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COMPARATIVE STUDY ON THE BEHAVIOUR OF *PLECTRANTHUS FORSTERI* AND *COLEUS BLUMEI* SPECIES GROWING ON THE GROUND AND IN VERTICAL SYSTEMS FOR GREEN FAÇADES IN THE CLIMATE OF NORTH-EAST ROMANIA

Mirela COJOCARIU[1], Elena-Liliana CHELARIU[1], Ciprian CHIRUȚĂ[1], Roxana PAȘCU[1], Bogdan-Vlad AVARVAREI[2]

[1]"Ion Ionescu de la Brad" Iasi University of Life Sciences, Faculty of Horticulture, 3 Mihail Sadoveanu Alley, Iasi, Romania
[2]"Ion Ionescu de la Brad" Iasi University of Life Sciences, Faculty of Food and Animal Sciences, 8 Mihail Sadoveanu Alley, Iasi, Romania

Corresponding author email: julia@uaiasi.ro

Abstract

The flowering species Plectranthus forsteri and Coleus blumei, stand out with their compact foliage, particularly decorative and a high degree of coverage in a short time. This paper aims to study the behaviour of these species in vertical systems for green façades, in the climatic conditions of North East part of Romania. The vertical experiment was set up on the façades of an experimental module built specifically to test the strength and adaptability of several ornamental species in this system. The experimental structure was made of height levels that were applied on the four facades of the module oriented towards the four cardinal points. A ground control variant has also been set up. The study found that Plectranthus forsteri and Coleus blumei grown in vertical systems for green façades show high adaptability regardless of the cardinal orientation. On the ground, Plectranthus forsteri behaved well, creating a compact and uniform layer unlike Coleus blumei which had a more modest behaviour in the experience.

Key words*: Plectranthus, Coleus, green façades.*

INTRODUCTION

Plectranthus forsteri Benth. (syn. *P. coleoide*s Benth.) and *Coleus blumei* Benth. (syn. *C. hybridus* Cobeau, Coleus x *Solenostemon scuttellarioides* (L.) Codd.) are two flowering species commonly used mainly as potted plants for both interior decoration and for the decorations of balconies and terraces in the warm season.

The *Coleus* species is also found in the seasonal decoration of parks and gardens, in borders, carpets, florals, arabesques (Toma, 2009). A study conducted in Bucharest identifies the species present in the decorative assortment of four out of six analysed parks (Mănescu et al., 2019). The classification of flowering species according to decorative features places the two species in the same category, those decorative by leaves, but they have other similar characteristics, such as a similar degree of branching, short-term coverage and moderate environmental requirements. *Pectranhtus forsteri* develops longer shoots (stems), about 100 cm, which makes this species an excellent plant for hanging pots, the edge of railings or other places where it can display its hanging port (Toma, 2009), once rooted, tolerates drought (https://plants.ces.ncsu.edu/plants/plectranthus-forsteri-marginatus/).

Coleus blumei is more compact, shoots usually have shorter lengths of about 40-60 cm, with less hanging port. Species is very sensitive to excess moisture and low temperatures. Both prefer sunny locations.

From a coloristic point of view, *Plectranthus* is presented only in shades of green and green with white-yellow (Chelariu, 2015), while *Coleus* offers a very varied range of colours pink, red, purple, green, yellow and various combinations between them (Toma, 2009). Its attractive foliage is of interest throughout the year (https://plants.ces.ncsu.edu/plants/coleus-scutellarioides/).

This causes the association of the two species to lead to floral arrangements with special decorative effects.

A growing concern among researchers is to find solutions to reduce the pollution installed in cities caused by excessive urbanization, which produces many negative effects on public health (Peschardt et al., 2012; Price et al., 2015). Expansion of green areas would substantially contribute to its reduction, reduce the urban island effect and contribute to raising quality of life (Chiesura, 2004; Pérez-Urrestarazu et al., 2016), but the lack of free construction land makes it remains, at this moment, a desideratum. One possible solution would be to extend these areas to the roofs and façades of existing buildings by creating green roofs and façades (Ghazalli et al., 2019). At the same time, they would make a substantial contribution to reducing aridity and beautifying densely built urban areas (Dascălu and Cojocariu, 2016).
In order for green façades to achieve their intended purpose, it is absolutely necessary to plant them with ornamental species that grow harmoniously, have a high degree of coverage, decorate for as long as possible and, of course, require little maintenance.
Therefore, in order to include plants in an assortment of decorative species that best meet the above requirements, they need to be tested in advance in local climatic conditions.

MATERIALS AND METHODS

The study material is represented by two flowering species *Plectranthus forsteri* (Figure 1a) and *Coleus blumei* (Figure 1b) decorative by leaves.


a) *Plectranthus forsteri*


b) *Coleus blumei*

Figure 1. Study material - seedling

In order to establish the experiment, a uniform, branched seedling was used, purchased from local producers of flowering floricultural material. Plants were placed on the faces of an experimental structure built in order to study the behaviour of flower species planted vertically. Each face of experimental module was oriented towards a cardinal point.
Experience was established in the didactic field of the Floriculture discipline within the Faculty of Horticulture from ULS Iași and the research was carried out from the end of May when seedling was planted, until mid-October 2021.
Faces of experimental structure (Figure 2) consist of four equal, individual tiers arranged in layers. Total height is 2.40 m. Levels have been numbered from bottom to top, so that level 1 (P1) is at the bottom, closest to the ground, and level 4 (P4) at the top of the vertical module.

Figure 2. Experimental module - West and South façades - August 2021

Specimens of *Plectranthus forsteri* and *Coleus blumei*, respectively, were placed in groups, on each level, one below the other, on two adjacent, distinct columns. In the floral didactic field, a control variant was set up, planted on the ground, for each species. Other annual and perennial flowering species are also being studied on the experimental structure.
Levels of experimental module benefited from 25 litres of water each month. Control variant did not receive additional water supply. No fertilizers were used in any variant.

Figure 3. Control variant *Plectranthus forsteri* - August 2021

Figure 4. Control variant *Coleus blumei* - August 2021

Characteristics of seedling before planting had the following average values for *Plectranthus forsteri*: diameter = 13.40 cm; height 12.95 cm; number of shoots = 1.80, length of shoots = 13.75 and for *Coleus blumei* diameter = 11.00 cm; height = 8.65 cm; number of shoots = 1.47; shoot length = 8.68 cm.

After planting, observations were made at an interval of about 6 weeks, on the following parameters: plant diameter, plant height and number of shoots and their length.

After first measurement in July, *Coleus blumei* plants were shortened to about 10 cm.

For plants placed vertically, plant diameter was considered to be the distance measured between the extremities of the plant, parallel to the façade, horizontally, and the height of the plant was considered to be the distance from the façade to the extremity of the plant measured perpendicular to façade.

Photographic monitoring was also performed to perform a dynamic visual assessment of ornamental characters. Initial rooting rate was also calculated during the monitoring period (survival rate). Comparisons were made between levels, between façades of experimental module and façades of experimental module and the control variant. Anova Single Factor and Anova Two Way with Replication were used for statistical interpretation of the data.

RESULTS AND DISCUSSIONS

Annual flowering species have a rapid growth rate and maintain their aesthetic values for several months during a growing season (Draghia and Chelariu, 2011) and are therefore often used for the decoration of parks and gardens - grown on the ground or balconies and terraces - grown in pots and planters. It is precisely these qualities mentioned above that have attracted the attention of our research team to be studied in vertical systems, for green façades.

During the summer-autumn season of 2020, under similar conditions, the hybrid 'Big' of species *Begonia semperflorens* was studied (Cojocariu et al., 2020) and in the summer-autumn season of 2021, simultaneously with the species presented in this paper, species *Antirrhinum majus*, as well as a species with erect stems, with red leaves and flowers belonging to the species *Begonia semperflorens* (works in progress) were monitored.

All these mentioned species showed a very good adaptability to vertical planting in systems for green façades ensuring a constant decoration throughout the monitored period.

At the same time, during 2020, a series of ten perennial flower species were tracked (Cojocariu et al., 2022) whose behaviour has been studied to identify a wider range of ornamental plants that can be used with good results in various roofing systems for buildings in Eastern Europe.

In the same geo-climatic conditions of Iași city during 2014-2015 period, a study was carried out that proposes as a support for plants grown vertically a multifunctional modular prototype to be used in open spaces analyses the behaviour of three perennial flower species: *Sedum spurium*, *Sedum reflexum* and *Vinca major* (Dascălu and Negrea, 2016).

This paper deals with the vertical behaviour of flower species *Plectranthus forsteri* and *Coleus blumei*.

Calculation of initial degree of rooting and during observation period was performed comparatively both between the levels of experimental module and on variants (the façades of experimental module oriented towards a cardinal and control point).

In July, in the case of *Plectranthus forsteri*, percentage of rooting on the respective levels by variants was 100%. By levels, the survival rate was high, especially on levels 3 (P3) and 4 (P4) where, in October, rooting/survival rates were 94.73% and 100%, respectively (Table 1). Exception is level 1 (P1), where most of the plants were lost. Here, in October, only 61.53% of the initially planted specimens survived.

On cardinal and control guidelines, percentage of loss was small during the monitoring period.

Thus, in October, on experimental module, the lowest percentage of rooting/survival of 82.35% was registered on Eastern façade and the highest, of 88.23% on Western façade. Control variant did not lose any plants during this period (Table 2).

Table 1. *Plectranthus forsteri* - Percentage of rooting/ survival rate on levels

Level	JULY	AUGUST	OCTOBER
P1	100%	69.23%	61.53%
P2	100%	94.11%	88.23%
P3	100%	94.73%	94.73%
P4	100%	100%	100%

Table 2. *Plectranthus forsteri* - Percentage of rooting / survival rate on variants

Variants	JULY	AUGUST	OCTOBER
North	100%	85%	85%
East	100%	94.11%	82.35%
South	100%	87.5%	87.5%
West	100%	94.11%	88.23%
Control	100%	100%	100%

At the level, diameter of *Plectranthus* plants had a unitary development, within the same set of measurements. Towards the end of monitoring period this continued for the plants on levels 2 (P2), 3 (P3) and 4 (P4) where plant diameter received average values between 28.67 (P2) and 29.80 (P4). On level 1 (P1), plants developed less, where the obtained average value was 26.54 cm (Figure 5).

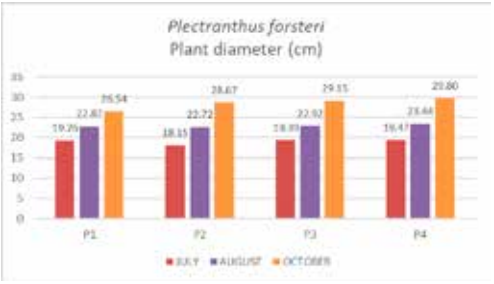

Figure 5. *Plectranthus forsteri* plant diameter dynamics on vertical module levels

Regarding height of *Plectranthus forsteri* plants (Figure 6), the lowest values were obtained on level 2 (P2) in all months in which observations were made. The highest values were reached by plants on levels 4 (P4) in October (27.11 cm) and on level 3 (P3) in August (20.79 cm). There were no significant differences in the same set of measurements.

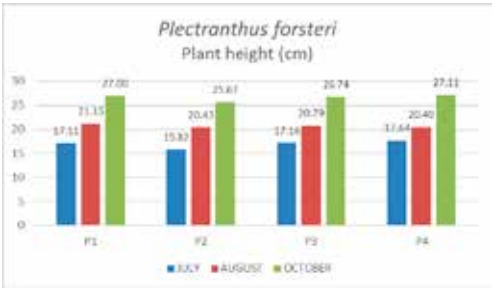

Figure 6. Height dynamics in *Plectranthus forsteri* on vertical module levels

Number of shoots per plant in June had from a statistical point of view, p *value* = 0.179635 > 0.05, equal averages per level, plants developing uniformly in terms of this parameter, but starting with August the number of shoots per plant recorded different average values (Table 3). Thus, plants on level 1 (P1) developed more shoots (3.0 in August and 3.25 in October respectively) compared to level 3 (P3) (1.83 in August and 2.56 in October respectively) and level 4 (P4) (2.00 in August and 2.17 respectively in October).

Table 3. Dynamics of number of shoots in *Plectranthus forsteri* on vertical module levels

Levels	JULY	AUGUST	OCTOBER
P1	2.43	3.00	3.25
P2	2.35	2.44	2.80
P3	1.79	1.83	2.56
P4	1.89	2.00	2.17

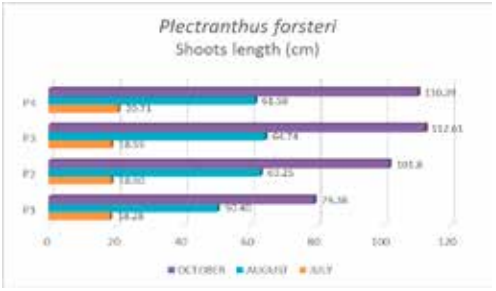

Figure 7. Dynamics of *Plectranthus forsteri* shoots' length on vertical module levels

In July and August, length of shoots per plant did not differ significantly in any of tiers. In October, on levels 2 (P2), 3 (P3) and 4 (P4), length of shoots obtained average values between 101.80 cm (P2) and 112.61 cm (P3). Also in October, on level 1 (P1) plants had an average shoot length of 79.38 cm (Figure 7).

Following Anova Two-Factor with Replication test, values of 1.72E-48 and 0.001565, respectively, were determined for p *value*, both lower than < 0.05, which indicates that both months in which measurements were made and cardinal orientation of the façade influenced the length of the shoots. In addition, interaction between these two factors (month and cardinal orientation) is also significant (p *value* = 0.005981 < 0.05).

Regarding diameter of *Plectranthus forsteri* plants on faces of experimental structure, there were no differences between the average values obtained in the same measurement.

Thus, in July they were in the range of 18.35 cm in the West and 19.96 cm in the South (Figure 8), in August in the range of 22.76 cm in the North and 23.48 cm in the West (Figure 9) and in October in the range of 28.20 cm in the North and 30.50 in West (Figure 10).

Diameter of plant, in control version, was larger than on the faces of vertical module, in each month of observations. It reached an average value of 25.39 cm in July, 35.56 in August and 44.00 cm in October.

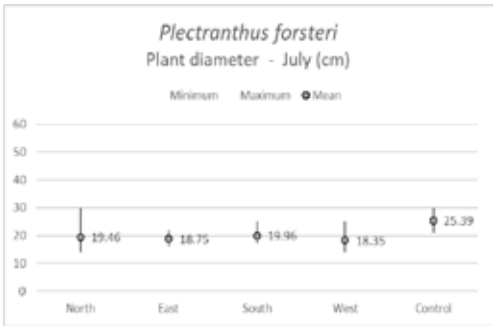

Figure 8. *Plectranthus forsteri* plant diameter on cardinal orientations and control - July 2021

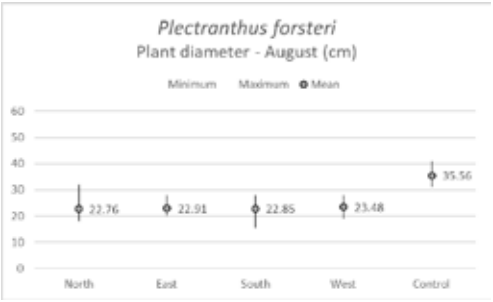

Figure 9 *Plectranthus forsteri* plant diameter on cardinal orientations and control - August 2021

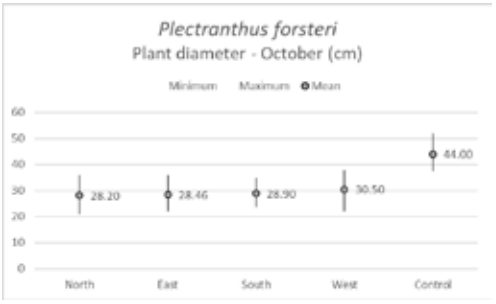

Figure 10. *Plectranthus forsteri* plant diameter on cardinal orientations and control - October 2021

In July, height of *Plectranthus* plants, on the faces, had close average values between 15.70 on North and 17.88 on East and different average values for control variant where a value of 25.75 cm was reached.

Starting from August, they developed differently in terms of height, both between faces of experimental module and between them and control variant. In August and October, the lowest values for this parameter, on the vertical structure, were obtained on Northern orientation (19.17 cm in July and 24.38 cm in August) and the highest on Western orientation (22.36 cm in August and 29.33 cm in October). The East and South orientations occupy the intermediate segment with 19.17 cm (August) and 20.50 (October) on East, respectively 20.48 cm (August) and 27.84 cm (October) on South. At control variant, height of plant reached an average value of 25.75 cm in August and 29.10 cm in October (Figure 11).

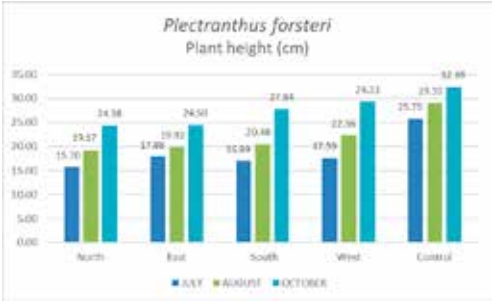

Figure 11. *Plectranthus forsteri* plant height - on cardinal orientations and control

These observations were statistically confirmed by Anova Single Factor test. Height of *Plectranthus forsteri* plant recorded equal average values on faces of experimental module

(p *value* = 0.29284 > 0.05) only in July. In August and October, the averages on cardinal orientations were different (August: p *value* = 0.041368 < 0.05; October p *value* = 0.041368 < 0.05). Compared to control variant, the averages were different in all three months (July: p *value* = 2.7E-10; August: p *value* = 1.16E-12 < 0.05, October: p *value* = 1.84E-12 < 0.05).
Number of shoots per plant had different averages both between cardinal orientations and compared to control variant in all the months in which observations were made (Table 4).

Table 4. Number of shoots in *Plectranthus forsteri* on cardinal orientations and control

Variants	JULY	AUGUST	OCTOBER
North	3.00	3.22	3.33
East	2.00	2.07	2.15
South	2.00	2.33	2.42
West	1.53	1.56	2.20
Control	2.29	4.07	4.93

On vertical structure, the highest number of shoots per plant was obtained on North façade (July: 3.00, August: 3.22, October: 3.33) and the lowest on West façade (July: 1.53; August: 1.56; October: 2.20) and East façade (July: 2.00; August: 2.07, October: 2.15). For control variant *Plectranthus* had the highest number of shoots per plant in August (4.07) and in October (4.93). On the vertical module, length of shoots had a variable evolution during monitoring period. Thus, in July, no different values were registered on any of the faces (p *value* = 0.484353 > 0.05), these being in the range of 18.24 cm on Southern façade and 20.10 cm on Northern façade (Figure 12).

Figure 12. *Plectranthus forsteri* shoots length on cardinal orientations and control - July 2021

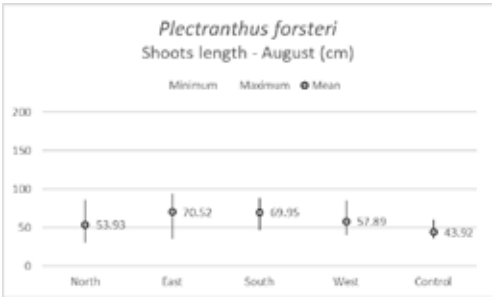

Figure 13. *Plectranthus forsteri* shoots length on cardinal orientations and control - August 2021

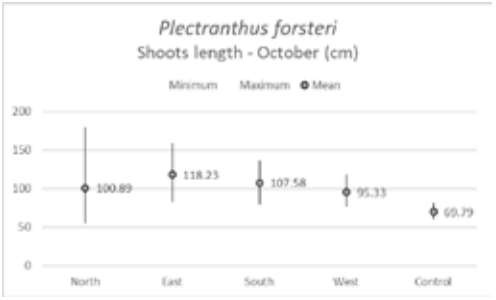

Figure 14. *Plectranthus forsteri* shoots length on cardinal orientations and control - October 2021

In August, the values were different (p *value* = 0.00272 < 0.05), ranging from 53.93 cm in the North to 70.52 cm in the East (Figure 13). In October, the averages become close again (p *value* = 0.063879 > 0.05), lengths of shoots gaining values in the range of 95.33 cm in the West and 118.23 cm in the East (Figure 14).
Between those four façades of the vertical experimental scheme and control variant, the average values are different in all three months in which observations were made (July: p *value* = 3.15E-08 < 0.05; August: p *value* = 2.05E-06 < 0.05; October: p *value* = 1.41E-06 < 0.05). Length of shoots, for control variant, had a moderate increase. If in July, length of shoots at species *Plectranthus* reached the highest average value of all variants - orientation and control - (29.90 cm) in August and October, this parameter recorded the lowest average values between variants (43.92 cm in August and 69.79 cm respectively in October). This development is justified by the culture system used.

Also, in the case of *Coleus blumei*, a high degree of rooting is recorded on the landings. In July, it was between 91.66% on level 3 and 100% on levels 1 (P1) and 2 (P2). Level 1 (P1), as at previous species, recorded the lowest percentage of rooting / survival, which was 75.0% in October (Table 5).

Table 5. *Coleus blumei* - Percentage of rooting/survival rate on levels

Levels	JULY	AUGUST	OCTOBER
P1	100%	83.33%	75.0%
P2	100%	91.66%	91.66%
P3	91.66%	83.33%	79.16%
P4	95.83%	95.83%	91.66%

Initially good rooting percentage and high survival rate were also obtained on cardinal orientations and control. Thus, in July, on experimental module, percentage of rooting varies between 95.83 on North, South and West orientations and 100% on East orientation. It can also be seen that this orientation was the most favourable for *Coleus blumei*, rooting/ survival percentage being, at the end of monitoring period, of 95.83%, the highest value recorded on vertical experimental structure. Similarly, as at previous species, control variant of *Coleus blumei* did not lose any plants during period in which observations were made (Table 6).

Table 6. *Coleus blumei* – Percentage of rooting / survival rate on variants

Variants	JULY	AUGUST	OCTOBER
North	95.83%	87.5%	83.33%
East	100%	95.83%	95.83%
South	95.83%	83.33%	79.16%
West	95.83%	87.5%	79.16%
Control	100%	100%	100%

On levels, in July and August, diameter of *Coleus blumei* plants had a unitary development. The average values were in July between 20.09 cm on level 2 (P2) and 22.40 cm on level 4 (P4) and in August between 23.84 cm on level 2 (P2) and 24.76 cm on level 4 (P4). In October, there are differences for plant's diameter. The biggest difference is between level 1 (P1) where diameter reached an average value of 29.14 cm and level 4 (P4) where the obtained average value was 31.75 cm (Figure 15).

To determine whether the two factors (month in which measurement was performed and the level on experimental module) influenced the diameter of plant, an Anova Two Factor with Replication test was performed.

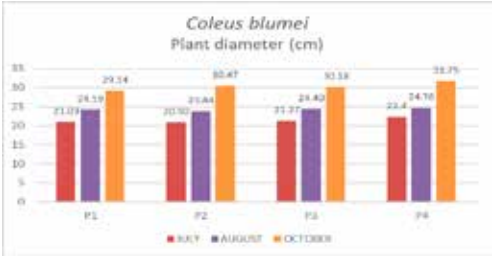

Figure 15. Dynamics of *Coleus blumei* plant diameter on vertical module levels

Thus, calendar month in which measurement was made influenced the diameter of plant, obtaining different average values per month (p *value* = 3.11198E-82 < 0.05). The averages obtained on levels were equal (p *value* = 0.099601017 > 0.05) which indicates that the level did not influence this biometric parameter. For the interaction between calendar month and level was determined p *value* = 0. 848120633 > 0.05 which shows that there is no interaction between those two factors.

Similarly, as in *Plectranthus*, plant height at *Coleus blumei* did not differ significantly in the same measurement. The average values in July were between 13.13 cm on level 2 (P2) and 14.80 cm on level 4 (P4) (Figure 16). In October differences were even smaller, of approx. 0.4 cm between levels.

The order of obtained values, from lowest to highest, is kept in each month in which measurements of biometric aspects were made. Plants on level 1 (P1) have the lowest height in all three sets of measurements. Followed by level (P2) and level 3 (P3) and, finally, with the highest height, the plants on level 4 (P4).

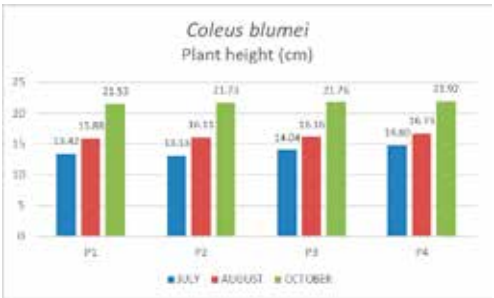

Figure 16. Height dynamics at *Coleus blumei* on vertical module levels

The variation in the number of shoots per plant was insignificant both between levels within the same measurement and between measurements (Table 7). Following Anova Single Factor test, this fact was statistically confirmed, with values higher than 0.05 for p *value* (July: p *value* = 0.216055; August: p *value* = 0.414283 and in October p *value* = 0.695675).

Table 7. Dynamics of number of shoots at *Coleus blumei* on vertical module levels

Levels	JULY	AUGUST	OCTOBER
P1	2.04	2.10	2.28
P2	2.13	2.36	2.41
P3	1.91	2.05	2.16
P4	1.65	1.96	2.14

Regarding length of shoots per plant at *Coleus* species, a p *value* = 0.003788 < 0.05 was obtained in July, which indicates a different development of the shoots per plant in that month. On level 4 (P4), shoots had the longest lengths, average being 18.06 cm. At the opposite pole are plants on level 2 (P2) where length of shoots reached an average value of 14.27 cm.
After measurements, in July, plants were shortened to about 10 cm from the plan of the façade. This pruning was beneficial because, later, development of the shoots of *Coleus blumei* plants on the vertical module was more uniform. In August, the average values for length of shoots received values between 22.05 cm (P1) and 23.14 cm (P4).

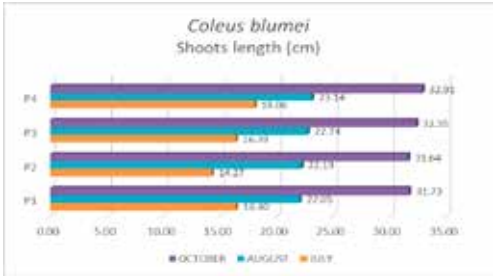

Figure 17. Dynamics of *Coleus blumei* shoots length on vertical module levels

Diameter of *Coleus blumei* plants on the faces of experimental module did not differ between the average values obtained in the same measurement. The lowest values were noted on North façade, and the highest on South façade in all three months in which observations were made.

The average values of diameters on faces of vertical module were in July, between 20.54 cm on North and 21.85 cm on South (Figure 18) in August between 23.65 cm on North and 25.40 cm on South (Figure 19) and in October between 28.70 cm on North and 32.11 on South (Figure 20).
At control variant, plant diameter had values close to the average values obtained on the faces of experimental module. If in July the average was 23.82 cm, higher than any value obtained on experimental structure, in October plant diameter had an average of 28.51 cm, lower than any value obtained on experimental structure in the same month.

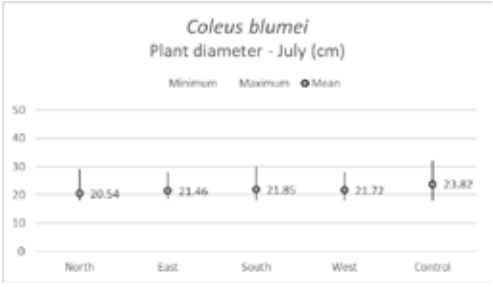

Figure 18. Diameter of the *Coleus blumei* plant on cardinal orientations and control - July 2021

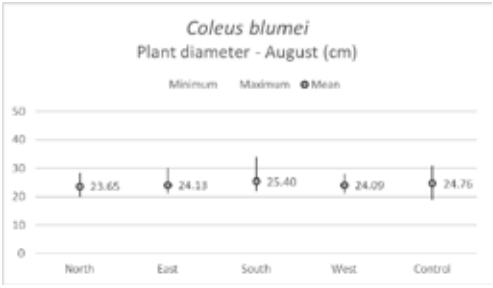

Figure 19. Diameter of the *Coleus blumei* plant on cardinal orientations and control - August 2021

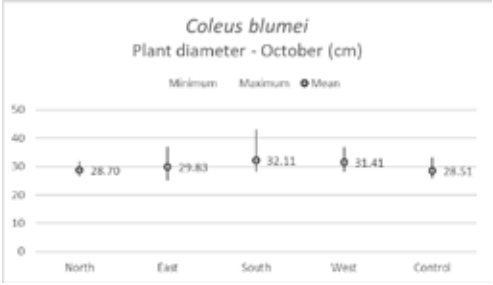

Figure 20. Diameter of the *Coleus blumei* plant on cardinal orientations and control - October 2021

There were no differences in height of *Coleus blumei* plants between faces of experimental module in any month in which observations were made. Statistically, the following values were obtained for p value: July (p *value* = 0.653596), August (p *value* = 0.894886), October (p *value* = 0.443128) higher than 0.05, which confirms the observations done previously. At control variant, plants had a higher height than the one on experimental module, in all monitoring months (Figure 21).

Figure 21. Height of *Coleus blumei* plant on cardinal orientations and control

Statistical analysis performed for all 5 variants (North, East, South, West and control) calculates a p *value* <0.05 (July p *value* = 5.18262E-09; August p *value* = 2.35326E-07; October p *value* = 2.56867E-09) which confirms that plants on the ground developed differently in height than those planted vertically.

The average number of shoots in *Coleus* plants on cardinal orientations and control didn't differ significantly between faces of vertical module or between them and control variant, regardless of month in which observations were made (Table 8). In July, on cardinal orientations, it received values between 1.78 (West) and 2.09 (North) and in October, between 2.00 (West) and 2.50 (North). The highest average value was obtained at control variant, in each month in which observations were made.

Table 8. *Coleus blumei* - Number of shoots on cardinal orientations and control

Variants	JULY	AUGUST	OCTOBER
North	2.09	2.33	2.50
East	1.92	2.04	2.09
South	1.96	2.30	2.42
West	1.78	1.81	2.00
Control	2.42	2.64	2.85

The order of the obtained values was kept by variants in all three sets of measurements. Thus, the lowest value was on West followed by East, South and North.

Between faces of vertical mode, in July and August, the average values for length of shoots don't register differences (July p *value* = 0.405428 and August p *value* = 0.873599, both values being > 0.05) (Figure 22 and Figure 23). In October, however, p *value* = 8.3E-21 < 0.05 indicating that length of shoots was different on cardinal orientations (Figure 24). The highest average value of 38.48 cm was obtained on Southern façade and the lowest on the Eastern one of only 28.99 cm.

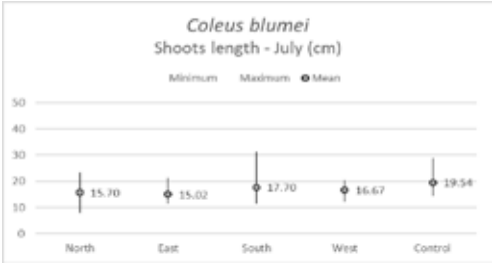

Figure 22. *Coleus blumei* shoots length on cardinal orientations and control - July 2021

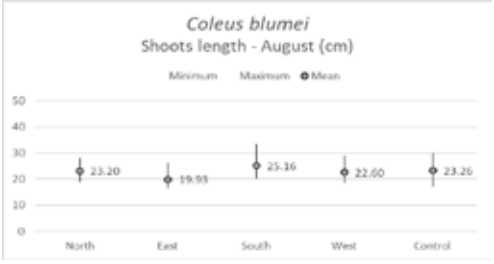

Figure 23. *Coleus blumei* shoots length on cardinal orientations and control - August 2021

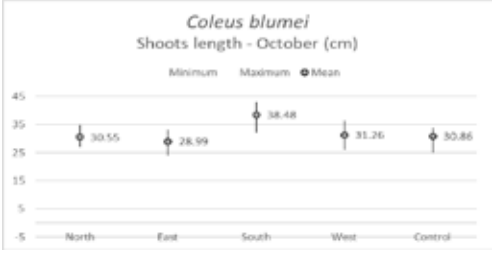

Figure 24. *Coleus blumei* shoots length on cardinal orientations and control - October 2021

At control variant, the obtained values were higher than those on vertical structure of 19.54 cm in July and 23.26 cm in August.

In October, however, the average length of shoots at control variant obtained an average value of 30.86 cm, lower than that obtained in Southern orientation, within the same set of measurements.

CONCLUSIONS

Plectranthus forsteri and *Coleus blumei* have shown high adaptability to vertical planting. They had a high initial rooting and a good survival rate, quickly covering the vertical surface. For *Plectranthus* species, levels 3 (P3) and 4 (P4), respectively Western orientation obtained the best results from this point of view and *Coleus* species on levels 2 (P2) and 4 (P4) respectively on Eastern orientation. At control variant, for both species, the rooting percentage and survival rate was 100% throughout the experiment.

In July and August, both on levels and on faces of experimental module, diameter of *Plectranthus forsteri* plants had a unitary development, within the same set of measurements. In October, there are differences between plants on levels 2, 3 and 4 compared to those on level 1 (P1), where their diameter is lower. A similar evolution was found in the case of *Coleus blumei*, except for October, when on level 4 (P4) plants grew more in diameter.

On the vertical module, length of shoots at *Plectranthus* species had a variable evolution during the monitoring period.

Position of *Plectranthus* plants in vertical system, as well as the hanging character of the plant, favoured growth in length of its shoots, especially on upper levels as well as on Eastern orientation. A similar evolution on levels but with smaller differences was also observed in the case of *Coleus blumei* species. For this, Southern orientation was the most favourable for the increase in length of shoots.

At control variant, *Plectranthus forsteri* had a good behaviour, creating a compact and uniform layer unlike *Coleus blumei* which recorded a more modest behaviour on the ground in the experiment.

Periodic visual evaluation showed that those two species studied maintained their aesthetic values throughout the experience.

At the same time, maintenance works were minimal from establishment until end of the season.

All these recommend these two species to be used in decoration of vertical surfaces. Also, the uniform appearance on ground of *Plectranthus* species recommends it to be used for compact floral borders.

REFERENCES

Chelariu, E.L. (2015). Floricultură – plante de apartament, *Ed. „Ion Ionescu de la Brad" Iaşi*

Chiesura, A. (2004). The Role of Urban Parks for the Sustainable City, *Landscape and Urban Planning* 68:1 129–138.

Cojocariu, M., Chelariu, E.L., Chiruță, C., Amișculesei, P., Bulgariu, E. (2020). The behaviour of *Begonia semperflorens* in vertical systems used for green façades, in climatic conditions specific to the North-Eastern part of Romania. *Scientific Articles USAMV Iaşi - Horticulture Series*, vol. 63, issue 2.

Cojocariu, M., Chelariu, E.L., Chiruță, C. (2022). Study on Behavior of Some Perennial Flowering Species Used in Vertical Systems for Green Façades in Eastern European Climate, *Applied Sciences*, 12(1), 474; https://doi.org/10.3390/app12010474, ISSN: 2076-3417

Dascălu, D.M., Negrea, R. (2016). Plastic waste storage as multifunctional "green" modules for territorial use, *Environmental Engineering and Management Journal*, vol. 15, no. 8, 1855-1866

Draghia, L., Chelariu E.L. (2011). Floricultură*. Ed. „Ion Ionescu de la Brad" Iaşi*, ISBN 978-973-147-074-0

Mănescu, C.R., Dobrescu, E., Nujnoi, S., Toma, F., Petra, S. (2019). Toxic plant species in parks located in city centre of Bucharest, *Scientific Papers. Series B, Horticulture*, vol. LXIII, no. 1, ISSN 2285-5653

Ghazalli Aini Jasmin, Brack, C., Bai Xuemei, Said, I. (2019). Physical and Non-Physical Benefits of Vertical Greenery Systems: A Review, *Journal of Urban Technology*, DOI: 10.1080/10630732.2019.1637694, ISSN: 1063-0732

Pérez-Urrestarazu, L., Fernández-Cañero, R., Franco-Salas, A., Egea, G. (2016). Vertical Greening, Systems and Sustainable Cities, *Journal of Urban Technology* 1–21.

Peschardt, K.K., Schipperijn, J., Stigsdotter, U.K. (2012). Use of Small Public Urban Green Spaces (SPUGS), *Urban Forestry and Urban Greening* 11:3, 235–244.

Price, A., Jones, E.C., Jefferson, F. (2015). Vertical Greenery Systems as a Strategy in Urban Heat Island Mitigation, *Water, Air, and Soil Pollution* 226:8, https://doi.org/10.1007/s11270-015-2464-9

Toma, F. (2009). *Floricultură și artă florală, volumul III, Specii utilizate ca plante în ghivece pentru decorul interioarelor*, Ed. Invel Multimedia.

Toma, F., (2009). *Floricultură și artă florală, volumul IV, Specii utilizate pentru decorul parcurilor și grădinilor*, Ed. Invel Multimedia.

***https://plants.ces.ncsu.edu/plants/plectranthus-forsteri-marginatus/

***https://plants.ces.ncsu.edu/plants/coleus-scutellarioides/