Conservation and Sustainable Use of Wild Species as Sources of New Ornamentals

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Keywords: wild harvesting, germplasm conservation, wild species, national collections, heritage varieties

Abstract

While only about 1–200 species are used intensively in commercial floriculture (e.g. carnations, chrysanthemums, gerbera, narcissus, orchids, tulips, lilies, roses, pansies and violas, saintpaulias, etc.) and 4–500 as house plants, several thousand species of herbs, shrubs and trees are traded commercially by nurseries and garden centres as ornamentals or amenity species. Most of these have been introduced from the wild with little selection or breeding. In Europe alone, 12 000 species are found in cultivation in general garden collections (i.e. excluding specialist collections and botanic gardens). In addition, specialist collections (often very large) of many other species and/or cultivars of groups such as orchids, bromeliads, cacti and succulents, primulas, rhododendrons, conifers and cycads are maintained in several centres such as botanic gardens and specialist nurseries, as are 'national collections' of cultivated species and cultivars in some countries. Specialist growers, both professional and amateur, also maintain collections of plants for cultivation, including, increasingly, native plants. The trade in ornamental and amenity horticulture cannot be fully estimated but runs into many billions of dollars annually and there is considerable potential for further development and the introduction of many new species into the trade. Despite this, most of the collections are ad hoc and no co-ordinated efforts have been made to ensure that adequate germplasm samples of these species are maintained for conservation purposes and few of them are represented at all adequately in seed banks. Few countries have paid much attention to germplasm needs of ornamentals and the Ornamental Plant Germplasm Center in conjunction with the USDA National Plant Germplasm System at The Ohio State University is an exception. Generally there is a serious gap in national and international germplasm strategies, which have tended to focus primarily on food plants and some forage and industrial crops. Adequate arrangements need to be put in place to ensure the long- and medium-term conservation of representative samples of the genetic diversity of ornamental species. The problems of achieving this will be discussed. In addition, a policy for the conservation of old cultivars or 'heritage' varieties of ornamentals needs to be formulated. The considerable potential for introduction of new ornamental species needs to be assessed. Consideration needs to be given to setting up a co-ordinating structure with overall responsibility for the conservation of germplasm of ornamental and amenity plants.

INTRODUCTION

Genetic diversity of ornamentals is an invaluable resource, that has to be preserved. German Minister of Agriculture, 2000.

Because ornamentals play a much smaller role in human affairs than food or fodder plants, little concerted efforts have been made to collect and conserve their genetic resources. This neglect is shared with other groups of plants, notably medicinal and aromatic species (Heywood, 1999a). However as McDonald (1996) has observed, while flowers and ornamental plants may not fill a basic survival need, they do enhance the aesthetic value of living and the use of plants for ornament dates back to the early stages

of many peoples. Today, landscaping plants, cut flowers and houseplants are part of an industry worth more than $11 billion in annual sales in the United States alone, thus clearly indicating their importance to the people. In the United Kingdom, amenity horticulture, including the nursery trade and garden centres, landscape architecture and management, public parks and private and public gardens, is a major industry, currently earning over £500 million each year and employing some 500,000 people. The export trade from the Netherlands in tulips alone is worth £ 1330 million annually, while the total world exports of bulbs and tubers in 1998 was worth US$675 589 000 and the global floricultural exports in the same year amounted to US$ 8 394 750 000 (Pertwee, 1999). The top ten exporting countries are listed in Table 1.

It must be remembered that all the plants used in ornamental and amenity horticulture and the diversity of cultivars derived through selection and breeding, originally came from wild plants. Curiously, there are today two antagonistic trends: on the one hand, the number of cultivars grown and offered for sale is being reduced as streamlining of operations by commercial nurseries leads to simplification; for example, the number of tulip cultivars listed in the 1996 International Register of Tulip Names by the Koninklijke Algemene Vereeniging voor Bloembollencultuur (KAVB) (van Scheepen, 1996), is over 5600 of which 2600 are in general cultivation. In contrast, as Pavord (1999) points out, half the cut flower market in tulips is dominated by just ten cultivars, a situation that she characterizes as ‘a hideous reductio ad absurdum for a flower that nature equipped with more than a thousand tricks’.

Market saturation by traditional materials has provoked an increasing interest in novelties, both in the form of cultivars or new introductions from the wild, and more and more countries are looking to their native flora as a source of such introductions. Regions where intensive work is being undertaken include the eastern Mediterranean which is the home of many commercial ornamental plants, especially geophytes, such as *Allium*, anemones, ranunculus, cyclamen, *Muscari*, *Narcissus*, *Ornithogalum*, *Lilium*, *Scilla*, and *Tulipa*. In Israel, for example, recently introduced species include geophytes: *Oncocyclus* irises, *Uriginea maritima*, *Scilla hyacinthoides*, annuals: *Lupinus pilosus* and *Centaurea crocodylleum*; and herbaceous perennials: *Eremostachys laciniata* and *Helichrysum sanguineum* (Halevy 2000). Both in Australia (Plummer et al., 2000; Jones, 1995) and South Africa, particular emphasis is being placed on the introduction of native genera and species as commercial ornamental crops, both as cut flowers and pot plants. There are significant developments too in Latin America where Boyle (1991) has described the genetic resources of the native herbaceous ornamental crops as vital to commercial horticulture, and also in Northeast Asia (Japan, Korea, China and Taiwan) where the floricultural industry has been developing rapidly over the past ten years (Okhawa, 2000).

PLANT INTRODUCTIONS

The introduction of wild species into cultivation for ornament began in several civilizations not long after the first domestications of plants for agriculture. In China, for example, unimproved wild species were used for ornament in the Xia dynasty (2100 BC – 1600) BC) and possibly before then. The first cultivar known in China (long before the term cultivar was introduced into the Horticultural Code in 1953), was probably the Jiahua C*hrysanthemum*) as evidenced by a poem of Tao Qian (355~ 417), and it is reported that the yearly income of one who cultivated a thousand mu of gardenia was equal to that of a marquis who collected taxes from a thousand families (Wang and Zang, 1993), while the cost of a tree peony with deep red flowers was equivalent to the taxes paid by ten middle class families. And this is many centuries before the development of tulipomania!

I will not review the various phases of plant introductions as these have been well documented by others. There has, as Hewett (1993) has commented, been a large element of serendipity in the introduction of new or different plants from the various continents into cultivation, involving missionaries, travellers, explorers, diplomats, sea captains, and tourists. The transformation of these introductions of wild growing species into potential

commercial cultivars was largely undertaken by highly skilled, observant, and entrepreneurial nurserymen, many of whom were very talented plantsmen who initiated plant improvement programmes themselves by selection and breeding. What they and institutional breeders that later became involved did not apparently appreciate was the need to ensure that the resultant ornamental crops or garden plants had a broad genetic basis.

KNOWLEDGE BASE

One of the first requirements for any conservation action is a knowledge of what needs to be conserved. It is a truism of conservation that you cannot conserve what you do not know. The number of species that are used globally for ornamental purposes, as annuals, perennials, shrubs, pot plants for foliage and floral display, dried materials, cut greenery from trees, shrubs, herbs, grasses, ferns, cultivated cut flowers (live or dried), wild gathered live or dried flowers, geophytes (bulbs, corms, rhizomes, tubers, rootstocks), trees in parks and gardens and roadside trees, is difficult to estimate but is probably of the order of 20 000 – the *European Garden Flora* (1986 –2001) alone covers some 12 000 species that are found in cultivation in general garden collections (i.e. excluding specialist collections and botanic gardens). Up to 100 000 species are in cultivation in the world's network of 1600 botanic gardens and arboreta.

The recently published Mansfeld's *Encyclopedia of Agricultural and Horticultural Crops* (Hanelt, 2001) includes in the title the tell-tale phrase '(Except Ornamentals)' and the Leipzig report, *The State of the World's Plant Genetic Resources for Food and Agriculture* (FAO, 1998), states 'A large number of countries in their Country Reports pointed to lack of knowledge about indigenous plant genetic resources and the need for surveys, inventories, taxonomic studies, and other analyses of existing diversity. Given the emphasis on filling certain identified gaps in existing collections and adding new species to collections (e.g. "under-utilized crops,"ornamentals, spices, aromatic, medicinal, forage species, etc.), the absence of good inventories becomes a bigger and bigger obstacle to planning and prioritising of collecting and other conservation activities'.

In fact, most countries do not have an inventory of the native and exotic species in cultivation. For example, at a symposium on the 'Conservation and sustainable Utilization of genetic resources of ornamental plants' organised by the Zentralverband Gartenbau (ZVG), the umbrella organization for horticulture and the Information Centre for Genetic Resources in Germany, where participants discussed the present situation in Germany concerning the numerous ornamental collections it became obvious, that due to the lack of information, the first step is to document the collections of ornamentals held by Botanic Gardens, in public institutions, at commercial breeders and by numerous hobbyists, and make information available. A similar need exists in most other countries.

Not surprisingly, many of these plants in cultivation and those that are propagated and sold – the basic material of the industry – are incorrectly named. In addition to the diversity of species, the consistent naming, equivalence, and recognition of the many tens of thousands of available cultivars is a major and almost insoluble problem.

WILD HARVESTING

Wild harvesting for the cut-flower trade occurs in many parts of the world, for example in the fynbos in South Africa. According to Turpie et al.(1998):

'the wildflower industry has two components: fresh flowers and dried flowers, both of which continue to be harvested from the wild. Products comprise flowers (Proteaceae) and greens (comprising many taxa including *Leucadendron* foliage, ericas, etc. for use as filler material) for the fresh industry, and flowers, including *Leucadendron* cones and other products, for the dried flower industry.

At least 100 species are used in the wildflower industry (Cowling & Richardson 1995). However, the numbers of species used and indeed, which species are used, changes subject to fluctuating

market demands created by local and overseas fashions'.

The fynbos flower industry as a whole currently generates a gross income of R149.3 million per year (1997 prices), of which R91.5m and R37.8m is from the export of fresh and dried flowers, respectively, and R20m is from local sales (SAPPEX News, July 1999). And Turpie & al. estimate that natural vegetation (veld) is responsible for 57.6%, or R86m, of this turnover.

In Australia, Jones (1995) notes that a large number of native cut flower species are picked from the wild (bush-picked), and are generally of poor quality and available in only small quantities. A remarkable example reported by Smith (1999) is *Doryanthes excelsa*, one of the most outstanding monocots found in the Australian bushland. 'It carries massive flower spikes (scapes) that may attain 8 metres in height. These impressive flowering stems are highly sought after to provide floral designers with dramatic feature flowers for large imposing hotel foyer arrangements. At present the commercial appeal for this unique Australian plant is escalating with an increase in demand both on local and overseas markets. At present very few stems come from commercial row production with the vast majority of supply coming from bushland to the north of Sydney. The high returns for the cut flowers has created a situation where stems are being removed illegally from the roadside, private properties and national parks' (Smith, 2000).

Research into developing new ornamentals is concentrating, therefore, on introducing wild harvested species into commercial cultivation, thereby improving quality and relieving the environmental impact on wild stands.

GERMPLASM CONSERVATION

'Genetic materials for ornamental plants are not centrally collected and maintained anywhere in the world', J. Metzger, 1996.

The importance of conserving samples of the enormously diverse heritage of ornamentals is increasingly being recognized. For example, the German Minister for Agriculture in his opening address of the symposium on 'Conservation and sustainable utilization of genetic resources of ornamental plants' stated that the genetic diversity of ornamentals is an invaluable resource, that has to be preserved; and it is worth noting that the title of one of the symposia that is being organized at the ISHS Congress in 2002, is 'Plant genetic resources: the Fabric of Horticulture's Future'. Many ornamental crops have been developed from a narrow genetic base and breeders in the past have tended to use only a limited repertoire of wild species as the germplasm base. A major reason for genetic resource conservation is to ensure that the genetic diversity that may be needed for future breeding programmes is available, either from genes from the wild or from older forms or cultivars of the species, so that the industry will be able to react more quickly and efficiently.

The techniques and methodologies for plant genetic resource conservation were originally developed some 30-40 years ago when the traditional crops grown by farmers were disappearing and with them the genetic diversity they contained (Pickersgill, 2000). They were aimed at the conservation of the genetic diversity represented in farmers' traditional land races that were at risk of erosion through being supplanted by more advanced, high yielding modern cultivars. This led to the setting up of rescue missions to collect this diversity and store it ex situ in seed banks or in some instances in field gene banks. The conservation of genetic resources has evolved considerably and today, not only is it multidisciplinary and involving a wide diversity of technical and scientific approaches employed, ranging from surveying and sampling and analytical techniques for characterizing genetic diversity, and seed storage methodologies to genomics to bioinformatics, but embraces important socio-economic and political considerations.

Consideration needs to be given to how these approaches may be adapted for application to plants of ornamental value or potential. Some of the questions that have to be considered are:

- the purpose of ex situ collections
- how much genetic diversity is needed
- appropriate sampling methods
- costs of ex situ collection, storage and maintenance
- dynamics of ex situ conservation

Surveying and Sampling

Whether dealing the diversity of wild plants with an actual or potential value for sustainable exploitation as new ornamentals or with cultivars of plants already in cultivation, the genetic conservation of ornamentals involves surveying what material available and employing appropriate sampling techniques. With wild species, it is their local populations that are sampled so as to access available genetic diversity which is used as starting point for the breeding, and sustainable production of new ornamental plants. In the case of already existing cultivars, a range of samples needs to be made of material in cultivation.

Just what is adequate or appropriate in terms of sampling depends on what is the intended purpose of such conservation – is it long-term storage of ornamental plant diversity, or of alleles that are considered of potential use in short term or future breeding programmes, or for ready access to material for physiological or other research.

In recent years, a more rational and scientific approach to plant genetic resource sampling has been adopted by germplasm collectors. As Hawkes et al. (2000) point out, the goal of the collecting mission will largely determine the actual method of collecting. For example, an agricultural genetic resource-collecting mission differs from a general botanical collecting mission although each can learn from the other.

Because it is not in fact feasible to sample all the variation in every population, or to conserve all alleles ex situ, the best that can be attempted is to sample as much diversity as possible from the range available. Hawkes (1992) admits that even a few seeds are better than nothing but warns that this would not be sufficient to represent the diversity if the species being sampled.

A good example of genetic sampling is the selection, breeding and development project in the Australian Geraldton wax (*Chamelaucium uncinatum*), begun in 1991 with a focus on collecting the genotypic variation. Over 500 genotypes from more than 60 populations were collected with the intent of selecting and introducing superior plant lines into commercial cultivation. Forty-five superior genotypes were selected for further trialing at sites around Australia, and in Israel and California. This trial allowed the identification of genotypes tolerant of different soil and climatic conditions. The Waxflower crossing program began in 1995 using the initial *C. uncinatum* collection, plus collections of other species, as a genetic basis. The breeding program is a joint project between Agriculture Western Australia and the University of Western Australia. This partnership has become the model for co-operation for institutions and industry within the Centre for Australian Plants that aims to develop primarily indigenous, but also non-indigenous, plants for Australia's commercial benefit and also to improve the conservation of the Australian flora..

The Problems of Conserving Wild Species

The conservation of the genetic diversity of wild species is a challenge that has still to be faced and poses a series of problems. As Frankel et al. (1995) note that 'Most of the wild and weed relatives of domesticates have not been collected and conserved to an extent commensurate with their promise'. This is true even for the major crops although there has been an increasing effort towards this in the past 10–15 years. Frankel & al.'s remarks apply with even more force to the vast majority of wild species including those that are not fully domesticated. As Debouck (2000) points out, the enormous amount of variation and ecologically highly specific requirements of wild species and relatives of crops often makes their ex situ conservation difficult. When it comes to their in situ conservation, the problems are no less acute as we shall see.

One of the major differences between the sampling of wild species and agricultural crops is that in the former, many are widely dispersed over considerable geographical areas while the latter occur in large planted populations. As a consequence, it is much easier to obtain large samples. In the case of ornamental crops, however, the distinction is not so clear as they are often grown on a relatively small scale. Size of sample, alone, is not necessarily a good indicator of the amount of genetic diversity they contain since as Lawrence et al. (1995) have shown, smaller collections may be acceptable provided they have been sampled from throughout the whole distribution area of a species.

Ex situ – Seeds Banks, Field Gene Banks, National Collections

While many seed banks, both regional and national, contain some accessions of plants of ornamental importance, they have not been deliberately or systematically gathered in most cases. As Englemann and Engels (1999) observe medicinal, spice, aromatic and ornamental species are hardly present in ex situ collections. The main plant genetic resources organizations and agencies such as FAO and the CGIAR institutes have not afforded them much priority although they are mentioned in the Global Plan of Action (GPA) for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture' (FAO, 1996). Some institutions have devoted considerable effort to ornamental species and their conservation such as the Gatersleben Gene Bank and the Ornamental Plant Germplasm Center run in conjunction with the USDA National Plant Germplasm System at The Ohio State University. Field gene banks for ornamental species that have recalcitrant seeds are also rare. Generally there is a serious gap in national and international germplasm strategies which have tended to focus primarily on food plants and some forage and industrial crops.

National Collections

In a number of countries there are groups that have developed or are developing and maintain national collections of cultivars and other collections of material of garden plants for conservation purposes. The most highly developed is the British National Plants Collection Scheme initiated by the National Council for the Conservation of Plants and Gardens (NCCPG). Today there are over 600 National Collections holding together in excess of 50 000 plants. 'The collections are maintained by a broad spectrum of garden enthusiasts ranging from large institutions, colleges and local authorities to nurseries, gardens and private individuals. These are all linked by one common purpose: to develop comprehensive, well-researched Collections of living plants, to conserve the genetic stability of named cultivars but variability of species, and to protect them against the vagaries of fashion, disease and extinction, thus ensuring the availability of an abundant variety of plant material both for today and for future generations.'(NCCPG, 1998).

The North American Plant Preservation Council has adopted a different approach: instead of having 'national collections,' its purpose is 'to establish plant collections in various places on the North American continent, so that NAPPC collections will be established in as many areas and climate zones as possible and be accessible to as many interested people as possible. These collections will be used to preserve plants in danger of disappearing forever, and for research, horticultural study, education and dissemination to interested nurseries and gardeners. Collections will be established at botanical gardens, colleges and universities, and by specialist nurseries and interested individuals.' (NAPPC, 1995).

Various other types of collection exist such as the National Rose Collection at Mount Lofty Botanic Garden South Australia, the National Boxwood Collection at the US National Arboretum, the National Collection of chrysanthemums at the Latvian National Botanic Garden. In Australia, the Ornamental Plant Collections Association (OPCA) maintains some 70+ collections. In France, Le Conservatoire des Collections Végétales Specialisées (CCVS) organises some 130+ collections.

In 1996 The Herb Society of America established a series of Plant Collections

held by Units or groups of members of the organization, to encourage 'the cultivation and preservation of the living germplasm of herbs, playing a conservation role by encouraging the cultivation, reintroduction, and preservation of uncommon herbs for posterity and serve as a repository of authentically labeled taxa' (Herb Society of America, 2001).

Special Role of Botanic Gardens

Botanic gardens have played a major role over the centuries in introducing wild species of ornamental value into cultivation and today house enormously diverse collections, totalling as noted above of the order of 100 000 species. Many gardens (probably a majority) do not have accurate inventories of their collections and often their accessions policies have been serendipitous, leading to enormous overlaps and suplications.

With rare exceptions, it is only recently that botanic gardens have paid serious attention to cultivating their native wild species as opposed to exotics. Through organizations such as Botanic Gardens Conservation International (BGCI), the American Association of Botanic Gardens and Arboreta (AABGA) and several regional and national associations, strenuous efforts are being made to organize this enormously important resource in a more effective manner and to coordinate and inventory their accessions.

However, before the value of botanic garden collections for genetic conservation can be assessed, the following issues need to be considered (Heywood, 1999):

- obtaining accurate figures on the numbers of accession
- obtaining accurate figures on the number of species, subspecies, varieties, hybrids, cultivars that these accessions represent
- the size of the individual accessions and the adequacy of the sampling
- the number of accessions that are collected from the wild
- the accuracy of identification of the accessions
- the quality of documentation of the accessions
- the way in which the accessions are maintained within the botanic garden, their exposure to possible hybridization with other species (in the case of 'living collections)
- the method and conditions of storage in the case of seed

Most of the accessions are held in the form of growing plants, either in the open air or under glass. They may in some cases be maintained in special conservation collections but the commonest situation is for them to form part of the display material in beds, borders, rock gardens, arboretum or avenues or other plantings, or in conservatories, alpine houses, temperate, subtropical and tropical greenhouses. Although there are some important conservation collections maintained in some gardens, many species are represented by a single tree or shrub, or specimen in a greenhouse and do not therefore represent an adequate genetic resource sample. On the other hand, many botanic gardens are now beginning to establish seed or gene banks, although usually the focus is on native species that are rare or endangered, rather than on ornamental species.

In situ Conservation– Protected Areas, Gene Sanctuaries, Micro-Reserves

The preferred method of biodiversity conservation today is in situ – that is, in natural or semi-natural ecosystems, in line with the Convention on Biological Diversity's emphasis on the 'ecosystem approach'. The basic argument for in situ conservation of species within ecosystems is that it will allow the evolutionary processes that shape the genetic variability and adaptability of plant populations to continue to operate, unlike ex situ conservation where the genetic variation is fixed (and may deteriorate in storage).

For the conservation of target species of ornamentals, the initial focus should be on Protected Areas but a serious constraint is that for most of these areas, inventories have not been made of the species they contain. It has to be recognized that in situ conservation is a relatively untested approach and little practical experience has been

gained so far. As Germany noted in its National Report in Preparation of the 4th International Technical Conference on Plant Genetic Resources, 'active and secure in situ conservation of genetic resources within ecosystems and natural habitats are largely unknown, especially against the background of fast and far-reaching environmental changes.'

Specifically for ornamentals, very few in situ experiments have been attempted: the orchid sanctuary maintained by the Botanic Garden, Orchid Research and Development Centre, Tippi, Arunachal Pradesh, India, is an exception and there are other such orchid sanctuaries in the country. For rare and endangered species, gene sanctuaries or microreserves are sometimes established but their viability is still untested. The in situ conservation of target ornamental species within ecosystems is still in its infancy and should be combined with ex situ approaches as part of an integrated conservation strategy.

CONSERVATION OF HERITAGE VARIETIES

Many countries have created organizations for the maintenance of ancient farm, fruit tree or garden varieties in seed banks, field genebanks or on-farm. These may be both government-supported or privately financed (including by NGOs). In the European Union, legislation that affects the sale of crop seeds is more restrictive than anywhere else in the world. Although it was introduced to prevent abuses such as the adulteration of seed or repackaging under other names, it means in effect that unless a cultivar is registered in at least one of the EU Member States, it may not be marketed. Thus ancient or 'heirloom' varieties or cultivars that have simply fallen out of favour cannot be sold if not properly registered. Although there are similar laws in countries outside Europe to protect cultivars, they do allow anyone to sell unregistered seeds under normal consumer protection alone.

Organizations for the conservation of such material are therefore of considerable importance for the maintenance of diversity. A valuable survey of the methodological issues involved is given by Marchenay (1986a) and a practical guide by the same author (Marchenay, 1986b). Extensive information on seedsaving and seedsavers' resources may be obtained from the website http://homepage.tinet.ie/~merlyn/seedsaving.html
Examples of such organizations are given in Table 2.

STRATEGIC NEEDS

As the above brief survey shows, the conservation and sustainable use of those wild species that may have potential for introduction as new ornamentals crops or as sources of genetic material that can be used in the development of existing crops, needs a much more coherent strategy than at present exists. This should be implemented at a national level and cover areas such as

- Surveying at national level of the various holdings, both in cultivation and in seed banks, of the different categories of species of ornamental or amenity value
- An assessment of the conservation status and needs of these resources
- Information and documentation resources and needs
- Identification of priority species or other taxa in need of urgent conservation action
- Assessment of the role of protected areas for the *in situ* conservation of target ornamental species
- Sampling methodologies
- The capacity of germplasm banks, botanic gardens and other institutions for the exploration and maintenance of genetic resources of ornamentals
- The role of the nursery trade in the conservation of ornamentals
- Research on germination, propagation and regeneration of seeds of ornamental species
- Setting achievable targets

I would suggest that a working party be established by ISHS, IPGRI, FAO and appropriate conservation organizations to explore these issues and prepare a report that can be submitted to the Conference of the Parties of the Convention on Biological Diversity.

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Tables

Table 1. World - All Floricultural Exports 1998 Top 10

TOTAL RANK $'000 *Source: Pertwee 1999*	EXPORTS	BULBS	PLANTS	FLOWERS	FOLIAGE
WORLD	8,394,750	817,023	2,858,874	4,087,994	630,859
1 NETHERLANDS	4,425,167	675,589	1,380,872	2,296,041	72,665
2 COLOMBIA	603,508	509	407	600,014	2,578
3 DENMARK	314,320	5,013	276,403	6,057	26,847
4 ITALY	298,705	2,541	144,757	80,158	71,249
5 U.S.A.	279,513	16,118	129,589	20,569	113,237
6 BELGIUM-LUXEM.	273,205	11,294	221,354	32,371	8,187
7 CANADA	247,782	15,801	159,548	15,984	56,449
8 ISRAEL	229,518	11,074	24,409	175,196	18,839
9 ECUADOR	202,289	6	168	201,883	232
10 GERMANY	201,736	7,807	143,890	29,041	20,998

Table 2. Seed saver and similar organizations.

- 'Pro Specie Rara' Foundation , Switzerland
- 'Arche Noah' with a large collection of vegetable, flower and cereal varieties, Austria
- The UK government-supported Heritage Seed Library and the Henry Doubleday Research Association, with its collection of traditional vegetable varieties
- The Biological Farming Association 'Elkana' and the Dika, an NGO aimed at the in situ/on-farm conservation of national agrobiodiversity, Georgia.
- The French Conservatoires botaniques nationaux.
- The French Conservatoire des collections végétals spécialisées.
- The French Association française pour la conservation des espèces végétales.
- The Seed Savers Exchange, Native Seed Search and Southern Seed Legacy, USA.