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EFFECT OF TYTANIT TREATMENT ON VEGETATIVE AND GENERATIVE PARAMETERS OF *RUDBECKIA HIRTA* CULTIVARS

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Abstract

Tytanit biostimulant treatment was applied to the Rudbeckia hirta varieties 'Aranyálom', 'Mackó' and 'Napfény' in the 2024 and 2025 vegetation periods, in a microplot experiment, in a raised bed. The vertical spread of the plants fell short of the values given in the variety description. The diameter of the capitulum inflorescences and the final height of the individuals also decreased after the biostimulant treatment compared to the untreated area. There was no significant difference in the number of inflorescences between the varieties studied and the treatments, only the two test years were statistically distinguishable from each other. No differences were observed in the diameter of the inflorescences between the varieties. In both test years, the vitality of the stands was outstanding, and no plant protection treatment was necessary. The applied treatment proved to be neutral for all parameters tested for the three tested taxa.

1 Introduction

The *Rudbeckia* genus consists of approximately thirty species native to North America. The genus includes annual, biennial, and perennial species [9], which are specifically prairie plants [4] [16]. *Rudbeckia* species can be easily integrated into urban environments, as they vary in size and their yellow, orange, red, or brown flowers are striking and highly decorative. They can be combined with both annual and perennial plants [6].

Rudbeckia hirta (black-eyed Susan) is a short-lived perennial, blooming profusely in the first year and its ornamental value decreases significantly from the second year, therefore it is used exclusively as an annual [22]. It is a widespread species in peasant gardens, which is currently experiencing a renaissance [7]. It is 60-100 cm tall, has a strong stem, forms well in bushes, and its large inflorescences bloom on long stems at the ends of branched shoots [21] [28]. The ray florets are yellow; the disc florets are blackish purple and sit in prominent cone-shaped receptacle [25]. The basal leaves are large, elongated-ovate. The stem and leaves are rough to touch and hairy [21] [28]. It can be used in public flower beds to create larger spots of color, either alone or in mixed beds [22] [20], in perennial beds [25], in containers [13] and in the home garden, and can also be used as an

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occasional cut flower [18] [19]. It is also used as a medicinal herb [3], has anti-inflammatory effects [4]. In North America, it is used in traditional medicine [29], and in homeopathy [14]. Its insecticidal properties have also been recognized [30].

It is sun-loving, moderately water-demanding species [21] [28], requires medium nutrient content, well-permeable soil [25]. It is propagated by sowing seeds [21] [28], the seedling growing period is 12 – 13 weeks [23]. Micropropagation plays a role in the selection and propagation of new varieties [26] [27]. It is a long-day plant, it needs more than 13 hours of light per day to flower [1].

The Hungarian-bred varieties ('Napfény', 'Glória', 'Mackó', 'Aranyálom', 'Sárgarigó', 'Botond', 'Kokárdás', 'Liliput', 'Őszi fény') are tetraploids [23], have excellent drought tolerance, have strong stems, are not prone to tilting or breaking in the wind, branch profusely and bloom abundantly [28]. The petal circle of the ray florets is thick and stiff, so the inflorescences are very durable, decorating the stem for up to a month. The petals are resistant to radiation and do not burn. The opened inflorescences are "overgrown" by new inflorescences, so the ornamental value of the individuals is always excellent [23]. The Marosi Tree Nursery in Csemő produces, selects, standardizes and promotes the *Rudbeckia hirta* varieties of excellent ornamental value, bred for the Hungarian climate. The grown seeds are sold to local governments for planting in public areas [15].

Due to climate change and increasing urbanization, Hungarian-bred varieties are becoming decreasingly suited to the changing climate and market demands [5].

A research group at the Hungarian University of Agriculture and Life Sciences has developed a new variety called 'Shady Girl' through mutation breeding, which was produced from the Rudbeckia hirta 'Őszi fény' variety [9]. As a result of mutation breeding, individuals with better abiotic stress tolerance are common [8]. Gamma-irradiation is a suitable method for breeding *Rudbeckia hirta*, as it promotes the creation of new, stress-tolerant varieties [10] [5]. The mutation induced by gamma radiation may pave the way for further urban application of *Rudbeckia hirta* in light of urbanization [11]. Titanium can be considered a biostimulant [17]. TYTANIT® is a liquid mineral fertilizer containing titanium, which helps plants use nutrients much faster. It has a positive effect on increasing the viability of pollen, enhances photosynthesis and increases the resistance of plants to fungal diseases. It increases yield and resistance to abiotic stress (adverse weather, environmental and growing conditions). TYTANIT® can be used in many agricultural and horticultural crops [31]. Its active ingredient is titanium sulfate 8.5 g/l (0.8 m/m). In addition to increased nutrient uptake, it has been proven to increase photosynthesis, because it increases the chlorophyll content of leaves by 50-60%. It significantly reduces the effects of drought stress during the growth phase. It increases biomass (stem, leaf) by 40-50% [32]. In the case of tomatoes, spraying TYTANIT has a positive effect on vegetative growth and increased yield [12]. The use of TYTANIT® to alleviate physiological stress caused by salinity in *Fragaria vesca* did not have the desired effect [2].

2 Material and Method

2.1 Location of the experiment

The tests were conducted on the campus of John von Neumann University in Kecskemét (Izsáki street 10). Here, a community garden was established in the spring of 2022 on the site of an abandoned tennis court. As the soil in the area is heavily compacted slag, the plants were placed in raised beds. The beds are 20 cm high and have an area of 2×3 m. The garden soil used has a high nutrient content and a compact structure. The tested bed is located in a sunny area and is equipped with a drip irrigation system.

2.2 The material of the experiment

The seeds of the *Rudbeckia* taxa were purchased from the “The Marosi Tree Nursery” in both years, from which seedlings were grown in propagation trays 108 in the Mészöly Gyula square greenhouse of the Faculty of Horticulture and Rural Development. The seedlings were planted in the raised beds on May 30, 2024, and June 16, 2025. In both years studied, after the plants had rooted, the plants planted in one of the beds were treated twice with TYTANIT® as a foliar fertilizer, at a dose of 2 ml per 10 liters of water. During the vegetation period, nutrient solutions were applied every

two weeks at a concentration of 1 permille using the Master 20-20-20+TE complex fertilizer. In addition, mechanical weeding was part of maintenance.

The varieties tested were the following:

- 'Aranyálom': 35-40 cm tall, inflorescence diameter 7-8 cm, 45-50 inflorescences per stem, ray florets are golden yellow, disc florets are rusty brown [23].
- 'Napfény': 80-85 cm tall, inflorescence diameter 10 cm, ray florets are golden yellow, rigid, form a right angle with the calyx and the stem, disc florets are rusty brown, 8-10 flower stalks per plants [23], tetraploid variety, good wind resistance [21] [28], overwinters in mild winters [24].
- 'Mackó': 40-45 cm tall, inflorescence diameter 12-13 cm, the petals of the ray floret are dark, warm brownish in tone, with washed-out shades of yellow and brown, they form a right angle with the stem, the disc florets are dark brown, 20-25 inflorescences open simultaneously [23].

2.3 Method of investigation

Measurements were carried out over two years during part of the vegetation period in which the development and ornamental value of the plants were most striking. The number of measurement occasions in 2024 and 2025 was 5-5 between June and August, at two-week intervals. A metal measuring tape was used to record the vegetative parameters, with which we measured the greatest width, length and height of each individual with centimeter accuracy, and we counted the number of flowers and buds per stem. At the peak of the flowering period, we measured the diameter of 30 inflorescences per variety in both the control and treated areas.

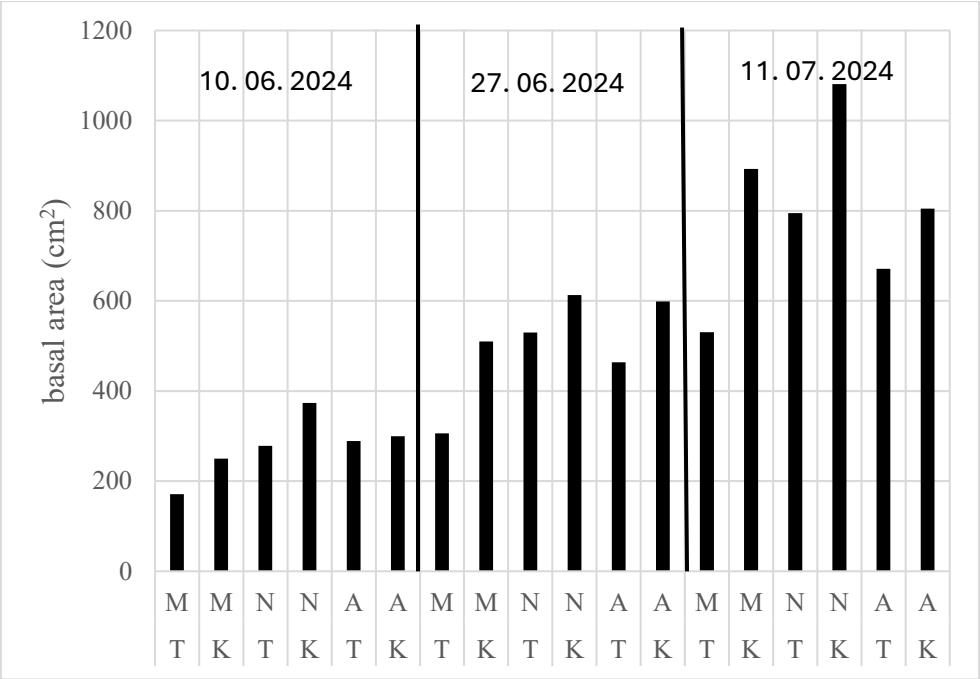
The basal area of the examined individuals was compared. The width and length data were averaged and then divided by two. The resulting radius was used to calculate the basal area of the plants. The measurement data were recorded in Microsoft Excel. Data was analyzed using the SPSS 29 statistical software package (IBM, New York, US), using analysis of variance method. Significant differences were determined using the Tukey test (SL=0.05).

3 Results

There was a strong two-way correlation between the four parameters examined (plant area, height, number of inflorescences and buds) (Pearson correlation SL value < 0.001 for all pairwise comparisons), so the four factors were analyzed together in a four-factor MANOVA test.

3.1 Development of varieties in 2024

The development of the plants was continuous during the study period (between June 10 and July 11, 2024). The plants reached 530-1080 cm^2 in four weeks from the 170-370 cm^2 area recorded at the beginning of the measurement (Figure 1). Thus, they doubled or tripled their size. The treated stand of the ‘Mackó’ variety had the smallest horizontal parameter at all three measurement times. The control plants of the ‘Napfény’ produced the highest average value. The control stands outperformed the treated plant groups at all measurement times and for all varieties. Significant differences emerged for all three varieties by the last measurement time.



M- ‘Mackó’, N- ‘Napfény‘, A- ‘Aranyálom’, T-treated, K-control

Figure 1. Horizontal spread of Rudbeckia hirta varieties under TYTANIT treatment, in raised beds, in 2024 (average of stands)

Among the varieties, ‘Aranyálom’ had the smallest plant height. From an average of 8-11.5 cm measured on June 10, it reached a final growth of 45-52 cm by July 11. ‘Mackó’ showed a size between 60-70 cm, while ‘Napfény’ showed a size between 70-80 cm at the last measurement date. It can also be stated with this vegetative parameter that the plants in the control stands showed stronger growth than in the treated area (the only exception to this was 'Aranyálom' in the initial measurements).

Inflorescences were not found during the first measurement; in the second measurement, only a negligible amount was found (0.1-0.7 pcs/plant). The ornamental value of the taxa was significant from the beginning of July, when the untreated stand of the ‘Napfény’ variety was outstanding (5.5 pcs/plant) compared to the other groups (1.6-3.7 pcs/plant). On July 29, 2024, the number of inflorescences of all examined plant stands showed a value between 6 and 10 pcs/plant. At this time, the control stands already had a higher average value compared to the groups treated with Tytanit.

The number of buds per plant ranged between 0.1-0.6 pcs/stem for all varieties and treatments at the beginning of June. Subsequently, the value of this generative parameter was outstanding during the second and third recording (values between 2-5.1 pcs/stem). The highest number of buds were developed by the control group of 'Napfény' (5 pcs/stem, on June 27, 2024) and the control individuals of 'Aranyálom' (5.1 pcs/stem, on July 11, 2024). By the last measurement date (July 29, 2024), the average number of buds in all stands decreased (1.3-2.4 pcs/stem).

3.2 Development of varieties in 2025

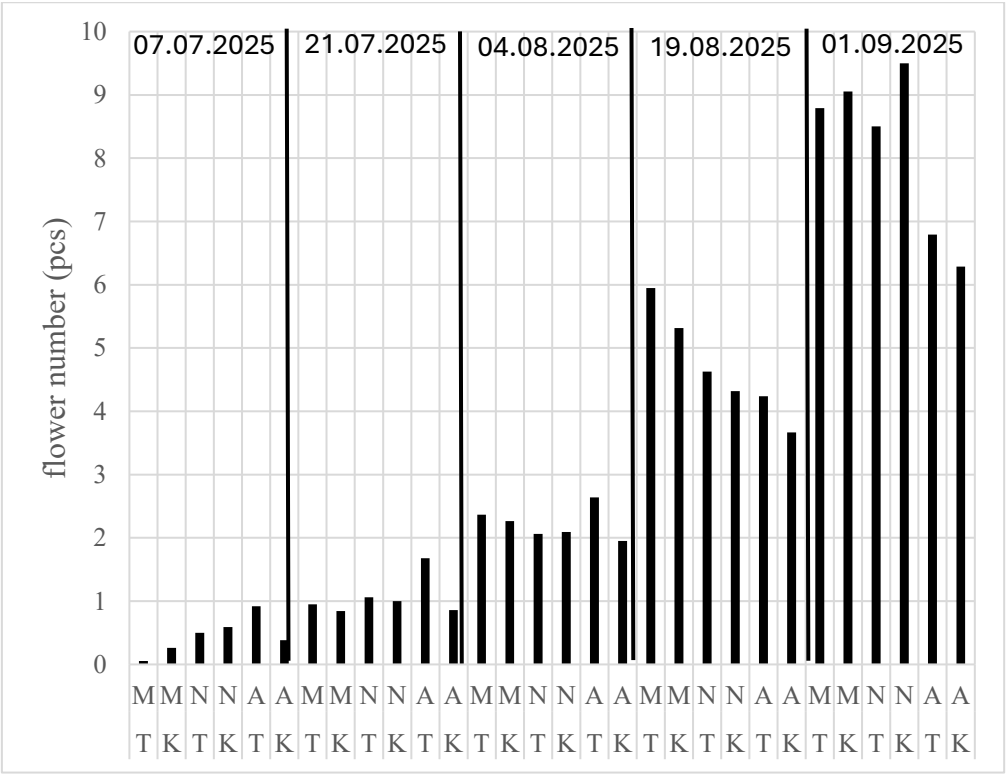
The average area of the examined plant groups did not reach 200 cm^2 on the first two measurement dates (June 24, July 7, 2025). By July 21, the horizontal parameters were in the range of 250-450 cm^2. The largest was the treated stand of 'Napfény', and the smallest was the control stand of 'Mackó'. On the fourth measurement occasion, the treated specimens of the 'Napfény' variety had already reached an average value of 825 cm^2, while the other 5 plant groups were in the size category of 630-680 cm^2. The differences partially disappeared on the last vegetative measurement occasion (August 19, 2025), when the stands showed values between 1035-1085 cm^2 (the treated group of 'Aranyálom', however, only reached an area of 840 cm^2).

In terms of plant height, the individuals of the taxon ‘Aranyálom’ were the smallest (final height 34 cm), while the stands of the other two varieties showed a nearly similar size (final height: ‘Mackó’

– 52-56 cm, ‘Napfény’ – 53-54 cm) in most of the measurement times. The vertical development was very balanced and dynamic during the two-month period examined (from June 24 to August 19), the stands grew by 5-15 cm in two weeks during this period.

Flowering in this vegetation began on July 7 (Figure 2), although at that time we found only sporadically developed capitulums (0.25-0.92 pcs/plant). No significant increase occurred in the following two weeks (average inflorescence numbers per plant: 0.84-1.68 pcs). The more intensive decorative period began in the first decade of August, when the average values approached or exceeded the average value of 2 pcs/plant for all varieties and treatments. After two weeks, the number of inflorescences in all stands doubled (3.7-5.9 pcs/plant). The highest decorative value was then possessed by the individuals of ‘Mackó’. At the last measurement, the two taller varieties (‘Mackó’ and ‘Napfény’) produced an average number of inflorescences of nearly 9 pcs/plant, while the ‘Aranyálom’ plant group developed an average of 6.3-7.0 inflorescences.

The number of buds per plant was similar to that of the inflorescences. At the beginning of July, it remained below the average value of 1 pc/plant in all areas (0.32-0.95 pcs/stem), while it increased slightly by the end of July (0.81-1.53 pcs/stem). After that, a large increase was observed, so that by August 4, the number of buds of the two tall varieties ('Mackó', 'Napfény') approached 4 pcs (3.75-4 pcs/stem), while in the case of 'Aranyálom' we calculated an average value of 2.34-2.56 pcs. This parameter showed the highest value on August 19, when the average value was 4 or more in all stands. The highest number of buds was measured in the ‘Napfény’ control (6.45 pcs/plant), the ‘Napfény’ treated (5.93 pcs/plant) and the ‘Mackó’ control (5.58 pcs/plant) plant groups. In the other three cases, values between 4 and 5 were recorded. By the first of September, the number of buds had decreased to between 2 and 3.5.



M- ‘Mackó’, N- ‘Napfény‘, A- ‘Aranyálom’, T-treated, K-control

Figure 2. Flower number of Rudbeckia hirta varieties after TYTANIT treatment, in raised beds, in 2025 (average of stands).

3.3 Comparison of varieties

The statistical analysis showed a strong, significant difference when comparing the varieties in the case of horizontal spread (MANOVA F=7.453; SL<0.001) and height (F=59.477 SL<0.001). The individuals of the ‘Mackó’ had a significantly smaller ground cover (478.29 cm^2), compared to which the specimens of the ‘Napfény’ variety had a significantly larger extent (595.21 cm^2). The

group of ‘Aranyálom’ plants did not differ statistically from the other two tested varieties (525.09 cm^2). Regarding height, the three taxa were classified into three statistically separate groups by the pairwise comparison test (Tukey test). The stand of the ‘Napfény’ variety had the largest vertical parameter (40.72 cm). The ‘Mackó’ variety was of medium size (34.73 cm), and the ‘Aranyálom’ variety was the smallest (25.3 cm) in this two-year study.

No statistically significant differences could be detected during the analysis of the number of flowers and buds. Based on the average values, the ’Napfény’ variety showed the highest average values for both generative parameters (1.82 flowers; 2.74 buds), but there was no significant difference compared to the less decorative ’Mackó’ (1.39 flowers) and ’Aranyálom’ (2.44 buds) taxa. A significant difference was observed in terms of inflorescence diameters. ’Aranyálom’ had the smallest inflorescence (10.11 cm). ’Mackó’ was in the middle, homogeneous group (10.83 cm), while ’Napfény’ had the largest parameter (11.43 cm) based on the results of the two-year experiment.

3.4 Effect of treatment

The biostimulant treatment had a significant effect on the vegetative parameters of the plant stand. MANOVA analysis revealed a difference in the area (F=8.914 SL<0.005) and height (F=6.147 SL<0.05) of the treated and control *Rudbeckia* plants. In both cases, the control stand had the higher value. There was no statistically significant difference in the generative parameters (Table 1).

Table 1. Comparison of vegetative and generative parameters of Rudbeckia stands under the influence of TYTANIT biostimulator treatment (averages of measurement data series from 2024-2025)

Treatment	horizontal size*	plant height*	number of flowers	number of buds
control	570,68 cm^2	35,37 cm	1,66 pcs	2,7 pcs
Tytanit	494,89 cm^2	32,38 cm	1,62 pcs	2,4 pcs

Note: the values in the columns marked with an asterisk are significantly different from each other (MANOVA SL<0.05).

Examining the diameters of the inflorescences, a statistical difference could also be detected: the capitulums of the *Rudbeckia* specimens in the control stand were significantly larger (11.18 cm) than those of the specimens treated with TYTANIT (10.53 cm).

3.5 Comparison of study years

The effect of year was detectable in both plant height and flower number based on the statistical analysis. MANOVA indicated a strong, significant effect in both cases (F value for height 21.569, for flower number 35.397, SL value for both parameters less than 0.001). The average height of the entire examined stand was more than 5 cm higher in 2024 (36.54 cm) than in 2025 (30.98 cm). The weather in 2025 had a positive effect on the flowers: then the average number of flowers was 2.11, while in 2024 the same value was 1.21. There was no statistical difference in the horizontal extent of the stand (521.12 cm^2 in 2024, 545.1 cm^2 in 2025) and the number of buds (2.54 in 2024, 2.56 in 2025).

4 Conclusions

Based on our research, the horizontal spread (ground cover) of the short growing ‘Aranyálom’ is medium, while ‘Mackó’ is narrow, and ‘Napfény’ has a more robust spreading habit based on the statistical analysis. This parameter can of course be influenced by several factors, but from a maintenance point of view, a difference of more than 100 cm^2 can be significant. The lateral spread of the plants was not affected by the effect of the year, thanks to the well-tolerant, undemanding parent species, but at the same time, the treated stand became significantly smaller as a result of the TYTANIT treatment. Since this liquid fertilizer basically affects the stress tolerance of plants, the size-reducing effect (width and height) requires further studies.

In terms of height, all three taxa were lower compared to the size reported in the literature, in the case of the ‘Napfény’ variety we experienced a significant reduction in size in 2025, which can be partly attributed to soil sickness and partly to planting two weeks later. In terms of flower numbers,

however, 2025 was significantly more decorative than the previous year, with compact, lower plants developing more inflorescences. The difference is likely due to weather differences.

In terms of the diameter of the inflorescences, ‘Aranyálom’ and ‘Napfény’ developed 1-2 cm larger, while ‘Mackó’ developed 1-2 cm smaller capitulums than the data in the variety description. At the same time, thanks to this, the stand showed a uniform image, as there was no noticeable difference in the size of the inflorescences between the varieties. The diameter of the inflorescence was significantly reduced by the TYTANIT treatment. The effect of the applied fertilizer on stress tolerance was not examined separately, but it could be established that the stands (both control and treated) were healthy in both years, no plant protection problems occurred, and no individual mortality was experienced.

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