

## Phenology and biometrical assesment of *Petunia* × *hybrida Grandiflora* cultivars in urban ecosystems in Arctic region

Natalya V. Saltan<sup>1,2\*</sup>, Ekaterina A. Sviatkovskaya<sup>1</sup>

<sup>1</sup>*Polar Alpine Botanical Garden-Institute – Subdivision of the Federal Research Centre, Kola Science Centre of Russian Academy of Sciences, 184209, Apatity, Murmansk region, Russia*

<sup>2</sup>*Peoples' Friendship University of Russia, 117198, Moscow, Russia*

### Abstract

Six new cultivars of *Petunia* × *hybrida Grandiflora* ('Aphrodita White', 'Success Salmon Morn', 'Dreams Red Picotee', 'Hulahoop Blue', 'Limbo Blue', 'Falcon Burgundy') were studied in urbanized areas in the Arctic zone (the city of Polyarnye Zori, the Polar-Alpine Botanical Garden-Institute in Kirovsk). Phenological analysis showed that the flowering duration of the cultivars was almost the same, 90–100 days, except for 'Success Salmon Morn' (74 days) and 'Dreams Red Picotee' (104 days). Biometrical analysis showed that the maximum diameter of flowers was found in Cv. 'Hulahoop Blue', and the minimum was typical for Cv. 'Falcon Burgundy'. In general, varieties with a flower diameter of 6–8 cm predominated. The number of flowers per plant was low in 'Falcon Burgundy' (1–3) and high in 'Limbo Blue' (12–16). For other varieties, this indicator varied from 4 to 10. Among the features of agricultural technology, the mandatory three to four weeks of hardening and regular application of fertilizers were highlighted both at the stage of seedlings and adult plants. For the 'Falcon Burgundy' cultivar, thickened planting was recommended. The study found that these six new varieties are promising for landscaping cities in the Arctic zone since they shows sufficient level of resistance to the conditions of the region.

**Key words:** cultivar, *Petunia* × *hybrida Grandiflora*, decorative traits, urban ecosystems, Arctic region

DOI: 10.5817/CPR2024-1-9

### Introduction

Decorative and floral design helps to increase the comfort of the human living environment, saturates urban areas with colourful natural components and gives them a picturesque and expressive atmosphere (Poje et al. 2013, Clay and Daniel

Received April 2, 2024, accepted June 27, 2024.

\*Corresponding author: N.V. Saltan <saltan.natalya@mail.ru>

**Acknowledgements:** This research was supported by state task "Strategy for the development and maintenance of PABGI collection funds as a basis for conducting scientific research in the field of introduction and ecology in the Arctic zone of the Russian Federation" (FMEZ-2024-0012, No – 1023032400462-1-1.6.19;1.6.20;1.6.4;1.6.11). Selection of soil substrates for landscaping in northern cities was carried out with the financial support of the Russian Science Foundation (project No. 23-17-00118).

2000, Kravanja 2006). Annual flowering plants are indispensable in landscaping, as they serve as a tool for correcting the colour scheme of a city against a backdrop of inexpressive residential buildings, create colour accents, highlight and transform tree and shrub compositions and improve the visual perception of objects (Todorova et al. 2004, Datta and Gupta 2022). The use of annual flowers in landscaping is of particular relevance in Arctic cities with a long, featureless winter period (Sviatkovskaya et al. 2023).

The scale of industrially developed Arctic territories and the low resistance of landscapes to anthropogenic loads leads to the need to establish a balance between the negative impact of the city and the natural environment. Urban environmental conditions can lead to changes in the ecological and physiological parameters of annual flowering plants and, accordingly, a decrease in their decorative qualities (Yagdarova 2013, Din Muhammad et al. 2024). However, there are ornamental plants that have exhibited a high capacity to tolerate and accumulate heavy metals and organic contaminants and can therefore remedy contaminated soils while simultaneously beautifying the environment. Such plants tend to accumulate pollutants in their nonfood biomasses, which is a significant boost to their economic and ecological value (Liu et al. 2018, Li et al. 2021).

One of the most ornamental crops among annuals is the luxurious and showy petunia flower, and for many years it has remained a commercially important ornamental crop and promising for the development of new varieties (Farooq et al. 2021). *Petunia* × *hybrida* (Hook.) Vilm. is a perennial plant of South American origin, obtained from crossing two wild species (*Petunia axillaris* (Lam.) Britton, Sterns & Poggenb and *Petunia integrifolia* (Hook.) Schinz & Thell). This plant is perennial in warm regions and cultivated as an annual in moderate and cold regions (Ando et al. 2005).

A special place is occupied by *Petunia* × *hybrida Grandiflora*, which have large, showy flowers that come in a variety of colors, including pink, purple, white, and red. They are great for adding color to gardens and beddins (Gabibova and Mamilov 2014). Currently, there are many varieties and hybrids of petunias, which are widely used in landscape design (Oyama-Okubo et al. 2018, Guo and Warner 2020). Modern variety series based on crossing selected parent pairs are distinguished by their compactness, uniform habit, resistance to unfavorable environmental conditions and diseases, continue to bloom until a frost (Kudryavets and Petrenko 2014, Baranova and Salomatin 2015, Kozlova 2019, Sokolova 2019).

When growing ornamental plants in a limited amount of root nutrition, the composition of the soil mixture is of great importance (Chulkova 2021). *Petunia* is demanding on the substrate and prefers loose, permeable and nutritious soil mixtures, while it can tolerate a temporary lack of moisture, but suffers from waterlogging (Kolesnikova 2004, Kozlova et al. 2023, Sahu et al. 2023).

The flowering of petunias is influenced by factors such as temperature, light, day length and sufficiency of nutrients. Increasing temperature, day length and light significantly accelerates flowering. Petunias are long-day plants and need short nights to flower (Haliapas et al. 2008). When day length increases, petunias require fewer days to grow. The optimal temperature conditions for flowering are around 20°C, and flowering decreases in extreme heat (Reshtia 2023).

In the Murmansk region, *Petunia* × *hybrida Grandiflora* is used as an annual plant. Regional research on it was first carried out by Polar Experimental Station of All-Union Institute of Plants in 1930. The Polar-Alpine Botanical Garden-Institute (PABGI) was an institution responsible for the research. In 1941, this species was included in the landscaping assortment for

the cities of the Far North (Avrorin 1941). Because the Murmansk region is a highly urbanized region of the Russian Arctic with a long-functioning industrial complex, the improvement of northern cities is an environmental priority for the sustainable development of the region (Antipov 2022). Recently, intensive breeding work has led

to the development of a huge number of *Petunia × hybrida Grandiflora* varieties have been developed and now decorate the cities of the south and central zones. The goal of our work is to test new varieties of this group of plants and select the cultivars which are most resistant to the harsh climatic conditions of the Arctic region.

## Material and Methods

### *Samples description*





In 2023, we tested six new *Petunia × hybrida Grandiflora* cultivars ('Aphrodita White', 'Success Salmon Morn', 'Dreams Red Picotee', 'Hulahoop Blue', 'Limbo Blue', 'Falcon Burgundy'). Seeds of the cultivars were obtained from seed companies – global leaders in seed breeding and producer of seed-raised flowers (Table 1) through the mediation of the Russian company SevZapAgro (St. Petersburg).

The life cycle of plants began with seedlings grown in the PABGI greenhouses, with appropriate temperature: +20°C (night) and +25°C (day). In April, the greenhouses were illuminated with mercury-vapor lamps (55 Lm W<sup>-1</sup> per 6 m<sup>2</sup>) from 03:00 to 9:00 a.m. and from 3:00 to 9:00 p.m. The main period for sowing seeds in the polar region is mid-March.

The boxes (size: 15 x 20 x 5 cm) were filled with fertile soil substrate (peat compost+sand 2:1), and then the seeds were sown. At the stage of formation of cotyledon leaves, the seedlings were planted in new boxes (size: 40 x 50 x 6 cm) with a distance of 3 x 3 cm between plants. Pinch-

ing was carried out over the five or six formed leaves, which contributed to better tillering. During the period, they were in the greenhouse, the seedlings were fed three times with the mineral fertilizer «Zdraven Turbo for Seedlings» (macroelements nitrogen (N) 13%, phosphorus (P) 6%, potassium (K) 26%, magnesium 2.5%, sodium humate 2%; trace elements boron 0.03%, manganese 0.04%, zinc 0.02%, copper 0.02%, molybdenum 0.005%) and for the development of the root system was applied twice the growth stimulator "Kornevin" (phytohormone – indolybutyric acid in concentration 5 g·kg<sup>-1</sup>).

From the day of sowing (day 0) until planting in the open ground (96 day), the plants were regularly monitored (dates of germination, picking, pinching, morphometric indicators). From the beginning of June, seedlings were hardened for 3 weeks. Table 1 shows the characteristics of varieties from seed manufacturers (h – plant height; d – flower diameter); the color and shape of the flowers are from seedlings grown in the region.

Cultivar (Seed company)	Photo	Plant height (cm) / Flower Diameter (cm)
‘Success Salmon Morn’ Benary (Germany)		15 8-10
‘Dreams Red Picotee’ PanAmerican Seed (USA)		25-35 8-10
‘Falcon Burgundy’ Sakata Group (Japan)		25 8-10
‘Aphrodita White’ Cerny (Czech Republic)		35-40 7-9
‘Hulahoop Blue’ Sakata Group (Japan)		30 7.5-8.0
‘Limbo Blue’ Sakata Group (Japan)		20 9-12

**Table 1.** Description of cultivars.

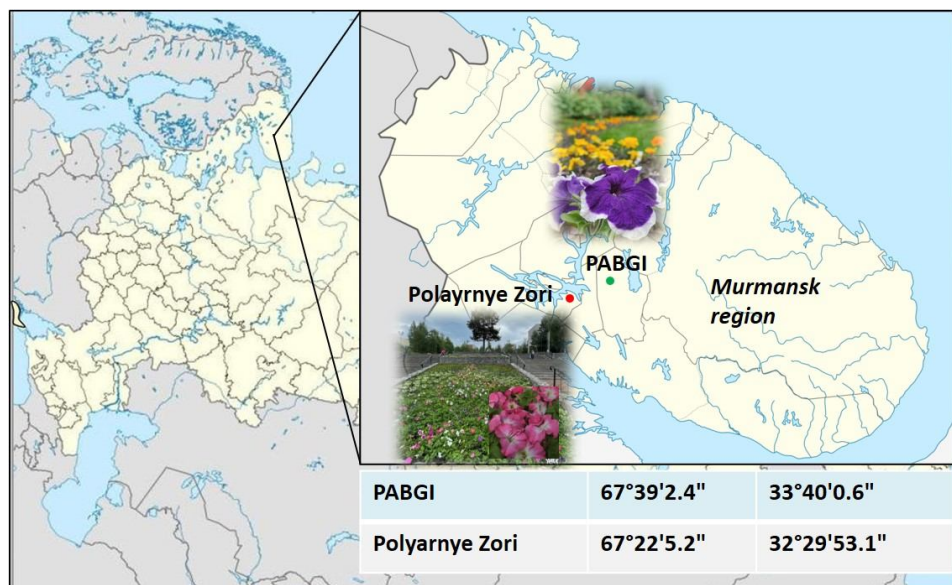
### Site characteristics

Experimental flower beds were created in urbanized areas of the Murmansk region with different climatic features: in the central part of the city of Polyarnye Zori and in the PABGI (conditionally classified as an urbanized area because it is located 10 km from the city of Kirovsk and is influenced by urban infrastructure and industrial enterprises for the extraction of apatite–nepheline ores), Fig. 1. The experiment was laid out in a completely randomized design with 100 pieces and three replications at the end of June 2023.

Natural regional soils are characterized by low nutritional status and high acidity (Pereverzev 2004) and are therefore unsuitable for growing annual crops. Besides local soils around Kirovsk are contaminated by the mining and metal industries, including toxic metals (Slipenchuk et al.

2019). Therefore, the same soil composed of peat compost and sand in a ratio of 2:1 with the addition of mineral fertilizer NPK 16:16:16, 50 g·m<sup>-2</sup> was used for flower beds in both locations. After planting, NPK 16:16:16, 30 g·m<sup>-2</sup>, was added every 2 weeks until August 15. Throughout the season, flower beds were cared for, including watering during dry periods and removing faded parts.

Before planting the plants, an agrochemical analysis of experimental substrates was carried out, in which acidity (by the potentiometric method), the content of nitrate (disulfophenol method), and ammonium (with Nessler's reagent) nitrogen exchange forms of phosphorus (by the Kirsanov method) and potassium (by the flame photometric method) were determined (Arinushkina 1970).



**Fig. 1.** Location and view of observation plots.

**Climate of experimental sites**

Polyarnye Zori is a town located in southern part of Kola Peninsula, beyond the Arctic Circle. The climate of Polyarnye Zori is continental, temperate cold and humid (Kottek et al. 2006). The average monthly air temperature in the summer-autumn period (June-September) ranges from +7.7°C (September) to +14.7°C (in July) and its average annual rainfall is 676 mm<sup>[1]</sup>. Polar day is from May 31 to July 13. The city belongs to the small towns of the Murmansk region with a population of about 14 thousand people. The main industry is electric power.

PABGI is located in the mountain belt of the Khibiny Mountains, 10 km north of the city of Kirovsk and is characterized by more severe climatic conditions. This is

the northernmost botanical garden in Russia, one of the three gardens in the world beyond the Arctic Circle. A feature of the climatic conditions of this area is the relatively short growing season (90-115 days), (Semko 1972). The average monthly air temperature in the summer-autumn period varies from +5.6°C (September) to +12.7°C (July) and its average annual rainfall is 738 mm<sup>[1]</sup>. During the growing season of plants, late spring and early autumn frosts are likely (Semko 1972). From May 26 to July 18 there is a polar day at the Khibiny latitude. The territory of the Garden belongs to specially protected natural areas of federal significance (Davydov et al. 2021).

**Data collection and data analyses**

During the period of plant growth in open ground (20.06.–30.09.2023), phenological observations were carried out weekly according to standard methods, and biometric indicators (number of flowers, flower diameter, plant height) were deter-

mined three times per season (Beideman 1974). During the period of mass flowering, the decorative qualities of the plants were assessed using Kozlova’s method (Kozlova 2016), Table 2.

<b>Sign</b>	<b>Point</b>	<b>Significance factor</b>	<b>Number of points *</b>
Bush compactness	1-5	3	3-15
Shoot strength	1-5	3	3-15
Sheet resistance to	1-5	2	2-10
Flower color resistance	1-5	2	2-10
Flower diameter	1-5	3	3-15
Waviness of the edge	1-5	2	2-10
Rain resistance	1-5	2	2-10
Foliage	1-5	1	1-5
Damage to flowers	1-5	2	2-10
<b>Total</b>		<b>20-100</b>	

**Table 2.** Card of the decorative value of *Petunia × hybrida Grandiflora* cultivars.

At the end of the season (late September through early October), plants were selected from each site to study the development of root systems. Each experimental plant was dug up and the roots were washed with warm water. As a result of pinching, the main root of *Petunia* is poor-

ly developed; adventitious roots receive the main development, thus forming a fibrous root system. After removing soil particles, the maximum length of the roots was measured per individual plant and the degree of their branching was assessed.

**Statistical analysis**

Mathematical processing of the results was done using standard software packages for statistical calculations (Microsoft Office Excel 2016). The correlation coefficient (r) was calculated by the square method (Pearson's method) for the significance level of 0.05.

Mathematical processing of the results was done using standard software packages for statistical calculations (Microsoft Office Excel 2016). The correlation coefficient (r) was calculated by the square method (Pearson's method) for the significance level of 0.05.

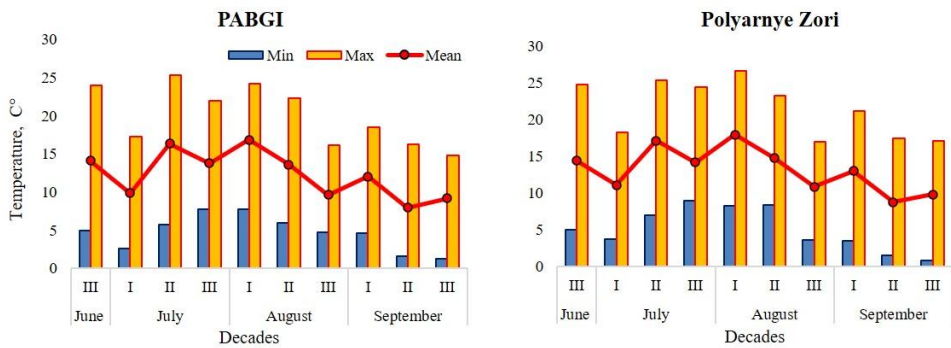
**Results**

**Climatic factors affecting flowering**

Average ten-day air temperature in Polyarnye Zori during summer/autumn 2023 varied from +10.6°C (September) to +14.5°C (August), which is below the optimal value (Fig. 2). The amount of precipitation for the season was estimated at 468 mm<sup>[2]</sup>.

temperatures was recorded over this period: from +9.7°C (September) to +13.4°C (August), typical autumn frosts (below 0°C) were not observed in September 2023. Precipitation amounted to 491 mm<sup>[2]</sup>. A feature of the weather conditions 2023 observed plots was a warm September compared to the long-term average.

In the PABGI, an even lower range of



**Fig. 2.** Weather conditions for the growing season 2023.

A specific feature of the territories located beyond the Arctic Circle is the presence of a polar day, when the sun does not set below the horizon and the dark period

of the day does not occur. The duration of the polar day in the PABGI is 10 days longer than in Polyarnye Zori.

The basis for the growth and development of annual crops is a fertile soil substrate. The flower beds examined in this study all had the following composition

(mg 100g<sup>-1</sup>): ammonium nitrogen – 5.28, nitrate nitrogen – 4.37 mg, phosphate content P<sub>2</sub>O<sub>5</sub> – 90.81, K<sub>2</sub>O – 17.13. The acidity was 6.3.

**Flowering duration**

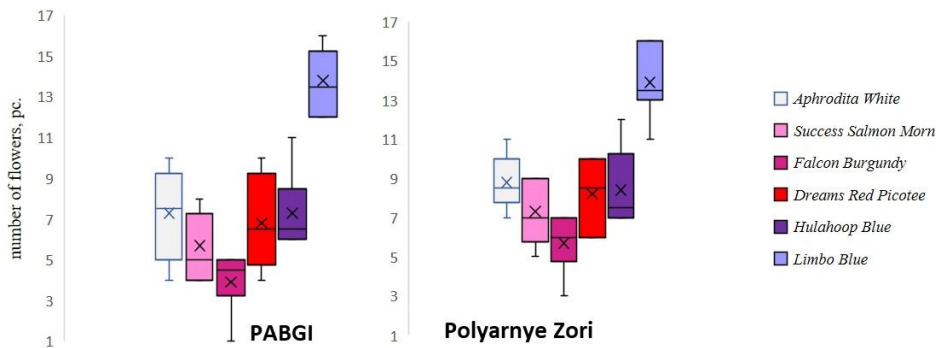
The *Petunia* × *hybrida Grandiflora* cultivars flowering began in the greenhouse and was divided into two periods: mid-June (‘Aphrodita White’, ‘Success Salmon Morn’, ‘Dreams Red Picotee’) and late June (‘Hulahoop Blue’, ‘Limbo Blue’, ‘Falcon Burgundy’). The flowering duration of the varieties was almost the same at 90–100 days, except for ‘Success Salmon Morn’ at 74 days and ‘Dreams Red Picotee’ at 104 days. Both of the latter varieties began flowering first, but ‘Success Salmon Morn’ finished on August 30

and ‘Dreams Red Picotee’ only at the end of September. The flowering duration indicator indicated the successful adaptation of most of the studied varieties, since the growing season in the polar region varies from 90 to 115 days. The seed setting phase was observed in all varieties, but only ‘Dreams Red Picotee’, ‘Aphrodita White’ and ‘Hulahoop Blue’ formed full seeds. The date of death of the above-ground part of the studied petunia varieties was the end of September.

**Number of flower per individual**

At the first significant cold snap, *Petunia hybrida* stopped flowering. Tests have demonstrated that this indicator at both locations was minimal for ‘Falcon Burgundy’ (1–3) and maximal for ‘Limbo Blue’ (12–16), Fig. 3. Such a spread in the

parameter is quite acceptable, since the abundance of flowering is largely determined by the characteristics of the variety. In other varieties, the number of flowers varied in range (4–10).



**Fig. 3.** Number of flowers of *Petunia* × *hybrida Grandiflora* cultivars.



### Flower diameter

The minimum average value of flower diameter (7 cm in Polyarnye Zori and 6.3 cm in the PABGI) was found in the variety ‘Falcon Burgundy’, while the highest values were found in the variety ‘Hulahoop Blue’ (9.1 cm on both sites). In general, cultivars with flower diameters of 6–8 cm predominated. In the city of Polyarnye Zori, ‘Aphrodita White’, ‘Limbo Blue’ and ‘Dreams Red Picotee’ corre-

sponded to the declared indicators of the varieties of seed companies (Table 1, Fig. 4). In the PABGI, this indicator was slightly lower for these varieties. In urbanized areas, the varietal parameters of ‘Falcon Burgundy’ and ‘Success Salmon Morn’ were slightly inferior, and only the variety ‘Hulahoop Blue’ stood out for its large flower diameter.

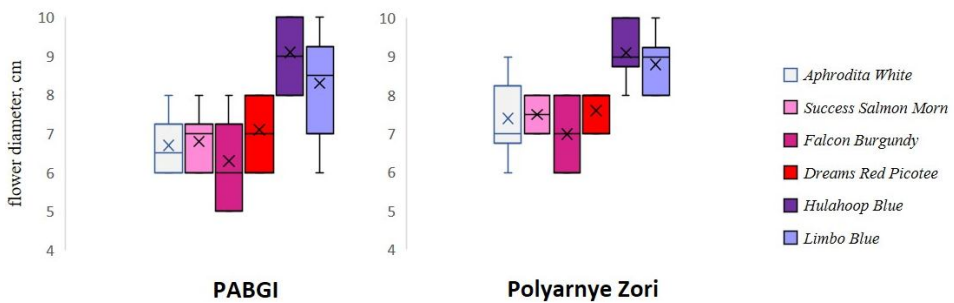


Fig. 4. Flower diameter of *Petunia × hybrida Grandiflora* cultivars.

### Plant height

Plant height was quite constant in the variety ‘Hulahoop Blue’ in both locations (24–26 – Polyarnye Zori; 23–25 cm – PABGI). The most variable in the PABGI was in the varieties ‘Dreams Red Picotee’ and ‘Aphrodita White’; in Polyarnye Zori, the indicator varied most in ‘Limbo Blue’

and ‘Aphrodita White’ (Fig. 5). The reason for this may be a lack of heat, in addition to the individual characteristics of the plants. Size dissimilarity did not significantly affect the decorative qualities of plants, since the predominant number of specimens had the same height.

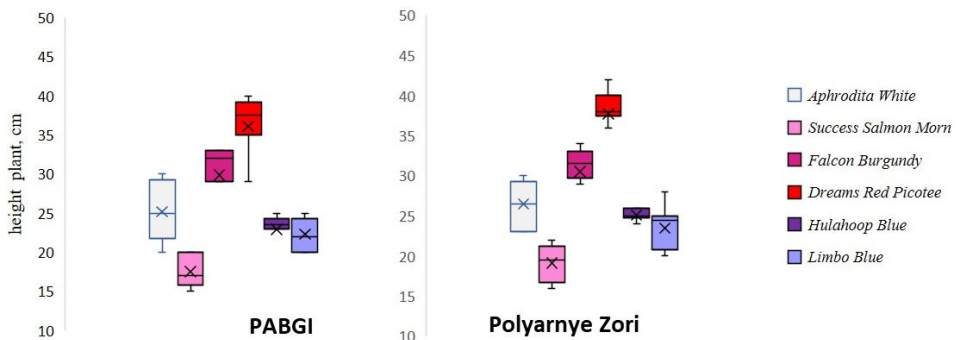


Fig. 5. Height of *Petunia × hybrida Grandiflora* cultivars.

### Root biomass

Fibrous root system of the species showed numerous lateral and adventitious roots of the same thickness, which helps to better strengthen the plant in the soil and improve its nutrition. Analysis of the root system (root length, branching) showed heterogeneity of development. The most developed root system was found in 'Dreams Red Picotee', 'Aphrodita White',

'Falcon Burgundy' with a root length of 15–19 cm in Polyarnye Zori and 13–18 cm in the PABGI, Table 3. Other varieties were characterized by a less developed root system (7–8 cm). A weak inverse relationship was revealed between the number of flowers in an individual plant and the development of its root system ( $r = -0.59... -0.62$ ).

Cultivar	PABGI	Polyarnye Zori
Dreams Red Picotee	<b>15.78±0.71</b>	15.28±0.84
Falcon Burgundy	14.84±1.06	<b>15.33±0.85</b>
Aphrodita White	14.82±1.22	14.70±0.82
Hulahoop Blue	8.02±1.07	8.61±0.72
Limbo Blue	8.31±0.70	8.48±0.63
Success Salmon Morn	<i>7.74±0.70</i>	<i>8.14±0.43</i>

**Table 3.** Root length of *Petunia × hybrida Grandiflora* cultivars. Note: The **maximum** values are shown in bold; *minimum* - in italics.

### Discussion

Among the studied varieties, the shoots that were the most resistant to negative environmental factors, both in the city of Polyarnye Zori and in the PABGI, were the low-growing varieties 'Limbo Blue' and 'Success Salmon Morn'. In these varieties, no breakage or lodging of plants were observed during periods of rain and strong wind. The resistance of the 'Limbo Blue' variety to unfavourable factors has been shown in a number of other works (e.g., Lebedeva et al. 2019, Mukhina et al. 2022). High grades were more difficult to tolerate bad weather, during which periods, there was a slight decrease in decorative effect.

The intensity of solar radiation in the Arctic zone is lower than in the southern regions, thus all varieties received a high score sheet resistance to fading. In most cultivars, flower burning was also not detected. A slight decrease in colour saturation was noted in the variety 'Limbo Blue' (Table 4, Table 5).

In the city of Polyarnye Zori, all varieties except 'Falcon Burgundy' were rated with the maximum score based on flower diameter. In the PABGI, the varieties 'Falcon Burgundy' and 'Aphrodita White' received lower points compared to the others. Microclimatic conditions, mainly lower air temperature, became a likely explanation for the lower value of the diameter of flowers in the 'Aphrodita White' variety in PABGI. The level of illumination could have a significant impact, since in the PABGI flowerbeds are to some extent shaded by the Khibiny mountains, whereas in the Polyarnye Zori they are located in open areas and are fully illuminated during the polar day in sunny time.

The waviness of the edge of a flower is another significant indicator of decorative-ness. Three varieties received the highest scores for this criterion at both sites: 'Aphrodita White', 'Falcon Burgundy' and 'Hulahoop Blue'.

ANNUAL ORNAMENTAL PLANTS IN THE ARCTIC REGION

Sign \ Cultivar	Aphrodita White	Dreams Red Picotee	Falcon Burgundy	Hulahoop Blue	Limbo Blue	Success Salmon Morn
Bush compactness	15	15	15	15	15	15
Shoot strength	12	12	12	12	15	15
Sheet resistance to fading	10	10	10	10	10	10
Flower color resistance to fading	10	10	10	10	8	10
Flower diameter	15	15	12	15	15	15
Waviness of the edge	10	6	10	10	6	8
Rain resistance	6	8	8	8	10	10
Foliage	4	5	5	5	5	4
Damage to flowers	8	8	8	8	8	8
Total, points	90	89	90	93	92	95

**Table 4.** Card of the decorative value of *Petunia × hybrida Grandiflora* cultivars in the city of Polyarnye Zori.

Sign \ Cultivar	Aphrodita White	Dreams Red Picotee	Falcon Burgundy	Hulahoop Blue	Limbo Blue	Success Salmon Morn
Bush compactness	15	15	15	15	15	15
Shoot strength	12	12	12	12	15	15
Sheet resistance to fading	10	10	10	10	10	10
Flower color resistance to fading	10	10	10	10	8	10
Flower diameter	12	15	12	15	15	14
Waviness of the edge	10	6	10	10	6	8
Rain resistance	6	8	8	8	10	10
Foliage	4	4	4	4	4	4
Damage to flowers	8	8	8	8	8	8
Total, points	87	88	89	92	91	94

**Table 5.** Card of the decorative value of *Petunia × hybrida Grandiflora* cultivars in the PABGI.

The lowest scores went to the cultivars ‘Dreams Red Picotee’ and ‘Limbo Blue’.

The cultivars ‘Success Salmon Morn’ and ‘Limbo Blue’ showed high resistance

to rain due to their strong stems. The remaining varieties laid down during the rain and returned to their previous positions within several hours after the rain ended;

as a result, they were rated 1–2 points lower.

The leafiness of the plants in four varieties ('Dreams Red Picotee', 'Hulahoop Blue', 'Falcon Burgundy' and 'Limbo Blue') in Polyarnye Zori was higher than in the PABGI, which is associated with warmer weather conditions. The damage to flowers of all varieties is rated equally as slightly above average (about 30%). One of the unfavourable factors in the region is strong wind, which can reach high speeds in summer.

The root system determines the normal growth of plants; its more powerful development contributes to an increase in the area of plant nutrition. Perhaps, in order to improve the condition of three varieties ('Aphrodita White', 'Falcon Burgundy', 'Dreams Red Picotee'), their development strategy was a more developed root system, while the varieties 'Hulahoop Blue', 'Success Salmon Morn', 'Limbo Blue' had the optimal size of their root system.

An assessment of the decorativeness of *Petunia* × *hybrida Grandiflora* cultivars in urban areas showed that the maximum score was given to the compactness of the

bush, characterized by a beautiful bush shape and good foliage, regardless of height (Table 4, Table 5). Another important criterion for decorativeness was the strength of the shoots. All cultivars included in this study had a high total decorative score in the conditions of the Arctic region. The variety 'Success Salmon Morn' received the highest ranking. It has been shown that a plant that has received a decorative score above 85 points can be recommended for urban landscaping (GOST 28329-89<sup>[3]</sup>, Sokolova et al. 2007).

It should be noted that in the methodology used for assessing the decorativeness of petunias, there is no indicator for the abundance of flowering on one plant. In our opinion, this also needs to be taken into account because the presence of only one or two flowers reduces colour perception, since the vegetative mass dominates. Of the studied varieties, only 'Falcon Burgundy' was characterized by low abundance; for other varieties, this parameter was at a sufficient level (4–10 flowers) and did not reduce the decorativeness of the plants.

## Conclusion

Analysis of the duration of flowering and biometric indicators of *Petunia* × *hybrida Grandiflora* cultivars, as well as assessment of their decorative properties, did not reveal significant differences in urbanized areas with different climatic features. The number of indicators decreased only slightly for 'Falcon Burgundy' and 'Aphrodita White' in the PABGI. It was shown that the actual parameters (flower diameter, plant height) of the studied varieties predominantly corresponded to the varietal genotypic characteristics. It should be noted that the 'Hulahoop Blue' variety in the studied areas exceeded the flower diameter specified by the seed manufacturer. It was revealed that regional weather

conditions did not limit the development of plants and did not reduce the decorative features of petunia.

The flowering duration of *Petunia* × *hybrida Grandiflora* was estimated to be from 90 to 100 days for most varieties, which corresponds to the length of the growing season in the region. The exception was the variety 'Success Salmon Morn', which had a minimum flowering period of 74 days. Still, this variety achieved the maximum decorative score.

Of the studied varieties, 'Falcon Burgundy' stood out as having the smallest number of flowers on one plant and the shortest flower diameter, making it necessary to plant the flowers more densely to

enhance the decorative effect. Varieties that were more resistant to unfavourable environmental factors were ‘Success Salmon Morn’ and ‘Limbo Blue’. In general, all varieties had a high decorative score, which indicated their high adaptability and stability and prospects for use in the region.

## References

- ANDO, T., KOKUBUN, H., WATANABE, H., TANAKA, N., YUKAWA, T., HASHIMOTO, G., MARCHESI, E., SUAREZ, E. and BASUALDO, I. L. (2005): Phylogenetic analysis of *Petunia sensu* Jussieu (Solanaceae) using chloroplast DNA RFLP. *Annals of Botany*, 96(2): 289-297. doi: 10.1093/aob/mci177
- ANTIPOV, S. K. (2022): Modeling of sustainable development of the Arctic regions of the Russian Federation (on the example of the Murmansk region).  *$\pi$ -Economy*, 15(6): 146-159. doi: 10.18721/JE.15610
- ARINUSHKINA, E. V. (1970): Guide to the chemical analysis of soils. Publishing house of Moscow State University, Moscow, 488 p. (In Russian).
- AVRORIN, N. A. (1941): How to plant greenery in cities and towns of the Murmansk region and the northern regions of the Karelian Finnish SSR. Kirovsk, 126 p. (In Russian).
- BARANOVA, E. G., SALOMATIN, V. A. (2015): Biological diversity and prospects for the decorative use of the resources of the hybrid *Petunia hybrida* of the collection of All-Russian Research Institute of Tobacco, Shag and Tobacco Products. *In: Questions, Hypotheses, Answers: Science of the XXI Century*. Krasnodar: Apriori, pp. 299–316. (In Russian). doi: 10.25930/wkyr-xf65
- BEIDEMAN, I. N. (1974): Methodology for studying the phenology of plants and plant communities. Novosibirsk: Nauka, 154 p. (In Russian).
- CHULKOVA, V. V. (2021): Features of the use of soil mixtures in the cultivation of ornamental plants. *Agrarnoe obrazovanie i nauka [Agricultural Education and Science]*, 2: 1-8. (In Russian).
- CLAY, G. R., DANIEL, T. C. (2000): Scenic landscape assessment: the effects of land management jurisdiction on public perception of scenic beauty. *Landscape and Urban Planning*, 49: 1-13. doi: 10.1016/S0169-2046(00)00055-4
- DATTA, S. K., GUPTA, Y. C. (2022): Floriculture and Ornamental Plants. Springer Nature, 895 p.
- DAVYDOV, D. A., BOROVICHEV, E. A. and PETROVA, O. P. (2021): A zoning concept of Polar-Alpine botanical garden-institute as protected area for nature conservation and tourism development. *Proceeding of the International conference «Intercarto. InterGis»*, 27: 312-322. doi: 10.35595/2414-9179-2021-3-27-312-322
- DIN MUHAMMAD, H., ANJUM, M. A. and NAZ, S. (2024): Silicon-mediated alleviation of salinity stress in *Petunia hybrida* by modulation of morphological, physiological and biochemical indices. *Journal of Soil Science and Plant Nutrition*. doi: 10.1007/s42729-024-01681-5
- FAROOQ, I., QADRI, Z. A., RATHER, Z. A., NAZKI, I. T., NEELOFAR BANDAY, N., RAFIQ, S., MASOODI, K. Z., NOURELDEEN, A. and MANSOOR, S. (2021): Optimization of an improved, efficient and rapid in vitro micropropagation protocol for *Petunia hybrida* Vilm. Cv. “Bravo”. *Saudi Journal of Biological Sciences*, 28(7): 3701-3709. doi: 10.1016/j.sjbs.2021.05.018
- GABIBOVA, E. N., MAMILOV, B. B. (2014): Variety and use in landscaping garden petunia, or hybrid *Petunia*. *Vestnik Donskogo gosudarstvennogo agrarnogo universiteta [Bulletin of the Don State Agrarian University]*, 2: 53-60. (In Russian).
- GUO, Y., WARNER, R. M. (2020): Dissecting genetic diversity and genomic background of *Petunia* cultivars with contrasting growth habits. *Horticulture Research*, 7: 155. doi: 10.1038/s41438-020-00373-2

- HALIAPAS, S., YUPSANIS, T. A., SYROS, T. D., KOFIDIS, G. and ECONOMOU, A. S. (2008): *Petunia × hybrida* during transition to flowering as affected by light intensity and quality treatments. *Acta Physiologiae Plantarum*, 30: 807-815. doi: 10.1007/s11738-008-0185-z
- KOLESNIKOVA, E. G. (2004): *Petunias, Surfinias, Calibrachoa*. MSP Publ., 64 p. (In Russian).
- KOTTEK, M., GRIESER, J., BECK, C., RUDOLF, B. and RUBEL, F. (2006): World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift [Meteorological Journal]*, 15(3): 259-265. doi: 10.1127/0941-2948/2006/0130
- KOZLOVA, E. A. (2016): Improving technologies for growing, propagating and assessing the decorative qualities of hybrid petunia lines (*Petunia × hybrida* Vilm.). *Abstract of the dissertation of a candidate of agricultural sciences*, Moscow, 22 p. (In Russian).
- KOZLOVA, E. A. (2019): Review of new F1 *Petunia* hybrids from the agricultural company "Aelita" *Vestnik landshaftnoj arhitektury [Journal of Landscape Architecture]*, 17: 466-48. (In Russian).
- KOZLOVA, E. A., MAKAROV, S. S., ZUBIK, I. N., ORLOVA, E. E. and KUZNETSOVA, I. B. (2023): Influence of some components of substrates on growth, development and decorative traits of hybrid *Petunia (Petunia hybrida* Vilm.). *Sovremennoe sadovodstvo [Contemporary Horticulture]*, 4: 156-164. (In Russian). doi: 10.52415/23126701\_2023\_0415
- KRAVANJA, N. (2006): Significant perceptual properties of outdoor ornamental plants. *Acta agriculturae Slovenica*, 87(2): 333-342. doi: 10.14720/aas.2006.87.2.15112
- KUDRYAVETS, D. B., PETRENKO, N. A. (2014): *Annual and Perennial Ornamental Plants for Flower Beds (Illustrated Atlas)*. Fiton XXI, 368 p. (In Russian).
- LEBEDEVA, A. N., ABAKINA, A. D. and GUDIEV, O. YU. (2019): Comparative assessment of the decorative and biological qualities of varieties of hybrid petunia (*Petunia × hybrida*). *Novosti nauk v agropromyshlennom komplekse [News of Sciences in Agro-Industrial Complex]*, 1-2: 95-98. doi: 10.25930/wkyr-xf65
- LI, J., ZHANG, Y., JIANG, X., LI, G., GAO, T. and YANG, Y. (2021): Effects of heavy metal accumulation in the soil on the physiological properties of *Petunia × hybrida* along an arterial road in Lanzhou City. *Plant Physiology Journal*, 8. doi: 10.13592/j.cnki.ppj.2020.0610
- LIU, J., XIN, X. and ZHOU, Q. X. (2018): Phytoremediation of contaminated soils using ornamental plants. *Environmental Reviews*, 26: 43-54. doi: 10.1139/er-2017-0022
- MUKHINA, O. V., CHUKHLEBOVA, N. S., DONETS, I. A. and GOLUB, A. S. (2022): Assessment of decorativeness of *Petunia* varieties (*Petunia parviflora* Juss.) when used in green construction. *Vestnik APK Stavropol'ya [Bulletin of agrarian and industrial complex of Stavropol region]*, 3(47): 42-46. doi: 10.31279/2222-9345-2022-11-47-42-46
- OYAMA-OKUBO, N., HAKETA, T., FURUICHI, H. and IIOKA, S. (2018): Characteristics of floral scent compounds in a new fragrant *Petunia* cultivar TX-794 'Evening Scentsation'. *The Horticulture Journal*, 87(2): 258-263. doi: 10.2503/hortj.OKD-090
- PEREVERZEV, V. N. (2004): *Forest soils of the Kola Peninsula*. Nauka, Moscow, 231 p. (In Russian)
- POJE, M., VUKELIC, A. and HAN DOVEDAN, I. (2013): Perception of flower beds in public green areas. *Agriculturae Conspectus Scientificus*, 78(2): 125-129.
- RESHTIA, S. R. (2023): Feasibility study of planting and developing atlas plants (*Petunia hybrida* L.) and *Chrysanthemums (Chrysanthemum morifolium* L.) in urban streets of karaj considering the effects of light pollution. *Journal for Research in Applied Sciences and Biotechnology*, 2(6): 286-291. doi: 10.55544/jrasb.2.6.40
- SAHU, P., KUMAR, A., SAHU, R. K., NAGENDRAPRASAD, H., MINJ, S. K. and PAINKRA, D. S. (2023): Effect of different growing media on growth and flowering of *Petunia (Petunia hybrida* L.). *International Journal of Plant & Soil Science*, 35(18): 1200-1206. doi: 10.9734/ijpss/2023/v35i183457
- SEMKO, A. P. (1972): Climatic characteristics of the Polar-Alpine Botanical Garden. *Flora and vegetation of the Murmansk region*. L.: Nauka, pp. 73–129. (In Russian).
- SOKOLOVA, T. A., BOCHKOVA, I. YU. and BOBYLEVA, O. N. (2007): *Color in landscape design*. Fiton+, 128 p. (In Russian).
- SOKOLOVA, M. A., KUZICHEV, O. B., GONCHAROVA, S. V. and PUGACHEVA, G. M. (2019): Modern directions of plant breeding of several floral varieties. *Dostizheniya nauki i tekhniki*

- agropromyshlennogo kompleksa [Achievements of science and technology of the agro-industrial complex]*, 33(2): 34-38. (In Russian). doi: 10.24411/0235-2451-2019-10209
- SLIPENCHUK, M., KIRILLOV, S., VOROBIEVSKAYA, E. and SEDOVAET, N. (2019): Anthropogenic pollution of the southern part of the Khibiny mountain massif and foothills. IOP Conference Series: Earth and Environmental Science, 302(1): 012024. doi: 10.1088/1755-1315/302/1/012024
- SVIATKOVSKAYA, E. A., SALTAN, N. V., RYBALKA, E. P. and ZAVODSKIKH, M. S. (2023): Features of growing new cultivars of annual flowering plants in the Kola Subarctic. *Vestnik RUDN Seriya Agronomiya i zivotnovodstvo [RUDN Journal of Agronomy and Animal Industries]*, 18(3): 42-46. doi: 10.22363/2312-797X-2023-18-3-334-349
- TODOROVA, A., ASAKAWA, S. and AIKOH, T. (2004): Preferences for and attitudes towards street flowers and trees in Sapporo, Japan. *Landscape and Urban Planning*, 69(4): 403-416. doi: 10.1016/j.landurbplan.2003.11.001
- YAGDAROVA, O. A. (2013): Ecological and physiological features of the ontogenesis of annual ornamental plants in an urban environment. *Abstract of the dissertation of a candidate of biological sciences*, Kazan, 22 p. (In Russian).

### Web sources / Other sources

- [1] Climate data of cities worldwide. <https://ru.climate-data.org/> (Accessed 20.03.2024).
- [2] Weather. <https://rp5.ru/> (Accessed 20.03.2024).
- [3] GOST 28329-89. Greening cities. Terms and Definitions. (In Russian).

### Supplementary Materials

When selecting varieties of annuals for cities in the Arctic, preference is given to warm tones. Of the 6 cultivars: 3 with pink-red shades ('Success Salmon Morn', 'Dreams Red Picotee', 'Falcon Burgundy'), 2 with blue-violet shades ('Hulahoop Blue', 'Limbo Blue'), 1 – white ('Aphrodita White'). This color scheme is favorable for perception and beneficial for public health. According to height, the studied varieties are conditionally divided into 2 groups: 1) 15-25 cm - 'Limbo Blue', 'Falcon Burgundy', 'Success Salmon Morn'; 2) from 25-40 cm - 'Aphrodita White', 'Dreams Red Picotee', 'Hulahoop Blue'.