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Biomorphological Analysis of Tulip Varieties on Substrates in Covered Ground in Turkestan

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Abstract

This study aims to advance Kazakhstan's floriculture industry by introducing promising tulip species and varieties for cultivation, implementing effective propagation methods, and adapting innovative cultivation technologies suitable for both open- and closed-ground conditions in the southern region of Kazakhstan. This study includes a novel introduction of exclusive tulip varieties, enabling the selection of source materials with desirable attributes for floriculture. Data analysis focuses on daily growth dynamics, plant height progression, and the evaluation of tulip varieties based on the coefficient of height variation across different substrates, such as soil, sawdust, and peat. These findings indicate significant varietal selectivity regarding substrate usage. Daily plant growth varies from 0.09 cm during the initial growth stage to 4.12–3.53 cm for Albatros and Delta Storm varieties during the flowering phase. Notably, the use of a peat substrate produces the tallest and most uniformly sized plants with enhanced decorative qualities, meeting market demands. This study introduces innovative methods for substrate selection that significantly influence the uniformity of tulip growth. Specific tulip varieties, including Albatros, Delta Storm, Fun for Two, Strong Power, and Dynasty, cultivated on a peat substrate with optimal water-physical properties, demonstrate even height and color properties, aligning with high consumer requirements. These findings recommend these varieties for covered ground conditions in Turkestan, advancing Kazakhstan's floriculture sector by adapting foreign technologies to local conditions.

Keywords: Varieties; Tulips; Temperature Regime; Plant Growth Dynamics; Height Variation.

1. Introduction

Tulips, a captivating species of terrestrial flora, have held an enduring fascination since their initial description by K. Linnaeus in 1753. These ornamental flowers have garnered unwavering attention from both the scientific community and enthusiasts. The Netherlands is a prominent global leader in tulip cultivation and flower production, exporting to more than 125 countries worldwide. In the post-Soviet regions, particularly Russia, more than 6 thousand distinct tulip varieties are cultivated [1, 2]. Kazakhstan is universally recognized as the ancestral homeland of tulips; however, it curiously lacks its indigenous tulip varieties. The absence of systematic efforts in tulip introduction, breeding, and seed

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production within Kazakhstan has left the nation uninformed regarding the effects of forcing and propagation techniques, which are essential in addressing the unique subarid conditions of its southern and south-eastern regions. Furthermore, only nine tulip varieties remain authorized for use within the Republic of Kazakhstan, with no varieties recommended since 2009 [3, 4]. In Kazakhstan, numerous horticulturists resort to forcing tulips, employing planting materials and techniques imported from countries such as the Netherlands and Turkey. This has led to the adoption of varieties unofficially approved for use within Kazakhstan's territories. A dedicated research team has established and is evaluating a collection comprising 14 wild and 35 exclusive tulip varieties. These evaluations consider morphobiological attributes, decorative qualities, success rates, and the potential for growth under different substrates and temperature regimes. This research recommends the best tulip varieties and optimal cultivation techniques for cut flowers and urban greenery [4].

The global floriculture industry has witnessed immense growth in profitability, with the Netherlands leading the export of tulip bulbs to 125 countries. Russia has taken the lead in floriculture in the post-Soviet space, particularly cultivating tulips. Russian scientists have been actively developing tulip growth technologies for cutting flowers and bulb production [5–7]. In contrast, Kazakhstan has yet to embark on systematic seed breeding, remaining dependent on foreign planting materials. Consequently, domestic tulip varieties and local planting material production are becoming increasingly relevant. Notably, tulips exhibit distinct characteristics in seed and vegetative propagation [8–11]. Unfortunately, most existing research on tulip propagation originates from authors abroad, particularly in Russia, and fails to account for Kazakhstan's unique soil and climatic conditions. A brief review of the literature reveals that research conducted by Kazakhstani scientists primarily focuses on species diversity, distribution, and biological and morphological aspects of tulips [12–15]. While existing technologies for tulip forcing and bulb propagation are tailored for closed environments in the Netherlands and, to some extent, Russia, these methodologies are ill-suited to Kazakhstan's diverse conditions. For instance, the Netherlands employs temperature ranges of +5°C to +9°C, but there is a lack of studies addressing the most suitable ranges for Kazakhstan's specific conditions. To add to the complexity, various soil and climatic factors influence open-ground tulip cultivation in Kazakhstan, which can vary significantly from region to region. Therefore, the adoption of moisture management methods and other elements of tulip cultivation technologies needs to be investigated, given the specific conditions of different regions, such as Turkestan [11].

Several studies have explored the impact of temperature variations on the morphological features of tulip populations [16, 17]. These studies also examined intraspecific variability, covering traits such as stem length, stem diameter, leaf size, bud length, and bulb characteristics [18–21]. Other research has investigated the growth rates of tulips within various soil mixtures, offering insights into the varietal specifics of tulips [22–24]. Bulbs and seeds hold valuable genetic material for ex situ tulip cultivation and preservation [25]. Economic interests have further driven studies on botanical development and technological advancements to enhance tulip reproduction methods, even concerning endangered species [26]. Importantly, when selecting tulip varieties, factors such as plant height, color, and the ability of buds to maintain their shape play a critical role. In Kazakhstan, the challenge of fluctuating temperatures, with daytime highs of +25°C in February and nighttime lows below freezing, necessitates substantial effort to maintain optimal conditions for forcing. These conditions are unlike any other region globally, leading to disparities in recommendations for planting material, such as the use of sawdust or even water by Dutch manufacturers. Disagreements among florists and researchers on the best practices highlight the need for rigorous research in this area. Consequently, this article investigates the influence of various substrates on the growth and development of tulip plants and the quality of commercial products using five distinct tulip varieties. This investigation will occur under the unique conditions of early spring forcing within greenhouses, providing valuable insights into an unexplored area of tulip cultivation that is highly relevant to the region.

This study focuses on the biomorphological evaluation of tulip varieties cultivated on different substrates in the unique climatic conditions of Turkestan's covered ground. This emphasis on biomorphological analysis in the specific context of *Tulipa* species cultivation in Turkestan distinguishes this study from prior studies. Although previous research has explored various aspects of tulip cultivation and forced flowering, the biomorphological assessment of tulip varieties concerning substrate choices in this region has not been comprehensively addressed. The novel aspect of this research lies in its combination of biometric measurements, substrate selection, and tulip variety evaluation, which provides insights into the growth, size, and quality of tulip plants in response to different substrates. By explicitly addressing this scientific gap, this study contributes to a more comprehensive understanding of the challenges and opportunities associated with tulip cultivation in Turkestan. Furthermore, this work extends beyond academia because it has practical implications for the flourishing floriculture industry in the region. In addition, the significance of this research is rooted in the broader context of the global floriculture sector. As floriculture has become a highly profitable industry worldwide, this study not only advances knowledge specific to Turkestan but also has implications for the broader field of horticulture. The findings from this research can inform best practices and substrate choices for tulip cultivation in similar climatic conditions elsewhere, offering practical guidance to horticulturists and floriculturalists. Hence, this study acknowledges the need to communicate the uniqueness and relevance of our work more explicitly.

The novelty of the present study lies in its comprehensive exploration of tulip cultivation under the distinct environmental conditions of southern Kazakhstan, where extreme climatic variations pose unique challenges. This study fills a significant scientific gap by providing specific insights into the introduction, growth dynamics, and adaptability of imported tulip varieties, a subject that has largely remained unaddressed in this region. By meticulously evaluating the varietal selectivity of substrates and their influence on tulip growth, our research not only contributes practical knowledge for local horticulture but also demonstrates the feasibility of cultivating exclusive tulip varieties in this challenging environment. The importance of this work to the field is underscored by its potential to facilitate the development of a competitive floriculture industry in southern Kazakhstan, offering economic opportunities and enhancing regional botanical diversity.

2. Material and Research Methods

The research was conducted in the Botanical Garden of the Khoja Akhmet Yassawi International Kazakh-Turkish University in 2022–2023. The study included five varieties of Dutch tulips: Albatros, Delta Storm, Fun for Two, Strong Power, and Dynasty. The study varieties belong to the garden class “Triumph”. Morphometric indicators of plant tulips were considered during the flowering period of the plant. The height of the plant, the height and diameter of the glass, and the length and width of the lower leaf were measured [2, 27]. Statistical data analysis was performed in MS Excel 2003 using the statistical software package Statistica 5.0 and standard indicators [28–30]. The study, collection, and processing of the received data were carried out according to generally accepted methods [31].

For forcing tulips, 3 variants of substrates were used:

1. Hardwood sawdust;
2. Peat + perlite + vermiculite (3+1+1);
3. Soil + river sand (2 + 1).

2.1. Brief Description of the Applied Substances

2.1.1. Hardwood Sawdust

The bulk of sawdust is cellulose (50%), lignin (27%), and hemicellulose (30%). Cellulose, which makes up the bulk of sawdust, is a fibrous substance that does not melt and does not go into a vapor state even when heated to 350°C. Cellulose is insoluble in water and most other inorganic and organic solvents. The porosity of sawdust is approximately 71–75% by volume. The density is 1.5–1.6 g/cm³ (GOST 23246-78). Without composting, the application of mineral fertilizers and sawdust as a source of nutrition for plants is of no interest.

2.1.2. Peat + Perlite + Vermiculite (3+1+1)

High peat by composition is the remains of herbaceous and woody vegetation, high ash content, pH 6.6. Peat at low degrees of decomposition has many voids between plant fibers and in the plant residues themselves; their porosity reaches 70%–80%. Due to the low density (0.16–0.2 g/cm³), the mass of peat in a certain volume is 8–10 times less than the mass of earth with a density of 0.8 g/cm³ in the same volume. Peat has a high moisture capacity, which can hold water 15–20 times its absolute dry weight. To prepare the substrate, peat was mixed with perlite and vermiculite in ratios of 3+1+1.

Perlite (fr. perlite, pearls), a rock of volcanic origin, among other volcanic rocks, is distinguished by the presence of constitutional water (more than 1%). The porosity is 8%–40%.

Vermiculite (from Latin Vermikulus - worm) is a natural material from the group of hydromica. It is a porous, elastic crumb when pressed, which retains moisture well in the soil (up to 500% of its own weight) and, when necessary, gives it to green plants. It is durable and can improve soil structure. The material is air-intensive and moisture-intensive. Its density is 0.15 g/cm³. The moisture capacity is 300–400%. To create favorable water and air conditions, the watering of vermiculite should be rare and moderate. The root system in the substrate with vermiculite develops better, and the plants' stress resistance increases.

2.1.3. Soil + River Sand (2 + 1)

Loamy, loose soils (on the territory of seed and fruit trees, in the center of the garden area). Loam includes the following components: 60% clay and 40% quartz sand of different fractions. The structure of loamy soil is cloddy because it includes both small dust-like components and rather large particles. It can retain and absorb water well and has high air permeability, which is extremely important for the respiration of roots and the maximum receipt of nutrient compounds from deeper layers. On average, the lowest moisture capacity of loamy soils is up to 60%. The total density is 2.6–2.7 g/cm³, and porosity is 0.5–1. Sand, which is part of the soil substrate, has a moisture capacity of 10%.

The experience was laid in four repetitions, 30 bulbs in each repetition, for a total of 600 bulbs. The bulbs were planted close to each other; planting was performed on December 30, 2022, in the ground, racks, and beds. The process of preparing bulbs for planting is shown in Figures 1 to 3.



Figure 1. Preparation of the peat substrate



Figure 2. Substrate racks ready for planting bulbs



Figure 3. Planting bulbs on racks

The experiment used “9-degree forcing technology” along with “5-degree”. In each phase of development, the biometric indicators of all 600 tulips were measured. Biometric measurements of the peduncle length, bud height, and height and diameter of the bulbs were measured with a ruler with an accuracy of 1 mm. The mass of the bulbs on electronic scales with an accuracy of 1 g, the belonging of the bulbs to a certain analysis according to the calibration stencil. Figure 4 shows the flow of processes used to obtain the results for this study.



Figure 4. Research methodology flowchart

3. Results and Discussion

The bulbs were stored in a dry and well-ventilated room from November 22 to 28 at a temperature of +50C and from November 29 to December 24, 2022 at a temperature of +90C. During the period from November 23 to 26, the bulbs were descaled and analyzed by diameter. They averaged from 4.3 to 4.8 cm, which corresponded to a calibration size of 12+. Before planting in the soil, tulip bulbs for disinfection were treated with the drug “Maxim” in a ratio of 2.0 ml/1 liter of water for 30 minutes. It protects tulip bulbs from Penicilliosis, fusarium (*Fusarium oxysporum* f. sp. tulipae), fungal infection Helminthosporium, and Botrytis tulipae.

The planting of tulips was carried out in a short time: on December 30, the soil temperature from the beginning of the planting to the end gradually decreased from +10.4°C to +6.6°C, and the air temperature from +9.0 to +5.5 °C, which is optimal for the initial growth and development of tulips. January observations are displayed in Figure 5.

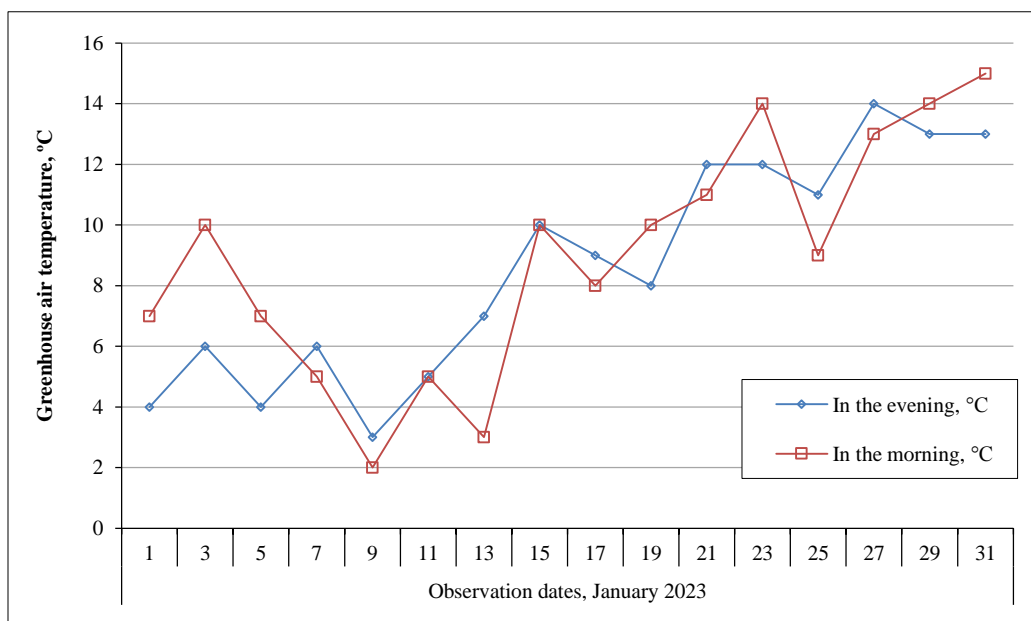


Figure 5. Air temperature in the greenhouse in the morning and evening, °C

During the initial growth period, cultivation conditions influenced the development of the tulip varieties’ root systems. In addition to the substrates used for rooting, the temperature in the greenhouse had an effect. Therefore, in early January, due to a thaw, the temperature in the greenhouse rose at night and in the morning to + 10 °C, and in the daytime to 150 °C. In the next 7-8 days, the temperature was lowered to +2 ... +5 °C, respectively, resulting in the tulip varieties successfully passing the rooting stage (Table 1).

Table 1. Root length of tulip varieties grown on various substrates, cm (01/17/2023)

Substrates	Tulip varieties				
	Albatros	Delta Storm	Fun For Two	Strong Power	Dynasty
Soil + river sand	5	3.5	3	3	3
Sawdust	2	2.7	2.2	1.1	1.2
Peat + perlite + vermiculite	6.2	4.2	5.7	6	5.3

The tulip root system is fibrous, devoid of root hairs, and when arranged in a bundle, it reaches a depth of 25-30 cm. Rooting of the bulbs depends on weather conditions, primarily soil moisture and temperature. As can be seen from the data in Table 1, substrates of different compositions influenced the process of rooting tulip varieties; the most favorable conditions for rooting were created on a peat substrate (4.2-6.2 cm). The Delta Storm had the shortest roots (4.2 cm).

These data allow us to consider that the most favorable conditions for the rooting of tulip varieties are created when they are cultivated in a substrate consisting of peat, perlite, and vermiculite in the ratio 3 + 1 + 1 and at a temperature in the morning and evening hours of +2 ... + 5 °C with a further increase in temperature to +10°C. The rooting process lasted approximately 3 weeks. From mid-January, the temperature gradually increased to +14°C, and from the end of January, the phase of active distillation began at a daytime temperature of +18...+20°C.

Depending on the biological needs, irrigation was performed at a soil moisture content of 60%: 12/29/2022, 01/07, 01/15, 02/10, 02/13, 02/18, 02/21, 02/25, and 02/27/2023. During active growth, simultaneously with watering on 13/02, 18/02, and 02/27/2023, foliar feeding was carried out with the water-soluble fertilizer Brexil Calcium (Brexil Ca) at a rate of 15-20 g per 10 L of water.

Usually, two to five leaves sit on the stem of tulips, which grow from the base of the aerial part to the middle of the stem. The lower leaves are large, oblong-lanceolate or broadly oval, often with wavy edges, sometimes sickle-curved. The upper ones are much smaller. In large flower-bearing bulbs, the sprouts are a flower-bearing stem tightly wrapped in leaves. At 10–12 days after germination, a leaf blade appears in the form of a tightly folded leaf, which then straightens and gradually increases in length (up to 8–10 cm) and width (up to 1.5 cm) [32]. During the growth and development of experimental plants, no discrepancies with general patterns were observed. The first biometric measurements were taken 31 days after planting the tulip bulbs when their height exceeded 3 cm (Figure 6).

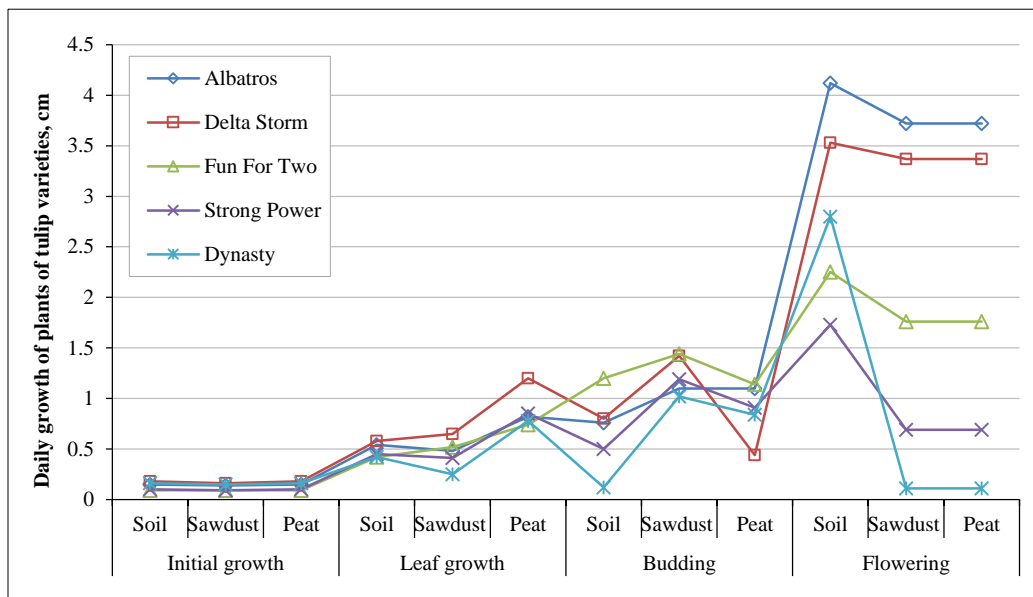


Figure 6. Dynamics of daily growth of tulip varieties on various substrates (29.01.-shoots, 13.02.-leaf growth, 24.02.-budding, 07.03.-flowering)

Experimental data on average daily growth, growth dynamics in height, and the coefficient of variation in the height of tulip varieties grown on various substrates were analyzed.

The dynamics analysis of plants' daily growth in the initial phases of development showed that during germination and growth of the first leaf, the daily growth on all types of substrates was 0.09–0.18 cm, but the largest increase was observed in Delta Storm varieties (0.16-0.18 cm), Dynasty (0.15-0.16 cm), and Albatros (0.14-0.15 cm) (Figure 6).

Varietal differences in the dynamics of daily growth in plants of tulip varieties begin to appear in the phase of rosettes of leaves. The largest increase per day was observed in all varieties on a peat substrate. During the phases of budding and flowering, the Dynasty variety showed the greatest sensitivity to substrates. Therefore, during the budding period, the growth on the soil substrate practically stops. On sawdust and peat, the growth is approximately at the level of other varieties, and in the flowering phase on the soil substrate, the average daily growth increases sharply to 2.8 cm/day. On sawdust and peat, it almost stops. Approximately the same dynamics were observed in the varieties Fun for Two and Strong Power.

In Albatros and Delta Storm plants, active plant growth continues during flowering. Therefore, their average daily growth in the flowering phase was 3.72–4.12 and 3.37–3.53 cm. Table 2 presents data on the growth dynamics of tulip varieties grown on various substrates.

Table 2. Dynamics of growth in height of tulip varieties on various substrates

Plant height of tulip varieties and seedlings					
Substrates	Albatros	Delta Storm	Fun For Two	Strong Power	Dynasty
Soil	4.97 ±0.15	5.56±0.20	3.22±0.18	3.14±0.18	5.60±0.22
Sawdust	4.45±0.15	4.86±0.22	2.75±0.12	2.93±0.39	4.65±0.16
Peat	4.58±0.15	5.64±0.17	2.69±0.11	3.09±0.48	4.92±0.17
Plant height of tulip varieties and leaf growth					
Soil	12.60±0.33	13.64±0.42	9.13±0.56	9.46±0.24	11.50±0.30
Sawdust	11.25±0.28	14.00±0.50	10.9±0.28	8.71±0.32	8.21±0.17
Peat	16.12±0.33	22.42±1.25	13.01±0.33	15.01±0.34	15.85±0.35
Plant height of tulip varieties and budding					
Soil	19.57±8.41	22.48±7.00	22.31±6.90	14.93±6.41	12.90±4.77
Sawdust	23.37±5.31	29.64±2.07	26.69±6.82	21.83±4.26	19.39±2.92
Peat	28.28±8.38	27.34±7.95	25.51±7.30	25.05±8.07	25.12±8.55
Plant height of tulip varieties and flowering					
Soil	64.98±0.47	61.37±1.09	47.03±0.53	33.98±0.19	43.70±0.21
Sawdust	64.38±0.44	66.73±0.37	46.05±0.26	29.42±0.46	20.67±0.22
Peat	68.52±0.74	68.50±0.48	47.27±0.43	48.55±0.43	53.30±0.29

As can be seen from the data in Table 2, in the initial period, the most intensive growth of all tulip varieties occurred on the soil substrate; the Delta Storm (5.64 cm) and Dynasty (5.60 cm) varieties showed the most intensive growth; their daily growth was 0.16 and 0.18 cm, respectively.

In the phase of development of rosettes of leaves, one can clearly see that the variety Delta Storm on a peat substrate reached a height of 22.42 cm, with a daily growth of 1.2 cm, and the varieties Dynasty on a sawdust substrate (8.21 cm) and Fun for Two on a soil substrate (9.13 cm), with daily growth of 0.25 and 0.42 cm, respectively. Varietal features of the influence of substrates on the growth dynamics of tulip plants begin to manifest in the budding phase. Therefore, on the sawdust substrate, the tallest plants were formed in Delta Storm (22.42 cm) and Fun for Two (26.69 cm).

It is of interest that on a peat substrate in all 5 varieties of tulip in the budding phase, the height of the plants turned out to be at the same level of 25.05±8.07.....28.28±8.38 cm. The difference is within the experimental error. Data analysis on the dynamics of daily growth and growth of tulip plant varieties in height proves their varietal selectivity to the substrates used. The tallest plants that meet the requirements of the market are obtained on a peat substrate. The soil substrate is slightly inferior. Varieties Dynasty and Strong Power on sawdust substrate form low-growing plants (20.67 ± 0.22 - 29.42 ± 0.46 cm), which are not typical for these varieties. However, these varieties grown on peat substrate fully met the highest consumer demand, especially for such decorative properties as the buds' height and flower coloration. Along with the height of plants, the uniformity of flowering plants in height from the beginning of the growing season to the end of flowering is of great importance and can be characterized by determining the coefficient of variation.

Figure 7 shows data on the coefficient of variation of the studied tulip varieties in different phases of development.

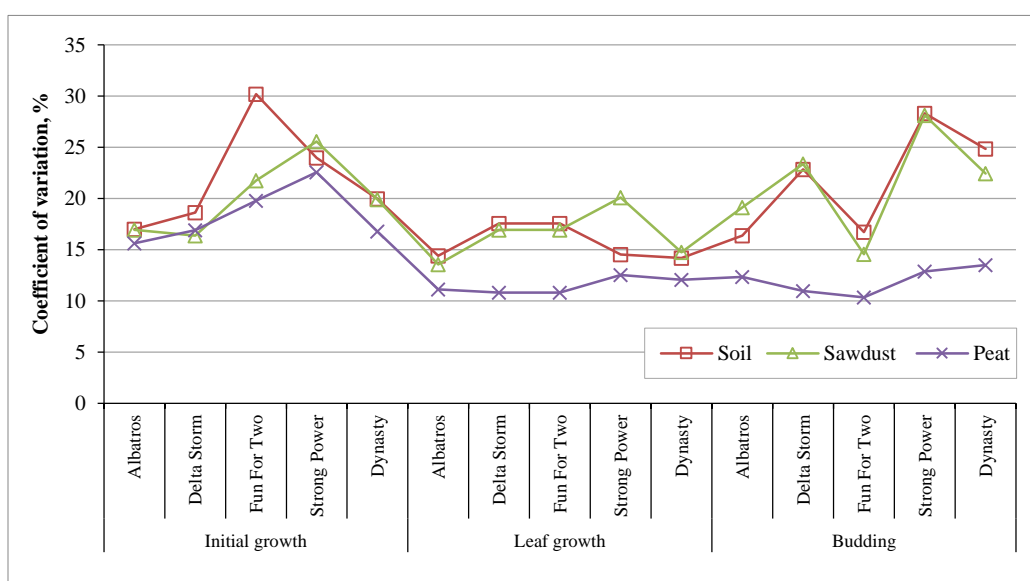


Figure 7. Plant height variation of tulip varieties on different substrates

As can be seen from the data in Figure 6, the variability of plant height on various substrates appears already in the initial period of growth, but the highest variability is observed in Fun for Two (30.19%) varieties on a soil substrate and Strong Power (25.55%) on sawdust. In general, in the initial period, in addition to the Fun for Two variety, a high degree of plant height variation was observed in the Strong Power and Dynasty varieties.

In the phase of development of rosettes of leaves, due to successful rooting and active photosynthetic activity, in addition to the Strong Power variety (20.08%), plant height stabilizes, and the coefficient of variation in plant height decreases to 11-18%. In the budding phase, due to the competition of plants for nutrients on soil and sawdust substrates, the height variation increases. Starting from the phase of development of rosettes of leaves on a peat substrate, the evenness of tulip plants in height is observed, and the coefficient of variation does not exceed 10-13%.

Elements of cultivation technology have influenced the formation of one of the most valuable features of tulip plants – the bud height. The largest tulip varieties were formed on a peat substrate (7.2-9.4 cm). A huge bud was formed by the variety Delta Storm (9.4 cm) on a peat substrate, and the rest, in terms of the bud height and its decorative effect, met the highest requirements of consumers, which indicates the influence of substrates on the growth, development, and formation of decorative features of tulip varieties.

Table 3. Bud height of tulip varieties grown on various substrates

Substrates	Tulip varieties				
	Albatros	Delta Storm	Fun For Two	Strong Power	Dynasty
Soil + river sand	6.5	8.8	7.2	8.1	8.0
Sawdust	6.1	8.2	6.6	7.5	7.9
Peat + perlite + vermiculite	7.2	9.4	7.6	8.6	8.3

On the basis of the study, a biomorphological assessment was performed on tulip varieties grown on various substrates in the conditions of Turkestan's closed ground. For all tulip varieties, the most favorable conditions for growth, development, and formation of decorative features were created on a peat substrate.

The current study investigates the impact of different substrates on the growth of Tulipa varieties, with a specific focus on critical growth parameters, such as flowering time, plant height, and other relevant characteristics. In comparison to the past studies, there are several notable distinctions. Most notably, while these studies explore various aspects of Tulipa species, none of them directly address the influence of growth substrates on these growth parameters. This key distinction highlights the novelty and uniqueness of the current study, as it explores the specific interactions between various Tulipa varieties and different substrates, offering insights into how substrates can influence growth and other characteristics. Cavusoglu's [33] study, which assesses the influence of growth media on *T. gesneriana* (Pretty Woman), shares certain similarities with the current research regarding substrate impact. However, it diverges by focusing solely on one Tulipa variety, the Pretty Woman, and by comparing the effects of two specific substrates, peat and perlite. In contrast, the current study significantly broadens the scope by investigating multiple Tulipa varieties and their responses to diverse substrates. Thus, the novel aspect of the current study lies in its comprehensive exploration of various Tulipa varieties, each displaying unique responses to different substrates. Hajdari et al. [34], on the other hand, takes a fundamentally different approach, delving into the phylogenetics of Tulipa species in Kosovo, with a particular emphasis on understanding their relationships and taxonomic considerations. This research stands in stark contrast to the current study, which primarily focuses on the cultivation conditions and growth of Tulipa varieties. The core focus of these studies is distinct, with Hajdari's work centered on taxonomy and genetic relationships, while the current research concentrates on practical aspects of cultivation.

Moreover, Sharma et al. [35] primarily focused on breeding objectives for *T. gesneriana*, aligning somewhat with the current study's emphasis on growth and flowering characteristics. Both studies underscore the importance of environmental factors in cultivating tulips, but they differ in their specific objectives. Sharma's work is primarily focused on breeding for environmental reasons and enhancing resistance to pathogens, whereas the current study explores the direct impact of growth substrates on growth parameters. Therefore, they offer complementary insights into enhancing tulip cultivation through different avenues. Jarecka-Boncena et al. [36] explored the effects of a novel substance, BTHWA, on tulip growth, with a strong focus on stimulating growth and disease prevention. Although this work shares some common ground with the current study in its examination of tulip growth, the two studies are fundamentally distinct in their approaches. Jarecka-Boncena's research focuses on the application of a specific substance and its outcomes, such as disease protection and growth stimulation. In contrast, the current study focuses on the influence of different substrates on growth parameters without the use of external substances. These two studies provide complementary insights into enhancing tulip cultivation through different methods. In addition, Pipinis et al. [26] focused on understanding the effects of temperature on seed germination and bulblet production in Greek endemic tulip species. Their research showcases unique temperature-dependent responses in two specific tulip species. Although both studies relate to tulip growth and cultivation, their approaches differ significantly. Pipinis' study focused on the influence

of temperature on seed germination and early growth, specifically within the context of Greek endemic species. In contrast, the current study addresses the broader topic of substrate effects on a range of Tulipa varieties. These studies complement each other by providing insights into various aspects of tulip cultivation.

The study on tulip cultivation under different substrates and environmental conditions offers valuable insights into how these factors affect the growth and development of tulip varieties. The preparation and storage of tulip bulbs represent a standard practice in floriculture. Storing bulbs under controlled temperature, particularly with a period of chilling, is a well-established technique for promoting flowering. The authors' approach of maintaining bulbs at +5°C is consistent with previous literature. However, it is worth noting that the authors could have provided more information on the chilling duration and its impact on subsequent growth, which is a key aspect discussed in previous studies. Moreover, disinfection of bulbs with the fungicide "Maxim" is a common practice to prevent fungal diseases. The authors follow a standard procedure for this treatment. This aligns with previous research emphasizing bulb disinfection's importance in ensuring healthy plant growth. Planting tulips at the end of December aligns with typical practices in temperate climates. This timing capitalizes on the chilling period and allows tulips to establish themselves before spring. The gradual decrease in soil and air temperatures during planting is well-considered because abrupt temperature fluctuations can stress the bulbs and affect their development. This aligns with existing research that highlights the significance of temperature management during planting. The impact of different substrates on tulip growth is an interesting aspect of this study. The results show that a peat substrate yields the best growth and development. This agrees with prior studies that have identified peat as an ideal substrate for tulip cultivation because of its water retention properties and favorable conditions for root development. The observed height and decorative quality of tulips on a peat substrate are consistent with the literature that emphasizes the importance of substrates in influencing plant characteristics. Furthermore, the coefficient of variation is a valuable metric for assessing the evenness of plant height throughout the growth stages. This study shows that tulips on a peat substrate exhibit the lowest variation in height, indicating a consistent and desirable growth pattern. This aligns with established research, which underscores the role of substrate in maintaining even plant growth.

4. Biomorphological Evaluation of Tulip Cultivars Grown on Various Substrates under Greenhouse Conditions in Turkestan

4.1. Albatros Variety

Plant height 64.38–68.52 cm, level, peduncle variation coefficient 12.34–19.13%, bud height 6.1–7.2 cm, growing season in the greenhouse 64 days, early flowering, dense leaves, pointed, light green, form a rosette around stems with buds. On each stem, one goblet-shaped bud blooms. Petal color: white with a yellowish sheen (Figure 8).



Figure 8. *Albatros* variety

4.2. Delta Storm Variety

Plant height 61.37–68.50 cm, leveled, especially on a peat substrate, the coefficient of variation of the peduncle is 10.98. On other substrates, the leveling decreases, the buds are very large, the height of the bud is 9.2–10.4 cm, the duration of the growing season in the greenhouse is 64 of the day, early-flowering, with delicate flowers, does not open buds for a very long time and is excellent in cutting, early-flowering peach-orange hue and lighter yellowish edging (Figure 9).



Figure 9. *Delta storm* variety

4.3. Fun For Two Variety

The height of the plant is 46.05–47.27 cm. Leveled, especially on a peat substrate, the coefficient of variation of the peduncle is 10.33%. On other substrates, the levelness decreased, and the duration of vegetation in the greenhouse was 68 days. A variety with a white color of buds, a creamy “pattern”, a bud height of up to 6.6–7.6 cm, a goblet shape, and a pleasant aroma.

4.4. Strong Power Variety

A variety characterized by a large bud, its height is 7.5–8.6 cm, and its diameter when fully opened is 7.5 cm. The bud is somewhat elongated and large, with a pointed tip, and the color of the petals is bright red, pomegranate. Plant height 33.98–48.55 cm, leveled, especially on a peat substrate, the height variation coefficient is 12.86%. The stem is dense, strong, erect, perfectly withstands large buds, and does not bend. The leaves are compact and gray-green (Figure 10).



Figure 10. Strong power variety

4.5. Dynasty Variety

Tulip White Dynasty of classical form, one of the early-flowering tulip varieties with strong peduncles up to 53.3 cm in height, stable, leveled, especially on a peat substrate, with a height variation coefficient of 13.49%. The leaves are medium in size, wide, light green, and look perfect with pink flowers. The flower is tall, goblet-shaped, up to 7.9–8.3 cm tall and 6 cm in diameter, slightly tapering upwards, painted white at the base of the petals, which smoothly turns into a delicate pink hue (Figure 11).



Figure 11. Dynasty variety

In the cultivation of a cultivated variety of tulips, by studying the agrochemical properties of the soil, a good result is obtained when the soil is treated with a drug containing special microorganisms [37]. To study the biomorphological features of cultivated varieties of tulips, as well as to study the influence of pre-planting preparation of tulip bulbs on the rate of growth and development of plants and the yield of marketable products, a special substrate mixture of turf has been developed. However, along with the turf mixture, no local soil or cheap sources of substrate were used. The vermicompost was distinguished by its high content of organic matter, macro- and microelements, and biologically active substances. Because of these studies, an increase in the total microbial number with the addition of vermicompost was established [38].

5. Conclusion

5.1. Findings of the Study

This study has yielded valuable insights into the introduction and adaptation of imported tulip varieties under the specific conditions of Turkestan. Assessment of various morphometric parameters, growth dynamics, self-renewal capacity, and resistance to diseases and pests offers critical data for the evaluation of these tulip species. The analysis of daily growth dynamics, height development, and the assessment of tulip varieties based on the coefficient of height

variation demonstrate their selectivity for the substrates employed. Notably, the Albatros and Delta Storm varieties have shown outstanding performance, with uniform height (coefficient var. 11–12%) and large decorative blooms, particularly when cultivated on peat substrate. This substrate, along with perlite and vermiculite, creates optimal conditions for the growth and development of tulip varieties. The study recommends the use of the tulip varieties Albatros, Delta Storm, Fun for Two, Strong Power, and Dynasty for forcing culture in greenhouse conditions within Turkestan, emphasizing the advantages of a peat substrate in this context.

5.2. Strengths and Limitations

This research highlights the varietal differences in the early stages of adaptation, which are influenced by climatic conditions and soil characteristics. The findings of this study provide essential insights into the adaptive potential of these tulip varieties, optimizing their growth within a greenhouse setting suitable for southern Kazakhstan.

5.3. Recommendations for Future Research

Future research endeavors should focus on exploring specific technologies tailored to the unique climatic conditions of Kazakhstan, addressing issues not yet thoroughly studied, such as the most suitable temperature regimes. It is essential to develop and adapt technologies that align with the region's specific needs and environmental challenges.

5.4. Practical Recommendations

The findings have practical implications in terms of tulip bulb production, varietal specificity, and the introduction of promising tulip varieties to the local market. These tulip varieties, which are resistant to diseases and well suited to the climate, hold significant promise for regional floriculture. They can serve as valuable genetic material for further breeding efforts, offering traits such as early flowering, unique coloration, and disease resistance.

5.5. Implications

The studied tulip varieties, Albatros, Delta Storm, Fun For Two, Strong Power, and Dynasty, have successfully adapted to the local climate and exhibited resistance to diseases, positioning them as promising plants for the region. These varieties offer economically valuable traits and can enhance the regional assortment of tulips.

5.6. Effectiveness of the Proposals and Scientific Novelty of the Research

This study makes a significant contribution to the floriculture landscape of southern Kazakhstan. This study introduces effective methods for cultivating exclusive tulip varieties, addressing a critical research gap in the region. The project's successful implementation has not only yielded competitive flower products but also established a modern scientific foundation for tulip selection in the challenging climate of southern Kazakhstan. The development of technologies for growing sought-after tulip varieties underscores the practical and scientific novelty of this research, creating new opportunities for the region's floriculture industry.

5.7. Future Viewpoints and Outlooks

Looking ahead, this research opens doors to several promising avenues. The development of tulip cultivation technologies tailored to the specific climatic conditions of southern Kazakhstan presents an exciting area for further exploration. Additionally, the incorporation of advanced breeding techniques could create new tulip varieties with even more desirable traits for the regional market. The potential to expand the local assortment of tulips with distinct features such as early flowering, unique coloration, and enhanced disease resistance holds substantial promise. Furthermore, these adapted varieties could play a vital role in establishing a more robust and competitive floriculture industry in southern Kazakhstan. Future studies may focus on optimizing the production processes and scaling up the cultivation of these promising tulip varieties, potentially transforming the region into a significant player in the global floriculture market.

6. Declarations

6.1. Author Contributions

Conceptualization, A.A. and B.Y.; methodology, N.S.; software, B.Y.; validation, N.S., A.A., and B.Y.; formal analysis, B.Y.; investigation, A.M.; resources, N.S.; data curation, A.A.; writing—original draft preparation, A.A.; writing—review and editing, A.A.; visualization, N.S.; supervision, A.A.; project administration, N.S.; funding acquisition, A.A., B.Y., N.S., and A.M. All authors have read and agreed to the published version of the manuscript

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

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6.4. Ethical Statement

This study adhered to ethical guidelines and principles for the responsible conduct of research. This study was conducted with full respect for the welfare of plants and minimized any potential harm. All procedures, from planting and cultivation to data collection, were performed using care to ensure the well-being of the plants. The authors followed the ethical guidelines established by the Khoja Akhmet Yassawi International Kazakh-Turkish University. In addition, we recognize the importance of preserving plant biodiversity and ecosystems, and we are committed to conducting research that contributes to the sustainable use and conservation of plant species.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies, have been completely observed by the authors.

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