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GROWING DYNAMICS OF CELOSIA TAXA

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Abstract
In a small plot experiment were tested four Celosia cultivars in a raised bed over two vegetation seasons (2022-2023). In 2022, 'Rózsalovag' and 'Aranybika' were taller and had larger lateral dimensions compared to the other two varieties. Regarding the number of flowers, a balanced trend was observed for 'Rózsalovag' throughout the growing season. In 2023, there were minor differences in the vegetative parameters, with the smallest lateral size observed in 'Aranybika'. 'Rózsalovag' and 'Arrabona' exhibited the highest ornamental value. In the drier year of 2022, all the investigated cultivars produced a statistically higher number of flowers compared to 2023. The results of the experiment also highlight the climate resilience and significance of these selections.

1 Introduction

The genus *Celosia* is native to the tropical regions of Africa and South America [20], belongs to the family *Amaranthaceae* and has about 60 species. It can be used in public spaces, gardens, balconies, indoors as a potted plant or cut flower [10], and in its native habitat it is also used as a food and medicinal plant [15].

The wild form is *Celosia argentea* [6], whose large-leaved varieties are the traditional leafy vegetable of West and Central Africa and are used as fodder and the flowers are also eaten in many places. It is also used in traditional medicine in Africa, China and Japan [25]. Its leaves contain phenolics, flavonoids, saponins, alkaloids, tannins, carbohydrates, glycosides, protein, gums, mucilage, vitamins [6] and betalains [13]; [17].

When we talk about *Celosia*, the ornamental plant, we usually think of a variety of *Celosia argentea*: *Celosia argentea var. plumosa* – with characteristic feather-like inflorescence, *Celosia argentea var. cristata* – its inflorescence resembles a cock's comb, *Celosia argentea var. spicata* – its inflorescence are narrow spike-like inflorescence [15], which can be grown for cutting, used fresh or dried [3].

In our study we are investigating *Celosia argentea var. plumosa* (plumed cockscomb), a contrasting annual ornamental species that is well suited to mixed beds, can be used as a border plant [1], and can be used in larger patches, larger flowerbeds and pots [26]. Because of its hairy, light habit, it is often planted in gardens and public areas [8]. Tolerant to moderately tolerant of high salinity soils [2]; [14].

Hungarian-bred annual ornamental plants have excellent drought tolerance and heat tolerance and are among the most climate change tolerant plants [7]. They bloom for a long time and have a strong branching capacity, so their maintenance is economical [22]. Fewer seedlings are needed per unit area [1]. Varieties that can tolerate extreme conditions are recent and are considered to be Hungarikums with a high demand on the world market [10].

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Celosia argentea var. plumosa is one of the most popular and successful species [22]. Its varieties branch from each leaf axil. The panicles of the lateral shoots, which form after the development of the central inflorescence, do not outgrow it [12] and thus form a dense, uniform floral display [16], the main ornament of the inflorescences are the many colorful bract leaves, which do not lose their color even under the influence of strong radiation [18].

2 Method

2.1 Location of the experiment

The tests were carried out in Kecskemét, on the campus of John von Neumann University (Izsáki street 10.). A community garden was created here in the spring of 2022 in the area an abandoned tennis court. As the soil in the area is heavily compacted red clay, the plants were placed in raised beds. The height of the beds is 20 cm, and the surface area is 2 × 3 m. The soil used is compact and has a high nutrient content. The examined beds are located in a sunny area with drip irrigation system.

2.2 The plant material of the experiment

Seed of *Celosia* taxa was purchased from the Marosi Horticulture in Csemő both years, and seedlings were grown in propagation tray 108 in the greenhouse of the Faculty of Horticulture and Rural Development in Mészöly Gyula Square. The seedlings were planted into the raised beds on 16 May 2022 and 23 May 2023. After rooting the plants were fertilized every two weeks during the growing season at a concentration of 1 part per thousand using the Master 20-20-20+TE complex fertilizer. In addition, the mechanical weeding was part of maintenance. The varieties tested were as follows:

- ‘Aranybika’: panicles lemon-yellow, brush-like, leaves light green. Height 40-45 cm, well branched, produces 12-14 inflorescences [19].
- ‘Arrabona’: inflorescences are bright orange red, turning red from mid-summer, leaves light green. Height 45-50 cm, very good branching capacity, produces 15-18 inflorescences. The second best known and most successful *Celosia* variety [19]. It is still very popular today with its colour-transparent inflorescences [8]. It is very drought tolerant [23], winning the title of Ornamental Plants of the Year in 2013 [24]. It is well tolerant of drought and heat [4], and is resistant to climatic extremes [9]. [11] treated seeds of the cultivar ‘Arrabona’ with gamma radiation to increase genetic diversity.
- ‘Bikavér’: the panicle inflorescence starts to open with a burning red color, then turns to a darker burgundy color by mid-summer. Another special ornamental value is the burgundy stems and leaves. Height 40-45 cm, good branching, develops 12-14 inflorescences [19]. One inflorescence bloom for 8-10 weeks. Tolerates high heat and high rainfall. It gives a striking color [21]. It is still a very popular variety [8].
- ‘Rózsalovag’: large, light pink panicle, light green leaves. Height 40-45 cm, very well branched, develops 14-15 inflorescences per stem [19].

2.3 Method of examination

Measurements were taken over two years during the part of the growing season when the development and ornamental value of the plants was most prominent. In 2022, the number of measurement occasions was 6 between June and September, while in 2023, the stands were evaluated 3 times in June and July, at two-week intervals.

To record the vegetative parameters, we used a metal measuring tape, with the help of which we recorded the maximum width, length and height of each individual with centimeter accuracy, as well as counting the number of flowers and floral buds per stem.

The measurement data were recorded in Microsoft Excel. Data was analyzed using the statistical software package SPSS 25 (IBM, New York, USA). Significant differences were determined using Tukey’s test (SL=0.05).

3 Results

3.1 Year 2022

From the data in *Figure 1*, the ‘Rózsalovag’ and the ‘Aranybika’ are taller than the other two taxa. The difference is not only in height, but also in horizontal parameters. ‘Arrabona’ and ‘Bikavér’ have a length and width of between 20-25 cm, the other two varieties have a lateral extension of between 25-30 cm. The ‘Aranybika’ shows a significant increase in height (15 cm) during the examined period. The other parameters of the other varieties increased only slightly between the summer surveys. Several individuals of the ‘Arrabona’ and ‘Rózsalovag’ had died by the second half of August, so their data are not shown in *Figure 1*.

When observing the flowers, a balanced trend was observed in the case of ‘Rózsalovag’. The average number of flowers ranged between 12 and 14 during this period of more than two months. The ornamental value of ‘Aranybika’ and partly of ‘Arrabona’ increased steadily until the first decade of August. For ‘Bikavér’, flower numbers also increased, but the peak of the decorative period was extended, with the highest number of flowers detected in early September. ‘Arrabona’ showed the highest number of buds in most of the dates measured. At the beginning of flowering, the first measurement date, the number of buds exceeded the number of flowers in three varieties (‘Aranygömb’, ‘Arrabona’, ‘Bikavér’).

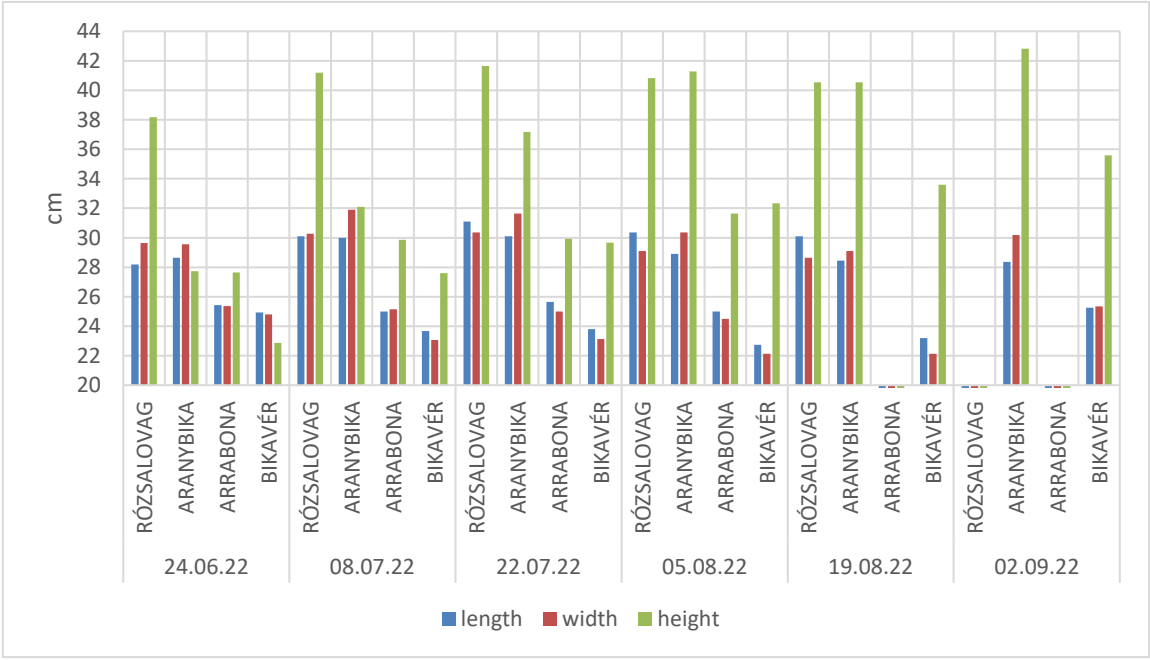

Figure 1. Vegetative development of Celosia argentea taxa in the year 2022 (average of stock)

3.2 Year 2023

The vegetative parameters showed minor differences this year. The lateral dimensions of the four examined taxa were almost identical (with maximum values of around 30 cm). The smallest was the ‘Aranygömb’ with a length and width of 27.08-27.67 cm. In terms of height, values of around 50 cm were recorded in the last measurement (28 July 2023). A significant change in height was observed in the period between the last decade of June and mid-July, when all four species elongated by 15-20 cm. Changes in the horizontal parameters were much more moderate during the measurement period (maximum increase of 10 cm or less).

The flowering period in this growing season started in the second decade of July (*Figure 2*). However, between the first and second measurement date, not only the number of flowers but also the number of buds increased significantly. ‘Rózsalovag’ and ‘Arrabona’ had the greatest decorative

value, and by the last days of July, the latter surpassed ‘Rózsalovag’ in the number of flowers. In terms of flower numbers, we experienced the lowest values in the case of ‘Aranybika’ (*Figure 2*).

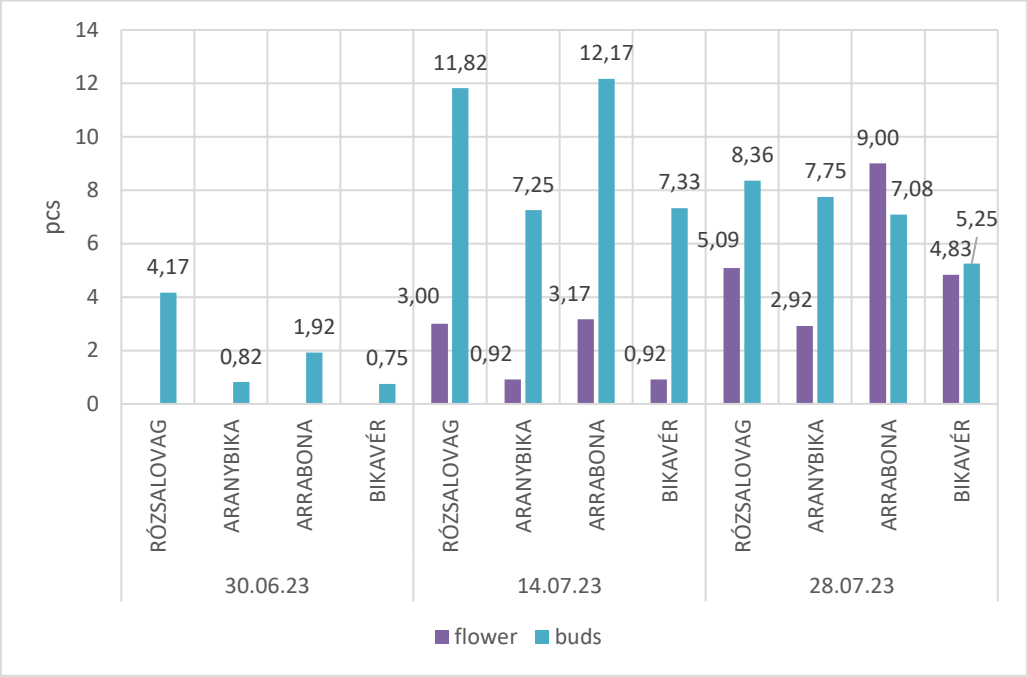

Figure 2. Generative development of Celosia argentea taxa in the year 2023 (average of stock)

3.3 Statistical evaluation

‘Rózsalovag’

Among the five examined parameters, the three vegetative (length, width and height) and two generative (number of flowers and buds) showed a close, two-way correlation (Pearson correlation value SL<0.001), so we examined them together using a three- and a two-factor MANOVA. Only plant length (Table 1) showed a significant difference between the two years (F=4.477, SL<0.005), not the other two parameters. The length of the tested plants of the cultivar ‘Rózsalovag’ was less in 2022 than in 2023. Significant differences were found for the generative parameters in both cases (F=70.859 for flowers, F=23.516 for buds, SL<0.001 in both cases). The specimens produced more flowers in 2022, while the number of buds was higher in 2023.

‘Aranybika’

Based on the correlation test, the five parameters were analyzed in three analyses: the two horizontal vegetative sizes were analyzed together with the number of buds in a three-factor MANOVA, while the flowers and plant heights were evaluated separately in a one-factorial analysis of variance. The results of MANOVA showed that the two horizontal parameters of the plants were significantly different in the two years studied (F value for length 14.208 and 22.309 for width data, SL<0.001 in both cases), but no statistical difference was found in the number of buds (SL=0.306>0.05). The plant population showed a stronger increase in the horizontal dimension in the first year (Table 1). A strong significant difference was also observed in the number of flowers (F=28.342 SL<0.001). The stand developed more flowers in the first year of the study than in 2023. The situation was reserved for height (F=7.578 SL=0.008Í0.05), with an average height of 32.33 cm in 2022 and 39.06 cm in 2023.

‘Arrabona’

The situation for this variety was similar to that of ‘Rózsalovag’ after the correlation test. The three vegetative parameters (length, width and height) and the two vegetative parameters (flower and bud number) were tested together. The three-factor MANOVA showed significant results for all values (SL<0.001 in all three cases). The plant population was smaller in the first (2022) year, while a significantly larger size was observed in the 2023 growing season. A strong difference (SL<0.001)

was also observed for flowers (Table 1). However, no significant difference was observed when comparing buds (SL=0.243>0.05). The number of flowers was higher in the year 2022.

'Bikavér'

The correlation values showed that the vegetative parameters and the number of buds were related (SL<0.05 for all pairwise correlations), while a separate one-factor analysis of variance was used to examine the number of flowers. The MANOVA table showed that the vegetative parameters tested showed a very strong (SL<0.001, in all three cases) and a strong (SL<0.05) significant difference in bud number between the two years. The values were lower in the 2022 growing season for length, width, height and bud number. Statistical analysis of the number of flowers showed that the ornamental value of this variety was significantly (SL=0.039<0.05) higher in 2022 than in 2023 (Table 1).

Table 1. Data on vegetative and generative parameters of Celosia argentea varieties in the first half of the growing seasons 2022 and 2023 (average of annual measurements)

Variety name	*Length*	*Width*	*Height*	*Nr. of flowers*	*Nr. of floral buds*
'Rózsalovag' 22	29.79 cm×	30.09 cm	40.33 cm	13.52 pcs×	2.82 pcs×
'Rózsalovag' 23	33.50 cm×	30.32 cm	43.56 cm	2.62 pcs×	8.00 pcs×
'Aranybika' 22	29.58 cm×	31.03 cm×	32.33 cm×	7.06 pcs×	4.33 pcs
'Aranybika' 23	25.14 cm×	25.56 cm×	39.06 cm×	1.28 pcs×	5.25 pcs
'Arrabona' 22	25.36 cm×	25.17 cm×	29.14 cm×	8.04 pcs×	5.88 pcs
'Arrabona' 23	33.64 cm×	30.19 cm×	40.22 cm×	4.06 pcs×	7.06 pcs
'Bikavér' 22	24.13 cm×	23.67 cm×	26.17 cm×	3.31 pcs×	2.87 pcs×
'Bikavér' 23	30.50 cm×	29.67 cm×	45.03 cm×	1.92 pcs×	4.44 pcs×

Note: in the case marked with an asterisk, there is a significant difference when comparing the two years (at SL=0.05 value)

4 Discussion

The 'Arrabona' and 'Bikavér' varieties were significantly smaller in 2022, when the monthly rainfall was 37.2 mm (June) and 1 mm (July), and the mean monthly temperature was 22.4°C (June) and 23.9°C (July) [5]. In contrast, in 2023, 84.3 mm of precipitation fell in June with a mean temperature of 20.5°C, while in July there was 26.1 mm of rainfall in Kecskemét and the mean temperature was 23.8°C, almost the same as in the previous year [5]. The drier weather and higher temperatures reduced the vegetative size of the plants in these varieties, which then did not reach the expected height reported in the literature [18]. From the point of view of decorative value, however, the most significant development is the number of flowers, which was significantly more in the drier and higher temperature year 2022 for all tested varieties. All taxa also reached the number of panicles reported in the variety descriptions [18] in 2023. So, the results of the experiment support the climate tolerance of these selections and the fact that their importance will remain in the future despite the warming and increasingly arid summers.

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