Conservation and utilisation of genetic resources of European elm species

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ABSTRACT

Elm species and Dutch elm disease

The number and names of elm species is a bone of contention among taxonomists. If the specific rank is granted to major taxonomic variants only, there are about 30 elm species in the world, out of which ca 20 in Asia and 6 in north America. The number of European elm species is only 3 if the English elm (*U. procera* Salisb.) and other minor taxonomic variants are considered as varieties within the vast Field elms group (*Ulmus minor* Mill. *sensu latissimo*).

The two Dutch elm disease (DED) pandemics that spread across Europe in the 1920s and 1970s have caused dramatic mortality in elm populations, and the disease still represents a great threat for each individual elm tree. It is estimated that more than 90% of mature *U. minor* were lost to the disease. DED is also causing heavy losses to Wych elm populations (*U. glabra* Huds.), which are found in the mountains and in the northern part of Europe. The third elm species native to Europe, the European white elm (*U. laevis* Pall.), is less attractive to the elm bark beetles (*Scolytus* sp.) which spread the spores of the fungus causing the disease (*Ophiostoma novo-ulmi* Brasier). It is therefore less damaged by DED, but still endangered because of the disappearance of the riparian ecosystem where it thrives.

Achievements of elm Breeding

Elm breeding for resistance to DED has permitted to release several resistant hybrid cultivars to the European market (Mittempergher & Santini 2004). These hybrids involve crosses with at least one resistant Asiatic species (generally *U. pumila* L., *U. japonica* Sarg. or *U. wallichiana* Planch.).

The Dutch breeding programme carried out at the Dorschkamp Research Institute between 1928 and 1992 has produced 4 generations of hybrid clones, and several of them have been released by Hans Heybroek (e.g. 'Commelin', 'Lobel', 'Dodoens', 'Plantyn', 'Columella'). In addition, several other hybrids in test in 9 countries are also released or about to be released (e.g. 'Lutèce' and #762 selected by INRA, France).

The Italian breeding programme started at Centro Nazionale delle Ricerche (Florence) in the late 1970s. It aimed at producing resistant hybrids adapted to the Italian climate and involved crosses of *U. pumila* with other material, including cultivars released by Hans Heybroek. Two cultivars ('San Zanobi' and 'Plinio') have been released by Lorenzo Mittempergher, and more will follow soon.

The Spanish breeding programme, which started at Universidad Politecnica Madrid (UPM) in the late 1980s, aims at preserving the native *U. minor* and obtaining resistant crosses with *U. pumila*. The hybrid material is currently being evaluated by Luis Gil's team, together with native material.

The American breeding programmes held in the USA in the last decades involved many types of crosses. The programme carried out by Gene Smalley at the Wisconsin University between 1969 and the late 1990s resulted in several *U. japonica* x *U. pumila* cultivars ('Sapporo Autumn Gold' and 'New Horizon') released and widely planted in Europe.

Genetically Modified Elms have been obtained and are being tested by Kevin Gartland's team at the Universty of Abertay (Dundee, Scotland). However, due to strong public opinion against GMO trees, it is unlikely that GM elms will be released in the next few years.

Methods and progress in elm genetic resources conservation

The enormous damage caused by the Dutch elm disease pandemics has led to the development of diverse national initiatives to collect germplasm and identify conservation stands. At the end of the 1990s, two complementory international

programs were launched in order to co-ordinate the conservation of elm genetic resources in a European perspective (Collin *et al.*, 2004). One was the GENRES 78 project, which was carried out over 5 years (1997-2001) and benefited from the financial support of the European Commission (EC). It involved 17 forest research teams in nine European Union Member States, and was focused on the *ex situ* conservation of elms. The other is the European Forest Genetic Resources (EUFORGEN) co-operative programme, which was established in 1994 to promote the dynamic conservation and sustainable utilisation of forest genetic resources in Europe, and which has defined conservation strategies for the European species of elms.

The GENRES 78 EU Project enabled the satisfactory completion of the six following tasks.

1) A common database was built to list and describe the ca. 2000 clones held by project participants; it proved particularly helpful for the selection of the priority-conservation clones to exchange between partners and conserve in different places.

2) The molecular characterisation of a large sub-sample of the total collection was carried out using nuclear DNA markers (RAPDs and ISSRs on over 500 clones) and chloroplast DNA markers (PCR-RFLPs on over 700 clones); this permitted to clarify the taxonomy of elms and assess the extent of hybridisation (Goodall-Copestake *et al.* 2005), and to gain information on the routes followed by the elms when recolonising Europe after the Ice-Age.

3) The evaluation for desirable traits was facilitated by sharing expertise and adopting common protocols for experimentations and notations; a strong variability in bud burst period (Santini *et al*, 2004) and an interesting variability in resistance to DED (Solla *et al*., 2004) were found; knowledge on elm attractiveness for bark beetles was increased.

4) The rationalisation of the European elm collection was achieved through the selection of the priority-conservation clones to conserve in a restricted “core-collection” and the identification of geographic zones where complementary sampling was urgently needed; criteria for core-collection were taxonomy, geography, ecology and cpDNA diversity; genetic diversity and adaptive traits were not sufficiently taken into consideration due to the short duration of the project.

5) The long term conservation of the 850 core-collection clones was ensured by their duplication for conservation in low hedges (unattractive for the bark beetles) at two or more different Institutes, and by the cryo-preservation of buds of a 444 clone subsample in liquid nitrogen.

6) The dissemination of project results was carried out towards different kinds of audiences: scientists, professional foresters and arborists, and the general public. Outputs are expected for amenity planting, afforestation and the reconstruction of hedges. Because it will provide methodological support for the implementation of the "Noble Hardwoods" network's strategy, the project will also contribute to the identification and sustainable conservation of valuable elm genetic resources throughout Europe.

However, the rationalisation and complementation of the core collection must be continued.

The EUFORGEN "Noble Hardwoods" (new name: "Scattered broadleaves") network.

The European Forest Genetic Resources Programme (EUFORGEN) is a collaborative program among European countries aimed at ensuring the effective conservation and the sustainable utilisation of forest genetic resources in Europe. It was established in 1994 to implement Resolution 2 of the Strasbourg Ministerial Conference on the Protection of Forests in Europe. EUFORGEN is financed by the participating countries and is co-ordinated by the International Plant Genetic Resources Institute (IPGRI) in collaboration with the Forestry Department of FAO. It facilitates the dissemination of information and various collaborative initiatives. The Programme operates through networks in which forest geneticists and other forestry specialists work together to analyse needs, exchange experiences and develop conservation objectives and methods for selected species.

As a result of the needs identified by 30 European countries, *Ulmus* is one of the genera included in the scope of activities of the network. The gene conservation strategy for the European elm species aims at creating good conditions for the future adaptation of elm species in a changing environment. It recommends the dynamic management of gene resources in order to maximize the genetic diversity among the conservation populations. This can be achieved by appropriate sampling methods and the identification of many small *in situ* conservation stands representing a broad

array of site conditions. The strategy developed by the network provides guidance for the further development of national activities and encourages measures to be taken in each country.

Evaluation of native European elm material

Resistance to DED in native European elm species is low compared to Asiatic species and best hybrid cultivars. However, an interesting variability can be found within each European elm species (Solla *et al*. 2004, Pinon *et al*. 2005) and there is hope that the less susceptible material could be resistant enough for prudent use in the reconstruction of countryside hedges. Another possible use of the best clones is to include them in a breeding population. Mutiple-site experiments are being carried out in several countries and will enable a refined assessment of the best clones. Some preliminary work on the progenies of interesting clones has also started.

Growing elms as valuable broadleaves?

The demand for elm plant material is high and not properly satisfied in the case of forest and countryside uses. Owing to the fact that *Ulmus spp*. are generally not under national regulations on the trade of Forest Reproductive Material (FRM), hybrids cultivars are marketed for all kind of uses. Such cultivars are certainly well adapted to the demand for resistant elms for urban forestry, but one can doubt that their extensive use in rural hedges and woodlands should be encouraged. Their landscaping and wood values, habits and leaf shapes are different from those of the local elms, their genetic diversity is low and their good adaptation to the planting site conditions uncertain. In addition, the issue of 'genetic pollution' can be debated in the case of hybrids containing *U. pumila*, which crosses spontaneously with *U. minor* in Spain and Italy. The negative aspect of such an introgression would be a loss of identity for the native species, whereas the positive aspect would be a possible increase in its average resistance to the disease.

The present stage of selection of native European elms does not permit to release material with a high resistance to *O. novo-ulmi*. However, it seems possible to make a prudent use of some clones or progenies which combine desirable phenotypic traits (e.g. a close resemblance to local elms) and a lesser-than-average susceptibility to the agent of DED. This kind of material could be suitable for species diversity in

countryside hedges reconstruction projects. In addition, these planted elms will contribute pollen and seed and, in the long term, enhance the general resistance and dynamic conservation of the local elm genetic resource. Mixing them with tree species which cannot be infected by *O. novo-ulmi* is needed, and will reduce the chance of root-graft transmission of disease.

Perspectives: *ElmPops* project proposal

Static conservation in field clonal banks has been rationalised in western Europe in the frame of GENRES 78 project, and a pan-European dynamic conservation strategy has been defined by EUFORGEN. Perfectly resistant hybrid elm cultivars are available for urban forestry but the evaluation of sufficiently resistant native elm material for hedges and woodlands has to be refined.

In this context, a new elm project proposal has been submitted to the new GENRES call of the European Commission. The project proposes to coordinate the action of 12 contracting teams, representing 11 E.U. countries and 1 associated country. Its main objectives are: i) implement dynamic conservation through a network of natural conservation populations covering the ecological range of the species, and possibly complemented with artificial populations (seed orchards and reconstructed populations); ii) complement static conservation where needed; iii) facilitate the diversification, improvement and easy procurement of elm seed and plant material for the replanting of elms in forests and other environments devastated by DED.

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