The Effect of Different Bulb Sizes and Planting Times on Morphological Characteristics and Flower Quality of Daffodils (Narcissus tazetta L.) Grown in Greenhouse

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Article

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Abstract

Narcissus tazetta L. is an important ornamental geophyte widely cultivated for cut flower and bulb production; however, optimizing bulb size and planting time is essential to improve flower quality and production efficiency under greenhouse conditions. This study investigated the effects of bulb size and planting date on vegetative growth, flowering, and bulb characteristics during the 2022–2023 growing season. Bulbs collected from the natural flora of Hatay, Türkiye, were classified into four circumference groups (≤ 10 cm, 10–12 cm, 12–14 cm, and ≥ 14 cm) and planted on 15 September, 30 September, and 15 October at 15-day intervals in a greenhouse. Emergence time, flowering time, vegetative growth traits, flower quality parameters, bulb characteristics, and bulblet formation were evaluated. Bulb size significantly affected most measured variables. Although emergence occurred in all treatments, bulbs ≤ 10 cm did not flower at any planting date. Bulbs ≥ 10–12 cm were suitable for bulb production, while 12–14 cm and ≥ 14 cm bulbs were more appropriate for commercial flower production. The second and third planting dates improved flower quality and extended the harvest period. Optimizing bulb size and planting time can therefore enhance flower quality and prolong flowering duration in greenhouse-grown *N. tazetta*.

Introduction

The genus *Narcissus* L., belonging to the family Amaryllidaceae, is of European origin and widely distributed throughout the Mediterranean Basin, extending to parts of Asia including China and Japan. Globally, the genus comprises approximately 80–100 taxa. In Türkiye, nine taxa have been recorded, some occurring naturally and others naturalized over time [1, 2]. Among these, *Narcissus tazetta* L. is one of the most widespread and economically valuable species. It exhibits pronounced morphological variability, high environmental adaptability, early flowering habit, and a rich aromatic volatile composition, features that underscore its ecological significance and ornamental value [3, 4]. In Türkiye, *N. tazetta* subsp. *tazetta* occurs naturally in several provinces, including Hatay, which represents an important biogeographical area within the center of diversity of the genus [5].

Species of *Narcissus* are widely cultivated as cut flowers, potted ornamentals, and landscape plants due to their attractive and often fragrant flowers. Beyond ornamental use, the genus has pharmaceutical relevance owing to alkaloids such as galantamine, which is employed in the treatment of neurological disorders and Alzheimer’s disease [6, 7]. Increasing commercial interest has therefore stimulated research on bulb production, breeding, and cultivation practices aimed at improving flower quality and productivity [8].

Plant growth and flowering in *Narcissus* are strongly influenced by environmental and agronomic factors. Light availability and cultivation systems regulate photosynthetic performance, vegetative development, and flower bud formation. In addition to environmental conditions, both bulb size and planting time represent fundamental agronomic determinants of plant performance. Bulb size directly reflects stored carbohydrate reserves and generative capacity, thereby influencing scape elongation, flower number, and overall floral quality [9, 10]. Salem and Selem [11] demonstrated that bulb weight (100–200 g), together with cold storage duration (1–5 weeks at 5°C), exerted synergistic effects on vegetative growth, flowering performance, and metabolite composition in *N. tazetta*. Similarly, Slezák et al. [12] identified bulb size as the most influential factor determining final plant performance in *Narcissus poeticus*, highlighting its central role in productivity.

Planting time, on the other hand, regulates chilling accumulation, root–shoot synchronization, and floral initiation processes [13]. Earlier planting generally promotes vigorous vegetative growth and timely flowering, whereas delayed planting may reduce scape elongation and floral quality [14]. Empirical studies conducted under Mediterranean and subtropical conditions confirm that optimized planting schedules under protected cultivation improve cut-flower performance and economic returns. For example, Sarıçam et al. [15] reported that early planting under greenhouse conditions enhanced cut-flower quality in several commercial cultivars, while Chaudhary et al. [16] identified mid-September as the optimal planting date for maximizing vegetative and floral traits in *N. tazetta* 'Paper White'. Furthermore, research conducted in Türkiye demonstrated that both bulb size and planting date significantly affect bulb development and yield components, emphasizing the importance of integrated management strategies [17].

Genotype-dependent variability also contributes substantially to plant performance. Mirzaei and Chehrazi [18] reported significant differences among native *Narcissus tazetta* populations under temperate climatic conditions, indicating that both genetic background and environmental factors shape vegetative and physiological responses. However, controlled studies integrating local genetic resources with production-oriented factors such as bulb size and planting date remain limited, particularly for populations originating from Hatay.

Given Hatay's ecological heterogeneity, high genetic diversity, and the commercial relevance of its naturally occurring double-flowered *Narcissus tazetta* genotypes, region-specific cultivation strategies are required. Therefore, the present study aimed to evaluate the combined effects of three bulb size classes and three planting dates on vegetative growth, flowering characteristics, and bulb productivity of *Narcissus tazetta* genotypes collected from Hatay and cultivated under unheated greenhouse conditions. The results are expected to provide a scientific basis for optimizing bulb grading and planting schedules, thereby supporting sustainable ornamental production under protected cultivation.

Materials and Methods

The plant material used in this study was identified as *Narcissus tazetta* by Dr. Samim Kayıkçı. A voucher specimen (Fulya_05) has been deposited in the Herbarium of Hatay Mustafa Kemal University (HMKU). The bulbs were obtained in August from a local producer (Necati Sefa) located in Derince district, Antakya/Hatay Province, Türkiye (80 m a.s.l.; 36.3100840 N, 36.2154850 E). The plant material was supplied by the local producer and was not collected from natural populations. All research procedures complied with relevant institutional, national, and international guidelines and regulations. After lifting, bulbs were classified into four size classes based on circumference: 8.1–10 cm, 10.1–12 cm, 12.1–14 cm, and ≥ 14.1 cm. Planting was carried out in the research greenhouse of the Department of Horticulture, Hatay Mustafa Kemal University. The experiment was conducted under unheated greenhouse conditions. The experiment was established as a factorial arrangement consisting of four bulb size classes and three planting dates: 15 September, 30 September, and 15 October.

Bulbs were planted in 15 cm diameter plastic pots, with two bulbs per pot. The growing medium consisted of a 1:1:1 (v/v/v) mixture of soil, peat, and perlite (Fig. 1). The experimental design included three replicates for each treatment combination. Each replicate consisted of 10 bulbs, resulting in 30 bulbs per bulb size × planting date combination. Prior to planting, bulbs were treated against fungal diseases by immersion in a 4% Benomyl fungicide solution for 10 minutes, following the protocol of Çığ and Alp [19]. Throughout the growing period, standard cultural practices were applied. Weeds emerging in the pots were removed manually, and the growing medium was loosened during weeding to improve root-zone aeration.

Fertilization was performed three times at 15-day intervals, beginning on 24 November. A compound NPK fertilizer (15 g per pot) was applied to the canopy projection area of each pot. Plants were grown under unheated greenhouse conditions and irrigated with tap water as needed, depending on substrate moisture status. Temperature data were recorded throughout the vegetative period from planting to bulb lifting using a data logger system installed in the greenhouse.

Morphological characteristics were evaluated under three main categories: floral, leaf, and bulb traits (Fig. 2).

Floral traits were assessed through quantitative measurements, including flower diameter (cm), flower stalk length (cm), flower length (cm), pedicel length (cm), perianth tube length (cm), ovary length (cm), and the number of flowers per flower stalk. All linear measurements were recorded in centimeters using standard measuring procedures.Flowering time was determined as the number of days from planting to the opening of the first fully developed flower. All observations and measurement protocols were conducted in accordance with the methodology described by Zeybekoğlu [19]. Leaf traits were evaluated after the completion of the flowering period. The assessed parameters included leaf number per plant, leaf length (cm), and leaf width (cm). Leaf length and width measurements were obtained from three randomly selected leaves per plant, and mean values were calculated for statistical analysis. All procedures were performed following Sarı [16]

Bulb-related characteristics were determined at harvest and included bulb emergence rate (%), daughter bulb formation rate (%), bulb circumference (cm), and bulb width (cm). Bulb circumference was measured at the widest equatorial point using a measuring tape. All bulb measurements and rate calculations were carried out according to the methodology described by Sarı [16]

The experiment was conducted in a completely randomized factorial design with three replications. The treatments consisted of two factors: planting time (three levels: 15 September, 30 September, and 15

October) and bulb size (four levels based on bulb circumference: ≥14 cm, 12.1–14 cm, 10.1–12 cm, and 8.1–10 cm).Data were subjected to two-way analysis of variance (ANOVA) using the General Linear Model (GLM) procedure in SPSS statistical software. The main effects of planting time and bulb size, as well as their interaction effect (planting time × bulb size), were evaluated. When the F-test indicated significant differences, treatment means were separated using Duncan's multiple range test at the 5% significance level ($p \leq 0.05$).

Results

Effects of Planting Time and Bulb Size on Floral Traits

The effects of planting time and bulb size on flower diameter of *Narcissus tazetta* are presented in Table 1. Two-way ANOVA revealed that both planting time and bulb size significantly affected flower diameter ($P \leq 0.05$), whereas their interaction was not statistically significant ($P > 0.05$).

Among planting dates, the highest mean flower diameter (3.70 cm) was obtained from the first planting (15 September), while the lowest value (3.28 cm) was recorded in the third planting (15 October). This result indicates that earlier planting promoted improved floral development, likely due to a longer vegetative growth period and more favorable temperature conditions during floral differentiation.

Bulb size also had a significant effect on flower diameter. Bulbs with a circumference ≥ 14 cm produced the largest flowers (3.60 cm), whereas bulbs in the 10–12 cm class yielded the smallest flowers (3.30 cm). Larger bulbs generally possess greater carbohydrate reserves, which enhance floral organ development and final flower size. The absence of a significant interaction effect suggests that the influence of bulb size on flower diameter was consistent across planting dates.

The highest individual mean value (3.81 cm) was observed in bulbs ≥ 14 cm planted on the second planting date, whereas the lowest value (3.15 cm) was recorded in 10–12 cm bulbs planted on the third planting date (Table 1). These findings confirm that both early planting and larger bulb size independently contribute to increased flower diameter.

From a horticultural perspective, maximizing flower diameter is particularly important for ornamental quality and market value. Therefore, planting larger bulbs at earlier dates may be recommended to improve commercial flower performance in *Narcissus tazetta* cultivation.

Variance analysis indicated that both planting time and bulb size significantly affected flower stalk length ($P \leq 0.05$), while the interaction between the two factors was not significant ($P > 0.05$) (Table 1). The longest flower stalks were observed in the third planting date (32.16 cm), whereas the shortest were recorded at the second planting date (23.83 cm).

Regarding bulb size, bulbs with a circumference of 12–14 cm produced the longest flower stalks (30.21 cm), while the shortest were obtained from 10–12 cm bulbs (23.33 cm). The maximum individual stalk length (36.82 cm) occurred in bulbs ≥ 14 cm planted on the third planting date.

These results suggest that later planting favors elongation of the flower stalk, possibly due to environmental conditions such as higher temperatures or light intensity during stem elongation. Larger bulbs also contributed to longer stalks, likely reflecting greater carbohydrate reserves supporting stem growth. The lack of a significant interaction indicates that the effects of planting time and bulb size on stalk length were additive rather than synergistic.

Similarly, flower length was significantly influenced by both planting time and bulb size ($P \leq 0.05$), whereas their interaction was not significant ($P > 0.05$) (Table 1). The longest flowers were recorded in the third planting date (40.85 cm), while the shortest flowers occurred at the second planting date (31.91 cm).

Bulbs with a circumference of 12–14 cm produced the longest flowers on average (39.04 cm), whereas bulbs of 10–12 cm circumference had the shortest flowers (30.42 cm). The maximum flower length (46.29 cm) was measured in bulbs ≥ 14 cm planted on the third planting date.

These findings indicate that both larger bulb size and later planting contribute independently to increased flower length. Longer flowers are likely a result of enhanced stem and floral organ development supported by the carbohydrate reserves of larger bulbs and favorable growth conditions associated with the third planting period.

From a horticultural standpoint, manipulating planting time and selecting larger bulbs can be used as practical strategies to optimize flower stalk and flower length, which are important quality traits for ornamental Narcissus production.

Table 1
Effects of different planting times and bulb sizes on flower diameter (cm), flower stalk length (cm) and flower length (cm) in daffodil cultivation.

Flower diameter (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	3.58	3.80	3.71	3.70 a
September 30	3.17	3.20	3.81	3.39 b
October 15	3.15	3.26	3.43	3.28 b
Mean	3.30 b	3.42 ab	3.60 a	
Flower stalk length (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	25.00	29.22	26.72	26.98 ab
September 30	21.00	25.75	24.75	23.83 b
October 15	24.00	35.67	36.82	32.16 a
Mean	23.33 b	30.21 a	29.43 ab	
Flower length (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	31.00	39.11	36.22	35.44 ab
September 30	28.00	34.00	33.72	31.91 b
October 15	32.25	44.00	46.29	40.85 a
Mean	30.42 b	39.04 a	38.74 a	

Statistical analysis showed that planting time had no significant effect on pedicel length ($P > 0.05$), whereas bulb size significantly influenced this trait ($P \leq 0.05$) (Table 2). The interaction between planting time and bulb size was not significant.

Bulbs with a circumference ≥ 14 cm produced the longest pedicels (5.20 cm), while the shortest pedicels were observed in 10–12 cm bulbs (3.78 cm). These results indicate that pedicel length, as a generative trait, is closely related to bulb size and stored carbohydrate reserves, rather than environmental conditions at planting.

The effects of planting time and bulb size on perianth tube length were not statistically significant ($P > 0.05$) (Table 2). Among planting dates, the highest mean perianth tube length (1.39 cm) was recorded in the first planting, while the lowest value (1.27 cm) occurred in the third planting.

Regarding bulb size, bulbs with a circumference of 12–14 cm exhibited the highest mean perianth tube length (1.36 cm), whereas bulbs of 10–12 cm and ≥ 14 cm showed similar values (1.31 cm). The interaction between planting time and bulb size was also not significant. However, the maximum individual perianth tube length (1.54 cm) was measured in the second planting using bulbs of 12–14 cm and ≥ 14 cm, while the minimum (1.07 cm) was recorded in the second planting with 10–12 cm bulbs.

These findings suggest that perianth tube length is relatively stable across planting dates and bulb sizes, indicating that it may be a more genetically determined trait compared to other floral dimensions.

Ovary length was significantly affected by planting time ($P < 0.05$), but not by bulb size alone ($P > 0.05$) (Table 2). The highest mean ovary length (1.16 cm) occurred in the first planting, whereas the lowest value (0.88 cm) was recorded in the third planting.

Although differences among bulb size classes were not statistically significant, the highest mean ovary length (1.08 cm) was observed in bulbs of 12–14 cm, and the lowest (0.93 cm) in bulbs ≥ 14 cm.

Importantly, the interaction between planting time and bulb size had a significant effect on ovary length ($P < 0.05$). The maximum ovary length (1.23 cm) was measured in the second planting using bulbs of 12–14 cm and ≥ 14 cm, while the minimum value (0.76 cm) occurred in the second planting with bulbs ≥ 14 cm.

These results indicate that ovary length is influenced by both planting time and its interaction with bulb size, suggesting a combined effect of environmental conditions and resource availability on reproductive organ development.

The effects of planting time and bulb size on the number of flowers per stem were found to be statistically significant ($p < 0.05$). With respect to planting time, the highest mean number of flowers per stem (7.22) was recorded at the second planting time, while the lowest value (4.05) was observed at the third planting time. In terms of bulb size, bulbs with a circumference of ≥ 14 cm produced the highest number of flowers per stem (6.55), whereas the lowest value (5.17) was obtained from bulbs with a circumference of 10–12 cm (Table 2).

The interaction between planting time and bulb size also had a statistically significant effect on the number of flowers per stem ($p < 0.05$). The maximum number of flowers per stem (7.67) was measured at the second planting time using bulbs with a circumference of 12–14 cm, while the minimum value (3.33) was recorded at the third planting time in bulbs with a circumference of 12–14 cm (Table 2).

Table 2
Effects of different planting times and bulb sizes on pedicel, periant tube,ovary length (cm) and number of flowers in *Narcissus tazetta* cultivation.

Pedicel length(cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	4.17	5.44	5.25	4.95
September 30	3.67	5.10	5.24	4.67
October 15	3.50	3.75	5.11	4.12
Mean	3.78 b	4.76 b	5.20 a	
Periant tube length (cm)				
Planting time	**10–12 cm**	**12-14cm**	**≥ 14 cm**	**Ortalama***
September 15	1.43	1.35	1.39	1.39
September 30	1.07	1.54	1.19	1.27
October 15	1.42	1.20	1.36	1.33
Mean	1.31	1.36	1.31	
Ovary length (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	1.08	1.19	1.20	1.16 a
September 30	1.00	1.23	0.76	1.00 ab
October 15	1.00	0.82	0.83	0.88 b
Mean	1.03	1.08	0.93	*
Number of flowers per stem (number)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	5.0	6.67	7.33	6.33 ab
September 30	7.0	7.67	7.0	7.22 a
October 15	3.5	3.33	5.33	4.05 b
Mean	5.17 b	5.89 a	6.55 a	

The effects of planting time and bulb size on the onset of flowering were found to be statistically significant ($p < 0.05$). According to planting times, the appearance of the first fully opened flower occurred 87 days after planting at the third planting time, whereas flowering was observed 110 days after planting at the first planting time. In terms of bulb size, the earliest flowering was recorded in bulbs with circumferences of 12–14 cm and ≥ 14 cm (98 days), while the latest flowering occurred in bulbs with a circumference of 10–12 cm (105 days) (Table 3).

The interaction between planting time and bulb size had a statistically significant effect on the onset of flowering ($p < 0.05$). The earliest onset of flowering was recorded 85 days after planting at the third planting time using bulbs with a circumference of 10–12 cm, whereas the latest flowering was observed 119 days after planting at the second planting time in bulbs with a circumference of 10–12 cm and ≥ 14 cm.

Table 3
Effects of different planting times and bulb sizes on the onset of flowering (days) in *Narcissus tazetta* cultivation.

Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	112	107	112	110 a
September 30	119	99	97	105 a
October 15	85	89	87	87 b
Mean onion size	105 a	98 b	98 b	

Effects of Different Planting Dates and Bulb Sizes on Leaf Characteristics

According to the results of the analysis of variance, the effect of planting date on leaf number was not statistically significant, whereas the effect of bulb size on leaf number was found to be statistically significant ($P \leq 0.05$). Under greenhouse conditions, the highest mean number of leaves (5.11 leaves plant^{-1}) was recorded in the first planting date, while the lowest value (4.67 leaves plant^{-1}) was observed in the second planting date. However, differences among planting dates were not statistically significant (Table 4).

When evaluated in terms of bulb size, an increase in leaf number was observed with increasing bulb circumference. The lowest mean leaf number (4.33 leaves plant^{-1}) was obtained from bulbs with a circumference of 10–12 cm, whereas the highest mean value (5.33 leaves plant^{-1}) was recorded in bulbs with a circumference of 14 cm and above. These differences were statistically significant.

The interaction between planting date and bulb size on leaf number was not statistically significant. Considering the combined effects of the treatments, the highest leaf number (5.67 leaves plant^{-1}) was recorded in the second planting date using bulbs with a circumference of 14 cm and above, while the lowest value (3.00 leaves plant^{-1}) was observed in the second planting date with bulbs of 10–12 cm circumference.

Neither planting date nor bulb size had a statistically significant effect on leaf width, and their interaction was also not significant ($P > 0.05$). Mean leaf width ranged from 1.75 to 1.96 cm among planting dates, with the highest value recorded at the second planting date. Among bulb sizes, leaf width varied between 1.73 and 1.95 cm, with slightly wider leaves observed in bulbs ≥ 14 cm (Table 4).

The maximum leaf width (2.12 cm) was obtained from bulbs ≥ 14 cm planted at the third planting date, while the minimum value (1.40 cm) was recorded in 12–14 cm bulbs at the same planting date.

The longest leaves were recorded at the third planting date (49.39 cm), while the shortest were observed at the first planting date (34.78 cm). Although bulb size showed an increasing trend, differences among bulb size means were not statistically significant. The longest leaves (54.10 cm) were obtained from bulbs ≥ 14 cm planted at the third planting time (Table 4).

Table 4
Effects of different planting times and bulb sizes on the number of leaves, leaf width, leaf length in *Narcissus tazetta* cultivation.

Number of leaves (number)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	5.0	5.0	5.33	5.11
September 30	3.0	5.33	5.67	4.67
October 15	5.0	5.0	5.0	5.0
Mean	4.33 b	5.11 ab	5.33 a	
Leaf width (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	1.67	1.83	1.74	1.75
September 30	1.92	1.97	1.98	1.96
October 15	1.73	1.4	2.12	1.75
Mean	1.77	1.73	1.95	
Leaf length (cm)				
Planting time	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	37.17	33.44	33.74	34.78 b
September 30	36.17	39.81	39.45	38.48 b
October 15	41.27	52.81	54.1	49.39 a
Mean	38.2	42.02	42.43	

Effects of Planting Time and Bulb Size on Bulb Traits

The effects of planting time and bulb size on bulb emergence and bulblet formation in Narcissus tazetta are presented in Table 12. Bulb emergence was generally high across all treatments, with a 100% emergence rate recorded in most planting times and bulb sizes. However, in the third planting time, emergence decreased slightly to 90% in bulbs with circumferences of 12–14 cm and ≥ 14 cm (Table 5).

Bulblet formation rate was strongly influenced by bulb size and planting time. In all planting times, bulblet formation increased with increasing bulb circumference. The highest bulblet formation rate (11%) was obtained from bulbs ≥ 14 cm planted at the first planting time, whereas the lowest rate (1%) was recorded in bulbs ≤ 10 cm planted at the second planting time.

Table 5
Effects of different planting times and bulb sizes on bulb emergence percentage (%) and bulblet formation rate (%) in *Narcissus tazetta* cultivation.

Planting time	Bulb size	Emergence (%)	Bulblet formation rate (%)
15 Eylül	≤ 10 cm	100	2 c
15 Eylül	≥ 14 cm	100	11 a
30 Eylül	≤ 10 cm	100	1 c
30 Eylül	≥ 14 cm	100	8 a
15 Ekim	12–14 cm	90	6 ab
15 Ekim	≥ 14 cm	90	9 a

Both planting time and bulb size significantly affected bulb circumference, and their interaction was also statistically significant. The highest mean bulb circumference was recorded in the second planting time (12.54 cm), while the lowest value was observed in the first planting time (10.98 cm). Among bulb sizes, bulbs ≥ 14 cm produced the largest circumference (13.11 cm), whereas bulbs ≤ 10 cm resulted in the smallest circumference (10.33 cm) (Table 6).

The maximum bulb circumference (14.64 cm) was obtained from bulbs ≥ 14 cm planted at the third planting time, while the minimum value (9.88 cm) was measured in bulbs ≤ 10 cm at the same planting time. These findings suggest that delayed planting combined with larger bulb size enhances bulb development, although excessive bulblet formation may reduce the final size of the bulb.

Statistical analysis revealed that both factors significantly influenced bulb height. The tallest bulbs were obtained from the third planting time (6.11 cm), whereas the shortest bulbs were recorded in the first planting time (5.54 cm). Bulb height increased consistently with increasing bulb size, reaching a maximum mean value of 6.43 cm in bulbs ≥ 14 cm, while the lowest mean value (5.00 cm) was observed in bulbs ≤ 10 cm (Table 6).

The highest bulb height (7.04 cm) was measured in bulbs ≥ 14 cm planted at the third planting time, whereas the lowest value (4.90 cm) occurred in bulbs ≤ 10 cm planted at the second planting time.

Table 6
Effects of different planting times and bulb sizes on bulb circumference, bulb height (cm) in Narcissus tazetta cultivation.

Bulb circumference					
Planting time	**≤ 10 cm**	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	10.4	10.98	11.33	11.2	10.98 b
September 30	10.72	12.08	13.85	13.5	12.54 a
October 15	9.88	12.48	12.86	14.64	12.47 a
Mean onion size	10.33 c	11.85 b	12.68 ab	13.11 a	
Bulb height (cm)					
Planting time	**≤ 10 cm**	**10–12 cm**	**12–14 cm**	**≥ 14 cm**	**Mean**
September 15	5.03	5.22	6.1	5.8	5.54 b
September 30	4.9	5.65	6.4	6.45	5.85 ab
October 15	5.07	5.9	6.43	7.04	6.11 a
Mean	5.00 c	5.59 b	6.31 a	6.43 a	

Discussion

Flower diameter in *Narcissus tazetta* has been reported to range from 67.13 to 88.41 mm under greenhouse and open-field conditions [22] and from 2.85 to 4.43 cm among different ecotypes [23], with natural populations generally exhibiting diameters around 4.0 cm [24]. In the present study, flower diameter of bulbs with a circumference ≥ 14 cm planted on 15 September fell within these reported ranges and was comparable to the higher values observed under protected cultivation. These results indicate that larger bulbs and early planting under greenhouse conditions can produce flower diameters consistent with or exceeding previous reports.

Flower stalk length in *Narcissu*s spp. has been reported between 11.3 and 21.3 cm [25] and from 16.77 cm in open-field to 35.84 cm under greenhouse conditions [26]. In this study, flower stalk length was significantly affected by both planting time and bulb size, corroborating previous findings that temperature variation strongly influences this trait [27, 28].

Flower length in *N. tazetta* has been reported from 29.2 to 61.7 cm [20], while *N. pseudonarcissus* exhibited lengths of 10.8–26.2 cm [29]. Pedicel length has been shown to vary with planting time, with September plantings producing the longest pedicels (4.4 cm) and later plantings producing shorter pedicels (3.1–3.2 cm) [21]. In the present study, pedicel length increased with bulb size, whereas delayed planting reduced pedicel length, consistent with these findings. Morphological differences among ecotypes may explain discrepancies with higher pedicel lengths reported previously [24].

Perianth tube length in this study (1–2 cm) aligns with previous reports [20, 23, 30] but is lower than values reported earlier [1] (1.8–3.0 cm). Ovary length in this study exceeded previously reported values for *N. tazetta* (0.57–0.78 cm) [23, 31], likely reflecting the effect of greenhouse cultivation.

Flower number per stem in the present study (1–7 flowers) was within the range reported previously [32] but higher than those reported under both open-field and greenhouse conditions [33, 26]. Consistent with previous studies [34, 35], larger bulbs produced more flowers per stem.

The period from planting to flowering in *N. tazetta* has been reported to range widely, from 41.1 days in Mersin/Erdemli to 128 days in Adana/Karataş [20] and 49–79 days in a narrower range [36]. In this study, differences in bulb size and planting time were major factors influencing flowering onset, which is critical for potted plant production.

Leaf number per plant in this study increased with bulb size and was consistent with previous reports [37, 20]. Leaf width values were comparable to those reported previously [23], while variations from other studies [38, 39] likely reflect cultivar and environmental differences. Leaf length was greater than values reported earlier [25,40], which may be due to greenhouse conditions, light intensity, temperature, and genetic variation. Both larger bulb size and delayed planting promoted leaf elongation.

Overall, larger bulbs provided greater carbohydrate reserves, enhancing vegetative growth and bulblet initiation. These findings align with previous studies highlighting the positive relationship between bulb size and propagation efficiency in *N. tazetta* [21, 17]. Collectively, these results confirm that bulb size is a key determinant of growth and flowering traits, consistent with earlier reports on Narcissus species [24].

Conclusions

The present study clearly demonstrated that bulb size is the primary factor influencing flowering performance and yield in *Narcissus tazetta.* Bulbs with a circumference of 10 cm or less failed to produce flowers at all planting dates, whereas bulbs measuring 14 cm and above exhibited the highest flowering rates and superior performance. These results indicate that bulbs with a minimum circumference of 12 cm should be used for commercial flower production, while smaller bulbs should be grown separately for bulb enlargement purposes.

Planting time also played a significant role in flower quality and production continuity. Under greenhouse conditions, the second and third planting dates (15 October and 30 September) provided more favorable results in terms of flowering quality and duration. Staggered planting dates successfully extended the flowering period from February to April, enabling a continuous flower supply, which is particularly important for commercial cut flower production. Overall, the combined use of appropriately sized bulbs and optimized planting schedules is recommended to improve yield, flower quality, and market sustainability in *Narcissus tazetta* cultivation.

Declarations

Author Contributions: Both authors contributed equally to this work.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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Figures

Figure 1

Experimental stages of *Narcissus tazetta*: (a) bulb planting; (b) experimental layout in the greenhouse; (c–d) vegetative emergence; (e–f) bud formation; (g) flowering stage; (h) overall experimental view; (i) bulb lifting after the vegetation period.

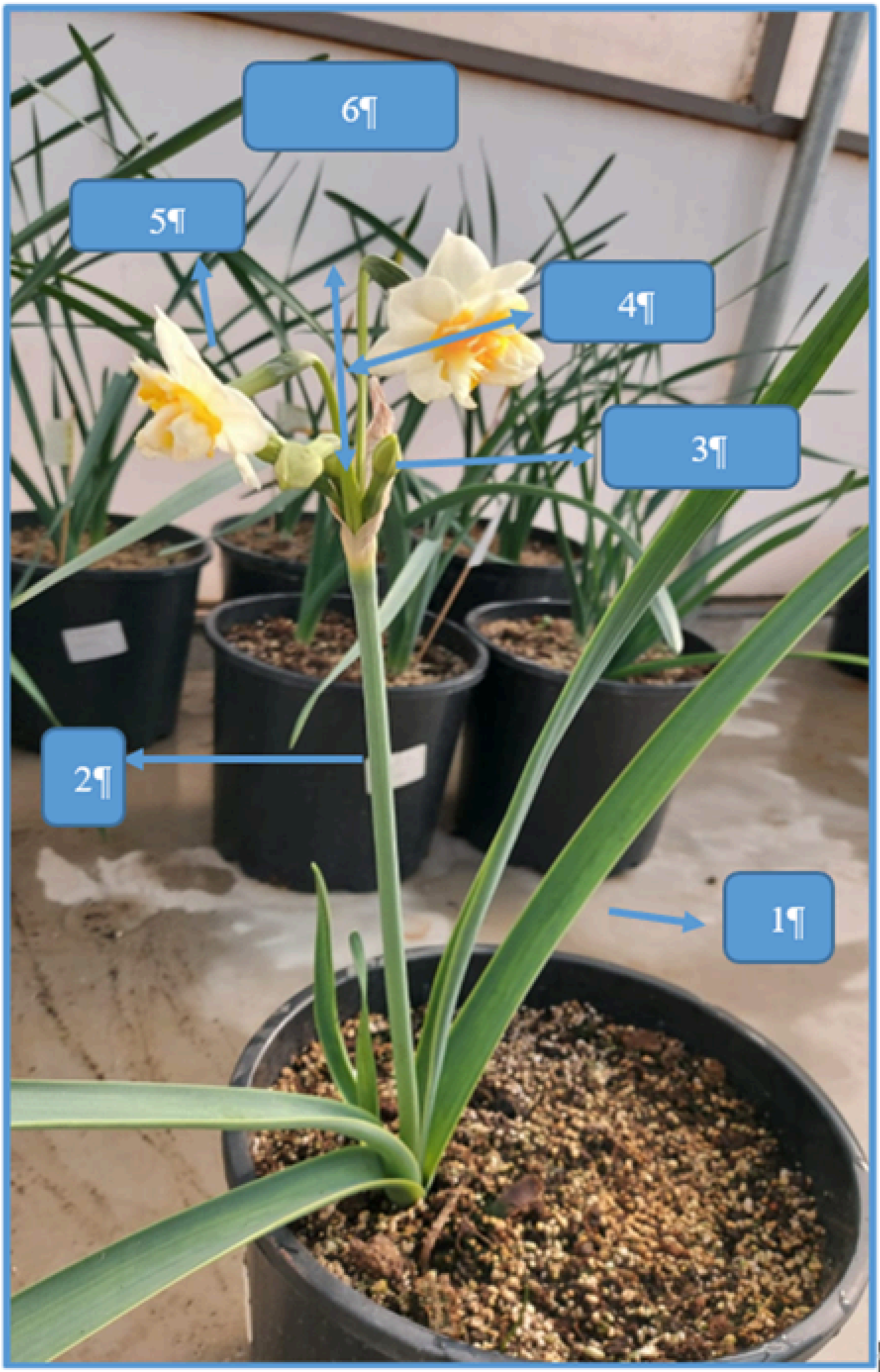

Figure 2

Vegetative and floral structures of *Narcissus tazetta* used for morphological measurements. 1, Leaf; 2, Flower stalk (scape); 3, Floret; 4, Flower diameter; 5, Perianth tube; 6, Pedicel;