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Efficiency of Using Growth Simulators for the Cultivation of Planting Material of the "*Abies* mill". Genus.

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ABSTRACT

The effects of root fertilizing the seedlings of Khingan fir (*Abies nephrolepis* (Trautv.) Maxim.) and Manchurian fir (*A. holophylla* Maxim.) cultivated in the nurseries with growth simulators: Epin-extra, Zircon, Krezatsin. The most effective drug is "zircon".

Keywords: Khingan fir, Manchurian fir (*Abies Holophylla*), forest nursery, seedlings, growth simulators, planting material, root fertilizing.

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INTRODUCTION

Far Eastern forests are diverse and rich in floristic composition. There are 5 representatives of the "Fir" variety (*Abies* Mill.) alone in the forest fund of the Far East: Khingan (*Abies nephrolepis* (Trautv.) Maxim.), Manchurian (A. *holophylla* Maxim.), Mayra (A. *mayriana* Miyabe et Kudo), Sakhalin (A. *sachalinensis* Mast.), and Wilson (A. *wilsonii* Miyabe et Kudo). Fir is the most prevalent in Sakhalin, Primorsky and KKhabarovsk regions [18, p. 104; 20, p. 14; 21, p. 17].

Along with spruce, the Khingan fir is very common on the continental part of the Far East, in taiga spruce-fir forests; Khingan fir is one of the main forest forming species of the Far East dark coniferous forests. Both in the spruce-fir forests and the cedar-broadleaf forests there is a second growth. Occasionally there are small areas of pure fir plantations. It grows mostly on mountain slopes, rising up to the mountains of up to 1200 m above sea level, to the upper limit of forests. It is also encountered in mixed forests of river valleys. This gives it a sense of a mountain consolidating tree species that assist in maintaining the ecological balance in the mountain forests of the Far East. Trees are up to 20-25 m, more rarely –at least 28-30 m high and 35-45 cm in tree trunk diameter. Trunks are slim. Crowns are thick, conical, peaked. At an early age, the bark is smooth, light silver, with age it darkens and cracks. Swellings –"nodules" scattered in the crust are filled with clear and fragrant resin –fir balm. Turpentine, rosin, medicines, various varnishes, adhesives for lenses in the optical industry are produced from it. Fir needles are raw materials for the production of coniferous essential oils. Wood of the Khingan fir is the least valuable among the Far Eastern coniferous species, but in case of significant reserves, it performs a prominent role in wood consumption. It is used as building and saw logs, poles. It is a good material for box-packaging made of plaster lath [21, p. 16].

In the southern part of the Primorsky Krai, one of the authentic, original formations – black fir-deciduous forests – is wide spread; it is unique and rich, varies in floristic composition, characterized by its uniqueness from other formations of the southern Far East; the main forest-forming species in such forests is Manchurian fir [3, p. 115; 20, p. 18; 21, p. 16]. Manchurian fir is one of the main forest-forming species, the largest coniferous species of the Russian Far East [4, p. 3; 5, p. 62; 6, p. 45]; it is a slender tree with a thick laticone spreading crown, up to 50 (55) m in height and 21 m in diameter of the trunk and with the volume of up to 20 m^3 [2, p. 3; 20, p. 18; 21, p. 16]. It grows in the south of Primorsky Krai, within the northeastern part of China, in the mountains of Korea. It grows in the composition with the Korean cedar and broadleaf species, mainly on mountain slopes and usually occupy the lower belt. It grows up to 400-500 m high above sea level on mountains. It is found in broad river valleys among mixed forests. It does not form pure plantations, but in some parts of the area it dominates as part of mixed forests, enters the first growth. It is demanding to soil fertility and humidity. The needles are longer than of other Far Eastern species of fir, about 2.5-4 cm in length and 3 mm in width: flat, hard, sharp with whole (forked) tips, hence, the name of "holophylla" (whole leaf) [21, p. 17]. By quality of wood, it is superior to other kinds of fir, spruce and even the Korean cedar [6, p. 45].

Black fir forests are characterized by the complexity of phytocenoses and high biodiversity as by floristic richness they surpass cedar [4, p. 4]. In the past, wood was widely used in the national economy: as a building material (lumber, mine counter, poles, railway sleepers), raw material for the pulp and paper industry. Selected specimens were logged as resonant wood. They were cut down as New Year trees on a large scale.

After the ban on logging the Korean pine, the Manchurian fir became the main object of logging. This led to a reduction in its stocks and prohibition of harvesting. However, despite the administrative prohibitions, areas and stocks of the Manchurian fir continue to decline. Poaching, logging of young trees for the New Year holidays and forest fires contribute to this trend.

The main conservation directions of the Far East fir are the forest protection from fires, illegal logging of timber and Christmas trees, reforestation. The measures for its accelerated recovery are necessary.

Tree species of the "fir" genus are promising for the use in silvicultural production and green building in the Russian Far East. In this regard, the problem of increasing the production of planting material and shortening its growing period is relevant and of practical and scientific importance for forestry. It is possible to solve it through the use of growth stimulants (regulators). On the background of high farming techniques, seeds or seedlings treatment with stimulants increases the height and biomass of seedlings by 20-30%, promotes

good assimilation rate and growth on the silvicultural area [9, p. 171; 10, p. 57; 11, p. 90; 12, p. 62; 13, p. 314; 14, p. 189; 15, p. 129; 16, p. 104; 17, p. 20-21; 21, p. 17; 22, p. 107; 23. p. 11].

The analysis of literary sources shows that the use of growth stimulants (regulators) is widely used in agriculture and started on a trial basis in forestry, can be effective for growing Far East tree species, in particular – of the "Fir" genus.

This paper studies the effectiveness of the influence of the following growth stimulants (regulators): Epin-extra, Zircon and Krezatsin for growing seedlings of the Khingan fir and Manchurian fir. According to its physiological effect, these stimulants refer to the class of growth regulators; they increase seed germination, growth, flowering, root formation, activate the processes of chlorophyll synthesis, resistance to fungal and infectious diseases, drought, cold. They are safe for humans, animals and beneficial insects, environmentally harmless. The drugs are included in the list of pesticides and agrochemicals permitted for the use on the territory of the Russian Federation; are easily soluble in water and freely sold by a trading network [10, p. 54].

The first experiments in Russia on the use of growth stimulators in the cultivation of tree species planting material were held in the European part of Russia and the Far East: in the KKhabarovsk and Primorsky regions.

The literary sources reflect two directions of work: seed treatment before sowing to improve their ground germination [8 p.10-15; 11, p. 90; 12, p. 62; 16, p. 104; 17, p. 20-21], and root fertilizing of seedlings at a nursery [9, p. 171; 10, p. 57; 12, p. 62; 13, p. 314; 14, p. 189; 15, p. 129].

The goal of the work is to study the efficiency of using growth stimulators Epin-Extra, Zircon and Krezatsin for root fertilizing of the Khnagin fir seedlings (*Abies nephrolepis* (Trautv.) Maxim.) and the Manchurian fir seedlings (*Abies holophylla* Maxim.)

The studies were conducted on the territory of the Gornotayezhnaya station named after V.L. Komarov of the Far East branch of the RAS.

Based on the set goal the following tasks were solved:

1. To analyse forest vegetation conditions on the job site;
2. To sow the Khangin fir and Abies Holophylla seeds at a nursery of the Gornotayezhnaya station of the Far East branch of the RAS.
3. To conduct root fertilizing of the seedlings of the Khnagin fir and Manchurian fir with the solutions of growth stimulants: Epin-extra, Zircon and Krezatsin;
4. Agro technical care and subsequent observations over the growth of seedlings in height, diameter of the root collar, root system and phytomass.
5. Analysis of the stimulants' effect: Epin-extra, zircon and krezatsin on the growth of the Khangin fir and Manchurian fir seedlings.

Forest growth conditions of the research object are due to peculiar climatic conditions of the region. The climate of the study region is monsoonal [19, p. 19-57]. The peculiarity of the climate is formed under the influence of two opposing airflows in winter and summer periods. Elevated pressure sets over the Asian continent, and low pressure –over the Pacific Ocean. Air masses of cold and dry air emerging over Yakutia, Transbaikal area and Mongolia penetrate the south of the Far East, creating the winter or the continental monsoon.

The relief of the territory is mountainous. The growing season averages 178-189 days. The distribution of precipitation throughout the year is uneven: the least amount falls during the winter-spring period, the biggest –in the summer-fall period. Air humidity reaches its maximum value in the summer period, minimum value – in April and May. Strong winds and intense solar radiation, which in this period is due to the large number of maximum mainly clear days, lead to strong moisture evaporation and drying of the upper layers of soil. This is especially dangerous for conifers, the leaf apparatus of which is ready for photosynthesis. Soils are brown mountain-forest and low podzolic.

In general, forest growth conditions of the mountain taiga station area are characterized by a monsoon climate, characterized by a warm humid summer with significant amount of precipitation during the second half of vegetation and dry clear winter; complex and diverse soil cover, diversity of forest flora, conducive to the growth of the "Fir" genus representatives, the formation of coniferous and mixed coniferous-deciduous forests [19, p. 57].

In the experiments, we used growth stimulators (regulators) of natural and chemical origin.

Epin-Extra is a synthetic analogue of a natural phyto-hormone. The mechanism of its effect is the following: it activates plants' own phyto-hormones that are necessary in a particular phase of development. According to the effect on plants, **Epin-Extra** refers to the class of growth simulators: improves seed germination, growth, flowering, root formation; activates the processes of chlorophyll synthesis, resistance to fungal and infectious diseases, drought, cold.

Zircon is a natural growth stimulant-regulator, root-former, inducer of flowering and disease resistance; it is a mixture of hydroxicoric acids. It is produced by the Russian company NNPPNESTM from the plant raw material – Echinacea (*Echinacea*). It is a decorative and medicinal plant with beautiful flowers resembling large chamomiles. Solution in polypropylene ampoules. It has an antiviral effect.

Krezatsin is a triethanolamine salt of the ortho-cresol acetic acid $C_{15}H_{25}NO_6$. It is characterized by a wide spectrum of biological activity. The drug is easily soluble in water and alcohol, insoluble in ether. It is of low toxicity. It is recommended for presowing, root and foliar treatment of cereal and vegetable crops, fruit and decorative trees and shrubs to enhance seed germination and root formation, resistance to fungal and infectious diseases, improve cold resistance, growth acceleration and biomass accumulation.

METHODOLOGY

Research experiments on the use of environmentally safe growth simulators were conducted in the nursery of the Gornotayezhnaya station named after V.L. Komarov of the Far East branch of the Russian Academy of Science. Seeds of the Khangin fir and Manchurian fir were collected in the arboretum of the station, during spring time they were subject to snow retention and sown in nursery beds with levelled agricultural background.

Soil is forest, grey, of medium power, moist, medium sandy loam.

Soil preparation consisted in preliminary manual digging of soil and making beds for sowing seeds. Height of beds wasaround 20 cm from the soil surface. Location of sowing lines in beds is transverse. The distance between the centres of sowing lines is 20 cm, between the experimental variants –40 cm. The seeds were sown in transverse lines followed by embedding. The depth of embedding: Khanging fir –1.5 cm, holophylla –2 cm. After sowing, the surface of beds was compacted and mulched with a 1 cm layer of fresh sawdust. Crops were shaded with shields.

After germination and the start of seedlings growth in height and in the second year (in June), root fertilizing of seedlings was carried with the freshly prepared solutions of stimulants: Epin-extra, Zircon and Krezatsin. Feeding was carried out in the evening hours, in dry weather with no rain in the forecast. Concentration of water solutions: 1 ml/10 l ($1 \cdot 10^{-4}$) and 1 ml/100 l ($1 \cdot 10^{-5}$). The control group is seedlings that were not treated at the root with growth simulators.

Seedlings had been tended agro technically for 2 years; the care consisted of weeding and soil loosening between sowing lines: in the first year of seedlings growth d outit was carrietwice, in the second year –once.

After the vegetation period of seedlings is over, 25 pc. plants were taken from each variant of the experiment according the random sample method (one in five seedling) (to provide a small sample during the statistical processing); height of the overground parts was measured.

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Average values and model samples were calculated. For each experimental variant, three model seedlings were dug out, the diameter of the root collar of these seedlings and the length of the root fibril were measured, mass of the root system and the aboveground part (trunk, needles) were determined in a fresh state. The seedlings were divided into the root system and the aboveground part (trunk, needles), dried, weighed; specified growth indicators were determined in the air-dry state.

Materials of field experiments were processed in the statistical application programme Microsoft Excel "STATISTICS" [7, p. 43-45].

The results were compared by the experimental and control variants.

RESULTS

According to the meteorological observations carried out on the Gornotayezhnaya station, during the experimental works weather conditions were within the average perennial limits. The positive effect of root fertilizing with stimulants on the growth of experimental fir seedlings was already evident in the first year of growth (Fig. 1-3). Activation of the root system growth is observed. The most effective impact was noted when fertilizing with the solution of Zircon. Therefore, at a concentration of the drug of 1 ml/10 litres of water, the length of Khangin fir seedlings root fibril exceeded the one of the control group by 12.5%; with the Epin-Extra and Krezatsnin fertilizers respectively:

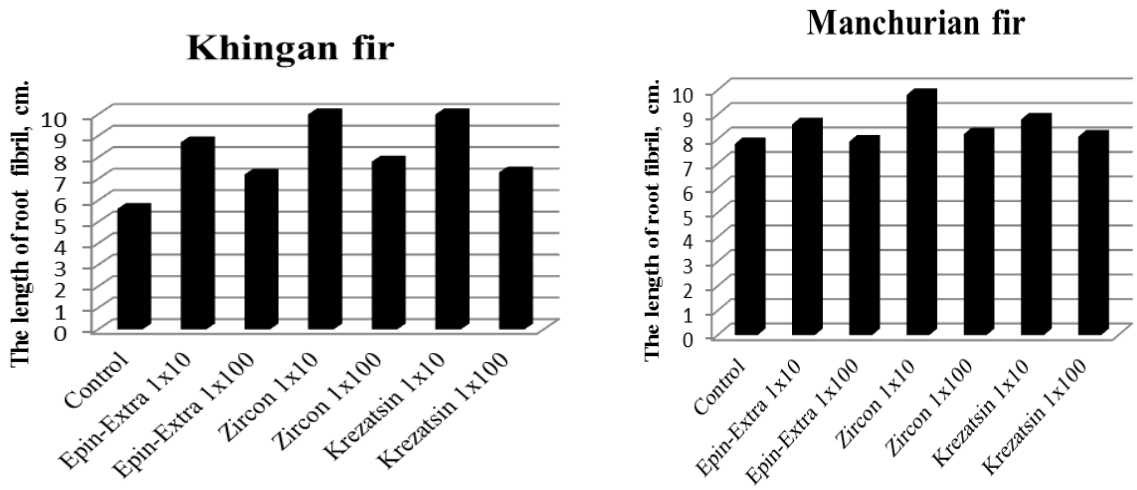

Fig 1: The influence of root fertilizing with stimulators on the growth of one-year seedlings' length of root fibril.

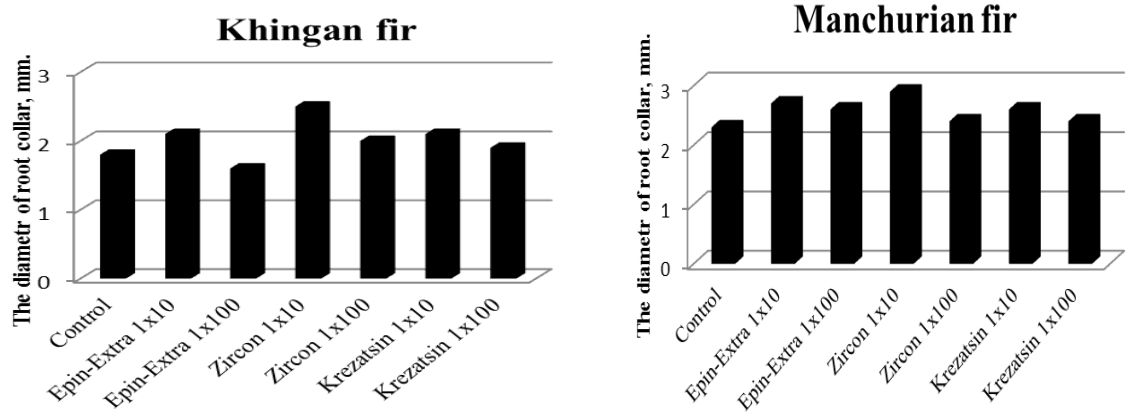

Fig 2: The influence of root fertilizing with stimulators on the growth of one-year seedlings' diameter of root collar.

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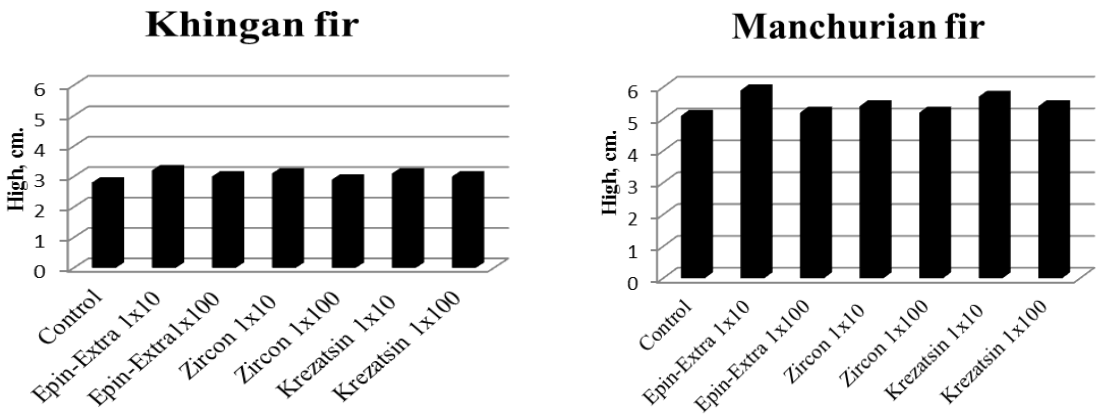

Fig 3: The influence of root fertilizing with stimulators on the growth of one-year seedlings' height.

9.7 and 2.8%. At lower concentration of the solution, the exceedances relative to the control decreased and stayed between 1.4 and 8.3%.

At the solution concentration of 1 ml/10 l, the rate of increase of the Manchurian fir length of the root fibril exceeded the control: when fertilizing with Zircon by 25.6%, Epin-Extra and Krezatsin –respectively: by 10.3 and 12.8%.

Simultaneously with the increase in the length of the root fibril, an increase in the growth rate of the root collar diameter was observed. However, in the first year of the Khangin fir growth there were no significant differences between the effects of stimulants and their concentrations; at a solution concentration of 1 ml/10 l exceedances to the control amounted to - 11.1%, at a concentration of 1 ml / 100 l – 5.6%. For the Manchurian fir, a noticeable increase in the root collar diameter of the seedlings fertilized with stimulants was already observed in the first year of growth. Thus, fertilizing with the solution of Epin-extra with the higher concentration increased the rate of growth, compared to the control by 17.4%; respectively: with Krezatsin – by 12.8%; Zircon – by 26.1%. At a lower concentration of the solution, exceedances to the control amounted to respectively: 13.0; 4.3 and 4.3%.

Active development of the seedlings root system stimulated better growth in height. At a solution concentration of 1 ml/10 l growth indicators for height exceeded the control of Khangin fir: with fertilizing of stimulants solutions: Epin-Extra – by 14.3%, Zircon and Krezatsin – by 10.7%. At a weaker concentration of the solution, the growth rate of seedlings decreased and exceeded the control by 7.1%; 3.6%; 7.1% respectively. The growth activity in height of the Khangin fir also exceeded the control. With the Epin-Extra solution – by 15.7% (solution concentration of 1 ml/10 l) and 2% (solution concentration of 1 ml/100 l). With the zircon solution – by 5.9 and 2.0% respectively; Krezatsin – by 11.8 and 5.9%.

Growth activation of one-year seedlings stimulated their growth in the second year, and in combination with the conducted root fertilizing led to further growth of the root system and the overground part.

With the growth stimulant fertilizing at a higher concentration, the root fibril of the Khangin fir exceeded the control by 55.4% (Epin-Extra), 98.2% (zircon), 80.4% (krezatsin). Solution concentrations of 1ml/100l decreased these growth indicators to 28.6; 39.3 and 30.4% respectively. Growth activity of root fibril length is also observed for the Manchurian fir; in the end of the second year when fertilizing with the solutions at a concentration of 1ml/100l exceeded the control by 59.8% (Epin-Extra), 88.5% (Zircon), 64.4% (Krezatsin). Lower concentration of solutions decreased these indicators to 32.2; 57.5 and 48.3% respectively. Similar growth dynamics is also observed for the root collar diameter. Depending on the species diversity of fir and stimulator solution concentration, exceedances over the control amounted to 5.6-47.8%.

More active growth of the root system of the seedlings is observed when fertilizing with zircon and krezatsin at a solution concentration of 1 ml/10 l. Growth of the seedlings root system led to the growth

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activation in height. Depending on the growth stimulator and its concentration, the height of seedlings reliably exceeded the control of the Khnagin fir by 3.6 – 64.3%; the Manchurian fir – 17.6 – 84.3%. At the end of the second growth of experimental seedlings, the start of the crown formation is noted. This way, with the zircon solution root fertilizing at a concentration of 1 ml/10 l, 44% of the Khangin fir seedlings and 84% of the Manchurian fir formed buds of side sprouts; at a concentration of 1 ml/100 l –4 and 8% respectively. Application of Epin-extra led to the formation of side buds on 12 and 36% of the seedlings respectively (Table 1).

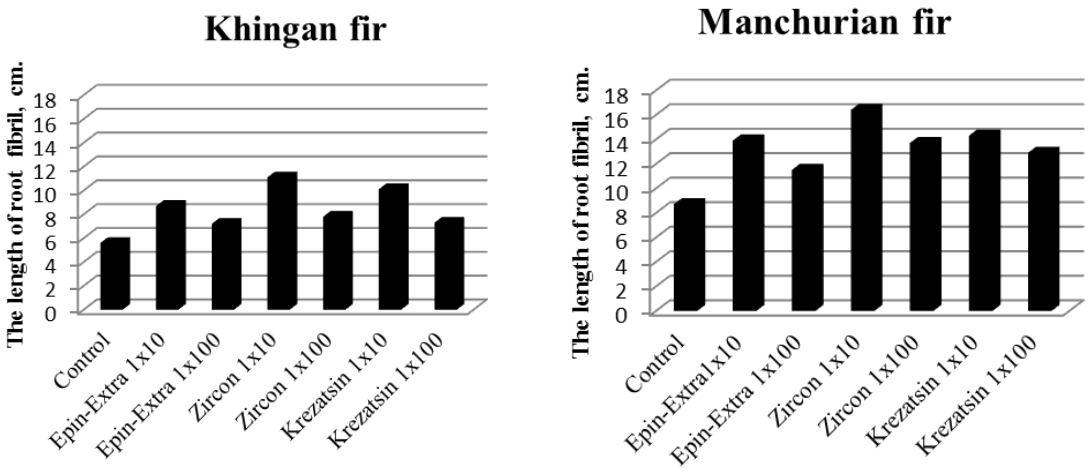

Fig 4: The influence of root fertilizing with stimulators on the growth of two-year seedlings' length of root fibril.

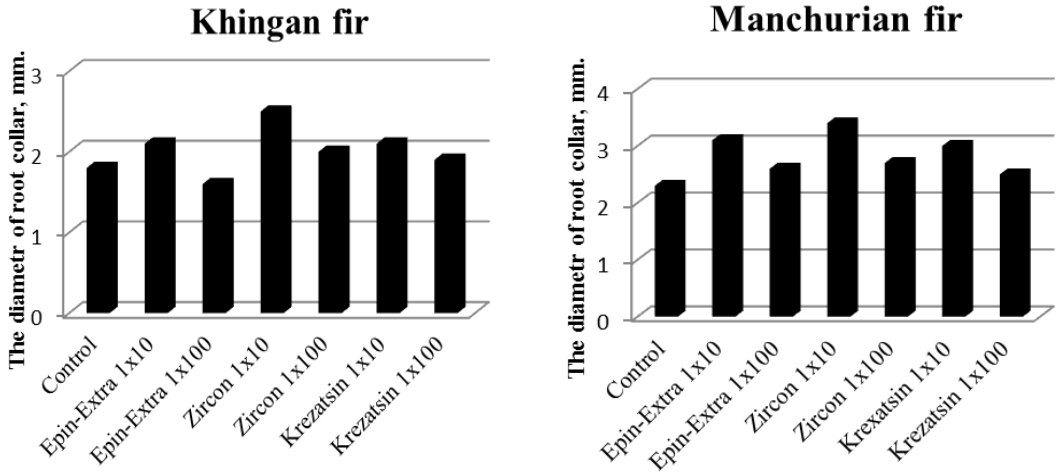

Fig 5: The influence of root fertilizing with stimulators on the growth of two-year seedlings' root collar diameter.

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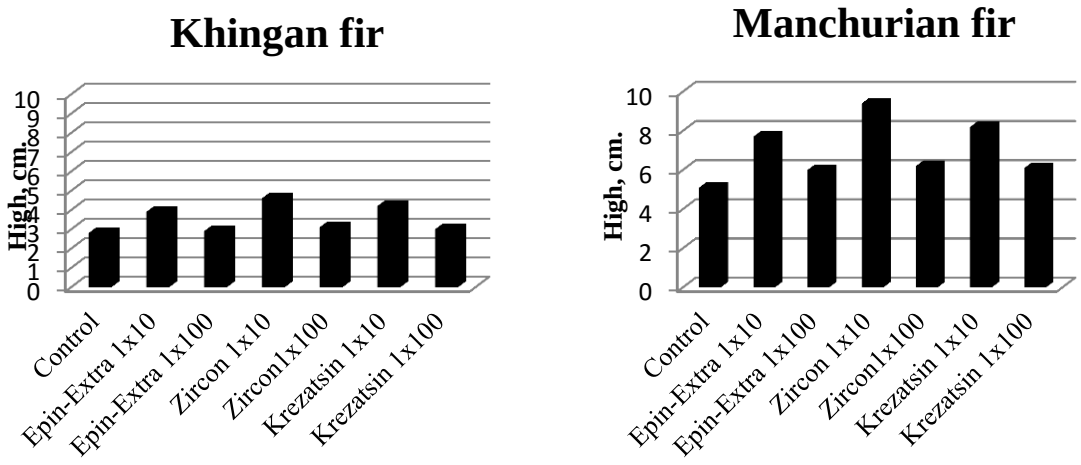

Fig 6: The influence of root fertilizing with stimulators on the growth of two-year seedlings' height.

Table 1: The influence of growth stimulators on crown formation of fir seedlings

No. percentage point	Growth stimulator	Solution concentration	Initiation of side buds of two-year seedlings, %	
			Khnagin fir	Manchurian fir
1	Control	x	x	x
2	Epin	1 ml/10 l	12	36
3	Epin	1 ml/100 l	-	3
4	Zircon	1 ml/10 l	44	84
5	Zircon	1 ml/100 l	4	8

At the beginning of the vegetation, three-year seedlings' intitiated side buds began to develop side shoots (Figure 7).

Fig 7: Initiation of side buds of the Manchurian fir two-year seedlings is shown on the left. The start of side shoots growth of three-year seedling is shown on the right.

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At the end of vegetation of the second year seedlings fertlized with zircon at a solution concentration of 1 ml/10 l, 28% of the Manchurian fir seedlings reached the requirements of the current industry-specific standard (OST) of sizes [1, Vol. 1].

Despite the fact that root fertilizing of the three-year seedlings stopped, their growth activity remained and reliably exceeded the control at a solution concentration of 1 ml/10l: for the Khangin fir root fibtril lenth by 13.3-41.8%; root collar diameter –by 3.1-48.1%; height –28.7-47.0%. For the Manchurian fir, these indicators amount to 26.4 – 43.4; 16.7 – 50.0; 10.5 – 19.7% respectively (Fig. 8-10).

Lower indicator values are noted in seedlings fertilized with the Epin-Extra solution, high –with the zircon solution. With lower concentrations of the solutions to 1ml/100l, exceedances to the control, depending on a growth simulator, indicators decreased for the Khangin fir to 2.0-18.4%; fir the Manchurian fir –to 3.9-15.8%.

By the end of vegetation, the three-year seedlings of the Khangin fir and Manchurian fir reached and even exceeded the requirements of the current industry-specific standard (OST) by 18-24% [1, Vol. 1].

CONCLUSIONS

Our first experiments suggest that the application of growth stimulants-regulators in forestry for growing planting material of the Khangin fir and Manchurian fir is possible.

Growth stimulators used in the experiments –Epin-Extra, Zircon and Krezatsin –are effective when growing seedlings of the "Fir" genus. The most active drug is Zircon.

The solution concentration of 1 ml/10 l more effectively stimulates root formation of seedlings and their growth in height, root collar diameter, root system and biomass, development of side shoots and formation of plants crown.

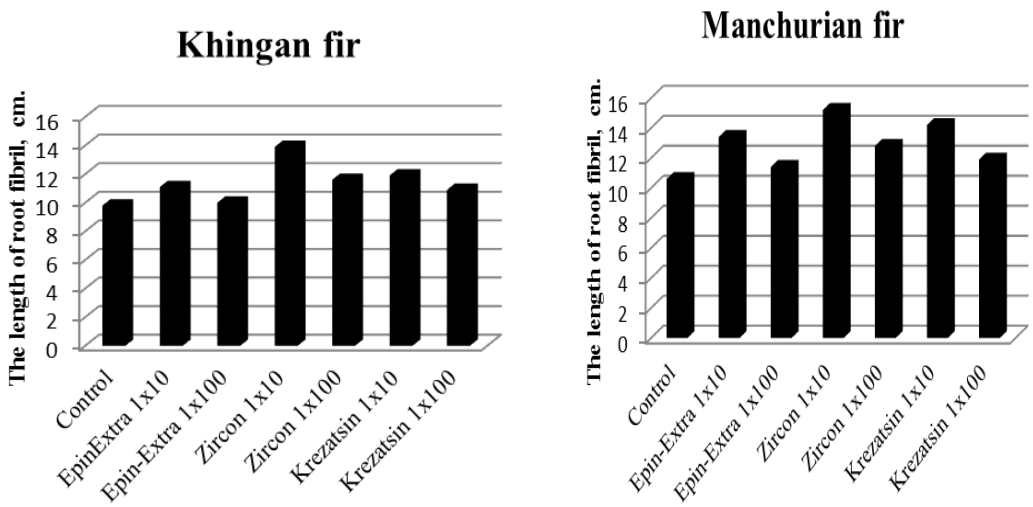

Fig 8: The influence of root fertilizing with stimulators on the growth of three-year seedlings' length of root fibril.

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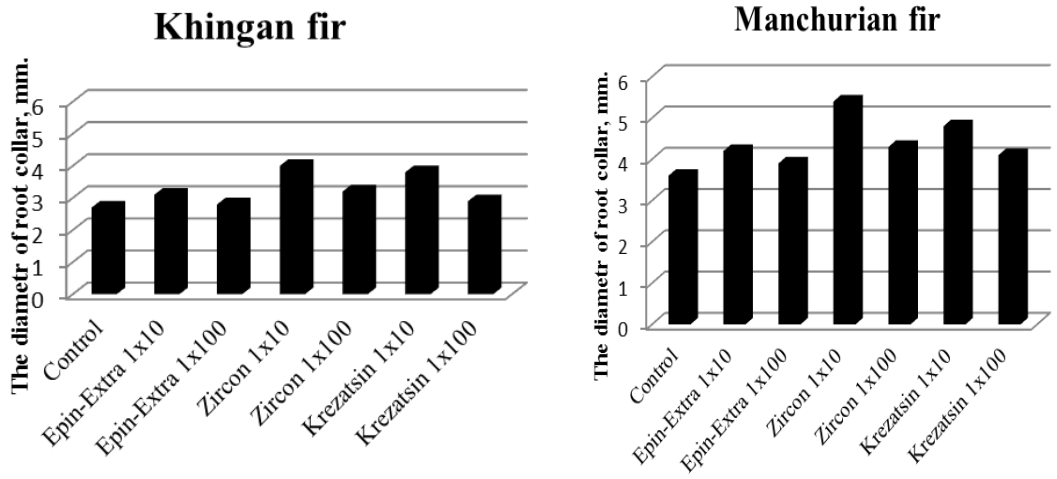

Fig 9: The influence of root fertilizing with stimulators on the growth of three-year seedlings' root collar diameter.

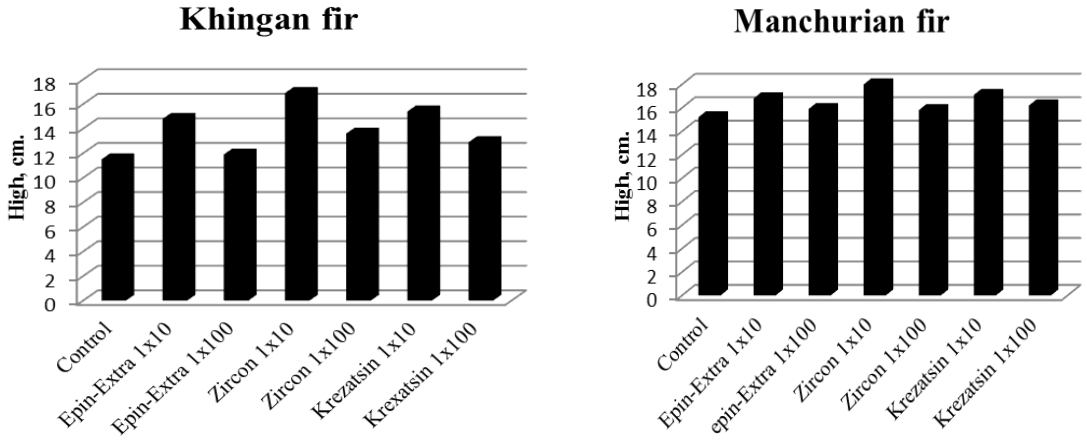

Fig 10: The influence of root fertilizing with stimulators on the growth of three-year seedlings' height.

We revealed the possibility of shortening the cultivation period of planting material by one year.

We consider it expedient to broaden the experiment and study the effect of higher concentrations of the solutions on seedlings growth, as well as expand the range of used growth stimulants.
It is necessary to calculate the production costs and cost-effectiveness of using growth stimulants in the cultivation of planting material.

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