Conservation through plant breeding and *in situ* conservation

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Abstract

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Although in a rather primitive phase of modern plant breeding some breeders behaved like 'stamp collectors', the necessary variability for continuous progress in plant breeding has forced the search for new genes to solve new problems. Even though artificial mutation offers possibilities to find suitable variation, wild relatives of cultivated plants offer a different approach as they can be tested for specific traits in order to see whether nature had already created and tested the genes sought for. Gene manipulation by genetic engineering has emphasized even more the need for wild resource conservation, as any species can be the source of important genes for use in any other species. Besides, for modern breeders agroecological data are very important, and are now included in germplasm collection studies. Amongst breeders there is agreement on the increasing need to preserve natural stands of wild species as it is impossible to collect and preserve all the wild relatives required in plant breeding today. This leads to according an increasing importance to*in situ* conservation of natural resources in plant breeding practice. Thus, if only because of professional needs, plant breeders have became strong advocates of natural resources conservation that is thus transformed into an economic activity.

Breeding as 'stamp collecting'

Some environmentalists consider that plant breeders spoil natural environments by producing modern, high yielding varieties. Plant breeding and, in fact, the whole agriculture, is in the 'eye of the hurricane' of the ecological movement and is a favourite target of the so-called 'green' associations. Blame has to be placed not on agriculture or on plant breeding but on a *bad agriculture*. In fact plant breeders can be excellent conservationists of wild species both *ex situ* and *in situ*.

Many plant breeders were simply acting as 'stamp collectors' in the past. They collected races and varieties, only paying attention to the places where the samples were collected. These collectors did not even take into consideration the very old agricultural practice of the seed exchanges between neighbouring villages, a practice already documented by the first agricultural writers, well known in all agricultural epochs and still existing there where seed companies do not yet control the market. This practice was probably felt necessary in order to reduce 'seed degeneration', also very well described by many ancient agricultural writers, but very likely these collectors dismissed it with contempt. This 'seed exchange effect' that could only be removed by studying large collections, can produce an important bias when germplasm studies refer to adjacent regions, especially if they are rich in agroecological niches.

Perhaps it is ignorance that leads to a situation in which many collectors are only interested in the actual specimen itself, isolated from any other feature; the fact is that many collections were formed as if they were 'stamp collections'. The accessions were used in crossing schemes and, more frequently than not, thrown away later. Many genes that could be of outstanding importance in our present day agriculture were discarded. The collected samples of varieties or landraces were seen as sources of only a few genes, usually qualitative in character. Hence, their origins were of little importance.

This scant attention to the biological environment where cultivars and landraces thrived for long periods, this recording of only a single fact out of a complex set of data, provoked many mistakes in early germplasm collections as the names of many accessions were linked to the place of the last sender and not even to that of the first collector. Generally speaking, these early breeders were not interested in wild species, even in the cases in which these species were close relatives of the cultigen they were breeding.

Plant breeding and natural resources: a new concept of 'wild relatives'

This kind of breeding was efficient because intraspecific variability had not yet been fully exploited, and existing cultivars and landraces were easily available and still rich in useful genes. New cultivars obtained by using these collections were able to yield much more than the traditional ones. Had they been sown in the regions where they were obtained, they would not have produced any significant damage to the natural resources nor helped reduce the tremendous genetic variation still existing in the first half of this century. But these new cultivars were very soon transported and sold in distant regions, thanks to very rapid transportation and to highly efficient marketing techniques.

The necessary variability for continuing progress in plant breeding was becoming scarce. The lack of such variability became a problem. Because of the increasing genetic uniformity of the new cultivars and the narrowing of genetic diversity in the most important crops, new races of all kinds of pests appeared and spread rapidly, ravaging whole regions in developed countries. New genes were sought to solve the new problems, but the only sources for these genes were *artificial mutation* and *wild relatives* (today there is a new source: genetic engineering). Artificial mutation works at random, creating new genes that have to be identified, tested, isolated, transferred to another genotype, tested again in their new genetic background etc.

Wild relatives offer a different approach: they can be tested for specific traits in order to see whether nature had already created and tested the genes sought for. In most cases these genes were certainly there, in natural biotypes, forms, races, populations or individuals. Wild relatives of the cultigens were seen as huge reservoirs of genes. Genetic engineering has widened even more these gene pools as the goal is to discover a useful gene in any species; molecular biology has considerably weakened the concept of 'wild relative' by practically removing the barriers to crossing. Thus, gene manipulation has emphasized still more the need for wild resource conservation, as *any species can in principle be the source of important genes for any other species.*

Germplasm collections that had been formed by including almost exclusively cultivated materials began to widentheir scope. Wild *close* relatives were collected at the beginning of this new period; very soon not so close relatives were also included in collections and, finally, almost everything having some probability of sharing a few genes with a given cultigen. In the past, the importance of a germplasm collection was measured by its quantity of cultivars; later, the index was the amount of landraces and of primitive forms. At the present time, an unavoidable index is the number of wild species and the level of intraspecific variation. In the future, it will certainly be almost everything, as virtually any living being can be a carrier of useful genes for any crop. Some extreme examples are well known: glyphosate resistance has been transferred from *Salmonella tiphymurium* to tobacco and other plants; genes for resistance to insects are being taken from *Bacillus thuringiensis*, etc.

A modern germplasm collection: *ex situ* conservation

Modern collections are different from those which were formed in the past, not only in the range of species gathered and stored. Two important shifts in connection with germplasm collection are worth mentioning. The first concerns the different approach to the collecting task itself: agroecological details are important data and are included in collection studies by well prepared breeders. The second is the special care in preserving the natural stands in the case of wild species; this is being felt as a necessity even for breeders not interested in natural resources conservation *per se*, as it is quite impossible to gather in germplasm collections of all potentially useful materials: everything could be now become useful, as mentioned above. The second line of reasoning leads us to recognize the increasing importance of *in situ* conservation of natural resources.

The study of the ecology of the regions surveyed is necessary not only in order to evaluate the possibilities for practical breeding, but also in order to explore similar areas in the future. Many recent papers can be mentioned, including: van Slageren & al. (1989) on wheat, barley, chickpea and lentil and their wild relatives in several well described climatic zones of the Near East, and Prosperi & al. (1989) on *Medicago* in the Iberian peninsula, also characterizing the zones surveyed in order to relate them to the different samples collected.

The work of our research group in Córdoba on interspecific crosses and derived alloploids between *Triticum* spp. (especially *turgidum*) and *Hordeum chilense* led to collecting the latter in Chile and Argentina; surveying and collection were performed with the assistance of the Department of Ecology of the Universidad Católica de Chile at Santiago. Stands of *H. chilense* located were characterized before samples were taken.

A different, though rather similar approach is that of checklists or indicator crops (Hammer 1991, Hammer & al. 1991). These lists are prepared in order to facilitate the field work, but in addition they provide abundant information about wild flora and crop patterns.

Although this kind of work is carried out from a practical point of view, i.e. to collect wild materials for breeding purposes, it has one important advantage over classical germplasm collections: if some of the gathered populations were lost in their natural habitats (for example, by overgrazing or by excesive weeding), *they could be replaced by using the stored material.* Plant breeding, even the most practical one, can be a good reason for natural resource conservation and not for genetic erosion.

In situ conservation

In situ conservation *sensu stricto* has always been a sensitive matter. Sociological problems have difficult solutions, because farmers will always have the right to grow high yielding cultivars if they want to; there is no reason to force a farmer to participate in unprofitable agriculture for ever. On the other hand, there are many advantages for *in situ* conservation. One of them is the possibility of finding genes for adaptation to different environments; but perhaps the most important advantage is the maintainance of co-evolution involving the cultigen, its wild relatives and a variety of biotic factors such as pests and diseases.

Although there are many reports on *in situ* conservation, most of them refer to medicinal or aromatic plants, tropical shrubs and trees, and forest trees. Very few attempts have been recorded on maintaining crops and/or their wild relatives. As Noy-Meir & al. (1988) pointed out, very little is known about the scientific basis permitting effective conservation in nature. Some of the questions these authors raise concern the relative importance of the inter and intra population variation, the geographical pattern of variation and its stability, nature and origin. All these variables, once known, could help in deciding on factors such as the area to be preserved, the dynamics of the conservation and alien factors affecting it. It is easy to talk about conserving landraces in their original places, or send the populations or cultivars back to their place of origin for "rejuvenation", but to demonstrate the feasibility of these proposals requires more than simple words. Thus, the Ammiad site in Israel (Noy-Meir & al. 1988) serves as an excellent example for other species.

Better knowledge of the process of crop evolution is undoubtedly helping in this matter. Understanding the role of weed forms or companion weeds (Harlan 1992) as *natural* bridges between the cultigen and conspecific wild materials is of particular importance. In modern agriculture, companion weeds and cultigens only meet in the boundaries of the cultivated plots, which act as living laboratories where new forms are continuously arising. 19th century French botanists correctly identified hybrids between wheat and *Aegilops;* these crosses occurred in the already advanced French agriculture of the 19th century (Godron 1857, Vilmorin 1911). In the second half of the 20th century, the triticale "Armadillo", which was *the* breakthrough in triticale breeding, was produced in a similar way in the CIMMYT fields in Mexico (introgresion of rye into wheat following a natural, not programmed, cross). These are only two examples, whose interest lies in the fact that these instances occurred in modern cultivated fields.

Many others cases could be added, for example those studied in South America by Quirós & al. (1992) on potatoes, by Rick (1950) and Rick & al. (1977) on tomatoes, by Hadjichristodoulou (1992) on barley in Cyprus, Letschert & Freese (1993) on sugar beet, etc. All of them point to the same fact: there is an important source of variation that can be used by the breeder, produced by natural crosses between a cultigen and their wild relatives. All these fields could be named *natural breeding stations*, and although their existence is well known by the scientist interested on crop evolution, their importance for a *practical* use by breeders is now being considered. Those places already identified should be protected in order to be sampled periodically for screening. If farmers can be convinced about the usefulness of not destroying their field plot boundaries, a giant step will have been made towards more ambitious programmes of wider *in situ* conservation. In fact, clean boundaries and well weeded farms reduces crop evolution to the experimental breeding plots; this is not *scientific agriculture* but, as Hyams (1952) called it, just *industrial agriculture*. If in the future agriculture has to be scientific, it is very probable that it will be much more similar to current techniques of 'minimum tillage' than to industrial models of cultivation. Scientific agriculture should permit crop evolution under natural conditions and, as a consequence, the maintainance of natural stands of wild relatives of cultivated species.

Concluding remarks

The work of breeders is, in a certain sense, becoming similar to that of modern botanic gardens. Collaboration between breeders and botanic gardens is not yet very strong, very probably because of a rather psychological reason: it seems that there is a certain reluctance to invade an alien field of activity. But both activities, that of the breeders and that of the botanists, will have to collaborate very closely in the future. As Seberg & von Bothmer (1991) point out, very little is known about the genetic structure of most wild species (even in Triticineae, the material they refer to) in such important traits as quantitative characters related to yield; these authors advocate more comprehensive research on both agronomic and quality traits and the desirability of doing that by both *ex situ* and *in situ* methods of conservation. Given the difficulty of the subject, this certainly seems to be the most logical course of action.

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