biology and life sciences forum

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Proceeding Paper

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

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† Presented at the 2nd International Electronic Conference on Plant Sciences—10th Anniversary of Journal Plants, 1–15 December 2021; Available online: https://iecps2021.sciforum.net/.

Abstract: This study presents the first results of a research aimed to evaluate the potential use of Mediterranean wild gephyte for ornamental purposes. This work is based on a previous research carried out in 2013 that consisted in 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 nearby Irsina (Matera province, Southern Italy). The propagating material was splitted 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, (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 completely randomised factorial design with 3 replicates of each combination of the 16 experimental trearments (4 diameters × 4 cutting modalities). During the trial, some phenological (emergence, anthesis, senescence) and morphological (number of leaves, leaf size, number of flowers, number of bulblets, number of capsules) parameters were evaluated. Results for the different modalities cutting were similar regardless of the diameter class; deep cutting gave significantly lower values for most of the morphological parameters, except for the number of bulbets which was higher. A delay of senescence was also observed. Besides, the basal plate emptying method generated a higher number of flowers, and also a larger number of capsules.

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

Citation: Potenza, G.; Vairo, F.; Castronuovo, D.; Fascetti, S.; Candido, V. Use of Native Geophytes of Ornamental Interest: The Case Study of *Sternbergia lutea* (L.) Ker. Gawl. Ex Spreng. *Biol. Life Sci. Forum* **2021**, *1*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Giedre Samuoliene

Published: 30 November 2021

1. Introduction

The use of Mediterranean herbaceous species in urban and/or degraded areas represents an opportunity to which we can adhere 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 that have an aesthetic and naturalistic value in the contexts of 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 *Sternbergia* genus (*Amaryllidaceae*) for commercial use were made, both as a cut flower and as a water-saving ornamental geophyte [1,2]. The genus *Sernbergia* species have a great ornamental potential.

However, complex processes occur inside the geophyte storage organs during dormancy period, such as organogenesis, 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*, *Hyacintus*, *N. tazetta*, *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 which extends to the Caucasus, North Persia and the mountains of Central Asia 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) and 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 trade as 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 collection of *S. lutea* (L.) from the 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 plant 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 a 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 the highly naturalness areas.

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

In particular, the *S. lutea* bulbs collection 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 four classes: <20 mm diameter, 20–24 mm diameter, 25–29 mm diameter, ≥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), bulb 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.

Afterwards, 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. To facilitate the healing of the cuts, the bulbs were kept at 20° C and 40–50% relative humidity (R.H.) for two weeks.

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 the 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, slow-release fertilizer (Nitrophoska® gold); it had a pH of 6–7 and an 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 were used. Moreover, weeds were removed with manual weeding operation. 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 characters were recorded: emergence dates, 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, 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: number of side small bulbs (daughter bulbs or bulbets) per plant, diameter of the mother bulb (main bulb) and of the daughter bulbs. All collected bulbs were counted and sized. The propagation material was kept for planting in the next crop cycle.

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

3. Results and Discussion

3.1. Morpho-Phenological Traits

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

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

Variation Source	Traits										
	Emergence (d) Days after Transplanta-tion)	Senescence (d) Days after Transplanta-	Leaves/Plants (n.)	Leaf Lenght (cm)	Leaf Width (cm)	Cycyle Lenght (gg)	Flowers/Plant (n.)	Cap-sules/Plamt (n.)	Mother bulb Calibre (mm)	Daugh-ter/Mother Bulbs (n.)	Average Size of Daughter Bulbs (mm)
Years (Y) [1]											
2014-15	30.0	221.3	7.3	9.1	0.4	191.3	0.7	0.6	28.9	1.2	15.5
2015-16	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	171.4c	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	187.4b	0.7 a	0.6 a	25.4 b	1.1 b	13.6 b
SV	27.9 bc	218.3	6.2c	8.1 b	0.4 a	190.4ab	0.6 a	0.4 a	26.2 b	0.5 c	15.7 b
Significance [2]	**	ns	**	**	**	**	**	**	**	**	**
Interactions [2]											
Y x Cal	**	**	n.s.	n.s.	n.s.	**	n.s.	*	**	n.s.	ns
Y x T	**	n.s.	**	**	**	*	n.s.	*	**	**	ns
Cal x T	**	n.s.	**	*	n.s.	**	*	**	**	**	**
Y x Cal x T	**	**	**	n.s.	n.s.	**	n.s.	n.s.	**	n.s.	ns

[1] 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.

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

During the second growing period, plants entered senescence 5.5 days earlier than in the first one. 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 emergence of more than 24 days. The same trend was observed for the crop cycle length, while the senescence date didn't varied statistically.

The number of leaves/plant increased significantly as the calibre of the bulbs increased in 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/plant, respectively; leaf width increased significantly only in plants obtained from the largest bulbs (calibre 4).

The number and bulbets calibre harvested at the end of the crop cycle was significantly influenced by the bulbs size planted in the previous fall in according to [2,12]. Specifically, there was an average increase of 0.8 bulbets/mother-bulb from the two calibres lower (1 and 2) to the upper two ones (calibres 3 and 4). The flowers number and capsules/plant increased significantly as the diameter of the planted bulbs increased, but only with the largest bulbs (calibre 4) it was 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 of all the morpho-phenological traits. Among the compared cutting modalities, the deep cutting one drastically reduced leaf development whose 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. About 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 in the date of emergence; finally, the senescence period remained statistically unvaried.

At the end of crop cycle, the number of lateral bulbets/mother-bulb was influenced by the cutting modality. The best results were provided by deep incisions, which induced the formation of a higher number of bulbets (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 induced the formation of about 1.1 bulblets/mother-bulb, i.e., a higher value than the control. Moreover, the deep cut resulted in the production of bulbets of a smaller size than the control (−10.3 mm) and the other two theses (about −4 mm).

Considering the interactive effect "years X calibers" (Y x Cal), it should be osserved that as the diameter of the planted bulbs increased, there was a progressive prolongation of the biological cycle in according to [2,12]. The "Years X Cuts" (Y x 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, greater proliferation of lateral bulbets was observed with the deep cut compared to the control and other walker incision techniques. In the second year, the number of bulbets obtained with surface cutting increased significantly to a value similar to bulbs with deep incisions. The "Calibers x Cut" (Cal x 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 x Calibers x Cuts" (Y x Cal x T) was significant for only a few parameters, specifically leaf number and bulb-mother 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]. Each stage is regulated by numerous internal and external factors.

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

Table 2. Bulbs calibre and basal plate cutting method influence on *S. lutea* anthesis (4 calibers 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 0.05P according to the Student-Newman-Keuls test. [2],* Significance at 0.95P, ** Significance at 0.01P. n.s. = no significant differences.

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).

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

In the experimental trial, the influence of calibre on the variation of the pheno-morphological trails 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 obtains *S. lutea* bulbs of a size suitable for commercialization as an ornamental plants, larger planting materials gave different growth rates, flowering increases and bulbet formation capacity in according to [1,2,4,9,12].

About the four different cutting methods that we used on the basal plate, in order 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 on the Autochthonous Flora of Southern Italy [15].

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