



Proceeding Paper

Use of Native Geophytes of Ornamental Interest: The Case Study of *Sternbergia lutea* (L.) Ker. Gawl. Ex Spreng [†]

Giovanna Potenza ^{*}, Francesco Vairo, Donato Castronuovo ID, Simonetta Fascetti ID and Vincenzo Candido ID

School of Agricultural, Forestry, Food and Environmental Sciences, University of Basilicata, Viale dell'Ateneo Lucano, 10, 85100 Potenza, Italy; vairo91f@gmail.com (F.V.); donato.castronuovo@unibas.it (D.C.); simonetta.fascetti@unibas.it (S.F.); vincenzo.candido@unibas.it (V.C.)

* Correspondence: giao76.potenza@gmail.com

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Abstract: This study presents the first research results aimed to evaluate the potential use of Mediterranean wild geophytes for ornamental purposes. This work is based on previous research carried out in 2013 that consisted of a screening of native geophytes, whose bulbs were collected in highly natural contexts. The present work is focused on a pot trial on *Sternbergia lutea* (L.) Ker. Gawl. Ex Spreng bulbs. In particular, the trials were carried out on 204 samples of *S. lutea*, collected from uncultivated lands near Irsina (Matera province, Southern Italy). The propagating material was split into 4 diameter classes: <20 mm, 20–25 mm, 25–30 mm, and >30 mm. The bulbs of each size class were subjected to 3 cutting methods: (1) deep cross incisions, (2) superficial cross incisions, and (3) emptying of the basal plate; uncut bulbs were considered as a control. At the end of September 2014, the bulbs were planted in 4.5 L pots at a density of 3 bulbs pot^{-1} . Pots were arranged in a completely randomised factorial design with 3 replicates of each combination of the 16 experimental treatments (4 diameters \times 4 cutting modalities). Some phenological (emergence, anthesis, senescence) and morphological (number of leaves, leaf size, number of flowers, number of bulbils, number of capsules) parameters were evaluated during the trial. Results for the different cutting modalities were similar regardless of the diameter class; deep cutting gave significantly lower values for most of the morphological parameters, except for the number of bulbils, which was higher. A delay of senescence was also observed. The basal plate emptying method generated a higher number of flowers and a larger number of capsules.

Keywords: native geophyte; ornamental interest; wild bulbs; urban biodiversity



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1. Introduction

The use of Mediterranean herbaceous species in urban and/or degraded areas represents an opportunity we can adhere to both as individual citizens, starting from the backyard of our homes, and as professional figures or institutions, contributing to the knowledge and conservation of the national flora. Urban environments, which are currently dominated by exotic species, could be places of biodiversity and native.

The use of obvious ornamental native plants with an aesthetic and naturalistic value in urban furniture, green spaces for recreation, socialization, and environmental education is necessary.

The Mediterranean region has a high diversity of geophyte species, many of which are being employed as ornamental plants. In recent years, attempts to grow the *Sternbergia* genus (*Amaryllidaceae*) for commercial use were made, both as a cut flower and as a water-saving ornamental geophyte [1,2]. The genus *Sternbergia* species have great ornamental potential.

However, complex processes occur inside the geophyte storage organs during the dormancy period, such as organogenesis, the development of newly formed flowers and

leaves and degradation of the storage materials [3]. Mediterranean geophytes can be divided into two groups based on their life cycle: (1) synanthous geophytes, in which leaves and flowers appear immediately one after the other, and the course of events is growth, storage, flowering and dormancy; (2) hysteranthous geophytes, in which flowers and leaves appear separately, and the course of events is growth, storage, dormancy and flowering [4].

S. lutea belongs to the synanthous group. In summer, the leaves dry up, and the bulb remains dormant in the ground. The bulb sprouts again in autumn (September–October) [5].

Many common “classic” bulbous ornamental plants originated from the Middle East and Central Asia (such as *Anemone*, *Ranunculus*, *Cyclamen*, *Hyacinthus*, *N. tazetta*, and *Lilium candidum*). Several tulips [6] and many more attractive species can be found in these regions.

On the contrary, *Sternbergia* is mainly a Mediterranean genus that extends to the Caucasus, North Persia, and Central Asia mountains in the east and to Hungary and Rumania in the north [2,7–9].

This genus has great potential as an ornamental plant [1,2,9] because of its attractive golden and white (only in *S. candida*) flowers which open in early spring and autumn.

The genus *Sternbergia* is divided into seven species. Two of them are vernal (*S. fischeriana* (Herbert) Rupr. and *S. candida* Mathew and T. Baytop). Five are autumnal (*S. lutea* (L.) Ker-Gawl. Ex Sprengel, *S. sicula* Tineo ex Guss., *S. greuteriana* Kamari and Artelari, *S. clusiana* (Ker-Gawl.) Ker-Gawl. and *S. colchiciflora* Waldst. and Kit.) [8].

S. lutea (L.) Ker-Gawl. Ex Sprengel is the most important species for bulbs traded as an ornamental and medicinal plant, especially in Turkey [2,10,11].

In recent years, international agreements have been employed throughout the world for the protection of endangered geophytes, and the collection of *S. lutea* (L.) from natural habitats is now forbidden.

S. lutea can be propagated from seeds and bulblets. However, propagation of seeds takes five or more years from seed to grow plants capable of flower production. On the other side, the bulblet formation capacity of bulbs is low [1,2,10].

This study presents the first results of research aimed to test the potential use of Mediterranean geophyte wild genotypes for ornamental purposes. This work is based on previous research carried out in 2013 that consisted of a screening of native geophytes, whose bulbs were collected in highly natural contexts with institutional permission. The present work is about a pot trial on *S. lutea* bulbs.

2. Material and Methods

This research follows a stage of retrieval and first screening, which started in 2013 with the collection of propagation material in highly natural areas.

This study was carried out at the School of Agricultural, Forestry, Alimentary and Environmental Sciences of the University of Basilicata (SAFE) from 2014–2016. Cultivation trials were conducted *ex situ* at the Macchia Romana University Campus in Potenza in southern Italy.

In particular, the collection of *S. lutea* bulbs took place in an uncultivated area of Irsina, Province of Matera (40°47'40" N, 16°09'43" E, 260 m. a.s.l.).

The collected propagation material was brought to the SAFE’s Horticulture Laboratory and subjected to a careful selection to remove soil residues and other impurities. Eventually, it was dried and properly stored before being used for the planting of the two species, following the experimental protocol.

The bulbs were categorized into different size classes. In particular, *S. lutea* bulbs were divided into <20 mm diameter, 20–24 mm diameter, 25–29 mm diameter, and ≥30 mm diameter.

For each size class, four different cutting (incision) methods were used on the basal plate: deep cross incisions (TP), superficial cross incisions (TS), basal plate emptying (SV), and bulbs with no incisions (control, C).

Before planting, the bulbs were exposed to a tanning treatment. The bulbs were immersed for 30 min in hot water (40 °C), to which a 5% concentration of copper oxychloride was added.

Afterward, the bulbs were placed with the tips pointing downwards in a properly sterilised dry sand in a ventilated oven at 100 °C for 24 h. The bulbs were kept at 20 °C and 40–50% relative humidity (R.H.) for two weeks to facilitate the healing of the cuts.

Sixteen experimental treatments were compared using bulbs belonging to 4 size classes (1, 2, 3, 4) which were subjected to 4 cutting modes (C, TP, TS, SV). Each experimental treatment was repeated three times. A total of 48 pots were prepared, each of which contained 3 bulbs (144 bulbs in the whole trial). In the first year, the crop cycle started on the 15th of September 2014 (planting date) and ended on the 18th of June 2015, when the extraction occurred. In the second year, the cultivation took place from the 15th of September 2015 to the 15th of June 2016. The bulbs were planted in plastic pots (terracotta colour) of 4.5 l (irregular truncated cone shape with an upper base of 28 cm in diameter and a height of 12 cm, “Marchioro ebla pot”). On the bottom of each container, a 2 cm layer of red volcanic lapillus (10–12 mm granulometry) was prepared; then, a universal potting soil was added until each pot was completely filled. The universal soil used (Compo Sana) was composed of neutral sphagnum peat, perlite, and a slow-release fertilizer (Nitrophoska gold); it had a pH of 6–7 and organic matter content of 40%.

In each cultivation cycle, the split-plot experimental scheme was followed with three repetitions, placing the different calibres in the plots and the cutting methods in the parcels. The elementary parcel consisted of a single pot.

The containers were placed in the open air, lying on a soil surface adequately mulched with black polyethylene (3 mm thick). After the planting, the pots were irrigated manually and covered with a non-woven fabric sheet until the plants began to emerge. During the entire vegetative cycle, no fertilization or phytosanitary substances were used. Moreover, weeds were removed by manual weeding. From the emergence of the plants to their complete senescence, the main phenological and morphological parameters were measured on every plant in each pot. In particular, the following characteristics were recorded: emergence dates and the beginning and end of anthesis and senescence (expressed in terms of days from the planting). Furthermore, the following morphological parameters were measured on the plants in full vegetative activity: number/plant and dimensions (length and width) of leaves, number of flowers/plant, and number of capsules/plant. After the complete senescence of the plants, the pots were brought to the laboratory, and the bulbs contained in them were extracted. After cleaning the bulbs from impurities and soil residues, the following characteristics were measured: the number of small side bulbs (daughter bulbs or bulblets) per plant and the diameters of the mother bulb (main bulb) and the daughter bulbs. All collected bulbs were counted and sized. The propagation material was kept for planting the next crop cycle.

All collected data were subjected to analysis of variance (ANOVA) by separating the average values, which were statistically different, using the Student–Newman–Keuls (SNK) test for the main effects and the least significant difference (LSD) test for interactions.

3. Results and Discussion

3.1. Morpho-Phenological Traits

The morpho-phenological parameters of *S. lutea* are presented in Table 1. They vary considerably over the two years depending on bulb circumference size (caliber) according to [12] and cutting methods. Considering the effect of the annual growth cycle, plants showed a more remarkable development in the first crop cycle than in the second one; the results concerning the bulb yield are similar to [2].

The leaves produced in the first year were 3.7 cm longer than in the second year, while their width remained statistically unchanged.

Table 1. Bulb calibre and basal plate cutting method influence some morpho-phenological traits of *S. lutea* 4 caliber size classes (1, 2, 3, 4) which were subjected to 4 cutting modes (C, TP, TS, SV) in two years (Y).

Variation Source	Traits										
	Emergence (d) Days after Transplantation	Senescence (d) Days after Transplantation	Leaves/Plants (n.)	Leaf Length (cm)	Leaf Width (cm)	Cycle Length (gg)	Flowers/Plant (n.)	Capsules/Plant (n.)	Mother Bulb Calibre (mm)	Daughter/Mother Bulbs (n.)	Average Size of Daughter Bulbs (mm)
Years (Y) ¹											
2014–2015	30.0	221.3	7.3	9.1	0.4	191.3	0.7	0.6	28.9	1.2	15.5
2015–2016	34.8	215.8	4.9	5.4	0.4	181.0	0.4	0.3	19.6	1.0	13.2
Significance ²	**	**	**	**	**	**	**	**	**	n.s.	*
Calibers (Cal) ¹											
1	45.7 a	219.1	3.5 d	6.1 b	0.3 b	173.4 d	0.0 c	0.0 c	17.8 d	0.5 b	8.0 a
2	34.9 b	218.3	5.2 c	7.4 a	0.4 b	183.4 c	0.4 b	0.3 b	22.8 c	0.9 b	12.8 b
3	27.7 c	218.1	6.7 b	7.6 a	0.4 ab	190.5 b	0.6 b	0.5 b	26.5 b	1.5 a	15.1 b
4	21.3 d	218.6	8.9 a	8.0 a	0.5 a	197.4 a	1.2 a	1.0 a	30.0 a	1.6 a	18.0 c
Significance ²	**	n.s.	**	*	**	**	**	**	**	**	**
Cuts (T) ¹											
C	21.3 c	216.8	7.8 a	9.3 a	0.4 a	195.5 a	0.7 a	0.6 a	28.2 a	0.4 c	21.1 c
TP	50.1 a	221.5	3.3 d	4.2 c	0.3 b	171.4 c	0.2 b	0.2 b	17.3 c	2.4 a	10.8 a
TS	30.2 b	217.6	7.1 b	7.4 b	0.4 a	187.4 b	0.7 a	0.6 a	25.4 b	1.1 b	13.6 b
SV	27.9 bc	218.3	6.2 c	8.1 b	0.4 a	190.4 ab	0.6 a	0.4 a	26.2 b	0.5 c	15.7 b
Significance ²	**	n.s.	**	**	**	**	**	**	**	**	**
Interactions ²											
Y × Cal	**	**	n.s.	n.s.	n.s.	**	n.s.	*	**	n.s.	n.s.
Y × T	**	n.s.	**	**	**	*	n.s.	*	**	**	n.s.
Cal × T	**	n.s.	**	*	n.s.	**	*	**	**	**	**
Y × Cal × T	**	**	**	n.s.	n.s.	**	n.s.	n.s.	**	n.s.	ns

¹ All data were subjected to one-way analysis of variance (ANOVA) with the MSTAT-C software (version 2.0); Crop and Soil Department, Michigan State University, East Lansing, MI). Treatment means were separated based on the Stu-dent-Newman-Keuls test at $p \leq 0.05$. Values in the columns not having any letters in common are significantly indifferent at 0.05P according to the Student-Newman-Keuls (SNK) test. ^{2,*} Significance at 0.95P, ^{**} Significance at 0.01P. n.s. = no significant differences.

During the second growing period, plants entered senescence 5.5 days earlier than the first period. In contrast, emergence occurred earlier (4.8 days earlier) in the first crop cycle; in addition, the biological cycle was reduced by almost 10 days in the second vintage.

In particular, as the size of the bulbs increased, the average time for plant emergence was progressively reduced and, moving from the smallest bulbs (size 1) to the largest ones (size 4), there was an advance in the emergence of more than 24 days. The same trend was observed for the crop cycle length, while the senescence date did not vary statistically.

The number of leaves/plants increased significantly as the calibre of the bulbs increased according to [1,2,12], ranging from a minimum of 3.5/plant (calibre 1 bulbs) to a maximum of 8.9/plant (calibre 4 bulbs). With the two intermediate calibres (2 and 3), the increases, compared to the smaller bulbs, were 1.7 and 3.2 leaves/plants, respectively; leaf width increased significantly only in plants obtained from the largest bulbs (calibre 4).

The number and calibre of the bulblets harvested at the end of the crop cycle were significantly influenced by the size of the bulb planted in the previous fall, according to [2,12]. Specifically, there was an average increase in 0.8 bulblets/mother-bulb from the two lower calibres (1 and 2) to the upper calibres (calibres 3 and 4). The flower numbers and capsules/plants increased significantly as the diameter of the planted bulbs increased. Still, only with the largest bulbs (calibre 4) was it possible to reach values of 1.2 flowers and 1 capsule per plant. On the contrary, none of the plants obtained from the smallest

bulbs (calibre 1) flowered. These results agree with earlier findings for various geophyte species [1,4,9].

The basal plate cutting method also resulted in significant variations for almost all the morpho-phenological traits. Among the compared cutting modalities, the deep cutting modality drastically reduced leaf development; leaf number/plant decreased by 4.5 units, compared to the control, and by 3.8 and 2.9 units, compared to the other two cutting modalities (superficial incision and basal plate emptying, respectively). A similar trend was observed for leaf length, whereas width was significantly reduced only when bulbs were subjected to deep cutting. Regarding the plant emergence, the different types of cutting resulted in a greater delay with deep cutting (by almost 29 days) compared to the control, followed by superficial incision (almost 8.9 days) and basal plate emptying (6.6 days).

The biological cycle period was significantly reduced with deep cutting (by 24 days compared to the control), showing an almost opposite trend to the one observed on the emergence date; finally, the senescence period remained statistically unvaried.

At the end of the crop cycle, the cutting modality influenced the number of lateral bulblets/mother-bulb. The best results were provided by deep incisions, which induced the formation of a higher number of bulblets (2.4/mother-bulb). The emptying of the basal plate of *S. lutea* had no effect, as the level of proliferation was statistically similar to the control, whereas the superficial cut method induced the formation of about 1.1 bulblets/mother-bulb, i.e., a higher value than the control. Moreover, the deep cut method resulted in the production of bulblets of a smaller size than the control (~10.3 mm) and the other two theses (about ~4 mm).

Considering the interactive effect of “years × calibers” ($Y \times Cal$), it should be observed that as the diameter of the planted bulbs increased, there was a progressive prolongation of the biological cycle according to [2,12]. The “Years × Cuts” ($Y \times T$) interaction confirmed the greater vegetative development of plants in the first vintage, but with deep cutting, both number/plant and leaf length remained statistically unchanged across the two crop cycles. In addition, a greater proliferation of lateral bulblets was observed with the deep cut compared to the control and other walker incision techniques. In the second year, the number of bulblets obtained with surface cutting increased significantly to a value similar to bulbs with deep incisions. In the “Calibers × Cut” ($Cal \times T$) interaction, it should be noted that the effect of the size of the mother bulbs was very evident on the number of flowers/plant, the production of which also varied in relation to the mode of cutting. In general, the number of flowers increased as the caliber of bulbs increased, but with deep cuts, only those of caliber 4 gave flowers; finally, there was no flowering with the use of the smallest bulbs (caliber 1). The interactive effect “Years × Calibers × Cuts” ($Y \times Cal \times T$) was significant for only a few parameters, specifically leaf number and mother-bulb diameter.

3.2. Flowering Parameters

Flowering in geophytes is divided into several stages: induction, initiation, differentiation, maturation and growth of the organs, anthesis and senescence [3]. Numerous internal and external factors regulate each stage.

Flower emission occurred when bulbs in the three higher calibre classes (calibers 2, 3, and 4) were used, whereas the smaller bulbs (calibre 1) did not exhibit ‘flower strength’ (Table 2).

Considering the different cutting modes, deep incisions provided flowering only for the plants produced by the largest bulbs (calibre 4) (data not shown).

For all traits, bulb size had no significant effect. Considering the effect of the basal plate incisions, deep cutting induced a slight advance in the onset of flowering and prolonged the emergence-flowering interval (pre-flowering phase).

The flowering stages of numerous ornamental geophytes have been described in detail, as such knowledge is essential in geophyte flower forcing (for example, *tulip* [13], *Allium rothii* [3], *Narcissus tazetta* [14]).

Table 2. Influence of bulb calibre and basal plate cutting method on *S. lutea* anthesis (4 calibres of size classes (1, 2, 3, 4) which were subjected to 4 cutting modes (C, TP, TS, SV)).

Variation Source	Traits			
	Anthesis (Day from Transplanting)	Anthesis End (Day from Transplanting)	Post Flowering (gg)	Senescence (gg)
Calibres (Cal) ¹				
1	-	-	-	-
2	25.1	31.8	6	186.7
3	23.6	30.1	5.3	187.7
4	22.8	29.2	6	189.5
Significance ²	n.s.	n.s.	n.s.	n.s.
Cuts (T) ¹				
C	22.9 ab	29.5	5.8 ab	186.6
TP	20.7 a	28.4	3.0 b	191.0
TS	24.1 ab	30.7	5.6 ab	185.7
SV	25.1 a	31.2	6.9 a	191.0
Significativity ²	*	n.s.	**	n.s.

¹ Values in the columns not having any letters in common are significantly indifferent at 0.05 P according to the Student–Newman–Keuls test. ²* Significance at 0.95 P, ** Significance at 0.01 P. n.s. = no significant differences.

In the experimental trial, the influence of calibre on the variation of the phenomorphological traits was confirmed. In particular, larger bulbs had positive effects on flower stem formation. These results obtained concerning the flower stem formation are similar to [10,14]. The plant flower was also significantly influenced by the cutting method.

In conclusion, agamic propagation is the quickest way to obtain *S. lutea* bulbs of a size suitable for commercialization as an ornamental plant; larger planting materials gave different growth rates, flowering increases and bulblet formation capacity according to [1,2,4,9,12].

Regarding the four different cutting methods that we used on the basal plate, to exploit the results obtained, which are very innovative, it would be advisable to extend the investigations further in the future, considering other cutting methods and other autochthonous geophytes such as the species present in the collection of the University of Basilicata and mentioned in the manuscript, *The Autochthonous Flora of Southern Italy* [15].

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/IECPS2021-11934/s1>.

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