Characterization and Evaluation of Fruit Germplasm for a Sustainable Use

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Abstract

The existing ex situ collections of fruit tree germplasm may valuably provide either a source of genes potentially useful as raw material in plant breeding, or plants directly valid for a sustainable production. With respect to the latter item, we refer to those local varieties that, having evolved for a very long period in a location, and having developed adaptative traits well integrated with the environmental, agronomic, cultural and traditional features of the site and more or less recently have been replaced with new cultivars. The requirements of modern agriculture, such as sustainability call for the cultivation of a wider range of diverse material that could better respond to the different aspects involved. Specifically, if it is necessary to obtain new varieties with a broader genetic base, capable of producing under diverse conditions and to respond to different stresses – i.e. pests, drought, low fertility of the soil etc. –, on the other hand, in some cases, the re-introduction of old local varieties and the safeguard of traditional farming systems and landscapes, can be very profitable from an economic and socio-economic point of views.

In general, the lack of information about plant genetic resources conserved have the effect of limiting the use that can be made of large existing collections, restricting the value and the usefulness of a collection even within the owning institute and among other potential users (Frankel, 1977). Hence, assessing the traits of the germplasm conserved in a collection is an essential prerequisite to a proper and wide utilization of the plant material conserved and it is the first step toward a further definition of the roles that the accessions can play in sustainable production, through the direct use or in breeding programmes.

The activity undertaken by the Istituto Sperimentale per la Frutticoltura on fruit tree germplasm characterization and evaluation is reported. The activity is carried on within a national project on "Plant Genetic Resources", and concerning fruit trees germplasm it involves 21 institutes belonging to Mi.P.A.F., Universities, the National Research Council and regional research centres. The fruit species involved are 27 for a total of 13,027 accessions. An overview of the main descriptors used is also provided.

INTRODUCTION

The concept of sustainable development and sustainability defines the development «… which meets all the needs of the present without compromising the ability of future generations to meet their own needs» (The U.N. Brundtland Commission, 1987).

This general definition applied at the contemporary agriculture means, among other things, the cultivation of a wider range of diverse material with a broaden genetic base, capable of producing under diverse conditions and to respond to different stresses – *i.e.* pests, drought, low fertility of the soil –, or the re-introduction of old local varieties and the safeguard of traditional farming systems and landscapes.

Hence, the establishment of a sustainable agriculture is strictly connected with an appropriate use of genetic resources, according to the different aspects listed and stressed below:

- a horticultural aspect concerning the preservation of soil, water, climate and human resources and the use of a low input agriculture;

- an environmental aspect, relating to the protection of the soil from erosion, the exercise of a low impact agriculture, the re-qualification of degradated areas;
- a socio-cultural issue, with reference to the preservation of human resources, the safeguard of traditional landscape, the conservation and preservation of traditional knowledge and culture, both to be combined with the practices and applied according to the needs of modern agriculture;
- an economical aspect, concerning the production of well accepted and paid goods by the market, the diversification of the offer, the preservation of niche markets.

The existing ex situ collections of genetic resources may valuably provide either a source of genes potentially useful for plant breeding, or plants directly valid for a sustainable production; relatively to the fruit tree germplasm collection. We refer to those local varieties and neglected species that, evolved for a very long period in a location, have developed adaptative traits well integrated with the environmental, agronomic, cultural and traditional features of the site and more or less recently have been replaced with new cultivars and more remunerative species.

Different international organizations and entities, recognising the importance of indefeasibility of an appropriate conservation, use and management of genetic resources in order to achieve a global sustainable development, have established multilateral conventions and plans, involving different countries, with a special attention to the developing countries and their local communities. Recently, the 31st FAO Conference has adopted “The international treaty on plant genetic resources for food and agriculture”, whose objectives are the conservation and the sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use for a sustainable agriculture and food security, in harmony with the Convention on Biological Diversity. This Treaty, at present, is applicable to a limited list of crops, which will be reviewed by the Governing Body of the Treaty, which constitute the multilateral system of facilitated access and benefit sharing established; the horticultural crops included are listed in table 1.

In order to undergo a way of a sustainable agriculture, taking into account the above mentioned aspects and the potential future needs, one objective could be the identification of crops and species requiring special collecting attention either because of their productive importance in a region, or because of their endemic or threatened situation: As example of the latter item, table 2 reports the European horticultural plants that present higher priorities for collecting, according to Holubec (1999).

As a matter of fact, another objective is the assessment of attributes and quality of the material already collected and the evaluation of their suitability to a sustainable use: knowledge of what is available in genebanks and which characteristic it possesses is a precondition to the access and to the use of the material conserved.

Usually, the lack of information about the plant genetic resources conserved has the effect of limiting the use that can be made of large existing collections, restricting the value and the usefulness of a collection even within the owning institute and much more to other potential users (Frankel, 1977). Hence, assessing the traits of the germplasm conserved in a collection is an essential prerequisite to a proper and wide utilization of the plant material conserved and it is the first step toward a further definition of the roles that the accessions can play in sustainable production, through the direct use or the use in breeding programmes.

CHARACTERIZATION AND EVALUATION

Usually, in the practice of the germplasm character assessment, two orders of investigation are identified: characterization and evaluation (Chapman, 1989).

Characterization generally concerns qualitative, mono-oligogenic and strongly heritable characters, which are independent of the environment. Characterization allows the morphological and biophysical identification (*i.e.* in peach, flower type, flesh colour, leaf glands, flesh-stone adhesion are discriminant characters between phenotypes).

Evaluation is related to quantitative, oligo-polygenic traits that are susceptible to environment differences but are generally useful in crop improvement. It includes yield, agronomic performance, stress susceptibility, disease and pest resistance and biochemical and cytological traits.

While traits covered under characterization are easy to score, and in theory need only to be scored once, handling and interpreting quantitative data presents greater problems since the absolute value obtained may depend greatly on the environment as it varies within and among trials. For this reason, several checks repeated in different years and in different sites are needed, in addition to the adoption of specific statistical procedures.

Molecular biology techniques, on their own and in combination with other biotechnological approaches, have a significant impact on genetic resources characterization and evaluation, since they are independent on the growth stage of plants and their growing and environmental condition, and can offer an insight of the distribution and extent of genetic variation within and between species.

As a rule, the characterization and evaluation data are recorded according to descriptors that play a key role in the assessment of plant genetic resources (PGR). A descriptor is generally defined as an identifiable and measurable trait of a plant accession. It includes a descriptor name, descriptor definition and a list of possible states of the descriptors, and their codes (Denčic, 1999).

A descriptor list collects all the information available and it allows the identification of the single accession. Several international organizations and institutes have developed different lists of descriptors some of which specifically for the collection of germplasm major traits data: among these, notable is the International Plant Genetic Resources Institute, one of the Consultative Group on International Agricultural Research centres specifically devoted to the conservation and use of plant genetic resources. The adoption of internationally recognized and used descriptor lists permit homogeneity among the data that can facilitate and rationalize the exchange of information and plant material.

In the practice of the germplasm description, we can distinguish three different levels of assessment and data recording (Chapman, l.c.):

1) Passport data that include all basic information on the origin and type of accession, details of the site of collection (for local varieties and wild material) or breeding history (for "advanced" material) and taxonomy. Often they are recorded as multi-crop passport descriptors.
2) Preliminary characterization and evaluation that include a basic morphological and physiological description of accessions.
3) Further characterization and evaluation that typically include the assessment of other characters of interest, beyond the basic description. Generally stress tolerance, disease and pest resistance and quality characters are detected. They require specific procedures, abilities, infrastructures, equipments and a multidisciplinary approach.

In the current practice of the germplasm collection activity, the data are recorded using the passport and species-specific descriptor lists internationally standardized as guideline, which the germplasm collection curator can also modulate with the respect to the particular needs.

In this regard, table 3 reports a comparison among the descriptor lists used for peach in Italy by the Research Institute belonging to the Ministry of Agricultural and Forestry Policies, in the European Community Project on *Prunus* Gen Res 61 and the U.S. Department of Agriculture (Okie, 1998): while the characterization data (mono or oligogenic traits) are in general the same for the three descriptor lists, on the other hand the choice of evaluation descriptors reflect more the specific environmental and phytosanitary conditions.

ASSESSMENT OF GENETIC RESOURCES SUITABILITY FOR A SUSTAINABLE USE

Taking into consideration the arguments discussed above, in order to assess genetic resources suitability for sustainable agriculture – i.e. their potential use as raw material or as source of useful genes in breeding programmes aimed at the development of new more versatile varieties with respect to the environment, inputs, pests and diseases, etc.–, the evaluation approach is much more important and informative than the characterization approach. In fact, the genetic resources focal traits under consideration for this purpose are quantitative traits such as ability to respond to different environmental conditions; resistance, tolerance and susceptibility to biotic and abiotic stresses; productivity, quality, nutriceutical properties, postharvest behaviour and processing suitability.

In the current practice, the evaluation is, often, less accomplished than characterization, because of the difficulties that it implies. Table 4 shows, according to the Italian situation, the frequencies with which the evaluation descriptors are present in the descriptor lists or, when present, they are recorded during the description activities: in general the evaluation appears not significantly represented.

THE FRUIT TREE GERMPLASM CHARACTERIZATION AND EVALUATION ACTIVITY AT ISF: A CASE STUDY.

The activity on fruit tree germplasm undertaken by the Istituto Sperimentale per la Frutticoltura (ISF) can provide an example of the matters illustrated above.

In fact, this Institute, with the support of the Ministry for Agricultural and Forestry Policy (Mi.P.A.F.), responsible in Italy for plant genetic resources for food and agriculture (PGRFA), has a more than decennial experience with respect to fruit tree germplasm assessment (Fideghelli et al., 1989). At the moment the ISF is carrying out and coordinating a project on plant genetic resources. This project, aimed at coordinating and harmonising the ex situ collection, conservation, characterization, evaluation and utilization activities on PGRFA achieved in Italy by different Institutions and entities, provides an action specifically focused on the assessment and study of the management and the safeguard of fruit tree genetic resources present in most of the Italian research institutes belonging to Mi.P.A.F., Universities, the National Research Council and regional research centres. As general information, among the 21 Institutes interviewed, 27 species of fruit trees of a total number of 13,027 accessions are conserved ex situ. The number of varieties is 7,668, 34 % of which are of Italian origin. Most of the fruit tree varieties collected consists of cultivars and obsolete varieties (79.5 %). Breeder's selections amount to 3.0 %, while wild material and rootstock cultivars count 2.1 % and 0.4 % of the varieties, respectively. For 14.9 % of the varieties it was not possible to acquire this type of information.

Actually, the major part of the activity has been devoted to the collation of basic information concerning the different accessions conserved, as a first step toward a deeper knowledge of the Italian fruit tree germplasm. In order to achieve this task, on the basis of the IPGRI descriptors, two orders of descriptors lists were developed: one of general passport descriptors, suitable for all the species (Table 5), and another list for a preliminary characterization and evaluation, specific for each fruit tree species conserved. In particular the number of descriptors was limited to those able to supply sufficient and simple, but also highly discriminant data. For instance, the specific descriptor list for Peach (Table 6) considers morpho-physiological distinctive traits – usually scored in the varietal trials and abundantly reported in literature – that permit discrimination among accessions.

It was possible to gather a different number of characters for varieties. Considering the percentage of the varieties completely described on the total, among the major species, more data are available at the moment for peach (64.6 %) less for plum (30.4 %), pear (21.9 %), cherry (20.0 %), almond (13.4 %), apricot (11.3 %) and apple (6.1 %) which have relatively large gaps in preliminary characterization and evaluation.

Relatively to the types of the accessions data collected (Table 7), it was more difficult to acquire some information: among the general descriptors, the data concerning the origin or the discovery (year, site, breeder or collector name), the genetic origin and the pedigree of the variety, Among the specific descriptors, the phenological information about the blooming time is less known compared to the ripening time of the morphological data, the fruit size seems to be more assayed than the fruit shape. In addition, there are species-specific characters that encountered several difficulties to be found, for example the tree bearing habit and the type of skin colour of apple.

CONCLUSIONS

Since the fruit tree germplasm collections represent a valuable resource of useful material in view of a global sustainable agriculture development, much more has to be done in order to evaluate their potential effective use and to make decision about what material should be advantageously conserved or further collected. This means to improve the evaluation efforts and approaches, focusing the attention on the assessment of crucial traits for sustainability and using modern molecular biology techniques that can be profitably applied for advanced investigation of the material.

Furthermore, adopting, as widely as possible, common assessment, description and data organization procedures should be desirable to facilitate the development, at national or international level, of an efficient integrated system for management, diffusion and exchange of the fruit tree genetic resources and the relevant information recorded.

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Tables

Table 1. List of horticultural crops covered under the multilateral system.

Crop	Genus	Crop	Genus
Breadfruit	*Artocarpus*	Sweet Potato	*Ipomoea*
Asparagus	*Asparagus*	Grass pea	*Lathyrus*
Beet	*Beta*	Lentil	*Lens*
Brassica complex	*Brassica et al.*	Apple	*Malus*
Pigeon Pea	*Cajanus*	Cassava	*Manihot*
Chickpea	*Cicer*	Banana/Plantain	*Musa*
Citrus	*Citrus*	Beans	*Phaseolus*
Coconut	*Cocos*	Pea	*Pisum*
Major aroids	*Colocasia, Xanthosoma*	Potato	*Solanum*
Carrot	*Daucus*	Eggplant	*Solanum*
Yams	*Dioscorea*	Faba bean/Vetch	*Vicia*
Strawberry	*Fragaria*	Cowpea et al.	*Vigna*

Table 2. Fruit crops and species requiring special collecting attention in Europe (Holubec, 1999).

SPECIES	NOTES
Ribes petraeus	Red currant- Central Europe, Carpathians
Ribes sardoum	Endemic in Sardinia
Vitis sylvestris	Wild progenitor, in forests along rivers from central and south Europe to Pontus and Caucasus
Malus pumila	Wild progenitor of apple, from Asia to Balkan and Europe, highly introgressed with escaped cultivated forms, old landraces available as valuable introgressants
Prunus s.l.	Many cultivated spp. In Europe, many escaped types often introgressed to wild spp., several wild spp. as useful donors of disease resistance
Prunus domestica	Plum - originally domesticated in Caucasus, spread to Europe in ancient times, various types introgressed to *P. spinosa* and other, some more tolerant to PPV
Cerasus avium	Cherry – Europe to West Asia, valuable healthy mountain cherry in central Europe
Cerasus fruticosa	
Cerasus prostrata	
Amygdalus communis	Almond – cultivated in Mediterranean often escaped and naturalized
Amygdalus nana	Low almond – Southeast Europe, resistance donor
Amygdalus (Prunus) webbii	Wild almond – South Balkan, south Italy, Spain
Phoenix theophrastii	A closely related species to date palm *P. dactylifera*, occurs scattered in Crete found also in southwest Turkey, growing along streams or on places with a good access to groundwater

Table 3. Comparison of descriptors lists used for peach in Italy, Europe and USA.

Descriptor	MiPAF	GenRes61 EU	USDA Byron	Descriptor	MiPAF	GenRes61 EU	USDA Byron
1 Accession name	X	X	X	20 Fruit size	X	X	-
2 Synonyms	X	X	X	21 Fruit type	X	X	X
3 Accession number	X	X	X	22 Fruit shape	X	X	X
4 Institution code	X	X	X	23 Flesh colour	X	X	X
5 Genus	X	X	X	24 Flesh type	X	X	X
6 Species	X	X	X	25 Flesh adhesion	-	X	X
7 Site of origin	X	X	X	26 Quality	-	X	X
8 Breeder (person or Institution)	X	X	X	27 Looks	-	X	X
9 Year of release	X	X	X	28 Yield	-	-	X
10 Status of the sample	X	X	X	29 Chilling	-	-	X
11 Genetic origin	X	X	X	30 Susceptibility to Sharka	-	X	-
12 Tree type	X	X	-	31 Susceptibility to *Taphrina deformans*	-	X	-
13 Tree habitus	X	X	X	32 Susceptibility to aphids	-	X	-
14 Tree use	X	-	X	33 Susceptibility to drought	-	X	-
15 Fruit use	X	X	X	34 Bacterial spot	-	-	X
16 Kind of collection	X	X	X	35 Remarks	-	-	X
17 Sanitary status	X	X	X	36 Citation	-	-	X
18 Leaf glands	X	X	X	37 Protection status	-	X	X
19 Ripening time	X	X	X				

Table 4. Frequency of the available evalution descriptors in the case of Italy

DESCRIPTORS	FREQUENCY
- Suitability to different environmental conditions	Low
- Resistance, tolerance, susceptibility to biotic stress	Medium
- Resistance, tolerance, susceptibility to abiotic stress	Medium
- Productivity	High/medium
- Quality	Medium
- Nutriceutical properties	Very low
- Postharvest behaviour	Low
- Processing suitability	Low

Very high	81-100%
High	61-80%
Medium	41-60%
Low	21-40%
Very low	0-20%

Table 5. General passport descriptor list

1 Accession name
2. Institution code
3. Accession number
4. Genus
5. Species
6. Synonyms
7. Site of origin
8. Breeder
9. Year of release
10. Accession status
11. Genetic status
12. Tree habitus
13. Tree use
14. Fruit use
15. Kind of collection
16. Sanitary status

Table 6. Specific descriptor list for Peach

17. Flower type (showy, non showy)
18. Type of leaf glands (none, reniform, globose)
19. Ripening time
20. Fruit type (peach, nectarine)
21. Fruit shape (flat, oblate, round,ovate, obvate, elliptic)
22. Flesh colour (white, yellow)
23. Flesh type (melting, non melting)
24. Flesh adhesion (freestone, clingstone)

Table 7. Frequency of descriptors available for the fruit tree accessions collected in Italy

Descriptors	**Almond**	**Apple**	**Apricot**	**Cherry**	**Pear**	**Peach**	**Plum**
1 Accession name	Very high	Very high	Very high	Very high	Very high	Very high	Very high
2 Institution code	Very high	Very high	Very high	Very high	Very high	Very high	Very high
3 Accession number	High	Low	Very high	High	High	Very high	Very high
4 Genus	Very high	Very high	Very high	Very high	Very high	Very high	Very high
5 Species	Very high	Very high	Very high	Very high	Very high	Very high	Very high
6 Synonyms	Very low	Low	Low	Very low	Low	Low	Low
7 Site of origin	Very high	Very high	Very high	Very high	Very high	Very high	Very high
8 Breeder	High	Medium	Medium	High	Medium	High	High
9 Year of release	Low	Low	Medium	Low	Low	High	Medium
10 Accession Status	Very high	High	Very high	Very high	High	Very high	Very high
11 Genetic origin	Very high	High	Very high	High	High	Very high	Very high
12 Tree habitus	Very high	High	Very high	High	High	Very high	Very high
13 Tree use	Very high	High	Very high	Very high	High	Very high	Very high
14 Fruit use	Very high	High	Very high	Very high	High	Very high	Very high
15 Kind of collection	Very high	High	Very high	Very high	High	Very high	Very high
16 Sanitary status	High	Low	High	High	Medium	Very high	High

Very high	81-100%
High	61-80%
Medium	41-60%
Low	21-40%
Very low	0-20%