Influence of substrate and plant growth regulators on the rooting of *Chrysanthemum*

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Abstract. The purpose of the research is to study the influence of the substrate and plant growth stimulants on the rooting of cuttings of some varieties of *Chrysanthemum coreanum* (H. Lev. & Vaniot) Nakai garden group 'Multiflora'. Four varieties of *Chrysanthemum* introduced into the South-Ural Botanical Garden-Institute of Ufa Federal Research Center of Russian Academy of Sciences ('Sunbeam Bronze Bicolor', 'Meridian Red', 'Ditto Dark Pink' and 'Daybreak Apple Blossom') were used as research objects. We examined the influence of two types of substrates (sand and vermiculite) and four growth stimulants on the rooting of chrysanthemums (Zircon, Lignohumate brand AM potassium, Beres Super seaweed extract, Beres AminoComplex). It was revealed that the treatment of chrysanthemum cuttings with plant growth regulators contributed to an increase in the number (by 7−117%) and length of roots (by 3−118%) in the majority of the studied objects. It was noted that positive results from the use of preparations were obtained when chrysanthemum cuttings were placed in vermiculite, in contrast to options with sand as a substrate. It has been shown that the greatest effect is noticeable when cuttings are soaked in Beres AminoComplex and Beres Super solutions compared to the control option. Varietal differences in chrysanthemums to the effects of root formation stimulants during vegetative propagation have been revealed. Thus, in the varieties 'Ditto Dark Pink' and 'Daybreak Apple Blossom', an improvement in the biometric parameters of cuttings was observed when rooted in vermiculite after exposure to plant growth regulators. It was noted that when chrysanthemum cuttings are soaked for three hours, in contrast to their wetting, the number of roots increases by 38−88% in all variants of the experiment.

1 Introduction

Chrysanthemums are one of the oldest perennial ornamental crops of the autumn flowering period, which occupy the second place in the yield of flower products in the world [1, 2].

The 'Multiflora' garden group of *Chrysanthemum coreanum* (H. Lev. & Vaniot) Nakai appeared relatively recently, quickly gaining the attention of amateur gardeners and landscape designers with its abundance of flowering and winter hardiness [3]. It is

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distinguished by its genetic ability to form a spherical bush shape without pinching or pinching due to the strong branching of shoots [4, 5]. The demand for this group of chrysanthemums is steadily growing, since they are low-growing and suitable for forming a flower border, as well as a container crop [6]. Multiflora is widely used in green construction in many cities in Europe, Japan and China [7].

The simplest method of vegetative propagation in chrysanthemums is dividing the bush. However, due to the small number of planting units obtained from one mother plant, it is used quite rarely [8]. Therefore, green cuttings can be considered the best way to propagate chrysanthemums. The advantage of this method is that in young individuals obtained by cuttings, the root system is completely renewed, while during division some of the old coarsened roots are preserved.

It is known that chrysanthemum is an easily rooted crop in various soil and artificial substrates [9]. However, the quality of the root system of young plants, their further growth and development is influenced by many factors, including the use of root formation stimulants during cuttings [10].

The purpose of the research was to study the effect of substrate and plant growth stimulants on the rooting of cuttings of some varieties of the *Chrysanthemum coreanum* (H. Lev. & Vaniot) Nakai garden group ‘Multiflora’.

2 Materials and research methods

We studied the influence of two types of substrates (sand and vermiculite), as well as four types of growth stimulants on the rooting of chrysanthemums:
− Zircon (root formation and growth stimulator, anti-stress preparation) – solution 1,0 ml/l;
− Lignohumate brand AM potassium (natural growth stimulator) – solution 9,0 ml/l;
− Beres Super seaweed extract (hereinafter referred to as Beres Super) (natural growth biostimulator based on seaweed extract) – solution 15,0 ml/l;
− Beres AminoComplex (highly active biostimulant) – solution 15,0 ml/l.

Chrysanthemum coreanum (H. Lev. & Vaniot) Nakai garden group ‘Multiflora’ was used as mother plants: ‘Sunbeam Bronze Bicolor’, ‘Meridian Red’, ‘Ditto Dark Pink’ and ‘Daybreak Apple Blossom’ (Figure 1). Donor plants of these varieties initially grew in open ground conditions, then were transplanted into containers and transferred to a heated greenhouse. In the second ten days of February, when their growing season began, thirty cuttings were taken for each experimental variant. The tips of young shoots grown on mother plants were used as cuttings.

‘Sunbeam Bronze Bicolor’

‘Meridian Red’

‘Ditto Dark Pink’

‘Daybreak Apple Blossom’

Fig. 1. Objects of study – varieties of *Chrysanthemum coreanum* garden group ‘Multiflora’

The experiment was carried out in ten variants in triplicate. We also considered two methods of processing cuttings: wetting the sections and soaking them in solutions of plant growth stimulants for three hours. Cuttings of cuttings of ‘Sunbeam Bronze Bicolor’ and ‘Meridian Red’ varieties of control plants were moistened in water, and experimental ones − in solutions of growth stimulants, in doses recommended by the manufacturers. Cuttings of the varieties ‘Ditto Dark Pink’ and ‘Daybreak Apple Blossom’ were soaked for three hours in solutions of the studied preparations. Half of the plants were rooted in sand, the other half in vermiculite. Propagation and care of cuttings was carried out according to known methods [9].

30 days after rooting and growth of the cuttings, ten specimens were selected from each experimental variant for biometric study: the length and number of first-order roots were measured.

Mathematical processing of experimental data was carried out using standard methods [11] using statistical packages of the Microsoft Excel 2003 program and the AgCStat add-in [12].

3 Results and its discussion

Wetting sections of chrysanthemum cuttings. As a result of the study, it was revealed that when vermiculite is used as a substrate for rooting, an increase in root length is observed by 12−93% in most experimental variants, while the number of roots decreases by 7−43% (Table 1).

Table 1. The influence of substrate and growth stimulants on the rooting of cuttings of some varieties of *Chrysanthemum multiflora*

Varieties	Substrate	Options	Root length, cm	Number of roots, pcs.
‘Sunbeam Bronze Bicolor’	Sand (control)	Water (control)	3,86±0,83	3,63±0,44
		Zircon	2,00±0,65	1,17±0,72
		Lignohumate	3,57±0,72	2,43±0,97
		Beres Super	4,00±0,44	2,48±0,65
		Beres AminoComplex	5,00±0,79	3,55±0,86
	Vermiculite	Water (control)	5,43±0,48	2,06±0,48
		Zircon	3,86±0,59	1,55±0,51
		Lignohumate	4,00±0,38	1,08±0,36
		Beres Super	5,29±0,68	2,29±0,54
		Beres AminoComplex	4,29±0,47	2,37±0,67
‘Meridian Red’	Sand (control)	Water (control)	7,00±0,71	4,98±0,48
		Zircon	8,75±0,48	5,01±0,63

		Lignohumate	10,75±2,75	4,80±1,06
		Beres Super	7,25±1,49	5,55±1,09
		Beres AminoComplex	10,25±0,63	5,51±0,35
	Vermiculite	Water (control)	10,25±2,56	2,98±0,32
		Zircon	9,25±1,49	2,78±0,13
		Lignohumate	10,50±0,29	2,23±0,56
		Beres Super	13,25±2,95	2,35±0,42
		Beres AminoComplex	13,50±0,65	3,40±0,39

According to the literature, regulators of root formation and plant growth have different biological activities [13]. When wetting of cuttings of the 'Sunbeam Bronze Bicolor' variety were wetted in the version with sand with a solution of Lignohumate and Zircon, lower root length and number of roots were observed compared to the control (by 7,5−48,2 and 33,1−67,8%, respectively). Treatment with Beres Super had virtually no effect on the length of the roots, but reduced the number of roots by 31,7% compared to the control. Wetting with Beres AminoComplex solution, on the contrary, contributed to an increase in root length by 29,5%, but had virtually no effect on their number.

In cuttings of the 'Meridian Red' variety in the variants with Zircon and Lignohumate, an increase in root length was noted by 25,0 and 53,6%, respectively, compared to the control, while the number of roots changed slightly. Wetting with Beres AminoComplex solution caused an increase in the length of roots and their number by 45,45 and 10,6%, respectively, compared to the control. In cuttings whose sections were moistened with Beres Super, the length of the roots did not change significantly, but their number increased by 11,4% compared to the control.

In cuttings of 'Sunbeam Bronze Bicolor' placed in vermiculite in the variants using Lignohumate and Zircon, lower values of length (by 26,3−28,9%) and number of roots (by 24,7−47,5%) were observed compared to control. Wetting cuttings of Beres Super did not significantly affect the length of the roots, but contributed to an increase in their number by 11,2%. In variants using Beres Amino complex, a 21,0% shorter length of roots was observed than in the control variant, but a 15,1% greater number of roots compared to the control (Figure 2).

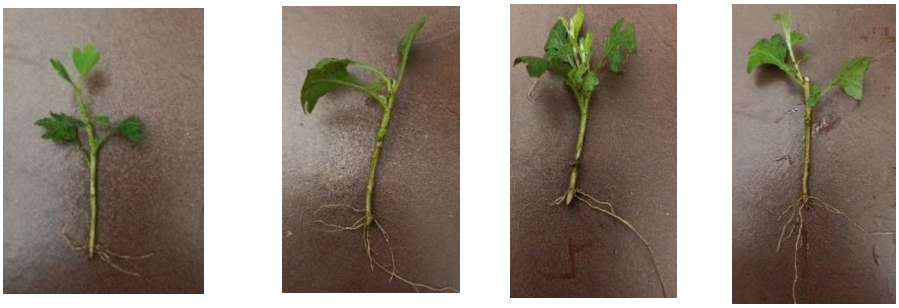


Fig. 2. The influence of substrate and growth stimulants on the rooting of cuttings of the 'Sunbeam Bronze Bicolor' variety

In cuttings of 'Meridian Red', sections of which were moistened with Beres AminoComplex, an increase in the number of roots and their length was recorded by 31,7 and 14,1%, respectively, compared to the control. The use of Beres Super promoted root growth by 29,3% compared to the control, while their number decreased by 21,1%. When treated with Zircon, a decrease in the length and number of roots was observed by 9,8 and

6,7%, respectively, compared to the control. The use of Lignohumate slightly increased the length of roots, but reduced their number by 25,2%.

Our research allowed us to draw the following conclusions: the best substrate for rooting chrysanthemum cuttings of the *Chrysanthemum coreanum* garden group 'Multiflora' is vermiculite. The effect of growth stimulants on the length and number of roots is variety-specific, which is consistent with the conclusions of other authors [5, 14]. Thus, cuttings of 'Sunbeam Bronze Bicolor' were more favorably influenced by wetting Beres Super (the length of the roots changed slightly, the number of roots increased by 11,2%), and cuttings of the variety 'Meridian Red' turned out to be more responsive to wetting Beres AminoComplex (length and number of roots increased by 31,7 and 14,1% compared to control).

Soaking chrysanthemum cuttings. As a result of the study, it was revealed that when vermiculite is used as a substrate for rooting cuttings of 'Daybreak Apple Blossom', an increase in root length is observed by 13,0−23,8% in most experimental variants, while the number of roots decreases by 5,6−64,6% compared to rooting in sand (Table 2).

Table 2. The influence of substrate and growth stimulants on the rooting of cuttings of some varieties of *Chrysanthemum coreanum* garden group 'Multiflora'

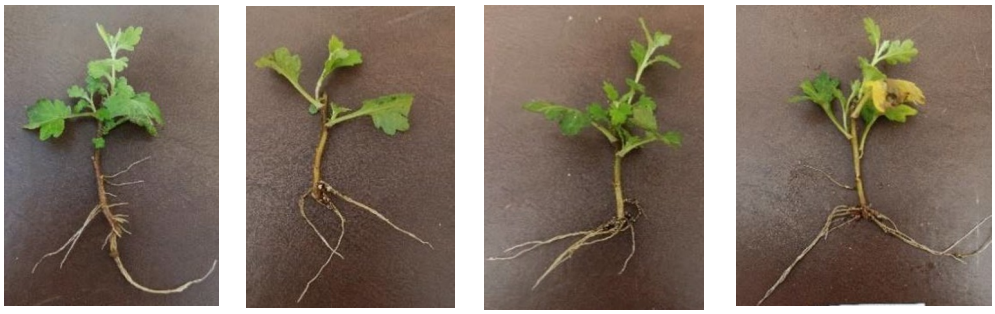
Variety	Substrate	Options	Root length, cm	Number of roots, pcs.
'Ditto Dark Pink'	Sand (control)	Water (control)	4,63±0,69	10,00±0,55
		Zircon	4,20±0,32	7,20±1,66
		Lignohumate	1,01±0,09	9,00±1,97
		Beres Super	4,39±0,64	9,80±0,80
		Beres AminoComplex	5,76±0,38	8,80±0,97
	Vermiculite	Water (control)	4,12±0,79	5,60±1,08
		Zircon	4,17±0,86	9,40±1,21
		Lignohumate	4,40±0,24	8,80±1,46
		Beres Super	4,63±0,65	10,40±1,12
		Beres AminoComplex	4,52±0,51	9,20±0,86
'Daybreak Apple Blossom'	Sand (control)	Water (control)	3,61±0,52	13±1,95
		Zircon	4,04±0,51	10,6±0,87
		Lignohumate	3,28±0,44	9,6±1,03
		Beres Super	4,16±0,44	9±0,95
		Beres AminoComplex	4,69±0,75	12,8±0,86
	Vermiculite	Water (control)	2,43±0,84	4,6±1,63
		Zircon	5,00±0,17	10±1,92
		Lignohumate	3,83±0,66	4,4±0,51
		Beres Super	5,01±0,82	9,2±1,02
		Beres AminoComplex	5,30±0,42	8,2±0,97

In experiments with cuttings of 'Ditto Dark Pink', a mixed picture was observed. In variants with soaking in Beres Super, when rooted in vermiculite, the length and number of roots increased by 12,4 and 85,7% compared to the control. In cuttings soaked in Zircon and Beres AminoComplex and placed in vermiculite, a decrease in root length was noted by 3,8 and 21,5%, respectively, while the number of roots increased by 30,5% and 4,5%, respectively, compared to rooting in sand. When cuttings were soaked in Lignohumate and placed in vermiculite, an increase in root length by 335% was observed, while their number decreased slightly by 2,2% compared to rooting in sand. Cuttings standing in water took less root in vermiculite; a decrease in the length and number of roots was observed by 11,0

and 44,0% respectively. Thus, further study of the influence of the substrate on the rooting of chrysanthemum cuttings of the *Chrysanthemum coreanum* garden group 'Multiflora' is necessary.

When comparing the effect of preparations on the rooting rates of 'Ditto Dark Pink' cuttings when placed in sand, it was revealed that when they are soaked in a Beres AminoComplex solution, an increase in root length is observed by 24,4% compared to the control, while the number of roots decreases by 12,0%. In other variants of the experiment, a decrease in the parameters of length (by 5,1−78,1%) and number of roots (by 2,0−28,0%) was observed compared to the control.

When cuttings of 'Ditto Dark Pink' treated with the studied preparations were placed in vermiculite, an increase in the length and number of roots was observed by 1,2−12,4% and 57,2−85,7% respectively, compared to the control variant. The most dramatic change in parameters was observed in the variant with Beres Super treatment (Figure 3).



Sand Water | Vermiculite Water | Vermiculite Beres Super | Vermiculite Beres AminoComplex

Fig. 3. The influence of substrate and growth stimulants on the rooting of cuttings of the 'Daybreak Apple Blossom' variety

When cuttings of 'Daybreak Apple Blossom' were placed in sand, an increase in root length was observed in the variants treated with Zircon, Beres Super, Beres AminoComplex by 11,9−29,9%; in the variant with Lignohumate, a decrease of 9,1% was noted. At the same time, the number of roots decreased by 1,5−30,7% compared to the control.

When vermiculite was used as a substrate, the treated plants showed an increase in root length by 57,6−118,1%, while the number of roots increased in most experimental variants by 78,2−117,3%, compared to the control, with the exception of the variant with Lignohumate, where the number of roots changed slightly.

4 Conclusions

It was revealed that the treatment of chrysanthemum cuttings with plant growth regulators (Zircon, Lignohumate, Beres Super, Beres AminoComplex) contributed to an increase in the number and length of roots in most of the studied objects.

It was noted that positive results from the use of preparations were obtained when chrysanthemum cuttings were placed in vermiculite.

It was shown that the greatest effect was achieved by soaking chrysanthemum cuttings in solutions of Beres AminoComplex and Beres Super.

Varietal differences in chrysanthemums to the effects of root formation stimulants during cuttings have been revealed. Thus, in the varieties 'Ditto Dark Pink' and 'Daybreak

Apple Blossom' an improvement in biometric parameters was observed when rooted in vermiculite after exposure to plant growth regulators.

It was noted that when chrysanthemum cuttings are soaked for three hours, in contrast to their wetting, the number of roots increases in all variants of the experiment.

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References

1. I.V. Voinyak, *Modern varieties of chrysanthemums for landscaping populated areas in Moldova*, in Proceedings of the VIII international forum 'Protection and rational use of forest resources', Part 2, 8-10 June 2015, Blagoveshchensk, Russia (2015)
2. V.S. Mokhno, E.V. Bratukhina, Subtropical and ornamental gardening, **58** (2016)
3. S.V. Tsekhanovich, News of the National Academy of Sciences of Belarus, **64**, 1 (2019)
4. L.A. Klementieva, *Border varieties of garden chrysanthemum in the south of Western Siberia*, in Proceedings of the International. scientific-practical conf., dedicated 100th anniversary of Omsk State Agrarian University 'Scientific innovations for agricultural production', 21 February 2018, Omsk, Russia (2018)
5. K.R. Rakhimzyanova, D.A. Tyrina, M. Putyatina, E.V. Palchikova, *The influence of drugs on the intensity of root formation in cuttings of chrysanthemum multiflora*, in Proceedings of the National. scientific-practical stud. conf. 'Modern problems of greening the urban environment', 23 April 2020, Novosibirsk, Russia (2020)
6. S.G. Denisova, A.A. Reut, Agrarian Bulletin of the Urals, **4**, 207 (2021). DOI: https://doi.org/10.32417/1997-4868-2021-207-04-64-73
7. S.V. Tsekhanovich, *Chrysanthemum of the multiflora group (Chrysanthemum multiflora) in landscaping of populated areas of Belarus*, in Proceedings of the Republic. scientific-practical seminar 'State and prospects for the development of green construction in the Republic of Belarus', 26-27 April 2018, Minsk, Belorussia (2018)
8. A.G. Zolotareva, Biological diversity and introduction of plants (2021)
9. N.V. Smykova, GNBS Bulletin, **131** (2019). DOI: https://doi.org/10.25684/NBG.boolt.131.2019.16
10. S.G. Denisova, A.A. Reut, Subtropical and ornamental gardening, **64** (2018)
11. G.M. Zaitsev, Mathematical statistics in experimental botany, (Moscow: Nauka, 1984)
12. P.P. Gonchar-Zaykin, V.G. Chertov, *Add-in to Excel for statistical assessment and analysis of the results of field and laboratory experiments*, in the collection: rational environmental management and agricultural production in the southern regions of the Russian Federation (2003)
13. A.E. Basiev, N.G. Ovanyan, *Growth, development and decorative qualities of chrysanthemums depending on growth regulators*, in Proceedings of the 10th

international. scientific-practical conf. 'Prospects for the development of the agro-industrial complex in modern conditions' Part 1, 10-11 June 2021, Vladikavkaz, Russia (2021)

14. A.E. Basiev, T.E. Bagaev, *The influence of treating cuttings of chrysanthemum multiflora with various root formation stimulants on plant rooting*, in Proceedings of the 10th Intern. scientific-practical conf. 'Prospects for the development of the agro-industrial complex in modern conditions' Part 1, 10-11 June 2021, Vladikavkaz, Russia (2021)