The effect of growth stimulators on the vegetative reproduction of North American tree species in the conditions of the Omsk region

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Abstract. The relevance of studying the growth and development of North American cypress tree species in the Omsk region is due to the short period of their use in urban landscaping. The issues of effective production of planting material of these rocks in the West Siberian region have not been fully studied. The use of North American species in the landscaping of the city will expand the range of conifers and reduce the anthropogenic load. The research is devoted to the study of the effect of growth stimulants on vegetative reproduction by green cuttings of representatives of the Cypress family in 2018-2021 in the conditions of the southern forest-steppe of the Omsk region. It has been established that all the studied preparations have a positive effect on the rooting of green cuttings of different forms of Western thuja. The green cuttings of the studied junipers took root better under the influence of heteroauxin, kornevin and ribav extra. An increase in the diameter of the root neck in the studied rocks was observed under the influence of kornevin.

1 Introduction

Green spaces in urban ecosystems perform health, structural planning and decorative functions, enrich the atmosphere with oxygen. At the same time, they experience a high anthropogenic load, are exposed to chemical, physical, and biological pollution. Performing the role of light filters, plants are often influenced by unfavorable conditions of the urban environment: their physiological and biochemical processes change markedly, structures responsible for photosynthesis, respiration, and water exchange are destroyed. The development of an adaptive response under mild stress contributes to the better survival of plants in changing climatic conditions and of technogenic pollution.

Currently, an urgent task is to expand the species composition and introduce new tree and shrub species used in landscaping settlements in Russia. In comparison with European countries, the total number of coniferous species used in the practice of landscape design is small. This is especially true for the territory of Siberia and the Far East [1]. Due to the short period of use of species of North American origin in the Omsk region, the nature of the growth of these species is still insufficiently studied, the issues of their sustainability in the urban environment are practically not covered. All this underlines the need to study the ecological and biological features of the introducers [2].

Recently, North American tree species of the Cypress family have become interesting for landscaping the city of Omsk, the reproduction of which is of great practical importance. The mother plants of this family grow in the arboretum parks of the city [3]. Cypress (*Cupressaceae* Neger) is the largest coniferous family by the number of genera and the third by the number of species. One of the values of these plants is a huge amount of essential oils evaporating from the leaves, which purify the air from microbes. Cypress − evergreen long-lived (90−800 years) shrubs and trees, which are valuable material for park construction. The advantages of these plants are well known: longevity, color of needles that persists in winter and summer, high decorative qualities, health-improving properties. Since the flora of the Omsk region is not rich in species diversity of coniferous species, studies on the technology of growing introduced species in the conditions of the southern forest-steppe of the Omsk region are of undeniable practical significance [4, 5]. Due to the large number of highly decorative artificially bred forms, winter hardiness, durability and resistance to urban conditions, North American tree species are

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widely distributed in decorative gardening on all continents in many climatic zones. Numerous garden centers strive to meet the demand for planting material, but often this material is not viable for our conditions (other climatic factors). Plants begin to develop various diseases, most often there is drying of branches and sunburn. Therefore, it is important to obtain planting material from acclimatized plants by vegetative propagation.

Previously, vegetative reproduction was used in garden practice, but the rooting of most coniferous plants is extremely slow. There are very few works on vegetative reproduction of conifers. Most of them have been released only in the last 25 years. This phenomenon is not accidental, it is explained by the difficulty of root formation of stem cuttings of coniferous species and especially the duration of rooting of cuttings. The manifestation of interest in cuttings over the past 25 years coincides with the discovery of special substances (auxins) in plants that promote root formation, and simultaneously with the production of some organic acids, which in their action turned out to be equivalent to auxins [6].

To accelerate and enhance shoot formation in the cuttings of woody conifers, which take root especially difficult, they are pre-treated with organic and mineral acids. The action of acids on cuttings causes increased metabolism and accumulation of organic substances in the lower part of the cuttings that promote root formation [7].

The most common method of reproduction is by green cuttings. The plants used in the landscaping of the urban environment grow in conditions of various technogenic loads. Therefore, they must be adapted to the stress caused by both technogenic pollution and sudden fluctuations in weather conditions, which has been noted in recent years. It is possible to increase the stability of introducers in various ways: hardening, exposure to variable temperature, as well as growth stimulants [8].

The use of growth stimulants reduces the period required for root formation under normal conditions and provides significant time savings. The effectiveness of growth stimulants depends on many factors: concentration, duration of treatment, condition of cuttings and mother plants, and of course, the type of stimulant.

The effect of growth stimulators can be species- and non-species-specific, therefore, when studying their effect on some cultures, it is impossible to accurately predict the result with others. However, the ultimate goal of using growth stimulants is to increase the percentage of rooting, increase growth, which is achieved by the correct selection of concentration and exposure when processing the material [9, 10].

The use of vegetative reproduction of conifers is of practical importance, so it allows you to obtain plants with the necessary economically valuable characteristics. Cuttings of most coniferous species do not take root in the open ground, since constant temperature and humidity are needed for their root formation. Different breeds require different conditions for rooting cuttings, so different types of greenhouses are used, in which the necessary regime is artificially created. One of the important factors during rooting is that the substrate temperature should be 3-5 °C above the air temperature [11].

In our experience, we studied the effect of various growth stimulants on the rooting of green cuttings in the conditions of the city of Omsk. Plant growth regulator ribav-extra contains a natural complex of biologically active substances produced by mycorrhizal fungi isolated from ginseng root: L-glutamic acid (0.00196 g/l), L-alanine (0.00152 g/l). Heteroauxin contains the active substance β-indolylacetic acid, a chemical of high physiological activity that affects growth processes. Zircon contains a mixture of hydroxycoric acids (chlorogenic, chicory and kaftaric). Kornevin is a biostimulating preperation for plants, which includes indolyl butyric acid (5 g/kg), which, when it gets on the plant, irritates its integumentary tissues, stimulating the appearance of callus and roots.

The purpose of the experiment is to study the influence of growth regulators on the process of root formation and biometric indicators of the studied North American species.

2 Materials and methods

The experiments were conducted in 2018−2021 in the educational and scientific laboratory of perennial crops “Garden named A. D. Kizyurin” of the educational and experimental farm: propagation by green cuttings - in a film greenhouse. In the experiment, the effect of growth regulators on the regenerative ability of green cuttings of representatives of the Cypress family, as well as on biometric indicators (height, length and number of roots, diameter of the root neck), was studied.

Stem cuttings of 10−15 cm representatives of the Cypress family (Western thuja, Western thuja Woodwardi variety, Cossack juniper, common juniper) were used to lay the experiment. Before planting, green cuttings were treated with growth regulators by immersing cuttings: for 8 hours in a 1% solution of kornevin, for 14 hours − in a 1% solution of heteroauxin, for 16 hours − in a 1% solution of ribav extra, for 12 hours − in a 1% solution of zircon. Cuttings without treatment with growth stimulants were used as a control. All experiments were carried out in three-fold

repetition, in each repetition of 25 cuttings. The cuttings were planted in a stationary greenhouse with fine dispersion irrigation. Sand was used as a substrate. 5 days after planting, by carefully pulling out the cuttings, systematic monitoring of the development of the callus and the formation of roots was carried out.

3 Results and discussion

Studies have shown that different forms of the same species can be cut with more or less success.

The appearance of roots on cuttings is preceded by the process of formation of new healing tissues, which grow and form an outgrowth - a callus. The appearance of a callus does not always lead to the formation of roots. According to the results of our research, it was found that the callus began to appear on the 20th day after planting in cuttings of the genus thuja and on the 25th day in junipers. Callus formation in green cuttings of Western thuja was intensively carried out when treated with growth stimulators heteroauxin (95.4%) zircon (96.4%), ribav extra (97.8%) under control (80.8%). The same trend was observed in thuja of the Western Woodward variety: heteroauxin (89.2%), ribav extra (86.6%), zircon (84.6%) under control (76.8%). In Cossack and common juniper, the best indicators of callus formation were in variants with heteroauxin, ribav extra and kornevin.

In the control variant of the western thuja planted without treatment with growth stimulants, the root ability was: in 2018 – 78.2 %, in 2019 – 79.2 %, in 2020 – 80.8 %, in 2021 – 70.7 %. In general, the highest rooting of green cuttings of Western thuja was in experiments with treatment with heteroauxin, ribav extra, zircon (Fig. 1).

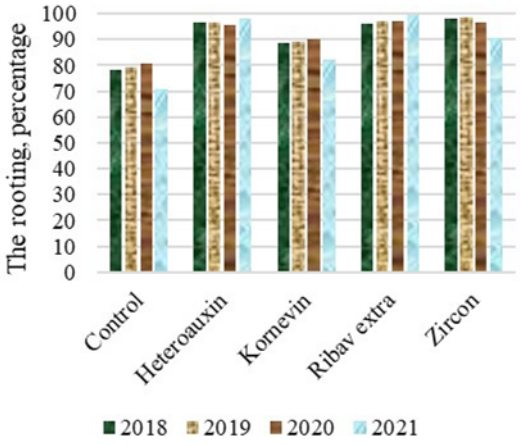

Fig. 1. Rooting of green cuttings of western thuja, $LSD_{05} = 1.09$.

The control variant of the Western thuja has the Woodward variety: in 2018 – 73.3 %, in 2019 – 74.2 %, and in 2020 – 76.8 %, in 2021 – 70.6 %. The highest percentage of rooting in the Western thuja is spherical in variants using heteroauxin and ribav extra (Fig. 2).

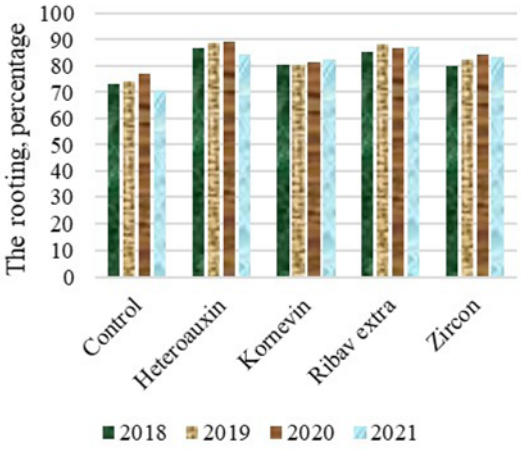

Fig. 2. Rooting of green cuttings of thuja of the western Woodward variety, $LSD_{05} = 1.12$

When rooting green cuttings of Cossack juniper in the experiment with the use of zircon, the percentage of rooting was lower than control. Treatment of green cuttings of Cossack juniper with heteroauxin, kornevin, ribav extra positively affected rooting (Fig. 3).

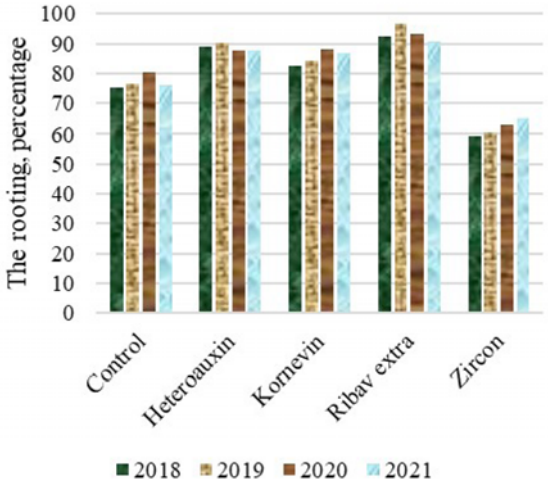

Fig. 3. Rooting of green cuttings of Cossack juniper, $LSD_{05} = 1.08$.

In the control variant of the common juniper, planted without treatment with growth stimulants, the rooting rate was 79.9 % in 2018, 80.6 % in 2019, 80.1 % in 2020, and 77.3 % in 2021. Whereas in the variants with heteroauxin, kornevin, ribav-extra, the rooting of green cuttings of ordinary juniper was more successful. At the same time, the percentages of rooting with the use of zircon were lower than the control (Fig. 4).

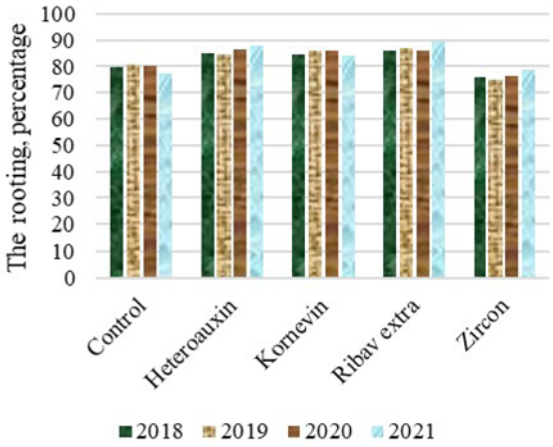

Fig. 4. Rooting of green cuttings of common juniper, $LSD_{05} = 1.16$

Thus, during vegetative reproduction of representatives of the genus Thuja, growth stimulators heteroauxin, kornevin, zircon, ribav extra increased the rooting of cuttings, and during the reproduction of junipers, an increase in the percentage of rooting was observed when using heteroauxin, kornevin, ribav extra.

The data obtained allow us to state that an increased increase in relation to the control was observed when treated with growth stimulators ribav extra (Fig. 5). The growth of rooted cuttings in the treatment variant with kornevin was at the control level. The growth of green cuttings of Western thuja treated with the stimulant heteroauxin was lower or at the control level.

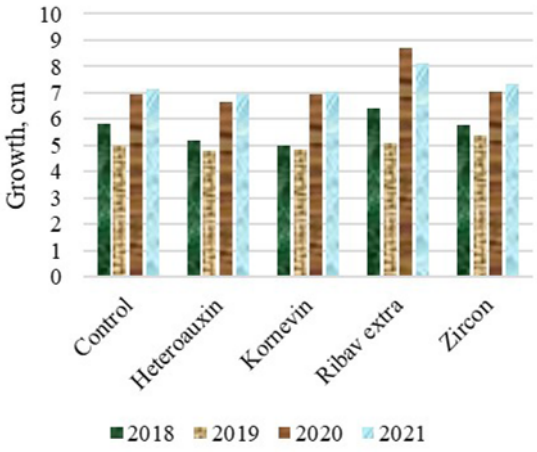

Fig. 5. Growth of rooted cuttings of Western thuja, $LSD_{05} = 0.12$

When rooting green cuttings of Western thuja in comparison with the control, the stimulator of root formation of the roots contributed to the formation of a larger diameter of the root neck. The diameter of the root neck in green cuttings treated with ribav extra, heteroauxin, zircon compared with the control was smaller (Fig. 6).

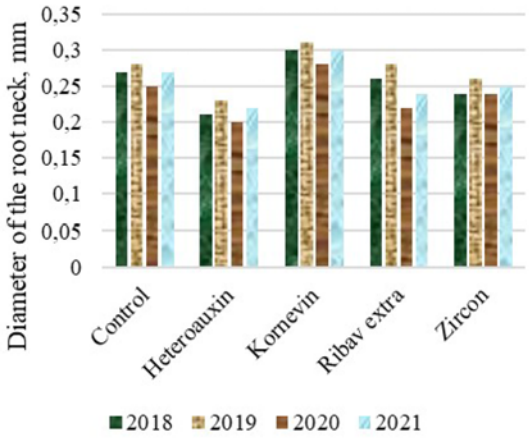

Fig. 6. Diameter of the root neck of rooted cuttings of Western thuja, $LSD_{05} = 0.01$

Thus, when propagated by green cuttings of Western thuja, kornevin contributed to the production of stronger cuttings seedlings.

Observations of rooted cuttings of thuja of the Western Woodward variety showed an increased increase in comparison with the control when treated with growth stimulators ribav extra and heteroauxin. The green cuttings of the Western thuja are spherical, treated with the stimulants zircon and kornevin, had an increase below control (Fig. 7).

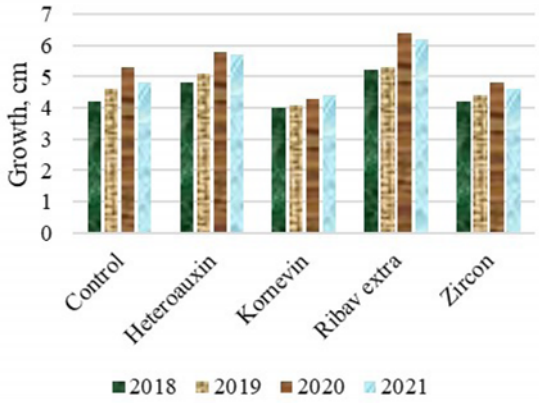

Fig. 7. Growth of rooted cuttings of thuja of the western Woodward variety, $LSD_{05} = 0.13$.

The root formation stimulators heteroauxin and kornevin contributed to the formation of a larger diameter of the root neck in the cuttings of the Western thuja, the shape is spherical in comparison with the control. Green cuttings treated with ribav extra and zircon, in comparison with the control, had a smaller diameter of the root neck (Fig. 8).

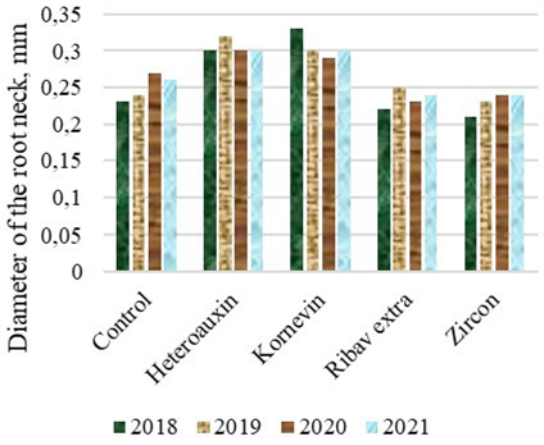

Fig. 8. Diameter of the root neck of rooted cuttings of thuja of the Western Woodward variety, $LSD_{05} = 0.01$.

In the rooted cuttings of Cossack juniper in the variant with ribav extra and kornevin, the growth and diameter of the root neck were higher in comparison with the control (Fig. 9, 10).

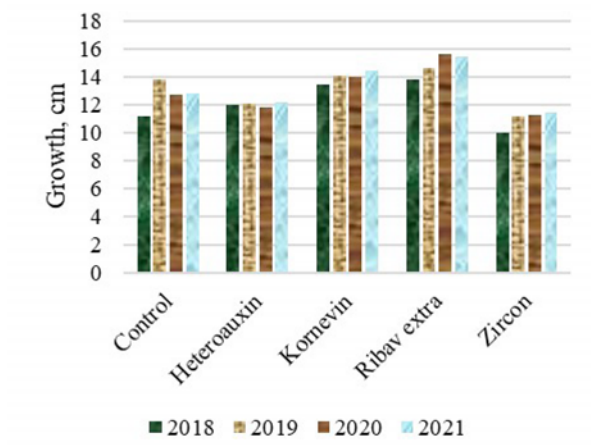

Fig. 9. Growth of rooted cuttings of Cossack juniper, $LSD_{05} = 0.15$.

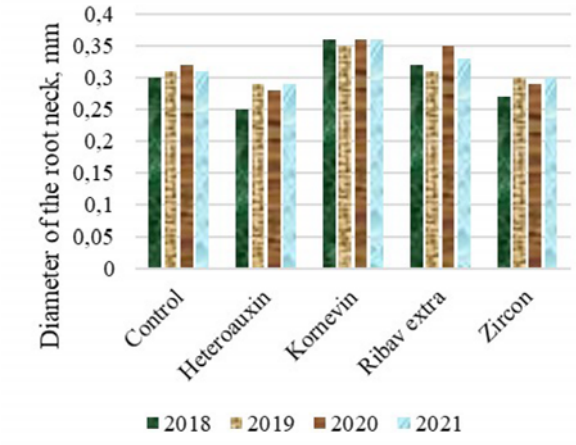

Fig. 10. Diameter of the root neck of rooted cuttings of Cossack juniper, $LSD_{05} = 0.01$.

The growth of green cuttings in common juniper when treated with growth stimulants exceeded the control variant in all experimental variants, except for the experiment with the use of heteroauxin (Fig. 11).

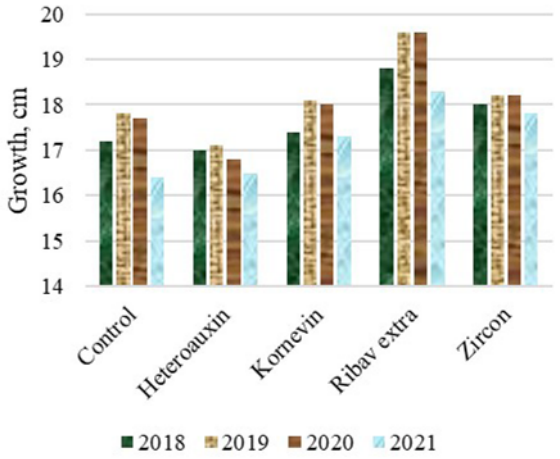

Fig. 11. Growth of rooted cuttings of common juniper, $LSD_{05} = 0.20$

The diameter of the root neck of the rooted cuttings of ordinary juniper was higher than the control only in the variant with the root (Fig. 12).

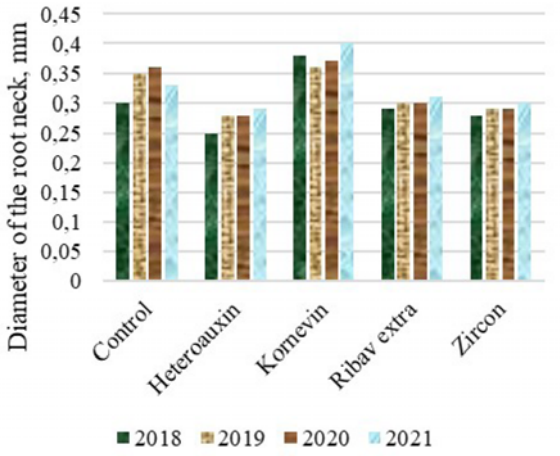

Fig. 12. The diameter of the root neck of the rooted cuttings of the common juniper, $LSD_{05} = 0.01$.

The preparations heteroauxin, ribav extra, zircon had a significant stimulating effect on root growth in Western thuja (Fig. 13, 14). Compared with the control, the number of roots in the Western thuja increased by 29.7−162.5 %, while the length of the roots increased from 3 to 32.4 %.

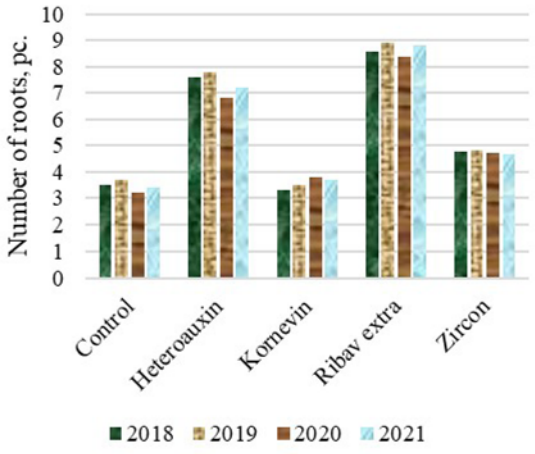

Fig. 13. The number of roots in rooted cuttings of Western thuja, $LSD_{05} = 0.32$.

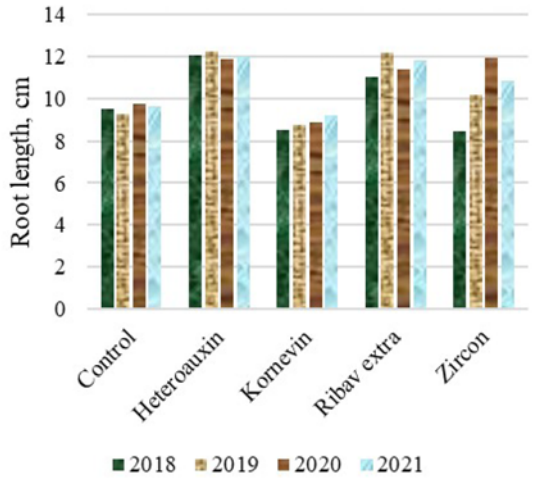

Fig. 14. The length of the roots of the rooted cuttings of the Western thuja, $LSD_{05} = 0.64$

The Western thuja has a spherical shape, the number of roots increased by 60.5-147 % with the use of heteroauxin, ribav extra, zircon (Fig. 15). At the same time, the root length of this form of Western thuja increased from 4.8 to 34.2 % under the action of heteroauxin (Fig. 16). Observation of the growth of the root system of the green cuttings of the Western thuja of the two studied forms showed that the growth stimulator kornevin inhibited the process of root formation. The root-forming ability of cuttings of different forms of thuja treated with this stimulant is significantly lower than that in the control. It is possible that the concentrations and consumption rates of the preparation recommended for all fruit and berry and ornamental crops require further adjustments for specific tree species. The growth regulators heteroauxin, ribav extra and zircon consistently exceeded the control variant in the number of roots, but had a lower value in the length of the roots (Fig. 13, 14, 15, 16).

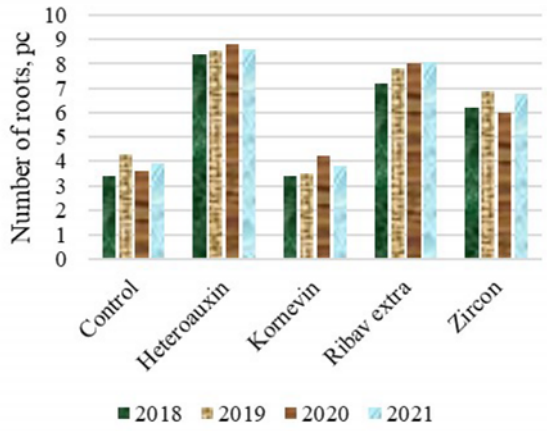

Fig. 15. The number of roots in rooted cuttings of Western thuja Woodwardi variety, $LSD_{05} = 0.22$.

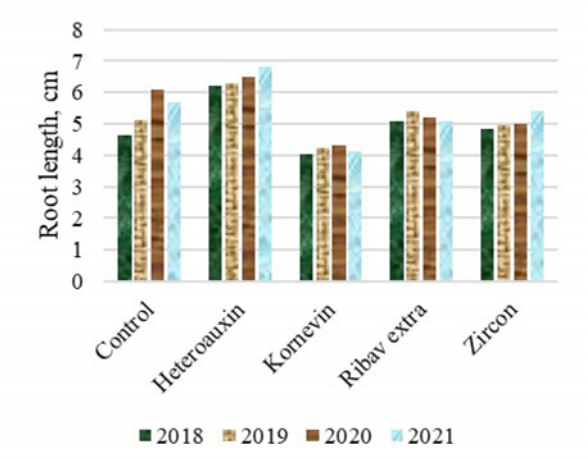

Fig. 16. Root length of rooted cuttings of Western thuja Woodwardi variety, $LSD_{05} = 0.56$.

In the studied junipers, the number of roots and the length of the roots exceeded the control variant under the influence of all the growth regulators tested (Fig. 17, 18, 19, 20). In all experimental variants, the number of roots and the length of the root system were higher than the control at a significance level of 95 %.

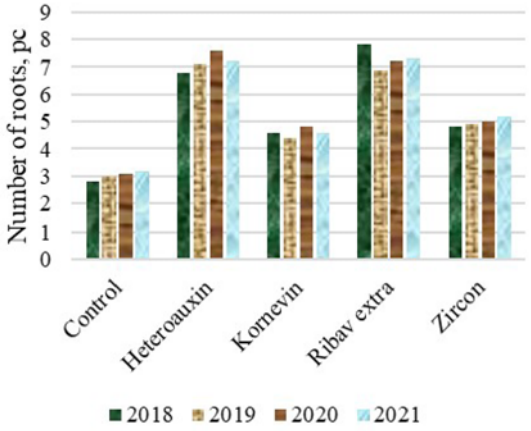

Fig. 17. The number of roots in rooted cuttings of Cossack juniper, $LSD_{05} = 0.28$.

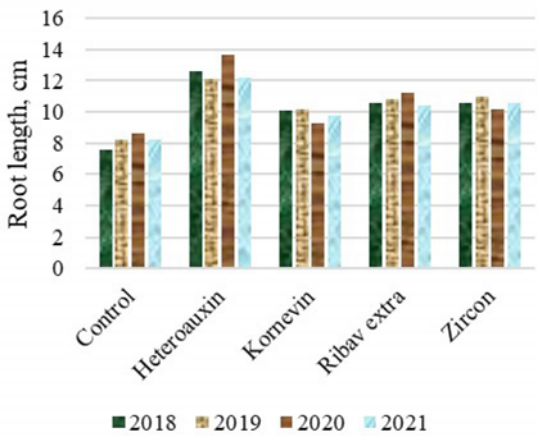

Fig. 18. The length of the roots of the rooted cuttings of the Cossack juniper, $LSD_{05} = 0.66$.

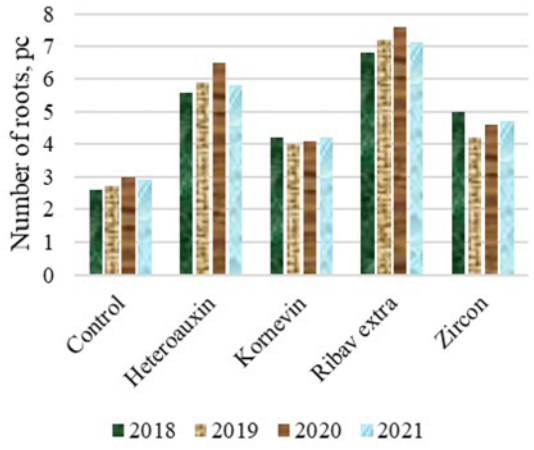

Fig. 19. The number of roots in the rooted cuttings of the common juniper, $LSD_{05} = 0.33$.

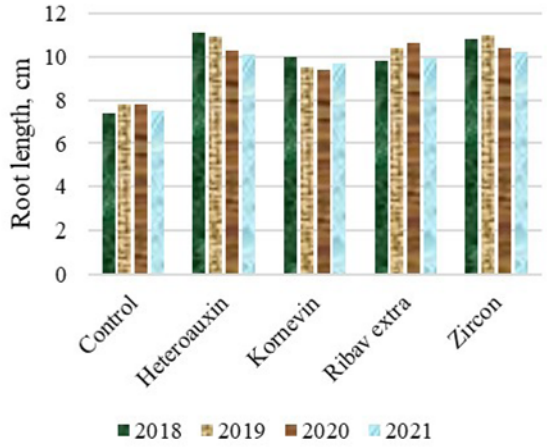

Fig. 20. The length of the roots of rooted cuttings of common juniper, $LSD_{05} = 0.62$.

4 Conclusion

Cuttings are a fast and cost-effective way to propagate decorative and valuable, but slow-growing conifers. The use of chemical growth stimulants increases the root ability of cuttings, increases the efficiency of reproduction and the practical yield of finished products, contributing to the strengthening and adaptation of young plants to environmental conditions.

During vegetative reproduction of representatives of the genus Thuja, active callus formation and high rooting were influenced by growth stimulants: heteroauxin, kornevin, zircon, ribav extra, and during reproduction of representatives of the genus Juniper by heteroauxin, kornevin, ribav extra.

The greatest stable increase in growth was found for thuja and juniper when they were treated with ribav extra.

The greatest increase in the diameter of the root neck was found in all the studied species of thuja and juniper when they were treated with kornevin.

All the growth regulators studied had a positive effect on increasing the number and length of thuja and juniper roots, except for the recorded inhibitory effect of kornevin on cuttings of western thuja seedlings.

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