Sustainable Mediterranean Agriculture. Citrus, Olives, Bees and Flowers at Hanbury Botanical Gardens

www.giardinihanbury.com
Hanbury Botanical Gardens
(Mortola Cape, Ventimiglia)
since 1867
Hanbury Botanical Gardens
www.giardinihanbury.com

- 18 Hectares
- 3 glasshouses
- >4,000 taxa
- 1 seedbank
- 1 Botany lab
- 1 Herbarium with 21,000 specimens
- 1 Museum of Wood with a wood collection
- 1 guest house
- 1 meeting room

Staff
1 President/director; 2 Curators; 2 administrative technician; 3 Technicians; 12 gardeners; 2 plant nursery technicians

Main goals
- Plant Acclimatization
- Nature conservation (reintroduction)
- Dissemination of best practices in floriculture
- Cultural tourism (50,000 visitors each year)
- Teaching and popularization
- Support to botanical research

Main Living plant collections
- Succulents
- Citrus
- Acacia
- Cycas
- Brugmansias
- Salvia
- Bamboo
- Australian forest
- Exotic Fruits
- Fragrances Garden
- Italian Giardinetti
- Japanese Garden
- Palms
- Olive trees
Regional Protected Area of Hanbury Botanical Gardens
www.giardinihanbury.com

Land: 19 Hectares
Marine: 4.6 sq Km
2 Sites of European Community Importance
Gardens is a plural word because there are many gardens and many collections.
The role of Botanic Gardens

• Botanical gardens are important plant collections. They are an excellent biodiversity display, but they are not only a museum.
• Hanbury Botanical Gardens (GBH) are also a center where studies on sustainable agriculture are developed.
• These studies may help to solve some problems linked to global change.
Global Change
Global change is much more than climate change. It is real, it is happening now and it is accelerating. 

New strategies and research at GBH

A lot of researches were carried out or are in progress at GBH (Giardini Botanici Hanbury).

1. *Citrus*. Monitoring and Biological control of scale in Citrus cultivations

2. *Inula Project*. Integrated protection in greenhouses and Olive groves

3. *Bees*. Role of bees for pollination in an exotic garden

4. LIFE + SUMFLOWER: European project on Sustainable Management of Floriculture in Western Riviera
PROJECT 1: *Citrus*

Citrus collection: about 260 plants of **ancient varieties** for ornamental or production. Some plants introduced by Thomas Hanbury, other by Cecil and Dorothy Hanbury; other later. Recent introductions: donation of some scions from Palais Carnoles (Menton, Fr) collection. **Over 50 varieties** of bitter orange, sweet orange, lemon, lime, bergamot, and others. A plant of *Microcitrus australis* is the oldest living individual of this species in Europe.

Collection aims:

a) conservation of plant breeding of the collection itself  
b) conservation of ancient varieties (genetic diversity)  
c) demo purposes: make the public aware to the biodiversity of citrus
## GBH Citrus collection

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus aurantifolia (Christm.) Swingle</td>
<td>Limetta</td>
</tr>
<tr>
<td>Citrus aurantifolia (Christm.) Swingle 'Mejicana'</td>
<td>Lima Mexicana</td>
</tr>
<tr>
<td>Citrus aurantium L.</td>
<td>Arancio amaro</td>
</tr>
<tr>
<td>Citrus aurantium L. 'Bigaradier à Gros Fruit'</td>
<td>Arancio amaro a grosso frutto</td>
</tr>
<tr>
<td>Citrus aurantium L. 'Corniculata'</td>
<td>Arancio amaro comuto</td>
</tr>
<tr>
<td>Citrus aurantium L. 'Salicifolia' o 'Granito'</td>
<td>Arancio amaro a foglia di salice</td>
</tr>
<tr>
<td>Citrus bergamia Risso et Poit. 'Castagnaro'</td>
<td>Bergamotto - Castagnaro</td>
</tr>
<tr>
<td>Citrus bergamia Risso et Poit.</td>
<td>Bergamotto</td>
</tr>
<tr>
<td>Citrus clementina Hort. ex Tanaka</td>
<td>Clementino</td>
</tr>
<tr>
<td>Citrus deliciosa Ten.</td>
<td>Mandarino mediterraneo</td>
</tr>
<tr>
<td>Citrus hystrix DC.</td>
<td>Combava o papeda di Maurizio</td>
</tr>
<tr>
<td>Citrus junos Tanaka</td>
<td>Arancio yuzu</td>
</tr>
<tr>
<td>Citrus limetta Risso</td>
<td>Limetta dolce romana</td>
</tr>
<tr>
<td>Citrus bergamia Risso 'Melarosa'</td>
<td>Bergamotto melarosa</td>
</tr>
<tr>
<td>Citrus limon Burm.f.</td>
<td>Limone Lunario</td>
</tr>
<tr>
<td>Citrus limon Burm.f. cfr. 'Lunario'</td>
<td>Limone incannellato o scannellato</td>
</tr>
<tr>
<td>Citrus limon Burm.f. 'Arancio in limone'</td>
<td>Limone rugoso - limoneira</td>
</tr>
<tr>
<td>Citrus limonia Risso et Poit. 'Dulcis'</td>
<td>Limonia detto Pero del Commendatore</td>
</tr>
<tr>
<td>Citrus maxima Merr.</td>
<td>Pummelo o Sciadocco</td>
</tr>
<tr>
<td>Citrus maxima Merr. (polpa rosa)</td>
<td>Pummelo o Sciadocco</td>
</tr>
<tr>
<td>Citrus maxima Merr. (frutto compresso ai poli)</td>
<td>Pummelo o Sciadocco</td>
</tr>
<tr>
<td>Citrus medica L.</td>
<td>Cedro comune</td>
</tr>
<tr>
<td>Citrus medica L. 'Aurantiata'</td>
<td>Cedro della Cina</td>
</tr>
<tr>
<td>Citrus medica L. 'Cedrat de Corse'</td>
<td>Cedro di Corsica</td>
</tr>
<tr>
<td>Citrus medica L. 'Diamante'</td>
<td>Cedro di Diamante o cedro liscio</td>
</tr>
<tr>
<td>Citrus medica L. 'Firenze'</td>
<td>Cedro di Firenze</td>
</tr>
<tr>
<td>Citrus medica L. 'Sarcodactylis'</td>
<td>Cedro Mano di Buddha</td>
</tr>
<tr>
<td>Citrus medica L. var. medica</td>
<td>Cedro</td>
</tr>
<tr>
<td>Citrus myrtifolia Raf.</td>
<td>Chinotto</td>
</tr>
<tr>
<td>Citrus x paradisi Macfad.</td>
<td>Pompelmo</td>
</tr>
<tr>
<td>Citrus x paradisi Macfad. a polpa rosa</td>
<td>Pompelmo</td>
</tr>
<tr>
<td>Citrus x paradisi Macfad. cfr. 'Schambar'</td>
<td>Pompelmo Schambar</td>
</tr>
<tr>
<td>Citrus x paradisi Macfad. 'Oroblanco'</td>
<td>Pompelmo Oroblanco</td>
</tr>
<tr>
<td>Citrus reticulata Blanco</td>
<td>Mandarino Ponkan</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck.</td>
<td>Arancio dolce</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Arancio Doppio'</td>
<td>Arancio doppio - Navel</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Hamlin'</td>
<td>Arancio dolce biondo</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Moro'</td>
<td>Arancio dolce Moro</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Piccolo Frutto'</td>
<td>Arancio dolce piccolo frutto</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Vaccaro'</td>
<td>Arancio dolce Vaccaro</td>
</tr>
<tr>
<td>Citrus sinensis Osbeck. 'Vaniglia'</td>
<td>Arancio dolce Vaniglia</td>
</tr>
</tbody>
</table>
PROJECT 1: Citrus

GBH Citrus collection

Citrus maxima

Citrus hystrix

Citrus aurantium ‘corniculata’
Citrus pests and diseases

MORPHOLOGY

HOST PLANTS AND DAMAGES

Panonychus citri
PROJECT 1: Citrus

Method

Inventory and cartography of the Citrus tree

Sampling of Citrus leaves

DIRECT OBSERVATION

Unaspis yanonensis

Aonidiella Aurantii

Aphytis mellinus

Morphological identification

Genetic analysis by barcoding or genotyping

Aphytis yanonensis

Coccobius fulvus
(Hymenoptera, Aphelinidae)

Aphytis sp.
(Hymenoptera, Aphelinidae)

ADDITIONAL SAMPLING

PROJECT 1: Citrus
The identification on morphological basis is not sufficient. To discover the identity of the introduced bio-control agents a more advanced technique was employed:

**Barcoding method**

- DNA Extraction (zygem Kit)
- Amplification (Qiaxcel DNA Fast Analysis Kit)
  - Primers CB1 et CB2
  - Cytochrome B oxidase (mitochondrial gene)
- Sequencing (Beckman genomics)
- Sequence analysis: Mega 6
- Alignment with ClustalW 1.81

**PROJECT 1: Citrus**
All *Aphytis* sp. sequences grouped with *Aphytis yanonensis* control sequences

Three different hypotheses:

- The species introduced in 2008 was in fact *A. yanonensis*
- The species introduced was *A. melinus* but it did not persist following introduction (control highly efficient? no more hosts?)
- *A. yanonensis* is naturally present in relation with the presence of its host *Unaspis yanonensis*.

The study demonstrated the considerable complexity in monitoring both pest and biocontrol agents (parasitoid insects) and highlighted the need for a rigorous scientific approach in organic farming.
Project 2. Inula

Hanbury Botanical Gardens
www.giardinihanbury.com
Ecosystem services and potential unintended effects related to a Mediterranean plant, *Ditrichia viscosa* (= *Inula viscosa*)

Implications in integrated protection in greenhouses and Olive growing

https://www6.paca.inra.fr/inula/Le-projet-Inula
http://www.giardinihanbury.com/ricerca/progetti/in-coro/progetto-inula

The project INULA is coordinated by Michela Ion Scotta (Sophia Agrobiotech. Nice) with the participation of Hanbury Botanical Gardens
**PROJECT 2: Inula**

* Ditrichia viscosa (Asteraceae) or INULA VISCOSA

**Biological control agent:**
- **genre** Eupelmus

**Olive grove**

**INULA FLY**

**Phenology – Morphological and molecular study**

**Greenhouse**

**Predatory bug of genre Macrolophus**

**Myopites stylata**

**parastisme**

**olive fly** Bactrocera oleae

**whiteflies**

**mobility**

**phytophagie**

**Phenology – Morphological and molecular study**
PROJECT 2: *Inula*

Methodology

- **2013**
  - 35 sites
  - 2 sampling of galls / site
  - 2 sampling of olives / site
  - Strengthening of *M. stylata*

- **2014**
  - 35 sites
  - 1 sampling of galls / site
  - 1 sampling of olives / site

- **19 sites mixte Olive growing et D. viscosa**
- **10 T- sites with only Olive growing**
- **6 sites T+ with only D. viscosa**
Context of research

- **Difficult morphological identification**
  - Small insects
  - Morphological characters are difficult to distinguish
    - e.g. the depression scrub

- The cooperating PhD student identified 4 species, 2 of them new:
  - **E. confusus**: D. viscosa & Olive
  - **E. gemellus**: D. viscosa & Olive
  - **E. urozonus**: D. viscosa & Olive
  - **E. kiefferi**: D. viscosa only

Optimization of control *B. oleae* via *Eupelmus*: a community problem!
First results

Relative proportion of the different species of Eupelmus

D. viscosa

- **E. kiefferi**: 92.4%
- **E. urozonus**: 4.9%
- **E. confusus**: 2.7%
- **E. gemellus**: 0%

328 females

**Olive**

- **E. kiefferi**: 50%
- **E. urozonus**: 16.7%
- **E. confusus**: 33.3%
- **E. gemellus**: 0%

12 females

Species common of Eupelmus to Inula and olive groves

**E. confusus** and **E. urozonus**

Majority on Inula and absent in olive groves **E. Kiefferi**
PROJECT 2: *Inula*

Experiment is in progress…

Field trial of biological control with the introduction of *E. confusus*
Limits of biological control:

- Lack of data on the phylogeny of species and on their host specificity
- Difficulties to accurately assess the success of a biological control agent following introduction – complexity of the communities

Necessary: better understand the mechanisms sustaining interactions between insect hosts and their parasitoids (genetics, molecular approaches)

- Improve biological control
  e.g. develop markers associated with success on a given host (quality control of strains, selection of successful strains)

- Develop the “Biocontrol”
  e.g. use recent technologies to develop bio-insecticides (derived from “enemies”) and deliver them into pest targets, improve the SIT approach (sterile insect technique), imagine new strategies.
Project 3. Bees
Since December 2011, the Hanbury Botanical Gardens (GBH) host a small apiary, whose bees favor the reproduction of the plants grown here, and in particular the exotic ones that can not attract their traditional animal pollinators, absent in our latitudes.
Study aims
- to investigate the relationship between bees and the exceptional variety of plants available in Hanbury Botanical Gardens
- stimulate the production of seeds and fruit through cross-pollination by bees and consequently increase biodiversity of the on-farm seedbank
PROJECT 3: Bees

Methods
- melissopalynological techniques (analysis of pollen grains contained in honey)
- behavioral observations

1. Monthly sampling of:
   - pollen of the taxa visited by bees
   - portion of honeycomb
2. Preparing standard slides and comparison with palynotheque

3 Analysis
- Qualitative microscopic analysis
- Quantitative microscopic analysis
Results of Melissopalynological analysis:

• Some pollen types are exclusive of GBH: *Brachychiton discolor, Fremontodendron californicum, Lagunaria petersonii, Cistus ladanifer.*

• Other pollen types reflect the landscape of the gardens and groves surrounding GBH: *Olea europaea, Prunus sp.*, *Citrus sp.*, *Paulownia sp.*, *Parthenocissus sp.*, *Cercis sp.*, *Gleditsia sp.*, *Acacia sp.*, *Mahonia sp.*, *Ipomoea sp.*, *Brugmansia sp.*

• Vegetation dominated by exotic naturalized plants is testified by granules of: *Eucalyptus sp.* and *Ailanthus altissima.*

• Mediterranean maquis and garrigue of inland are represented by *Quercus ilex, Pistacia sp.*, *Rhamnus alaternus, Erica arborea, Viburnum tinus, Clematis sp.*
PROJECT 3: Bees

Lagunaria patersoni

Cistus ladanifer
Melissopalynological analysis of honey:

- Some pollen types are exclusive of GBH: Brachychiton discolor, Fremontodendron californicum, Lagunaria petersonii, Cistus ladanifer.
- Other pollen types reflect the landscape of the gardens and groves surrounding GBH: Olea europea, Prunus sp., Citrus sp., Paulownia sp., Parthenocissus sp., Cercis sp., Gleditsia sp., Acacia sp., Mahonia sp., Ipomoea sp., Brugmansia sp.
- Vegetation dominated by exotic naturalized plants is testified by granules of Eucalyptus sp. and Ailanthus altissima.
- Mediterranean maquis and garrigue of inland are represented by Quercus ilex, Pistacia sp., Rhamnus alaternus, Erica arborea, Viburnum tinus, Clematis sp.
PROJECT 3: Bees

Results

Melissopalynological analysis of honey:

• Some pollen types are exclusive of GBH: Brachychiton discolor, Fremontodendron californicum, Lagunaria petersonii, Cistus ladanifer.

• Other pollen types reflect the landscape of the gardens and groves surrounding GBH: Olea europea, Prunus sp., Citrus sp., Paulownia sp., Parthenocissus sp., Cercis sp., Gleditsia sp., Acacia sp., Mahonia sp., Ipomoea sp., Brugmansia sp.

• Vegetation dominated by exotic naturalized plants is testified by granules of Eucalyptus sp. and Ailanthus altissima.

• Mediterranean maquis and garrigue of inland are represented by Quercus ilex, Pistacia sp., Rhamnus alaternus, Erica arborea, Viburnum tinus, Clematis sp., Agave sp.
PROJECT 3: Bees

Drosantherum.
Results
The investigations allowed to define a very original and complex geographical origin of honey, in which human action and wild, exotic and native vegetation are mixed in a unique way.

The analyzes relating to three years of sampling are currently underway to confirm the results already obtained.
Project 4. Flowers

Hanbury Botanical Gardens
www.giardinihanbury.com
PROJECT 4: Flowers

**Sustainable Management of Floriculture in Western Riviera**

http://www.sumflower.eu/

- Start / End: 2010-2013
- Partners: 6
- Budget: € 1.769.416
- CE contribution: € 879.913
**Sustainable Management of Floriculture in Western Riviera**

**Main objectives**

- creating a sustainable system of management for floriculture and ornamental horticulture, encompassing the social, economic and environmental component of the territory;
- analyzing, evaluating and reducing the main environmental impacts of floriculture by improving the efficiency of the sector, without neglecting profitability;
- assisting floriculture SMEs in the application of the best available techniques and innovative technologies and practices to ensure compliance with national and EU environmental policies;
- showing, in quantitative terms, in the context of the Gothenburg strategy, the opportunities and the economic benefits arising from sustainable floriculture;
- checking and improving current methods of certification for floriculture products, with an added value in terms of both quality and sustainability.
**SUstainable MAnagement of FLOriculture in WEstern Riviera**

**Environmental impact: Emergy results**

<table>
<thead>
<tr>
<th></th>
<th>Imperia</th>
<th>Savona</th>
<th>District</th>
<th>Italy (Ulgiati et al., 1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total resources requirement</td>
<td>2.63E+21</td>
<td>9.17E+21</td>
<td>1.07E+22</td>
<td>1.26E+24</td>
</tr>
<tr>
<td>(Sej)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>% Renewable resources R</td>
<td>35.45</td>
<td>26.27</td>
<td>29.57</td>
<td>9.53</td>
</tr>
<tr>
<td>% Not renewable internal resources N</td>
<td>0.08</td>
<td>0.03</td>
<td>0.05</td>
<td>28.18</td>
</tr>
<tr>
<td>% External not renewable resources F</td>
<td>64.46</td>
<td>73.69</td>
<td>70.37</td>
<td>62.30</td>
</tr>
<tr>
<td>ELR (environmental load) = F+N/R</td>
<td>1.82</td>
<td>2.81</td>
<td>2.38</td>
<td>9.49</td>
</tr>
<tr>
<td>EYR (yield to economy) = total/F</td>
<td>1.55</td>
<td>1.36</td>
<td>1.42</td>
<td>1.61</td>
</tr>
<tr>
<td>EIR (dependence) = F/ (N+R)</td>
<td>1.81</td>
<td>2.80</td>
<td>2.38</td>
<td>1.65</td>
</tr>
<tr>
<td>EmDensity (sej/m²)</td>
<td>2.11E+12</td>
<td>2.82E+12</td>
<td>2.52E+12</td>
<td>4.12E+12</td>
</tr>
</tbody>
</table>

- **Not renewables**
- **Low yield to economy**
- **Not self sufficient**
**Sustainable Management of Floriculture in Western Riviera**

Emergy consumption per unit area according to structure type

<table>
<thead>
<tr>
<th></th>
<th>Greenhouse</th>
<th>Open field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergy/unit area (sej/m²)</td>
<td>1.47E+13</td>
<td>6.13E+12</td>
</tr>
<tr>
<td>%R</td>
<td>1.04%</td>
<td>3.24%</td>
</tr>
<tr>
<td>%F</td>
<td>98.96%</td>
<td>96.76%</td>
</tr>
<tr>
<td>Footprint/unit area (gha/m²)</td>
<td>1.91E-03</td>
<td>1.16E-03</td>
</tr>
</tbody>
</table>
PROJECT 4: Flowers

Sustainable Management of Floriculture in Western Riviera

Growers’ experience and knowledge

application of the best available techniques and innovative technologies

Good agricultural practices
SUstainable Management of FLOriculture in WE stern Riviera

Main results

• 10 representative floriculture SMEs involved in SUMFLOWER;
• 243,500 m² of agricultural surface utilized (ASU), of which 32,000 m² in greenhouses, 103,500 m² in open fields, 21,000 m² in pots;
• over 2,000 plant samples analyzed;
• 4 pilot farms regularly monitored for biosafety;
• good growing substrate by re-use of green waste (compost) mixed with 20-60% peat;
• a total of .25-50% of agrochemicals less with perfect floriculture products;
• a total of 16,174 kWh produced by renewable energy sources; 8,588 kg CO2 less in the atmosphere;
• 30% less water used for floriculture thanks to automated irrigation.
The end