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Invasive species in Botanical Garden of Ajuda (Portugal)

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Introduction

Botanical gardens have been identified as a source of invasive plants in the past and have often contributed to its spread in part because they answer a great number of requests they get from around the world to distribute their plants or seeds. Botanists, conservationists, foresters, agroforesters and horticulturalists have, and often still are, to varying degrees, responsible for the introduction and planting of woody alien species, but there is no evidence to show that scientists responsible for their introduction were aware of the potential problems. Many invasive plants have been introduced by their uses as food or as medicine but also as ornamentals and they continue to be admired by gardeners who may not be aware of their weedy nature. Many of the qualities that make plants valuable in gardens also make them potentially invasive. Easy germination and propagation, hardiness, rapid growth, abundant flowers, and resistance to insects and diseases are qualities that are desirable in ornamental plants, yet also are characteristics of weedy plants. The Botanical Garden richness is due to the introduction of species from around the world but it is known that some species became invasive under new environmental conditions. This is very clear at the Botanical Garden of Ajuda where some species do not become invasive until they are neglected for a long time. This is the case of *Salpichroa origanifolia* (Lam.) (Fig 1) Thell, *Fallopia aubertii* (L. Henry) Holub and *Wedelia glauca* (Hortega) Hoffm., which were introduced many years ago in the collection and have become the worst weeds in the Botanical Garden itself.

Figure 1 . *Salpichroa origanifolia* (Lam.) Thell

The Botanical Garden is divided into two terraces: the upper terrace with the botanical collection and the lower terrace with a romantic garden in a perfect symmetry drawn by *Buxus sempervirens* L. This shrub offers those perennial invaders the perfect refuge; they compete with the ornamental plant for light, nutrients, water and provide favourable conditions for *Buxus* root diseases (*Cylindrocarpon* sp.). The present and current management of those invasive species consists of rhizome-pulling and shoot-cutting every two weeks. Due to the historical characteristics of this Botanical Garden, founded in 1768, for a long period only manual and mechanical control were used. These management procedures gave a good control

of the species *Rubia tinctoria* Salisb. and *Commelina virginica* L.*;* nevertheless other control measures are necessary, e.g. chemical control.

The perennial Solanaceae *S. origanifolia* (synonym: *Physalis origanifolia* Lam., *Atropa origanifolia* (Lam.) Desf., *A. rhomboidea* Hook and *S. rhomboidea* (Hook) Miers; common names: huevo de gallo, azucena de las pampas, corota pampas, lily of the valley, cock's eggs, lily of the valley vine) is native to the West of South America (Cullen *et al.*, 2000). In Portugal the species is already naturalized from north to central mainland Portugal (Fig. 2) near the coast, and in the Azores islands. It propagates by seed and specially by rhizomes. At the Garden flowering occurs in spring and summer.

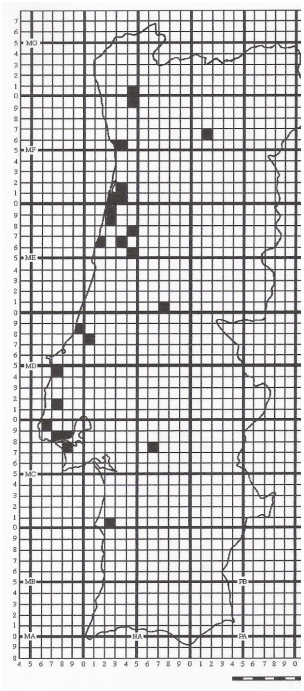

Figure 2 *Salpichroa origanifolia* distribution in mainland Portugal.

The perennial and climber broad-leaved species *F. aubertii* (synonym: *Bilderdykia aubertii* (Henry) Moldenke*, Polygonum aubertii* Henry; common names: silver lace vine, mile a minute) is a Polygonaceae native from Eastern Asia, with densely twining stems up to 15m long, with a strong annual growth. From July to August tiny white flowers are borne abundantly on short branchlets, but due to the intensive plant cutting, every two to three weeks, it rarely flower in the Botanical Garden of Ajuda. Though tolerant of poor soils, it will grow much quicker in a fertile ground and it prefers sunny sites.

The Asteraceae *W. glauca* (Fig.3) (synonym*: Pascalia glauca* Ortega; common names: sunchillo, yuyo sapo, clavel amarillo) is originated from South America and is considered a toxic weed in Argentina, Brazil, Bolivia, Chile and Paraguay due to presence of a toxic compound. Seed and vegetative propagation are common. Sprouting occurs at the end of the winter, flowering in the summer and then the aerial stems die.

Figure 3. *Wedelia glauca* (Hortega) Hoffm.

The main objective of this research was to increase the understanding of the biology and/or control of the three species.

Material and methods

Seeds from *S. origanifolia* were collected from the Botanical Garden of Ajuda and were submitted to germination tests performed in light and temperature-controlled incubations at 15ºC, 20ºC, 25ºC and 30ºC, as well as under alternate 15/20ºC and 20/30ºC regimes with 12-hr daily photoperiods.

The vegetative propagation of *S. origanifolia* rhizome fragments, herbaceous and lignified, was studied under the temperature regimes of 15ºC, 20ºC, 30ºC, 15/20ºC and

following concentrations: 0, 5, 10, 20 e 40 g a.i. L^{-1}.

Figure 4. Protection of *Buxus sempervirens*

20/30 ºC at total darkness. The vegetative propagation *W. glauca* rhizome fragments, one and two or more years old, was also studied under 15/20ºC alternate temperature regime at total darkness and 12-hr light.

In order to evaluate the effectiveness of the chemical control of *S. origanifolia* and *F. aubertii,* foliar herbicides were assayed in the Botanical Garden of Ajuda conditions. For *S. origanifolia* glyphosate (9 and 18 g a.i L^{-1}), MCPA (2 and 4 g a.i. L^{-1}) and 2,4-D+MCPA (1.75+1.5 g a.i. L^{-1}) were applied. For *F. aubertii* glyphosate was applied in the

Results

For *S. origanifolia* highly significant differences (P<0.01) were obtained for the different temperature regimes. The best germination result (90%) was obtained with seeds at 15ºC and 15/20ºC (Table 1). Seed germination began after 5 days; the germination time was 11 days for the modalities with the best germination result. Germination curves show an exponential form until, approximately, day 15, after which time the germination curves evolve more gradually (Fig. 5).

The sprouting efficiency of *S. origanifolia* was higher than 85% at all temperature regimes but better in lignified rhizomes (Fig. 6A). For *W. glauca,* no differences were observed under the two light regimes, but for the oldest rhizomes, fragments sprouting per node were significantly higher than for the 1-year old ones (Fig. 6B). Figure 7 and 8 illustrates herbicide efficacies for *S. origanifolia* and *F. aubertii* in the Botanical Garden of Ajuda conditions. MCPA showed low efficacy for *S. origanifolia* (Fig. 8). Only glyphosate applications gave a good control for either both species. Indeed, good efficacies were obtained with 10 g a.i. L^{-1} glyphosate.

Table 1. Germination of *Salpichroa origanifolia* seeds collected in the Botanical Garden of Ajuda, Lisbon, and then tested in 50-day trials.

Temperature regime (ºC)	Germination (%)
15	91 a
20	79 b
25	30 d
30	3 e
15-20	92 a
20-30	60 c

Values in the germination column with different letters are significant different from each other at P≤0.05 level (Fisher's Protected LSD Test).

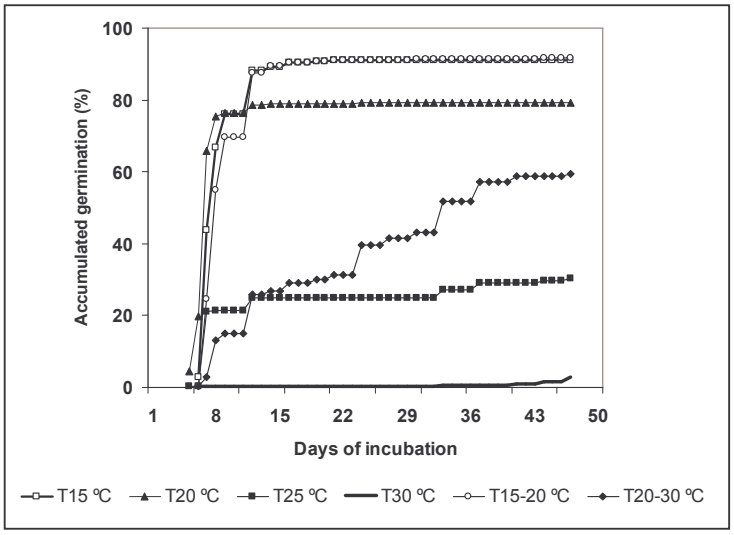

Figure 5 Cumulative time courses for germination of *Salpichroa origanifolia* seeds under different temperature regimes.

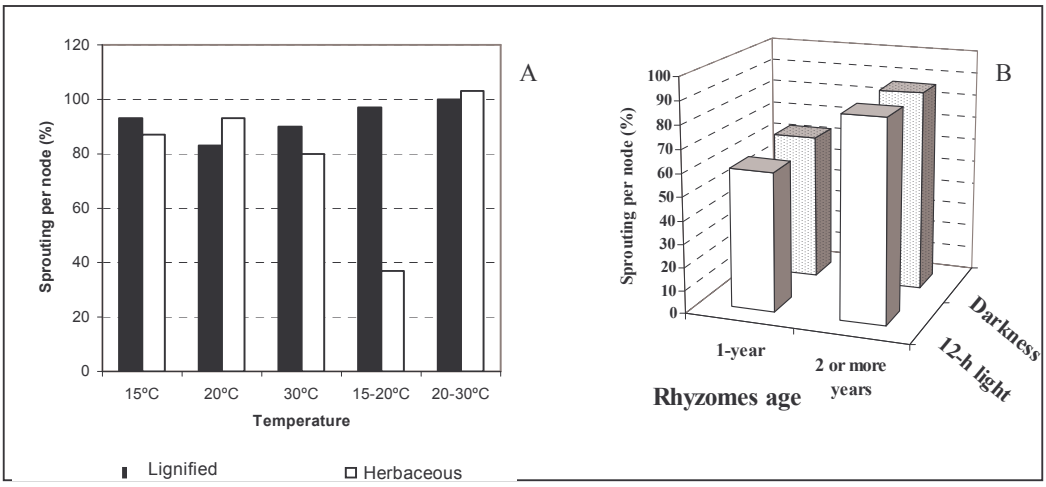

Figure 6. Sprouting per rhizome node (A) for *Salpichroa origanifolia* at different temperatures and at total darkness; (B) for *Wedelia glauca* under 15/20ºC alternate temperature regime at total darkness and 12-hr light.

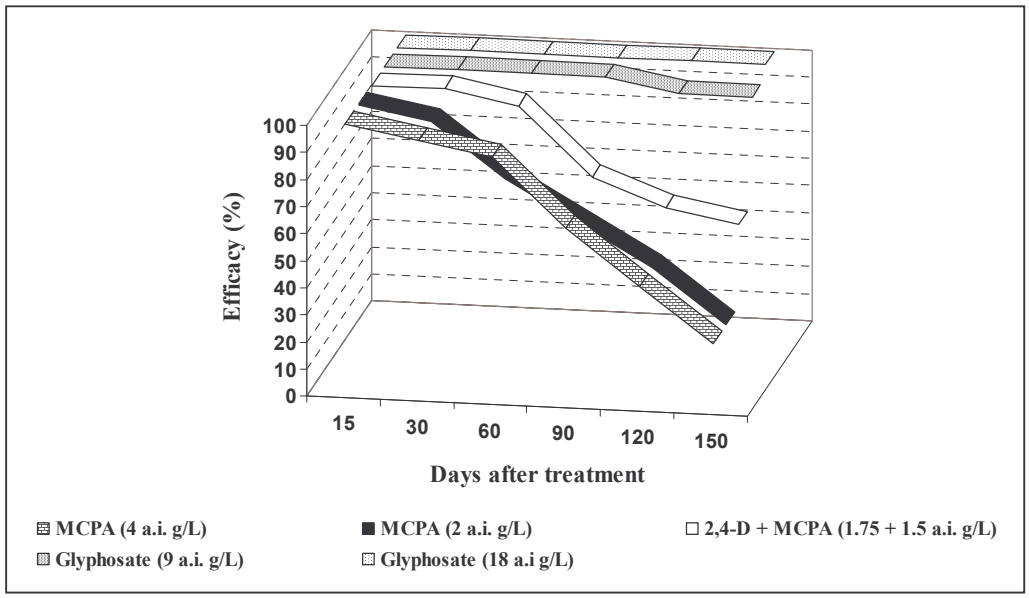

Figure 7. Mean efficacy of MCPA, 2,4-D+MCPA and glyphosate for control *Salpichroa origanifolia.*

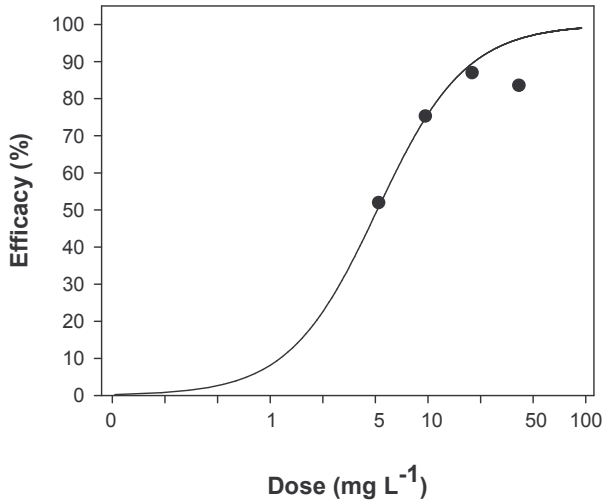

Figure 8. Mean efficacy and predicted dose-response curve of glyphosate for control on *Wedelia glauca* sprayed at spring.

Conclusions

These first studies show a good efficiency of the herbicide glyphosate to control those rhizomatosous species. Multi-programmed applications of 10 g a.i. L^{-1} glyphosate seem necessary to control *S. origanifolia* and *F. aubertii,* according to the density of invasion. For *W. glauca,* chemical control and seed germination studies are necessary. Biology research of *F. aubertii* must also be considered.

Nowadays other invasive problems are arising, e.g. with the species *Oxalis latifolia* Kunth and *Nothoscordum gracile* (Aiton) Stearn, which will be object of future studies.

Final considerations

Some of our worst weeds were first introduced as ornamentals. To combat the sale and spread of invasive plants, adequate legislation was introduced in different countries of Europe. Several countries have produced lists of invasive plants, e.g. the Canadian Botanical Conservation Network has prepared a list of invasive species found in Canada, including a description of each species and control method for small-scale invasions. In Portugal, at the web page www.uc.pt/invasoras, prepared by researchers of Coimbra University and Polytechnic Institute, people can also find this kind of information for the principal invaders at the country. In Spain very good information can be found at hidra.udg.es/invasiber. In the USA, much information is given at the web site of the Center for Invasive Plant Management or of the Invasive Plant Council of New York State. The number of international groups organized to educate the public about invasive plants is increasing. On the individual level, people are becoming aware of the presence of invasive plants in the gardens, and developing a greater interest in native plants. To find information on plants that are just beginning to show signs of invasiveness in a region can be difficult. For example, *Asparagus densiflorus* (Kunth) Jessop from South Africa, is a very popular ornamental in Portugal, yet it is becoming invasive in warmer regions, such as it happens in some parts of America and New Zealand; for this reason, it is probably not a wise choice for gardeners of Mediterranean Region. One good way to check the potential invasiveness of any plant is the database of invasive weeds around the world compiled by Randall (2001), that estimates 18 500 worldwide. We can also attempt to predict which species will be successful invaders in particular communities, looking at the natural ecology of the species and trying to use what we learn to see how favourable the new area might be for the species, or comparing biogeographic characteristics, or looking for taxonomic patterns in invasiveness.

In December 2001, experts from across the globe met in St. Louis, Missouri to explore and develop workable voluntary approaches for reducing the introduction and spread of non-native invasive plants, which are serious threats to protecting biodiversity and ecosystems in the United States and other countries. The Missouri Botanical Garden and the Royal Botanic Gardens, Kew convened this Workshop. It brought together for the first time some of the most respected leaders in their fields. Two major tasks were worked:

1. Findings and Principles that frame the invasive species problem and present the underlying basis for successful efforts to address it; and,

2. Draft Voluntary Codes of Conduct that help govern decisions made by commercial, professional and government groups whose actions affect the spread of invasive plant species including government agencies, nursery professionals, the gardening public, landscape architects and botanic gardens and arboreta.

These components were presented in the Saint Louis Declaration.

In October 2002, the Chicago Botanic Garden hosted the second workshops about the critical issue of preventing invasive plant introductions. This workshop identified education as one of the most important motivating factors for the public, businesses, and institutions. The development of educational materials targeted to different audiences, including the media, was set as a goal for the future.

What can we do?

- Identify locally important invasive plants.
- Remove invasive exotic species from existing collections and prevent accession of any exotic plant known to be invasive.
- If your botanical garden borders a natural area, consider having only native plants in the collection. This will demonstrate to the public that beautiful native landscape material is available.
- Choose plants for your collection carefully. Sharing, it seems, isn't always a good thing. For this reason many US botanical gardens have restricted the distribution of some seeds.
- Create an invasive plant database, available to other botanical gardens and arboreta, with a scheme based on species life history traits, that will also include exotics already known or suspected to be invasive (such as the data base of the North Carolina Botanical Garden)
- Use herbicides carefully as a last resort to remove invasive plants.
- Make others aware of invasive plants.

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