

Piotr SALACHNA, Agnieszka ZAWADZIŃSKA

COMPARISON OF GROWTH, FLOWERING AND BULBS YIELD OF FOUR *ORNITHOGALUM* L. SPECIES GROWN IN THE GROUND

PORÓWNANIE WZROSTU, KWITNIENIA I PLONU CEBUL CZTERECH GATUNKÓW *ORNITHOGALUM* L. UPRAWIANYCH W GRUNCIE

Department of Horticulture, West Pomeranian University of Technology, Szczecin

Streszczenie. Celem badań przeprowadzonych w latach 2009–2010 w warunkach klimatycznych Szczecina było porównanie cech morfologicznych, przebiegu kwitnienia oraz współczynnika przyrostu liczby i masy cebul czterech gatunków: śnieodka arabskiego (*Ornithogalum arabicum* L.), śnieodka wątpliwego (*Ornithogalum dubium* Houtt.), śnieodka Saundersa (*Ornithogalum saundersiae* Bak.) i śnieodka wiechowatego (*Ornithogalum thyrsoides* Jacq.). Cebule sadzono do gruntu co roku 10 maja, a zbiór cebul przeprowadzono w pierwszej dekadzie października. Stwierdzono, że oceniane gatunki śniedków różniły się istotnie cechami morfologicznymi, kwitnieniem i plonem cebul. Uprawiane w gruncie gatunki *O. arabicum*, *O. saundersiae* i *O. thyrsoides* co roku kwitły i tworzyły cebule przybyszowe. Spośród uprawianych gatunków, *O. saundersiae* cechował się najdłuższym okresem kwitnienia, miał najdłuższe liście i szypuły kwiatostanowe, a jego kwiatostany zawierały najwięcej kwiatów. Ponadto cebule mateczne *O. saundersiae* wytworzyły najwięcej cebul przybyszowych. Rośliny *O. dubium* nie wytworzyły kwiatostanów i cebul przybyszowych w obu latach badań.

Key words: Arabian starflower, geophytes, Giant Chinchinchee, Sun star.

Słowa kluczowe: geofity, śniedek arabski, śniedek Saundersa, śniedek wątpliwy, śniedek wiechowaty.

INTRODUCTION

Considering the acreage, Poland is the fourth European manufacturer of ornamental bulbous plants (Wróblewska 2009), but our flower bulb market is characterized by lower level of competitiveness than that of the leader countries. To strengthen the position of this floriculture branch, it is necessary to continuously expand the assortment by introducing new species and previously unknown cultivars. A valuable group of bulbous plants that is worth a permanent incorporation to the market offer is the genus *Ornithogalum* L., comprising about 200 species belonging to Asparagaceae family. Especially interesting are the taxa from Africa and the Mediterranean region, successfully grown for cut flowers, as well as attractive potted plants (Armitage and Laushman 2008; Reinten et al 2011; Salachna and Zawadzińska 2013). *Ornithogalum* species are characterized by very decorative, cluster type

inflorescences composed of star-shaped white (*Ornithogalum arabicum* L., *Ornithogalum saundersiae* Baker, *Ornithogalum thyrsoides* Jacq.), yellow or orange (*Ornithogalum caudatum* Ait., *Ornithogalum dubium* Houtt.) flowers. Apart from their decorative value, some taxa are also used in medicine, as their bulb tissues contain substances with antineoplastic properties (Mulholland et al. 2013; Yu et al. 2013; Asadi et al. 2014). In the climatic conditions of the Central Europe, the bulbs of thermophilic species of *Ornithogalum* should be dug out in the autumn and stored until spring in frost-proof conditions. There is not enough detailed information on the growth and yield of *Ornithogalum* species not overwintering in the ground, which inhibits popularization of these plants among domestic producers and people dealing with gardens and green area design.

The aim of the study was to compare morphological traits, blooming course, and the bulbs yield in four species of *Ornithogalum* grown in the ground.

MATERIAL AND METHODS

The study was conducted in the years 2009-2010, in the experimental field plots of the West Pomeranian University of Technology in Szczecin (53° 25' N, 14° 32' E, 25 m asl., sub-zone 7a USDA). Plant material included the bulbs of four species: Arabian starflower (*O. arabicum* L.), Sun star (*O. dubium* Houtt.), Giant Chinchinchee (*O. saundersiae* Baker), and Chinchinchee (*O. thyrsoides* Jacq.), brought each year from the Netherlands. The bulb circumference was 5–7 cm (*O. dubium*, *O. thyrsoides*) and 14–16 cm (*O. arabicum*, *O. saundersiae*). Kaptan (1.5%, w/v) treated bulbs were planted in the ground on 10th May each year, on 100 cm wide beds, at a space equal to double diameter of the bulbs. The bulbs were placed in sandy loam soil with pH 6.5 and average nutrient content: N-NO₃ – 51.0 mg · dm⁻³; P – 45.6 mg · dm⁻³; K – 96.5 mg · dm⁻³. The primary fertilizer was Azofoska (13.6 N : 2.8 P : 15.0 K : 9.0 Ca : 2.7 Mg + microelements), at a dose of 40 g · m⁻². In the third decade of July, an additional dose of 30 g · m⁻² of Azofoska was used. In mid-September the leaves were counted, their length was measured and their greenness index was determined using Chlorophyll Meter SPAD-502 (Minolta Co., Ltd.). SPAD values were calculated based on the readings from the middle leaves. Plant growth and development were regularly observed. The number of days from planting the bulbs to the beginning, complete and end of flowering was determined. The number of inflorescences produced by a single bulb, stem length and number of flowers per inflorescence were specified. Measurements were performed in 10 random plants per replication. The bulbs were harvested in the third decade of September by digging out the whole plants, which were then dried for two weeks at 18–20°C. After yellowing of the aboveground parts, the bulbs were separated from the shoots and leaves, counted and weighed to work out the numerical and weight coefficients. Mean monthly air temperatures were (2009/2010): May (12.5°C/9.70°C), June (14.1°C/16.4°C), July (18.5°C/21.6°C), August (18.5°C/17.4°C), and September (14.4°C/12.2°C).

The experiment was designed as a univariate study in a random block arrangement. Each object consisted of 80 bulbs, 20 bulbs for each repetition. The measurement results for each year of the study were verified statistically using analysis of variance, and confidence half intervals were calculated based on Tukey's test at a significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

When new and little known geophyte species and cultivars are introduced into the horticulture in our climatic conditions, comparative studies on plant growth and development, as well as phenology and morphology, are very valuable from the practical perspective. Results of these studies are used to determine the possibilities of using the plants and to prepare recommendations for the producers interested in their cultivation (Krzymińska 2003; Wraga and Placek 2009).

Ornithogalum species grown in the ground differed significantly in the leaf number, length and greenness index (Table 1). The highest number of leaves were developed by *O. thyrsoides* plants (mean 9.88), and the lowest by *O. dubium* (mean 4.13). The leaves of *O. thyrsoides* may be used for vegetative propagation (Blomerus and Schreuder 2002), and thus the greater the number of leaves per plant, the more material can be obtained for leaf cuttings. Among the evaluated species, the longest and therefore the most impressive leaves were observed in *O. saundersiae*, and the shortest in *O. dubium*. The leaves of *O. saundersiae* retained their ornamental value throughout the whole vegetation period, while the leaves of *O. thyrsoides* and *O. arabicum* began to dry out at the beginning of flowering. Possibly, the leaves of *O. saundersiae* do not dry out, because in natural conditions the species does not have a definite dormancy period, but it is a evergreen perennial (Kariuki and Kako 1999). The leaves of *O. dubium* and *O. thyrsoides* were characterized by significantly higher greenness index, as compared to the other two species with brighter leaf blades (Table 1).

Table 1. Characteristics of the leaves of *Ornithogalum* L. species grown in the ground
Tabela 1. Charakterystyka liści gatunków *Ornithogalum* L. uprawianych w gruncie

Species Gatunek	Number of leaves Liczba liści		Length of leaves Długość liści [cm]		Index of greening Indeks zazielenienia [SPAD]	
	2009	2010	2009	2010	2009	2010
<i>Ornithogalum arabicum</i> L.	7.00	7.50	37.5	33.4	38.3	40.2
<i>Ornithogalum dubium</i> Houtt.	4.50	3.75	7.38	9.78	51.9	57.6
<i>Ornithogalum saundersiae</i> Bak.	8.25	7.00	65.2	55.7	45.1	42.9
<i>Ornithogalum thyrsoides</i> Jacq.	10.5	9.25	29.5	25.6	59.6	54.7
LSD _{0,05} – NIR _{0,05}	1.210	1.603	5.805	4.569	9.011	7.440

In both years of the study, the course of flowering depended on the taxon. *O. thyrsoides* and *O. arabicum* produced first flowers significantly earlier (on average on 83rd and 86th day of the culture, respectively), while *O. saundersiae* began flowering usually on 105th day of the culture (Table 2). An analysis of the number of days from the beginning to the end of flowering revealed that the decorative period was the longest in *O. saundersiae*, whose flowers typically retained their ornamental value for 38 days. The flowering period of *O. arabicum* was the shortest and it lasted for only 19 days. *O. dubium* plants did not produce inflorescences in either year of the experiment. A study conducted by De Hertogh and Gallitano (1997) evaluated growth and flowering of five breeding lines of *O. dubium* grown in a greenhouse at 15–21°C. Two lines did not produce any flowers, and the other began

flowering after 114–147 days, depending on bulb circumference and year of the study. In another experiment (Luria et al. 2002), *O. dubium* plants grown in a phytotron at 32/27°C (day/night) began flowering after 90 days, and those grown at 17/12°C produced first flowers only after 121 days. Given the above, it may be concluded that *O. dubium* is characterized by a long period of growth and high thermal requirements, which may explain why the plants did not flower in our conditions. A recommended solution may be planting *O. dubium* bulbs into pots in early spring, growing them in a greenhouse and transferring to the ground at a later date. There have been also attempts at field growing of new cultivars of *O. dubium*, obtained as a result of breeding and interspecies crossing (Niederwieser 2004), which are less demanding and have a shorter growing season.

Table 2. Flowering course in *Ornithogalum* L. species grown in the ground
Tabela 2. Przebieg kwitnienia gatunków *Ornithogalum* L. uprawianych w gruncie

Species Gatunek	Number of days from bulb planting to: Liczba dni od posadzenia cebul do:					
	beginning of flowering początku kwitnienia		complete of flowering pełni kwitnienia		end of flowering końca kwitnienia	
	2009	2010	2009	2010	2009	2010
<i>Ornithogalum arabicum</i> L.	83.0	89.8	94.2	101b	103	107
<i>Ornithogalum dubium</i> Houtt.	–*	–	–	–	–	–
<i>Ornithogalum saundersiae</i> Bak.	102	107	123	128	140	146
<i>Ornithogalum thyrsoides</i> Jacq.	81.2	84.5	93.5	99.7	109	115
LSD _{0.05} – NIR _{0.05}	7.750	8.666	15.08	18.52	15.09	19.44

*plants did not flower – rośliny nie zakwitły.

The species compared in the experiment differed in their generative traits (Table 3). *O. thyrsoides* plants produced significantly more inflorescences from a single bulb (mean 1.33) than *O. arabicum* and *O. saundersiae* that produced one inflorescence. The longest stems were seen in the inflorescences of *O. saundersiae* (mean 129 cm), and the shortest in *O. thyrsoides* (mean 31.8 cm). These results confirmed the findings of Salachna (2014), who claimed that *O. saundersiae* bulbs with a circumference of 14–16 cm might produce very long inflorescences in the summer. They can even compete with cut inflorescences of *O. saundersiae* imported to Europe from Kenya and Israel (Cut flowers... 2009).

Table 3. Characteristics of the flowering in *Ornithogalum* L. species grown in the ground
Tabela 3. Charakterystyka kwitnienia gatunków *Ornithogalum* L. uprawianych w gruncie

Species Gatunek	Number of inflorescences per bulb Liczba kwiatostanów z cebuli		Scape length Długość szypuła		Number of florets per inflorescence Liczba kwiatów w kwiatostanie	
	2009	2010	2009	2010	2009	2010
	<i>Ornithogalum arabicum</i> L.	1.00	1.00	49.8	42.5	16.7
<i>Ornithogalum dubium</i> Houtt.	–*	–	–	–	–	–
<i>Ornithogalum saundersiae</i> Bak.	1.00	1.00	135	122	82.5	76.5
<i>Ornithogalum thyrsoides</i> Jacq.	1.25	1.40	34.7	28.9	30.1	27.7
LSD _{0.05} - NIR _{0.05}	0.105	0.211	11.06	7.810	6.045	8.091

*plants did not flower – rośliny nie zakwitły.

The highest number of flowers per inflorescence was seen in *O. saundersiae* (mean 79.5), which also explains its longest flowering period among the investigated species (Table 3). The lowest number of flowers was found in *O. arabicum* (mean 15.7). The flowers of *O. arabicum* and *O. saundersiae* have white sepals and a characteristic dark green ovary serving as an additional decorative element (De Hertogh and Le Nard 1993). In both species, the flowers are very similar, while inflorescences differ significantly in the stem length and number of flowers, which is important while identifying the plants offered on the market under interchangeable names.

The species of *Ornithogalum* were characterized by different bulb yield (Table 4). In both years of the study, *O. saundersiae* plants had significantly higher weight coefficient (mean 3.08). The other species had lower bulb weight coefficient and did not differ significantly from each other in this respect. Numerical coefficient was the highest in *O. saundersiae*, and for both years in was on average 3.85. The propagation rates for *O. saundersiae* plants grown in the field were higher than those for the plants grown in an unheated plastic tunnel. For these parent bulbs of *O. saundersiae* with the circumference 14–16 cm, the weight-related propagation rate was 1.12 and the numerical coefficient was 1.83 (Salachna 2014). *O. dubium* plants did not produce adventitious bulbs in either year of the study. Scientific literature lacks any reports confirming a formation of adventitious bulbs by *O. dubium* grown in the field or in pots. In horticultural practice, this species is primarily propagated by seeds, and its cultivars and selected lines are propagated by means of *in vitro* techniques (Tun et al. 2013).

Table 4. Bulb yield in *Ornithogalum* L. species grown in the ground
Tabela 4. Plon cebul gatunków śniedków (*Ornithogalum* L.) uprawianych w gruncie

Species Gatunek	Weight coefficient Współczynnik wagowy		Numerical coefficient Współczynnik liczbowy	
	2009	2010	2009	2010
<i>Ornithogalum arabicum</i> L.	1.30	0.78	2.19	2.57
<i>Ornithogalum dubium</i> Houtt.	0.95	1.12	1.00	1.00
<i>Ornithogalum saundersiae</i> Bak.	3.70	2.45	4.13	3.57
<i>Ornithogalum thyrsoides</i> Jacq.	1.25	0.94	2.45	1.34
LSD _{0.05} – NIR _{0.05}	0.515	0.624	0.709	0.287

CONCLUSIONS

1. *O. arabicum*, *O. saundersiae* and *O. thyrsoides* can be grown in the ground for cut flowers in the climate conditions of Szczecin.
2. *O. saundersiae*, due to its decorative leaves, inflorescence size and length of flowering period is the most attractive species to be planted in gardens and green areas. Species is characterized by high bulb yield.

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Abstract. The aim of the studies in the years 2009–2010, carried out in the climate conditions of Szczecin, was to compare the morphological traits, the course of flowering and the increase in number and weight of bulbs of four species: Arabian starflower (*Ornithogalum arabicum* L.), Sun star (*Ornithogalum dubium* Houtt.), Giant Chinchinchee (*Ornithogalum saundersiae* Bak.), and Chinchinchee (*Ornithogalum thyrsoides* Jacq.). The bulbs were planted in soil after the 10th of May, and harvested in the first decade of October. The investigated species of *Ornithogalum* were found to differ significantly in their morphological traits, flowering and bulb

yield. Field-grown *O. arabicum*, *O. saundersiae* and *O. thyrsoides* flowered and produced adventitious bulb each year. Among the cultivated species, *O. saundersiae* was characterized by the longest flowering period, it had the longest leaves and inflorescence scapes, and its inflorescences contained the highest number of flowers. The parent bulbs of *O. saundersiae* produced also the greatest number of adventitious bulbs. The *O. dubium* plants did not produce inflorescences or adventitious bulbs in either year of the study.

