

## A Global Conservation Strategy for Strawberries

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### Abstract

The strawberry, *Fragaria* L., a horticultural crop of global economic significance, is listed in the International Treaty on Plant Genetic Resources for Food and Agriculture, Annex 1. In 2005, about 3.6 million MT of strawberries were produced in 75 countries. *Fragaria*, which includes about 26 species, has centers of diversity located in Eurasia and North and South America. The primary cultivated gene pool is octoploid. Landraces have been lost through human encroachment, natural disasters, and displacement by commercial cultivars. Geneticists have bred new strawberry cultivars for more than 300 years but the primary cultivated gene pool is restricted. A global conservation strategy is in preparation to reduce the erosion of diversity in wild genetic resources and to protect the availability and accessibility of the wild and cultivated gene pools. An international team of strawberry genebank managers, geneticists and researchers is defining protocols to specify protocols for sustainable and secure conservation of strawberries in perpetuity. A survey of ex situ collections of strawberry was performed to identify the present status of genebank activities. Technical guidelines for the safe movement of *Fragaria* germplasm were reviewed and updated. Eligibility criteria for genebanks to be recognized as part of the global conservation system will be established. A unified approach for the global conservation of *Fragaria* will be suggested.

### INTRODUCTION

The strawberry, *Fragaria* L., is a horticultural crop of global economic significance. The genus contains about 26 species (Darrow, 1966; Hancock et al., 1996). *Fragaria* has centers of diversity located in Eurasia and North and South America. The primary cultivated gene pool is octoploid (Scott and Lawrence, 1975; Hancock et al., 1996). Landraces are being lost through human encroachment, natural disasters, such as volcanoes, and displacement by commercial cultivars as developing countries rush to meet potential exportation possibilities. Plant scientists have been breeding new strawberry cultivars for more than 300 years, but the primary cultivated gene pool has a narrow germplasm base (Hancock et al., 1996).

### Global Crop Diversity Trust

The Global Crop Diversity Trust (Trust) is a joint initiative of the Food and Agriculture Organization of the United Nations (FAO) and the International Plant Genetic Resource Institute (IPGRI) on behalf of the centers of the consultative group on international agricultural research (CGIAR). The Trust is a public-private partnership that was established under law in October 2004. The core of the Trust is composed of an endowment fund explicitly dedicated to the conservation of plant genetic resources in perpetuity. The Trust is an essential element of the funding strategy for the crops referred to in Article 15.1(b) of the International Treaty for Plant Genetic Resources for Food and Agriculture (PGRFA). These crops are commonly referred to as the Annex 1 crops of the International Treaty.

To address the needs for securing the conservation of Annex I crops in a timely fashion, the Trust requested that expert committees be formed to provide advice concerning technical matters of crop specific conservation. The mission of these

committees is to develop written documentation specifying a strategy for global conservation for the efficient and effective conservation of the crop genepool and ensure the availability and accessibility of material and related information for crop improvement. The PGRFA Annex 1 includes major agronomic and about 20 horticultural crops.

#### **MOU between ISHS and Trust**

On November 30, 2005, a memorandum of understanding was signed between the International Society for Horticultural Science (ISHS), and the Trust. The ISHS Commission on Plant Genetic Resources agreed to coordinate technical advice from ISHS commodity sections and working groups to assist the Trust in its mission. Both organizations, the Trust and ISHS, determined that strawberries would be a good horticultural model for strategy development. The objective of this report is to describe the procedures, now underway, for the development of a global strategy for the conservation of strawberry plant genetic resources.

#### **PROCEDURES**

First, a chair for the expert committee was chosen. The committee chair and the staff of the Trust discussed the development of a questionnaire of responses that would provide necessary information to the Trust in the development of the Strategy. The questionnaire was created and an on-line and an electronic document that could be emailed were prepared and distributed. Strawberry contact lists from FAO and ISHS were obtained. The questionnaire was established at the end of April 2006 and was open through August 2006. Responses that were returned electronically to the committee chair were uploaded to the on-line service. The questionnaires were tallied by an internet-based survey portal.

An expert committee was selected by requesting participants from broad global regions and specific areas with known strawberry conservation efforts. Unfortunately, not all of the requested participants from desired regions accepted invitations to be on the committee. Notably missing were representatives of Asia, Oceania, and Africa. To ensure representation additional efforts were taken to obtain information from those regions through survey responses to be tallied in the final report.

#### **Expert Committee Meeting**

A committee of 18 international strawberry scientists met in Corvallis, Oregon, from 5 through 8 July 2006. This committee consisted of four genebank managers from Canada, Chile, Germany and the United States; four breeders from France and the United States, three virology/pathologists from Greece and the United States, four molecular geneticists from the United States, two plant physiologists, and the Regional Strategy Representative from the Americas.

A two-hour video teleconference with Rome was arranged on the first day so that the Trust could interact with the committee members in Corvallis. The committee took their charge from the Trust and discussed issues in the following two days of meetings. A tour of the local genebank was provided, and some members participated in a post-conference strawberry collecting expedition for native octoploid species of regional interest. Coordination and linkages between the genebanks were discussed and suggestions for improvement were devised. Additional contacts were suggested to increase the distribution for the questionnaire data. The committee adjourned with writing assignments for the working subcommittees.

#### **Survey**

The survey website was contracted for and arranged by the staff of the Trust. Initially one month was provided for responses, but that proved insufficient. Only about half of the estimated 50 country collections answered the questionnaire before the committee meeting, so additional email follow-up was required to secure a higher response percentage.

In some cases no representative from particular collections responded. In some cases, estimates were prepared from recently published manuscripts that contained applicable questionnaire information.

### **Strategy Preparation**

During the Corvallis meeting, the committee discussed previously initiated, though incomplete, strategies for other horticultural crops, such as bananas and potatoes. Unlike these crops, strawberries had no specific, previously designated CGIAR center or global researcher network. Therefore, this strategy will not only develop a procedural document, but will also serve to establish global links and coordinate global strawberry conservation efforts.

The expert committee divided into subcommittees by area of expertise. Subcommittees worked on the following strategy components:

- Origin and taxonomy of wild and cultivated strawberry
- Status of existing collections
- Technical recommendations for genebank management
- Linkages and Information Management
- Safe Movement of Genetic Resources
- Gaps in genetic resources and information
- Recommendations for funding priorities and needs

The timeline for the strategy completion is estimated at 1 year from initial inquiries (Table 1).

## **RESULTS AND DISCUSSION**

The committee members described significant strawberry conservation activities in the Americas, Europe, Asia, and Oceania. In 2005, about 3.6 million MT of strawberries were produced in 75 countries (FAOSTAT, 2006) but the five largest producers were United States, Spain, Korea, Japan, and Mexico (ERS, 2005). Significant total acreage in strawberry production also exists in Poland, Russian Federation Turkey, Serbia/Montenegro, and Germany. Strawberry has a high crop value per acre and small acreage farms are increasing in developing countries, such as China, where farmers are diversifying production to remain competitive. Although World cultivated production is increasing (Fig. 1), genebanks in some countries, notably Australia and Scotland, have recently been closed or reduced. Developing countries or regions where significant native species exist, such as Chile, China, India and Russian Siberia, have only minimal resources which support strawberry collections.

Thus far the committee has received about 30 survey responses from 27 countries (Fig. 2), including 20 genebanks. Additional responses are being sought.

### **Genebank Standards**

The committee recognized and appreciated the global mission of the USDA ARS NCGR-Corvallis genebank. Of the presently established genebanks, Corvallis is essentially operating as a "center." *Fragaria* genebank preservation procedures were comparable in Canada, Chile, Germany and the United States (Geible et al., 2004; Reed et al., 2004; Roudeillac and Boxus, 1997). The primary collections of clonal strawberry cultivars were preserved as protected plants in the field or in screened enclosures. These enclosures were designed so that insects, e.g., aphids, have minimal access to vector diseases. From these clean, identified, foundation materials, secondary collections were prepared and stored for mid-term storage, of 5 to 10 years, as tissue cultured plantlets under refrigerated conditions. Protocols for long term backup, for more than 10 years, used cryogenically stored meristems, collected from tissue cultured plantlets. Representatives of populations of wild species were stored as cleaned, dried seeds at -20°C in freezers. Pollen was stored frozen or in liquid nitrogen. Europeans have established a system of genebanks, linked together for ensuring adequate redundancy of germplasm resources strawberry genetic resources (Geible et al., 2004; Roudeillac and Boxus, 1997).

To support ongoing genetic mapping efforts and eventual sequencing of *Fragaria*, the committee suggested international accessibility to mapping populations be supported as part of a genetic resource management plan.

Coordinated global information management systems for strawberry genetic resources lag behind that of other crops. While an association of strawberry genebanks has been established for countries in the European Union (Roudeillac and Boxus, 1997), inventory and observational data is not yet linked through the publicly accessible websites as planned. No other intra-country genebanks links are known.

#### **Safe Movement of Strawberry Genetic Resources**

The committee has recognized the following precepts:

- Strawberry propagules that are to be distributed should be free of soil, pests, and diseases.
- Many germplasm-borne pathogens of strawberry are symptom-less and cannot be detected visually. Clonal accessions should be tested for viruses and other pathogens by internationally recommended procedures prior to foreign exchange.
- Germplasm borne pathogens can be eliminated from infected plants by thermo-therapy, chemotherapy, apical meristem culture or by various combinations of these procedures.

The committee highly recommends that genebanks adopt pathogen testing and elimination procedures for safe movement of strawberry genetic resources. Suggested procedures are described in Martin (2001).

#### **Gaps in Strawberry Genetic Resources**

The committee determined that several germplasm categories are incompletely represented in national genebanks and these gaps need to be addressed. Among these were wild relatives of the cultivated strawberry, landraces, obsolete improved varieties, advanced improved varieties, breeding/research materials with specific traits of interest, inter-specific derivatives, mapping populations, and transgenic lines. Specifically the committee suggests that for improved representation of *Fragaria* genetic resources the following should be obtained. 1) diploids and tetraploids from Asia; 2) native octoploids from northwestern Alaska; 3) *F. virginiana* from Canada and the United States; 4) *F. moschata* and *F. viridis* from Eastern Europe, and 5) heirloom varieties that possess unique genetics.

In addition, publicly accessible databases of inventories should be established at genebanks that do not have them now. These inventories should be electronically linked, and uniform in ontology, so that information and observations of *Fragaria* genetic resources can be globally shared and accessible.

### **CONCLUSIONS**

#### **Recommendations for Priorities and Needs**

In summary, though strawberry production is increasing and becoming more economically important on the global scene (Fig. 1), some countries have insufficiently invested in conservation of *Fragaria* genetic resources. Former strawberry collections are being closed or have reduced staff or effort; others have inadequate support for strawberry preservation and distribution. The committee suggests that two additional centers for strawberry conservation be established at pre-existing genebanks to better represent significant native wild *Fragaria* species and landraces. An Asian center, perhaps at the Chinese Academy of Sciences genebank in Beijing, China, could be expanded to include diverse, wild Chinese and Asian strawberries. Also, one of the university collections in Chile should be expanded to represent diverse native *F. chiloensis* from that region and nation. International distribution of strawberry genetic resources should be facilitated through these centers, and other national genebanks because of quarantine requirements due to pathogen concerns. The strategy for conservation of strawberry genetic resources

will contain specific protocols for genebank management, plant distribution, and information management. With this strategy, the objective of conserving strawberry genetic resources in perpetuity will come one step closer to realization.

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### Tables

Table 1. Timeline for strawberry strategy 2006-2007.

December	Initial determination of a chair of the expert committee
February to May	Selection of the expert committee
April	Preparation of questionnaire
29 April to August	On-line availability of questionnaire and receipt of emailed document form
5 – 8 July	Expert committee meeting at genebank in Corvallis, Oregon
28 July	Response of historical taxonomic and “gap” subcommittees
1 August	Response of technical genebank management and safe movement of germplasm subcommittees
1 August	Receipt of final responses from additional genebank query
10 August	Compilation of survey responses
14 August	Report of strawberry survey progress to IHC, Seoul, Korea
1 March 2007	Submission of first draft to committee members for review
1 June 2007	Submission of committee approved draft to Trust staff
1 July 2007	Revision/ Request for Approval
1 July 2007	Submission of Strategy for publication to ISHS

Figures

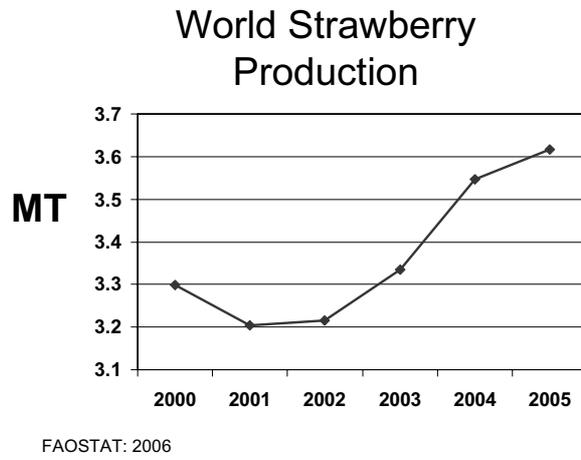


Fig. 1. World production of strawberries, 2000 to 2005.

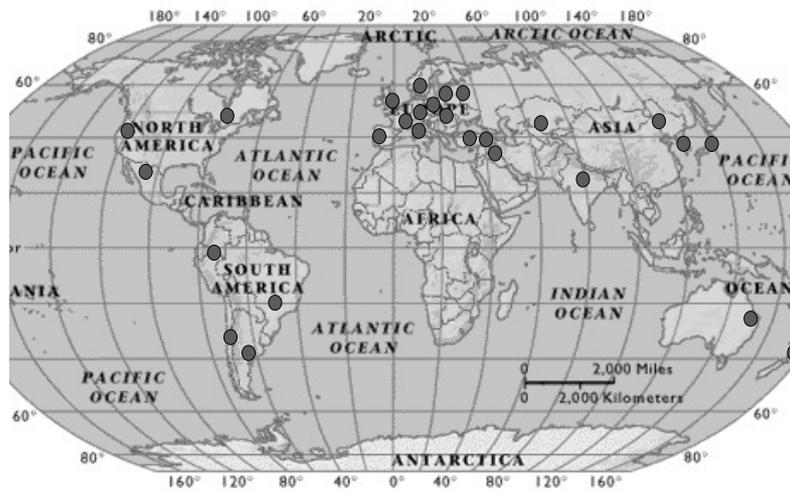


Fig. 2. Location of strawberry genebanks and major *Fragaria* collections, 2006.