The influence of some rooting biostimulators on *Chrysanthemum* cultivars via stem cuttings

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ABSTRACT

Chrysanthemum is one of the top cultivated flowers, the undisputed queen of gardens in the autumn season. Due to its exceptional decorative qualities having a special range of shapes and colors, storage resistance, suitability in different cultivation systems and the possibility of cultivation all over the year chrysanthemum is one of the most loved and appreciated flowers. It is one of the major crops worldwide and it is cultivated as cut flowers and potted plants, depending on market demand. In Romania, nowadays, the cultivated areas with *Chrysanthemum* are developing quickly through potted cultures which have gained a significant increase. Also, due to the progress made in the selection of chrysanthemums, many cultivars have been introduced in the recent plant assortment. The present study was carried out to evaluate the influence of three rooting biostimulators on five potted chrysanthemums cultivars to determine the most efficient way to obtain a significant result for roots and aerial part's growth and development. The greatest effects of rooting were obtained with Radistim 1 biostimulator. In which case was determined an increase of rooting percentage, number of roots, the height of plants, number of leaves and number of branches.

Keywords: *Chrysanthemum*, cuttings, rooting, potted plants, propagation, cultivars.

INTRODUCTION

Chrysanthemum in many countries, including the United States, China and Japan, is considered the number one crop (Cockshull, 2019). *Chrysanthemum* flowers are mainly used for cut flower, loose flowers for garland making, general decoration, hair adornments and religious functions (Kumar, 2015). However, nowadays, can be found in landscape architecture arrangements or private gardens (Vidraşcu and Teodorescu, 1993; Anderson, 2007), but also in flower shops and floral design using the most cultivated species for the production of cut flowers, both in a greenhouse and in the field is *Chrysanthemum × hortorum* Hort. (Cantor, 2016; Su *et al.*, 2019). Due to the diversity of shapes and sizes of the inflorescence, the multitude of colors, its suitability for modern homes, make this flower species to be highly appreciated by the general public, and can be grown sustainably while simultaneously providing an economic benefit for growers.

The dwarf and compact growing types (spray chrysanthemums) are cultivated as potted plants for decorating indoors and outdoors whereas the erect and tall growing types (standard chrysanthemums) are grown as cut flowers for bouquets and vase decoration

(Singh and Chettri, 2013). Chrysanthemums are used either as cut flowers or grown in pots and the success in the cultivation of this plant is principally due to the great diversity of cultivars (Jamal Uddin *et al.*, 2015). Generally, due to the richness of shapes and colors, chrysanthemums can be combined with each other, but can also be combined with other flowering species. As a cut or in potted flowers, chrysanthemums can be used for numerous occasions all year round (Buta *et al.*, 2013).

Chrysanthemums are mostly propagated by the vegetative method by cuttings (Toma, 2009). There is, however, great variability in the ability to form adventitious roots and regenerate new individuals by cuttings. Some cultivars are relatively easy to propagate by cuttings, however some species have a low capacity to root (Cojocariu and Tănase, 2019). The cuttings are harvested from mother plants especially cultivated and set up for this purpose. They are harvested from the shoots that have grown at the base of the bushes, when they have reached a length of 8–10 cm and 4–5 leaves, after which they are shaped by removing the leaves from the base on 3–4 cm long and cut 1/3 of the top of the leaves to reduce transpiration (Vidrașcu and Teodorescu, 1993).

Rooting of cuttings is done at a temperature of 20–22°C, and relative humidity of 80–90%. Rooting time is between 23–25 days, which could be season or plant depending.

Treatment with biostimulators is considered to have an important influence in increasing the rooting process and the percentage of rooted cuttings. Hormone treatment is one of the most important factors due to enhance the initiation of the root primordia and growth through cell multiplication (Fogasa and Fett-Neto, 2005). Hormones support the mobilization of sugars and nutrients by the hydrolysis of starch to the base of the cuttings (Das *et al.*, 1997). The plant growth regulators like auxin are used to increase the percentage of rooting in stem cuttings for quick root initiation and to increase the number of roots per cutting (Garande *et al.*, 2002). A new method of propagation of chrysanthemum through leaf cuttings complementary to the conventional method of shoot tip propagation was developed under *in vivo* conditions by Singh and Chettri, (2013), leaf cuttings were treated with a combination of plant growth regulators (IBA and Kinetin). This propagation technique is particularly useful when propagating material is scarce as from a small quantity of initial propagating material, a large number of plants can be produced.

The present study presents the effect of some growth regulators on the rooting of mum cuttings and their influence on the morphological and biometrical characteristics of obtained plants.

MATERIALS AND METHODS

The experiment was carried out at the University of Agricultural Sciences and Veterinary Medicine, at the didactic greenhouse of the Floriculture, during the season, 2019–2020.

Five cultivars of potted *Chrysanthemum* plants were used as mother plants: 'Avalon cream', 'Avalon orange', 'Avalon purple', 'Ditto pink', 'Ditto dark pink' (Figure 1).

From each of the five cultivars, terminal (top) stem cuttings were taken from healthy mother plants, at the end of February. The cuttings were prepared as 6–8 cm cuttings, the first pairs of leaves were suppressed and only 3–4 leaves were left on the top. The rooting biostimulators used were: Radistim 1 and Razormin. The treated cuttings were planted in a substrate consisting of peat and perlite 1:1 ratio.

The studied factors were: **Factor A:** the chrysanthemum cultivar, with five graduations: a₁ – 'Avalon cream'; a₂ – 'Avalon purple'; a₃ – 'Avalon orange'; a₄ – 'Ditto pink' and a₅ – 'Ditto dark pink' and **Factor B:** the type of rooting biostimulator with three graduations: b₁ – Untreated (Control); b₂ – Radistim 1; b₃ – Razormin.

Through the combination of factors and their graduations, 15 experimental variants resulted, which were placed in randomized blocks, in 3 replicates each. Control was the untreated variant. There were 10 cuttings per treatment for each cultivar, a total of 30 cuttings/cultivar with a total of 450 cuttings.

Figure 1. Chrysanthemum biological materials: 'Avalon cream' (a), 'Avalon purple' (b), 'Avalon orange' (c), 'Ditto pink' (d), 'Ditto dark pink' (e)

After 25 days observations were made on the percentage of rooting and after 8 weeks days biometric measurements were taken and the cuttings were planted in pots. The observations and determinations were made consisting measurements of the dimension and number of roots/cutting, length of roots and plants were recorded - height of cuttings, number of branches/plants, number of leaves/per plant, number of roots per cutting.

The data were interpreted statistically by calculating the average of experience, and the differences between the variants were established by analysing the variance and using the Duncan test (Ardelean *et al.*, 2005).

RESULTS AND DISCUSSIONS

It can observe that the average number of cuttings rooted was 26.27 out of a total of 30, and the variability depending on the variation between 21 (untreated cuttings) and 30 (cuttings treated with Radistim 1) (Table 1). The rooting percentage for each experimental variant was between 66.66% ('Avalon orange' – untreated) and 100.00% for 'Avalon cream' and 'Avalon purple' treated with Radistim-1. All five cultivars studied in the experiment treated with Radistim 1 had over 93.33% rooting percentage. In a study, Cojocariu and Tănase (2019), reported that the rooting capacity of chrysanthemum cuttings could be also influenced by substrate. Rotting could be influenced by the stem type, from basal shoots or the stem tip of the vegetative growth period, although a higher yield was observed at cuttings and shoots grown at base (Johti *et al.*, 1987).

In the current study, it was analysed the combination of A factor (cultivar) and B factor (treatment) on the high of rooted cutting, number of shoots, number of leaves, number of roots and interaction between these traits. 'Ditto dark pink' obtained the highest values in terms of rooted cutting height (12.50 cm) with significant superior differences compared with other studied cultivars. No significant differences were determined between cultivars 'Avalon orange' (9.50 cm) and 'Ditto dark pink' (12.50 cm) regarding the height of the rooted cuttings (Table 2).

Table 1. Results obtained at the cuttings rooting

No. Var.	Cultivar	Treatments	Number of cuttings	Number of rooted cuttings	Rooting percentage (%)
1	'Avalon cream'	Untreated	30	24	80.00
		Radistim-1	30	30	100.00
		Razormin	30	29	99.66
2	'Avalon purple'	Untreated	30	25	83.33
		Radistim-1	30	30	100.00
		Razormin	30	29	99.66
3	'Avalon orange'	Untreated	30	20	66.66
		Radistim-1	30	29	99.66
		Razormin	30	27	90.00
4	'Ditto pink'	Untreated	30	22	73.33
		Radistim-1	30	28	93.33
		Razormin	30	26	86.66
5	'Ditto dark pink'	Untreated	30	21	70.00
		Radistim-1	30	29	99.66
		Razormin	30	25	76.67
Average experience (Control)				26.27	87.57

Table 2. Influence of cultivar on the height of rooted cuttings

No. var.	Cultivar	Height of rooted cuttings (cm)	Significance of difference*
1	'Avalon cream'	10.50	AB
2	'Avalon purple'	11.50	AB
3	'Avalon orange'	9.50	A
4	'Ditto pink'	11.50	AB
5	'Ditto dark pink'	12.50	B

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

The results presented in Table 3 demonstrate the influence of the treatment on the height of the rooted cuttings, highlighting the importance of Radistim 1 hormonal treatment. Cutting treated with this substance achieved an average height of 12.9 cm.

Table 3. Influence of treatment on the height of rooted cuttings

Nr. var.	Biostimulator (treatment)	Height of rooted cuttings (cm)	Significance of differences*
1	Untreated	7.4	A
2	Radistim-1	12.9	B
3	Razormin	9.8	AB

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

At the first four experimental variants the interaction between cultivar and treatment does not influence the height of rooted cutting. In the same way, in the case of treatment with Razormin the results are almost similar except for 'Avalon purple' cultivar. However, at v_6 , v_8 , v_9 , v_{10} interaction between cultivar and hormonal treatment with Radistim 1 has an important influence on the height of rooted cuttings. Cultivars as 'Avalon cream', 'Avalon purple', 'Avalon orange', 'Ditto pink' and 'Ditto dark pink' present significant differences comparing with 'Avalon purple' (Figure 2).

Figure 2. Influence of cultivar × treatment interaction on height of rooted cuttings. Bars represent standard errors. Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

As it is presented in Table 4, the cultivar (factor A) has no influence on rotted cuttings branches; no significant differences were reported. Analysing Table 5, results from the second experimental factor (B) – hormonal treatment does not influence rotted cuttings branches, in the same way as the first factor (A).

Table 4. Influence of factor cultivar on the number of branches

No. var.	Cultivar	Number of branches	Significance of differences*
1	'Avalon cream'	2.10	A
2	'Avalon purple'	1.95	A
3	'Avalon orange'	1.85	A
4	'Ditto pink'	1.95	A
5	'Ditto dark pink'	2.25	A

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Table 5. The influence of the treatment on the number of branches

No. var.	Treatment	Number of branches	Significance of differences*
1	Untreated	1.65	A
2	Radistim-1	2.15	A
3	Razormin	1.98	A

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Figure 3. The influence of cultivar × treatment interaction on the number of branches. Bars represent standard errors. Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Regarding the influence of the interaction of cultivar and biostimulator and as the results shown in Figure 3 no significant differences were obtained, described variants forming a homogeneous group symbolized by the letter A.

Table 6. The influence of cultivar on the number of leaves of the plant

No. var.	Cultivar	Number of leaves	Significance of differences*
1	'Avalon cream'	8.50	BC
2	'Avalon purple'	7.30	AB
3	'Avalon orange'	6.70	A
4	'Ditto pink'	9.00	C
5	'Ditto dark pink'	9.80	C

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

The highest average value of the number of leaves formed was recorded for cultivar 'Ditto dark pink' (9.80 as average) and the lowest value was for cultivar 'Avalon orange', an average of 6.70 leaves. Data presented in Table 6 demonstrate that from the five studied cultivars 'Ditto pink' (9.00) and 'Ditto dark pink' (9.80) achieved a higher number of leaves than the other studied cultivars.

Similar results were obtained by Cojocariu and Tănase (2019) at *Chrysanthemum indicum* 'Carmina', the greatest number of leaves formed was determined for TSF (top stem fragment) cuttings in peat substrate 100% – 9.12 leaves as average, and the lowest value was for perlite (average 7 leaves).

It was determined the significant influence of hormonal treatment on the number of leaves, with major impact of both biostimulators Radistim 1 (9.40 leaves), followed by Razormin (8.20 leaves), while the number of leaves in case of untreated cuttings was only 6.25 (Table 7).

Table 7. The influence of treatment on the number of leaves of the plant

No. var.	Variant (treatment)	Number of leaves	Significance of differences*
1	Untreated	6.25	A
2	Radistim-1	9.40	B
3	Razormin	8.20	AB

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Figure 4. The influence of cultivar × treatment interaction on the number of leaves of the plant. Bars represent standard errors. Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Cultivar 'Ditto pink' presented the highest number of roots (11.50). Differences comparing with cultivars V₁, V₂, V₃ and V₅ were statistically significant (Table 8).

Table 8. The influence of cultivar on the number of roots

No. var.	Cultivar	Number of roots	Significance of differences*
1	'Avalon cream'	8.83	A
2	'Avalon purple'	9.50	A
3	'Avalon orange'	9.40	A
4	'Ditto pink'	11.50	B
5	'Ditto dark pink'	9.70	A

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Treatment with Radistim 1 presents significant differences in the case of the number of roots (11.50) comparing with the control variant (Table 9).

Table 9. The influence of treatment on the number of roots

No. var.	Variant (treatment)	Number of roots	Significance of differences*
1	Untreated	8.60	A
2	Radistim-1	11.50	C
3	Razormin	10.30	AB

*Notes: Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

Regarding the number of roots in the interaction of cultivar and rooting treatment with biostimulators, variants v_6 , v_7 , v_9 and v_{10} , treated with Radistim 1 obtained significant differences compared to the untreated variants followed by the variants treated with Razormin (Figure 5). The best results at the cultivar interaction with Radistim 1 treatment are reported at 'Avalon cream' and 'Avalon purple', which registered over 15 roots/rooted cuttings.

Similar results were obtained by Petter, (1992). The literature indicates a correlation between cultivar and rooting success of the cuttings, but with the use of IBA in different concentrations, the results were obtained for Chrysanthemum cv. Crimson Robe, cv. Polario, cv. Escort, cv. Sterling and cv. Luysona at 50 ppm IBA, by spraying or immersing in root stimulator, thus obtaining a more compact root system.

Figure 5. The influence of cultivar × treatment interaction on the number of roots. Bars represent standard errors. Letters represent the statistically significant difference at $p < 0.05$ (Duncan test)

CONCLUSIONS

Propagation by cuttings using different rooting biostimulators is a reliable technology that is applied for commercial purposes because it allows the large-scale production of a wide range of species especially *Chrysanthemum*. Treatment of cuttings is a crucial step in the adventitious root formation of chrysanthemum because it is a major exogenous factor affecting root formation and development of cuttings.

Radistim 1 obtained better results in the rooting of chrysanthemum cuttings and showed significance in the vegetative growth of cuttings. The rooting percentage was over 98.53% for Radistim 1 at all studied cultivars followed by the Razormin with 90.53%, while the untreated cuttings rooted only in a percentage of 74.66%.

Based on the observations it can be concluded that rooting of the cuttings at *Chrysanthemum* is cultivar and biostimulator dependent. Our study could be useful for growers and flower companies to select the greatest and treatment for cultivation.

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