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Ecology

New Technologies for Cultivation of Industrial Forest Crops in the Subtropical Zone of Western Georgia

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Despite the fact that Georgia belongs to a number of countries rich in forested areas, the effective use of wood resources is very limited and cannot meet the demand for wood in the country even minimally. For a country with such a mountainous terrain and difficult orographic conditions, such as Georgia, forest wood is not the most important forest product, because other components of the multifaceted importance of forest resources gain much more state importance in the development of public production. In this regard, first of all, the ecological functions of mountain forests deserve special attention, in particular, soil-protective, water-regulating, anti-erosion water-protective, anti-avalanche, sanitary-hygienic, agro-forestry-improvement functions of forest ecosystems and others. The need to find alternative ways to prevent the deterioration of the protective functions of mountain forests and to meet the systematically growing demand for forest wood products of the country is on the agenda. In this regard, the creation of industrial plantations of fast-growing, valuable forest varieties with high technical properties, especially introduced plant species, is of particular importance. Slow growth is a big drawback for woody forest species used in industrial plantations since the plant's growth rate and the ability to quickly accumulate biomass are highly dependent on the selection of the plant species used for the plantation, soil fertility, and a well-developed root system. Therefore, the next step in the implementation of high-performance forestry plantations is the selective selection of fast-growing woody plants with high technical properties. Guided by scientifically based methods of optimal frequency of planting, we developed an appropriate model for growing promising, highly productive, fast-growing forest crops in the slightly swampy area of Kolkheti in the forest-crop districts. Using new progressive technology to create highly productive plantation of valuable fast-growing woody species (poplars, oriental sycamore, Liriodendron-tulip tree and others) in the weakly swampy area of the Kolkheti plain, in our experiments, the total production of wood worth 3-3.5 times more than from the local plant species was obtained for each hectare of forest plantation of the industrial purpose plantation of the above-mentioned new plant species. *© 2023 Bull. Georg. Natl. Acad. Sci.*

bioelements, biomass, forest crops, soil surface response, subtropical forests, erosion, snow avalanches

Forests of Georgia are divided into mountain and plain forests according to the terrain conditions. Mountain forests occupy 98% of the entire forested area, plain forests – 2%, which are spread mainly on the Colchis plain and also in the lower areas of the rivers: Mtkvari, Alazani, Iori, Khrami and

others. 98% of forests belong to forests of complex orography and high mountains, 80% of which are located on slopes of 350 and more.

In the 30s-50s last century, a large-scale involuntary selective cutting took place in the mountain beech, spruce and pine forests of Georgia. With these cuttings only a large number of healthy trees were removed, and the forest was left with firewood, small-sized assortments, rotten, deadwood, broken-stemmed and overgrown trees. The trees left in the grove during felling suffered severe mechanical damage, and the clearing of the grove contributed to the wind movement of the trees. It is significant that the cause of this depression of the mountain forest environment-creating functions was mainly the result of thoughtless, mostly immature human action, no one thought about preserving and strengthening the beneficial social and ecological properties of forests, forest restoration and renewal measures were almost nowhere carried out [1-4].

The deterioration of the condition of the local forests was also facilitated, approximately at the same time, by the insufficiency of the population's agricultural land fund, arable land, pastures, and hayfield. In order to increase the areas of this type of agricultural land, the intensified exploitation of forests and the process of transforming forest fund lands were underway.

There was and is still a problem in large areas of the forest area, disordered, intensive grazing of livestock, due to the negative consequences of which, the process of natural renewal in significant areas of the forest has been practically stopped. It should also be noted that severe weather conditions are characteristic of individual regions of the Republic of Georgia. As a result, the optimal stability of natural complexes was violated on large areas of the forest, which led to the release of vital natural resources – flora and fauna. In the individual formations of the mountain forests of the Republic, due to unsatisfactory natural renewal, deforestation is observed on large areas, in entire areas, a large part of such forests have lost their protective functions. The consequences of the deterioration of the ecological stabilization of the forest were mainly manifested in the replacement of high-productivity forest species with non-forest phytocenosis-forming species, The decrease in the frequency of forest groves was accompanied by the disruption of the hydrological regime (unstable discharge of rivers and streams, floods, drying of part of the springs, etc.), the strengthening of the action of water-caused erosion and cold winds, snow avalanches, the decrease of the functions determining resort and recreational purposes, etc. In the complex of vertical zoning of the forest, the disruption of the optimal afforestation of the water-gathering basins and the activation of the highly negative processes of lowering the subalpine (upper border of the forest) climatic boundaries and their degradation, and, most importantly, the forests were losing soil-protection, water-protection, water-regulation, erosion and avalanche-preventive functions.

Overexploitation of forests was going on intensively in Racha-Lechkhumi, Abkhazeti, Ajara, Kakheti, Kolkheti Plain, and elsewhere. Basically, it is the reasons mentioned above that should explain the great material losses that came to the public economy of the Republic. For example, in 1977-1990, according to the results of our research, as a result of the deterioration of the protective functions of the mountain forests in Adjara, during this time about 800 residential houses, and more than 60 public and other engineering buildings were deformed or completely destroyed. In Ajara, currently, more than 700 families are in the danger zone of active natural processes, up to 300 active landslide bodies, and up to 180 flood-producing basins have been recorded. 98% of the territory of mountainous Ajara is a potential arena for snow avalanches. During two decades, 1500 ha of arable land was lost as a result of erosion processes. In 1977-1987, about 2,000 cases of avalanches, landslides, floods and other natural events were recor-

ded in Adjara, and the public economy suffered significant losses, and there were human casualties as well [5].

The above-mentioned gross violations in forest use and the decades-long disproportion between forest restoration and forest consumption have practically excluded any possibility of continuous use of the main forest product – wood. Therefore, it was no coincidence that for many years a number of Georgian scientists and practicing foresters fought with dedication for the importance of forests in Georgia, for the mistakes made in forest exploitation and the need to improve the state of the field, led by Academician Vasil Gulisashvili, the founder of mining forestry as a science and the Georgian School of Forestry Scientists.

Foreign researchers-experts also offer unmistakable and accurate conclusions made on the basis of important theoretical and practical experience of planting artificial forest. For example, UN experts are convinced that the growth of timber production is impossible without the creation of large plantations. As evidenced by the achievements of New Zealand, Brazil and other countries, the productivity of forest plantations in artificial conditions is 5-7 times higher than that of natural forests. Plantations are cost-effective and they can be harvested 3-5 times earlier than natural forests. The plantation can be resistant to polluting compounds, extreme temperatures, pathogens of pests and diseases, increased humidity, drought and other stress factors.

The scientific research conducted in this field and the results of practical implementation have found significant coverage in the periodical publications of the results of the scientific research work conducted on the mentioned problems by scientific biologists and botanists of many countries of the world: found out that under conditions of 50 cm of groundwater in the soil (especially at the beginning of May), a twenty-year-old plantation of poplar planted on it gives as much wood as a sixty-year-old alder grove [6]. A lot of attention is paid to the testing of poplar species in Canada and the USA [7]. He recommends 16 poplar clones for the province of Quebec, 10 fast-growing poplar clones for the Ontario region, noting that the following hybrids show the best growth at six years of age: Populus alba x eurpameriacana – 214 h=7.4 m; d = 10 cm; Populus alba x eurpameriacana I – 45/51 h = 6.6 m; d = 10 cm; Populus alva x dividing h =7.4 m; d = 10 cm; Populus alba x Sieboldi h =7.1 m; d = 10 cm. The author indicates in his research that the Canadian poplar on the marshy soils of Beverly and Wainfleet, in the first case, the average height (h) of the 20-year-old poplar plant reached 18.6 m, the diameter (d) – 30 cm, and in the second case – the average height of 35-year-old Canadian poplar did not exceed 30.6 m, and the diameter was 30 cm. We can get acquainted with the detailed methodical guidelines for the technology of breeding hybrids between poplar species in the works by [8; 9; 10] and others. As a result of 18 years of work, brought out new species of hybrid poplar and somewhat increased the yield of plants that provide raw materials for the production of cellulose [2]. A poplar plantation, during the first ten years, grows at a rapid rate of 1.5-2.0 meters per year. In subsequent years, the increase falls rapidly. The average and current increase reaches a maximum in the 15-16-year-old crop, and at the age of 25, the poplar culture reaches absolute maturity in terms of quantity. This is the period of forest crop when the average annual increment of timber per unit area reaches its maximum amount. At this time, the average and current increment of wood approaches each other or becomes equal.

It is an accepted and proven theory that mineral nutrition elements are in the soil in soluble and bound forms [11; 12]. Water-soluble nutrients are insignificant, only 0.2% of the total supply. Almost 98% of bioelements are found in organic compounds, humus, and hard-to-dissolve inorganic compounds, and they are also included in the mineral composition. Plant cells will have the ability to absorb only those ions that they especially need. In

this respect, different plants are sharply distinguished from each other.

The quantitative ratio of individual bioelements is a distinct feature for individual species and families, as well as for different plant organs. The mentioned ratio changes according to the age of the plant. Trees and shrubs usually contain more nitrogen than potassium.

In some areas (for example, in the narrowed soil area), low soil fertility is caused by insufficient amounts of nitrogen, phosphorus and potassium, which are present in this soil in an easily mobile form. In addition, the low fertility of compacted soil often depends on its poor physical composition and excessive acidity. Therefore, it is necessary to thoroughly study the mentioned properties of the soil and select the assortment of cultivated species accordingly. When the soil does not have favorable conditions for the normal growth and development of plants, it is necessary to fill it with fertilizers, carry out melioration measures, etc. [7].

The root is the most important part of the plant used for industrial plantation of woody forest species. The type and shape of the roots (multiaxial, brushy) significantly determines the effectiveness of forest crops. Effective root depth varies by species. Therefore, for creation of plantations, plant selection and soil treatment should be done taking into account the peculiarities of the root system.

The maximum plant root depth is not suitable for most situations, which is due to soil-climatic conditions (for example, unfavorable soil moisture, or conditions of poor soil fertility at great depths). It is known that for most species of herbaceous plants, the effective depth is only 30-60 cm, since 90% of their roots are located at this depth. The effective depth of tree roots is 3-6 m, although individual roots can go much deeper into the soil. In some technologies, it is necessary that the root depth reaches up to 9 m, so that it can supply water-dissolved nutrients from the ground water to the above-ground organs of the plant.

Summarizing all the above, we come to the conclusion that selection of the range of woody species to be used in forest culture for the purpose of artificial planting of forests in the natural zones of Western Georgia, i.e. for the creation of industrial plantations of woody plants, the complex agro-industrial study of their environmental conditions, adaptation to the mineral nutrition elements of the soil and physical-mechanical features of the soil, creation of favorable conditions for intensive plant growth, the development of scientifically based measures and the works of implementation in production, if we do not take into account our researches, have not been carried out.

Results and Discussion

Based on the actuality of the modern requirements of the above problem and taking into account the methodological guidelines, the conclusions made were the basis for the work of the group of scientists and educators of the Department of agro-ecology and Forestry of Batumi Shota Rustaveli State University, on the research topic: "Agri-production characterization of the soils of the natural zones of Western Georgia for the purpose of cultivating their industrial forest crops".

Based on the study of the soil-climatic conditions and natural vegetation cover of the subtropical zone of Western Georgia, in order to produce industrial plantations of fast-growing forest species, we identified the following administrative-territorial districts, sub-districts and municipalities in the subtropical natural zone of Western Georgia, which is the basis of areas for the cultivation of industrial forest plantations of woody plant species:

District of mixed subtropical forests, 0-500-600 meters above sea level, in which three sub-districts were distinguished:

Relatively wetland sub-district, with the following administrative municipalities: Batumi, Kobuleti, Chokhatauri, Ozurgeti and Lanchkhuti, which in turn are divided into the following forestry and

cultural areas: a) 0-300 m above sea level; b) region of subtropical forest forming species.

Humid sub-district, 0-300-500-600 meters above sea level, with the following administrative municipalities: Sokhumi, Gudauta, Gulripshi and Gagra, from which, in turn, the following forestry-cultural districts were distinguished: a) primary introduction area, from 0-300 m above sea level; b) subtropical forest forming species area, within the limits of 300-500-600 meters above sea level.

District of mixed subtropical forests, 0-500-600 m above sea level. The region of mixed subtropics of Georgia occupies a relatively narrow strip along the Black Sea, which occupies a relatively wide area in the middle of the Kolkheti plain, and then gradually narrows in the direction of the south and northwest. This entire area, which has a variety of surface features, was divided into two uneven parts – 1) plains and 2) hilly parts of the mountain foot-hills.

The part of the plain, known as the Kolkheti plain, occupies a wide area, the lower reaches of Rioni, Khobi, Enguri and other rivers and has low elevations, 5-10 m above sea level. The result of the accumulative action of the mentioned rivers and their tributaries is the creation of the Kolkheti plain, which, as is known, was represented as a sea bay in the past. It is bordered by the Black Sea from the west. To the east and northeast, the Kolkheti plain occupies higher part and is represented by a system of terraces along the main rivers of Western Georgia.

Around this issue, 12 km away from the city of Poti, on the cloddy and sandy soils of the left bank of the Rioni River (location "Sagorodo"), a test plot was allocated for an industrial plantation of poplars (balsam and red-veined poplars), eastern sycamore and liriodendron (tulip tree), in order to conduct experimental trials. Soil incisions and their morphological description were made on the pre-selected test soil type. Soil samples were taken for analysis according to individual horizons. The following laboratory works were carried out in the samples of the given soils: mechanical analysis of the soil using $Na_4P_2O_7$ total humus content – with Turin method; total nitrogen content – with Kjeldahl method; soil reaction – with PH electrometric method; soil assimilation with the phosphorus – with onian method; $CaCO_3$ – volumetric method in soil. Data were entered into appropriate tables. On the trial plot, with different layouts (1.0 x 1.0 m, 2.5 x 2.5 m, 4.0 x 4.0 m, 6.0 x 6.0 m). We planted the test trees named above. All practical works provided by agro-techniques and full protection of technological processes were carried out on the plot. In order to fully feed the plants with mineral fertilizers in the plantation, we replenished the soil nutrient supply and enriched the soil fertility with different combinations and doses of complete mineral fertilizers (NPK), according to the trial options. Among the variants of the testing (forms of fertilizers, doses, cultivation, etc.), a control variant was also allocated. In order to analyze the comparative data of the relationship between the results of the analysis of test options and the biological features of natural forest plants, some indicators of the growth and development of alder (Alnus barbata C. M. M.) widespread in Kolkheti and wood stock per unit area were also evaluated. The obtained digital indicators, which were processed by the variational statistics method, were included in appropriate tables. The obtained digital data was processed with variation statistics analysis, with special attention to the essential difference data (t) and data validity (V %). The essential difference is calculated with the formula $t = \frac{M_1^2 - M_2^2}{\sqrt{m_1^2 + m_2^2}}$ and validity chance – in V %.

Conclusion

Based on the results of many years of trial-experimental research, it can be concluded that the most optimal layout for obtaining high results of planting balsam and red-veined poplar and eastern sycamore on the slightly swampy soils of Kolkheti

is 2.5 x 2.5 m and 4.0 x 4.0 m. It is worth noting the fact that one hectare of 25-year-old alder forest gives us only 200 cubic meters of wood. We have completely different picture in the 15-16-year-old planting of poplars, sycamores and tulip trees in different layouts. Thus, for example: balsam poplar – 1.0 x 1.0 m – 254.0 m^3/ha; 4.0 x 4.0 m – 351.2 m^3/ha; Red-veined poplar – 2.5 x 2.5 m – 298.3 m^3/ha; 4.0 x 4.0 m – 360.6 m^3/ha. Convincing results have been obtained for eastern sycamore and liriodendron (tulip tree) 1.0 x 1.0 m, 2.5 x 2.5 m and 4.0 x 4.0 m in cases of crop placement. It should also be taken into account that cellulose of both types of poplar, sycamore and tulip-tree wood, needed for paper and furniture production or in various fields of farming, is of much higher quality than alder wood in terms of technical characteristics and their wide-scale use.

Another conclusion can be made: if we get the above-mentioned promising, fast-growing, introduced tree-plant cutting rotation of 15-20 years taking into account the results of our own research and the results of the research of highly developed countries, in this period, it is quite possible to produce the necessary cuttings of the main use of high-quality mature wood. If 1000-1500 ha of land is allocated for this purpose in the weakly swampy area of Kolkheti, every year, we will get the amount of high-quality wood stock that is allowed by the forest management of Georgia.

It was revealed from the excerpts of the industrial designated areas for planting plantations of the forest fund of natural zones of Western Georgia that tens of thousands of hectares of land can be allocated freely in the administrative-territorial districts, sub-districts and municipalities of the mentioned zone. With this, serious economic, ecological and social problems will be solved along with meeting the constantly growing demand for wood in the country; unsystematic, excessive industrial deforestation in the country's mountain forests will be reduced, thereby creating favorable conditions for the restoration and renewal of unrenewable trees, low and medium frequency groves. The main demands of the development of the public economy of the mountain forests of the republic will be resolved: soil protection, water retention, sanitary-hygienic, water-regulating, anti-snow avalanche, anti-erosion functions, improvement of the functions of resort and recreational purposes.

ეკოლოგია

დასავლეთ საქართველოს სუბტროპიკულ ზონაში სამრეწველო ტყის კულტურების გაშენების ახალი ტექნოლოგიები

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მიუხედავად იმისა, რომ საქართველო მიეკუთვნება ტყის მასივებით მდიდარი ქვეყნების რიცხვს, ტყის მერქანი საქართველოში არის ძალიან ლიმიტირებული და ვერ აკმაყოფილებს ქვეყნის მოთხოვნილებას მინიმალურ დონეზეც. ისეთი მთიანი რელიეფისა და რთული ოროგრაფიული პირობების მქონე ქვეყნისთვის, როგორიც საქართველოა, ტყის მცენარეულობა არ წარმოადგენს ყველაზე მნიშვნელოვან პროდუქტს, რადგან ტყის რესურსების სხვა მრავალმხრივი მნიშვნელობის კომპონენტები გაცილებით მეტ სახელმწიფოებრივ მნიშვნელობას იძენს საზოგადოებრივი წარმოების განვითარებაში. აქედან გამომდინარე, ეკოლოგიური ფუნქცია იმსახურებს განსაკუთრებულ ყურადღებას, კერძოდ, ტყის ეკოსისტემების ნიადაგდამცავი, წყალმარეგულირებელი, ეროზიის საწინააღმდეგო წყალდამცავი, ზვავის საწინააღმდეგო, სანიტარიულ-ჰიგიენური, აგროსატყეო ფუნქციების გაუმჯობესება და სხვა. დღის წესრიგში დგას მთის ტყეების დაცვითი ფუნქციების გაუარესების თავიდან აცილებისა და ქვეყნის ხე-ტყის პროდუქციაზე სისტემატურად მზარდი მოთხოვნის დაკმაყოფილების ალტერნატიული გზების ძიების აუცილებლობა. განსაკუთრებული მნიშვნელობა ენიჭება მაღალტექნიკური თვისებების მქონე სწრაფმზარდი, ძვირფასი ტყის ჯიშების, განსაკუთრებით შემოტანილი მცენარეული სახეობების სამრეწველო პლანტაციების შექმნას. აქედან გამომდინარე, შემდეგი ნაბიჯი არის სწრაფმზარდი სელექციური მაღალტექნიკური თვისებების მქონე მერქნიანი მცენარეების გაშენება. მეცნიერულად დასაბუთებული მეთოდებით, ჩვენ შევიმუშავეთ პერსპექტიული მაღალპროდუქტიული სწრაფმზარდი ტყის კულტურების გაშენების შესაბამისი მოდელი კოლხეთის სუსტად დაჭაობებულ უბანში. ახალი პროგრესული ტექნოლოგიის გამოყენებით, კოლხეთის დაბლობის სუსტად დაჭაობებულ ტერიტორიაზე ჩვენ შევქმენით ძვირფასი სწრაფმზარდი მერქნიანი ტყის ჯიშის მაღალპროდუქტიული კულტურები: ვერხვები, აღმოსავლური ჭადარი, ლირიოდენდრონი – ტიტას ხე და სხვა. სწრაფმზარდი ტყის კულტურების თითოეულ ჰექტარზე მიღებულ იქნა მთლიანი წარმოების 3-3,5-ჯერ მეტი ხე-ტყის მერქანი, ვიდრე ადგილობრივი მცენარეული სახეობებიდან.

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