FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2014, 312(31), 153–158

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EFFECT OF BULBS SIZE ON THE INFLORESCENCES AND BULBS YIELD OF *ORNITHOGALUM SAUNDERSIAE* BAKER GROWN IN AN UNHEATED PLASTIC TUNNEL

WPŁYW WIELKOŚCI CEBUL NA PLON KWIATOSTANÓW I CEBUL ŚNIEDKA SAUNDERSA (*ORNITHOGALUM SAUNDERSIAE* BAKER) UPRAWIANEGO W NIEOGRZEWANYM TUNELU FOLIOWYM

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Streszczenie. Oceniono wpływ wielkości cebul na przebieg kwitnienia, jakość kwiatostanów i plon cebul śniedka Saundersa (*Ornithogalum saundersiae* Baker) uprawianego w nieogrzewanym tunelu foliowym. W doświadczeniu wykorzystano cebule o obwodzie: 12–14, 14–16, 16–18, 18–20, 20–22 i 22–24 cm. Z cebul o obwodzie 22–24 cm i 20–22 cm otrzymano rośliny, które kwitły najdłużej i miały szersze kwiatostany, o większej liczbie kwiatów. Rośliny, uzyskane z cebul o obwodzie 12–14 cm i 14–16 cm, rozpoczynały kwitnienie średnio o 15,7 dnia później; wytworzyły najmniej kwiatów w kwiatostanie. Najwięcej cebul przybyszowych otrzymano z cebul o największym obwodzie. Najwyższy współczynnik wagowy odnotowano dla cebul uzyskanych z cebul matecznych o najmniejszym obwodzie.

Key words: circumference of bulbs, cultivation under covert, geophytes, quality of flowers.
Słowa kluczowe: geofity, jakość kwiatów, obwód cebul, uprawa pod osłonami.

INTRODUCTION

Ornithogalum saundersiae Baker, also called the giant chincherinchee, is an interesting bulbous plant, native to South Africa (Erhardt et al. 2014). The most attractive feature of the species are white flowers with a characteristic black, olive-shaped ovary, several dozen of which are gathered in large inflorescences (De Hertogh and Le Nard 1993). As a horticultural plant *O. saundersiae* is grown mainly for cut flowers, which are characterized by very good longevity. It can be also used outdoors in the garden (Armitage and Laushman 2008) and as a potted plant (Salachna and Zawadzińska 2013). Apart from its ornamental value, the species is an important plant in clinical pharmacology, as its bulbs contain biologically active compounds of antitumor properties (Chin et al. 2009; Tang et al. 2013). Kenya is one of the main producers of *O. saundersiae,* with plantations yielding approximately 30 million of cut inflorescences annually. More than 80% of the plants from *Ornithogalum* genus, sold on Dutch flower markets, are imported (Cut flowers... 2009).

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Specialized literature lacks information on the principles of *O. saundersiae* cultivation under covert, which is why this study was undertaken, with an aim to evaluate the effect of bulb size on the course of flowering, inflorescence quality and bulb yield of *O. saundersiae* grown in an unheated plastic tunnel.

MATERIAL AND METHODS

The experiment was conducted in the years 2011–2012 in the Department of Horticulture, West Pomeranian University of Technology in Szczecin (Poland). The bulbs of *Ornithogalum saundersiae* obtained by own reproduction were stored at 22–25ºC and 60–70% relative humidity. The bulbs used in the study were treated with 0.7% Topsin and 1% Captan suspension, and their range of circumference (cm) was as follows: 12–14, 14–16, 16–18, 18–20, 20–22 and 22–24. The bulbs were planted every year on the 15th May, in an unheated plastic tunnel, in 100 cm wide beds, at a space equal to double diameter of the bulbs. The substrate consisted of a mixture of sandy loam soil and deacidified high peat (3 : 1). The pH and the content of macroelements in substrate are presented in Table 1. The substrate supplemented with Azofoska fertilizer (13.0 N : 2.8 P : 15.0 K : 2.7 Mg + microelements) at a dose of 40 g · m^{-2}. During growing, the plants were regularly watered and weeded, and a single dose of 30 g · m^{-2} of Azofoska was administered before flowering.

Table 1. The pH and the mineral element content in the substrate
Tabela 1. Odczyn i zawartość składników mineralnych w podłożu

Year Rok	pH H_2O	N-NO_3	P	K	Ca	Mg
		mg · l^{-1}				
2011	6.3	19	82	165	690	190
2012	6.1	32	122	113	570	158

The earliness and the length of flowering was measured. At the beginning of anthesis the following parameters were assessed: a number of inflorescences per bulb, a length of inflorescences peduncle, an inflorescence diameter and a flower diameter. At the end of the anthesis based on the number of pedicels flowers per inflorescence were counted. The bulbs were harvested each year in early October. The whole plants were dug out and they remained loosely spread indoors for 4 weeks, in a light and dry room, at a constant temperature of 18–22ºC. Following complete drying of the aboveground part, the bulbs were separated from the shoots, cleaned, counted and weighed in order to determine coefficient of propagation.

The study was designed as a univariate experiment involving randomized sub-blocks with 4 replication, each comprising 20 bulbs. Results were statistically verified using the analysis of variance model using ANALWAR 4.6 software, and the obtained means were grouped using Tukey's test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

In geophytes, the size of bulbs or corms, usually assessed on the basis of their circumference, affects the plant flowering performance and flower quality (Han 2001; Fernandez et al. 2009; Patil and Jadhav 2010). In our study, *O. saundersiae* bulbs of all sizes were capable of flowering. One bulb produced on average one inflorescence, regardless of its circumference (Table 2). Kariuki and Kako (1999), who studied growth and development of *O. saundersiae* in Kenyan climatic conditions, demonstrated that the bulbs of 5–11 cm in diameter produced from 1.1 to 1.4 inflorescences. Greater number of inflorescences in plants grown in Africa may result from using larger bulbs and may be due to the fact that *O. saundersiae* does not exhibit a distinct dormancy period in tropical conditions and it is grown in the ground all year round as an evergreen perennial (Kariuki and Kako 1999).

Table 2. The flowering of *Ornithogalum saundersiae* Baker in relation to size of planted bulbs. Mean values for years 2011–2012
Tabela 2. Kwitnienie *Ornithogalum saundersiae* Baker w zależności od wielkości posadzonych cebul. Wartości średnie z lat 2011–2012

Trait Cecha	Circumference of planted bulbs Obwód cebul posadzonych [cm]					
	12–14	14–16	16–18	18–20	20–22	22–24
Number of inflorescences per bulb Liczba kwiatostanów z cebuli	1.00 a	1.00 a	1.00 a	1.00 a	1.00 a	1.00 a
Earliness of flowering [days] Wczesność kwitnienia [dni]	90.2 b	87.8 b	74.5 a	73.7 a	76.7 a	68.2 a
Length of flowering [days] Długość kwitnienia [dni]	34.0 bc	31.9 c	40.7 b	45.9 b	56.2 a	55.1 a

Means in rows followed by the same letters do not differ significantly at α = 0.05 – Średnie w rzędach oznaczone tymi samymi literami nie różnią się między sobą istotnie przy α = 0,05.

O. saundersiae bulb size determined the earliness of flowering (Table 2). In the plants grown from the bulbs of 12–14 cm and 14–16 cm in circumference the flowering started on average on the 89th day of the cultivation period, that is 15.7 days later than in the other plants. Similarly, Luria et al. (2002) showed that in the plants of *Ornithogalum dubium* Houtt., grown from the bulbs weighing approximately 0.5 g, flowering began later than in the plants grown from the bulbs of weight exceeding 2.0 g. On the other hand, Kaneythipe and Ruamrungsri (2004), in a study on *Ornithogalum arabicum* L., found that plants obtained from the bulbs of 3.0–4.0 cm in diameter started the flowering phase earlier than those derived from the bulbs of a diameter greater than 5.0 cm. In our study, the number of days from the beginning to the end of *O. saundersiae* flowering depended on bulb circumference (Table 2). In the plants grown from the bulbs of 20–22 cm and 22–24 cm in circumference the flowering period was significantly longer, and this was associated with an increased number of flowers per inflorescence (Table 3).

It was found that the bulb size significantly affected the length of *O. saundersiae* peduncles. The smallest bulbs (12–14 cm in circumference) yielded inflorescences with shorter peduncles, but they were still almost twice as long as a commercially acceptable minimum length of 60 cm (Table 3).

Table 3. The quality of inflorescences of *Ornithogalum saundersiae* Baker in relation to size of planted bulbs. Mean values for years 2011–2012
Tabela 3. Jakość kwiatostanów *Ornithogalum saundersiae* Baker w zależności od wielkości posadzonych cebul. Wartości średnie z lat 2011–2012

Trait Cecha	Circumference of planted bulbs Obwód cebul posadzonych [cm]					
	12–14	14–16	16–18	18–20	20–22	22–24
Length of inflorescence peduncle Długość szypuły kwiatostanowej [cm]	112 b	125 a	130 a	129 a	135 a	124 a
Inflorescence diameter Szerokość kwiatostanu [cm]	6.05 c	7.34 bc	8.12 b	8.70 b	11.2 a	10.7 a
Number of flowers per inflorescence Liczba kwiatów w kwiatostanie	54.7 c	55.2 c	68.3 b	80.8 b	99.5 a	91.5 a
Flower diameter Średnica kwiatu [cm]	3.02 a	2.98 a	2.93 a	3.18 a	2.98 a	3.13 a

Explanations see Table 2 – Objaśnienia zob. tab. 2.

Similar results were published by Kariuki and Kako (1999). They noticed that the scapes of *O. saundersiae* plants grown from the bulbs of a diameter smaller than 5 cm were significantly shorter than in the plants grown from the bulbs of 9.1–11 cm in diameter. The correlation between the bulb size and the length of *O. saundersiae* scapes was also claimed by Kihara et al. (2013). They showed that the scapes longer than 60 cm were formed in 80% of the plants grown from the bulbs with a circumference exceeding 23 cm and only 20% of the plants obtained from the bulbs with a circumference below 18 cm.

The size of *O. saundersiae* bulbs affected the number of flowers per inflorescence, but not their diameter (Table 3). The greatest number of flowers per inflorescence was observed in the plants grown from the largest bulbs, i.e. 22–24 cm and 20–22 cm in circumference, while the least florets were produced by the plants obtained from the bulbs of 12–14 cm and 14–16 cm in circumference. Similarly, more flowers per inflorescence were found in *O. arabicum* plants grown from bulbs of a diameter larger than 5.0 cm (Kaneythipe and Ruamrungsri 2004).

Results of numerous studies usually indicate a direct correlation between the yield of the daughter bulbs and the size of mother bulbs (Han 2001; Addai and Scott 2011; Kim et al. 2013). A similar trend was found in our experiment. The larger the mother bulbs of *O. saundersiae,* the greater the number of daughter bulbs (Table 4).

Table 4. The yield of bulbs of *Ornithogalum saundersiae* Baker in relation to size of planted bulbs. Mean values for years 2011–2012
Tabela 4. Plon cebul *Ornithogalum saundersiae* Baker w zależności od wielkości cebul posadzonych. Wartości średnie z lat 2011–2012

Trait Cecha	Circumference of planted bulbs Obwód cebul posadzonych [cm]					
	12–14	14–16	16–18	18–20	20–22	22–24
Numerical coefficient Współczynnik liczbowy	1.05 d	1.12 d	1.08 d	1.29 c	1.57 b	2.42 a
Weight coefficient Współczynnik wagowy	2.25 a	1.83 b	1.62 c	1.58 c	1.36 d	1.34 d

Explanations see Table 2 – Objaśnienia zob. tab. 2.

The numerical coefficient was the lowest in plants obtained from mother bulbs of 12–14 cm, 14–16 cm and 16–18 cm in circumference, and the highest one was in plants derived from mother bulbs with a circumference of 22–24 cm. A reverse tendency was observed for the value of weight coefficient that decreased significantly with increasing circumference of the mother bulb (Table 4). The highest weight coefficient was found in the bulbs obtained from mother bulbs with a circumference of 12–14 cm, while its lowest values were perceived in plants grown from mother bulbs with a circumference of 22–24 cm and 20–22 cm. Hetman et al. (2007), who investigated the effect of size of *Allium moly* L. bulbs on the plant yield, also found that the weight yield of daughter bulbs was greater from of mother bulbs with a smaller circumference.

CONCLUSIONS

1. Size of *Ornithogalum saundersiae* Bak. bulbs affects the course of flowering, inflorescence quality and bulb yield.
2. Bulbs with a circumference of 22–24 cm and 20–22 cm produce plants that bloom longer, have larger inflorescence diameter and greater number of flowers.
3. Plants grown from the bulbs of 12–14 cm and 14–16 cm in circumference bloom later and have fewer flowers per inflorescence.
4. The largest bulbs were characterized by the highest bulb numerical coefficient, and the smallest bulbs by the highest weight coefficient.

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Abstract. The aim of the study was to evaluate the effects of bulb size on the course of flowering, inflorescence quality and yield of bulbs of *Ornithogalum saundersiae* Baker cultivated in an unheated plastic tunnel. Six sizes of bulbs were used in the experiment (12–14, 14–16, 16–18, 18–20, 20–22 and 22–24 cm in circumference). It was found that the bulbs with a circumference of 22–24 cm and 20–22 cm produced plants that bloomed longer, had larger inflorescence diameter and greater number of flowers. Plants grown from the bulbs with a circumference of 12–14 cm and 14–16 cm began the anthesis on average 15.7 days later than the other plants and produced the least flowers per inflorescence. The highest bulb numerical coefficient was achieved by planting bulbs of the largest circumference. The highest bulb weight coefficient was observed in plants derived from the smallest bulbs.