

Effect of bulb weight on the growth and flowering of *Herbertia lahue* subsp. *lahue* (Iridaceae)

Pamela Morales¹, Flavia Schiappacasse¹, Patricio Peñailillo¹, and Paola Yañez²

¹Departamento de Horticultura, Facultad de Ciencias Agrarias, and ²Instituto de Biología Vegetal y Biotecnología, Universidad de Talca.

Abstract

P. Morales, F. Schiappacasse, P. Peñailillo, and P. Yañez. 2009. Effect of bulb weight on growth and flowering of *Herbertia lahue* subsp. *lahue* (Iridaceae). Cien. Inv. Agr. 36(2):259-266. Bulb weight or size is one of the critical factors affecting the vegetative growth and flowering of bulbous species. This study assessed the effect of bulb weight on the growth and flowering of *Herbertia lahue* subsp. *lahue*. This bulbous species, commonly known as “lahue,” has the potential to be used as an ornamental plant. Lahue bulbs were collected during their dormant period from Tregualemu (Región del Maule), grouped by weight categories and planted in Talca in an unheated polyethylene greenhouse. Phenology data, flowering characteristics and the number of newly formed bulbs were recorded for one season. Plants emerged 2-3 weeks after planting and flowered during the spring, between 8 and 9 months after planting. During fruit set, the leaves began their senescence process and reached dormancy during the summer. Lahue behaved as a typical geophyte adapted to a seasonal climate such as the Mediterranean climate of Central Chile. Bulbs weighing 0.35 g or more were able to flower. However, bulbs greater than 0.75 g produced more and better quality flowers. The average multiplication rate of the bulbs was 1-1.13 bulblets per planted bulb, regardless of the bulb weight; there was no correlation between multiplication rate and bulb weight. This study demonstrated that it is possible to grow lahue as a pot plant or garden plant and that the size of the bulb will determine if flowering can be achieved.

Key words: Chilean bulbs, geophyte, Mediterranean climate.

Introduction

The geophyte *Herbertia lahue* (Molina) Goldblatt belongs to the Iridaceae family and is comprised of three subspecies: *H. lahue* subsp. *lahue*, a species endemic to central Chile; *H. lahue* subsp. *amoena* (Griseb.) Goldblatt from southern Brazil, Argentina and Uruguay, and

H. lahue subsp. *caerulea* (Herb.) Goldblatt from the south of the USA (Ravenna, 1968; Goldblatt, 1975, 1978; Goldblatt and Manning, 2008).

In Chile, *H. lahue* subsp. *lahue*, known locally as “lahue,” grows in Mediterranean climates from the region of Valparaíso (33°03' S) to the region of Los Ríos (39°51' S) (Figure 1), in humid soils that are rich in organic matter. Lahue flowers in the spring months.

Morphologically, *H. lahue* subsp. *lahue* is a perennial herb, with tunicated and ovoid bulbs

covered with bright brown, paper-like tunics. The stems are simple and the linear-lanceolate leaves form plicate blades. The flowers include two whorled sets of tepals. The three external tepals are purple-blue to violet in color, with white basal claws covered with violet spots. The three internal tepals, smaller than the former ones, differ only by an intense purple color at the base. The three yellow-green stamens provide a contrast in the center of the flower. *H. lahue* subsp. *lahue* is a bulbous plant with ornamental potential because of its attractive foliage - similar to small palm leaves - and its delicate colorful flowers, which have the appearance of small irises (Figure 2) (Hoffmann, 1989; Bridgen *et al.*, 2002; Schiappacasse *et al.*, 2003).

ing and multiplicative capacity of this species. The scarce investigations that have already been carried out on Chilean geophytic plants agree with investigations on commercial species, which have demonstrated that bulbs with a minimum size are required for blooming and the production of high quality flowers (Kim *et al.*, 1998a, b; Yañez *et al.*, 2005). That is, starting from a specific minimum size, bulbs bloom and produce a large number of flowers per inflorescence, a large number of floral stems, and long stems and floral pieces (Halevy, 1990). On the other hand, the geophytic habit confers the benefits of vegetative reproduction through the development of numerous lateral buds that are able to create small bulbs (bulbils) or other type of underground organs; this capacity to grow bulbils is central for the industry of ornamental bulbous species (Rees, 1966, 1969 and 1992).

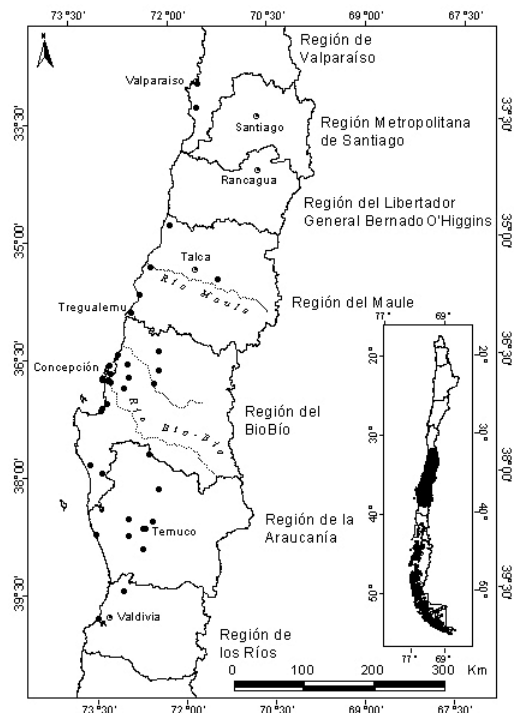


Figure 1. Geographical distribution of *Herbertia lahue* subsp. *lahue* ("lahue") based on the information obtained in the herbarium of CONC Herbarium (Universidad de Concepción, Concepción, Chile).



Figure 2. A *Herbertia lahue* subsp. *lahue* ("lahue") plant in its natural habitat, showing both foliage and flower.

The present study had the objective of studying the effect of bulb weight of *H. lahue* subsp. *lahue* on blooming capacity, flower quality and vegetative reproduction.

Materials and methods

Origin of bulbs

Bulbs of *H. lahue* subsp. *lahue* were collected during the summer (January) in Tregualemu

The flowering season, foliage permanence, vegetative propagation and seed propagation of "lahue" have been previously studied (Schiappacasse *et al.*, 2003, 2005). However, it is necessary to optimize crop management, and specifically, to know the effect of bulb weight on the flower-

(Commune of Curanipe, VII Region, Chile) (35°57'36" S; 72°40'36" W, at 427 m above sea level). This zone has a Mediterranean climate, characterized by moderate thermal changes. January is the hottest month, with maximum mean temperatures of 18.6°C, and winters are mild and without frost, with minimum mean temperatures of 7°C in July. The relative humidity is high due mainly to the strong influence of the sea. The dry season extends for about seven months (Santibañez and Uribe, 1993). An edaphic analysis of the area shows that the soils derive from sea sediments that have good drainage, allowing good radical development, but the soil has overall low fertility (Ciren-Corfo, 1996).

Classification and planting of bulbs

The bulbs were classified according to their fresh weight into five categories: (i). 0.15 ± 0.1 g, (ii). 0.35 ± 0.1 g, (iii). 0.75 ± 0.1 g, (iv). 1.35 ± 0.1 g and (v). 1.75 ± 0.1 g.

On February 11, 2000, groups of 25 bulbs for each weight category were planted 4 cm deep in 12×25×35 cm plastic containers. A substrate composed of a mixture of 1/3 sand and 2/3 vegetable soil was used (pH 5.59; electrical conductivity of 0.218 dS·m⁻¹).

The containers with the bulbs were covered with a 0.15 mm-thick polyethylene cover with UV filter and placed in a cold greenhouse located in Talca (35°30'S, 70°18' W, at 111 meters above sea level). The absolute minimum temperature was -2°C in July, and the absolute maximum temperature was 40.1°C in December. Irrigation was performed manually and the frequency was determined according to the observation of the substrate, from planting to the first signs of foliage senescence.

Evaluation

The following parameters were recorded for each weight category: (i) date of emergence (appearance of the first leaf in 60% of the plants), (ii) date of flowering (day when 60% of the plants presented flowers in anthesis), (iii) duration of

flowering (period from the appearance of the first flower to the senescence of the last flower) and (iv) date of senescence (date when the desiccation of the last green among all plants occurs). From this information, we determined the days from planting to emergence, the percentage of emergence, the days from planting to flowering, the percentage of flowering and the days from planting to senescence. In addition, during flowering, the number of flowers per plant was recorded and the flower diameter – considered to be twice the tepal length - was measured. The length of the floral stem, measured from the soil level to the flower base, and the diameter of the floral stem, measured in the middle zone of the stem, were also recorded. At the end of the season, after the flowers' senescence, the number and final weight of the harvested bulbs were recorded to estimate their natural multiplicative rate.

Experimental design and statistical analysis

The experiment was designed at random using the five different categories of initial bulb weight as treatments. The experiment was performed with six repetitions of five bulbs each. The results were studied for variance and the averages were separated according to the test of minimum significant differences (LSD) ($p \leq 0.05$). For this purpose, the program Statgraphics Plus was used (Manugistics Inc., Rockville, USA). Percentage values were transformed by $\arcsin\sqrt{x}$ before analysis.

Results

Crop phenology

The emergence of the plants occurred 2 to 3 weeks after planting, reaching 100% emergence in all the weight categories (Table 1). The plants bloomed in early November, about 8 months after planting. The bulbs from weight category 0.35 ± 0.1 g bloomed significantly ($p \leq 0.01$) later than the heavier bulbs (Table 1). The period of flowering expanded as the bulb weight increased, reaching a maximum average of 22 days in bulbs weighing 1.75 ± 0.1 g. Foliage se-

nescence manifested as an irreversible process, beginning in November. The time between planting and leaf senescence was not significantly affected by the bulb weight and occurred between late November and early December (data not shown).

Percentage of flowering and flower quality characteristics

The bulb weight of *H. lahue* spp. *lahue* had a considerable effect on its blooming capacity; small bulbs were either unable to bloom or only bloomed minimally (Table 2). The bulb weight required for blooming was 0.35 ± 0.1 g, but 100% flowering and better quality flowers were obtained with bulbs 0.75 g and heavier, which produced more and bigger flowers per plant. These characteristics led to a more attractive appearance of the plants and allowed the flowering period to last longer (Table 1).

Multiplicative capacity and bulb weight at the end of the season

In all the weight categories, the bulbs experienced a variation in their weight at the end of a growth cycle with respect to their initial weight and the time they were planted (Table 3). These variations were greater in the lighter bulbs, which did not flower and reached the minimum size necessary for flowering in only one season. Conversely, the bulbs belonging to the two heavier categories - which bloomed and produced more and bigger flowers per plant, suffered a reduction in weight. Finally, there was no effect of the initial weight of the bulb on its multiplicative capacity; on average, one bulbil was produced for each bulb planted in all the weight categories evaluated.

Discussion

In greenhouse conditions, *H. lahue* subsp. *lahue* showed a phenological behavior similar to that described for the plants in their natural habitat (Schiappacasse *et al.*, 2003). The emergence and development of the foliage occurred

in the fall and winter, while floral morphogenesis was very fast and occurred in early spring when the plants had 8 to 12 leaves, between 28 and 30 weeks after planting (data not shown). Anthesis occurred in mid-spring, about 8 to 9 months after planting. Thus, the flowering season coincides with that of the other members of the Iridaceae family living in the Mediterranean zone of Chile (Hoffmann *et al.*, 1998; Valenzuela, 1998). Fruiting began during summer and the aerial parts immediately began to dry, with the bulb lying under the soil. Therefore, the course of the phenological events of *H. lahue* subsp. *lahue* would be: vegetative growth, flowering, fruiting and recess. Hence, this is a geophytic species that is well adapted to a temperate Mediterranean climate with pronounced seasonal differences and habitats characterized by a long growth season (5-6 months of continuous growth). In these habitats, many geophytes expand their leaves after the first rains for a late bloom in winter or spring (Dafni *et al.*, 1981).

On the other hand, regarding the phenological behavior we have described and following the classification of geophytes proposed by Halevy (1990), *H. lahue* subsp. *lahue* should be considered as a bulbous species with synanthous leaves, that is, the leaves and flower emerge concomitantly; it is deciduous, as its foliage dries in unfavorable seasons; and it is perennial, as the same bulb remains for the next growth season.

The flowers of *H. lahue* subsp. *lahue* are arranged in a cymose inflorescence (rhipidium), commonly limited to a flower per peduncle. This type of inflorescence architecture has been described for *H. lahue* subsp. *caerulea*, with 2 to 5 flowers (Goldblatt, 2003) and for *H. crosae*, with 1 to 2 flowers (Roitman and Castillo, 2004). The flower of *H. lahue* subsp. *lahue* is ephemeral (it opens early in the morning and closes in mid-afternoon) in its natural environment as well as under cultivation (Schiappacasse *et al.*, 2003). The short life of the flowers is a common feature in species of the *Herbertia* genus (Goldblatt, 1975; Roitman and Castillo, 2004) and in other members of the Iridaceae family, such as *Calydorea xiphioides* (Schiappacasse *et al.*, 2003) and *Tigridia pavonia*. In spite of the short duration of these plants' flowers individu-

Table 1. Effect of bulb weight on emergence and flowering time of *Herbertia lahue* subsp. *lahue*.

Mean bulb weight g	Emergence		Flowering		
	%	Time from planting days	Date ¹	Time from planting days	Flowering period ² days
0.15 ± 0.1	100	23.2 ^{ns}	nf ³	nf ³	nf ³
0.35 ± 0.1	100	13.7	18-Nov	270.7 b ⁴	7.6 c ⁴
0.75 ± 0.1	100	13.7	06-Nov	259.0 a	15.7 b
1.35 ± 0.1	100	15.2	06-Nov	259.3 a	17.3 b
1.75 ± 0.1	100	12.7	05-Nov	257.7 a	22.2 a

¹Date of first open flower.²Days from first open flower to the last flower in the group of plants.³Plants did not flower.⁴Means followed by the same letter, in each column, are not statistically different according the least significant difference (LSD) test (p = 0.05). ns = non significant.**Table 2.** Effect of bulb weight on flowering percentage, number of flowers, and flowering characters of *Herbertia lahue* subsp. *lahue*.

Mean bulb weight g	Flowering, %	Flowers/ bulb, no.	Flower characteristics		
			Floral diameter, cm	Length of floral stems, cm	Diameter of floral stems, mm
0.15 ± 0.1	nf ¹	nf	nf	nf	nf
0.35 ± 0.1	53.3 b ²	0.7 c	4.5 c	7.4 c	1.3 ^{ns}
0.75 ± 0.1	96.7 a	1.9 b	4.7 b	8.6 b	1.6
1.35 ± 0.1	100.0 a	2.1 b	4.8 a	9.2 ab	1.7
1.75 ± 0.1	100.0 a	2.9 a	4.9 a	9.6 a	1.9

¹Plants did not flower.²Means followed by the same letters, in each column, are not statistically different according the least significant difference (LSD) test (p = 0.05). ns = non significant.**Table 3.** Effect of bulb weight at planting of *Herbertia lahue* subsp. *lahue* on its weight and multiplicative capacity at the end of the growing season.

Initial bulb weight g	Final bulb weight g	Bulbils per bulb no.
0.15 ± 0.1	0.60 d ¹	1.00 ^{ns}
0.35 ± 0.1	0.78 c	1.00
0.75 ± 0.1	0.91 bc	1.00
1.35 ± 0.1	0.97 b	1.13
1.75 ± 0.1	1.11 a	1.07

¹Means followed by the same letter in each column, are not statistically different by the LSD test (p≤0.05). ns = non significant.

ally, new flowers are produced for a period of up to 8 weeks. Consequently, they are regarded as excellent outdoor plants (De Hertogh and Le Nard, 1993). Likewise, the short endurance of the flower is not relevant for the cultivation of *H. lahue* subsp. *lahue*, as several flowers often

emerge from the same peduncle (up to 3 in larger bulbs), which improves their appearance as an ornamental species and extends the overall flowering period. It needs to be considered that, although bulbs weighing as little as 0.35 ± 0.1 g are able to bloom, bulbs weighing $\geq 0.75 \pm 0.1$

g would be better with respect to the number and quality of flowers (up to 3 flowers per plant, larger perigone size and taller the floral peduncle). Therefore, these heavier bulbs should be chosen for improved flowering.

In addition, within a growing season, bulbs below the minimum flowering size achieved a larger size and bloomed during the following season. It is important to highlight, however, that all the bulbs planted, regardless of their weight in the first season, will be able to produce flowers in the second and subsequent seasons. These results are consistent with those obtained for other geophytes that grow in the coastal desertic and semidesertic zones of Chile (Kim *et al.*, 1998a, b; Yañez *et al.*, 2005), and for “huilli” from Coquimbo (*Leucocoryne coquimbensis*), a plant of perennial bulbous habit that grows in the coastal desertic and semidesertic zones of Chile (Kim *et al.*, 1998b).

The number of bulbils harvested after a single growth cycle of a mother bulb was 1 to 1.13 bulbils, which indicates that *H. lahue* subsp. *lahue* has a very low natural multiplicative capacity when compared with commercial species such as tulip (*Tulipa sp.*) and gladiolus (*Gladiolus sp.*). Although Ravenna (1975) and Goldblatt (1975 and 1978) do not mention the multiplicative capacity of other *H. lahue* subspecies, the results we obtained are similar to the results found for other Chilean geophytic species such as *Calydorea xiphioides* (Iridaceae), whose natural multiplicative capacity is 1.5 bulbils (Valenzuela, 1998), or *L. coquimbensis* (Alliaceae), which produces 1.1 to 1.6 bulbils (Kim *et al.*, 1998b). Both geophytes possess a perennial bulb similar to *H. lahue* subsp. *lahue*. According to Hartmann *et al.* (1997) and Rees (1992), a low multiplicative capacity seems to be a characteristic of perennial bulbs such as daffodil (*Narcissus*) and hyacinth (*Hyacinthus orientalis*), compared with bulbs of annual renovation.

Natural pollinators of *H. lahue* subsp. *lahue* have not been found, and it is unknown whether the flowers are self-fertile, but this species is known to have a good capacity for seed production (80 to 90 seeds per capsule). This may

suggest a degree of autogamy, as occurs in *C. xiphioides*, where a high degree of autogamy determines a high efficiency of fruit and seed production (Rojas, 2001). Reproduction via seed is essential for most of the Iridaceae species; many species normally do not increase their number except by seeds, although they have bulbs or corms with the potential to produce vegetative propagules (Goldblatt and Manning, 2008).

However, for commercial production of *H. lahue* subsp. *lahue*, it would be feasible to increase the number of bulbils through methods of artificial vegetative multiplication such as bisection (Schiappacasse *et al.*, 2003) or *in vitro* cultivation. Alternatively, propagation could be performed by seeds, which may reach high percentages of germination (89 to 100%) at 15 or 20°C (Schiappacasse *et al.*, 2003, 2005).

According to the results of this study and current knowledge, *H. lahue* subsp. *lahue* is a geophytic species, distributed in the Mediterranean region of Chile, able to be cultivated and to achieve excellent annual flowering if bulbs with weight equal to or greater than 0.35 g are used. Use of larger bulbs allows the producer to obtain adequate flowering and produce flowers of good quality for a long period - although the flowers are ephemeral, the flowering of the total population of plants may endure up to 22 days in larger bulbs. Finally, these species have great ornamental potential, and it is feasible to use them as garden or potted plants.

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Resumen

P. Morales, F. Schiappacasse, P. Peñailillo y P. Yañez. 2009. Efecto del peso del bulbo sobre el crecimiento y floración de *Herbertia lahue* subsp. *lahue* (Iridaceae). Cien. Inv. Agr. 36(2):259-266. El peso o tamaño del bulbo es uno de los factores críticos que influye tanto en la capacidad de crecimiento vegetativo como en la floración de las especies bulbosas, dependiendo éste de las especies, variedades y cultivares. En el presente estudio se evaluó el efecto del peso del bulbo sobre el crecimiento y floración de *Herbertia lahue* subsp. *lahue*, una planta bulbosa con potencial ornamental conocida vulgarmente como “lahue”. Se recolectaron bulbos de “lahue” en su período de receso en la localidad de Tregualemu (Región del Maule). En laboratorio fueron agrupados en diferentes categorías de peso y se cultivaron en Talca en un invernadero frío de polietileno. Durante una temporada se registraron datos fenológicos del cultivo, de las características florales y del número de bulbillos producidos. La emergencia de la parte aérea ocurrió 2-3 semanas después de la plantación. La floración ocurrió 8 meses después de la plantación, en plena primavera. Durante la fructificación comenzaron a marchitarse las hojas y la planta entró en receso durante la época de verano. Así, el “lahue” se comporta como un geófito adaptado a un clima estacional como el templado Mediterráneo de Chile central. La floración ocurrió en bulbos de 0,35 g o más, sin embargo, bulbos mayores a 1,35 g resultaron mejores respecto a la cantidad y calidad de las flores. La capacidad multiplicativa natural del “lahue” fue de 1-1,13 bulbillos y no se encontró correlación significativa de esta variable con el peso del bulbo. A la luz de los resultados obtenidos en este estudio se propone utilizar el “lahue” como planta de maceta o jardín.

Palabras clave: Bulbosa chilena, geófito, clima mediterráneo.

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