A comprehensive application of fertilizers for growing plantations in forest nurseries: A brief review

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Abstract. Agricultural sectors must provide, clothe, and feed an increasing world population with energy while mitigating the impact on the atmosphere and on other undesirable factors. The land available to agricultural production in most parts of the world is small. Thus, the only way to increase output is to increase the yield from land currently being used. Crop yields without proper plant nutrition are minimal. Responding to the production challenge in an environmentally friendly manner requires a thorough comprehension of plant nutrition by fertilizers as a component of crop production, which encompasses many critical factors, including improved crop varieties, water management, and integrated pest management, etc. This paper is a state of art on the numerous update and feasible technologies of application of various fertilizers for growing plantations in forest nurseries.

1. Introduction
Based on many years of research, Sukachev wrote that the experimental method should be applied with precise consideration. All this matters in the complex of meteorological factors that are associated with light, heat and moisture. These elements can be used both as cultural resources and the growth and development of woody vegetation [1].

Dobrowolski et al (2017) [2] notes that each tree species normal growth and development, nutrients are needed in a strictly defined ratio and quantity.

In the works of Pyatnitsky (1953) [3], it was found that the largest number of small roots in pine seedlings is formed when soil moisture is 60\% of the moisture capacity level, and the optimum moisture content of pine seedlings is 40-60\% of the total moisture capacity. Approximately this conclusion was reached by P.M. Pankratova on the basis of vegetation experiments.

Rodionov recommended to apply poplar crops in the first year on brown soils of the Astrakhan region to carry out 8-9 irrigations with a rate of 350 m\(^3\)/ha, in the second year 5-7 irrigations and in the third year 4-5 irrigations. In this case, the irrigation rate should be 2800-3200 m\(^3\)/ha.

For an apple tree belonging to moisture-loving species, the range of the lower optimal soil moisture is 70-85\% of the total irrigation moisture capacity [4, 5].
Fimkin (1967) [6] in the Fergana Valley on slightly saline light gray soils with groundwater occurrence within the second meter, good results on the survival rate and growth of sycamore crops were obtained with 7 irrigations in the first, and 5 irrigations in the second and third years after planting with an irrigation rate of 400 m³/ha.

Evsevich (1965) [7], studying in Belarus the effect of various fertilizers on the growth and development of pine seedlings in a nursery on sod-podzolic soils, found that under the influence of full fertilization (N45P90K90), the absolutely dry weight of 100 seedlings at one year of age was compared with control 142%, and in two years - 200%. T. Dakeev (1979) studied the effect of nitrogen fertilizers on the growth of spruce planting material. The growth rate of spruce in height was most influenced by ammonium sulfate (20.5%), sodium nitrate (54.7%) and carbamide (47.0%). The seedlings yield at the same seeding rate (200 pcs. Per 1 linear metres) when fertilized with ammonium nitrate was 120 pcs., In the control - 96 pcs. for 1 linear metres, i.e. increased by 25%.

In Swedish nurseries, the following fertilization system is used. 12.000 c/ha of mineral fertilizers are applied annually [8]. Before sowing or planting seedlings, 4 centners/ha of superphosphate and ammonium sulfate are introduced in sowing. In the first year, the crops are fed in the summer with ammonium sulfate 1.5 c/ha. In the second year, in early spring, crops are fed with superphosphate 2 c/ha, potassium magnesium 1.75 c/ha and ammonium sulfate 2 c/ha, and transplanted plants, respectively, 2.2 and 2 c/ha. This fertilization system makes it possible to annually grow up to 80 million pine and spruce plants in the nursery covering an area of 62 hectares.

Recommendations on the use of fertilizers in forest nurseries available in the CIS countries, the most developed should be considered the recommendations for the taiga zone of the European part of Russia, drawn up by Stratonovich (1967) [9]. Previously, the authors studied in some detail the soil fertility in the forest nurseries of their zone. This made it possible to establish critical levels of soil supply with basic nutrients, which correspond to good growth and development of cultivated seedlings. Scales of soil humus, phosphorus and potassium provision were compiled.

These scales helped to give an overall assessment of the soil fertility of forest nurseries. It turned out that all nurseries in the Arkhangelsk region are poor in humus, and 60% of the soils of nurseries in the Leningrad region and all soils in the Arkhangelsk region are extremely poor in potassium and phosphorus.

2. Impact of Fertilizers on Seedlings and Root Systems

The growth and development of root systems of trees and shrubs depends on soil and soil conditions. The studies of Rakhteeenko (1952) [10], Rakhteeenko and Krot (1968) [11] showed that through the soil environment it is possible to regulate the growth of the aboveground part and root system, to grow more resistant seedlings of tree species with an optimal ratio of aboveground and underground organs. Mineral fertilizers on leached medium loamy chernozem in Kazakhstan have improved pine growth. The experimental plants exceeded the control ones by 26.3-28.7%. The greatest plant growth was observed when N20 P120 K20 was applied.

Application of phosphorus fertilizers in nurseries on ordinary heavy loamy chernozem at doses of 45 and 90 kg/ha promoted an increase in seed germination energy and seedling safety, increased the yield of standard pine seedlings, respectively, by 5 and 25%, and their weight by 24-30% [12].

El-Ramady et al. [13] and Negrao et al. [14] showed that when determining the quality of planting material, one should pay attention not only to the external signs of seedlings and seedlings, but also take into account the ecological and physiological indicators - the ratio of the aboveground organs of
seedlings and their absorbing surface root systems. The larger it is, the higher the quality of the planting material.

Fertilizers are also widely used in nurseries of foreign countries. In Germany, organic and mineral fertilizers are used to increase soil fertility in nurseries [15]. The types and rates of fertilizers are established on the basis of systematic soil studies (every 2 years), taking into account the need for nutrients in each field of the nursery.

Mironov (1977) [16] emphasized that survival is determined not only by the mass of the root system and the reserve plastic substances deposited in it, but also by the mass of needles. From the first day of planting of seedlings, the needles provide photosynthesis and the supply of new amounts of plastic substances to the root system, where they are most needed for the regeneration of the absorbing roots. Matveeva et al. (1978) [17] found that seedlings and saplings of Siberian larch with a diameter of 3.0-9.0 mm are distinguished by better survival rate and growth compared to seedlings and seedlings with a diameter of 2.02.9 mm - 3.00 mm

Fertilizers are widely used in experimental and industrial work with tree seedlings in nurseries in Bulgaria [18]. The introduction of various forms of nitrogen fertilizers against the background of phosphorus and potassium fertilizers before sowing to a depth of 10-12 cm has a positive effect on the growth of spruce seedlings. Ammonium sulfate and potassium nitrate had the maximum effect on the increase in the diameter of 3-year-old seedlings in comparison with the control, by 38.1 and 33.3%, respectively. Height growth rates were particularly influenced by ammonium sulfate, sodium nitrate and urea. The height of the seedlings when using these fertilizers increased by 58.9%, 54.7% and 47.0%, respectively, compared with the control. The yield of standard seedlings increased by 25%.

According to Kazakhstan Research Institute of Forestry (the experiments were carried out in the nursery of the Kokchetau-Makatinsk uplands), pine seedlings are most responsive to the improvement of phosphorus nutrition [19]. The most effective were doses of 80 and 120 kg/ha P₂O₅ in granular form. Nitrogen, potash, nitrogen-potassium fertilizers acted positively, but less effective than phosphorus fertilizers. The joint action of the three main elements (N, P, K) in the ratio 1: 4: 1 proved to be especially effective; 2: 4: 1; 2: 6: 1.

3. Impact of Fertilizers on Plant Growth Rate

In the complex of agrotechnical measures that provide a high yield of standard planting material and have a tremendous impact on the growth and development of woody plants, tillage occupies an important place. When processing the soil, its physical and chemical properties are improved, conditions are created for the accumulation and preservation of moisture, air, heat, which in turn contributes to the activation of microbiological processes in the soil, the decomposition of organic substances and the accumulation of assimilable forms of nitrogen, phosphorus, potassium and other elements, improvement growth of root systems of cultivated species [20].

The rates of fertilizing with mineral fertilizers are established depending on the degree of provision of the arable layer with the corresponding elements of mineral nutrition, on the granulometric composition of the soils, as well as on the breed and age of the seedlings [21].

With an optimal ratio of the mass of thin roots and the aerial part, the growth rate of plantings, their resistance to unfavorable environmental factors are determined by the initial mass of seedlings and seedlings. This pattern is typical for all types of planting material, including those from greenhouses and those with a closed root system. Plants that have reached the maximum size at the minimum age of the planting material retain higher growth rates in the plantings [22].
Fertilizing the soil is of great importance for the accelerated growth and development of plants. The effect of fertilizers on soil and plants is very diverse, but under certain conditions it can be harmful. The correct application of fertilizers should regulate the acidity of the soil solution, increase the vital activity of soil microorganisms, improve the structure of the soil, create an optimal ratio of nutrient forms assimilated by plants and thereby contribute to better root activity and optimal (but not maximum) development of the aboveground part [23].

The effect of the introduction of mineral elements can be ambiguous and depends on the dose. Excess fertilization, as a rule, has no effect and negatively affects the yield and quality of fruits [24]. According to many experts, it is possible to significantly increase the yield of seedlings in forest nurseries by introducing modern methods of growing young trees in production, aimed at optimizing the vital factors of the plant organism. One of the most effective and economically quickly recoupable methods of regulating the growth and development of seedlings is the use of mineral fertilizers [1, 25]. Violation of nitrogen metabolism in plants leads to a delay in the synthesis of proteins, to cause a suspension of growth and underdevelopment of leaves. The whole plant turns light green. The lower leaves begin to turn yellow prematurely; upon drying, they acquire a light brown or yellow color. Lightening begins from the veins and the adjacent part of the leaf blade. The stems and leaves are thinner than usual. Defoliation comes prematurely. Phosphorus starvation disrupts protein metabolism, negatively affects the development of roots, impairs the process of photosynthesis, growth of shoots and leaves, which leads to a general weakening of plants. In deciduous trees, the lower leaves turn yellow and brown, and when dry they become light brown, sometimes almost black. The lack of potassium weakens the synthetic processes in plants, sharply reduces the amount of carbohydrates, especially sucrose and starch, slows down the outflow of plastic substances from the leaves, which begin to turn yellow at the tips, and the rest of them remains green; the tips and edges gradually die off and turn brown. The general appearance of the plant becomes mottled yellow. Potassium deficiency usually becomes noticeable in late summer.

To prevent the depletion of the soil, fertilizers should be used with an average and especially low supply of them with one or another nutritional element. However, it should be borne in mind that any fertilization will give the greatest effect only with an uninterrupted supply of plants with moisture and air [26].

4. Impact of Nutrients

All nutrients are of great importance in the life of plants, and therefore their reserves in the soil must be replenished in a timely manner. Most often, soils lack three basic elements: nitrogen, phosphorus and potassium. The provision of the soil with these macroelements of mineral food is characterized by the content of their mobile forms. None of the elements can be replaced by another. Nitrogen is a part of organic compounds of proteins, chlorophyll, and enzymes. Phosphorus is a part of nucleic acids and complex proteins of protoplasm. Almost all the processes of synthesis and decay of the most important organic compounds inside the plant organism occurs with the participation of phosphoric acid. Potassium activates the activity of many enzymes, increases the water content of protoplasmic colloids, i.e. increases drought resistance of plants [27].

In Uzbekistan, for the first time, experiments to identify the effect of fertilizers on planting material of tree species were started in 1960 by the former Central Asian Scientific Research Institute of Forestry [28] on the soil of a meadow-bog type with annual seedlings of some tree species. A fertilizer application scheme was tested, coordinated with the zonal station of fertilizers and agrosoil studies of
the Uzbek scientific institute of inorganic chemistry. In a one-year experience, the best result for the development of the aerial part and the root system of seedlings of locust and pinnate elm was obtained with the introduction of nitrogen and phosphorus at 90 kg / ha. For ash-leaved maple, the greatest effect was achieved with the introduction of nitrogen and phosphorus at 90 kg / ha, for downy ash - with the introduction of nitrogen 60 kg / ha and phosphorus 90 kg / ha.

Major work on the study of the mineral nutrition of tree species and the use of fertilizers in forest nurseries was carried out in 1961-1965 under the guidance of Doctor of Biological Sciences T.A. Zheltikova (1969) [29]. The target was the development of norms and terms for the introduction of mineral fertilizers in irrigated forest nurseries to improve the quality of planting material, reduce the time of its cultivation and increase the yield of standard seedlings per unit area of nurseries. Experimental work was organized on sierozem in the Don-Kurgan nursery of the Tashkent forestry enterprise of Uzbekistan, the Shakhrintau nursery in Tajikistan, on the meadow-boggy soils of the Dendrological Park of the former Central Asian Scientific Research Institute of Forestry and on the newly irrigated takyr soil in the nursery of the Turkmen LOS.

Research on the cultivation of the planting material of Karelian birch was carried out in the closed and open ground of the nursery of the educational farm Tashkent Agricultural Institute A.S. Ablaev (1985) [30]. According to his data, seedlings grown in greenhouses reach the size at the age of one year, allowing the creation of forest crops. So, in a greenhouse, the average height of seedlings is 71.2 cm, diameter is 5.2 cm. In open ground, seedlings reach a height of only 8.5 cm per year with a diameter of 2.4 mm.

5. Conclusions

Thus, the analysis of the literature concerning the issues we are developing shows that most of the works are devoted to the study of the peculiarities of growing planting material for the purposes of reforestation and protective afforestation, and very little for green construction. In addition, the available data are often contradictory. There is no information on the effectiveness of mineral fertilizers, irrigation regimes and growth stimulants when growing ornamental plants such as tulip, paulownia and magnolia, which makes it urgent to study these issues.

The group of researchers has many years of experience in research and development and recommendations for growing planting material of various tree species in various soil and climatic conditions of Uzbekistan. They developed recommendations, published a number of articles on the use of fertilizers, irrigation regimes, seeding rates, etc.

Conflicts of Interest

The authors declare no conflicts of interest.

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