Propagation Studies on Chilean Geophytes

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Abstract

Chilean geophytes are distributed throughout the country, between Arica (18°29’ South latitude) and Tierra del Fuego (54°20’ South latitude). However, the greatest diversity is concentrated in the central part of the country, which has a Mediterranean climate. There are about 40 genera, and, depending on the species, they have a great potential either as garden plants or as cut flowers.

A 4-year study was conducted to test different methods of both sexual and vegetative propagation on 19 species: *Alstroemeria pseudospathulata*, *Bomarea salsilla*, *Calydorea xiphioides*, *Conanthera bifolia*, *Herbertia lahue*, *Leucocoryne coquimbensis*, *L. ixioides*, *L. purpurea*, *Libertia sessiliflora*, *Pasithea caerulea*, *Phycella australis*, *Placea arzae*, *Rhodophiala bagnoldii*, *R. montana*, *R. phycelloides*, *R. rhodolirion*, *R. splendens*, *Tecophilaea violiflora* and *Tropaeolum polyphyllum*.

The seeds of most of the species either germinated poorly or did not germinate when placed in standard conditions (20°C and moist conditions). To find the optimum germination procedures various seed treatments were tested including: soaking, chilling, and scarification, among others. The treatments were considered satisfactory when more than 70% germination was achieved. All species that were studied can be propagated efficiently by seeds when the appropriate treatment is being used, except *Libertia sessiliflora*. The bulbs, depending on their size, were also propagated asexually by cutting into halves, or into more sections. All species can be vegetatively propagated by these techniques with the exception of *Alstroemeria pseudospathulata*. Techniques of scooping, cross cutting, and twin scaling were also tested in some species with good results. Further research on these and other aspects on the cultivation of the Chilean geophytes are required, and are currently underway.

INTRODUCTION

There are more than 40 genera of geophytes that grow naturally within Chile. Among them, about 19 of the monocotyledonous genera are endemic (Muñoz and Moreira, 2000). Chilean geophytes are distributed throughout the entire country, between Arica (18°29’ South latitude) and Tierra del Fuego (54°20’ South latitude); however, the greatest diversity is found in the central part of the country, which has Mediterranean-type climate (Hoffmann et al., 1998).

The urban growth and the agricultural and forestry activities are affecting the conservation status of the Chilean geophytes. Their degree of endemism, their small population sizes and localization make them more susceptible than other plants to any change in their habitat.

The biological study of the Chilean geophytes is necessary both for their domestication and for their ex situ conservation. Although studies about flowering physiology have been conducted in *Leucocoryne* (Kim and Ohkawa, 1998; Kim et al., 1998a; Kroon, 1989; Ohkawa et al., 1998), and *Zephyra* (Kim and Ohkawa, 1997; Kim et
al., 1996, 1997, 1998b), few studies have been conducted with either seed or vegetative multiplication of Chilean geophytes (Thompson and Newman, 1979; King and Bridgen, 1990; Bridgen, 1991; Lu et al., 1995; De la Cuadra et al., 2002).

The aim of this work was to study both the sexual and vegetative propagation of 19 Chilean geophyte species.

MATERIALS AND METHODS

Plant Material

Studies were conducted between years 1997 and 2001 with the following 19 Chilean geophyte species: Leucocoryne coquimbensis, L. ixioides, L. purpurea (Alliaceae); Alstroemeria pseudospathulata, Bomarea salsilla (Alstroemeriaceae), Phycella australis, Placea arae, Rhodophiala bagnoldii, R. montana, R. phylloclada, R. rhodolirion, R. splendens (Amaryllidaceae); Pasithaea caerulea (Hemerocallidaceae); Calydoarea xiphooides, Herbertia lahue, Libertia sessiliflora (Iridaceae); Conanthea bifolia, Tecophilaea violiflora (Tecophilaeaceae); Tropaeolum polyphyllum (Tropaeolaceae).

Seeds and vegetative propagules (bulbs, corms, tubercles, etc.) of these species were collected from their natural habitat in different sites where the species were abundant. These habitats included young pine tree plantings, sides of rural roads, savannah of Acacia caven, and coastal and Andes mountain ranges. All experiments were performed in facilities of the Talca University, located in Talca, Chile (35°23’ South latitude and 71°40’ West longitude, 110 m above sea level).

Seed Germination Techniques

Seeds were stored in airtight glass containers, with silica gel, at room temperature. With all of the species that were studied, except for Alstroemeria pseudospathulata and Bomarea salsilla, seed germination was first tested under standard conditions, which consisted of 20°C and moist conditions without previous treatment. If the seeds did not germinate, or germinated in low percentages, different treatments were applied. The additional treatments were mechanical scarification using sandpaper or a knife, acid scarification with sulphuric acid by immersion for a definite period of time (until a change in the color of the seed coat), hot water scarification, immersion in sodium hypochlorite, and stratification at 8°C. Darkness treatments were performed by placing the seeds in acrylic boxes covered with aluminum foil. All seeds were first soaked in water for 1 or 2 days, unless otherwise stated. Seeds were placed on pleated filter paper inside acrylic boxes and held in germination rooms maintained at different temperatures (depending of the experiment) and constant light. When the stratification treatment was applied, seeds were held in a refrigerator at an average temperature of 8°C. Distilled water was used to wet the filter paper, and a fungicide (Thiram) in the powdered form was applied on top of the seeds. In most of the experiments 4 replications of 25 seeds each were used. Seed germination was checked after three, five and seven days, and then weekly; and the number of germinated seeds was recorded. Germination was defined as the moment when the radicle was clearly visible. Germination values were expressed as percentage. These were arcsine-transformed for statistical analysis.

All data were subjected to analysis of variance (ANOVA), and also, Duncan’s multiple range test. Different experiments were performed from 1998 to 2001 until a satisfactory result was achieved in each species.

Vegetative Propagules Propagation Techniques

The different vegetative propagation techniques used commercially in geophyte species were reviewed in Hartmann et al. (1997), Rees (1992), van Leeuwen and van der Weijden (1997), and Mori et al. (1997). For each Chilean geophyte that was studied, some vegetatively propagated techniques were attempted considering the characteristic of the geophytic organ, particularly its type and size. Division was applied to corms, rhizomes,
and small bulbs; while chipping, scoring, scooping, and twin scaling were applied in larger bulbs. All techniques were applied during the dormancy period of the propagules measurement of the perimeter of the material (except in rhizomes, where the length of the rhizome was measured). The cuttage was followed by disinfections of the pieces through immersion in a fungicide solution (Benomyl and Captan, 2 g/L each). Then these pieces were placed in plastic containers filled with wet pine tree sawdust as substrate, and kept on propagation benches at 20°C by bottom heating. The substrate humidity and temperature were checked daily. After 3 months the pieces were removed from the containers and the number of new propagules formed from each piece was recorded. The multiplication rate was calculated as the number of units obtained per initial unit. In most cases, it was not possible to conduct statistical analysis, since the number of propagules of the same size was too small.

RESULTS AND DISCUSSION

Seed Germination

Although the germination requirements between species are different, some groups of species showed a similar response pattern. Seeds of *Alstroemeria pseudospathulata* and *Bomarea salsilla* germinated after they were held under a warm-cold temperature treatment, which consisted of four weeks at 25°C, followed by four or eight weeks at 8°C (Table 1).

In some species the highest seed germination percentage was reached when seeds were exposed to a chilling treatment at an average temperature of 8°C. This was the case of: *Conanthera bifolia*, *Leucocoryne purpurea*, *Leucocoryne coquimbensis*, *Leucocoryne ixioides*, *Rhodophiala rhodolirion*, and *Tropaeolum polyphyllum*. The duration of the chilling period and the best germination temperature after chilling varied among the species (Table 2).

On other hand, good germination at either 15°C or 20°C without any other treatment was shown by *Rhodophiala bagnoldii* (63-79%), *Rhodophiala montana* (91%), *Rhodophiala phycelloides* (98-100%), *Rhodophiala splendens* (83-95%), and *Herbertia lahue* (89-100%). Seeds of *Calydorea xiphioides* showed a higher germination percentage at 15°C (92.5%) than at 20°C (49.2%). In the case of *Phycella australis*, *Tecophilaea violiflora* and *Placea arzae* the best germination temperature was even lower than in the species above mentioned. Seeds of these three species reached higher germination percentages at constant 8°C than at 15°C or 20°C (Table 3).

Seeds of *Pasithea caerulea* germinated adequately after that they were soaked in water for three days and held at 15°C without any other particular treatment. *P. caerulea* reached a 97% of germination after two weeks under this temperature regime. *Libertia sessiliflora* seeds only germinated at 15°C and constant light, however, the highest germination percentage obtained with this species was around 25%. The reason for this reduced germination percentage seems to be the low seed viability, which was determined with the Tetrazolium test (Hartmann et al., 1997).

Vegetative Propagation

During active growth, *Pasithea caerulea* plants were divided vertically into 2 sections. After 3 weeks, one plant was obtained from each section, nevertheless the survival of those sections was not high, and so the method must be improved. The same method was applied in plants of *Libertia sessiliflora*, but in this case the survival was very good. The *Alstroemeria pseudospathulata* plants did not survive transplanting; despite the fact that it was attempted several times, so no vegetative propagation method was performed. This division method was applied in other *Alstroemeria* species successfully, so the problem was attributed to the different morphology of *A. pseudospathulata* plants.

Propagules of *Tropaeolum polyphyllum*, *Tecophilaea violiflora*, and *Bomarea salsilla* were not vegetatively propagated due to lack of enough plant material.

The species with smaller bulbs (*Calydorea xiphioides*, *Herbertia lahue*, and
Leucocoryne spp.) were divided into 2 vertical sections, yielding from 1 to 4 bulblets from each section. Droppers were found in Leucocoryne spp., and similar structures were also found in Conanthera bifolia. The Conanthera bifolia corms of different sizes were divided into 2 vertical sections with good results. Division into 4 sections was tested with the biggest corms collected (perimeter >6 cm), giving the same number of corms per initial corm as the corms divided into 2 sections, and the distribution by size of the newly formed corms showed higher percentages in smaller sizes.

The species with larger bulbs could be cut into more sections, and other methods could be applied. Phycella australis bulbs were divided into 2, 4, or 6 sections, and also scooping and scoring were performed; all methods gave good results. Placea arzae bulbs were satisfactorily divided into 2 or 4 vertical sections. In all Rhodophiala species, all techniques tested were very successful.

The natural propagation in bulbs and corms was very low in all species; the multiplication rates ranged from 1 to 1.2. These rates were greatly improved with the artificial asexual propagation methods.

OTHER OBSERVATIONS

The species that could be classified as spring flowering plants are: Bomarea salsilla, Calydorea xiphioides, Conanthera bifolia, Herbertia lahue, Leucocoryne spp., Libertia sessiliflora, Pasithea caerulea, Phycella australis, Placea arzae, Rhodophiala bagnoldii, Rhodophiala phycelloides, and Tecophilaeas violiflora. All these plants grow in the semi-desertic and mediterranean regions. The summer flowering species are Alstroemeria pseudospathulata, Rhodophiala montana, R. rhodolirion, R. splendens, and Tropaeolum polyphyllum; all of them inhabit the Andean region.

The bulbs of Herbertia lahue were able to flower in one growing season from seeds, and also from bulb cuttage in halves. Pasithea caerulea plants were also able to flower from seed in one growing season, but the inflorescence was considerably smaller than the inflorescence developed from older plants.

The species that flowered consistently under greenhouse conditions in Talca were Bomarea salsilla, Calydorea xiphioides, Conanthera bifolia, Herbertia lahue, Leucocoryne spp., Libertia sessiliflora, Pasithea caerulea, Phycella australis, Rhodophiala bagnoldii, R. phycelloides, and Tecophilaeas violiflora. The species that flowered erratically were Placea arzae, Rhodophiala montana, R. rhodolirion, and R. splendens.

CONCLUSIONS

The seeds of the different Chilean plant species that were studied can be propagated efficiently when an appropriate treatment is being used. The exception is Libertia sessiliflora, in which none of the tested methods gave a good result. It is recommended for this particular species to study aspects related with the seed viability, such as determining the best moment to collect the seeds, the storage conditions, and finds a good test to determine the viability for such small seeds.

All species can be vegetatively propagated by artificial methods. The exception was Alstroemeria pseudospathulata.

ACKNOWLEDGEMENTS

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Literature Cited

Tables

Table 1. Effect of a temperature regime of 25°C followed by 8°C on the germination percentage of *Alstroemeria pseudospathulata* and *Bomarea salsilla* seeds. Results of the evaluation made at the end of the period at 8°C.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of weeks at 25°C</th>
<th>Germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8°C</td>
<td></td>
</tr>
<tr>
<td><em>A. pseudospathulata</em></td>
<td>4</td>
<td>42.5</td>
</tr>
<tr>
<td><em>Bomarea salsilla</em></td>
<td>4</td>
<td>71.4</td>
</tr>
</tbody>
</table>

Table 2. Germination percentages of six Chilean geophytes seeds held at 15°C or 20°C after a chilling period at 8°C. Chilling period ranged from three to six weeks depending on the species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Chilling period (weeks)</th>
<th>Germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With chilling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15°C</td>
</tr>
<tr>
<td><em>Conanthera bifolia</em></td>
<td>6</td>
<td>92.07</td>
</tr>
<tr>
<td><em>Leucocoryne coquimbensis</em></td>
<td>3-4</td>
<td>NT</td>
</tr>
<tr>
<td><em>Leucocoryne ixioides</em></td>
<td>5-6</td>
<td>NT</td>
</tr>
<tr>
<td><em>Leucocoryne purpurea</em></td>
<td>3-4</td>
<td>NT</td>
</tr>
<tr>
<td><em>Rhodophiala rhodolirion</em></td>
<td>3</td>
<td>89.0</td>
</tr>
<tr>
<td><em>Tropaeolum polyphyllum</em></td>
<td>4-6</td>
<td>55.6</td>
</tr>
</tbody>
</table>

NT = treatment not tested

Table 3. Effect of three temperature regimes on the seed germination percentage of three Chilean geophyte species. For each species the values showed in this table were recorded at the end of the experiment, which is indicated as total number of weeks in the column time.

<table>
<thead>
<tr>
<th>Species</th>
<th>Time (Weeks)</th>
<th>Temperature (°C)</th>
<th>Germination (%)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><em>Phycella australis</em></td>
<td>10</td>
<td>97.5</td>
<td>51.0</td>
<td>0</td>
</tr>
<tr>
<td><em>Placea arzae</em></td>
<td>3</td>
<td>85.0</td>
<td>50.0</td>
<td>NT</td>
</tr>
<tr>
<td><em>Tecophilaea violiflora</em></td>
<td>8</td>
<td>96.7</td>
<td>NT</td>
<td>60.0</td>
</tr>
</tbody>
</table>

** Significant at \( P \leq 0.01 \)

NT = treatment not tested