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PROSPECTS FOR THE USE OF 2-(QUINOLINE-4-YLTIO) SUCCINIC ACID DERIVATIVES IN THE TECHNOLOGY OF VEGETATIVE REPRODUCTION OF *THUJA OCCIDENTALIS* L. AND THE *PLATYCLADUS ORIENTALIS* (L.) FRANCO HORTICULTURAL VARIETIES

It is known that ornamental varieties of *Thuja occidentalis* L. and *Platycladus orientalis* (L.) Franco are widely used in landscaping. The lack and high cost of planting material of these varieties encourages Ukrainian horticultural material producers to look for ways to accelerate their propagation. A promising path is a search for new effective and environmentally friendly stimulants of rooting. It was found that disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA) can be considered such a substance with potential growth regulator properties. The experiments were conducted in the horticulture laboratory of the Khortytsia National Training and Rehabilitation Academy in 2018-2020. The authors evaluated the effect of aqueous solutions of the disodium salt of 2-(quinolin-4-ylthio) succinic acid (DNCB) in the concentrations of 10, 25 and 50 mg/l on the rooting and development of green cuttings of Thuja occidentalis "Danica", "Columna", "Globosa"; Platycladus orientalis "Morgan", "Aurea nana", "Pyramidalis" in comparison with the control group where the plants did not receive treatment and their rooting was with "Kornevin" (4-(indol-3-yl) butyric acid). Mother plants are 10-15 years old. Green cuttings were rooted according to the usual technology. In the control group, cuttings were planted for rooting without special preparation. The additional control group comprised cuttings, previously treated with "Kornevin" powder. Before planting, the experimental cuttings had their basal parts immersed for 12 hours in DSQSA solution in the concentrations of 10, 25, 50 mg/l. The experiment was repeated three times, 30 cuttings each. Lowland peat with perlite (1:1) was used as a substrate for rooting. Cuttings were rooted in the greenhouse made of film. At the end of September, the survival of cuttings, as well as the number and length of roots were counted. Rooted cuttings were planted in the open ground for growing. Overwintering plants were counted next years spring. Consequently, the most effective DSQSA concentration was 50 mg/l for rooting most varieties, and 10 mg/l for "Columna" variety. It was found that improving the quality of the root system provided a more successful (10-20 %) rooted cuttings overwintering.

Keywords: *Thuja occidentalis*; *Platycladus orientalis*; ornamental horticultural varieties; plant growth regulators; green cuttings; rooting.

Introduction / Вступ

Currently, the arsenal of a landscape designer comprises a wide range of planting material. The most popular group of ornamental plants are conifers. They are valued for frost resistance, unpretentiousness, ornamental effect, and physiognomic stability throughout all seasons. Conifers usually make the basis of any winter landscape since they retain the shape and color of the crown in the winter period. They form a unique winter composition in combination with shrubs and deciduous trees with colourful bark and an interesting branching pattern. *Thuja occidentalis* L. and *Platycladus orientalis* (L.) Franco have an outstanding place among conifers in landscape gardening. These two species are morphologically plastic and have many horticultural varieties that are attractive owing to their unusual crown shape, the color of the needles, dwarf growth, etc. The high demand and cost of planting material make Ukrainian planting material producers look for ways to accelerate the reproduction of these forms in the Ukrainian climatic conditions. Horticultural varieties of ornamental plants are reproduced vegetatively because these forms either do not form seeds, or seed offspring will not imitate the ornamental features of mother plants. The most common method of vegetative propagation of plants is by stem cuttings [22, 24] using growth regulators. Synthetic preparations with auxin activity (heteroauxin, β-IBA, etc.) are traditionally used as rhizogenesis stimulators. However, high-quality drugs are

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expensive; they are considered moderately toxic compounds, and with some plant species they cause intense callus formation without roots [19, pp. 93-95; 9, pp. 9-12]. Therefore, a promising direction is a search for new growth regulators, which in their rhizogenic activity would not be inferior to synthetic auxins, would have a positive influence on the quality of the newly formed cutting root system and combine environmental safety with low cost.

Object of research: disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA), a new substance with potential growth regulator properties;

Ornamental horticultural varieties of *Thuja occidentalis* and *Platycladus orientalis* include:

Thuja occidentalis "Danica". A dwarf variety with a spherical crown shape; in 10 years it reaches 60 cm in height. The crown is dense, all branches are arranged vertically. The colour of the needles in summer is brilliant deep green, in winter – slightly brown-green. It grows well in direct sunlight and shade [12].

Thuja occidentalis "Columna". A fairly tall tree with a narrow columnar crown. The annual growth is 20 cm in height, 5 cm in diameter. It reaches 3 m in height by the age of ten. The needles are dark green with a particular glow. The colour persists throughout all seasons. It grows in well-lit areas or with little shading. Frost resistance is up to -25-30 °C [13].

Thuja occidentalis "Globosa". A shrub with a regular spherical crown shape. It grows slowly and reaches the height of 60 cm in 10 years. Skeletal branches are dense enough, with straight flat vertical shoots. The colour depends on the seasonality: the shrub is pale green in spring, dark green in summer, grey-green in autumn and brown in winter [12].

Platycladus orientalis "Morgan". A tree with a slow growth rate and a dense pyramidal crown pointed at the top. The annual growth is only 5-7 cm. The adult plant reaches 150 cm in height. The colour of the needles is emerald green, lemon green or light green in spring and summer. In winter, the colour changes to red-bronze with a hint of orange [12].

Platycladus orientalis "Aurea nana". A dwarf variety with a pyramidal crown is 1 m in height. Annual growth is 8-10 cm. The branches are thin and tender. The needles are very small, golden-yellow in spring and dark brown in winter.

Platycladus orientalis "Pyramidalis". A shrub with a narrow columnar crown, 0,8-1,5 m wide and to 4 m tall. It grows slowly and its annual growth is about 10 cm. The colour of the needles is dark green throughout the year [12].

The subject of research: comparative test of disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA) as a rhizogenic stimulator in the reproduction technology of *Thuja occidentalis* and *Platycladus orientalis* horticultural varieties.

The purpose *of the* research*:* to determine the possibility of using disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA) as a rhizogenic stimulator in the reproduction of *Thuja occidentalis* and *Platycladus orientalis* horticultural varieties, instead of drugs with auxin activity.

To achieve the above-mentioned goal, the following main objectives are identified:

1) Rooting green cuttings of *Thuja occidentalis* and *Platycladus orientalis* horticultural varieties according to the proposed method;
2) Recording of the rooted cuttings;
3) Assessment of the quality of the formed root systems, taking into account the length and number of roots;
4) Planting the rooted cuttings for growing in open ground;
5) Recording of the overwintered cuttings in the spring.

Analysis of recent research and publications. According to several studies [11, pp. 23-25; 10, pp. 13-17; 20; 23, pp. 96-100], the ornamental varieties of *Thuja* and *Platycladus* have a significant share in the vegetation range of urban green spaces, parks, dendrological and botanical gardens, etc. Planting material of such garden forms is in constant demand. The most common method of ornamental cultivars propagation is cutting and microclonal propagation. In the absence of an equipped laboratory, the only way to obtain planting material is to propagate by stem cuttings. It is known that the survival span of green cuttings of horticultural varieties of *Thuja* and *Platycladus* is variable [16, pp. 132-139; 19, pp. 93-95; 21, pp. 9-14], so the use of rooting stimulants is a mandatory element of cutting technology. The search for the most effective growth regulators for vegetative reproduction of conifers was previously performed by M. T. Tarasenko (1991) [24], L. P. Skaliy, E. G. Samoshchenkov (2002) [22], M. M. Lisovyi (2015, 2019, 2021) [16, pp. 132-139; 15, pp. 47-50; 14, pp. 9-14], N. V. Nilov, S. A. Khasbulatov, C. C. Chukuridi (2015) [19, pp. 93-95], S. V. Rezvyakova, A. G. Gurin, E. S. Rezvyakova (2017) [21, pp. 9-14], V. M. Kovaliov, M. M. Janina (1999) [9, pp. 9-12]. Recently, scientists of Zaporizhzhya National University are engaged in the synthesis of new substances that have potential biological activity. According to their research [2, pp. 36-42; 3, pp. 8-10; 4, pp. 51-56; 5, pp. 100-103; 6, p. 32], derivatives of (2-methyl (phenyl)-6-R-quinolin-4-yl sulfanyl) carboxylic acids, in particular, disodium salt 2-(quinolin-4-ylthio) succinic acid can be considered such new substances with potential properties of plant growth regulation.

Materials and methods of research. The experiments were conducted in the horticultural laboratory of the Khortytsia National Educational Rehabilitation Academy in 2018-2020. As growth regulators, the authors used the auxin activity drug "Kornevin" (4-(indol-3-yl)-butyric acid 5 g/kg (further – IBA)) in the powder form and disodium salt of 2-(quinolin-4-ylthio) succinic acid in the aqueous solution form, in the concentration of 10, 25 and 50 mg/l (further – DSQSA).

Cuttings were cut from mother plants in the active growth phase (the end of May). Mother plants were 10-15 years old. The traditional green cutting technology was employed [23]. Control group cuttings were planted for rooting without previous preparation. The additional control group was made of cuttings treated with auxins according to the traditional technology: basal parts of the cuttings were immersed in clean water and then in the powder "Kornevin" right before planting. Experimental group cuttings were processed the following way: 12 hours before planting, basal parts of the cuttings were immersed in the DSQSA solution in the following concentrations: variant 1-10 mg/l, variant 2-25 mg/l, variant 3-50 mg/l. The experiment was repeated three times, 30 cuttings each.

Cuttings were planted for rooting in a greenhouse covered with plastic wrap. A mixture of lowland peat with perlite (1:1) with the addition of dolomite flour (2 % by weight of the substrate) was used as a substrate for rooting. The substrate layer was 10-15 cm thick. The substrate for ro-

oting rested on a 10-cm layer of humus. The planting scheme for cuttings was 2,5×5 cm. Watering in the greenhouse was performed manually, twice a day, in the morning and the evening. From mid-August, watering was reduced and the cuttings gradually hardened. At the end of September, the survival of cuttings, as well as the number and length of roots were calculated. Then the cuttings were planted in the open ground for growing. The following spring, overwintering plants were recorded.

The experimental results were statistically processed by the dispersion analysis method according to B. A. Dospekhov (1985) [7] with the use of MS Excel spreadsheets.

Research results and their discussion / Результати дослідження та їх обговорення

In the experimental *Thuja occidentalis* variety "Danica" cuttings (Table. 1), rooting was observed at the level of 84.3 %. The quality of the root system was good: the average number of roots was about 13 pieces, with a length of 6.12 cm. Preparation of cuttings of this variety using IBA allowed to obtain 100 % survival. On average, they have 16 roots, which is 23.5 % more than in the control group. The length of the roots also increased and amounted to 7.15 cm (17 % more than the control indicators) (Figure. 1). Of three variants of DSQSA use, the most effective was the concentration of 50 mg/l. Immersing the cuttings in this solution allowed to increase their survival to 96.6 %, which is 12.3 % more than in the control group. The number and length of roots were almost at the level of the control group with IBA. In the variant with the DSQSA concentration of 10 mg/l, it was possible to improve only the number of roots, which increased compared to the control group by almost 1.4 times. Cuttings of this variety tolerate winter well: on average, for 2 years the safety of cuttings did not fall below 79.6 %. Cuttings overwinter best after treatment with IBA (90.7 %) and in the experimental group with the concentration of 50 mg/l (96.4 %).

The control samples of the *Thuja occidentalis* "Columna" took root by 68.9 %, the average number of roots is 8 pieces, with an average length of 4 cm – these are the lowest among all samples of this variety. When treated with IBA, the percentage of rooting increased by 72.2 %, the number and length of roots increased insignificantly – to 8.67 pieces and 4.12 cm. The most effective was the treatment of the cuttings with DSQSA at the concentration of 10 m/l; with it, the survivability amounted to 79.0 %, which is 10 % more than in the control group. Treatment with DSQSA at the concentration of 50 mg/l affected only the amount of roots formed, on average there were 12.12 pieces, which is the highest rate for this variety. The cuttings overwintered most successfully after DSQSA treatment: liveability increased by 12-18 % compared to the control group (fig. 1,*a*).

Table. 1. The treatment effect of DSQSA solutions on the rooting and development of Thuja occidentalis green cuttings (average for 2018-2020) / Вплив обробки живців Thuja occidentalis розчинами дінатрієвої солі 2-(хінолін-4-ілтіо) бурштинової кислоти на їх приживлюваність і розвиток (середнє за 2018-2020 рр.)

Variety	"Danica"				"Columna"				"Globosa"			
Indicators Processing options	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %
Control	84.3	12.89	6.12	79.6	68.9	8.04	4.00	78.4	77.9	11.31	5.23	79.4
IBA	100	15.92	7.15	90.7	72.2	8.67	4.12	82.6	84.1	12.98	6.91	91.3
DSQSA 10 mg/l	76.2	17.94	6.98	85.8	79.0	11.52	8.93	91.4	80.1	7.67	8.86	90.0
DSQSA 25 mg/l	92.4	14.95	6.26	80.9	76.2	11.67	5.34	88.4	91.4	13.04	7.15	88.1
DSQSA 50 mg/l	96.6	14.41	6.92	96.4	71.4	12.12	5.82	95.9	95.1	13.66	7.23	92.3
LSD_{05}*	6.2	2.11	0.98	6.4	4.5	2.32	1.04	6.3	5.8	2.06	1.02	6.5

*LSD_{05} – the least significant difference.

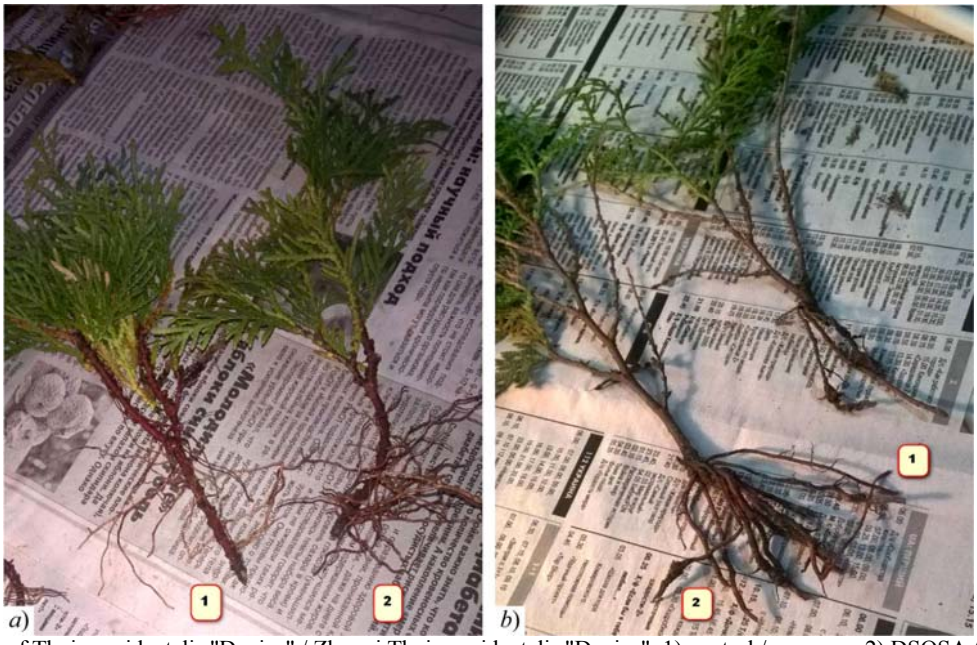

Figure 1. Cuttings of Thuja occidentalis "Danica" / Живці Thuja occidentalis "Danica": 1) control / контрол; 2) DSQSA 50 mg/l / ДНКhБК 50 мг/л (*a*); Cuttings of Platycladus orientalis "Aurea nana" / Живці Platycladus orientalis "Aurea nana": 1) control / контрол; 2) DSQSA 50 mg/l / ДНКhБК 50 мг/л (*b*)

Table. 2. The treatment effect of DSQSA solutions on the rooting and development of Platycladus orientalis green cuttings (average for 2018-2020) / Вплив обробки живців Platycladus orientalis розчинами дінатрієвої солі 2-(хінолін-4-ілтіо) бурштинової кислоти на їх приживлюваність і розвиток (середнє за 2018-2020 рр.)

Variety	"Morgan"				"Aurea nana"				"Pyramidalis"			
Indicators Processing options	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %	Survival %	Number of roots, pcs	The root length, cm	Overwintering, %
Control	60.5	10.45	6.75	74.9	55.8	4.78	6.90	60.0	65.0	10.21	5.98	80.0
IBA	68.9	13.54	8.12	87.9	63.1	6.81	5.98	71.9	78.5	11.75	6.34	90.5
10 mg/l	71.2	16.34	7.12	90.9	59.4	7.12	6.05	64.4	78.8	8.67	6.43	77.9
25 mg/l	73.7	10.36	8.17	78.8	77.9	8.12	6.56	65.9	85.6	8.90	7.34	80.6
50 mg/l	75.5	12.04	6.34	75.0	78.5	9.60	6.34	70.0	90.1	9.34	7.12	91.5
LSD_{05}	6.4	2.15	0.94	6.6	4.2	2.38	0.97	6.6	6.5	2.11	1.00	6.2

The "Globosa" variety in the control group took root by 77.9 %; the average length of the roots is 5.23 cm, the number is 11.31 pieces. Preparation of cuttings using IBA improved survival to 84.1 %, the length of the roots increased to 6.91 cm, the number – up to 12.98 pieces. DSQSA in the concentration of 50 mg/l demonstrated the best efficiency among all samples, the survival rate was 95 %. The number of roots is 13.66 pieces with an average length of 7.23 cm. In cuttings prepared using DSQSA at a concentration of 10 mg/l, the length of the roots significantly increased, up to 8.86 cm, whereas the number of roots in this variant of the experiment was the lowest in the variety – 7.67 pcs. The survivability of the cuttings was noted at the level of the variant with IBA during the winter in all experimental variants.

Platycladus orientalis cuttings are generally worse rooted than *Thuja occidentalis* ones. In the control group, cuttings of the variety "Morgan" (Table. 2) took root by 60.5 %. Root quality is average, the length is 6.75 cm, and the quantity is 10.45 pcs. Treatment of cuttings with IBA increased the number of rooted cuttings to 68.9 %. The highest percentage of rooting (75.5 %) was observed after the treatment of cuttings with DSQSA in the concentration of 50 mg/l. However, the quality of the roots was average: the number was about 12 pieces, the length was 6.34 cm. The number of roots significantly increased to 16.34 pieces, with the use of DSQSA in the concentration of 10 mg/l. In winter conditions, the best (87.9-90.9 %) cuttings were preserved in the group with IBA, and in the experimental group with the concentration of DSQSA of 10 mg/l.

In the control group of the variety "Aurea nana", only 55 % of cuttings, which formed on average less than 5 roots, rooted. Their average length was 6.9 cm. The best results were obtained by treatment of cuttings with a solution of DSQSA in concentrations of 25 and 50 mg/l. In these cases, it was possible to obtain rooting at the level of 77.9-78.5 % with good quality of the root system: the number of roots increased to 8-9.6 pieces, which is by 1.8-2 times better than the control version (fig. 1,*b*). The length of the roots remained at the control level. In this variety, the use of DSQSA at a concentration of 25 and 50 mg/l exceeded the efficiency of IBA, which is a classic stimulator for root formation. Cuttings of this variety are poorly preserved in winter and for two winters the survivability averaged 60-72 %. The best indicators are in the groups with IBA and 50 mg/l DSQSA.

In the control group of the variety "Pyramidalis", cuttings rooted by 65 %. The number of formed roots is 10.21 pcs. The average length is 5.98 cm. Treatment of cuttings with IBA improved survival to 78.5 %, in this case cuttings have the largest number of roots –11.75 pcs. The average root length is 6.34 cm. Cuttings treated with 50 mg/l DSQSA show the best percentage of rooting – 90.1 %, but the length and number of roots have average values – 7.12 cm and 9.34 pieces. The variety "Aurea nana" confirmed the geberal trend for overwintering: the best survival of cuttings was observed in the variants with IBA and DSQSA 50 mg/l (90.5-91.5 %).

Thus, all surveyed varieties demonstrate a positive effect of pre-planting treatment of cuttings with DSQSA solution in certain concentrations on both survival and quality of the root system. Besides, rooted cuttings overwinter more successfully.

Discussion of research results. Previous investigations by some authors have shown the possibility and effectiveness of using biologically active substances as rooting stimulators for coniferous species cuttings instead of classical auxins: Epin-Extra, Zircon [8, pp. 43-46]; Planrise, Trichodermine [1, pp. 39-41]; Radipharm [19, pp. 93-95]; Fumar, Rhizopon AA poeder, etc. [25, pp. 213-217]. Disodium salt of 2-(quinolin-4-ylthio) succinic acid can also be considered a biologically active substance [2, pp. 36-42; 3, pp. 38-10; 4, pp. 51-56; 5, pp. 100-103; 6, p. 32]. Our studies suggest the possibility of using disodium salt of 2-(quinolin-4-ylthio) succinic acid as a rhizogenic stimulator for *Thuja occidentalis* and *Platycladus orientalis* cuttings instead of auxin substances. Previously, the rhizogenic activity of this substance has not been studied.

Thus, based on the results of the work performed, it is possible to formulate such scientific novelty and practical significance of the research results.

The scientific novelty of the obtained research results is that it is for the first time that the disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA) was tested as a rhizogenic stimulator in the coniferous species green cutting technology.

The practical significance of the research results – the authors discovered the possibility of using disodium salt of 2-(quinolin-4-ylthio) succinic acid (DSQSA) as a rhizogenic stimulator in the propagation technology of *Thuja occidentalis* and *Platycladus orientalis* garden forms instead of traditional auxins.

Conclusion / Висновок

The positive effect of DSQSA on all tested varieties *Thuja occidentalis* and *Platycladus orientalis* was manifested. In the cuttings of *Thuja occidentalis* varieties, the most effective was the concentration of 50 mg/l ("Danica", "Globosa"). In the "Danica" variety, immersing the cuttings in this solution increased the rooting by 96.6 % and ensured the successful cutting overwintering by 96.4 %. In the "Globosa" variety, survival was 95 %, root quality and

overwintering improved by more than 12 %. In the "Columna" variety, the best rooting and overwintering rates were observed in the variant with the concentration of 10 mg/l (rooting – 79.0 %, survival – 91.4 %). In general, in the experimental variants survival of the cuttings during the winter increased by 12-18 % compared with the control group.

The use of DSQSA solution on *Platycladus orientalis* cuttings at a concentration of 50 mg/l increased the rooting and improved root system quality for all tested varieties ("Morgan", "Aurea nana", "Pyramidalis") by 10-15 % and provided more successful overwintering of rooted cuttings (10-20 %).

Thus, the disodium salt of 2-(quinolin-4-ylthio) succinic acid can successfully replace auxins in the process of green cuttings reproduction of *Thuja occidentalis* and *Platycladus orientalis* ornamental horticultural varieties.

References

1. Barayshchuk, G. V. (2009). The use of biologically active preparations in the introduced breeds reproduction. *Achievements of science and technology of the Agro-Industrial Complex, 4*, 39–41. [In Russian].
2. Brazhko, O. A., Zavgorodniy, M. P., Karpun, E. O., Brazhko, O. A., Romanenko, Ya. I., & Bogdan, A. M. (2019). Chemometric methods for research of biological activity of quinoline derivatives. *Scientific Journal "ScienceRise", 1*(54), 36–42. https://doi.org/10.15587/2313-8416.2019.155424
3. Brazhko, O. A., Zavgorodniy, M. P., Lagron, A. V., Kornet, M., & M., Dobrodub, I. V. (2017). Synthesis and biological activity of derivatives (2- methyl (phenyl)-6-R-quinolin-4-yl-sulphanyl) carboxylic acid. Science Review, 7(7), 8–10.
4. Derevyanko, N. P. (2019). Development of the flowers root system under the influence of growth regulators made on the basis of heteroaryl carboxylic acids. Bulletin of KhNAU. *Crop production, selection and seed production, fruit and vegetable growing and storage, 1*, 51–56. [In Ukrainian].
5. Derevyanko, N. P., Brazhko, O. A., Zavgorodniy, M. P., & Vasylieva, T. M. (2016). Efficacy and safety of new plant growth stimulants based on heteroaryl carboxylic acid derivatives. *Agroecological journal, 3*, 100–103. [In Ukrainian].
6. Dobrodub, I. V., Zavhorodniy, M. P., Klimova, O. O., & Brazhko, O. A. (2019). Biological activity of derivatives (2-methyl) (phenyl) -6-R-quinolin-4-ylsulfanyl) carboxylic acids. Abstracts of II International Scientific and Practical Conference "Priority directions of science development", Lviv, 32 p. [In Ukrainian].
7. Dospekhov, B. A. (1985). Methods of field experience (with the basics of statistical processing of research results). Moscow: Agropromizdat. [In Russian].
8. Fadeeva, N. A., & Zakharova, N. G. (2021). The use of growth regulators as the coniferous crops survival rate increase technique. *Bulletin of the Chuvash State Agricultural Academy, 2*, 43–46. [In Russian].
9. Kovalev, V. M., & Yanina, M. M. (1999). Methodological principles and using methods of new generation growth-regulating drugs in crop production. *Agrarian Russia, 1*(2), 9–12. [In Russian].
10. Kovalevskii, S. B., & Tatarchuk, R. Y. (2018). Cultivars of the genus Thuja L. and Juniperus L. in the rocky gardens of Kiev. *Scientific Bulletin of UNFU, 28*(10), 13–17. https://doi.org/10.15421/40281002
11. Kovalevskyi, S. B., & Kryvokhatko, H. A. (2019). Kompleksna otsinka dekorativnosti roslin kultivariv Thuja Occidentalis L. *Scientific Bulletin of UNFU, 29*(2), 23–25. https://doi.org/10.15421/40290204
12. Krussman, G. (1986). Coniferous breeds. Moscow: Forest Industry. [In Russian].
13. Kucheryaviy, V. S. (2015). Thuja occidentalis and its decorative forms in landscaping of Lviv. Abstract of Candidate Dissertation for Agricultural Sciences (06.03.03 – Silvics and forestry). Lviv, 241.
14. Lisoviy, M. M. (2021). Influence of growth stimulators on risogenesis of Thuja Occidentalis L. clones in vitro conditions. *Scientific Bulletin of UNFU, 31*(3), 9–13. https://doi.org/10.36930/40310301
15. Lisovyi, M. M. (2019). The effect of growth stimulators on the initiation of Thuja occidentalis L. explants in vitro conditions. *Scientific Bulletin of UNFU, 29*(5), 47–50. https://doi.org/10.15421/402905099
16. Lisovyi, M. M., & Huz, M. M. (2015). Polymorphism and features of vegetative propagation by cutting of decorative forms Thuja occidentalis L. *Forestry and agroforestry, 126*, 132–139. [In Ukrainian].
17. Hrynyk, H. H., Zadorozhnyy, A. I., & Hrynyk, O. M. (2021). The trunk bioproductivity of spruce stands of the Polonyn ridge of the Ukrainian Carpathians. *Scientific Bulletin of UNFU, 31*(6), 26–34. https://doi.org/10.36930/40310603
18. Hrynyk, H. H., Oszako, T. M., & Tkaczyk, M. (2019). The investigation of the influence of phosphites as stimulants of resistance of common oak trees (Quercus robur L.) to pathogens of the Genus Phytophthora in the Krotoszyn plateau (Poland). *Scientific Bulletin of UNFU, 29*(8), 09–24. https://doi.org/10.36930/40290801
19. Nilov, N. V., Khasbulatov, S. A., & Chukuridi, S. S. (2016). Vegetative propagation of decorative forms and species of thuja (Cupressaceae) using growth stimulants. Collection of articles based on the materials of the IX All-Russian of young scientists conference "Scientific support of the agro-industrial complex", Krasnodar: Kuban State Agrarian University, 93–95. [In Russian].
20. Pushkar, V. V. (2004). Conifers in garden and park construction. Kyiv: High school. [In Ukrainian].
21. Rezvyakova, S. V., Gurin, A. G., & Rezvyakova, E. S. (2017). Reproduction of conifers by green cuttings using new biological products. *Bulletin of the Oryol State Agrarian University, 2*(65), 9–14. [In Russian].
22. Skaliy, L. P., & Samoschenkov, E. G. (2002). Plant propagation by green cuttings. Moscow: MAA. [In Russian].
23. Sliusar, S. I. (2002). Determination of the seasonal decorative effect of species of Taxodiaceae family, which are introduced into Right-bank Forest Steppe of Ukraine. *Introduktsiia roslyn, 2*, 96–100. [In Ukrainian].
24. Tarasenko, M. T. (1991). Green cuttings of horticultural and forest crops. Moscow: MAA. [In Russian].
25. Tockman, V. S. (2015). Peculiarities of vegetative propagation of Thuja occidentalis L. in the North-eastern part of Ukrainian Forest-steppe. Bulletin of Sumy National Agrarian University. *Agronomy and Biology Series, 9*(30), 213–217. https://repo.snau.edu.ua:8080/xmlui/handle/123456789/4266

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ПЕРСПЕКТИВИ ВИКОРИСТАННЯ ПОХІДНИХ ХІНОЛІН-БУРШТИНОВОЇ КИСЛОТИ В ТЕХНОЛОГІЇ ВЕГЕТАТИВНОГО РОЗМНОЖЕННЯ САДОВИХ ФОРМ *THUJA OCCIDENTALIS* L. ТА *PLATYCLADUS ORIENTALIS* (L.) FRANCO

Великий попит і висока вартість саджанців декоративних форм *Thuja occidentalis* L. і *Platycladus orientalis* (L.) Franco змушує українських виробників садивного матеріалу шукати способи їх пришвидшеного розмноження. Відомо, що вико-

ристання регуляторів росту є обов'язковим елементом технології вегетативного розмноження декоративних порід. Тому перспективним напрямом є пошук нових регуляторів росту, що поєднали б в собі високу різогенну активність, екологічну безпеку і низьку вартість. З'ясовано, що такою новою речовиною з потенційними властивостями регулятора росту рослин можна вважати дінатрієву сіль 2-(хінолін-4-ілтіо) бурштинової кислоти (ДНХБК). Експерименти проведено в лабораторії садово-паркового господарства Хортицької національної навчально-реабілітаційної академії упродовж 2018-2020 рр. На зелених живцях *Thuja occidentalis* "Danica", "Columna", "Globosa"; *Platycladus orientalis* "Morgan", "Aurea nana", "Pyramidalis" оцінено вплив водних розчинів ДНХБК у концентраціях 10, 25 і 50 мг/л на їх укорінення і збереженість упродовж зими. Вік маточних рослин – 10-15 років. Технологія зеленого живцювання – загальноприйнята. Контрольні живці висаджували на укорінення без попередньої підготовки. Додатковий контроль – живці, оброблені порошком "Корневін" (4-(індол-3-іл) масляна кислота). Експериментальні живці перед висадкою витримували впродовж 12 год зануреними базальними частинами в розчин ДНХБК у концентраціях 10, 25 і 50 мг/л. Повторність досліду триразова, по 30 живців. Живці укорінювали в парнику із плівки. Субстрат – низинний торф у суміші з перлітом (1:1). Приживлюваність живців, кількість, довжину коренів враховано наприкінці вересня. Укорінені живці висаджено у відкритий ґрунт на дорощування. Навесні наступного року виявлено кількість рослин, що перезимували. Встановлено, що позитивний результат дії ДНХБК на укорінення живців більшості сортів проявився в концентрації 50 мг/л, на сорті "Columna" – у концентрації 10 мг/л. Виявлено, що поліпшення якості кореневої системи забезпечило успішнішу (на 10-20 %) перезимівлю вкорінених живців.

Ключові слова: туя західна; широкогілочник східний; декоративні садові форми; регулятори росту рослин; зелене живцювання; приживлюваність.