Flowering geophytes of Chile have ornamental potential

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Introduction

Chile's unique geographical location in the southwest corner of the South American continent has permitted the development of a notable and unique flora. Plant species exist in Chile that do not exist anywhere else in the world. Chile's geographical isolation, with the ocean on the western and southern sides, the Andes Mountains reaching as high as 6,500 meters to the east, and a desert to the north has made it an isolated botanical wonder with tremendous genetic diversity.

Of the 5,000+ native flowering plant species that grow in Chile, 50% are exclusives of that country (Zizca, 1992). There are 28 families of monocotyledons with 220 genera and more than 1,000 species. The petaloid geophytes (bulbs, corms, rhizomes, tubers, and other underground storage organs) are represented by approximately 180 species, with almost 90% of them endemic (Hoffmann, 1989). These plants are found all over the country: in the northern part of Chile encompassed by the hot, dry Atacama Desert, in the temperate central part with Mediterranean-like weather, and in the cool, moist southern part of Chile. It is not surprising to find distinctive species, genera and even complete endemic botanical families (Arriagada and Zollner, 1995).

There is a great potential for new plant development from native Chilean species (Hughes, 2000). In addition to the botanical potential that was already mentioned, Chile shows an economic scenario that makes the development of commercial products attractive. Chile is the third largest exporter of floriculture products in South America, after Colombia and Ecuador, valued at $8.5 million (Hughes, 2000). Much of Chilean floriculture production is consumed domestically, although there is a growing market of bulbs (*Lilium*, *Tulipa*) for export.

In 1996, the estimated area dedicated to cut flower production in Chile was more than 2,800 hectares. Chile has sustained positive growth levels for the past ten years. The average per capita growth rate during those years has been 5.3%, which implies that every 13 years the income per inhabitant is doubled. This is an achievement of great significance given that during the period between 1960 and 1990, the nation required 55 years to double the income per inhabitant. This economic growth and movement toward increased global integration has formed a base for strong export growth as well. The expansion has been evenly distributed across all export sectors, from mining to newer, non-traditional

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products. Open trade policies and a sensitivity to market needs have developed commodity and value-added exports with trading partners in the United States, Europe, and Asia. Chile currently exports more than 3,600 products with more than 5,800 Chilean companies involved in more than 151 markets (CORFO, 1997). The potential for new ornamental plant development has grown exponentially.

Chilean Geophytes with Potential

Many of Chile's bulbous species would lend themselves well to commercial floriculture production. Bulbs are often easy to ship, inexpensive to produce, and grow rapidly after receiving the proper environmental conditions in the correct sequence. The challenge in developing production protocols is determining the proper environmental conditions and sequence for the rapid production of high quality flowers. The storage organs of bulbous species allow the plant to survive a period of adverse environmental conditions. Bulbs often have a dormancy requirement that must be broken by a period of warm or cold, or various combinations of warm and cold storage. Many bulbous species also have specific environmental requirements for flower induction, initiation, maturation and elongation, root growth, and foliage growth. The successful research on the scheduling and production of tulips, daffodils, hyacinths, and other bulb species is well documented (De Hertogh, 1996). The Chilean bulb species being investigated are also spring flowering and require a temperature sequence for proper development; these Chilean geophytes have the potential to be scheduled and produced for commercial production (Olate, et al., 2000).

Of the subclass Monocotyledonae, almost all of the Chilean petaloid monocots are located in the superorder *Liliflorae* (Watson and Dallwitz, 1991). The orders *Asparagales*, *Liliales* and *Burmanniales* have 9 families, 40 genera, and 180 species of Chilean geophytes. The nine families that are represented in Chile are *Alliaceae, Alstroemeriaceae, Amaryllidaceae, Anthericaceae, Corsiaceae, Hyacinthaceae, Iridaceae, Orchidaceae*, and *Tecophilaceae*. The families within the *Asparagales* order that have potential for new plant development in Chile include the *Alliaceae*, the *Amaryllidaceae*, the *Anthericaceae*, and the *Tecophilaeae*. A more detailed analysis of these families and their ornamental potential is detailed below.

Alstroemeriaceae. There are between 40-60 species of *Alstroemeria* (also known as lily-of-the-Incas, Peruvian Lily, or Inca lily; tambien conocida como lirio del campo, lirio de los incas, lirio peruano, o lirio inca) that grow throughout Chile (Bridgen, 1992). *Alstroemeria aurea* (*A. aurantiaca*) has flower colors of orange or yellow, is from southern Chile, and is used in breeding to incorporate long, sturdy stems and winter hardiness into hybrids. *Alstroemeria pelegrina* is from north-central Chile and is valuable in breeding programs for its large, open flowers. Other *Alstroemeria* species that have been used in breeding programs includes: *A. pelegrina alba, A. angutifolia, A. diluta, A. hookeri, A. kingii, A. ligtu, A. magenta, A. magnifica, A. pulchra, A. revoluta, and A. werdermannii*.

Since 1987, we have been breeding and studying *Alstroemeria* species from Chile and Brazil (Bridgen 1999; 2000). Since 1996, this research has been in cooperation with Eduardo Olate at the Pontificia Universidad Catolica de Chile in Santiago and Flavia Schiappacasse at the Universidad de Talca in Talca. The breeding program has introduced several cultivars of *Alstroemeria* including the world's only fragrant cultivar 'Sweet Laura□' (Figure 1).

Hybrid crosses with *Alstroemeria* have been made possible through the use of *in vitro* embryo culture. *In ovulo* embryos are removed from the ovaries approximately 7-14 days after pollination. These aseptic ovules are cultured on ¼ -strength Murashige and Skoog (MS) medium (Murashige and Skoog, 1962) in the dark at 18C until germination. Later, the plants are micropropagated on full-strength, liquid MS medium with 2 mg benzylaminopurine (BA)/liter. The liquid medium is not shaken; the explants only need to be cultured so that they are not submerged in the medium (Chiari and Bridgen, 2000). Cultivars that have been introduced from this breeding program include the Constitution Series of ‘Patriot□’, ‘Freedom□’ (Figure 2), ‘Redcoat□’, and ‘Liberty□’ (Bridgen, 1997). We have also successfully made an intergeneric hybrid with *Alstroemeria* and *Leontochir ovallei*, another member of the *Alstroemeriaceae.* In addition, tetraploids (2n=4x=32) were produced from sterile interspecific diploid (2n=2x=16) hybrids by applying *in vitro* chromosome doubling techniques (Lu and Bridgen, 1997).

Alliaceae. The *Alliaceae* family has one genus in particular that has tremendous potential for commercial development. The genus *Leucocoryne*, or Glory-of-the-Sun, is a bulbous plant species native to Chile. Its beauty, long postharvest vase life, uniqueness, and commercial and ornamental potentials have stimulated the idea to breed and develop this plant.

Leucocoryne plants also have practical advantages for the grower. The bulbs can easily be induced to flower with warm temperatures and dry environments (similar to the *Amaryllis* spp.). Once induced, bulbs can be shipped to growers who can plant them and, in a short turnover time, harvest a cut flower. The bulbs are inexpensive enough to be discarded after harvest of the flowers. *Leucocoryne* have the possibility of commercially producing the bulbs in Chile with subsequent shipment to the northern hemisphere in time for planting. As the seasons in South America are reversed from those in the northern hemisphere, the bulbs can be shipped from Chile after the bulbs have been induced to flower, but just in time for planting. Another advantage to Chile is that the country is free of many plant diseases and pests that make it a convenient place for plant propagation and production of seeds, bulbs, etc. *Leucocoryne* species that have been incorporated into our research program include *L. coquimbensis* (Fig. 3), *L. coquimbensis alba*, *L. ixioides*, *L. purpurea* and *L. purpurea alba*. In Chile, Levi Mansur of the Universidad Católica de Valparaíso in Quillota is breeding *Leucocoryne* for commercial release and Eduardo Olate is studying its micropropagation and commercial pot plant production.

Flavia Schiappacasse from the Facultad de Ciencias Agrarias at the Universidad de Talca has been studying the germination of *Leucocoryne ixiodes* seeds. She found that there is a greater percentage of seed germination if the seeds were stratified at 5-8°C for at least 3 or 4 weeks, with the greatest germination when seeds were stratified for 5 or more weeks. In all cases the seeds were soaked in water for 24 hours, and after the cold treatment they were left at 20°C. Schiappacasse’s[2] group has also studied *Leucocoryne coquimbensis* (Table 1) and *Leucocoryne purpurea* (Table 2).

Amaryllidaceae. The *Amaryllidaceae* has traditionally supplied many petaloid monocots to the world. One Chilean genus, *Rhodophiala,* has tremendous potential for the floriculture industry. *Rhodophiala* have large, showy flowers of red, pink, orange, and yellow. These plants can be forced for potted plant

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culture similar to the *Amaryllis* or they can be grown for their cut flowers. The yellow and orange colors of *Rhodophiala* open new possibilities that *Amaryllis* cannot provide. Species of *Rhodophiala* that are being used for breeding and development include *R. bagnoldii*, *R. phycelloides*, *R. laeta (*Figure 5*),* and *R. montana.*

Two other genera in the *Amaryllidaceae* with potential that is similar to the *Rhodophiala* are *Placea* and *Phycella*. They have similar appearance and growth habits to the *Amaryllis*. The possibility of intergeneric hybridization with these three genera in the *Amaryllidaceae* has not been eliminated.

Tecophilaceae. The *Tecophilaceae* family has two genera of particular interest to our programs: *Conanthera* and the monotypic genus, *Zephyra elegans*. The potential for *Zephyra elegans* as a cut flower has recently been demonstrated (Kim, et.al. 1996; Kim and Ohkawa, 1997). *Zephyra* is a cormous plant with limited flower colors of white to pale blue to blue. We are using *in vitro* techniques such as somaclonal variation and micropropagation to try to develop new flower colors and forms of this species. Micropropagation procedures are also being studied to determine quick and efficient ways to propagate this plant.

Several of the *Conanthera* species make great cut flowers as well as potted plants. We have been working with *C. bifolia, C. campanulata,* and *C. trimaculata* (Fig. 7). The postharvest vase life of these species is greater than 2 weeks.

Other species

Pasithea coerulea of the *Anthericaceae* is a rhizomatous plant that grows in almost all regions of Chile. It has a spectacular blue flower that also has potential as a cut flower crop, a garden flower and a potted plant. Several species of *Chloraea* of the *Orchidaceae* have long postharvest lives and are also are being studied in Chile for their use as cut flowers. *Herbertia lahue* of the *Iridaceae* family is also being evaluated in Chile by Flavia Schiappacasse at the Universidad de Talca.

New Procedures for Germplasm Preservation

Over-collecting, growing demographic pressures and diverse anthropogenic menaces such as the growth of agricultural and urban areas, overgrazing, overuse of natural resources, erosion, and man-made fires threatened valuable plant species. During the past decade there has been a growing awareness of the dangers of over collecting wild bulbous plants for the horticultural trade. Fortunately, efforts are being made to propagate geophytes through sexual and vegetative means. In order to insure the future of wild species, programs are needed to educate those who do not realize that their practices are harmful. In addition, new procedures and techniques need to be developed and implemented so that native geophytes can be harvested in a non-destructive manner.

To avoid the dangers of damage or extinction from collecting bulbs from the wild, conservation-through-cultivation initiatives, or the commercial production or "farming" of bulbs is an alternative (Bridgen, 2001). There are several advantages to the conversion to commercial agriculture: (1) It will lead to the controlled propagation of species in nurseries and greenhouses. Long-term survival of plants under cultivation will reduce pressures on wild stocks. (2) Commercially propagated plants can have their origin labeled at sale on all transit, trade and health documents. This process will help to make a distinction between commercially grown plants and those that are collected from the wild. The consumer will know the difference and hopefully this difference will affect their decision to purchase. (3) The threat of introducing unknown diseases or pests via wild plants will be reduced or eliminated. (4) High quality and healthy plants will be available for international trade. Plant health certificates, or phytosanitary certificates, will be easier to obtain for those who sell plants to other countries. (5) Commercially produced plants are easier to establish than those bulbs that are removed from their native environment. (6) The plants will not be subjected to an abrupt break in their growing period and can be expected to flower at a predictable time. (7) Native species and their habitats will not be damaged from collection in the wild. (8) Cultivation ensures a renewable, reliable supply of stock plants. (9) The collection of plants in the wild can be quick and cheap, but commercial production is even less expensive by saving on time and travel expenses. Plant micropropagation techniques can make commercial propagation much less expensive. (10) Collections of plants can easily be used for breeding and new plant development (Lu and Bridgen, 1997).

Although the collection of native geophyte species can endanger their survival, it cannot be ignored that the collection of native plant species is critical to the hybridization and development of novel plants. As world bulb trade issues are resolved, the phasing out of wild-source material for breeding may occur.

Plant tissue culture techniques such as embryo culture (Bridgen, 1994a), micropropagation (Lu et al., 1995; Chiari and Bridgen, 2000), somatic embryogenesis, and mutation breeding (Bridgen, 1994b) have been used to facilitate classical breeding and to enhance commercial plant propagation. Embryo culture procedures have been especially valuable to research programs with *Alstroemeria* and other Chilean geophytes (Bridgen, M.P. 1994b). Embryo rescue is useful because many interspecific crosses fail to produce viable seed and progeny *ex vitrum*. By removing immature embryos from the ovule and placing them on a sterile, nutrient medium *in vitro*, the embryos can survive and grow. Embryo culture can also be used to release embryos from dormancy requirements because immature embryos will often readily germinate *in vitro*. This bypass of the dormancy requirements also shortens the growing time of the plants.

The success with Chilean geophytes in our laboratory has led us to develop an *in vitro* techniques as a nondestructive harvesting technique for the collection of native geophyte plant species. After the plant parts are collected and successfully cultured *in vitro*, they can be used for a variety of purposes (Bridgen, 2001).

Conclusions

The continuous demand for new and special products in the floricultural market encourages the discovery of new genetic sources in areas that are less exploited. In that sense, Chile presents a unique botanical condition with an enormous potential due its high number of endemic species not yet developed genetically. By working together, horticulturalists, breeders, plant physiologists, botanists, environmentalists, and other interested parties can continue to develop procedures to utilize Chile's valuable resources without destroying their native habitat.

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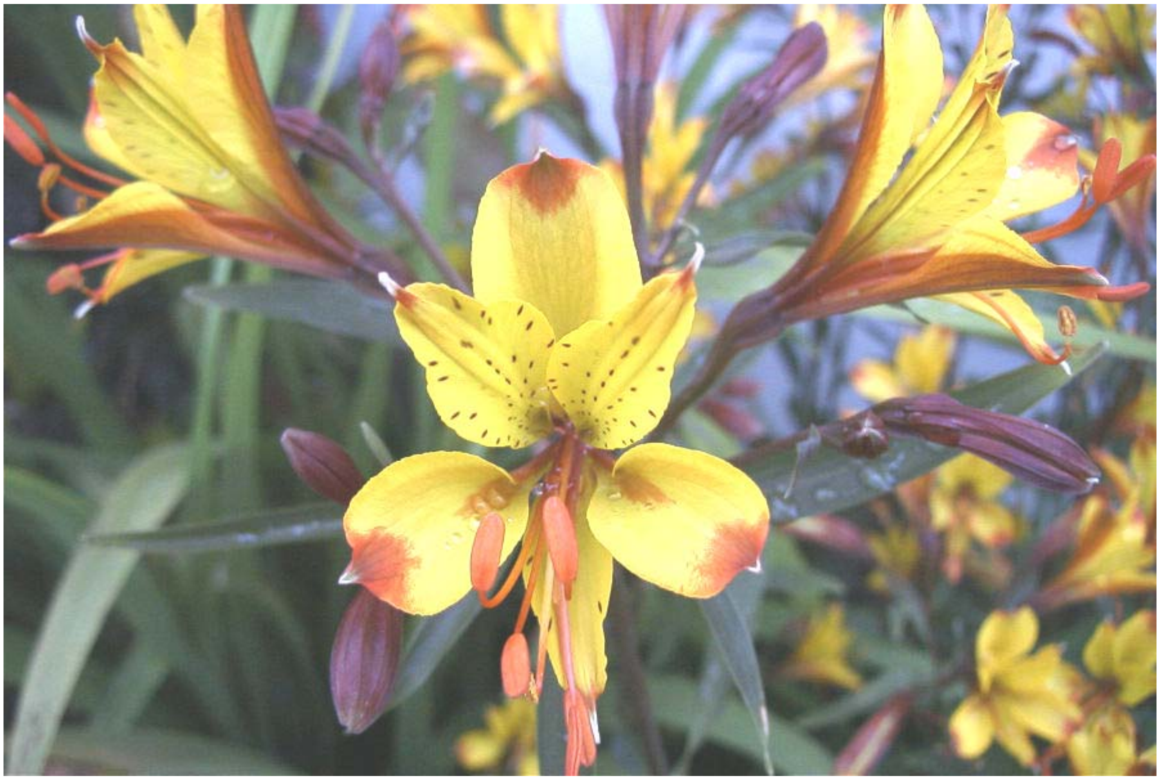

Figure 1. Alstroemeria ‘Sweet Laura’s

Figure 2. Alstroemeria 'Freedom's

Figure 3. *Leucocoryne coquimbensis*

Table 1. Seed germination of *Leucocoryne coquimbensis* when stratified up to 4 weeks.

Treatment	Germination (%)	
Weeks at 5-8°C	Mean	Standard deviation
4	94.6 a	1.8
3	86.6 a	4.4
2	74.6 b	7.1
1	49.3 c	3.6
0	1.3 d	0.9

Mean separation within columns by LSD test ($p \leq 0.05$)

Table 2. Per cent seed germination of *Leucocoryne purpurea* when stratified up to 4 weeks.

Treatment	Germination (%)	
Weeks at 5-8°C	Mean	Standard deviation
4	88.0 ab	5.3
3	96.0 a	2.7
2	74.6 bc	11.5
1	57.3 c	4.4
0	10.6 d	1.8

Figure 4. *Conanthera trimaculata* as a potted plant.

Figure 5. *Rhodophiala laeta*