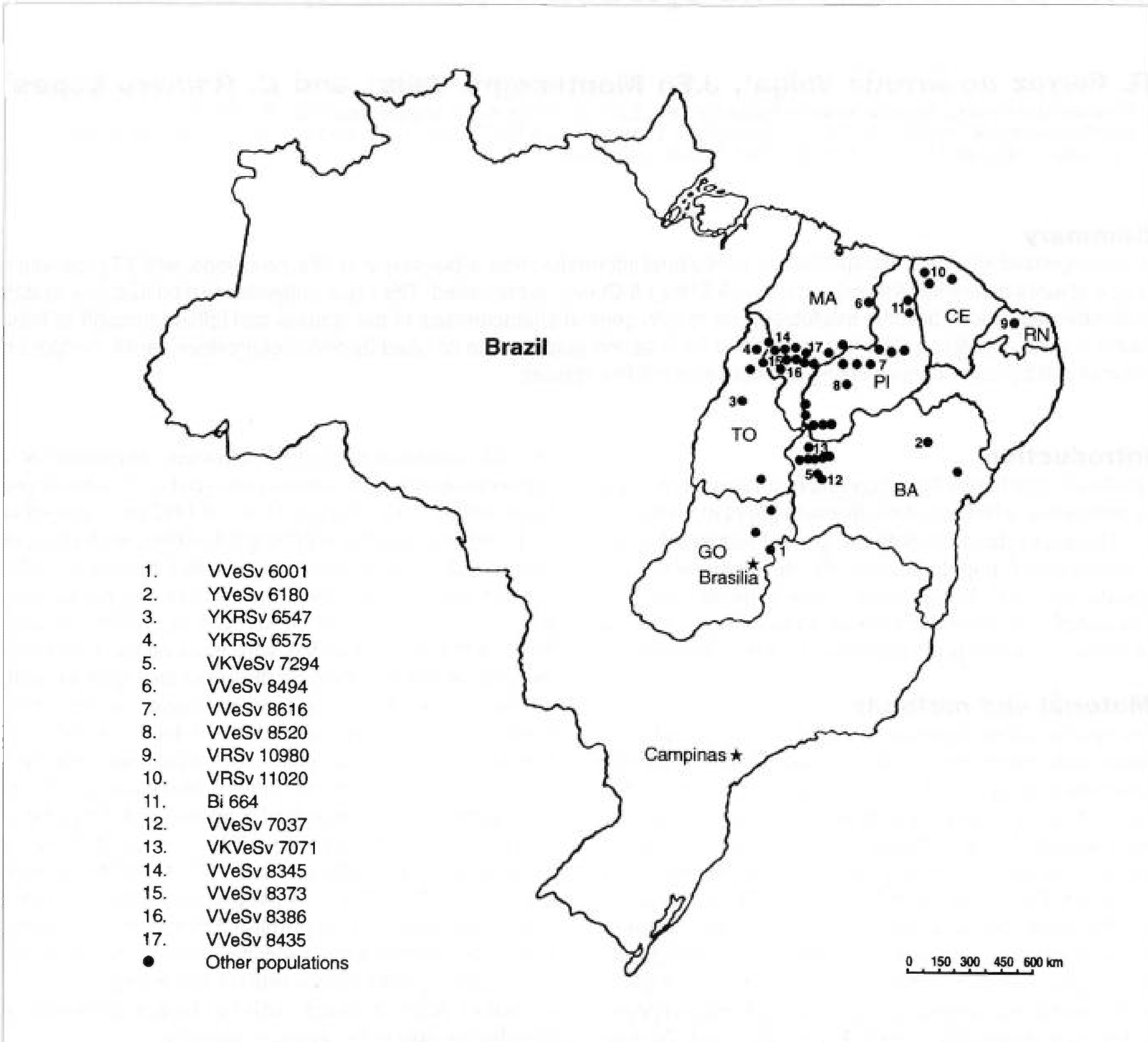

Fig. 1. Collecting sites of Brazilian populations of *Arachis sylvestris* (A.Chev.) A.Chev. States are: MA=Maranhão, CE=Ceará, RN=Rio Grande do Norte, PI=Piauí, TO=Tocantins, BA=Bahia and GO=Goiás.

is long, length of leaflet is medium or long, with medium or wide width: .... **1a1.1-1a1.2.**

1a1.1. Main stem without branch on apex, plant spread very wide (>100.1 cm), light green-ash leafage, purplish branch, pod segment width large, apical leaflet wide-elliptic and basal leaflet ovate, number of days for peak flowering within 122 days, leaflet length large (>3.5 cm) and wide (>1.7 cm), three insertion levels of reproductive branches in the main stem: **Population[1] VVeSv 6180/BA (2).**

1a1.2. Main stem with branch on apex, plant spread narrow (<60.0 cm), green-ash leafage, green branch, medium segment of pod width, apical leaflet obovate and the basal leaflet elliptic, peak flowering within 143 days, leaflet length medium (2.5-3.5 cm) and width medium (1.3-1.7 cm), four insertion levels of reproductive branches in the main stem: **Population VKRSv 6575/TO (4).**

1a2. Plant height long (15.1-20.0 cm), scarce branches on the apex of the main stem, purplish or greenish branch, wide segment of pod diameter and with short length (<0.5 cm) or medium (1.1-1.3 cm), main stem thickness medium (0.6-0.7 cm), cotyledonary lateral branch thin or medium, leaflet length and medium width: .... **1a2.1-1a2.2.**

1a2.1. Plant spread medium (60.1-80.0 cm) light green leafage, green branch, medium segment of pod length, leaflets wide-elliptic, cotyledonary lateral branch width thin (<0.4 cm), number of days to maturity – long cycle, peak flowering within 179 days, three insertion levels of reproductive branches in the main stem: **Population VKRSv 6547/TO (3).**

.1a2.2. Plant spread narrow (<60.0 cm), green-ash-brilliant leafage, purplish branch, short segment of pod length, apical leaflet obovate and basal leaflet wide-elliptic, cotyledonary lateral branch medium (0.4-0.5 cm), number of days to maturity – short cycle, peak flowering within 133 days, four insertion levels of reproductive branches in the main stem: **Population_VRSv 11020/CE (10).**

1a3. Plant height medium (10.1-15.0 cm), with scarce (n+1) branches on the main stem apex, purplish branch, segment of pod length short (<1.1 cm) and medium width, main stem thin or medium, cotyledonary lateral branch medium, leaflet length medium and narrow or medium width, two insertions levels of reproductive branch in the main stem: .... **1a3.1-1a3.2.**

1a3.1. Plant with scarce branchew, decumbent plant spread narrow (<60.0 cm), green-ash leafage, apical leaflet elliptic and basal leaflet ovate, main stem width thin (<0.6 cm), leaflet width narrow (<1.3 cm), number of days to maturity - short cycle, peak flowering within 112 days: **Population VKVeSv 7294/BA (5).**

1a3.2. Plant with compact branches, prostrate, plant spread medium (60.1-80.0), green leafage, apical leaflet wide-obovate and basal leaflet wide elliptic, main stem width medium (0.6-0.7 cm), leaflet width medium (1.3-1.7 cm), number of days to maturity – medium cycle, peak flowering within 154 days: **Population VVeSv 8345/MA (14).**

1a4. Plant height short (<10.0 cm), with scarce (n+1) branch on the main stem apex, purplish branch, segment of pod length medium (1.1-1.3 cm) and narrow or medium width, plant height medium thick, cotyledonary lateral branch medium thick, leaflet length and width medium: **1a4.1-1a4.2.**

1a4.1. Branch prostrate (n+1), plant spread medium (60.1-80.0), green leafage, medium segment of pod width, apical leaflet wide-obovate and basal leaflet suborbicular number of days to maturity – short cycle, peak flowering within 141 days, four insertion levels of reproductive branches in the main stem: **Population VVeSv 8616/PI (7).**

1a4.2. Branch decumbent (n+1), plant spread narrow (<60.0 cm), green-ash leafage, narrow pod width, apical leaflet elliptic and basal leaflet wide elliptic, number of days to maturity – medium cycle, peak flowering within 180 days, two insertion levels of reproductive branches in the main stem: **Population VVeSv 8435/MA (17).**

1b. Leaflets lower face without bristles, branches purplish, segment of pod diameter medium (0.5-0.6 cm) or large (>0.6 cm), leaflets of medium length (2.5-3.5 cm): .... **1b1-1b3.**

1b1. Plant height very long (>20.1 cm), with decumbent cotyledonary lateral branch, plant spread very wide (>100.1 cm), leafage light green, segment of pod length long (>1.3 cm), main stem diameter thick (>0.7 cm) and cotyledonary lateral branch diameter thick (>0.5 cm), four insertion levels of reproductive branches in the main stem: **Population VVeSv 6001/GO (1).**

1b2. Plant height medium (10.1-15.0 cm), with cotyledonary lateral branch prostrate, plant spread very wide (>100.1 cm), green-ash leafage, pod length medium (1.1-1.3 cm) and medium width, number of days to maturity – medium cycle, peak flowering within 133 days, apical leaflet shape wide-obovate and basal leaflet shape wide-elliptic, leaflet width narrow (<13 cm), plant height medium thick (0.6-0.7 cm) and cotyledonary lateral branch medium thick (0.4-0.5 cm), three insertion levels of reproductive branches in the main stem: **Population VRSv 10980/RN (9).**

1b3. Plant hmight short (<10.0 cm), cotyledonary lateral branch prostrate, plant spread medium (60.1-80.0 cm), green or green-ash leafage, pod length medium (1.1-1.3 cm) and width medium, apical leaflet wide-obovate and basal leaflet wide-elliptic, number of days to maturity –

[1] Abbreviations for team member collectors: **Sv** = Glocimar Pereira da Silva, **V** = José Francisco Montenegro Valls, **Ve** = Renato Ferraz de Arruda Veiga, **R** = V. Ramanatha Rao, **K** = Antonio Krapovickas.**( )** = Field number of each population. Locality: **MA** = State of Maranhão, **GO** = State of Goiás, **RN** = State of Rio Grande do Norte, **PI** = State of Piauí, **BA** = State of Bahia, **TO** = State of Tocantins, **CE** = State of Ceará (Brazil).

short or medium cycle, leaflet width medium (1.3-1.7 cm), main stem thickness diameter medium (0.6-0.7 cm) and cotyledonary lateral branch thickness medium (0.4-0.5 cm), four insertion levels of reproductive branches in the main stem: .... **1b3.1-1b3.2.**

1b3.1. Green leafage, number of days to maturity – medium cycle, peak flowering within 180 days: **Population VVeSv 7037/BA (12).**

1b3.2. Green-ash leafage, planting collecting cycle short, peak flowering within 133 days: **Population Bi 664/PI (11).**

2. Leaflet glabrous on upper face and hairy on lower face, cycle from number of days to maturity medium (271-330): .... **2a-2b.**

2a. Leaflets with bristles on low face, prostrate branch (n+1), plant spread: medium (60.1-80.0 cm), plant height short (<10.0 cm) or medium (10.1-15.0 cm), branch purplish or green, segment of pod length medium (1.1-1.3 cm), main stem thickness medium (0.6-0.7 cm), cotyledonary branch thickness medium (0.4-0.5 cm), leaflet narrow (<1.3 cm) or medium (1.3-1.7 cm): .... **2a1-2a2.**

2a1. Plant height short (<10.0 cm), green leafage, purplish branch, pod width (>0.6 cm), apical leaflet orbicular and basal leaflet wide-elliptic, peak flowering within 155 days, leaflet with short length (<2.5 cm) and narrow width, three insertion levels of reproductive branches in the main stem: **Population VVeSv 8494/MA (6).**

2a2. Plant height medium (10.1-15.0 cm), light green leafage, green branch, pod width medium (0.5-0.6 cm), apical leaflet elliptic and the basal leaflet wide-elliptic, peak flowering within 153 days, leaflet length medium (2.5-3.5 cm) and width medium, four insertion levels of reproductive branches in the main stem: **Population VVeSv 8373/MA (15).**

2b. Leaflets without bristles on the lower face, prostrate branch (n+1), plants diameter narrow (<60.0 cm), medium (60.1-80.0 cm) or wide (80.0-100.0 cm), branches purplish, pod length medium (1.1-1.3 cm) or long (>1.3 cm), leaflet medium (1.3-1.7 cm): .... **2b1-2b2.**

2b1. Plant height medium (10.1-15.0 cm), plant spread medium (60.1-80.0 cm) or wide (80.0-100.0 cm), green leafage, pod length medium or long and leaflet width medium (0.5-0.6 cm), leaflet length medium (2.5-3.5 cm), main stem thickness medium (0.6-0.7 cm), cotyledonary lateral branch thickness medium (0.4-0.5 cm), four insertion levels of reproductive branches in the main stem: .. **2b1.1-2b1.2.**

2b1.1. Plant spread medium, long pod length, peak flowering within 154 days, apical leaflet elliptic and basal leaflet wide-elliptic: **Population VVeSv 8386/MA (16).**

2b1.2. Plant spread wide, medium pod length, peak flowering within 142 days, apical leaflet wide-obovate and basal leaflet wide-elliptic: **Population VKVeSv 7071/BA (13).**

2b2. Plant height short (<10.0 cm), plant spread narrow, green-ash leafage, pod medium length and width medium (0.5-0.6 cm), apical leaflet elliptic and basal leaflet wide-elliptic, peak flowering within 154 days, leaflet length small (<2.5 cm), main stem thin width (<0.6 cm) and cotyledonary lateral branch thin width (<0.4 cm), two insertion levels of reproductive branches in the main stem: **Population VVeSv 8520/PI (8).**

Conclusions

1. The key presented here shows which populations of *A. sylvestris* are most similar. They can be classified in four groups (1.1, 1.2, 1.3 and 1.4) (Fig. 2):

1.1. VVeSv 6180, VKRSv 6575, VKRSv 6547, VRSv 11020, VKVeSv 7294, VVeSv 8345, VVeSv 8616 and VVeSv 8435, involving populations of the following States of Brazil: Tocantins, Ceará, Bahia, Maranhão and Piauí;
1.2. VVeSv 6001, VRSv 10980, VVeSv 7037, Bi 664, involving populations of the following States of Brazil: Goiás, Rio Grande do Norte, Bahia and Piauí;
1.3. VVeSv 8494 and VVeSv 8373, both of Maranhão State in Brazil;
1.4. VVeSv 8386, VKVeSv 7071 and VVeSv 8520, involving populations of the following States of Brazil: Maranhão, Bahia, and Piauí.

2. The classification proposed by the key could be useful for morphological characterization of each population of *A. sylvestris* if a genebank contains these germplasm acessions. It can be seen that they are separated by only a few characters.

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1a. Leaflets hairy on abaxial face, and with bristles on abaxial face:	1b. Leaflets hairy on abaxial face, and without bristles on abaxial face:	2a. Leaflets glabrous on adaxial face, and with bristles on abaxial face:	2b. Leaflets glabrous on adaxial face, and without bristles on abaxial face:
1a1. 1a1.1. Without branches on the main stem apex:			
VVeSv 6180/BA(2)			
1a1.2 With branches on the main stem apex:			2b1. Plant height medium, leaflet medium:
VKRSv 6575/TO(4)			
1a2. 1a2.1. Plant spread medium:	1b1. Plant height long, branches decumbent:		2b1.1. Plant spread medium:
VKRSv 6547/TO(3)	**VVeSv6001/GO(1)**		**VVeSv 8386/MA(16)**
1a2.2. Plant spread narrow:	1b2. Plant height medium, branch prostrate:	2a1. Plant height long, purplish:	2b1.2. Plant spread wide:
VRSv 11020/CE(10)	**VRSv10980/RN(9)**	**VVeSv8494/MA(6)**	**VKVeSv 7071/BA(13)**
1a3. 1a3.1. Plant compact, scant, decumbent:	1b3. Plant height long:	2a2. Plant height medium, green:	2b2. Plant height short, leaflet small, plant spread narrow:
VKVeSv 7294/BA(5)	1b3.1. Leaflet green:	**VVeSv 8373/MA(15)**	**VVeSv 8520/PI(8)**
1a3.2. Plant compact abundant, prostrate:	**VVeSv7037/BA(12)**		
VVeSv 8345/MA(14)	1b3.2. Leaflet green-ash:		
1a4. 1a4.1. Leafage green, plant prostrate:	**Bi 664/PI(11)**		
VVeSv 8616/PI(7)			
1a4.2. Leafage green-ash, plant decumbent:			
VVeSv 8435/MA(17)			

Fig. 2. Key summary to identification from 17 populations of *Arachis sylvestris* (A.Chev.) A.Chev. Abbreviations: States: Bahia (BA), Ceará (CE), Goiás (GO), Maranhão (MA), Piauí (PI), Rio Grande do Norte (RN),Tocantins (TO); Collectors: Antonio Krapovickas (K), Glocimar Pereira da Silva (Sv), José Francisco Montenegro Valls (V), Luciano de Bem Bianchetti (Bi), Renato Ferraz de Arruda Veiga (Ve), V. Ramanatha Rao (R); Field numbers are shown in parentheses.

Résumé

Clé d'identification des populations brésiliennes d'arachide,* Arachis sylvestris *(A. Chev.) A.Chev.

Le présent article décrit une clé organisée avec l'information organographique et agricole provenant de conditions de laboratoire et de terrain, avec 17 populations d'une espèce d'arachide (*Arachis sylvestris* (A.Chev.) A. Chev.). La clé est soumise à des modifications à mesure que parviennent des données sur de nouvelles populations. Elle commence par des caractéristiques générales de l'espèce et continue par celles trouvées dans chaque population. La clé est faite avec intention de servir à la recherche; elle sera utilisée par des banques de matériel génétique actif, des conservateurs d'*Arachis* et par des chercheurs travaillant sur des populations de cette espèce.

Resumen

Clave de identificación de las poblaciones brasileñas de cacahuete,* Arachis sylvestris *(A. Chev.) A. Chev.

Se presenta una clave organizada con información organográfica y agrícola de laboratorios y de condiciones de campo, con 17 poblaciones de una especie de cacahuete (*Arachis sylvestris* (A. Chev.) A. Chev.). Esta clave podrá sufrir modificaciones a medida que se disponga de datos de nuevas poblaciones. Se comienza por las características generales de las especies y se sigue con aquéllas que se han encontrado en cada población. La clave se aplica para fines de investigación, para que sea utilizada por bancos de germoplasma activos, conservadores de *Arachis* e investigadores que se ocupan de las poblaciones de esta especie.

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Studies on the *in vitro* conservation of potato (*Solanum tuberosum* L.) germplasm in Pakistan

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Summary
Meristem-tip cultures of potato (*Solanum tuberosum* L.) were established on Murashige and Skoog (MS) medium containing benzyl adenine and naphthalene acetic acid; and multiplied by subculturing on hormone-free MS medium. *In vitro* conservation was studied using two temperature regimes (17 and 25°C) and four osmotic stress levels (0, 1, 2 and 3% w/v mannitol) over a period of 6 months. Storage period and incubation temperature significantly influenced potato culture survival and growth. Stress levels significantly affected the shoot growth, but had no significant effect on survival. Culture survival decreased with high temperature (25°C) and longer storage period.

Introduction
Grout and Henshaw (1978) stated that seed storage is applicable to many species as a method of conservation, but is less suitable for general use with potato, because of strong heterozygosity in many cultivars and various degrees of sterility. A further disadvantage is that discrete clones cannot be maintained by the use of seed for storage. Much potato germplasm is conserved by tuber propagation, which is not ideal since valuable accessions are exposed to a wide range of environmental hazards, both in the field and in storage. Thieme (1992) considered *in vitro* conservation to be a practical alternative to field collections which are expensive, vulnerable and difficult to maintain, especially for crop plants that can be vegetatively propagated such as the potato.

Tay and Liu (1992) showed that the slow growth of potato plantlets in hard agar could be exploited for germplasm conservation to retard culture growth. Westcott *et al.* (1977) successfully stored potato cultures for 6 months using minimal or enriched media and growth inhibitors.

The *In vitro* Conservation Laboratory of the Plant Genetic Resources Institute (PGRI) at the National Agricultural Research Centre, Islamabad has been established with the objective of conserving vegetatively propagated crops and fruit trees by the use of *in vitro* conservation techniques. Preliminary work was started on the *in vitro* conservation of potato, using the minimal growth techniques.

Materials and methods
Potato (*Solanum tuberosum* var. Desiree red) shoots were taken from plants grown in the glasshouse of the National Agricultural Research Centre, Islamabad. Shoots containing 3-4 nodes were harvested, defoliated and sectioned into single nodes leaving a small petiole. Nodes were disinfected for 10 minutes using 20% sodium hypochlorite solution with 1% active chlorine and 1 drop of Tween 20/50 ml of solution. The nodes were rinsed three times with sterile distilled water. The meristems were excised with the aid of a dissecting microscope; efforts were made to maintain a uniform size of 5.0 mm.

For meristem-tip culture establishment Murashige and Skoog's (1962) nutrient medium (MS) + 1.0 mg/L benzyl adenine (BA) + 0.05 mg/L naphthalene acetic acid (NAA) was used. Other additives included were sugar (20 g/L), inositol (100 mg/L), thiamine-HCl (2.0 mg/L), nicotinic acid (0.5 mg/L) and pyridoxine-HCl (0.5 mg/L). These supplements and growth regulators were added to the MS inorganic salts before the pH adjustment. The pH was adjusted to 5.8 with 1N or 0.1N sol}tion of NaOH or HCl prior to the addition of 0.8% agar. Culture medium was dispensed at 10 ml per test tube and autoclaved at 121°C for 20 min. Each test tube was inoculated with meristem a day after media preparation. Cultures were incubated at 25±2°C constant temperature with a 16-h photoperiod. The above-mentioned MS modified medium was used for the multiplication of the established cultures without using any hormones. A single nodal cutting was placed in each tube, which contained 20 ml medium. After 3-4 weeks, plantlets obtained were again subcultured in the same manner to obtain a large number of plantlets. Minimal growth medium was used for the *in vitro* conservation experiment by modifying MS medium with the addition of 0, 1, 2 and 3% w/v mannitol as osmotica. Medium was dispensed at 20 ml per tube (24x150 mm with screw-cap) and a single nodal cutting was placed in each tube. Two temperature regimes, 17°C (as low) and 25°C (as high, control), were used as incubation temperatures. Data were recorded periodically over a period of 6 months (0, 0.5, 1, 2, 3, 4 and 6 months). Each treatment consisted of 22 replicates. Data were recorded for percentage survival of the cultures and shoot growth (mm) as the percentage of growth over the initial length of explant. The data were analyzed using a 3-factorial analysis of variance for the following factors.

- Factor A = Two temperatures (17 and 25°C)
- Factor B = Four osmotic stress levels (0, 1, 2 and 3% w/v mannitol)
- Factor C = Storage period (0-6 months)

Results and discussion
In vitro survival of the preserved potato plantlets declined significantly with the increase of storage period after 4 months (Fig. 1). While the osmotic stress (0-3% w/v mannitol) had no significant effect on the plantlet survival, the culture survival was significantly higher at the lower temperature regime.

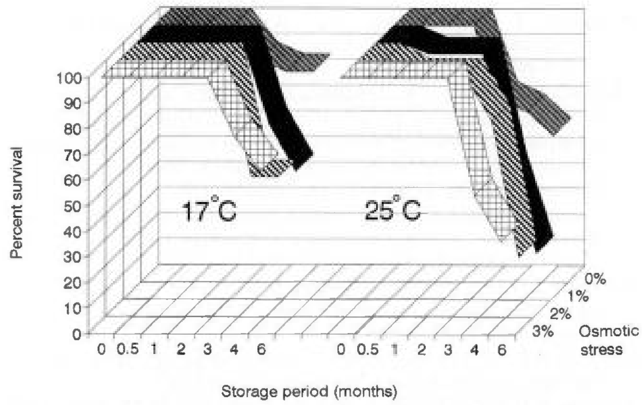

Fig. 1. Effect of temperature and osmotic stress on the survival of *in vitro* stored potato cultures.

After 3 months the survival of plantlets at 17°C and 25°C was 96.6% and 90.3% respectively, but at 6 months it had declined to 62.5% in the former temperature regime and to only 33.8% in the latter regime (Fig. 1). Westcott (1981) reported that a reduction in temperature from 22 to 6°C resulted in an average survival rate of 29% in shoot cultures of six *Solanum* species. However, a switch to a temperature regime of 12/6°C day/night increased the average survival rate of the six species to 83%.

The effect of temperature regime at various stress levels remained non-significant although some encouraging interactions of thewe stress levels with the storage period were observed (mainly after 4 months). In mannitol-free media the survival at 25°C and 17°C was 71.43% and 86.36%, respectively, after 3 months of culture, whereas it was 57.14% and 81.82% after 6 months. However, it may be noted that within each temperature regime survival was higher when cultures were not subjected to stress, and even then the survival of cultures with 3% osmotica at 17°C was higher (63.64%) than at 25°C with any stress level, i.e. from 0 to 3% osmotica (Fig. 1), which indicates the suitability of low temperature for obtaining higher survival of stored cultures. Le and Collet (1988) reported that they successfully cultured potato nodal cuttings in a solidified agar medium at a temperature of 2-4°C and with a photoperiod of 12 h. All 20 cultivars under study were successfully stored for at least 12 months. The technique seems to be promising for germplasm storage and micropropagation of desirable genotypes.

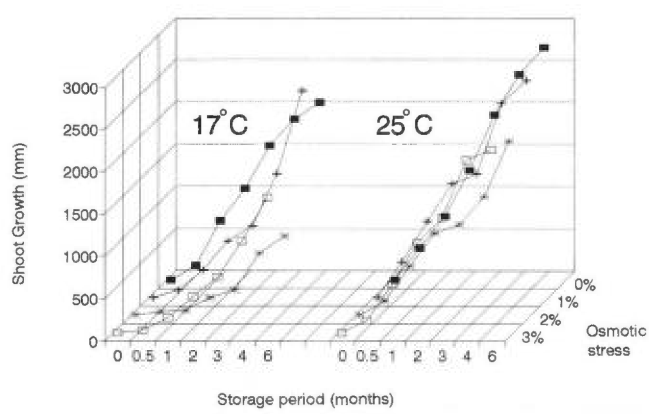

Fig. 2. Effect of temperature and osmotic stress on the shoot growth of *in vitro* stored potato cultures.

The shoot growth was significantly reduced at the lower temperature regime 17°C compared with 25°C. Similarly, shoot growth was significantly reduced with increase in the osmotica (Fig. 2). Chandra and Grag (1992) found that all four Indian tetraploid cultivars of potato that had been conserved *in vitro* on a high osmotica medium had 48 chromosomes, confirming chromosome stability during *in vitro* conservation. However, at 3% osmotica a slight increase in growth over 2% osmotica was observed at both temperatures, but the corresponding growth at each osmotic stress level was always reduced at the low temperature regime. The plantlets showed significant increase in growth over the storage period and likewise the increase in growth was always found to be significantly reduced at the lower temperature. At every stress level the reduction in growth with the progression of storage period was more significant at higher osmotica, whereas the growth of control (0% mannitol) was at par with 1% mannitol. However, it was observed that reduction in growth (23.2%, 2194 mm) due to lowering of temperature alone (0% osmotica) was more than the reduction in growth at 25°C and 3% osmotic stress (20.8%, 2264 mm), whereas the growth was only 1696 mm (40.65% reduction) in the case of 17°C with 3% mannitol at 6 months (Fig. 2). The data suggest that 17°C was more suitable for the storage of potato cultures *in vitro* in medium containing either no osmotica or a 3% w/v mannitol. The results also indicate the merit of further investigations on the conservation of shoot-tips at lower temperature at appropriate daylength to confirm the findings of Le and Collet (1988).

Thus for the *in vitro* conservation of potato cultures (var. Desiree red), a 17°C incubation temperature alone (i.e. 0% osmotica) was found to be more suitable for slow growth, as a high percentage of survival (81.8%) was obtained in this case along with the significant reduction of plantlet shoot growth (except 3% osmotica with 17°C). Goodwin *et al.* (1980) found that potato shoots cultured on solid medium without hormones produced aerial tubers about 12 weeks after inoculation. Similarly, in this study, the cultures kept at 17°C without osmotic stress produced aerial stem tubers at a later stage. Those stem tubers can also serve as storage organs. Zaida and Elizabeth (1991) obtained the most clear-cut enhancement of tuberization by decreasing the hours of light, on very late clones. At 4 weeks, tuberization was about 90% at 12 h light, 40% at 16 h and 10% at 20 h. Sim}larly, Schilde-Rentschler *et al.* (1985) have also concluded that tubers produced *in vitro* can be used for potato germplasm storage and distribution.

The next best suitable medium is the one containing 3% osmotica in conjunction with a 17°C incubation temperature, because of its high regeneration capacity on subculturing after storage and acclimatization to soil environment, i.e. 100%. The tubers produced in 0% osmotica at 17°C treatment showed 100% regeneration/sprouting and developed into healthy

plants, acclimatized to soil conditions. Thieme (1992) has also described a technique for *in vitro* tuberization of tissue taken from tetraploid and dihaploid clones, varieties and wild potato species, and storage of the microtubers in the dark at low temperature. Maintenance of the collection is economical because energy and labour inputs are low. The material is easily propagated and the method can be adapted for a wide range of genotypes.

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Résumé

Etudes sur la conservation* in vitro *de matériel génétique de pomme de terre* (Solanum tuberosum *L.) au Pakistan

Des cultures de méristèmes apicaux de la pomme de terre (*Solanum tuberosum* L.) ont été établies sur un milieu semi-liquide (Murashige et Skoog - MS) contenant du benzyladénine et de l'acide naphtalène acétique, et multipliées par repiquage sur un milieu MS exempt d'hormones. On a étudié la conservation *in vitro* en utilisant deux régimes de températures (17°C et 25°C) et quatre degrés de pression osmotique - 0, 1, 2 et 3 % (p/v) de mannitol - sur une période de 6 mois. La durée de la conservation et la température d'incubation ont influé sensiblement sur la survie et la croissance de la culture de la pomme de terre. Les degrés de pression ont eu une influence non négligeable sur le développement des poussew mais n'ont pas eu d'effet notable sur le taux de survie. Ce taux de survie a diminué sensiblement à température élevée (25°C) et dans le cas d'une période de conservation plus longue.

Resumen

Estudios sobre la conservación* in vitro *de germoplasma de papa* (Solanum tuberosum *L.) en el Pakistán

Se establecieron cultivos de ápice de meristemo de papa (*Solanum tuberosum* L.) en un medio de Murashige y Skoog (MS) que contenía benzil adenina y ácido acético de naftaleno; y se multiplicaron mediante subcultivo en medio MS libre de hormonas. La conservación *in vitro* se estudió usando dos regímenes de temperatura (17 y 25°C) y cuatro niveles de presión osmótica (0, 1, 2 y 3% p/v de manitol) durante un período de seis meses. El tiempo de almacenamiento y la temperatura de incubación tuvieron una influencia significativa en la supervivencia y crecimiento del cultivo de papa. Los niveles de presión afectaron de manera considerable el crecimiento del brote pero no tuvieron efectos importantes en la supervivencia. La supervivencia del cultivo disminuía a temperaturas altas (25°C) y en los períodos más largos de almacenamiento.

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Collecting indigenous forage legumes in northern Nigeria

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Summary
Tropical legumes with forage potential have been a neglected genetic resource as far as collecting of indigenous germplasm in West Africa is concerned. However, rapid agricultural intensification means that the genetic diversity of wild species is severely threatened, particularly in the subhumid and semi-arid zones of the region. Furthermore, regional projects dealing with the development of forage technology for improved livestock and crop production have a requirement for legume germplasm with adaptation to the prevailing climatic, edaphic and biotic constraints. Responding to these needs, four trips were conducted from November 1993 to January 1994 in northern Nigeria to collect indigenous forage legume germplasm of herbaceous and subshrub species. In total, 600 samples were collected of which 504 correspond to 66 species of 19 genera in the Papilionoideae subfamily, 53 to five species in the Caesalpinioideae (two genera), and four samples to the Mimosoideae (two genera). The most frequently collected genera were *Indigofera, Alysicarpus, Tephrosia, Crotalaria, Chamaecrista, Zornia, Stylosanthes* and *Desmodium.* Within the overall dry subhumid to semi-arid climate of northern Nigeria, several species seem to prefer particular ecological niches that are frequently characterized by different human or animal influences. Regarding the most relevant plant descriptors that were recorded, particularly outstanding drought tolerance was recorded for *Crotalaria senegalensis, Sesbania bispinosa, Alysicarpus ovalifolius, Chamaecrista rotundifolia, Crotalaria naragutensis* and *Desmodium hirtum.* The collected seed was deposited at the National Animal Production Research Institute, Zaria, with a duplicate at the International Livestock Research Institute genebank in Addis Ababa, Ethiopia. Additional, more focused collecting trips are suggested. Furthermore, collecting of native legume germplasm should expand to other countries of West Africa.

Introduction
In the subhumid and semi-arid zones of West Africa, ruminant nutrition is severely impaired by feed shortages, especially in the dry season. In Nigeria, the problem has been addressed at ILRI (International Livestock Research Institute, formerly International Livestock Centre for Africa - ILCA) by the introduction of forage legumes which can supplement ruminant diets during periods of stress when the native vegetation is inadequate in quality and quantity. Interventions in the form of improved pastures (Otsyina *et al.* 1987) which may contribute to both livestock and crop production (Tarawali 1991a) have been backed up by a programme to evaluate herbaceous forage legumes (Mohamed-Saleem and Otsyina 1984; Tarawali *et al.* 1989; Tarawali 1991b, 1994). This, however, has concentrated largely on the use of introduced species, with little emphasis on indigenous material. As a first step to explore the potential of indigenous plants, several trips to collect native legumes having forage potential were carried out during the 1993/94 dry season in northern Nigeria.

The subhumid zone of West Africa is characterized by 1000-1500 mm annual rainfall and a growing season of 180-270 days; the semi-arid region has an annual rainfall of 400-1000 mm and a growing season of 30-180 days. The length of the growing period, defined as the 'period when there is an excess of precipitation over potential evapotranspiration' forms the basis for the definition of different agro-ecological zones (Jagtap 1990). In northern Nigeria, the semi-arid and subhumid zones include four different agroecological zones: Arid/Semi-arid (A/S), Northern Guinea Savanna (NGS), Southern Guinea Savanna (SGS) and Mid-Altitude Woodland Savanna (WS); the latter lies above a height of 800 m. The predominant soils in these areas have plinthite or ferric properties (FAO/UNESCO 1990).

A rapidly increasing human population, expanding farming communities, increased settlement of formerly transhumant pastoralists and, not least, an increasing number of livestock, put a high pressure on the existing ecological potential. The consequences of such intensification become more and more obvious and mean that in the dry season forage availability is rapidly decreasing. In addition, fallow periods are shortening or becoming non-existent, so that the maintenance of soil physical and chemical structure is threatened. The genetic diversity of such ecosystems is under severe pressure.

Africa's contribution to the world's genepool of pasture and fodder plants is high, but mainly in grasses. Worldwide, 70-75% of grasses, but only 25-30% of legumes used as fodder, are of African origin (Le Houérou 1988). Most of these legumes belong to the Mimosoideae and Papilionoideae subfamilies.

Although the potential of indigenous material is recognized (Agishi 1983; Bayer 1990), there have never been major seed-collecting expeditions for indigenous legumes in northern Nigeria. Collecting of leguminous plants in West Africa has focused on wild relatives of crop plants (Ng 1991). Only one legume species, *Alysicarpus glumaceus,* was collected (Foster 1961).

The collecting trips referred to in this paper are the first ones to be conducted in northern Nigeria. In addition to collecting seed and describing outstanding features of the collected plants, information on collecting sites was recorded. This included both environmental data and habitat description. Such data are expected to enable the identification of preferences of species for particular environmental conditions.

Methods

Four collecting trips, each with a duration of 5-6 days, were made from November 1993 to January 1994 (Fig. 1).

The area covered ranged from 9° to 13° N and 4° to 14° E. different legume species was expected to be high. Only herbaceous and subshrub legumes were collected and the number of plants representing one ecotype was restricted to a maximum of four. The decision to take as many seeds as possible from only a few plants was based on the assumption that the best way to reach the highest diversity of genotypes of predominantly self-pollinating legume species was to collect seeds from only a few plants at as many sites as possible (Brown and Marshall 1993; Reid and Strickland 1983; Schultze-Kraft 1978).

At each collecting site, environmental data were recorded such as precise location, texture and pH of soil,

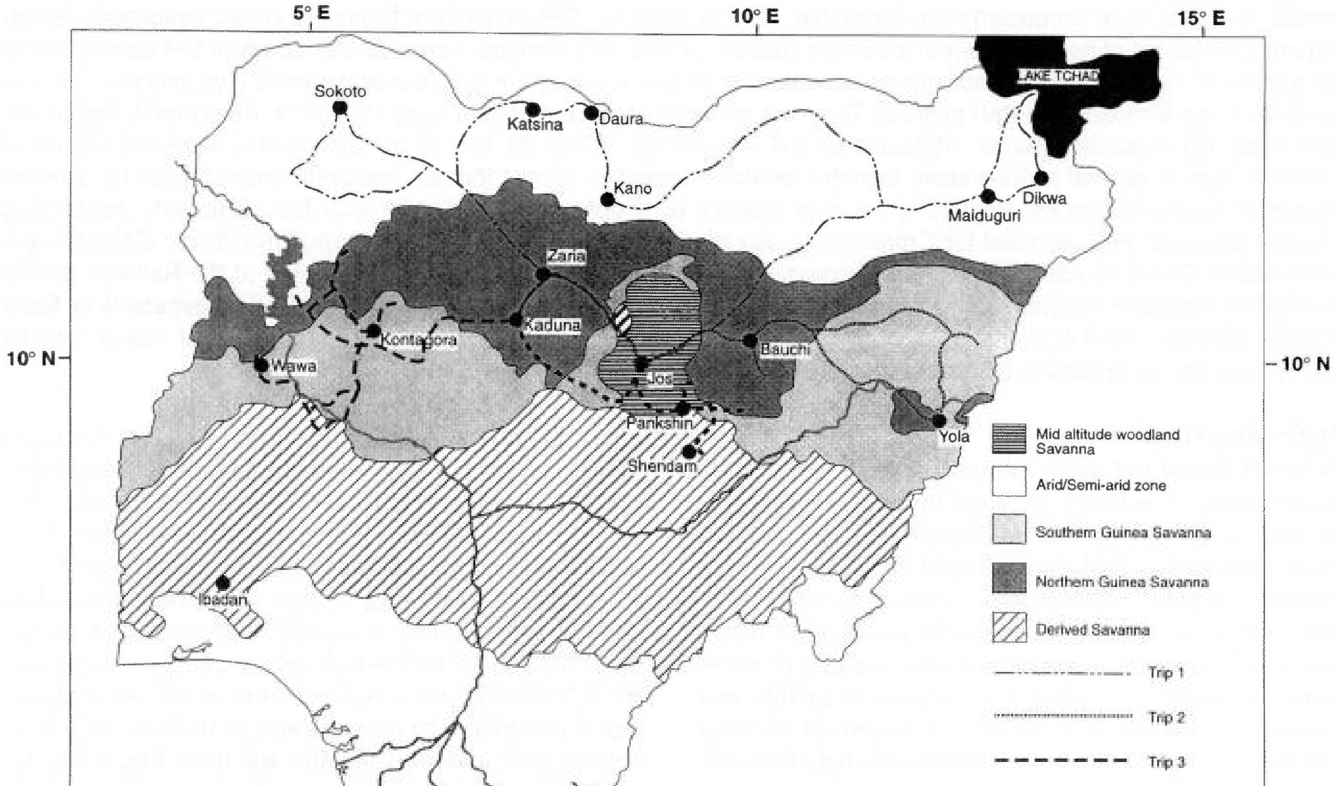

Fig. 1. Collecting trips in northern Nigeria (map based on climatological data from the IITA database, excluding the influence of cultivation).

Because the dry season starts earlier in the far north, the first trip covered the Arid/Semi-arid Zone from Sokoto to Lake Tchad. The second and third trips included the east (the area between Kaduna and Yola) and west (the area between Kaduna and Wawa) of northern Nigeria, respectively. The last trip was made to the Jos plateau, an area southeast of Jos and characterized by mid-altitude, low temperatures and relatively high rainfall with a 5-6 month growing period. In total, collections were made at 67 sites. The distance between the sites varied between 50 and 100 km, preference being given to sites where the numbev of

topography and surrounding vegetation. Information such as length of growing period, potential evapotranspiration and agro-ecological zone was provided by the Agroecological Studies Unit of the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria.

The habitat was classified at two levels: first a rough subdivision was made into bush, roadside or trail; for a more detailed description these were further divided into a total of 25 categories (e.g. irrigated farmland, riverside, edge of forest, former road, etc.). The plants were described according to the collecting sheet of the former ILCA,

Nairobi, Kenya, which includes ranking (0 to 5, where 0 = least) to determine the relative number of flowers, proportion of mature seeds, leafiness, relative abundance and intensity of grazing. Drought tolerance was added and was defined as the percentage of green leaves in relation to all leaves on one plant. Identification of genus and species followed Hutchinson and Dalziel (1958) and Ibrahim (1989). In some cases herbarium specimens were collected, mainly when a species could not be identified in the field. Seeds of different plants were put in separate paper bags. Collected seeds were stored at thm National Animal Production Research Institute (NAPRI), Zaria, Nigeria; duplicates were sent to the ILCA genebank in Addis Ababa, Ethiopia. Photographs were taken of most of the habitats to illustrate relationships between ecotypes and specific environmental influences. Detailed information on the methodology and the results are presented by Kaleja (1994).

Results and discussion

Seeds from 600 ecotypes of 74 identified and some unidentified species were collected. Most species belonged to the subfamily Papilionoideae, five species to the Caesalpinioideae, and two to the subfamily Mimosoideae. Table 1 shows the number of species and ecotypes per genus and the agro-ecological zone where the material was predominantly found.

Table 1. Overview of the different genera collected in Nigeria

Genus	No. of species	No. of ecotypes	Agro-ecological zone*
Subfamily Papilionoideae			
Abrus	1	1	WS
Adenodolichos	1	3	no preference
Aeschynomene	2	8	A/S, NGS
Alysicarpus	4	94	A/S, SGS
Calopogonium	1	2	no preference
Clitoria	1	1	SGS
Crotalaria	12	64	NGS
Desmodium	7	20	NGS
Eriosema	1	2	NGS, SGS
Glycine	2	3	NGS,SGS
Indigofera	17	116	NGS
Macrotyloma	1	1	NGS
Pseudarthria	1	1	NGS
Rhynchosia	1	1	WS
Sesbania	3	14	A/S
Stylosanthes	2	35	NGS
Tephrosia	6	85	NGS
Vigna	2	8	SGS
Zornia	1	45	A/S
Subfamily Caesalpinioideae			
Cassia	2	8	NGS
Chamaecrista	3	45	NGS
Subfamily Mimosoideae			
Acacia	1	1	A/S
Mimosa	1	3	A/S

* **A/S** - Arid/Semi-arid; **NGS** - Northern Guinea Savanna; **SGS** - Southern Guinea Savanna; **WS** - Mid-Altitude Woodland Savanna.

Herbarium samples were made for 38 species. The unidentified species belonged to the genera *Adenodolichos, Aeschynomene, Alysicarpus, Crotalaria, Indigofera, Macroptilium, Tephrosia* and *Vigna*.

Both the number of collecting sites and the number of ecotypes and species varied depending on the collecting area: in the dry north (growing period 30-150 days), the smallest number of ecotypes and species was found whereas the largest number of ecotypes was collected in the west (on average, 15 samples per site). Also the number of different species in this area exceeded those from other sites.

For further evaluation, the relationship between environmental data and species occurrence is of particular interest. For example, the number of species found below 200 m asl was clearly higher than those of sites above 800 m asl (30 and 19, respectively). Some of the species seemed to show preference for lowland (e.g. *Calopogonium mucunoides*) or highland habitats (e.g. *Indigofera capitata).* However, as only a few samples of these species were found, preferences can only be supposed.

Regarding soil texture, only general statements can be made. The majority of the legumes grew on loamy sand, loamy clay or sandy clay. With respect to pH, *Desmodium velutinum, Indigofera paniculata* and *Crotalaria macrocalyx* seem to prefer soils with pH >6. In contrast, *Desmodium barbatum* and *Mimosa pigra* were predominantly found on acid soils (pH around 4). Some species showed no preference for any particular pH; for example, *Chamaecrista rotundifolia* was found on soils with pH values varying from 4.5 to 7.9. Over all the collecting sites the pH ranged from 3.3 to 7.9; field margins and fallow land tended to have low pH values, highest values were for open woodland.

Most sites were in areas with annual rainfall between 900 and 1200 mm and growing periods between 2 and 6 months. Some species were broadly distributed over all growing periods (e.g. *Alysicarpus glumaceus, A. rugosus, Chamaecrista mimosoides, Zornia glochidiata). Indigofera arrecta* and *Sesbania bispinosa* were found mainly in agro-ecological zones with growing periods of only 2-3 months. The majority of species occurred in the Northevn Guinea Savanna zone, which has a growing period of 4-5 months. Sites that were located in the Arid/Semi-arid Zone were characterized by a very low number of ecotypes and species. Nevertheless some of the species found there are of interest because of their potential drought tolerance, including *I. arrecta, Crotalaria senegalensis* and *S. bispinosa.* Most ecotypes of these species still had green leaves while the surrounding herbaceous vegetation was completely dry. Although *Zornia glochidiata* is considered to be an annual, some plants in the Arid/Semi-arid Zone were still green at the end of the dry season.

The influences of human beings and animals on the distribution and variation of species were very visible. On all trips it was observed that there were differences in the number and kind of species found on roadsides, on trails

and in the bush. However, it is not possible to differentiate between influences that increase and those that decrease the variety of species. For example, animals reduce fodder plants by grazing (e.g. extreme overgrazing around waterholes) but they also distribute seeds (e.g. *Stylosanthes* spp. were frequently found on trails). Also human influence can have both effects. In national parks, where vegetation is protected, herbaceous legumes seldom occurred. most of them cannot compete with pressure from grasses (especially *Andropogon* spp.), shrubs or trees. In contrast, on roadsides the number of legume species was relatively high. On farmland the composition of species seems to be determined by time, manner and intensity of farming activities although it was noted that most legumes in such areas were annuals.

One of the most interesting plant characteristics, especially in relation to the legumes' potential as dry season fodder, is drought tolerance. We found considerable variation in this character. In addition to the aforementioned species *C. senegalensis* and *S. bispinosa*, particularly outstanding were *Alysicarpus ovalifolius*, *Chamaecrista rotundifolia*, *Crotalaria naragutensis* and *Desmodium hirtum*. All ecotypes of these species had more than 50% green leaves at the end of the dry season.

Outlook

This collecting of potential forage legumes contributed to the preservation of an important genetic resource which is threatened worldwide. Together with results from subsequent characterization and evaluation of the collected material, the information presented can be a basis for future collecting trips that should focus on smaller, specific areas or on individual species, with the aim of broadening the intraspecific variability. Extending the collecting trips to other West African countries should also be considered.

There is no doubt that in the future legumes will play an increasing role in the subhumid tropics as dry season forage, pioneer plants on degraded and wasteland, as a component in integrated crop-livestock systems to improve soil fertility, or as trap crops for weed and insect pests. Regarding these aspects, subsequent evaluation trials with the collected material will show to what extent indigenous legumes from West Africa can be considered as a promising option.

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Résumé
Collecte de légumineuses fourragères indigènes dans le nord du Nigéria
Les légumineuses tropicales ayant un potentiel fouragère ont été une ressource génétique négligée pour ce qui est de la collecte de matériel génétique indigène en Afrique de l'Ouest. Toutefois, l'intensification rapide de l'agriculture signifie que la diversité génétique des espèces sauvages est gravement menacée, particulièrement dans les zones subhumides et semi-arides de la région. En outre, des projets régionaux ayant trait au développement de techniques fourragères pour l'amélioration de la production animale et végétale ont besoin de matériel génétique de légumineuses pouvant s'adapter aux contraintes climatiques, édaphiques et biotiques existantes. Pour répondre à ces besoins, quatre missions de collecte ont eu lieu entre novembre 1993 et janvier 1994 dans le nord du Nigéria dans le but de récolter du matériel génétique de légumineuses fourragères indigènes provenant d'espèces herbacées et de sous-arbrisseaux. Au total, 600 éãhantillons ont été recueillis dont 504 correspondent à 66 espèces appartenant à 19 genres de la sous-famille des Papilionoideae, 53 à cinq espèces des Caesalpinioideae (deux genres) et quatre échantillons des Mimosoideae (deux genres). Les genres les plus souvent collectés étaient *Indigofera, Alysicarpus, Tephrosia, Crotalaria, Chamaecrista, Zornia, Stylosanthes* et *Desmodium*. Sous un climat comme celui du nord du Nigéria qui va généralement de sub-humide sec à semi-aride, plusieurs espèces semblent préférer des niches écologiques particulières souvent caractérisées par différentes influences humaines ou animales. Concernant les descripteurs de plantes les plus pertinents qui ont été enregistrés, une tolérance particulièrement forte à la sécheresse a été enregistrée pour *Crotalaria senegalensis, Sesbania bispinosa, Alysicarpus ovalifolius, Chamaecrista rotundifolia, Crotalaria naragutensis* et *Desmodium hirtum*. Les semences collectées ont été déposées à l'Institut national de recherche sur la production animale, à Zaria, et des duplications à la banque de gènes de l'Institut international de recherche en matière d'élevage, Addis-Abeba (Ethiopie). On envisage maintenant d'entreprendre d'autres missions de collecte plus ciblées. Par ailleurs, la collecte de matériel génétique de légumineuses indigènes pourrait s'étendre à d'autres pays d'Afrique de l'Ouest.

Resumen
Recolección de legumbres forrajeras autóctonas en el norte de Nigeria
Las legumbres tropicales con potencial forrajero han sido un recurso genético que se ha descuidado en lo que respecta a la recolección de germoplasma autóctono en Africa occidental. Sin embargo, una rápida intensificación agrícola significa que la diversidad genética de las especies silvestres está gravemente amenazada, especialmente en las zonas subhúmedas y semiáridas de la región. Además, los proyectos regionales que se ocupan del desarrollo de la tecnología forrajera para el mejoramiento de la producción ganadera y agrícola tienen necesidad de germoplasma de legumbres que se adapte al clima predominante y a las condiciones edafológicas y bióticas. En vista de estas necesidades, entre noviembre de 1993 y enero de 1994, se efectuaron cuatro viajes al norte de Nigeria para recoger germoplasma de legumbres forrajeras autóctonas de especies herbáceas y subarbustivas. Se recogieron en total 600 muestras, 504 de las cuales procedentes de 66 especies de 19 géneros de la subfamilia de las Papilionoideae, 53 de cinco especies de Caesalpinioideae (dos géneros), y cuatro muestras de Mimosoideae (dos géneros). Los géneros que se recogieron con mayor frecuencia fueron *Indigofera, Alysicarpus, Tephrosia, Crotalaria, Chamaecrista, Zornia, Stylosanthes* y *Desmodium*. Dentro del clima general seco, de subhúmedo a semiárido, del norte de Nigeria, varias especies parecen preferir nichos ecológicos particulares que se caracterizan a menudo por diversas influencias humanas y animales. En lo que respecta a los descriptores de plantas más importantes que se registraron, se dio una tolerancia a la sequía particularmente sobresaliente para *Crotalaria senegalensis, Sesbania bispinosa, Alysicarpus ovalifolius, Chamaecrista rotundifolia, Crotalaria naragutensis* y *Desmodium hirtum*. Las semillas recogidas se depositaron en el Instituto Nacional de Investigación de Producción Animal de Zaria, con un duplicado en el banco de genes del Instituto Internacional de Investigación Ganadera de Addis Abeba, Etiopía. Se propuso, además, que se hicieran viajes de recolección con objetivos más definidos. La recolección de germoplasma de legumbres autóctonas debería extenderse también a otros países de Africa occidental.

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Collecting in the Albanian mountains, 1995

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O malet e Shqiperise e ju o lisat e gjate,
Fushat e gjëra me lule q'ju kam nder mend dit' e nate.
Naim Frasheri[1]

Summary
After two missions in 1993, and one mission in 1994, a fourth collecting mission was carried out in Albania that focused on mountainous areas. One hundred and twenty accessions of landraces of cultivated plants and their wild relatives were collected. The material includes traditional species such as *Triticum monococcum*. The collecting done along the Albania–Greece border was sufficient to warrant an integrated programme with both countries.

Introduction
As a Mediterranean country, Albania is rich in plant genetic resources. In the new socioeconomic context of Albania in recent years it was possible to focus the interests of scientists from Albania and other countries on collecting and study of the plant genetic resources of Albania. Supported by IPGRI, a cooperative project was set up in 1993 and international collecting missions have been organized with participation of scientists from the Germplasm Institute of Bari, Italy, the Gatersleben Genebank, Germany, and the Agricultural University of Tirana, Albania. During the two expeditions in 1993, and the expedition in 1994, 220 and 354 accessions respectively were collected (Himmer *et al.* 1994; Gladis *et al.* 1995). Special studies of the Albanian germplasm collected by the H. Stubbe mission of 1941 (Stubbe 1982), and of germplasm collected in recent years, which is conserved in the Gatersleben Genebank, are jointly carried out by German, Italian and Albanian scientists. These studies have provided new information, especially concerning the genetic erosion phenomenon (Hammer *et al.* 1996a, 1996b), the introduction of crop plants in Albania, and the cultivation of plants during the Neolithic period (Hammer *et al.* 1995; Xhuveli and Schultze-Motel 1996).

During the autumn of 1995, with participation of scientists from the three above-mentioned institutions, and supported by IPGRI, the fourth international collecting mission in Albania was carried out.

Aims and methods
This mission aimed to obtain a multicrop collection, especially in the mountainous regions, and to collect information on crop plants and their wild relatives, to verify the check-list of cultivated plantw of Albania, to investigate the relationships between vegetation and cultivated plants of Albania and Greece, and to follow the route of the Hans Stubbe mission, 'Balkan 1941'. For these purposes, collecting was concentrated mainly on the mountains of the south and southeast part of Albania and in other areas where the elevation was up to 1000 m asl or more. The main characteristics of the agriculture of these zones are: poor soil and sloping land; dry and short summers; use of few inputs such as modern cultivars, fertilizers, pesticides and farm machinery; the tendency of farmers to produce food only for their own needs, and breeding of goats, sheeps and donkeys.

Sometimes the collecting route traversed dangerous rock outcrops and precipices. Following the advice of some authors (Prendergast 1993; Guarino 1995), during our exploration mission we used a small hand-held device, i.e. the Sony IPS-760 GPS (Global Positioning System) Receiver. The GPS is a satellite-based navigation system developed and maintained by the United States Department of Defense (DoD). The system, which was originally designed for military purposes, includes a separate signal (C/A code) for civilian use. Without notice, the DoD can change the characteristics of this signal, which will degrade the accuracy of the device.

The IPS-760 uses GPS signals (at present from three or four satellites, depending on their availability) to provide some essential navigation information such as latitude, longitude, altitude,[2] etc. In every district, the collecting team was accompanied and helped by the local experts.

[1] **Naim Frasheri** (1846-1900), born in the Frasheri village of Permeti district. Frasheri is located in mountains about 1100 m high, surrounded by a large forest (more than 700 ha) of *Abies alba*, *Pinus nigra* and other species. N. Frasheri was a great Albanian poet who belongs to the Romantic school. His poems, including the famous poem 'Bageti e Bujqesia' ('Livestock and Agriculture') (Frasheri 1977), are permeated by a strong love for his Albania. In the two lines written here, N. Frasheri says that he thinks always of the mountains, the high forests and the fields full of flowers. The collecting mission visited the Frasheri village and the abovementioned forest.

[2] During the mission we noted a discrepancy on altitude data between classical altimeters and the IPS-760 device; the most likely reason is that IPS-760 calculates the altitude based on the World Geodetic System (WGS84) coordinates. This altitude is not relative to the height above sea level. Another reason could possibly be related to the war in ex-Yugoslavia, very close to Albania, for which DoD, for military purposes, could have changed the satellite signal.

Special attention was paid to the plants along the Albania–Greece border. For this reason, the mission spent three days in Greece to visit and observe the agriculture, the vegetation and the genetic erosion in the northeastern part of Greece, near the Albanian border, as well as to hold discussions with colleagues at the Thessaloniki Genebank.

Table 1. Sites visited and the samples collected according to the height above sea level in Albania, 1995

Elevation (m a.s.l.)	Sites visited	No. of samples collected
0 to 700	13	49
700 to 1000	5	50
1000 to 1200	4	21
Total	22	120

Results and discussion

During the expedition, 22 sites in 13 districts were visited and 120 seed samples belonging to more than 40 crop plants and wild species were collected. Most of the samples were collected in mountainous regions (Table 1). The route of the mission is shown in Fig. 1.

Fig. 1. Collecting areas of the 1995 mission.

The samples collected, mostly cereals, pulses, some vegetables and cucurbits (Table 2), reflect the nature of the agriculture in the mountainous regions of Albania where maize, common beans, oats and onion are dominant, covering 20.8, 15, 5.8 and 5% of samples, respectively. Owing to the relative isolation of these zones and less influence by advanced agricultural practices (Fig. 2), the genetic erosion there is less expressed in comparison with lowland zones of western Albania (Hammer *et al.* 1994, 1995; Xhuveli 1994). However, the process of rapid abandonment of the villages, as observed in Frasheri and other villagers, is a factor which will strongly influence the increase of genetic

Table 2. The germplasm collected during the mission of 1995

Crop	Number of accessions	
Avena sativa	7	
Hordeum vulgare	2	
Secale cereale	5	
Triticum aestivum	2	
Triticum monococcum	2	
Zea mays	25	
Cereals		43
Cicer arietinum	1	
Lathyrus sativus	51	
Lens culinaris	1	
Phaseolus vulgaris	18	
Pisum sativum	1	
Vicia ervilia	2	
Vicia faba	2	
Pulses		30
Abelmoschus esculentus	1	
Allium cepa	6	
Allium porrum	1	
Allium sp.	2	
Anethum graveolens	1	
Atriplex hortensis	1	
Beta vulgaris	2	
Brassica oleracea	1	
Lactuca sativa	1	
Lycopersicon esculentum	3	
Petroselinum crispum	1	
Spinacia oleracea	1	
Vegetables		21
Citrullus lanatus	2	
Cucumis melo	4	
Cucurbita sp.	3	
Cucurbits		9
Bassia scoparia	1	
Helianthus annuus	1	
Ricinus communis	1	
Sorghum saccharatum convar. *technicum*	4	
Technical crops		7
Allium ampeloprasum	1	
Ammi visnaga	1	
Brassica sp.	1	
Diplotaxis muralis	1	
Foeniculum vulgare	1	
Medicago sativa	3	
Ocimum basilicum	1	
Raphanus raphanistrum	1	
Other crops and wild relatives		10
TOTAL		120

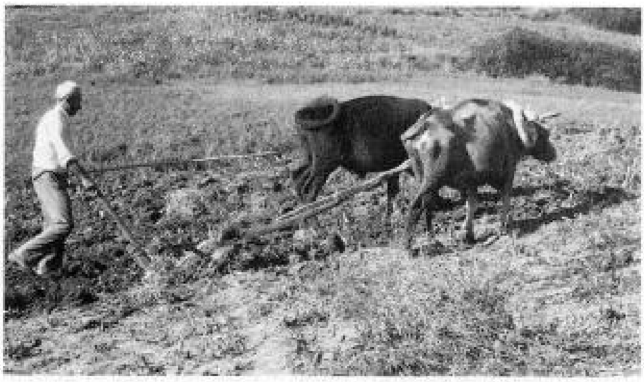

Fig. 2. Traditional farming methods in mountainous districts (area 4).

erosion in the coming years. Traditional agriculture was observed also in fruit trees, e.g. in the growing of the local cultivars of pears, apples, plums, quinces, walnuts, grapes, etc. Often wild root stocks (*Prunus mahaleb, Pyrus pyraster*) along the roadsides are grafted with local fruit varieties. The same situation can be found in other parts of the Mediterranean (Hammer *et al.* 1987). A special visit was paid to the slopes of the calcareous mountains in the north-western part of Albania, where the wild (spontaneous) form of *Punica granatum* frequently grows in a 50-70 km area from the Milot to the Shkoder zone. An interesting scientific discussion was held there on the hypothesis of Xhuveli (pers. comm.), who, based on the consideration of Zohary and Spiegel-Roy (1975), has proposed Albania as the first centre of domestication of pomegranate.

Cereals

Of 43 cereal samples collected in total, 25 belong to *Zea mays*. It is of interest that in the collecting sites above 700 m altitude, the Balkan type of maize (*Zea mays* convar. *aoristata*), resistant to drought, with yellow-red and flinty kernels and short spike, was found much more frequently than the white one. All samples collected in the sites up to 700 m asl (6 sites) have white kernels, while from 9 sites located at 700-1200 m, the white type was collected in 3 sites, the red type in 4 sites, and in one site, both types were collected (Fig. 3). The old local cultivars of *Avena sativa* and *Secale cereale* were found in several villages, but strong genetic erosion has occurred with the traditional cultivars of *Triticum aestivum*. The presence of weed seeds of *Agrostemma githago*, an indicator for landraces, was observed in many cases together with the seeds of rye and oat. Two samples of *Triticum monococcum* were collected in very remote villages (Figs. 4, 5). One sample of *T. monococcum* was collected in Kapinove (site 13, Berati district), 1000 m high, located on the shoulder of the Tomorri Mountain, and the second sample in Gjergjove (site 22, Skrapari district) at 850-900 m asl.

Pulses

Thanks to the strategy of this misson it was possible to reach the specific zones of cultivation of rare and old crops, characteristic for traditional ancient agriculture (Xhuveli and Schultze-Motel 1996), as *Vicia ervilia, Lens culinaris, Cicer arietinum, Lathyrus sativus* (5 samples), *Pisum sativum* and *Vicia faba*. According to the local farmers it is expected that the area of cultivation of chickpea, lentil, bitter vetch, pea and grass pea will be increased again, due to the poor soils which dominate in these regions. After maize, common bean (*Phaseolus vulgaris*), is the main crop plant of the areas. *Phaseolus* is the most popular and everyday food, especially during winter, in the poor mountain villages. The most adapted form seems to be *P. vulgaris* var. *nanus* with coloured seeds and early maturity.

Vegetables

Because the markets are far away, the vegetables produced in the mountain villages are mainly consumed in the area. Common vegetables such as tomato, peppers, okra, spinach, cabbage and others can be found in nearly every farmers' garden of the collecting areas. As in the other missions, special attention was paid to the collecting of *Allium* species, in particular to onion. Thanks to their good taste and long shelf life characteristics, a wide genetic variability of the red type of *Allium cepa* was observed as a dominant form.

Fig. 3. Maize cobs of the Balkan type close to the border of Greece (area 6).

Other crops and wild relatives

In contrast to lowland and hilly zones, in the mountain villages a greater genetic variability was observed for cucurbits, particularly for *Cucurbita*. Among the technical crops, *Sorghum saccharatum* convar. *technicum* was grown everywhere (in The Excursionist Flora of Albania (Demiri 1983), this species is mentioned as *Sorghum vulgare*). *Ricinus communis* is spreading fast as a

Fig. 4. Traditional farmhouse in the mountains (area 4).

Fig. 5. Storing fodder for winter feed (area 5)

decorative plant. An interesting primitive form of sunflower (*Helianthus annuus*) with a small head was observed as a decorative plant in the village of Memelish I, on the coast of Ohri Lake (Pogradeci district), while *Bassia scoparia* in rare cases is cultivated for use as a cleaning-broom.

During this mission the fast spread of *Helianthus tuberosus* as a home garden decorative plant, as well as a wild plant along the irrigation and drainage channels, was observed.

Some seeds from the small population of wild *Brassica* sp. were collected on the slopes of the coast region of Vlora district. This population, described by Xhuveli *et al.* (1995), continues to be endangered by genetic erosion. Though the presence of *Secale strictum* (*S. montanum*) in Albania was reported by Demiri (1983), during this mission it was impossible to find it. Taking into consideration that the joint expedition of the Germplasm Laboratory of Bari, Italy, with Greek specialists in 1977 close to the Albanian border collected *Triticum baeoticum* (Report of the Germplasm Laboratory, CNR-Bari, Italy), it should be of interest to visit the mountains of the southeast part of thm country, near the Greek border.

Conclusions

The southeastern region of Albania, especially its central part, still represents a rich reservoir of genetic variability. The fourth collecting mission, mainly in the mountains of this region, provided information on traditional agriculture, useful for improving the checklist of cultivated plants and allowed the collection of some relic crops of old local cultivars as *T. monococcum, A. sativa, S. cereale, C. arietinum, L. culinaris, V. ervilia* and *L. óativus*. Between different samples of maize collected, the higher frequency of the yellow Balkan type (*Z. mays* convar. *aoristata*) in comparison with white-grained maize was observed. The genetic erosion in mountainous regions is less evident than in other parts of the country. It was a general opinion of the mission participants that the next collecting expedition should be concentrated on local markets of small rural centres and in specific zones, for the possible collecting of *Triticum dicoccon* and such wild relatives as *Secale strictum, Brassica* spp. and perhaps *T. baeoticum*. Additional studies related to history, traditional agriculture and relations of Albanian agriculture to Greek practices and to the agriculture of South Italy inhabited by the Arberesh community (who emigrated from Albania to Italy during 15-16th centuries), would also be suitable targets of next missions. The establishment of the National Genebank continues to be a necessity for Albania.

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Résumé
Collecte dans les montagnes d'Albanie, 1995
Après deux missions en 1993 et une mission en 1994, une quatrième mission de collecte a été entreprise en Albanie, axée sur les régions montagneuses. Cent-vingt accessions de variétés locales de plantes cultivées et de plantes sauvages apparentées ont été recueillies. Le matériel comprend des espèces traditionnelles comme *Triticum monococcum.* La collecte effectuée à la frontière entre l'Albanie et la Grèce a été suffisante pour garantir un programme intégré avec les deux pays.

Resumen
Recolección en las montañas albanesas, 1995
Después de dos misiones en 1993, y de una en 1994, se ha llevado a cabo una cuarta misión de recolección en Albania cuyo objetivo eran las zonas montañosas. Se recogieron ciento veinte accesiones de variedades locales de plantas cultivadas y de sus parientes silvestres. El material comprendía especies tradicionales como el *Triticum monococcum.* La recolección efectuada en la frontera entre Albania y Grecia ha sido suficiente para asegurar un programa integrado con los dos países.

Collecting traditional berseem clover varieties in Egypt, and prospects for germplasm enhancement

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Summary
Egyptian clover (berseem, *Trifolium alexandrinum* L.) is still bred in the traditional way in Egypt. Farmers have a thorough knowledge of and a deep attachment to the local varieties of berseem. Standard types differ in agronomic adaptation and use. These include the single-cut type, Fahl, the multi-cut types Misqawi and Khadrawi, and other different local types. From eight to ten distinct local types of berseem are grown in the country on the basis of the number of cuts a variety can stand. Hundreds of local berseem germplasm accessions have been collected and evaluated. Selected superior lots were used for developing high-yielding cultivars by crossing high-performing accessions. Some of the developed cultivars outyielded the local varieties by 7-11%.

Introduction
Berseem (Egyptian clover), *Trifolium alexandrinum* L., is an annual plant with extraordinarily rapid growth, with succulent stems, abundant leaves and readily decomposable roots. It plays an important role in Egyptian agriculture where it is the foundation of the dairy and beef industry. In addition, it has an important role in the cropping system. It is grown in rotation with crops that are important to the country such as cotton. Berseem provides high yields of forage of exceptional nutritional value whether consumed directly as pasturage, green-chop, or conserved as hay or silage. It fixes more than 714 000 t of atmospheric nitrogen annually in Egypt (Kennedy and Mackie 1995; Hammam 1993). Berseem improves soil structure and tilth, and is important for soil conservation and reclamation. It is also a major honey crop and enhances the biological control of deleterious insects.

Berseem is indigenous to Egypt. DeCandolle (1886) stated that berseem is extensively cultivated in Egypt as fodder, its Arabic name is *bersym* or *berzun*, and its name does not occur in Hebrew and Armenian botanical works. Moreover, Muschler (1912) mentioned that it is only known from Egypt and Cyrenaica; its origin is uncertain. It is cultivated everywhere in Egypt where it is also subspontaneous. There is a thorough knowledge of and a deep attachment to the local varieties of berseem among Egyptian farmers.

Diversity
Several local types of berseem have evolved in response to local adaptation and agricultural use. These types are Misqawi, Khadrawi, Saidi, Fahl, etc., which differ in tillering and branching tendencies (Zaher 1949; Rammah 1969). Fahl lacks basal tillering capacity but upper branches develop from leaf buds along the stem when a stand is thin. Misqawi and Khadrawi have no stem branching but are able to survive successive cutting by virtue of their extensive crown bud development. Saidi has crown buds and can branch on the upper section of the stem but is not as persistent as Misqawi and a maximum of two cuts can be obtained.

The single-cut (or 'uni-cut') type Fahl is used as a catch crop preceding cotton. Saidi and Baali were once grown in basin-irrigated Upper Egypt, utilizing moisture in the soil following the Nile flood. They were adapted to a short growing season and limited moisture supply (Radwan and Rammah 1992).

Wide variations exist among local ecotypes and varieties of berseem for many important characteristics such as tillering. Several studies (Radwan 1970; Radwan *et al.* 1983; Hassaballa 1984; Rammah *et al.* 1984) have indicated wide variability in local berseem germplasm in respect to forage yield and related traits, flowering date, regrowth capacity and disease and insect tolerance. Variability among accessions reflects local adaptation to edaphic, climatic and management factors. This is well illustrated by the superiority of accessions from a particular geographic area over those introduced from outside. An extremely salt-tolerant strain was identified from an accession evaluation trial in Northern Delta (Rammah *et al.* 1984).

Collecting
Although berseem is widely grown in Egypt, seed is mostly harvested from small scattered fields. At present local diversity is eroding slowly. The increasing use of released cultivars accelerates the loss of valuable germplasm. These circumstances justified a collecting mission that was organized jointly by the Field Crops Research Institute (FCRI) and the International Plant Genetic Resources Institute (IPGRI) to gather germplasm of indigenous crops, especially berseem germplasm. Along with seed-gathering, a survey was carried out aimed at documenting the different local types. This was done by interviewing farmers who maintain their own seed to reduce the potential number of accessions (Radwan 1970). Details about the collecting process are reported in El-Nahrawy *et al.* (1992).

Local types of berseem
The different types of berseem are traditionally identified by the number of harvests they yield each growing season. Also used in the identification and description are agromorphological features such as the plant colour at the end of the growing season (brown, green) and the region of origin (Baheeri, Saidi). Information gathered from farmers indicates that there may be eight to ten distinct local types of berseem grown in the country (Table 1).

Table 1. Collected local types of berseem clover, the number of accessions from each and number of cuts (harvest) assumed possible (from survey data)

Local name	No. of accessions	No. of cuts	
		Mean[1]	Range
Baheeri	15	2.6	4-7
Baladi	83	4.5	3-7
Fahl/Khazuq	2	1.0	0-1[2]
Fallahi	8	4.3	3-6
Hilali	5	4.8	3-6
Khadrawi	26	6.1	4-10
Misqawi/Mazqawi	91	4.2	3-6
Mustadeem	2	5.0	5
Saidi	2	5.5	5-6

[1] Mean was calculated from data on the actual samples collected, but range shows the minimum and maximum number of cuts that farmers said the variety can tolerate.
[2] Zero (0) cut for thm Fahl/Khazuq type means that the crop is left for seed production.

Farmers like to grow particular types, but will discard a seedlot of a favourite variety which is infested with, for example, dodder (*Cuscuta*), which is a major problem, in favour of a clean seedlot of a less-liked variety. Such practices stimulate the hypothesis that applying traditional breeding methods to berseem may have great potential. The survey indicated that most farmers tend to use 4-5 cut types (Baladi, Misqawi). However, farmers producing milk and meat cultivate 7-8 cut types (Khadrawi, Beheeri, Mustadeem). Since the building of the High Dam in Aswan, the single-cut type (Fahl) has been used rarely. However, owing to its ability to grow faster, its great plant vigour, and relative drought tolerance in comparison with other berseem types, it is usually sown before planting cotton.

Distribution and characteristics

Fahl/Khazuq

This type gives only one cut. The name Fahl refers to plant growth and it looks more vigorous than other local berseem types. Khazuq refers to a local name encountered in Upper Egypt.

Baheeri

Refers to multi-cut type which gives up to six harvests and originated in the northwestern part of Delta, in contrast to Saidi, which was grown in the Upper Egypt.

Baladi (Fallahi)

Also a multi-cut type that is widely grown all over the country, but the name may indicate that its seed is produced and maintained by the growers.

Hilali

It is a multi-cut type which gives up to eight harvests. It is very localized, confined to Northern Delta. The plant stays green until the end of the growing season. It is salt-tolerant in comparison with other berseem types.

Khadrawi

It may yield up to 8-10 cuts per growing season based upon the growing period and the availability of irrigation water, especially at the end of the growing season. It is the most high-yielding type and stays green as long as irrigation is available.

Misqawi/Mazqawi

By far the most commonly grown multi-cut type all over the country and the name may refer to the high water requirements.

Mustadeem

This may be a synonym for Misqawi. The name also refers to the local type that lasts longer than Saidi or Fahl types.

Saidi

Rare type, it probably originated from Upper Egypt as indicated from the name.

Baali

Multi-cut type formerly grown in the basin-irrigated Upper Egypt, relying on moisture stored in the soil following the Nile flood.

It is not very common for one local type to have more than one name but different varieties may be called the same name. Local names do not refer to the number of harvests but often to geographical area (such Saidi and Beheeri) or to other physiological features. For example, Khadrawi means green and refers to the fact that this variety remains green up to seed set. Mustadeem means the variety continues for the whole growing season, or could not be replaced by cotton which is the case for Fahl type. Baladi is not a specific name but simply means that the type is not an improved or introduced one: the word means 'local'. Misqawi simply means frequently irrigated and may have been originally used as a name to distinguish forms which needed continuous watering from forms which could be sown while floodwater was retreating such as Fahl type. Some local types are more widely distributed (Misqawi) than others (Hilali), which may be confined to a small area. Hilali is found in northern parts of the Delta around Disuq district where most of the salt-affected soils are. This type has been recognized to be relatively tolerant of salinity.

Evaluation

Methods

Different numbers of collected accessions were evaluated at five research stations based upon the availability of seed. These consisted of 311 accessions at Sakha and Sids and 233, 196, and 128 accessions at Gimmeza, Nuboria, and Ismailia Stations, respectively.

Performance at each location was evaluated in a randomized complete block experiment. Plots consisted of single 4-m rows spaced 50 cm apart. Plots were kept free of weeds throughout the growing season. Soil fertility and moisture conditions were adequate for normal crop growth at all locations. The middle 3 m of each plot was used for observation. The check cultivar Giza 15 was replicated several times within each block. The seeding rate was 15 kg/faddan

(36 kg/ha). Superphosphate (15% P_2O_5) was applied at 150 kg/faddan (360 kg/ha) before sowing.

At all locations the plots were sited 400-500 m from neighbouring berseem fields. At each cutting, stand height, tillering, leafiness and leaflet size were visually scored on a scale of 1 to 5, where 1 indicates the lower limit of expression of each character. The incidence of damage from leaf rust and clover weevil was similarly scored prior to the third cutting. Date of first flower in each plot was recorded. The plots were cut with a hand sickle four times at both Sids and Gemmiza and three times at the three other locations. Cutting was done when the stand of most plots was 40-50 cm high and fresh weight was recorded. On the basis of seasonal forage yield, the lots which outyielded the check were selected at each location.

As mentioned before, this study is part of a long programme which aims to develop and use practical numerical analysis procedures to describe variation in representative samples of cultivated ecotypes of berseem clover and to document the different local types in Egypt. Data on forage yield of each cut at each location and seasonal forage yield were subjected to regular analysis of variance according to the procedures outlined by Steel and Torrie (1980). Moreover, characterization of the variability regarding important agronomic characteristics, i.e. stem length, single plant weight, crown diameter, leaf area, number of nodules per root system and root length, has been carried out and results will be published later.

Selected ecotypes from different locations of evaluation were used to develop composite berseem varieties by crossing high-performing accessions. These composite varieties were re-evaluated on farmers' fields in large-scale trials (18 provinces during 1992/93 and 1993/94 seasons) to determine the progress realized on the basis of selection practised among local types.

Results and discussion

A few studies (Radwan 1970; Ali 1977; Radwan *et al.* 1983; Hassaballa 1984; Rammah *et al.* 1984; El-Nahrawy *et al.* 1992) have revealed wide variability in local germplasm in forage yield and related traits, flowering date, regrowth capacity and disease and insect tolerance. Variations among 27 seedlots of Fahl ranged from 21.7 to 47.6 t/ha, 22.0 to 32.3%, and 68.3 to 92.9 cm for forage yield, leafiness and stand height, respectively (Radwan 1970). In addition, extreme variability was revealed among 289 seed lots of local Misqawi for seasonal forage yield (59.0%), tillering (62.%), branching (68.8%) and green yield per cut (78.8%) (Ali 1977). Wide variabilit} exists in forage yield among 331 seedlots of local berseem (Table 2).

Ranges differed widely between locations and collecting regions. The percentage of superior lots was relatively high at each location in which the seedlots were grown (Tables 2, 3). Differences in variability from one location to another may be a reflection of regional adaptation of the genotypes used (Rammah 1969). From accessions collected in Delta region 42, 25, 29, 19 and 19% outyielded the check at Sakha, Sids, Nuboria, Gemmiza and Ismaillia, respectively, whereas the percentages for accessions collected from Upper Egypt were 34, 20, 10, 14 and 18% for the same locations in the above order (results not shown). Thus collections might include well-adapted berseem ecotypes. It was obvious from the collection at each district that the Middle Delta zone, i.e. Gharbia, Monufia and Kafr El-Shakh, etc., might be considered as ecologically favourable for berseem (Tables 2, 3). The highest percentages of superior lots at most locations evaluated were from Lower Egypt (Tables 2, 3).

Moreover, there was little difference between modern cultivars and ecotypes of berseem (Table 4). This little

Table 2. Performance (fresh yield), at two locations, of berseem seedlots grouped according to geographic origin and number of superior lots selected from each region (adapted from El-Nahrawy 1980)

Region[1]	No. of lots	Trial location	Forage yield (t/ha)		% of superior lots that exceeded check[2] by more than 20%
			Mean	Range	
Middle Delta	100	Giza	56.2	40.5 - 72.4	12.0
		Gemmiza	63.3	45.5 - 83.1	19.0
Southern Delta	72	Giza	54.8	27.6 - 76.9	6.9
		Gemmiza	63.6	45.5 - 80.5	13.9
Middle Egypt	46	Giz	60.2	37.6 - 73.1	13.0
		Gemmiza	64.3	36.9 - 81.4	4.3
Upper Egypt	22	Giza	53.1	35.5 - 61.4	4.5
		Gemmiza	56.4	38.1 - 71.9	4.5
Fayoum	4	Giz	65.9	58.6 - 70.9	-
		Gemmiza	69.3	66.4 - 71.7	-
Unknown	87	Giz	50.2	29.3 - 71.4	3.4
		Gemmiza	58.6	37.4 - 79.1	4.6

[1] Middle Delta: Gharbia, Monoufia, Kafr El-Sheikh; Southern Delta: Sharqia, Daquhlia, Qalubia; Middle Egypt: Minia, Bani-Swif, Giza; Upper Egypt: Qena, Sohag, Assuit.
[2] Check cultivar was improved cultivar, Giza 10.

Table 3. Local berseem accessions which outyielded check cultivar (Giza 15) in seasonal forage yield by more than 20% at various locations, and their geographic origin in Egypt

Source	Accession no.	Location of evaluation: Sakha	Sids	Nuboria	Ismaillia	Gemmiza
Gharbia	348	+	+	+		
	373	+		+		
	383			+		
Kafr El-Sheikh	26	+				+
	32				+	+
	387	+			+	+
	389		+			+
	405	+				+
Beheira	44				+	+
Daqahlia	62		+		+	
	77		+		+	
Sharquia	80	+			+	
	83	+			+	
	17				+	+
Monufia	223	+	+			
Beni-sweif Assiut	48	+	+		+	

+ Superior to check with more than 20% of seasonal forage yield (adapted from El-Nahrawy *et al.* 1992).

progress in forage yield of developed berseem cultivars over local types (7-11%) may be because efforts for improvement started only recently. Chang *et al.* (1979) indicated that there is little difference between modern cultivars and ecotypes of traditional forages because of the short breeding history and long use in wild habitats. Our results as well as those of previous studies indicate that cultivated seedlots of berseem make up a potential source of genetic variability for berseem improvement.

Variation in productivity among farmers' seedlots is not unexpected since these lots are likely to differ either in seed quality characters or genetic potentiality or both. Accessions from each broad geographical zone should be collected and evaluated in a centralized location in the same zone and discretely stored under conditions which promote long life. For practical utilization of germplasm in breeding work it may be sufficient to develop core collections for each zone, where accessions of comparable classification are combined in one genepool. This also would reduce the regeneration load on the breeding station (Radwan and Rammah 1992).

Table 4. Performance of some developed berseem cultivars averaged over 18 provinces during 1992/93 and 1993/94 seasons

Cultivar	No. data-years	Herbage yield (t/ha): Mean	Range	% superiority over farmers' cvs.
Farmers' cvs.	**2**	**117.50**	**93.12 - 142.93**	–
Hilali	2	130.29	100.48 - 153.76	10.89
Giza 15	2	127.58	97.69 - 164.95	8.58
Sakha 4	1	126.79	92.55 - 167.93	7.91
Gemmiza 1	1	128.71	93.50 - 163.92	9.54

Source: Forage Crops Research Department, FCRI, ARC, Giza, Egypt.

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Résumé

Collecte de variétés traditionnelles de trèfle d'Alexandrie en Egypte et perspectives concernant l'amélioration du matériel génétique

Le trèfle d'Alexandrie (bersim, *Trifolium alexandrinum* L.) est encore amélioré de manière traditionnelle en Egypte. Les agriculteurs ont une très bonne connaissance des variétés locales de trèfle et y sont très attachés. Les types standard diffèrent par leur adaptation agronomique et leur utilisation. Ils comprennent le type à une coupe, Fahl, les types à plusieurs coupes, Misqawi et Khadrawi, et d'autres types locaux différents. De huit à dix types locaux distincts de trèfle d'Alexandrie sont cultivés dans le pays sur la base du nombre de coupes que chaque variété peut supporter. Des centaines d'accessions locales de matériel génétique de trèfle d'Alexandrie ont été collectées et évaluées. Certains lots supérieurs ont servi au développement de cultivars à haut rendement par croisement d'accessions à haute performance. Certains des cultivars développés ont donné un rendement supérieur de 7-11 % à celui des variétés locales.

Resumen

Recolección de variedades tradicionales de trébol alejandrino en Egipto y perspectivas para el mejoramiento del germoplasma

El trébol alejandrino, (bersim, *Trifolium alexandrinum* L.) se sigue cultivando en Egipto de manera tradicional. Los campesinos tienen un profundo conocimiento y gran apego por las variedades locales de bersim. Los tipos estándar difieren en lo que respecta a su adaptación agronómica y a su utilización. Entre ellos figura el tipo de un solo corte, Fahl, los tipos de cortes múltiples Misqawi y Khadrawi y otros tipos locales diferentes. En el país se cultivan de ocho a diez tipos locales distintos de trébol alejandrino basándose en el número de veces que puede cortarse una variedad. Se han recogido y evaluado cientos de accesiones de germoplasma de trébol alejandrino local. Algunos lotes mejores se usaron para desarrollar cultivares de alto rendimiento mediante el cruce de accesiones de calidad elevada. Algunos de los cultivares establecidos sobrepasaron los rendimientos de las variedades locales en un 7-11 por ciento).

Role of traditional cultivars and *in situ* conservation in sustainable agriculture: a case study in rice (*Oryza sativa* L.)

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Summary
On-farm (*in situ*) conservation plays an important role in the conservation of traditional varieties. Studies were undertaken in coastal areas of Orissa, India with salt-tolerant traditional rice (*Oryza sativa* L.) germplasm to evaluate the importance that local communities place on continued *in situ* conservation. This paper discusses (a) agricultural practices in the area, (b) aggregate diversities, (c) studies, using RAPD (random amplified polymorphic DNA) analysis, on the genetic variability among the varieties grown in a single area, (d) the importance of such on-farm conservation in saving these exotic varieties and (e) the possible role of these varieties in future rice breeding experiments. The use of sustainable rural agriculture is discussed in light of its potential to help modern agriculture in the development of new and better varieties.

Introduction
Modern agricultural practices, increasing dependence on newer crop varieties and erosion of traditional germplasm have partly determined the need to look for alternative sources of material and technology to increase food production (Harlan 1975; Hawkes 1983). The need for conservation and sustainable utilization of crop germplasm was realized very early in this century by Vavilov and others. Today conservation is one area of study that is constantly being redefined and revitalized.

Modern biology has contributed much to the utilization of traditional crop resources and has also indirectly helped conservationists concerned with germplasm characterization, utilization and enhancement (Balakrishna and Swaminathan 1994a, 1994b). Two methods of conservation – *ex situ* and *in situ* – have proven effective. While *in situ* conservation relies on the maintenance of germplasm by farmers on their farms, *ex situ* conservation depends on maintenance of germplasm in artificial conditions (Harlan 1984; Holden and Williams 1984).

There has always been a difference of opinion on the value of the *in situ* method of conservation with regard to access to the material. On the one hand, as long as traditional germplasm is in the hands of farmers it is not directly useful to the breeder (Brush 1991), and the threat of loss of germplasm due to unforeseen circumstances like natural calamities and disease outbreaks is immense. However, there are measures in favour of *in situ* conservation of agricultural germplasm (Wilkes 1985; Anikester 1988; Brush 1991; Zimmer and Duches 1991). The major advantage of *in situ* conservation is the maintenance of exotic characters which are not of interest to the breeders now, but may be in future.

The increasing importance given to research into sustainable management of biological resources in recent years has increased the role of traditional or folk varieties. Their value is being recognized and attempts are underway to turn the attention of breeders and researchers to analyzing the characters of such germplasm (Plucknett *et al.* 1987; Keystone Centre 1991; Pimental *et al.* 1992; NRC 1993; Balakrishna and Swaminathan 1994b). This is primarily because these varieties are geographically, genetically and ecologically diverse populations (Brown 1978; Cleveland *et al.* 1994).

Unfortunately, few scientific data exist on selection, maintenance and utilization of these traditional varieties or on their biology and genetics compared with other cultivated crop plants. This can lead to a lot of confusion between mere statements of their value and statements based on empirical evidence (Cleveland *et al.* 1994). Almost no information has been published on the genetic diversity or biological characteristics of such varieties that will lead to any sound conclusions on either their loss of diversity or probable maintenance of diversity. Although Brush *et al.* (1992) and Soleri and Cleveland (1993) described diversity on the basis of varietal names, this may not be accurate as names can be indications of distant genetic make-up and often may describe genotypic differences. This may not always be the case, as reported by Quiros *et al.* (1990) on potato germplasm in the Americas.

The present study primarily focuses on: (a) the effectiveness of *in situ* conservation, (b) its theoretical framework, (c) diversity present on-farm, (d) aggregate diversities, and (e) the preference of farmers to continue growing these traditional crop varieties. The study was conducted during 1992-95 in the state of Orissa in India, an area considered as one of the centres of origin for rice. Rice is the principal crop of farmers in the coastal regions where subsistence agriculture is practised. Owing to the proximity of the sea, all the areas have saline soils resulting from sea-water intrusion. The rice varieties that grow in this region have tolerance to salinity and submergence and also have good agronomic characters like aroma and fine grain (Table 1). The average productivity is about 2-2.5 t/ha.

This paper discusses (a) agricultural practices in the area, (b) aggregate diversities, (c) studies, using RAPD

Table 1. List of traditional varieties collected from the Orissa coast

Name	Place of collecting	Characters
Solla	Raj Nagar	Salt tolerant, golden yellow grain
Pattini	Bhitar Kanika	Salt and flooding tolerant
Neelavati	Kanika	Salt tolerant, aromatic variety
Haldigundi	Bhitar Kanika	Salt tolerant, fine grain variety
Pani Koili	Raj Nagar	Salt tolerant, good cooking quality
Champeishali	Loknath Prasad	Salt tolerant
Dahanagundi	Loknath Prasad	Salt tolerant, long grain type
Meghna	Raj Nagar	Salt tolerant, good yielding type
Bhula	Raj Nagar	Salt tolerant, flood resistant
Swarna	Kanika	High yielding variety (3.0 t/ha)

(random amplified polymorphic DNA) analysis, on the genetic variability among the varieties grown in a single area, (d) the importance of such on-farm conservation in saving these exotic varieties and (e) the possible role of these varieties in future rice breeding experiments.

Theoretical framework

Generally it is the social and economic benefits of crop genetic diversity that justify conservation (Brush 1991), but a traditional farmer still maintains the diversity even though it is not economically beneficial compared with the high-yielding varieties (HYVs). The reason is also not entirely social. On analysis, we have found that diverse crop resources are the aspects of no-risk farming: opting for value and risk, spreading out labour, cost-effective crop management and continued availability of food. These varieties are adapted for the agro-ecological zones in which they are grown. Considering no-risk and value versus risk options, the traditional farmers practise mixed cropping because the maturity dates of different crops are staggered, income is distributed over a longer period of time, and they consider mixed cropping to be a good soil management practice.

Most of the traditional rice varieties grown here are 6 months in duration. Sowing is done at the onset of monsoons in June and harvesting is done in November. This spreads farmers' labour requirements over the growing season. Agricultural inputs, essentially the external inputs like improved seed, fertilizers and pesticides, are never used, which keeps production costs low. The fact that these inputs are not required shows that the soil fertility is good and the crops are generally resistant to diseases and pests. The adoption of new technology is still slow in this area, mainly because of economic restrictions. Thus there is also a disequilibrium between needs and economies. This does not mean that their agriculture is 'inferior' either in quality or quantity. The farmers feel that the practicew make them more self-reliant and independent. Also, the yield components of these varieties do not vary despite the year-to-year cultivation.

In situ conservation of landraces or traditional cultivars requires different approaches to conservation, depending on the environment and pattern of growth. European and North American models of agricultural systems, where 'genetic erosion' is linked with the influence of technology and affluence, may not be entirely appropriate for a developing country.

The number of genotypes and morphotypes collected from the area of study varied from four to seven for an average household. All these varieties are being effectively used by the farmers. Modern varieties are not grown in these areas. Our collecting visit enabled us to collect as many as 20 varieties from a stretch of 4-5 km along the coast. Details of the farm size, preference for varieties, economic feasibility and the biological use of the germplasm were recorded.

Table 2. Farm size and preferred traditional varieties of rice grown in the study areas

Area	Farm size (ha)	No. of varieties grown	Preferred varieties
Raj Nagar	4.8 – 5.2	6	Meghna, Bhula, Pani koili, Solla, Champeishali, Bhula
Bhitar Kanika	4.5 – 5.0	4	Pattini, Haldigundi, Bhula, Neelavati
Kanika	4.0 – 4.8	5	Neelavati, Solla, Meghna, Pattini, Dahanagundi, Champeishali
Loknath Prasad	5.1 – 5.7	7	Solla, Swarna, Neelavati, Champeishali, Dahanagundi

Farm size

Unlike other traditional farm areas, this region has divided farm holdings. The average size range is 5-7 ha when the fields are near the sea and 4-5 ha when they are inland. Farms are maintained as one plot where all the different varieties are grown (Table 2).

Variety preference

Table 2 lists the traditional varieties that were collected during the study. Each of these varieties had at least one special character: 'Solla' is a golden colour rice yielding about 2.5 t/ha, 'Neelavati' is an aromatic variety, 'Pattini' is tolerant to flooding and so on. At least four of the twelve farm holdings surveyed had these varieties under cultivation.

Table 3. Relative amounts of money spent and net income for local farmers in study area

Area	Money spent (in rupees) on: Labour	Fertilizers	Harvest	Net income	Ratio of income/ money spent
Raj Nagar	360	100	540	4800	4.8
Bhitar Kanika	270	270	630	3800	3.2
Kanika	360	180	540	4100	3.7
Loknath Prasad	540	630	630	5200	3.2

Economic feasibility

Most of the farmers who live in the coastal areas are subsistence farmers. Their agriculture involves little money for transplanting (broadcasting is still popular), pesticides or fertilizers (Table 3). Low input requirements are due to the inherent nature of the germplasm to resist adverse abiotic and biotic stresses. The farmers never use an improved variety that costs them a lot of money.

Biological considerations

All the areas surveyed in the current study lie along the coasts. As the varieties that grow here have to tolerate salt and occasional flooding, without compromising the yield, the use of varieties over a long period of time is based on careful selection by these local farmers. The successful blending of microclimate with variety preference includes taking into account the biological parameters.

Genetic diversity and relatedness

Biological diversit} is often linked with environmental diversity in a specific pattern. The interesting genetic features observed during the study are the following: (a) the varieties are natural populations with convergent adaptation and specific ecological requirements, (b) the presence of diversity within farm holdings, and (c) the influence of fluctuating factors like fresh water inflow, sea level rise and human activity in terms of selection and generation of heterozygosity. All these greatly influence the pattern of diversity.

A detailed study was undertaken to assess the genetic variability, level of heterozygosity and allele influences

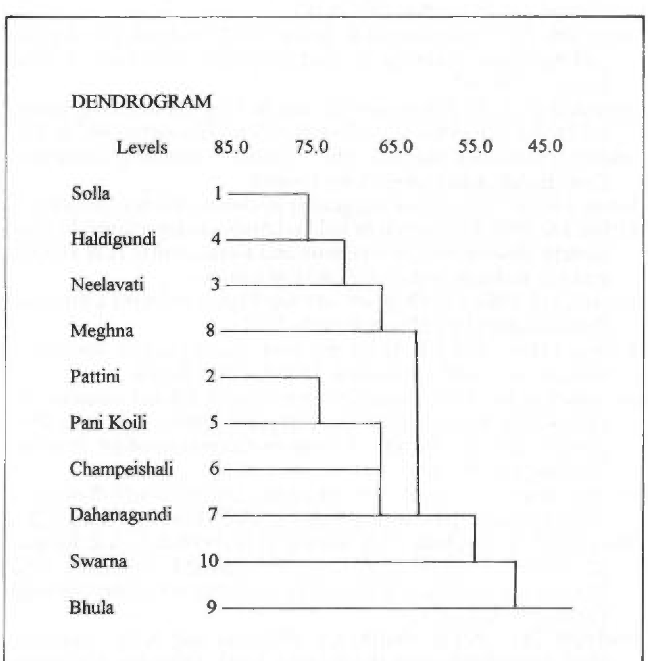

Fig. 1. Dendrogram showing the relationships of different rice varieties analyzed based on RAPD polymorphism using Jaccard's Index on GENSTAT 5, 1988

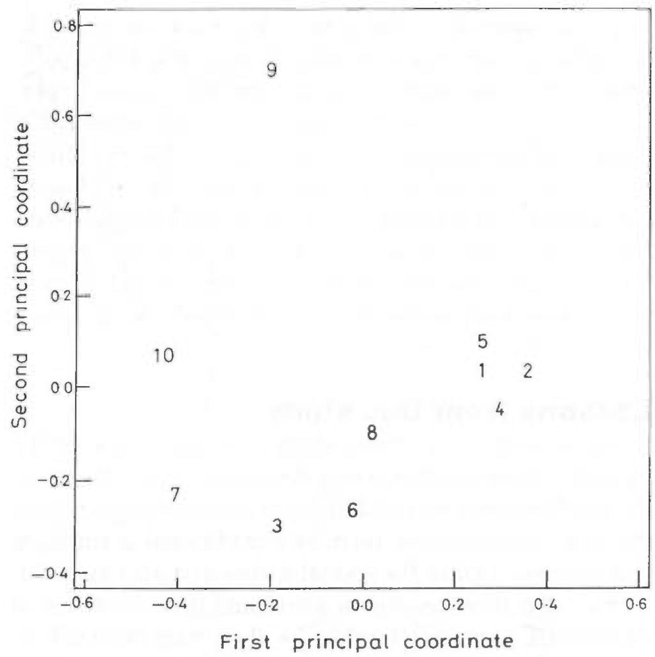

Fig. 2. Genetic distance map of different rice varieties analyzed based on RAPD data using Jaccard's Index

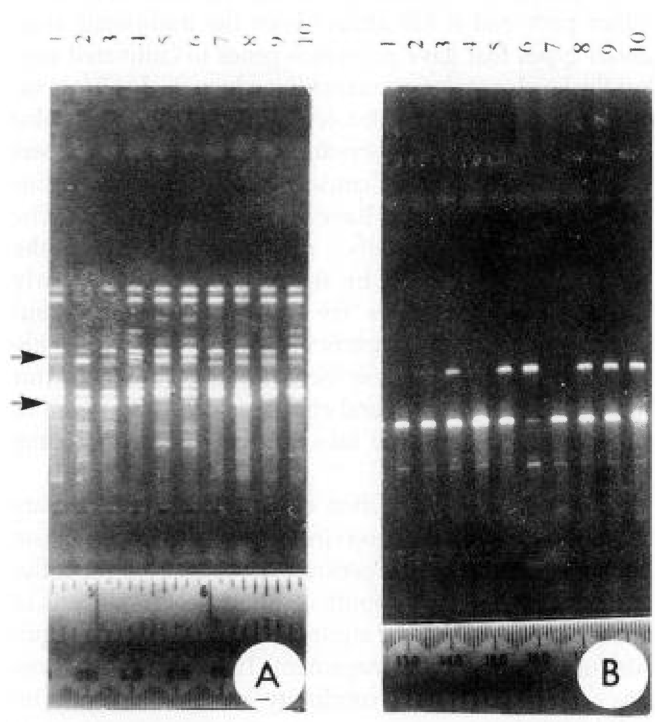

Fig. 3. Randomly amplified polymorphic DNA patterns of rice cultivars used in the study: A, Amplification using primer OPAF 4; BI Amplification using primer OPAR 12

at polymorphic loci. The genetic basis for variability of the selected varieties was investigated in a DNA polymorphism study using random amplified polymorphic DNA (RAPD) analysis (Williams *et al.* 1990). A total of 56 primers of 10 base strength were used and the polymorphisms were scored as the presence or absence of bands. The genetic variability data were analyzed using Jaccard's Indices (Genstat 5 Reference Manual 1987) and genetic diversity and distance maps were constructed (Figs. 1 and 2). Enormous variability was observed among varieties (Fig. 3A,B).

Lessons from this study

Farmers in the area of this study are well aware of the modern varieties that are being developed. They also know the kind of inputs required to practise modern agriculture, that the adaptations of their own traditional germplasm will perform well in the special niches and also meet different cultural and economic goals, and they are aware of the special commercial values of their varieties such as 'Neelavati', which is an aromatic rice. Therefore the subdivision of farming systems to incorporate modern varieties is not a priority for them. The study clearly shows that traditional farming is still preferred and the entire agricultural system is finely tuned. Market-oriented approaches to production cannot be said to be absent as there is commercialization of produce.

In this system the farmer acts not only as a selector of valuable germplasm but also as a breeder. Rice is known for its susceptibility to salinity. Production of rice in saline areas is a problem that still requires solutions (Yeo *et al.* 1990). Inherited tolerance to salinity in cultivated rice is rather poor and it has always been the traditional, non-dwarf types that gave resistance genes to cultivated rice, but the levels of tolerance are still inadequate. In Orissa we have a rich wealth of salt-tolerant rice varieties that also yield well. The *in situ* conservation practised in thewe areas is the primary source of conservation of these varieties which otherwise would have vanished completely. The levels of heterogeneity maintained within the germplasm, as evinced by the RAPD analysis, clearly prove that the varieties are different genetically but maintain common characters like salt tolerance. The genetic proximities of these varieties can be a boon for future breeders to pick and choose varieties to pyramid genes for salt tolerance into cultivated, high-yielding rice.

This kind of conservation enhances the sustainability of *ex situ* storage by preserving not only the germplasm but also the habitats that generate new variants. The influence of other external inputs is minimal and hence is of limited liability. It can be argued that continuity is a requisite for conservation management. The best aspect of on-site conservation is the continuity and sustainability involved within it.

The study empirically proves that biological diversity and on-site conservation should be studied together, the resource allocation decisions made by the farmers have sound implications, the aggregate diversity depends on the diversity both within and between farms, and the persistence of threshold diversity makes a farmer keep his economic options open to spread income risk to compensate for market imperfections and to use the natural resources sustainably.

Finally the intellectual property rights that the farmers hold are unique. They have their own seed material and have a good sense of common property resources. Thus not only do they hold a key to transform today's agriculture but they also have a stake to claim their rewards for conservation efforts.

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Résumé

Rôle des cultivars traditionnels et de la conservation* in situ *dans l'agriculture durable: une étude de cas concernant le riz* (Oryza sativa *L.)

La conservation à la ferme *(in situ)* joue un rôle important aux fins de la conservation des variétés traditionnelles. Des études ont été entreprises dans des zones côtières de l'Orissa, en Inde, avec du matériel génétique de riz traditionnel (*Oryza sativa* L.) résistant à la salinité, pour évaluer l'importance que les communautés locales attribuent à la conservation continue *in situ*. Le présent article examine a) les techniques agricoles appliquées dans la zone; b) des diversités regroupées, c) des études, à l'aide de l'analyse RAPD (polymorphisme aléatoire amplifiée de l'ADN) de la variabilité génétique parmi les variétés cultivées dans une seule zone, d) l'importance de cette type de conservation à la ferme pour la sauvegarde de ces variétés exotiques et e) le rôle éventuel de ces variétés dans les essais futurs d'amélioration du riz. Il examine également l'utilisation de l'agriculture rurale durable en tenant compte de sew possibilités d'aider l'agriculture moderne à mettre au point des variétés nouvelles et meilleures.

Resumen

Función de los cultivares tradicionales y la conservación* in situ *en una agricultura sostenible: estudio monográfico sobre el arroz* (Oryza sativa *L.)

La conservación en la granja *(in situ)* desempeña una función importante en la conservación de las variedades tradicionales. Se han hecho estudios en las zonas costeras de Orissa, la India, con germoplasma de arroz tradicional (*Oryza sativa* L.) resistente a la sal para evaluar la importancia que las comunidades locales atribuyen a la conservación continua *in situ*. Este artículo se ocupa de (a) prácticas agrícolas en la zona; (b) diversidades agregadas; (c) estudios sobre la variabilidad genética entre las variedades que se cultivan en una sola zona, utilizando el análisis del RAPD (amplificación aleatoria del ADN polimórfico); (d) la importancia de este tipo de consevvación en la granja, para la salvaguardia de estas variedades exóticas y (e) la posible función de estas variedades en los experimentos futuros de mejoramiento genético del arroz. La utilización de una agricultura rural sostenible se examina a la luz de su potencial de ayuda a la agricultura moderna para el desarrollo de nuevas y mejores variedades.

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Standardization of molecular genetic techniques for the characterization of germplasm collections: the case of random amplified polymorphic DNA (RAPD)

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Summary

Random amplified polymorphic DNA (RAPD) variation is being used increasingly to characterize germplasm collections. However, the technique has limitations due to the lack of reproducibility of results under certain conditions. Here we review some of the literature on the factors that are mainly responsible for variation in the generation of RAPD fragments, and examine ways to reduce these sources of unwanted variation. We propose a table containing a collation of all the descriptors thought necessary to describe the conditions and assessment procedures necessary for reproducible RAPD profiling of plant material. The standardization of procedure and presentation of results should facilitate the comparison of results both between and within laboratories working on similar material, and allow RAPDs to be used as a standard germplasm descriptor.

Introduction

The use, by breeders and others, of germplasm conserved *ex situ*, and the efficient management of collections, depends to a large extent on the availability of information on the genetic diversity which resides in the collections. The process of gathering this information is commonly referred to as characterization and evaluation: accessions are grown under suitable conditions and data are recorded for a number of descriptors, which may be defined as identifiable and measurable plant attributes. Characterization descriptors, such as flower colour, are highly heritable, easily seen by eye and equally expressed in all environments. They allow rapid discrimination of phenotypes. Evaluation descriptors, such as yield and disease resistance, are under polygenic control and susceptible to environmental influence but are important in crop improvement.

Description of the morphology of vegetative and reproductive organs and classical agronomic assessment has been the mainstay of genetic resources characterization and evaluation. However, in recent years new molecular genetic techniques have increasingly been used to describe plant germplasm collections (Rao and Riley 1994). The advantages of DNA markers for germplasm characterization are that any part of a plant can be used, only small amounts of tissue are required from which the whole genome can be assayed, generally the method of inheritance is simple, and growth conditions have no effect on expression.

A number of molecular techniques that are suitable for generating DNA profiles are currently available (Weising *et al.* 1995). A technique that is becoming particularly popular uses the polymerase chain reaction (PCR) to generate random amplified polymorphic DNA fragments (RAPDs) (Williams *et al.* 1990). RAPD analysis can be performed on any organism with no prior DNA sequence information. It is effective with tiny amounts of DNA. Indeed, in an extreme example, Brown *et al.* (1993) showed that RAPD amplification was possible with DNA isolated from a single tobacco protoplast. The technology is relatively simple and cheap, allowing the analysis of a large number of samples in a short time (Williams *et al.* 1993). However, in the past the technique has been rather prone to problems due to a lack of reproducibility of banding patterns between different laboratories, and even between different experiments in the same laboratory. To a certain extent, these problems have been much reduced as the mechanism of the PCR reaction generating RAPD fragments has been further understood (Weising *et al.* 1995), but careful adherence to protocols is needed for reproducible results (Penner *et al.* 1993).

The use of RAPDs to provide an assessment of the genetic variation of genebank collections will certainly increase in the future. It will thus become increasingly important that the protocols used be accurately described, so that they can be standardized. It is only on this basis that the following types of studies of importance to genebank curators, for example, will be possible:

(1) synthesis of the results obtained by different laboratories with different collections of the same species, which may or may not share duplicated material;
(2) comparison of the results obtained on the same collection at different times, for example after a number of regeneration cyles;
(3) estimation of the genetic diversity represented by any new additions to an already assessed collection.

Here we review some of the literature on the factors that are responsible for variation in the generation of RAPD fragments, and examine ways to reduce these sources of unwanted variation. We propose a standard table to be completed to accompany any RAPD assewsment of germplasm. Information provided in the table should facilitate the re-

producibility of RAPD results between laboratories studying the same species. Genebank curators normally carry out characterization and evaluation by scoring some or all (according to need) of the descriptors in a descriptor list. This is a collation of all the descriptors thought necessary to describe an accession of a given species, giving the character states each descriptor can take or the units and method of measurement. Standardized and internationally agreed descriptor lists are published by IPGRI for many crops. Although some of the newer descriptor lists mention molecular techniques for characterization and evaluation, little guidance is given on standardization of either experimental conditions or presentation of results. This is in marked contrast to the case of morphological and agronomic descriptors. The table presented here is intended to be a first step towards redressing this imbalance.

A. RAPD-PCR reaction chemicals

A.1. DNA extraction and template concentration

The method of DNA extraction is not particularly important, although the shelf life of the DNA depends on the extraction technique and storage conditions (Sambrook *et al.* 1989; Weising *et al.* 1995). PCR-based techniques do not require such pure DNA preparations (Edwards *et al.* 1991), so relatively quick and simple extraction methods can be employed. However, it would certainly help other workers and save them time to specify the most suitable DNA extraction method for the plant under study. On the other hand, the final template concentration is important, DNA quantities between 5 and 500 ng usually providing good results. RAPD patterns seem to be affected most by very low DNA concentration (i.e. pg of DNA; Williams *et al.* 1993; Weising *et al.* 1995), but very high DNA concentrations can also affect banding repeatability (Munthali *et al.* 1992). A DNA templ ate concentration of 10-50 ng/50 ml reaction volume has been suggested to be optimal (Weising *et al.* 1995).

A.2. $MgCl_2$ concentration

A change in $MgCl_2$ concentration can result in alteration in RAPD banding profiles (Williams *et al.* 1991, 1993; Wolff *et al.* 1993). Although reproducible bands can be obtained across a range of $MgC1_2$ concentrations, the intensity of bands is usually affected (Williams *et al.* 1993), as well as levels of background smearing caused by non-specific amplification. A concentration of about 2 mM (final reaction volume) is recommended as a starting point for optimization (Weising *et al.* 1995).

A.3. dNTP concentration

The dNTP concentration is usually recommended by the manufacturer but concentrations of 100 mM in the reaction volume are usual. The concentration ratio of dNTP to $MgCl_2$ may also be of importance as deoxynucleotide triphosphates appear to quantitatively bind Mg^{2+} (Erlich 1989).

A.4. RAPD primer concentration

Primers are easy to synthesise and several commercial companies produce them (e.g. Operon Technologies, Inc. and Pharmacia LKB). Primer concentration is thought to be optimal between 0.1 and 2.0 mM (Williams *et al.* 1993), and primer concentrations outside these limits usually result in lack of amplification.

A.5. Taq polymerase

A wide variety of RAPD banding patterns can be observed depending on the source of *Taq* polymerase used (Williams *et al.* 1993). In particular, truncated polymerases like the Stoffel Fragment (Perkin Elmer) can give radically different RAPD banding profiles compared with polymerases possessing 5' to 3' exonuclease (proof-reading) activity, e.g. *Taq* polymerase, Promega and AmpliTaq, Perkin Elmer (Sobral and Honeycutt 1993; Weising *et al.* 1995). Therefore, use of the same brand of *Taq* polymerase for repeat experiments is essential. Also, the purity of the *Taq* polymerase is important. The enzyme should be free of any contaminating bacterial DNA. This i{ generally not a problem with commercial enzymes. However, it is an important factor to consider if preparing your own polymerase.

A.6. PCR reaction volume

A reaction volume of 50 ml (made up to volume with freshly sterilized H_2O to prevent contamination) can be used, although to save on expensive chemicals a reaction volume of 25 ml is often preferred (Weising *et al.* 1995). Reaction volumes less than 25 ml do not generally give good reproducibility for RAPD-PCR reactions (Lowe, pers. observation).

A.7. Design of RAPD primers

Although the randomness of the RAPD-primer sequence is the cornerstone of the RAPD method, there seem to be some guidelines emerging for primer design. Fritsch *et al.* (1993) have examined the effect of G+C content on RAPD amplification and found that primers with a high G+C content (>60%) seem to be better for generating RAPD profiles. There were more bands of stronger intensity. Also, but to a lesser extent, primers with a higher G+C content of the last four 3' nucleotide bases also seem to be better for RAPD amplification. For experimental repeatability, it is obviously crucial to know the sequence of the RAPD primers used.

B. Hardware for RAPD-PCR

B.1. Thermocycler

The main difference between thermocyclers is the ramp time between critical temperatures, with newer machines now having extremely rapid ramp rates. It is essential that

a thermocycler is used that allows programming (and therefore standardization) of the ramp rate between the annealing and elongation steps of the cycle (see also below). Another problem with some of the older machines (now much reduced, owing to better designs) is temperature variation across the heating block. As with any other RAPD-PCR experiment, the effect of temperature fluctuation across the block should be examined by running replicates in several positions across the rows and columns of the heating block. However, positional effects generally seem to be minimal (Devos and Gale 1992; Weising *et al.* 1995).

C. RAPD-PCR programming conditions

C.1. Thermocycler temperature profile

Many different temperature profiles are suggested in different studies. Williams *et al.* (1990) originally suggested that a temperature profile of 1 min at 94°C, 1 min at 36°C and 2 min at 72°C be used. However, PCR amplification will still work effectively if these time periods are shortened, and by reducing the time at 94°C the life of the *Taq* polymerase may be significantly increased. For example, Yu and Pauls (1992) used only 5 sec at 94°C. The ramp rate between temperatures can be important, and particularly crucial is the ramp rate between primer annealing (36°C) and polymerase extension (72°C) temperatures. A primer may not have full homology to a target site and still result in polymerase amplification. So, if the rate of temperature increase is slow, the polymerase has a chance to add nucleotides onto the 3' end of the primer. This increases the melting temperature and prevents denaturation of the primer/target site complex at 72°C (Weising *et al.* 1995). The annealing temperature is critical: it is usually set at 5°C below the primer melting temperature (Innis *et al.* 1990). The annealing temperature for decamer random primers is usually set at 36°C (Williams *et al.* 1993). During optimization, the annealing temperature may be increased to reduce smearing or produce fewer, more distinct bands (Weising *et al.* 1995) and RAPD protocols have been published with annealing temperatures as high as 48°C (Levi *et al.* 1993). The number of cycles is also a variable parameter. Some studies recommend fewer cycles (e.g. 35; Munthali *et al.* 1992), while Weising *et al.* (1995) found significantly higher yields of DNA were obtained after 45 cycles than with 40 or fewer cycles. It is important to note that the time specified for a particular temperature should be the time spent at that temperature, as some brands of thermocycler start timing just before rgaching the specified temperature (e.g. older Techne models). With such machines, it may be important to make allowance for this extra time taken to reach a specified temperature in the programme times.

D. Analysis of RAPD-PCR fragments

Once generated, RAPD-PCR fragments need to be separated and visualized before they can be reliably scored. The most common technique is to separate RAPD fragments using agarose gel electrophoresis and then visualize the fragments by staining with ethidium bromide and observing the bands under UV light. The relative migration of fragments is affected not only by the concentration of agarose but also by the brand and purity of the agarose used. The buffer used for electrophoresis may also have an effect on the quality of visualization of bands and should be standardized. Polyacrylamide gel electrophoresis (PAGE) is also often used to separate RAPD fragments. This gives much better resolution of smaller RAPD fragments and in many cases can help to distinguish more fragments (Weising *et al.* 1995). Using silver staining instead of ethidium bromide can also improve the sensitivity with which RAPD fragments can be detected in polyacrylamide gels (Bassam *et al.* 1991; Milligan 1992; Pang *et al.* 1992). It is therefore important to specify the type of electrophoresis, the concentration of the gel and the chemical used for visualizing the RAPD fragments. Electrophoresis conditions (buffer type and concentration, duration and electric field) are also important factors affecting RAPD profile results.

E. Presentation of results

Once all the conditions of the RAPD-PCR protocol and visualization have been standardized the next problem is actually identifying co-migrating bands between different studies. Several molecular weight markers are available for calculating the size of fragments relative to the migration of a known standard (e.g. 123 bp ladder, Amersham). However, on agarose the RAPD bands cannot be reliably sized to anything better than a 5% error rate (i.e. for a band of size 100 bp conservative estimates of its size can vary between 95 and 105 bps; Sambrook *et al.* 1989). With this in mind, RAPD primers that are intended for germplasm genotyping should, perhaps, be those that do not reveal too much variation, as highly variable RAPD gels are difficult to compare in a standard manner without reference samples. Unless better sizing methods can be used and standardized, the problem of accurately sizing bands may still remain one of the major obstacles to the cross-referencing of results derived from different studies.

The RAPD fragments should also be named. One recognized standard is the primer name followed by the estimated size (in base pairs) of the fragment (e.g. OPA1-850 would be a fragment of 850 bps amplified using Operon primer 1 from kit A). Presence and absence of RAPD fragments is usually recorded in a table with each sample (e.g. accession) as the row labels, the name/reference of each RAPD fragment as the column labels, and in the data matrix the presence of a fragment indicated by 1 and absence by 0, with missing data being indicated by an asterisk (*).

Table 1. List of parameters that should be standardized in a RAPD-PCR reaction to allow cross-comparison of results from different RAPD profiling studies on the same species.

A. RAPD-PCR reaction chemicals

Reference for DNA extraction technique (optional) ________
DNA template quantity ________ (ng) and volume ________ (µl)
Concentration of $MgCl_2$ added ________ mM and volume ________ (µl). Final volume conc. ________ mM
Concentration of dNTPs added ________ mM and volume ________ (µl). Final volume conc. ________ mM
Concentration of primer added ________ mM and volume ________ (µl). Final volume conc. ________ mM
Taq polymerase brand ________ and volume ________ (µl). Number of units per reaction ________
PCR 10x buffer brand ________ and volume ________ (µl)
Volume of dH_20 used ________ (µl)
Total volume of PCR reaction ________ (µl)

Primer information

	Name	Sequence
1.	________	________
2.	________	________
3.	________	________
4.	________	________
5.	________	________
6.	________	________
7.	________	________
8.	________	________
9.	________	________
10.	________	________
etc.		

B. Hardware for RAPD-PCR

Make and model of thermocycler ________

C. Thermocycler temperature profiles

Cycle programme
Initial denaturation step: Temperature ________ (°C) and duration ________ (seconds)
Cyclic denaturation step: Temperature ________ (°C) and duration ________ (seconds)
Cyclic annealing step: Temperature ________ (°C) and duration ________ (seconds)
Ramp rate between annealing and extension step ________ (°C /s)
Cyclic extension step: Temperature ________ (°C) and duration ________ (seconds)
Total number of cyclic steps ________
Final extension step: Temperature ________ (°C) and duration ________ (seconds)

Any other temperature profile modifications (e.g. hot start, touchdown, etc.) ________

D. Analysis of RAPD-PCR fragments

Type of electrophoresis used (e.g. agarose, PAGE) ________
Brand of media ________
Concentration of gels used ________ (%)
Electrophoresis conditions: Current ________ (mA)
Voltage ________ (V)
Duration ________ (hours)
Chemical used to stain DNA (e.g. ethidium bromide, silver) ________
Type and recipe of electrophoresis buffer used (e.g. TAE, TBE) ________

E. Presentation of RAPD results

RAPD fragment presence/absence table. Presence should be indicated by 1, absence by 0 and missing data by *. Accession reference refers to genebank accession label, Primer reference is Primer label whose sequence is indicated above (e.g. OPH4) and fragment size in bps.

Conclusions

With the wider use of molecular techniques for describing germplasm in gene banks, standardization of these techniques for cross-comparison of results becomes a necessity. The RAPD-PCR is a technique now increasingly used in the characterization of germplasm collections, but in the past the technique has had problems with reproducibility. Today the PCR method that generates RAPD fragments is better understood and by annotating and following a set of procedural steps, results should be repeatable in different laboratories working on shared germplasm material. We have outlined such a table to be used for the annotation of RAPD-PCR reaction conditions and discussed the sources of errors of reproducibility in the RAPD-PCR reaction. Here we propose a table describing the important experimental steps in RAPD procedures. We suggest that such a table should be completed and included with each RAPD study characterizing a germplasm collection.

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Résumé

Normalisation des techniques génétiques moléculaires pour la caractérisation des collections de matériel génétique: arguments en faveur du polymorphisme aléatoire amplifié de l'ADN (RAPD)

La variation du RAPD est de plus en plus utilisée pour caractériser les collections de matériel génétique. Néanmoins, la technique a des limites dues au manque de reproductibilité des résultats dans certaines conditions. Nous passons ici en revue quelques études conduites sur des facteurs qui sont pour une bonne part responsables de cette variation dans la production de fragments RAPD, et examinons des moyens de réduire ces sources de variation indésirable. Nous présentons un tableau qui récapitule tous les descripteurs jugés nécessaires pour décrire les conditions et les procédures d'évaluation indispensables pour l'établissement de profils RAPD reproductibles de matériel végetal. La normalisation des procédures et la présentation des résultats devraient faciliter la comparaison des résultats à la fois entre et dans les laboratoires travaillant sur du matériel semblable et permettre d'utiliser les RAPD comme descripteur standard de matériel génétique.

Resumen

Estandarización de las técnicas genéticas moleculares para la caracterización de colecciones de germoplasma: amplificación aleatoria de ADN polimórfico (RAPD)

La RAPD se utiliza cada vez más para caracterizar las colecciones de germoplasma. No obstante, esta técnica está limitada por la falta de reproductibilidad de los resultados en ciertas condiciones. En este artículo se examinan algunas de las obras que se han escrito sobre los factores que son los mayores responsables de la variación en la generación de fragmentos de RAPD, y las maneras de reducir estas causas de variación no deseada. Se presenta un cuadro en el que se comparan todos los descriptores que se consideran necesarios para describir las condiciones y los procedimientos de evaluación que se precisan para especificar los materiales vegetales de RAPD reproducible. La estandarización de los procedimientos y la presentación de los resultados facilitaría la comparación de los rewultados entre los laboratorios, y dentro de los mismos, que trabajan sobre este material y permitiría utilizar los RAPD como descriptor estándar de germoplasma.

Finger millet (*Eleusine coracana* (L.) Gaertn.) in China

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Introduction

The genus *Eleusine* (Gramineae) includes 11 species that are distributed widely in the tropics and the subtropics (Goud 1989). In China two species, *E. indica* (L.) Gaertn. and *E. coracana* (L.) Gaertn. (finger millet), are found (Chen 1990). The wild *E. indica* is distributed over most of the provinces of China. It is used as a fodder crop, a green manure or a soil-conserving plant, and is also used in weaving and paper-making. According to ancient medicinal literature in China, plants of *E. indica* have medicinal use in protecting from or treating epidemic encephalitis B, dysentery, orchitis, hernia, enterogastritis, jaundice, dog bites and injuries from falls, fractures and strains. It can also be used to treat acute febrile disease, relieve internal heat or fever, and treat chronic diseases marked by deficiency of vital energy and lowering of body resistance. Filaments made from its stalks were widely used in cricket-fighting (a gambling game) in ancient China. The cultivated *E. coracana*, sporadically grown in some provinces of southern China, has as many uses as *E. indica*.

Since 1991, several hundreds of accessions of finger millet have been collected throughout China and preserved in the Chinese National Genebank (Li 1994). Some morphological characters and agronomic traits have been evaluated. However, very little information can be found in Chinese literature because the millet is a minor or neglected crop. Also, no archaeological remains of the millet have been identified among plant remains of the numerous early farming sites excavated in China so far. This paper will focus on the geographical distribution of germplasm resources of these millets and their traditional uses in China, and will discuss the infraspecific variation of the cultivated millets.

Origin

Finger millet is classified in the tribe Eragrosteae of the Poaceae. Hilu and de Wet (1976) designated finger millet as *E. coracana* subsp. *coracana* because both the cultivated cereal and the wild African relative (*E. coracana* subsp. *africana*) are tetraploid and they hybridize freely to produce fertile progenies. As to the origin of finger millet, some controversial opinions have been proposed (Hilu 1988, 1995). However, it seems to be widely accepted that it was domesticated in the east African highlands with subsequent movement into southern Africa and migration via human trade into India, possibly around 1000 BC (de Wet *et al.* 1984). The origin of finger millet in China is not known, but may have been introduced from the Indian subcontinent at least several hundred years ago, since 'Shoushitongkou', a comprehensive book on agriculture in ancient China, which was published in 1742, recorded finger millet cultivation.

Geographical distribution of germplasm in China

Finger millet is a minor crop in some regions of China. Therefore, collecting, conservation and rewearch of the minor crop did not receive attention until the beginning of the 1990s. During the period 1991-95, and in collaboration with various provincial and prefectural institutions, the Institute of Crop Germplasm Resources of the Chinese Academy of Agricultural Sciences collected 224 accessions of finger millet in China. They are stored in the National Genebank of China. A catalogue has also been published (Wu and Chen 1995). The geographical distribution of the germplasm is illustrated in Fig. 1.

Finger millet is cultivated mainly in some provinces of southern China such as Guizhou, Guangxi, Hainan, Yunnan and Xizang since it is typically a tropical crop. Basically, the numbers of millet germplasm accessions collected are in proportion to their production. The regions with larger areas of millet production have more landraces. Therefore, more landraces of finger millet may exist in Guangxi and Yunnan and expeditions for germplasm collecting of this cereal should concentrate on these areas of southwestern China.

Infraspecific variation of the germplasm

The accessions collected were grown and evaluated in the provincial capitals of their origin in order to make them mature normally. The exception was the accessions from Xizang, which were grown and observed in Beijing. Table 1 shows some quantitative characters of finger millet characterized in five provinces where the crop is important, namely Xizang, Yunnan, Guangxi, Hainan and Guizhou. Great variation exists in these accessions. In qualitative traits, for example, the grain colour of most of the accessions is brown and that of several accessions is grey, but the kernel (dehulled grain) colour varies greatly. Red is the major kernel colour (in about 50% of the accessions), followed by purplish red (about 33%), brownish red (8%) and purplish black (7%). A few accessions have purple or black kernels. In Xizang, two types of finger millet were found: one with strongly incurved and densely arranged spikelets and the other with slightly incurved and loosely arranged spikelets. The latter is believed to be an introduction from Burma (Wang 1983).

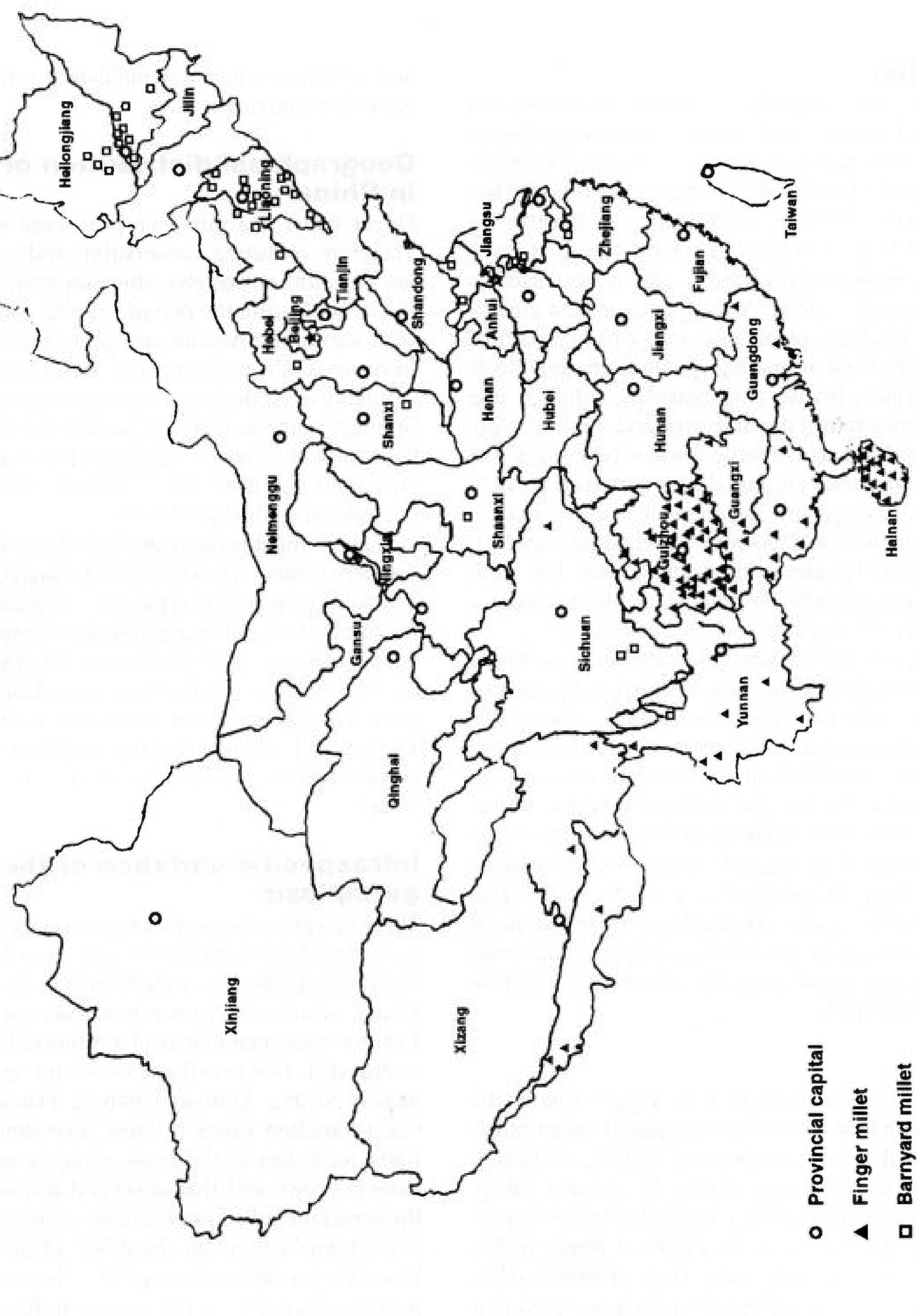

Fig. 1. Geographical distribution of finger millet and barnyard millet germplasm in China

Table 1. Some quantitative characters of cultivated finger millet in five provinces of China[a]

Character[b]	Xizang	Yunnan	Guizhou	Guangxi	Hainan
NOC	4.0 ± 0.8 (3-5)	5.7 ± 3.7 (1-11)	3.5 ± 1.6 (2-13)	4.7 ± 1.0 (1-7)	3.0 ± 1.8 (1-8)
LMC	105.2 ± 8.5 (85-120)	100.7 ± 7.6 (93-108)	130.0 ± 19.9 (63-160)	96.5 ± 14.0 (63-122)	103.9 ± 19.9 (56-142)
DMC	0.60 ± 0.11 (0.5-0.8)	0.62 ± 0.19 (0.4-1.0)	0.85 ± 0.26 (0.2-1.3)	1.01 ± 0.11 (0.8-1.3)	0.57 ± 0.31 (0.1-1.2)
NNC	4.6 ± 0.6 (4-6)	6.5 ± 1.2 (5-10)	16.9 ± 6.3 (4-25)	8.5 ± 1.4 (5-12)	8.4 ± 1.8 (6-12)
LMS	6.2 ± 1.5 (4-9)	6.4 ± 1.3 (5-10)	11.3 ± 3.0 (5-22)	8.1 ± 1.7 (5-15)	7.4 ± 1.1 (5-11)
NBS	11.8 ± 2.2 (9-17)	7.1 ± 2.0 (5-11)	7.1 ± 1.2 (3-11)	4.6 ± 1.5 (2-9)	10.4 ± 2.3 (6-17)
DOF	62 ± 2.7 (59-66)	97 ± 16.6 (62-118)	96 ± 7.3 (77-108)	100 ± 22.2 (64-192)	87 ± 24.0 (54-180)
TGW	1.8 ± 0.4 (1.2-2.5)	2.4 ± 0.5 (1.8-3.4)	1.9 ± 0.5 (0.9-2.9)	1.8 ± 0.3 (1.3-2.5)	2.0 ± 0.3 (1.5-2.8)

[a] Mean ± standard deviation (and range) are indicated for each character.
[b] Characters: NOC = number of culms including main culm and tillers; LMC = length of main culm (cm); DMC = diameter of main culm at the base (cm); NNC = number of nodes of main culm; LMS = length of main spike (cm); NBS = number of branches of main spike; DOF = days to flowering; TGW = 1000-grain weight (g).

Cultivation and uses

Finger millet is mainly cultivated in mountainous and hilly areas of southwestern China, where annual rainfall is more than 1000 mm. Farmers often grow finger millet in sloping fields where other crops, especially rice, cannot grow. Both direct sowing and transplanting are used. Spring-sown finger millet is sown at the beginning of April and transplanted in the first 10 days of May. Summer-sown finger millet is sown at the beginning of July and transplanted in the first 10 days of August. Direct sowing is done in late July. In some areas, some modern farming methods, such as fertilizer application and disease and pest control, are also used today. However, finger millet is a typical low-input crop. Farmers do not pay much attention to the management of the crop, with sowing and harvest usually being the only two farming practices. Because the maturity periods between main culms and tillers differ significantly, three to four harvests are required. Spikes from the main culms with early maturity are generally used as next year's sowing seed.

Finger millet is used as a cereal, the grains as ingredients for cakes or porridge. Grains are also used in brewing beer. Kernels of finger millet have a role in Chinese medicine, and are supposed to increase vital energy and be beneficial in treating sunstroke and heat symptom complexes. Stalks and leaves can be used as silage and hay. In addition, stalks may be used in weaving baskets and hats, and as raw material for paper-making. One interesting traditional use is that farmers in Guizhou and Guangxi spray grains of finger millet onto the floors of barns. The reason is not clear, but may be to prevent pest damage during the storage of other kinds of grains such as rice.

Although finger millet is a minor cereal in China, the crop is of considerable local importance in some areas or in case of disaster. However, little crop improvement through modern breeding has been achieved. Because of the requirement of food diversification in China (especially in cities), future emphasis will be placed on improvement of some promising minor crops. Thus, further studies on finger millet are urgently needed.

Acknowledgements

We would like to thank two anonymous reviewers for critical reading and advice. We are also grateful to Mr M. Steveivson for corrections. This study was supported by the Chinese government.

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News and Notes

FAO International Technical Conference on Plant Genetic Resources

Leipzig, Germany, 17-23 June 1996

The Leipzig Conference was the culmination of a process started in 1991 that aimed to assess the current situation of plant genetic resources for food and agriculture, and to reach agreement on priority action required, nationally and internationally, to address the most pressing needs and problems. The pr cess involved more than 150 individual country studies and 11 subregional meetings, which, together with inputs from a variety of technical meetings and electronic conferences, formed the basis of the two main documents tabled at Leipzig:

- The State of the World's Plant Genetic Resources for Food and Agriculture
- The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA).

FAO
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International Technical Conference on Plant Genetic Resources

The Leipzig Conference was attended by delegates from 150 countries and 54 organizations. Immediately prior to the Conference, a group of non-governmental organizations held a separate meeting to coordinate their own input to the discussions and they actively participated throughout the week.

The major part of the Conference was taken up with detailed negotiations over the wording of the GPA. Particularly contentious issues included the provision of funds to implement the GPA and the recognition of Farmers' Rights. Other issues that surfaced included terms and conditions for access, intellectual property rights and seed legislation. While views on financing tended to be polarized between the South and North, on many other issues the demarcation of positions was not so clear cut. In addition to discussions on the GPA, a considerable amount of time was devoted to negotiating the wording of the 'Leipzig Declaration'.

After a hard, and sometimes acrimonious, week of negotiation, compromise wording was finally agreed very late on Saturday night, and the Conference adopted the GPA, the Leipzig Declaration and the Conference Report in the early hours of Sunday morning.

In spite of the difficulties encountered, Leipzig represents an important step forward. It focused global attention on the importance of plant genetic resources and helped to increase awareness among a wide spectrum of policymakers. It demonstrated that there is global agreement on the nature and extent of the problems to be addressed and the steps that need to be taken nationally, regionally and internationally. It also showed that agreement on technical issues and strategies is possible, even among countries with widely different circumstances and holding widely different views.

While delegates were generally relieved that a compromise had been achieved and that the GPA had been adopted, there was also a strong realization that a final resolution of the major political issues is still pending. Leipzig was thus seen as just one step in the evolution of a global system for plant genetic resources rather than the launching of a new system *per se*. The next step will be the negotiations in December, at an extraordinary meeting of the FAO Commission on Genetic Resources, to revise the International Undertaking. These negotiations promise to be long and difficult. The outcome of the Leipzig Conference will also be discussed by the Conference of the Parties to the Convention on Biological Diversity, both at the meeting of its technical advisory body in September and at the third Conference of the Parties in Buenos Aires in November. It will also be presented to the World Food Summit in Rome in November.

For further information, see **http://web.icppgr.fao.org.** This is FAO's Web site for plant genetic resources information, with sections on the Conference; the FAO Commission on Genetic Resources for Food and Agriculture; Country and Sub-regional Information; Documents and Information on PGR; Discussion Fora; and the World Information System

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The World Food Summit

WORLD FOOD SUMMIT
Rome
13-17 November 1996

FAO is convening the World Food Summit in Rome from 13 to 17 November 1996 with the objective of renewing the commitment of world leaders to lasting food security for all. Heads of State and Government from close to 200 countries are expected to gather at FAO Headquarters to agree on a blueprint for a coordinated campaign, in partnership with civil society and international organizations, to eradicate hunger.

The personal participation of national leaders will mobilize all government ministries and agencies concerned with food security - from agriculture, fisheries, forestry and environment to foreign affairs, trade, economy and development cooperation This wide involvement, along with the active participation of NGOs, the private sector and other groups, is essential to develop a sound and realistic draft plan of action for the Summit, and subsequently to ensure achievement of the Summit's goals.

According to current estimates, by the year 2030 world population will rise from 5.7 thousand million to 8.7 thousand million. As population grows, *per capita* availability of arable land will decrease even further, thus heightening the need to intensify agricultural production and making greater demands on finite natural resources.

The Summit is expected to lead to the adoption of policies and strategies at international and national levels, as well as a plan of action for implementation by all parties concerned: governments, international institutions, and all sectors of civil society.

A wide variety of parallel events will take place in and around Rome at the time, including an NGO Forum (11-17 November), a Youth Forum (13-17 November), an inter-parliamentary meeting and a meeting of mayors' associations. NGO events on the theme of food security are taking place all over the world in preparation for the Summit.

A key aspect of the World Food Summit is the solid analytical foundation on which preparations are being based. In addition to draft policy statement and plan of action documents to be submitted for the direct consideration of the Heads of State and Government, the major issues of relevance are presented through a series of analytical background papers covering past development, the present situation and future trends.

Participating nations have expressed their determination to agree on concrete, achievable food security goals, which they can attain individually or in partnership with others.

International Plant Genetic Resources Institute - Vavilov-Frankel Fellowships 1997

The International Plant Genetic Resources Institute (IPGRI) has established the Vavilov-Frankel Fellowship Fund to commemorate the unique contributions to plant science by Academician Nikolai Ivanovich Vavilov (left) and Sir Otto Frankel (right). The Fund aims to encourage the conservation and use of plant genetic resources in developing countries through awarding fellowships to outstanding young scientists to enable them to carry out relevant, innovative research outside their own country for a period of between three months and one year. The research should have a clear benefit to the applicant's home country. Awards can be held concurrently with other sources of support. In 1997, a total of US$60,000 will be available for awards (maximum of $30,000 for any one award), which are intended to cover travel, stipend, bench fees, equipment, conference participation or any other appropriate use. Holders are encouraged to present the results of their research at an international conference. This can take place within one year of termination of the fellowship.

Applications for 1997 fellowships are invited from developing country nationals, aged 35 or under, holding a higher degree in a relevant subject area. Application forms may be obtained from: Vavilov-Frankel Fellowships, IPGRI, Via delle Sette Chiese 142, 00145 Rome, Italy. (Fax 39 6 5750309; Email: e.clancy@cgnet.com) and should be returned to this address.

Applications, preferably in English (or accompanied by an English translation), should include a completed application form, brief letter of application, full *curriculum vitae*, research proposal (maximum 1000 words) and letter of acceptance from the proposed host institute. The closing date for receipt of applications is 31 December 1996. The successful applicants will be informed by 31 March 1997 and are required to take up their fellowships before 31 December 1997.

Allium reference collection at Gatersleben

During the 5th meeting of the working Group on *Allium* of the European Cooperative Programme of Plant Genetic Resources Networks (ECP/GR) held at the Institute of Vegetable Crops in Skierniewice, Poland, an earlier recommendation was strongly supported that the *Allium* Research Collection at IPK, Gatersleben, Germany, be established as a reference collection for research purposes. The Working Group has recommended that researchers using **wild taxa** of the genus *Allium* should validate taxonomically their material by providing the Taxonomy Department of IPK with subsamples of their accessions for checking of their taxonomic identity. This material will be incorporated into the Gatersleben collection and the maintenance of safety duplicates at another place is intended.

The research collection of *Allium* at Gatersleben contains at present more than 2800 accessions, representing more than 300 taxa, and is qualified therefore to be used as reference for the identification of wild *Allium* species. The different areas of the distribution of *Allium* are, however, somewhat inadequately represented, e.g. American and East Asian species are much less numerous than Middle and Central Asiatic ones, which have been the subject of many special collecting missions by the staff of the Taxonomy Department at Gatersleben. A remarkable turnover of the collection by the loss of less robust taxa, difficult to grow under the subhumid conditions of Central Europe, contributes to some change of the species spectrum of the collection. Safety duplication, especially for the material which will be sent to Gatersleben for identity control, is therefore essential.

Technical Guidelines for the Safe Movement of Germplasm

Inevitably, the movement of germplasm involves a risk of accidentally introducing plant pests[1] along with the host plant. In particular, pathogens that are often symptomless, such as viruses, pose a special risk. In order to manage this risk, effective testing (indexing) procedures are required to ensure that distributed material is free of pests that are of quarantine concern.

In order to develop crop-specific overviews of the existing knowledge in all disciplines relating to the phytosanitary safety of germplasm transfer, FAO and IPGRI launched a collaborative programme for the safe and expeditious movement of germplasm.

The purpose of the joint FAO/IPGRI programme is to generate a series of crop-specific technical guidelines that provide relevant information on disease indexing and other procedures that will help to ensure phytosanitary safety when germplasm is moved internationally. The scope of the recommendations in these guidelines is confined to small, specialized consignments used in technical crop improvement programmes, e.g. for research and basic plant breeding programmes. When collecting germplasm, local plant quarantine procedures, for example pest risk assessment, should be considered.

The guidelines are written in a short, concise style. Suggestions for further reading are given at the end. The guidelines are divided into two parts. The first part makes general recommendations on how best to move the germplasm. The second part covers important pests which may infect, infest or contaminate germplasm that is moved following the general recommendations. The information given on a particular pest or disease is not exhaustive but concentrates on those aspects that are most relevant to quarantine.

Guidelines have been published for cocoa, edible aroids, *Musa* spp., sweet potato, yam, legumes, cassava, citrus, grapevine, vanilla, coconut, sugarcane, small fruit, small grain temperate cereals, stone fruits and *Eucalyptus* spp. In preparation are guidelines for *Allium* spp., potato and *Pinus* spp. Individual copies are available from IPGRI.

[1] Pest is as defined in the International Plant Protection Convention. It encompasses all harmful biotic agents ranging from viroids to weeds.

Indexing the world's known species

There are about 1.75 million different kinds of plants, animals, fungi and microorganisms in the world. A worldwide programme to make an index of the world's known species started in March 1996 in Manila, Philippines. The Species 2000 programme will allow users worldwide to verify the scientific name, status and classification of every known species of plant, animal, fungus and microorganism. The programme provides an important element in the information needed for the implementation of the Convention on Biological Diversity, especially by providing support for the preparation of surveys and inventory of biodiversity as well as providing a common medium for global communication about biotic resources.

Representatives of 18 taxonomic and species diversity databases met in mid-March at a United Nations Environment Programme workshop to give the formal go-ahead for the programme, which had been planned by the International Union of Biological Sciences, the Committee on Data for Science and Technology and the International Union of Microbiological Societies. Implementation of Species 2000 will involve:

1) forming a federation of the existing global master species databases for viruses, bacteria, protists, arthropods, molluscs, birds, mammals, fungi, plants and fossils
2) establishing a common access framework for member databases (such as World Wide Web home pages on Internet)
3) accelerating the development of the global master species datasets, by both completing existing systems and developing new ones
4) developing access among the federated databases with a view to providing a virtual index of all known species.

Proposals were developed and presented by a Project Design Team led by Dr Frank A. Bisby, coordinator of the World Database of Legumes. The intention of the Species 2000 plan is to create an array of global species databases covering each of the major groups of organisms. Each such database will cover all known species in the group using a consistent taxonomic system. The headquarters of the present databases are distributed throughout the world, and this trend will continue as new databases are added. An innovative feature of the Species 2000 programme is its Common Access System which will provide simultaneous access to the databases over the Internet. The feasibility of this approach was demonstrated at the workshop by Dr Junko Shimura of the World Data Centre for Microorganisms, Riken, Japan and Mr David Gee of the Palaeobiology Research Unit at the University of East London, UK.

Global master species databases are defined as taxonomic databases which

* cover a major group of organisms worldwide (e.g. fishes, legumes, bacteria)
* build up individual records for each known species in the group
* include a name and some synonyms for each species
* subject each species record to scrutiny by acknowledged taxonomic experts in the group, especially seeking responsible choice of taxonomic system(s) and taxonomic consistency between records.

Global master species databases typically contain a common absolute minimum of taxonomic species data, but vary considerably both in other data types and the style and medium of public dissemination. Such datasets often include common names, descriptions, images, geographical or ecological distribution, chemical or molecular data, germplasm sources and identification aids. Some are presently available on Internet or CD-ROM. The index will contain accepted names and synonyms (binomials with author), sources of the names (literature citations), and position in the classification.

In addition to providing on-line access to the most up-to-date version of each database in the array, Species 2000 will create an annual edition of a checklist holding a minimal entry for each known species. It is envisaged that this will become available on the Internet and on CD-ROM, and be used by many organizations as a standard comparator for species inventories and lists.

One hundred or more global species databases, each initially covering 10 000-25 000 species, will be needed for all species to be included. The existing global species databases may presently account for some 15-20% of the total, so substantial investment in new databases will be needed for full coverage of all taxa to be achieved.

See **http://molbiol.soton.ac.uk/~biology/sp2000/**. For further information, contact

- Species 2000 Secretariat, School of Biological Sciences, University of Southampton, Southampton, SO16 7PX, UK. Tel: +44-1703-592444, Fax: +44-1703-594434, Email: Sp2000@soton.ac.uk
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Book reviews

Transgenic Organisms - Biological and Social Implications

J. Tomiuk, K. Wöhrmann and A. Sentker, editors

1996. Hardback. ISBN 3-3743-5262-0. sFr 88. 280 pages Birkhauser-Verlag AG, Basel

Following the emergence of techniques to splice genes and synthesize novel genetic structures in the 1980s, techniques to produce and release genetically modified organisms into the environment were developed in the 1990s. The genetic engineering of organisms is a complex and multi-stage process involving: gene identification; artificial gene construction; splicing and development; transfer into host cells; gene integration into a host genome; active gene expression; selection of transgenic cells; regeneration to viable organisms; molecular verification of transgene expression; assessment of gene expression in organisms after sexual reproduction; ecological and biosafety field trials; regulatory endorsement; commercial exploitation; environmental release and monitoring for changes in efficacy and safety in genetically modified organisms (GMOs).

Numerous reports (scientific papers, specialized reports, conference proceedings, books) are available that describe the technical aspects of genetic engineering of plants, animals and microbes, and publication of guides to biosafety in release of GMOs is increasing. Transgenic Organisms: Biological and Social Implications is an excellent text that addresses the issues arising from a plethora of subjects concerning genetic modification.

This book contains the proceedings from a diverse group of scientists and moral philosophers debating the deliberate and unintentional release of GMOs. A short article (prologue) by the authors introduces the themes within the book, (i) the production of GMOs and (ii) their release into the environment. It focuses on the potential changes and stability of the new genetic information in modified organisms and the consequences for its horizontal transfer to other (related or unrelated) organisms in the environment. The initial contributions describe the various molecular techniques in the production of GMOs and the function of their transgenes. The chapter by P. Meyer, 'Inactivation of gene expression in transgenic plants,' includes important details of the possible mechanisms: DNA methylation, condensation of chromatin, RNA processing and stability and other pleiotropic effects. Important to the long-term expression and stability of transgenes is the activity of mobile DNA sequences, transposable elements within the host genome, especially in view of their discovery by Barbara McClintock. The impact of these 'jumping genes' on the genomes of organisms and their possible evolutionary consequences are discussed in two informative chapters (by W.J. Miller, L. Kruckenhauser, W. Pinsker and L. Bachmann, respectively). This aspect of evolutionary development is explored further in considering the 'Transmission of insect transposons into baculovirus genomes: An unusual host-pathogen interaction' (by J.A. Jehle). This is important in the exploitation of baculoviruses as environmentally benign biological control agents of insect pests.

The use of genetically engineered microorganisms (GEMs) in the environment can provide important applications for commercial, agricultural and public health purposes (bioremediation, biomining and biofertilization). It is well known that gene transfer between bacteria occurs via conjugation, transformation and transduction; however, more quantitative information is required regarding the 'Mechanisms and consequences of horizontal gene transfer in natural bacterial populations' (M.G. Lorenz and W. Wackernagel). Crucial to the release of GMOs is monitoring the environment; the submission by K. Smalla and J.D. van Elsas on 'Monitoring genetically modified organisms and their recombinant DNA in soil environments' clearly describes the procedures and techniques for sampling and processing soils along with cultivation and detection of GMOs and marker genes released from their DNA. Although regulatory approval is a key feature for the release of GMOs, in some circumstances, restrictions for microbial use are a requirement; T. Schweder discloses 'Two strategies for the biological containment of genetically engineered bacteria'.

The mid-1980s was a pioneer biotechnologist's time for speculation, on the conference circuits, about the advances and benefits of genetic engineering. The promotion of this 'new technology' at the XVIth International Congress of Genetics, Toronto, Canada (August, 1988) was no exception to raising the audience's awareness of its expectations, until a note of reality was injected into the proceedings by a renowned scientist who stated that "biotechnology is simply an adjunct to conventional plant breeding". With this in mind, the chapter by W. Friedt and F. Ordon 'Modern versus classical plant breeding methods - efficient synergism or competitive antagonism' is a welcome and readable contribution. Currently, views of the "modern biotechnological future" are focused on understanding the events after the release of GMOs into the environment. It is likely that releasing fertile genetically modified plants into the agri-environment will disseminate pollen, resulting in self- and cross-fertilization and geneflow into the crops' relatives and wild species. The chapters by K.D. Adam and W.H. Kohler on the 'Evolutionary genetic considerations on the goals and risks in releasing transgenic crops' and the 'Influence of transgenes on coevolutionary processes' by P.W. Braun provide excellent coverage of these subjects. In assessing the potential risks, processes involving geneflow and the spread of genes after GMO release, a chapter by J. Tomiuk and A. Sentker describes the 'History of and progress in risk assessment'. I.M. Parker and D. Bartsch present the 'Recent advances in ecological biosafety research on the risks of transgenic plants: a trans-continental perspective' to consider the concept of in-

vasiveness and its ecological relevance with respect to oilseed rape and sugar beet. Although many of these risk assessment features focus on environmental factors, the chapter by M. Teuber considers 'Genetically modified food and its safety assessment'. These biochemical, technological and toxicological evaluations are essential for legal acceptance and entrance into markets worldwide.

Unlike genetically modified animals, microbes and plants, the Human Genome Project (HUGO) with the utilization of potentially the entire human DNA sequence database began its 15-year development schedule in 1990. The impact of this research for DNA-based diagnosis, screening and therapy is appropriate in this book and is discussed in 'Genetic intervention in human beings' by M. Leipoldt. Moreover, these considerations are reflected in the ethical implications and public views of the chapters 'Transgenic organisms and evolution: ethical implications (T. Potthast) and 'Genetic engineering and the press – public opinion versus published opinion (A. Sentker).

Several major meetings have discussed the release of GMOs into the environment, including: in November 1990, the First International Symposium on 'The Biosafety Results of Field Tests of Genetically Modified Plants and Microorganisms' held at Kiawah, South Carolina; the Second International Meeting in Goslar, Germany 1992 and the Third International Meeting in Monterey, USA, 1994, and there will be others to discuss technical developments and reports from previous releases. This book addresses the contemporary issues in releasing GMOs into the environment, the contents are well balanced and considers sensitive subjects with clarity, purpose and a forward outlook. These are progressive times, and the authors condense the numerous contributions in a concise epilogue. This book gives an excellent overview of several complex subjects, the information is clear, intelligently compiled and presented, and should be recommended to research scientists and others associated with the release of genetically modified organisms.

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Sustainable Development

B. Nath, L. Hens and D. Devuyst, editors
1996. Hardback. ISBN 90 5487 115 6. 365 pages
European Centre for Pollution Research, London, in collaboration with The Free University of Brussels and United Nations Educational, Scientific and Cultural Organisation, Paris, ECPR, UNESCO, VUB University Press, Brussels

This book is one in the long series of books intended to help put into practice the recommendations of the World Conference on Environment and Development, and UNCED Agenda 21 outlined in Rio in 1992. It is divided in three main parts: I. Genesis, Landmarks and Conceptual Backgrounds of Sustainable Development (5 chapters), II. Methodological Developments in Sustainable Development (2 chapters), and III. Target Groups in Sustainable Development (5 chapters). Every chapter is organized rigorously. A review of the chapter contents, presenting the main topics, is followed by a summary of the chapter, the presentation of academic objectives, the history, evolution and main goals of the subject, the topics treated, a list of references and suggested reading, as well as a series of 'self-assessment questions' and answers.

In the first part of the book topics connected with the human, scientific and technological environment of sustainable development, the Pre-Brundtland Commission Era, and the Rio Conference still belong to science history. It was for example a pleasant surprise for the reviewer to find, that "The first government agencies for nature conservation were founded in two different countries in 1885. The United States created the Fish and Wildlife Service, and Hungary created the Centre for Research in Economic Ornithology. Both sought generally to address human environmental impact. Nature conservation reached the international stage as a result of the Hungarian agency's initiatives. They first addressed public concern that the massive slaughter of insectivorous birds migrating through southern Europe would expose crops to major insect damage" (Nicolson, 1987 cit. Hatcher 1996). In Hatcher's review the chronology of main scientific and social events leading to 'Our Common Future' is obligatory for graduate students of the Berzsenyi College (Univ. West. Hung.) in the History of Biology.

The same is true for chapters dealing with the presentation of the Rio Declaration on Environment and Development, respectively with Agenda 21. The 'digests' of this document (perhaps one of the most comprehensive one in the UN's history) presented in a separate box in Part I, Chapter 3 along with subtitles 'The implementation of Agenda 21' and 'An evaluation of the implementation of Agenda 21' are very useful reading.

Surprisingly, in Chapter 4, dealing with human demography and environmental resources there is no formal section dealing with genetic resources - the most important renewable resource for any human society based on agriculture, silviculture and even hunting and gathering. No-one can state with certainty, for example, the potential economic value of the germplasm of the large mammal species which became extinct during the Pleistocene in Europe because of the pressure of ancient human populations. Today large programmes have been initiated by UN/FAO and cooperative organizations (e.g. IPGRI) in order to save *in situ*/on-farm neglected germplasm of plants and animals. References to these activities would be welcome in a volume dealing with 'sustainable development'. Not even in Chapter 9, about problems related to the maintenance of biodiversity and the possible role of genetic engineering and agriculture in the future, is the problem of genetic resources treated in its own right.

The most practical part of the book (but also the smallest

one) is Part II, dealing with methodological problems in the study of sustainable development. This key issues are treated in two chapters - both reflect the inadequacy of methodological approaches in the field. Perhaps the best paper in this respect (placed in Part III) is that dealing with the role of local authorities in achieving sustainable development. Here the development of a **local** Agenda 21 for almost every European settlement is advised in a methodologically well-founded and comprehensive manner.

A.T. Szabó
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Ethnobotany: A Methods Manual

Gary J. Martin
1995. Paperback. ISBN 0-412-48370-X. 292 pages
Chapman and Hall, London, UK

This book is an introductory manual which provides an extensive treatment of the concepts and methods used in contemporary ethnobotany. It is designed as a 'how to' guide for both short- and long-term studies and may be applied to a range of research programmes, from documenting indigenous knowledge to quantitative evaluation of resource management. Botanists, conservationists and development workers in rural areas will find this a handy and important work to have on their shelf and in the field.

Martin divides the discipline into its six core subfields (botany, ethnopharmacology anthropology, economics, ecology and linguistics) which are addressed in individual chapters along with introductory and concluding remarks. Each unit begins with a brief theoretical background on a particular subfield, then proceeds to detail the specific practices involved (often weighing the merits of each) as well as the issues which scientists must confront throughout the research process.

The introductory section, 'Data collection and hypothesis testing,' gives an overview of ethnobotanical research. It outlines prefield preparation, fieldwork methods, and also suggests a number of ways to organize, analyze and present results.

The six subject sections are grouped by the nature of the information which they present. The chapters devoted to botany, anthropology and ecology are more practical in nature, discussing actual field methods and techniques in detail. Conversely, the units on ethnopharmacology, economics and linguistics tend to centre on the more theoretical aspects and issues raised by these respective disciplines, and on the contribution experts can make to ethnobotanical research. Concrete examples and disciplinary studies are used to illustrate key ideas and lend greater urgency to the important issues which are being addressed.

In the concluding chapter, 'Ethnobotany, conservation and community development,' Martin brings these separate subjects together to illustrate how ethnobotanical methods and concepts can make tangible contributions, particularly to the local communities where most research takes place.

In the past, ethnobotany has often been linked with purely academic studies or the search for new pharmaceutical products. Martin's book is a significant step in bringing ethnobotanical methods squarely into contemporary policies, research and development efforts to conserve biodiversity. In so doing, he clearly argues for the link between the need to manage endangered biological resources and the obligation to improve the lives of the rural poor. An important facet of this balance which receives relatively little attention in this work is the application of ethnobotanical research to local agricultural communities and the traditional cultivars they produce. Martin's work already indicates the potential value of ethnobotany both to plant genetics resources conservation and as an integral part of a development process involving local farmers and their communities. We look forward to further work in this vein.

Pablo Eyzaguirre and B. Landon Myer
IPGRI, Rome

Viruses of Plants - Descriptions and Lists from the VIDE Database

Brunt, A.A., K. Crabtree, M.J. Dallwitz, A.J. Gibbs and L. Watson
1996. Hardback. ISBN 0 85198 794 X. 99.50 pounds sterling (US$180 Americas only). 1504 pages
CAB International, Wallingford, Oxon, UK

This massive book contains descriptions and other very pertinent information on more than 900 viruses of plants. The coverage includes all known viruses of plants, not only those whose virions have been described, but also those such as umbraviruses that have no virion protein genes of their own, and use the virion proteins of their symbiotic helper viruses. The nomenclature follows the latest recommendations from the International Committee on Taxonomy of Viruses (ICTV): vernacular name, including generic name when approved; synonyms, standard acronyms and strains are given where applicable. First reports are cited with host, location and author. The descriptions are brief and cover the following: natural host range and symptoms, transmission, ecology and control, geographical distribution, experimental host range, properties of particles in sap, purification, particle morphology, physical and biochemical properties, replication, cytopathology, taxonomy and relationships, and references. The virus descriptions are preceded by summaries of the genera. The book also contains summaries of data for all the viruses that are definitive or tentative members of each accepted group or 'genus'.

The volume is a product of the international Virus Identification Data Exchange project (VIDE), which uses the DELTA

(Description Language for Taxonomy) database system to collect diagnostic information on all plant viruses. Information on over 500 characters is sought and stored in the database on each virus. The book will be a standard reference for plant pathologists and virologists. Viroids and the many transmissible agents that cause virus-like diseases, but whose infectious particles have not yet been characterized, are excluded. However, the database accession numbers of the genomic sequences of satellite RNAs are included.

Such a large book cannot easily be kept up to date, so it is excellent news to learn that VIDE is available on the World Wide Web (**http://biology.anu.edu.au/research-groups/MES/vide/**) and that updating will be done regularly (see page 66). Updating would be particularly desirable for the geographical distribution part of the database. For example, banana streak *badnavirus,* for which only the first report in Morocco is cited, has since been reported in many banana-producing areas in Africa, South and Central America, Asia, Oceania and Europe (references cited in FAO/IPGRI Technical Guidelines for the Safe Movement of *Musa* Germplasm, 1996). Information on the virus being seed-transmitted also would be important to include. The report on banana bract mosaic *potyvirus* spreading in the South and Central American region is probably a misprint which should be corrected in the update. In some cases the information on geographical distribution is missing, e.g. for chickpea bushy dwarf *potyvirus.* A statement like 'probably distributed worldwide' for plum pox *potyvirus* is misleading, as no reports from the American continent are cited. Since the collation of data (1991) the virus was reported from Chile (Roy and Smith 1994) and is subject to quarantine for example in the USA.

Thus, in summary, this volume would make an excellent contribution to any library, and access to a continually updated database on the World Wide Web is an extra bonus.

Marlene Diekmann
Germplasm Health, IPGRI, Rome

New books

Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to 2020

(Food, Agriculture, and the Environment Discussion Paper 14)
Sara J. Scherr and Satya Yadav - International Food Policy Research Institute, Washington, DC

Land degradation could indeed be a potentially serious threat to food production and rural livelihoods by the year 2020, particularly in more densely populated pockets of rural poverty. Further expansion of cultivation into areas of fragile soils or critical habitats for biodiversity preservation can lead to significant environmental deterioration unless carefully managed. In areas with rapidly increasing domestic and industrial demands for water, and those where growing populations reside in water-scarce environments, poor agricultural land management in 2020 could threaten water availability, quality and human health.

Many types of land degradation can potentially be reversed, but the process requires long-term commitment. Land-improving investments and better land management can definitely be encouraged through appropriate policies. Improved information systems and increased research and technology development are needed to develop and disseminate information on technical options. Public investment, co-financing and training programmes, together with supportive property rights, can promote farmer investment in land improvements. Institutional innovations in land use planning, particularly support for local organizations, should be explored. The broader policy context also should support rural development more generally, including developing marketing infrastructure, correcting distorted price incentives, encouraging rural income growth and diversification, and reducing discrimination against marginal regions in public investment.

It is urgent that policy-makers assess the types of degradation issues that will be most critical for their countries in 2020 and begin to take action now. The international community can play a catalytic role in promoting such planning, supporting research and development of information systems, and comparing experiences of various countries with different policy strategies and policy instruments.

Plant Genetic Resources Newsletter Index

There is an increasing recognition of the importance of biodiversity within the environmental and development fields. The fundamental work on plant genetic resources that the *Newsletter* has been publishing for many years is an essential resource to workers in this area. To make this information more accessible, an index of articles from issues 25 to 100 of the *Plant Genetic Resources Newsletter* has been prepared. The *Newsletter* started with issue 25 when the former publication, known as the *FAO Plant Introduction Newsletter,* broadened its scope to the field of plant genetic resources. For the sake of completeness, articles from the *Plant Introduction Newsletter* are also included.

All the bibliographic references have been extracted from the FAO Documentation Database. The *Plant Genetic Resources Newsletter* would like to acknowledge the efforts of the FAO Library and Documentation Systems Division, who did all of the work in extracting the information and preparing this index for publication.

The index will initially be distributed to libraries. Interested individuals may request a copy for their own use from the *Plant Genetic Resources Newsletter* Editorial Office.

Plant genetic resources in Cyberspace

Information resources on the Internet

The Internet is a vast collection of information, which has been described as a huge library with all the books thrown on the floor. This makes it difficult to obtain information quickly, even with the increasingly sophisticated search engines and web crawlers that are available. Below are listed some interesting addresses related to genetic resources, botany, etc. Please send information on other interesting sites via Email to the Managing Editor of the *Newsletter* (p.stapleton@cgnet.com).

The addresses given here were operating at the time of this issue of the *Newsletter* going to press (September 1996), but as the Internet is a volatile medium, they may not continue to be accurate.

IPGRI's web site live

IPGRI's web site is available on **http:/ /www.cgiar.org:/ipgri/**. The site is made up of a number of sections, reflecting IPGRI's decentralized structure. The content is arranged as follows:

This is IPGRI
Message from the Director General and Board Chair
IPGRI's Mandate, Mission and Objectives
IPGRI Strategy
Programme
Regional and Thematic Groups
Projects
Networks
Location of IPGRI and INIBAP offices and contact details
Information Resources
Press Information
Publications
Germplasm Databases
Library and Information Services
Training Materials
Staff Directory
Board of Trustees
Employment Opportunities

Plant virus taxonomy on-line

(Courtesy of Bob Batson, Kansas City, USA)
Thanks to a grant from the Australian Centre for International Agricultural Research, detailed descriptions of viruses of plants are now available on the Internet. Nearly all known plant viruses are included. The descriptions are derived from the VIDE (Virus Identification Data Exchange) database, using the DELTA system. The descriptions include data on host range; transmission and control; geographical distribution; physical, chemical and genomic properties; taxonomy and relationships; and selected literature references. We include the database accession numbers (up to Gb[89] and Em[44]) of the genomic sequences of viruses and of satellite RNAs, and provide links to the NCBI taxonomy database to facilitate searches for these and for more current accessions. There are generic-level summaries of data for viruses that are definitive or tentative members of genera or 'groups'. There are also tables (with appropriate links) listing over 1500 host plant species, and their reported (experimental) susceptibilities to these viruses. We hope this will be a useful tool for virologists and plant pathologists around the world. To access the descriptions, begin at URL **http:// biology.anu.edu.au/research-groups/MES/vide/** Contact Eric Zurcher CSIRO Division of Entomology, Canberra, Australia. E-mail: ericz@ento.csiro.au

Royal Botanic Gardens, Kew

Kew Web, the World Wide Web site of the Royal Botanic Gardens, contains hundreds of pages of information about Kew and its research activities. To access the page, go to: **http://www.rbgkew.org.uk/index.html**

The information in the site is arranged hierarchically reflecting Kew's research programmes: what's new on this server; visit the gardens: Kew and Wakehurst place; the collections; scientific research; conservation; education; heritage; publications; databases; other botanical and horticultural servers.

The site also has a search facility to locate information on a specific subject. Kew has two long-term aims for the site; to

provide an additional means of distributing scientific information, and to allow a browser to query the databases held at Kew. Five newsletters are published electronically, and a conservation database is available on plant re-introductions.

World's biggest environmental bookstore

The NHBS BookNet is a searchable database with information on 60 000 in print and forthcoming books, CD-ROMs, videos, reports, papers, etc. Covers all environment-related subjects. The site supplies private individuals, scientists, other academics, libraries, NGOs, IGOs, environment professionals and government agencies. BookNet offers powerful search facilities as well as browsing by subject and geographical area. Orders can be placed by email. The URL is: **http://www.nhbs.co.uk.**

Biodiversity Information Network 21

http://straylight.tamu.edu/bin21

The task of compiling biodiversity information databases that are adequate to support international conservation efforts is huge. It will be possible only through the concerted efforts of many agencies and many individuals. This site is attempting to create a biodiversity network as a mechanism to link information relevant to biodiversity and make it widely available by electronic and other means. Its purpose is to support the Convention on Biological Diversity and Agenda 21 that followed the Earth Summit at Rio, June 1992.

Intellectual Property Web Sites

This site contains many interesting references to groups dealing with intellectual property in the broadest sense. Sections include: NetRights; Papers; Copyright Law; IP Headlines; IP Law Sites; Organizations; Commerce; Technologies; Related Conferences; New Media; Standards and Technologies. The URL is: **http://www.netrights.com/IPSites.html.**

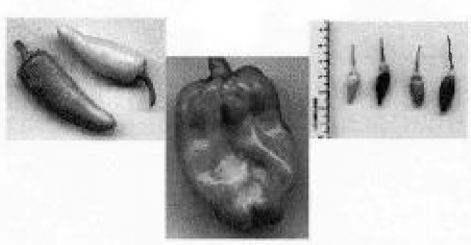
Capsicum *biodiversity*

(Courtesy Susana Moraleda, IPGRI, Rome)

Although not strictly scientific, the 'Chile[*sic*]-Heads' home page (**http://neptune.netimages.com/~chile/**) tells you "Almost everything you might want to know about chile peppers", including sections on eating: recipes, restaurants and festivals; growing, harvesting and preserving peppers; science: botany, chemistry and medicine; additional resources (books, magazines, catalogues, etc.); Other hot topics! (What's the hottest pepper?). Perhaps the most interesting section for a genetic resources worker is the cross reference to the 'Chile gallery' (**http://chile.ucdmc.ucdavis.edu:8000/www/gallery.html**), which consists of many pages of photographs of peppers, with some botanical and agronomic information, as well as the all-important 'Heat Range', measured in 'Scoville Heat Units'. Note that this is a very graphics-heavy site, but you can also ftp the photographs to speed things up.

Plant genome databases

The Plant Genome Project of the USDA provided funding for the development of three plant genome databases: SolGenes, GrainGenes and RiceGenes. All three are based on the ACeDB software and are under development at Cornell University. The URL for access to these and other plant databases via the World Wide Web is: **http://probe.nalusda.gov:8300**.



Erratum

In Newsletter 106, several photographs were omitted from the article "Insect pollination and isolation requirements in tomato collections (*Lycopersicon esculentum* Mill.)" by Th. Gladis *et al.* (pages 16-19). The correct photographs and their captions are printed below.

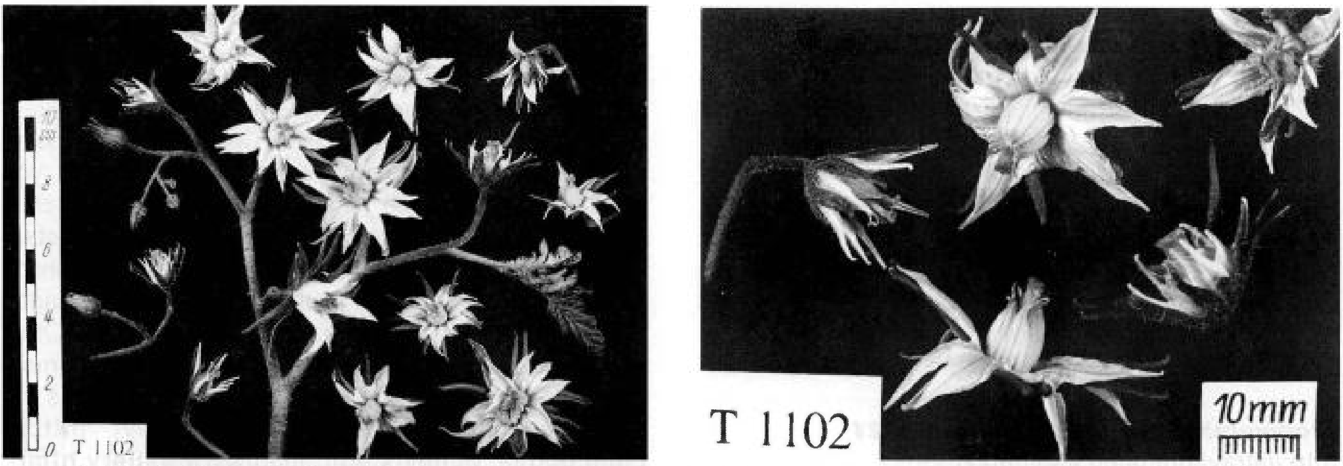


Fig. 1. Various floral characters were observed within one tomato plant (left), and even within one raceme (right)

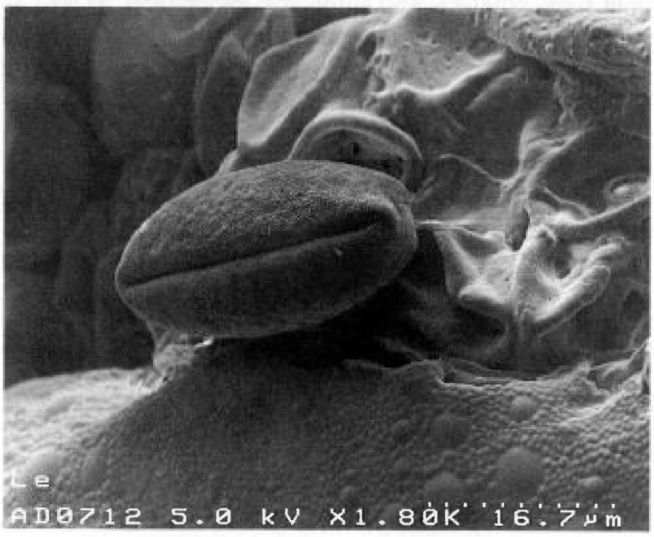


Fig. 2. Single pollen grain within the cone of anthers

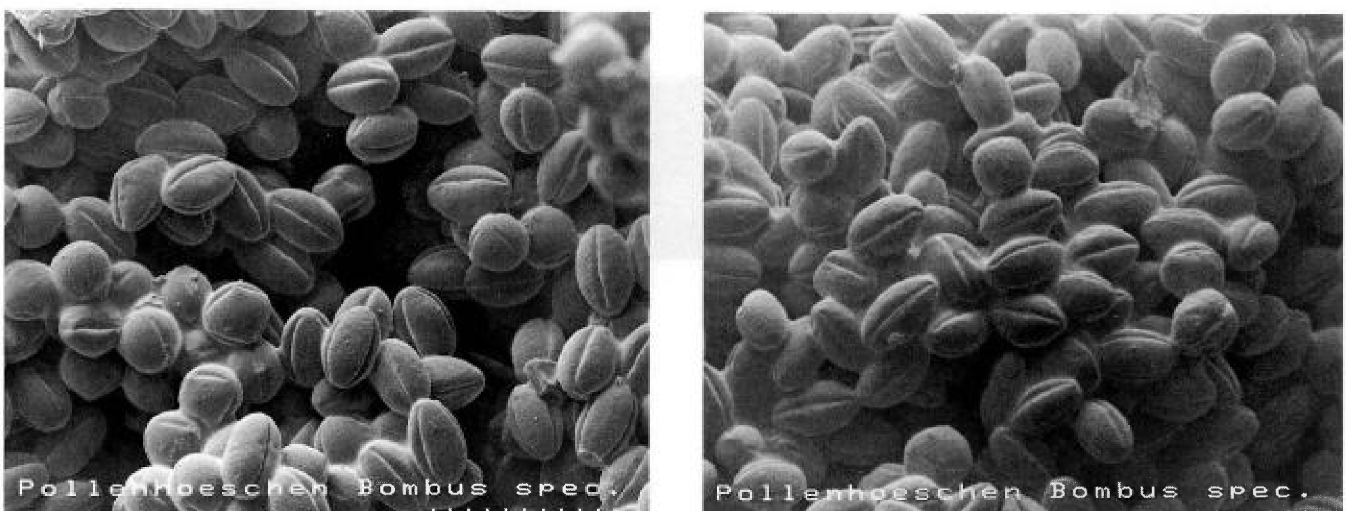


Fig. 3. Pollen loads of two bumblebee workers show how efficiently they collect tomato pollen

Conseils aux auteurs

Les textes dactylographiés seront préparés en anglais, en espagnol ou en français et envoyés en deux exemplaires au directeur de rédaction. Ils seront présentés en double interligne, avec de grandes marges (3 à 5 cm). Toutes les pages (y compris les tableaux, figures, légendes et références) seront numérotées à la suite.

Titre

Le titre sera le plus court possible et devra contenir le nom commun de toutes les espèces dont il est question dans le document, et le nom des principaux pays visités durant, par exemple, un voyage de collecte de matériel.

Nom et adresse des auteurs

Mentionnez le nom complet de tous les auteurs du document, ainsi que leur adresse à l'époque de l'étude. Indiquez leur adresse actuelle et leur adresse de contact en bas de page sur la première page du document; indiquez également l'auteur auquel doivent être adressées la correspondance et les épreuves.

Résumés

Articles et études doivent être accompagnés d'un résumé en anglais, en espagnol et en français. Envoyez un résumé de 200 à 250 mots au maximum dans la même langue que le texte dactylographié, ainsi que la traduction (y compris le titre) dans les deux autres langues, si possible. Placez-les à la fin de votre texte, après les références et avant les tableaux. Les résumés d'articles devraient mentionner l'objectif de l'étude (hypothèse et buts), le matériel et/ou les méthodes utilisés pour l'expérience, un résumé des résultats et les conclusions tirées de ces résultats.

Mots-clés

Indiquez au maximum six mots-clés qui serviront pour un index, par ordre alphabétique, au-dessous du résumé dans la langue de rédaction au début du texte dactylographié.

Texte principal

Faites bien ressortir les titres et les sous-titres, mais évitez les titres de plus de trois lignes. Ne mumérotez-pas les titres ou les paragraphes, qui devraient être mis en retrait.

Utilisez un langage simple. Il serait préférable qu'avant d'être soumis, le document soit mis en forme par une personne dont la langue maternelle est celle de la langue de rédaction.

Remerciements

Ceux-ci (de même que les dons ou l'aide, etc. éventuellement reçus) devraient figurer à la fin du texte et avant les références.

Références

Les références seront présentées par ordre alphabétique, dactylographiées en double interligne et indiqueront: auteur et année de la publication, par exemple (Dawsib, 1987). On évitera les citations de communications personnelles ou de données inédites. Ces citations ne devraient figurer que dans le texte, comme (E.D. Smith, communication personnelle) et non dans la liste des références. Abrégez les titres des périodiques comme il est indiqué dans le Bibliographic Guide for Editors and Authors (Biosis, Chemical Abstract Service and Engineering Index, Inc., 1974). Adoptez la présentation ci-dessous:

Périodiques

Molina-Cano, J.L., P. Fra-Mon, G. Salcedo, C. Aragonicillo, F. Roca de Togores et F. Gardia-Olmedo. 1987. Morocco as a possible domestication center for barley: biochemical and agromorphological evidence. Theor. Appl. Genet. 73:531-536.

Livres (édités par quelqu'un d'autre que l'auteur de l'article)

Hanelt, P. 1986. Cruciferae (Brassicaceae). Pp. 272-332 *in* Rudolf Mansfelds Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen), Vol. 2. (H. Schultze-Motel, ed.) Akademie-Verlag, Berlin, Allemagne.

Livres (même auteur et même éditeur)

Chapman, C. 1985. Genetic Resources of Wheat. A Survey and Strategy for Collecting, IBPGR, Rome, Italie.

Nomenclature

Taxinomique: suivre l'*Index Kewensis*. *Génétique:* les applications des termes phénotype et génotype devraient être conformes à Demerec *et al.* (Genetics 54:61-74, 1966); pour des résumés des abréviations génétiques, consultez le *Journal of Bacteriology* qui contient des conseils aux auteurs.

Unités: exprimez toutes les quantités en unités du système international. Si une unité traditionnelle ou locale est utilisée, ou une unité qui pourrait être connue dans un pays seulement, indiquez toujours l'équivalent en unités du système international afin que d'autres chercheurs puissent comprendre les quantités indiquées.

Préparation des figures et des tableaux

Figures et tableaux servent à étayer le texte et doivent être organisés logiquement, apparaissant là où ils sont mentionnés. S'il y a une grande quantité d'informations dans un tableau, il vaudrait mieux l'inclure dans une annexe à la fin de l'article. Les figures et les tableaux doivent être clairs et simples. Il s'agit de présenter un matériel complexe sous une forme facile à comprendre. Présentez les données dans le texte, dans une figure ou dans un tableau mais jamais dans les trois à la fois.

Instrucciones para los autores

Los textos deben redactarse en inglés, francés o español y entregarse por duplicado al director de redacción. Deben presentarse mecanografiados a doble espacio, con amplios márgenes (3-5 cm). Todas las páginas (incluidos los cuadros, figuras, leyendas y obras consultadas) se deben enumerar consecutivamente.

Título

El título ha de ser lo más corto posible y debe incluir los nombres común y genérico completos de las especies descritas en el documento, así como los principales países visitados, por ejemplo, durante el viaje de colección.

Autores/direcciones

Incluir los nombre completos de los autores del documento, junto con las direcciones de los autores en el momento de la realización del trabajo presentado. Indicar las direcciones actuales o postales como nota al pie de la primera página del documento. Indicar también el autor designado para recibir la correspondencia y las pruebas.

Resúmenes

Los artículos y recensiones se publicarán acompañados de resúmenes en inglés, francés y español. Entregar un resumen que no exceda las 200-250 palabras en el mismo idioma empleado en el texto mecanografiado, así como, de ser posible, las traducciones (incluido el título) a los otros dos idiomas. Incluir estas traducciones al final del documento, después de la bibliografía y antes de los cuadros. En los resúmenes de los artículos se debe mencionar el propósito de la investigación (hipótesis y objetivos), el material y/o los métodos experimentales, un resumen de los resultados y las conclusiones.

Palabras claves

Para facilitar la inclusión del documento en el índice, deberá incluirse un máximo de seis palabras claves, en orden alfabético, después del resumen en el idioma original y antes del texto mecanografiado.

Texto principal

La importancia relativa de los títulos y subtítulos debe distinguirse claramente, pero hay que evitar el empleo de más de tres niveles de encabezamiento. No enumere títulos o párrafos que se han de sangrar.

Utilizar un lenguaje sencillo y claro en el texto. Se aconseja que una persona cuyo lenguaje materno sea el empleado en el documento, revise el trabajo ante de presentarlo.

Reconocimientos

Los reconocimientos (al igual que las subvenciones, ayudas etc.) deberán incluirse después del texto y antes de la bibliografía.

Bibliografía

Las referencias bibliográficas deben presentarse en orden alfabético, mecanografiadas a doble espacio, e indicar autor y año de publicación, por ejemplo (Dawsib, 1987). Se deben evitar las citas de comunicaciones personales y datos no publicados. Estas citaciones han de aparecer sólo en el texto (E.D. Smith, comunicación personal), y no en la bibliografía. Abreviar los títulos de revistas de conformidad con el estilo de la Bibliographic Guide for Editors and Authors (Biosis, Chemical Abstract Service and Engineering Index, Inc., 1974). Seguir el modelo siguiente:

Revistas y periódicos

Molina-Cano, J.L., P. Fra-Mon, G. Salcedo, C. Aragonicillo, F. Roca de Togores y F. Gardia-Olmedo. 1987. Morocco as a possible domestication center for barley: biochemical and agromorphological evidence. Theor. Appl. Genet. 73:531-536.

Libros (editados por alguien que no es el autor del artículo)

Hanelt, P. 1986. Cruciferae (Brassicaceae). Pág. 272-332 *en* Rudolf Mansfelds Verzeichnis landwirtsschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen), Vol. 2. (H. Schultze-Motel, ed.). Akademie-Verlag, Berlin, Germany.

Libros (del mismo autor y editor)

Chapman, C 1985. Genetic Resources of Wheat. A survey and Strategy for Collecting. IBPGR, Rome, Italy.

Nomenclatura

Taxonómica: de conformidad con el *Index Kewensis*. *Genética*: los términos fenotipo y genotipo se deben aplicar de acuerdo con Demerce *et al.* (Genetics 54:61-74, 1966); para los resúmenes de las abreviaturas genéticas, consultar las Instrucciones para los Autores contenidas en el *Journal of Bacteriology*.

Unidades: expresar todas las cantidades con arreglo al sistema internacional. Si se emplea una unidad tradicional o local, o una unidad que tal vez se conozca sólo en un país, incluir siempre el equivalente en el sistema internacional para que los demás puedan entender perfectamente las cantidades.

Preparación de figuras y cuadros

Los cuadros y las figuras complementan el texto y deben presentarse de modo lógico, apareciendo cuando se mencionan. Si un cuadro contiene una gran cantidad de información, tal vez sea mejor incluirlo como apéndice al final del documento. Las figuras y los cuadros deben ser sencillos y claros. Su propósito principal es presentar información compleja en un modo fácilmente comprensible. Presentar los datos ya sea en el texto, en un cuadro o en una figura, pero nunca en las tres formas a la vez.

Instructions to authors

Typescripts should be prepared in English, French or Spanish and submitted in duplicate to the Managing Editor. Typescripts should be double-spaced throughout, with generous (3-5 cm) margins. All pages (including tables, figures, legends and references) should be numbered consecutively.

Title

The title should be as short as possible and should contain the common and full generic name of any species featured in the paper, as well as the main countries visited during, for example, collecting trips.

Authors/addresses

Include the full names of all authors of the paper, together with the addresses of the authors at the time of the work reported in the paper. Indicate current or postal addresses as a footnote on the first page of the paper; indicate also the author nominated to receive correspondence and proofs.

Abstracts

Articles and reviews will be published with abstracts in English, French and Spanish. Supply an abstract not exceeding 200-250 words in the same language as the typescript, as well as translations (including the title) into the other two languages, if this is possible. Include these at the end of the paper, after the references and before the tables. The abstracts of articles should mention the objective of the investigation (hypothesis and aims), the experimental material and/or methods, a summary of the results and the conclusions drawn from the results.

Key words

Provide a maximum of six key words for use in indexing purposes, in alphabetical order, below the native-language abstract at the start of the typescript.

Main text

The relative importance of headings and subheadings should be clear, but avoid using more than three levels of headings. Do not number headings or paragraphs, which should be indented.

Use simple clear language in the text. A native speaker of the language should preferably edit the paper before submission.

Acknowledgements

These (also grants, support, etc. if any) should follow the text and precede the references.

References

The references to the literature should be arranged alphabetically, typed double-spaced and in text referred to as: author and year of publication, e.g. (Dawsib, 1987). Citations of personal communications and unpublished data should be avoided. Such citations should in text appear in the text only, as (E.D. Smith, personal communication), and not in the reference list. Abbreviate titles of periodicals according to the style of the Bibliographic Guide for Editors and Authors (Biosis, Chemical Abstract Service and Engineering Index, Inc., 1974). Follow the style shown below:

Periodicals

Molina-Cano, J.L., P. Fra-Mon, G. Salcedo, C. Aragonicillo, F. Roca de Togores and F. Gardia-Olmedo. 1987. Morocco as a possible domestication center for barley: biochemical and agromorphological evidence. Theor. Appl. Genet. 73:531-536.

Books (edited by someone other than the author of the article)

Hanelt, P. 1986. Cruciferae (Brassicaceae). Pp. 272-332 *in* Rudolf Mansfelds Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen), Vol. 2. (H. Schultze-Motel, ed.). Akademie-Verlag, Berlin, Germany.

Books (identical author and editor)

Chapman, C. 1985. Genetic Resources of Wheat. A Survey and Strategy for Collecting. IBPGR, Rome, Italy.

Nomenclature

Taxonomical: in line with *Index Kewensis*. *Genetic*: applications of the terms phenotype and genotype should be in accordance with Demerec *et al.* (Genetics 54:61-74, 1966); for summaries of genetic abbreviations, consult the *Journal of Bacteriology* Instructions to Authors.

Units: express all quantities in terms of SI. If a traditional or local unit is used, or a unit that may be well known in one country only, always include an SI equivalent so that other workers can fully understand the amounts.

Preparing figures and tables

Tables and figures support the text and must be organized logically, appearing where they are mentioned. If there is a large amount of information in a table, it may be better to include it as an appendix at the end of the paper. Figures and tables should be clear and simple. Their major purpose is to present complex material in a form that is easily understood. Present data in the text, or as a figure, or a table, but never in more than one of these ways.

La version française des Conseils aux auteurs se trouve à la page 69.

La versión española de las Instrucciones para los autores se encuentra en la página 70.

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