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Research Article

Agro-mophological characterization, adaptational behaviour and flower abnormalities of *Lilium* L. cultivars in addition to a flower with stochastic flower formula

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Abstract

This experiment was undertaken to determine the adaptation of *Lilium* L. cultivars to North-Western part of Türkiye and to define morphologic plant growth characteristics at aboveground part, including flower life and flower abnormalities. The bulbs of the three *Lilium* L. cultivars, 'Profundo', 'Valverde', and 'Vonq', were sown to perlite in pots in June, 2021, and evaluated for emergence and flowering rates, stem and plant height, stem and flower diameter, leaf and flower number, flower abnormality rates, flower fragrance degree and flower life in 2022, after one year adaptation without removing the previous sown bulbs. As the results of the cultivars differences these were determined that, at the adaptive year; the emergence rates varied between 60.42-89.58%, flowering rates changed between 43.75-87.50%, stem heights changed between 40.63-48.25 cm, plant heights changed between 52.50-59.75 cm and these data showed statistically importance. In addition to the data in the adaptive year; stem diameters, leaf numbers, flower numbers flower fragrance degree and flower longevities also showed statistical importance between cultivars. The flower abnormality rates were found between 8.3-25% in cultivars although no statistical results. Interestingly a striking, stochastic case also was observed from a flower with 8 tepals, 8 stamen and 4 lobed stigma at 'Valverde' contrary to well-known flower formula. It has been concluded that 'Profundo' has more remarkable result in terms of longevity of flower compared to the other two varieties while 'Valverde' and 'Vonq' shared the same group with some precedence in most of the agro-morphologic characteristics e.g. plant height, stem height and stem diameter. *Lilium* L. 'Vonq' showed that the highest adaptive capacity among the cultivars with the highest emergence rate (89.58) in all sowed bulbs and flowering rate (87.50) in all emerged bulbs under the study conditions in the open-air.

Keywords: adaptation; cultivar; flower life; flower abnormality; *Lilium* L.; morphology; stochasticity

Introduction

The adaptation of initial plant materials for any kind of ornamental plants are important for landscaping, renovation, plant protection and agronomic applications. There are lots of studies on plant adaptation at genus, species, cultivar, strain etc. level. At the same time for a known plant taxon, adaptation studies to different climatic condition at the different ecologic zones have been done. The most studied plants

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were field crops (Bu *et al.*, 2015; Studnicki *et al.*, 2019; Hyles *et al.*, 2020;), vegetables (Hwang *et al.*, 2010; Baliyan and Rao, 2013; Markou *et al.*, 2020;), and fruits (Campoy *et al.*, 2012; Markou *et al.*, 2020; Parker *et al.*, 2020). Although less than the cultivated plant groups, there are also studies on the adaptation of ornamental plants (Assis *et al.*, 2011; Cai *et al.*, 2012; Zulfiqar *et al.*, 2020). In these studies, mostly the subjects of adaptation are growing environments, biotic and abiotic stress factors, or agronomic gaining of plant types.

Lilium L. belongs to the Liliaceae family, and it is possible to use as cut, pot, and garden plants with attractive flowers, have more than 100 species of the genus (Dhiman *et al.*, 2021; Zhou *et al.*, 2021; Bani Hani *et al.*, 2022). The plant was mentioned as one of the top ten bulbous cut flowers in the world and Northern Hemisphere will have a strong increase in lily bulb production due to the development of demand of some countries (Grassotti and Gimelli, 2011). There is no doubt that the lily plant is one of the most well-known geophytes in the world. The fact that there are many scientific studies on the growth and development, cultivation, vase life, the biochemicals that contains, the achievement of new cultivars, diseases and pests of the *Lilium* L. species and these are indications of the importance given to the plant (Wang and Roberts, 1983; Van Tuyl *et al.*, 2000; Kim *et al.*, 2007; Liu *et al.*, 2021; Tang *et al.*, 2021; Tigga and Fatmi, 2021; Abdel-Rahman, 2021; Wu *et al.*, 2022).

In the light of the previous studies, this study was carried out to contribute to the agriculture, trade, and biology of lily plants. The study was designed to evaluate adaptation of the three lily (*Lilium* L.) cultivars ('Profundo', 'Valverde', and 'Vonq') to North-Western part of Türkiye to define morphological plant growth characteristics at aboveground part in addition to flower life and flower abnormalities in pot culture under the non-covered fully open-air environmental condition.

Materials and Methods

Study site

The experiment was carried out between June 2021-July 2022 as pot experiment at the open-field experimental farm at the Kocaeli University, Agriculture Faculty in Kocaeli city, Türkiye. According to the meteorological data of Kocaeli Station during long-term (1991-2020), climatological normals of the city; the average highest and lowest temperature were in August (30.5 °C) and in January (3.5 °C), the average highest and lowest sun-take durations were in July (9.3 hours) and in January (2.5 hours), the average highest and lowest monthly total precipitations were 110.1 mm in December and 48.3 mm in May. The experimental location lies at 40°42' N latitude and 30°01' E longitude with an elevation of 77.4 m from sea level. The climate of the city is a transition between the Mediterranean and the Black Sea climates.

Plant material

Lilium L. cultivars ('Profundo', 'Valverde', and 'Vonq') were purchased from a registered agricultural company, its main area of investment is ornamental flower bulbs, in June, 2021. The bulbs were sown immediately without any pre-application in sub-plot in equal size. Before the sowing the bulbs, weights were measured from 50 bulbs each and the mean weights were found as 26.04 g/bulb at 'Profundo', 31.44 g/bulb at 'Valverde', and 32.32 g/bulb at 'Vonq' (Figure 1). According to the company brochures the cultivars have fragrances, and a bulb calibration was 12-14 cm in the cultivars. The flower tepal main colours is pink in 'Profundo', are yellow in 'Valverde' and in 'Vonq'. According to one of the main export-import flower bulb companies in Holland, all the three cultivars are OT hybrids (Anonymous, 2022). Grassotti and Gimelli (2011) emphasized that the recent introduction of new interspecific hybrids obtained from crosses between Oriental hybrids and Trumpet species (OT) have increased the availability of cut and pot cultivars.

Figure 1. The bulb samples of the *Lilium* L. cultivars; (A) After purcasing; (B) 'Profundo'; (C) 'Valverde'; (D) 'Vonq'

Figure 2. *Lilium* L. adaptation study; (A) The growth of cultivars at 2 weeks after sowing-June, 26, 2021 at first year; (B) An emerged plant sample after 2 weeks of the first emergence with before year's dry stalk at adaptive year-April, 18, 2022

Cultivation conditions and data criterions

The used pots were 20 cm in height with a volume of 2 liters. One bulb was sown to one pot in a depth of 10 cm in pot consisted with perlite alone. Hoagland's solution (Hoagland, 1920) was given with 250 ml water once in a week at above-ground growing seasons (Figure 2) (June-September, 2021 in the first sowing year and April-September, 2022 in the adaptational year) (Figure 3) beside that when water needed, additional irrigation was done equally especially hot summer days. No additional application was done. The plants were visited every day and noted characteristics for emergence and flowering time and durations. Vegetative and flower related characters were measured when occurred flowers fully opened. The recorded data that were mostly based on criterions of *Lilium* L. in the protocols of The International Union for the Protection of New Varieties of Plants (Anonymous, 2010) and The Community Plant Variety Office (Anonymous, 2012) were:

Emergence Rate: Calculated from all plants.

Flowering Rate: Calculated from all emerged plants.

Stem Height: Measured from the substrate level to the beginning of the tepals from all emerged plants

Plant Height: Measured from the substrate level to the top of the inflorescence from flowering plants

Stem Diameter: Calculated from average of the measurements from 5 cm above substrate level, middle of the stem height and 5 cm below from inflorescence from flowering plants

Leaf number: counted from the emerged plants

Flower number: Counted from flowering plants (Figure 4)

Flower Diameter: Measured as bird's-eye from the widest sides from flowering plants (Figure 5)

Flower Life: Calculated from beginning of the full opening to the tepal dropping days from flowering plants (Figure 6)

Flower Abnormality Rate: Calculated from not fully flowering plants in all emerged plants (Figure 7)

Flower Fragrance: Degreed as (1) absent or weak, (2) medium, (3) strong from flowering plants using the sense of smell with closed eyes.

Striking Stochastic Case: Introduced through a single case by chance encountered from one flowering plant (Figure 8).

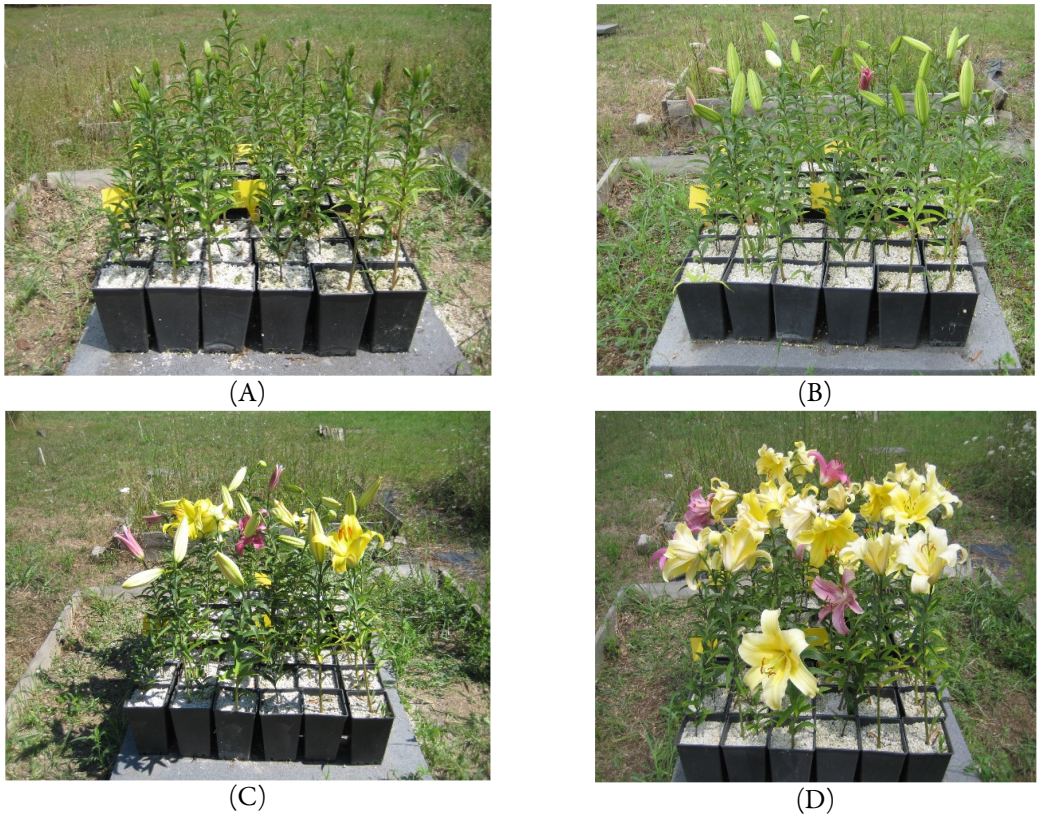


Figure 3. *Lilium* L. growth study after one adaptational year; (A) The growth of cultivars at 11 weeks after the first emergence-June, 15, 2022; (B) The growth of cultivars at 13 weeks after the firts emergence-June, 30, 2022; (C) The growth of cultivars at 14 weeks after the first emergence- July, 7, 2022; (D) The growth of cultivars at14.5 weeks after the first emergence- July, 11, 2022

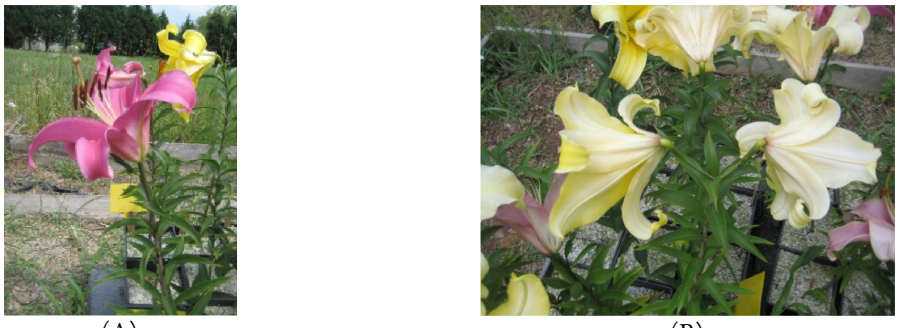
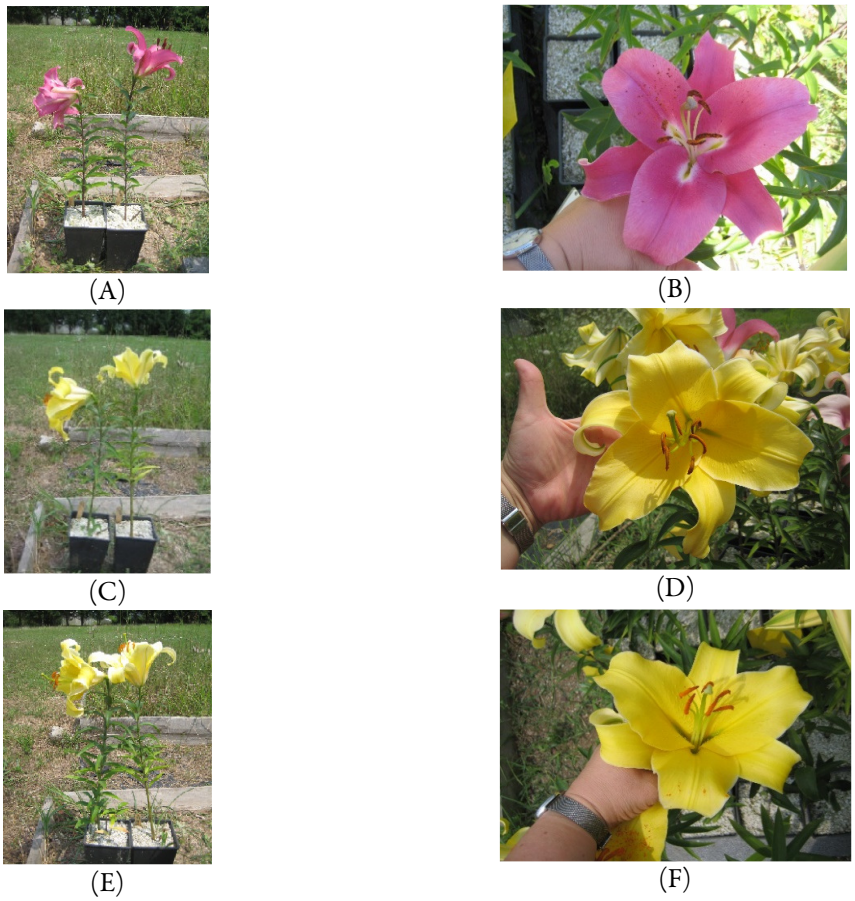


Figure 4. *Lilium* L. flower number samples; (A) One flower at 'Profundo'; (B) Two flower at 'Vonq'



(A) (B) (C) (D) (E) (F)

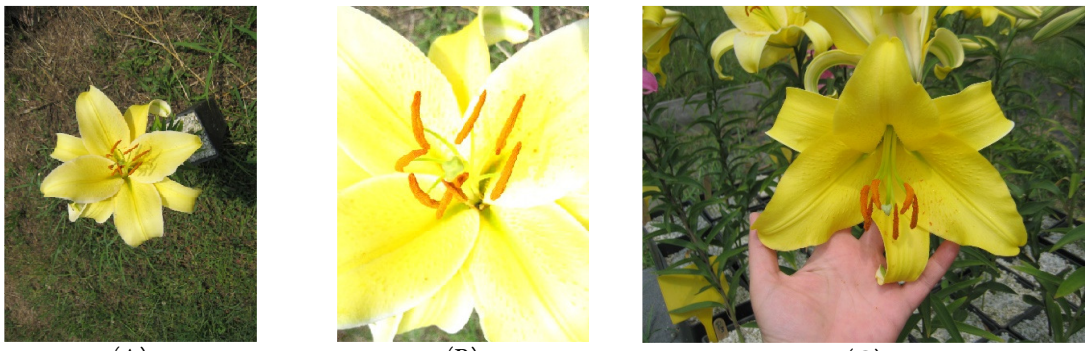
Figure 5. *Lilium* L. plant growth and flower diameter samples; (A, B) 'Profundo'; (C, D) 'Valverde', (E, F) 'Vonq'

(A) (B)

Figure 6. *Lilium* L. flower life; (A) A calculated sample as the beginning of the flowering when tepal start to opening; (B) A calculated sample as the end of flowering when tepal start to falling

(A) (B) (C)

Figure 7. *Lilium* L. flower abnormality samples on not fully flowering plants in cultivars; (A) 'Profundo'; (B) 'Valverde'; (C) 'Vonq'



(A) (B) (C)

Figure 8. The stochastic and generally known flowers of *Lilium* L. 'Valverde'; (A, B) The striking, stochastic case with the eight tepals, eight stamens and four lobed stigma; (C) Generally known flower with the six tepals, six stamens and three lobed stigma at 'Valverde' as being other *Lilium* L. cultivars

Results and Discussion

Results showed that among agro-morphological and quantitative parameters; emergence and flowering rates, plant and stem height, flower and leaf number, stem diameter, flower fragrance and flower life were statistically affected by the cultivars. Emergence and flowering rates varied between 60.42-89.58% and 43.75-87.50% respectively. Both of the results were in parallel in cultivars with the lowest sprouting (60.42%) and flowering (43.75%) in 'Profundo', with the highest sprouting (89.58%) and flowering (87.50%) rate in 'Vonq'. The 'Valverde' had averaged over the two cultivars with 77.25% in sprouting rate and 66.67% in flowering rates (Table 1, Figure 9 A and B). In all the three cultivars, 'Valverde', and 'Vonq' shared the same and higher statistical group in stem height (48.25 cm in 'Valverde' and 47.13 cm in 'Vonq', in plant height (59.75 cm in 'Valverde' and 57.90 cm in 'Vonq') and in stem diameter (6.01 mm in 'Valverde' and 5.68 mm in 'Vonq') (Figure 11A) in which parameters 'Profundo' showed the lowest results with 40.63 cm in stem height, 52.50 cm in plant height and 5.11 mm in stem diameter (Table 2, Figure 10A and B). Leaf number was also lowest in 'Profundo' with 25.38 leaves/plant and the highest in 'Valverde' with 29.63 leaves/plant (Table 2, Figure 11B). In 'Profundo', flower life longer than the other two cultivar with 8.63 days in which the flower life were 6.75 days in 'Valverde' and 6.65 days in 'Vonq', although the 'Profundo' showed the lowest results in plant growth parameters (Table 3, Figure 13). It was also observed that the number of flowers per plant increased in 'Profundo' (1 flower /plant), in 'Valverde' (1.25 flowers/plant) and in 'Vonq' (1.33 flowers/plant) order (Table 3, Figure 12A). Among the cultivar, 'Profundo', and 'Vonq' shared the same group with highly deep smell, actually 'Valverde' also had same enjoyable fragrance with lesser degree (Table 3, Figure 12B). Flower diameter and flower abnormality rate did not show statistically differences in cultivars. Flower diameter changed between 18.83-20.00 cm/flower (Table 3) and flower abnormality rate changed between 8.3-25% (Table 4, Figure 14).

Table 1. Emergence and flowering rates of *Lilium* L. cultivars

Cultivars	Emergence rate (%)	Flowering rate (%)
Profundo	60.42±3.61 b*	43.75±16.54 b*
Valverde	77.25±7.36 a	66.67±7.22 ab
Vonq	89.58±7.22 a	87.50±10.83 a
Mean	75.82	65.97
P Value	P≤ 0.01	P≤ 0.05

*Data; mean±S.D. having different letters in a single column are significantly different at $p \leq 0.05$ or $p \leq 0.01$, the level of Duncan Multiple Range Test.

Table 2. Agro-morphological vegetative characters of *Lilium* L. cultivars

Cultivars	Stem height (cm/plant)	Plant height (cm/plant)	Stem diameter (mm/plant)	Leaf number (number/plant)
Profundo	40.63±2.06 b*	52.50±1.92 b*	5.11±0.22 b*	25.38±0.48 b*
Valverde	48.25±3.30 a	59.75±3.28 a	6.01±0.24 a	29.63±2.75 a
Vonq	47.13±1.93 a	57.90±1.41 a	5.68±0.23 a	27.63±2.09 ab
Mean	45.33	56.72	5.60	27.54
P Value	P≤ 0.01	P≤ 0.01	P≤ 0.01	P≤ 0.05

*The Data; mean±S.D. having different letters in a single column are significantly different at $p \leq 0.05$ or $p \leq 0.01$, the level of Duncan Multiple Range Test.

Table 3. Agro-morphological flower characters of *Lilium* L. cultivars

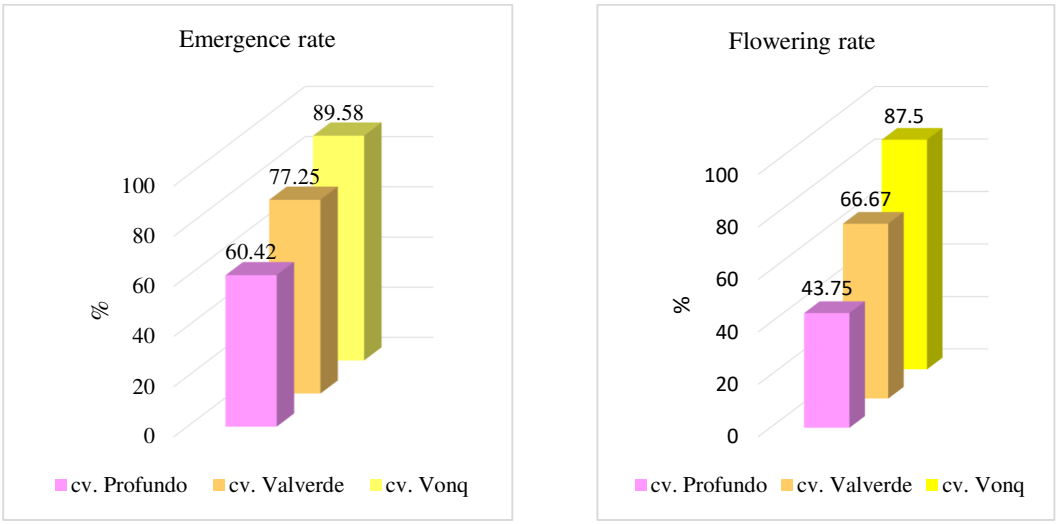
Cultivars	Flower number (number/plant)	Flower diameter (cm/flower)	Flower life (days/flower)	Flower fragrance (degree/flower)
Profundo	1.00±0.00 b*	18.83±1.31**	8.63±0.75 a*	3.00±0.00 a*
Valverde	1.25±0.29 ab	20.00±0.71	6.75±0.96 b	2.38±0.25 b
Vonq	1.33±0.00 a	19.16±0.49	6.65±0.40 b	2.78±0.15 a
Mean	1.19±0.21	19.33	7.34	2.72
P Value	P≤ 0.05	n.s.	P≤ 0.01	P≤ 0.01

*Data; mean±S.D. having different letters in a single column are significantly different at $p \leq 0.05$ or $p \leq 0.01$, ** Data; mean±S.D. having no letters in a single column are not significantly (n.s.) different at least $p \leq 0.05$, the level of Duncan Multiple Range Test.

Table 4. Flower abnormality rates of *Lilium* L. cultivars

Cultivars	Flower abnormality rate (%)
Profundo	25±31.93*
Valverde	25±16.65
Vonq	8,3±16.65
Mean	19.4±22.28
P Value	n.s.

*Data; mean±S.D. having no letters in a single column are not significantly (n.s.) different at least $p \leq 0.05$, the level of Duncan Multiple Range Test.



(A) (B)

Figure 9. Adaptational characters of *Lilium* L. cultivars; (A) Emergence rate (%); (B) Flowering rate (%)

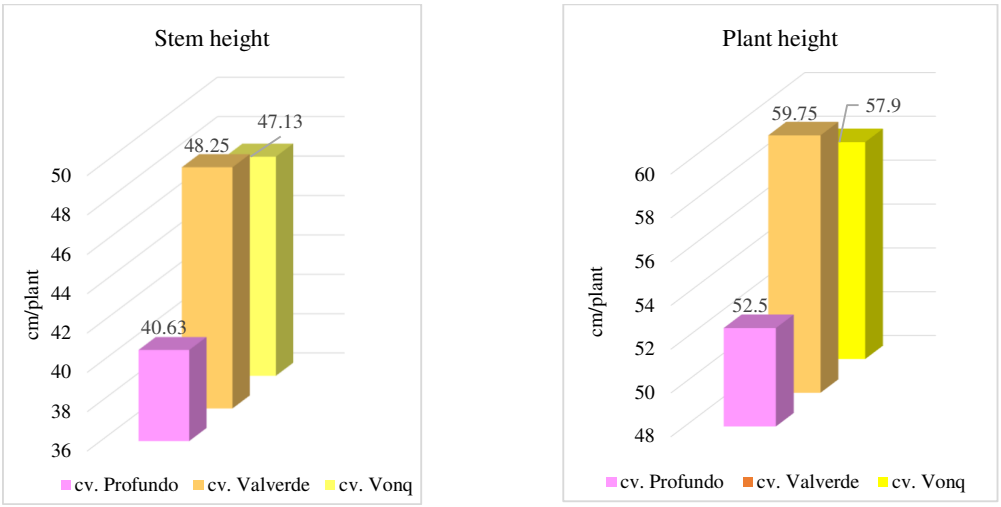
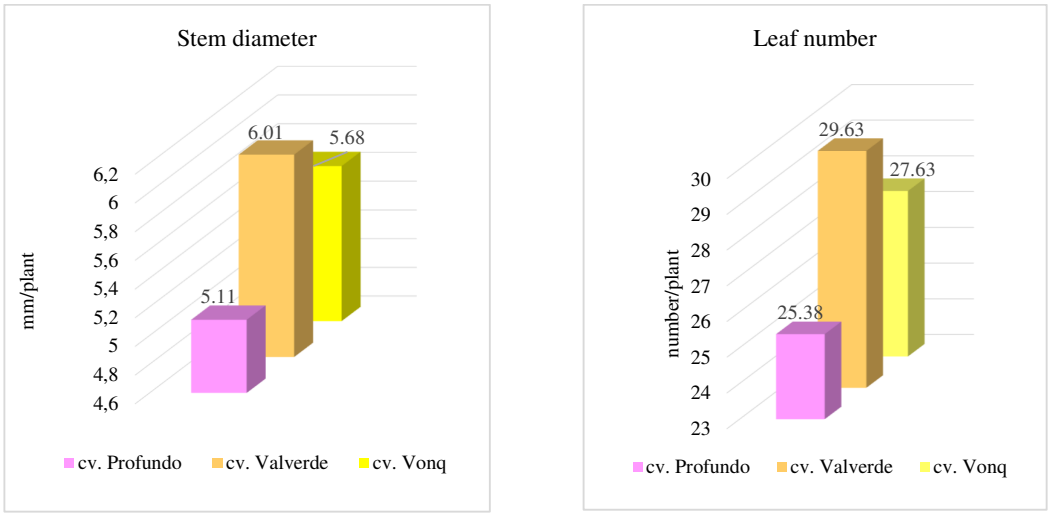
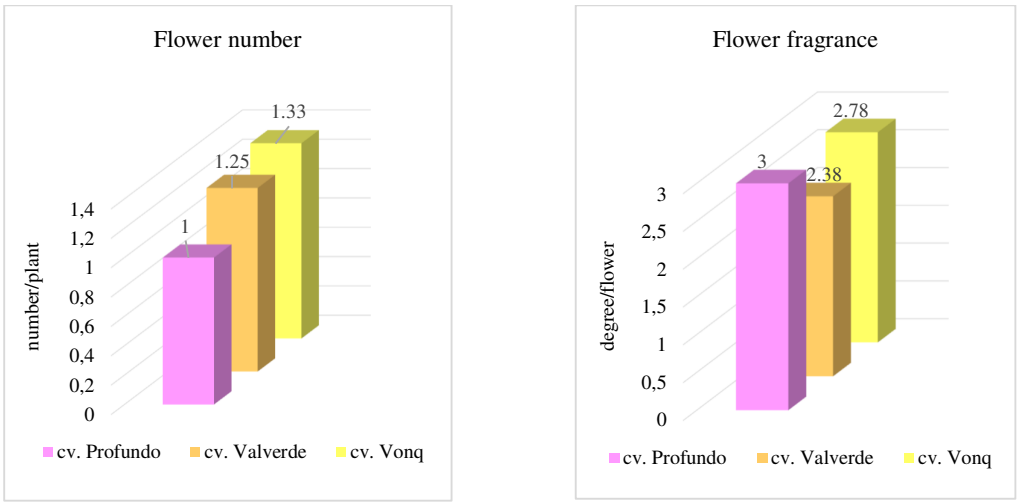


Figure 10. Agro-morphological vegetative characters of *Lilium* L. cultivars; (A) Stem height (cm/plant); (B) Plant height (cm/plant)



(A) (B)

Figure 11. Agro-morphological vegetative characters of *Lilium* L. cultivars; (A) Stem diameter (mm/plant); (B) Leaf number (number/plant)



(A) (B)

Figure 12. Agro-morphological flower characters of *Lilium* L. cultivars; (A) Flower number (number/plant), (B) Flower fragrance degree (1-3/plant)

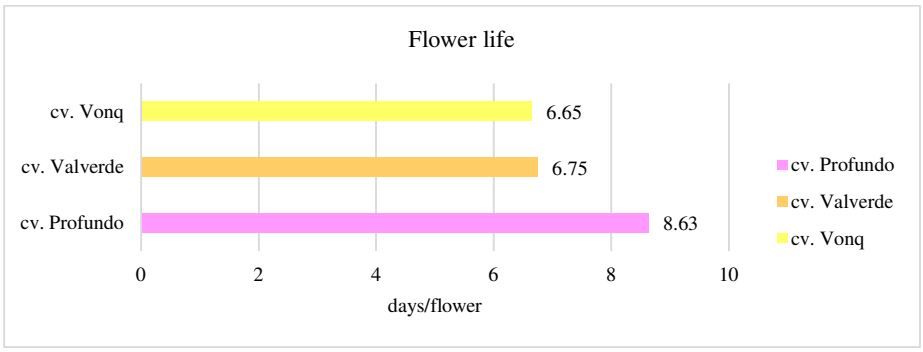


Figure 13. Flower life of *Lilium* L. cultivars (days/flower)

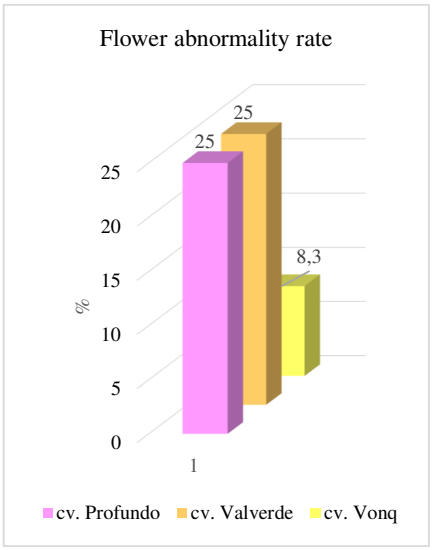


Figure 14. Flower abnormality rate of *Lilium* L. cultivars (%)

An important and supportive study was conducted with 30 genotypes of *Lilium* L. to assessment of genetic variability (Holkar *et al.*, 2022). According to the results of the study among lots of measurements; plant height varied between 24.53-77.05 cm, number of leaves between 17.05-77.10 per plant, flowering durations between 8.37-22.08 days, stalk length between 26.20-65.14 cm, stalk diameter between 4.03-12.07 mm and flower diameter was found between 10.64-20.18 cm. The research was concluded that there was a wide range of variability for various parameters in *Lilium*. Our results also supported the study and nearly all of our data were between the minimum-maximum value of the study. In another study at greenhouse (Bhandari *et al.*, 2016) was on growth substrates differences in sowed *Lilium longiflorum* 'Bach' and plant height (93.13-104.90 cm), stem diameter (8.49-9.51 cm) and number of flower buds per plant (2.40-3.46) were obtained higher than our cultivars in different substrates. The results showed that either growth substrate or cultivars can cause different results. Addition this idea, used greenhouse at study site in the mentioned study was different than ours that hold under open field condition. Similarly in another study on reusing of peat substrate under polyethylene greenhouse (Jiménez *et al.*, 2012), *Lilium* variety 'Helvetia' bulbs sown and stem length and diameter was found as 89.2 cm and 0.68 cm in the first use of peat. Again, the results and our results showed us there may be differences in cultivars and growing environments. In a study under shadenet house (Nongdhar *et al.*, 2019) *Lilium* L. 'Ercalano' bulbs were sown in the different growth substrate and plant height were found between 25.33-42.55 cm, number of leaves were found between 31.19-40.08 per plant, flower diameters were found between 153.48-175.62 mm, stalk diameter were found between 4.21-6.06 mm. The results were mostly close to our study, but cultivar differences occurred in the rest of parameters. According to another study on different growing environments as open field, polyhouse and shadenet; *Lilium* L. 'Pollyanna' were sown, and the lowest plant height was found as 23.4 cm at open field when the highest was 47.82 cm under shade net. Similarly stem length was the lowest as 27.38 cm at the open field when the highest was 49.78 cm under the shade net. The flower diameter was 119.66 mm under the shade net and 133.16 mm at polyhouse (Fatmi *et al.*, 2018). The study has also showed and explained that growing environment cause different results in a cultivar.

The flower abnormality rates which were calculated from all emerged but non fully flowering plants, varied between 8.3-25%. The condition can be explained with the famous ABC model (Coen and Meyerowitz, 1991). Sometimes simple shifts in the patterns of expression of ABC genes can cause out of type or extraordinary flowering in some plant species (Irish, 2017). It also may explain by epigenetic mechanism that steerable by external condition such as daylength or temperature (Huang *et al.*, 2021). According to our personal observation in the plants that had abnormal and undeveloped flowers, plant height and leaf number

remained below average than fully flowering plant in all the three cultivars. Insufficient maturity and insufficient cold period for bulbs or insufficient mineral uptake may be the reason for this situation. It is also possible that the differences in cultivars can be originating the reasons.

Interestingly a striking and stochastic flower formula also was observed from one flower with 8 tepals (four inner petals and four outer sepals), 8 stamen and 4 lobed stigma at 'Valverde'. In general flowers of *Lilium* L. are perfect and contain six petaloid tepals (three inner petals and three outer sepals), six stamens and a superior three-celled ovary with a three-lobed stigma (Simpson, 2010; Liang and Mahadevan, 2011; Dhiman *et al.*, 2021; Liu *et al.*, 2022). It is necessary to share here only one flower from a plant, which had eight tepals (four inner petals and four outer sepals), eight stamens and four lobed stigma, we encountered interestingly during the study. All flowers came from the cultivars, except the one, were suitable known flower formula. The reason for the inconsistent flower situation can be environmentally or genetically. Besson and Dumais (2014) emphasized that fluctuations are an integral part of biology but are too often interpreted as masking underlying deterministic processes. Organisms often harness stochasticity to ensure robust development (Roeder, 2018) The stochastic flower formula also can be another research topic for botanists and cell biologists who are indeterminist.

Conclusions

After the discussed studies, it was possible to say that plant growth parameters that show differences related with differences in cultivars, growth substrates, and growth environment. According to the study which was hold under natural environmental condition, 'Valverde' and 'Vonq' had higher adaptational, flowering and plant height capacity than 'Profundo' and the cultivars can be suitable for cut flower. In addition, 'Profundo' also can be suitable to be cut or pot with its longer flower life under the study environmental conditions. After the observation of the stochastic flower with 8 tepals, 8 stamens and 4 lobed stigma it could be also possible to say that nature has lots of secrets that remain to be revealed by scientists.

Authors' Contributions

Conceptualization, Data curation, Investigation, Methodology, Resources, Visualization, Writing - original draft, Formal analysis, Software, Validation, Writing - review and editing: A.C. The author read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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