ESTABLISHMENT OF DEMONSTRATION PLANTATIONS FOR INDUSTRIAL TIMBER PURPOSES OF FNY-EIP NATIVE BLACK POPLAR VARIETIES, WITH INNOVATIVE TECHNOLOGIES AND NEW VARIETIES PROVIDING HIGH YIELD AND EXCELLENT INDUSTRIAL RAW MATERIAL QUALITY AGAINST CLIMATE CHANGE WITH ITS TRAIT

PROJECT BOOKLET

SUMMARY OF RESULTS

VP3-16.1.1-4.1.5-4.2.1-4.2.2-8.1.1-8.2.1-8.3.1-8.5.1-8.5.2-8.6.1-17

PROJECT ID: 1924339364

SZÉCHENYI 2020

Miniszterelnökség

Content

I. Significance of the Project

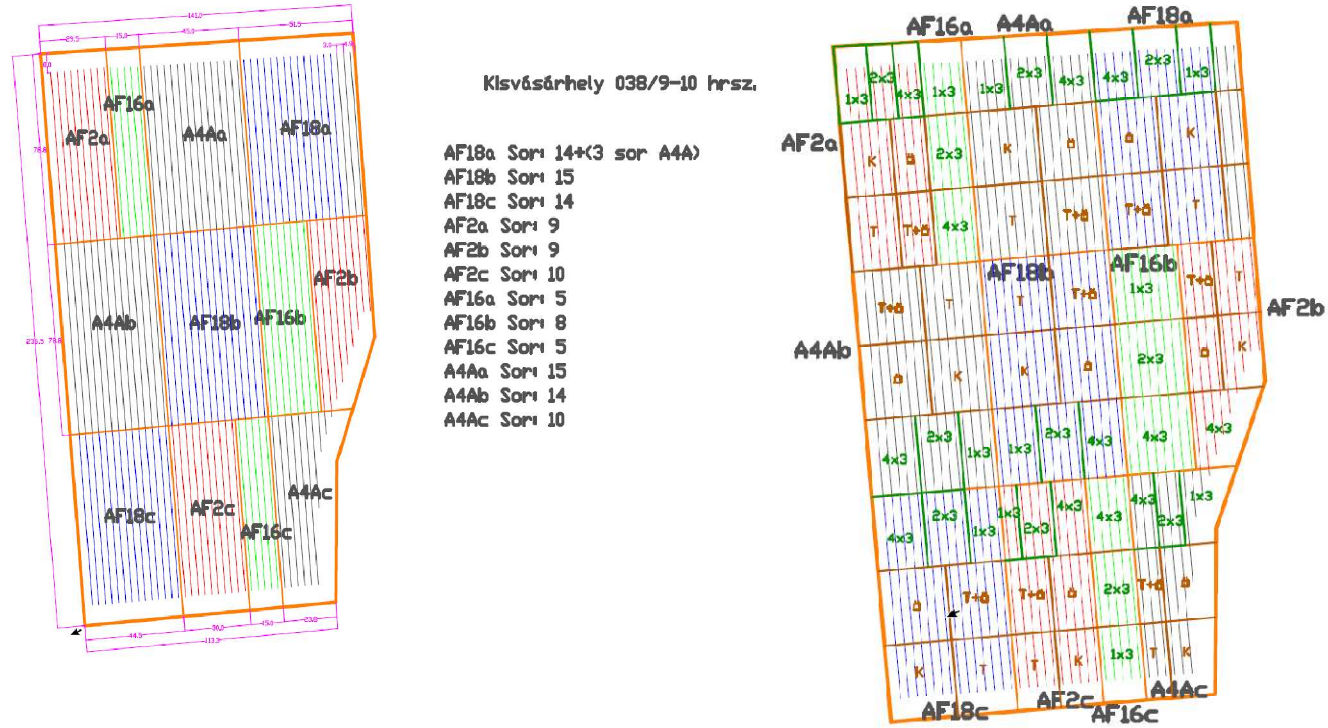
Profitable utilization of Hungary's arable land is of increasing importance. Due to the worldwide increase in logistics costs and increasing unpredictability, it is strategically important to use our natural resources as much as possible, to produce as much added value as possible, and to do it all in a sustainable manner. One of the utilization possibilities of agricultural land that cannot be profitably used for food production is to utilize it with industrial woody plantations that provide useful raw material. Woody industrial plantations can quickly adapt to market challenges and needs, in contrast to forest management. Their establishment is classified as an agricultural activity, the area can be converted back into arable land at any time, and the choice of tree species is completely dominated by economic considerations. Within the framework of traditional forest management, the proportion of noble poplar forests that provide industrial raw material is constantly decreasing, due to restrictive measures that are not always based on various professional grounds. In the meantime, the right quantity and quality of industrial raw materials would be increasingly important for wood processing, and through it for the construction industry and furniture industry.

In the course of the project, we investigated the applicability of poplar clones for industrial woody plantations, and we developed corresponding technologies that have not yet been subjected to industrial research trials in Hungary, on the available production sites. These clones, A4A, AF2, AF16, AF18, are Italian breedings, the purpose of which was to ensure resistance to the extremes of climate change, a high yield, and adequate quality industrial raw material.

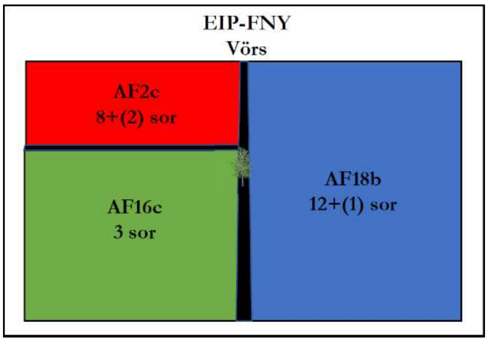
II. Project Planning

During the implementation of the project, we created experimental plantations of 3 ha each in 5 experimental areas (in Kisvásárhely, Zalavár, Vörs, Hereszny, and Aparhant), in which plots and subplots were created to carry out the planned research tasks. When planning the experiment, we took into account the statistically evaluable minimum sample numbers, measurement requirements, comparability, etc., required for the tests.

Creation of an experimental area in Kisvásárhely based on the calculations:



The experimental plantations were planted in the spring of 2020 after planning and official announcement.



We made individual boards to fix the individual parcels and sub-parcels in the field, with which we fixed the corner points.

III. The results of the project in brief

1. Origin test

In June 2020, we performed the rooting test, one of the results of which can be seen below:

Terület	Klón	Mért tőszám (db)	Megeredt egyedek száma (db)	Megeredési arány (%)
Kisvásárhely 038/9-10 hrsz.	A4Aa	1132	921	81,36
	AF2a	677	464	68,54
	AF16a	373	253	67,83
	AF18a	1081	1056	97,69
	A4Ab	777	650	83,66
	AF2b	632	269	42,56
	AF16b	616	477	77,44
	AF18b	1158	1023	88,34
	A4Ac	963	726	75,39
	AF2c	729	453	62,14
	AF16c	393	340	86,51
	AF18c	1030	926	89,90

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

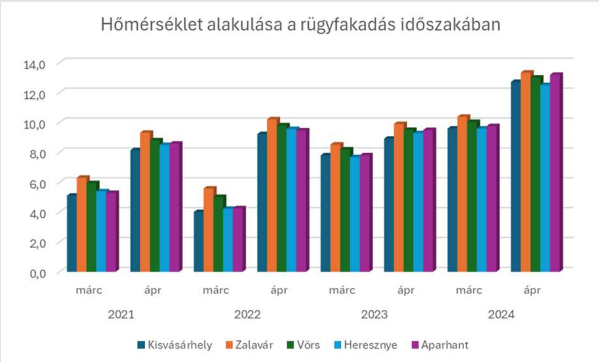
2. Comprehensive monitoring studies

Within the framework of the comprehensive monitoring studies, we observed and evaluated the following by visiting the plantations over a period of 5 years, mainly during the vegetation period, every 2 weeks, and recording their condition.

- Evolution of budding, comparative study depending on the analysis of meteorological data
- Evolution of total defoliation, comparative study depending on the analysis of meteorological data
- Recording shoot lengths in the first two growing seasons, comparing growth dynamics
- Examination of leaf shape and form
- Investigating the effect of crown shape and crown shaping
- Examination of leaf discoloration, leaf fall, and complete cessation of vegetation

2.1. Examination of bud break

The development of bud break is important primarily from the point of view of frost tolerance, vegetation time, and adaptability to Hungarian climate conditions. Based on the tests, it can be briefly said that at a two-week average temperature of around 6-7 °C, the budding of these clones begins in the following order.

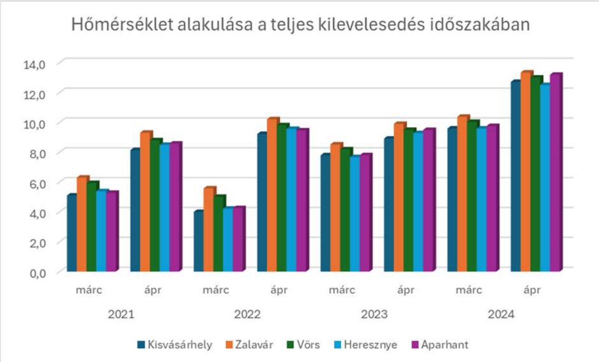


Rügyfakadás időpontjai 2021-2024.			
	Legkorábbi	Legkésőbb	Sorrend
A4A	március 28.	április 12.	3.
AF2	április 3.	április 21.	4.
AF16	március 16.	március 30.	1.
AF18	március 19.	április 1.	2.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

2.2. Evolution of complete defoliation

The complete defoliation also plays a significant role primarily in frost tolerance, the length of the vegetation period, and resistance to pests. Its scale and dynamics are important, because they basically determine the yield potential of the plant. Leaf shape and form and the LAI index are closely related to all of this.



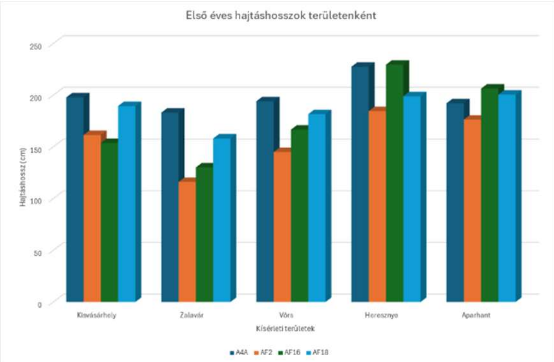
Teljes kilevelesedés 2021-2024.			
	Legkorábbi	Legkésőbb	Sorrend
A4A	április 2.	április 21.	3.
AF2	április 12.	április 30.	4.
AF16	március 24.	április 8.	1.
AF18	március 28.	április 12.	2.

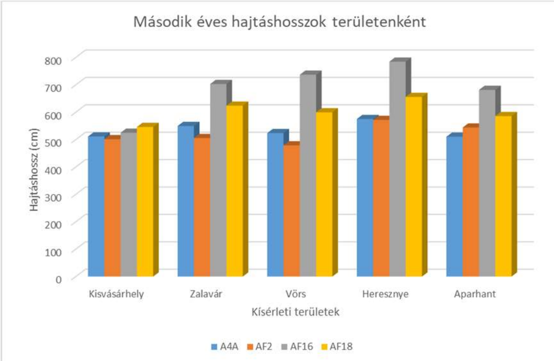
In the case of these clones, leafing takes place with the characteristic time lags shown above at an average temperature of around 9-10 °C for two weeks.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

2.3. Recording shoot lengths in the first two growing seasons

The growth of individual trees and the yield of the stand must be known for all other economic studies and for comparability. In the case of 1-2-year-old individuals, measuring the length of the main shoots to test the yield provides adequate information and the possibility of comparison between individual clones. The measurements were carried out per clone in each experimental area. We measured the shoot length of 240-240 individuals per clone, so that 80-80 individuals were measured from each of the created experimental plots a, b, c.





Regarding the individual clones, A4A, AF2, AF16 and AF18 produced the highest yield in the Heresznyei experimental area, while A4A produced the lowest values in Aparhant, AF2 in Vörs, AF16 and AF18 in Kisvásárhely. Comparing the individual clones, AF2 achieved the smallest growth in the second year as well. This is barely preceded by A4A by ~3%, followed by AF18 by ~16%. The largest total shoot length increase was achieved by AF16 in the second year.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

2.4 Examination of leaf shape and form

The aim of examining the leaf shape and form is to record the morphological characteristics of the given clone and to determine the average leaf size. The leaves can be described based on the characteristics of the leaf shape, leaf shoulder and leaf tip. During the study, the leaf shape and form of each clone: A4A, AF2, AF16, AF18 are examined every year during the duration of the project. After the leaves have fully developed, we examine them in June.

On the occasion of each test, we take a sample of 30 individuals, 5 leaves of average size and shape, for each clone in each experimental area. The average character was determined by visual inspection. We sample individual leaves of the top shoot, individual leaves of the side shoot, and we also take a sample from a depressed shoot. During the 5 years, the data of 15,000 letters were recorded.

Klón	Magasság	Szélesség	Alak
A4A	12,6	13,2	deltoid alakú
AF2	11,6	11,1	deltoid alakú
AF16	12,1	9,4	deltoid alakú
AF18	10,3	12,7	deltoid alakú

Based on the measurements and their evaluation, the average parameters typical of the clone shown in the table above were obtained.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

2.5 Investigating the effect of crown shape and crown formation

The shape of the crown is important in the design of the growing area, in the resistance to wind and snow pressure, and in the ratio of tree mass to trunk/crown. It is also a species characteristic, and its proportions change as a result of the applied pruning. During the experiment, the crown shape of 30 individuals per clone was described once a year in each experimental area during the months of June and July. Number of drives, location, number.

In short, it can be said that the clones all show the typical black poplar type of branch forming a sharp angle with the trunk. Stem cutting causes a ~30% increase in tip shoots for each clone. At the top shoot of the previous year, the individuals always grow a branch curve, in addition to the strong top shoot growth. These will later weaken and die.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

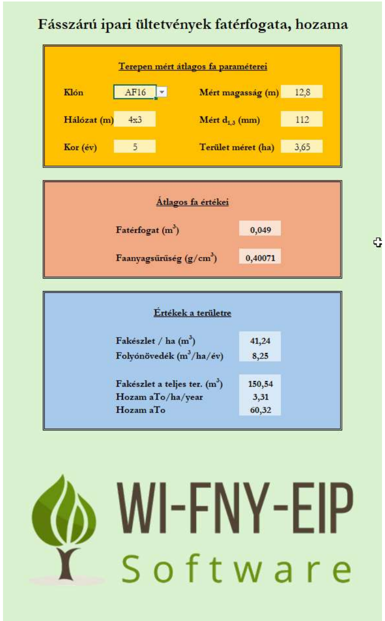
2.6 Examination of leaf discoloration, leaf fall and complete cessation of vegetation

The primary task of the autumn foliage coloring and leaf fall is to protect against the weather and prepare for the next growing season. Autumn foliage coloration is characteristic of the tree species, both in terms of its time, course, and the nature of the coloration. During the discoloration, the chlorophyll in the leaf is broken down into its components and stored together with the starch by reabsorption into the root, so the plant can store energy for defoliation at the beginning of the next growing season. They appear with the breakdown of chlorophyll, the xanthophyll and anthocyanin pigments that were previously suppressed by chlorophyll and therefore not effective, which cause the yellowish, reddish, or brown discoloration characteristic of the tree species. According to some researches, the strong and bright coloring also serves to protect against insects that damage trees, where the strong shades of color create the impression of an individual that is saturated with healthy, protective antibodies for the insects that are about to overwinter, so it is not advisable for the insect to use it.

Foliage discoloration, leaf fall, and complete cessation of vegetation are observed every year in each experimental area, and the typical period is recorded. The observation is carried out per clone in each experimental area, by visiting the area, and the typical period is determined based on whether at least 60-70% of the individuals of the examined clone have already fully defoliated. Data are recorded annually per experimental area and per clone. Of course, the length of the days, i.e. the lighting, significantly affects the coloration of the leaves, the fall of the leaves, and the complete cessation of vegetation. There is no significant difference between the typical time of the coloration of the leaves, the fall of the leaves, and the complete cessation of the vegetation, since each clone has a black poplar parent, and thus in their characteristics in this respect there is no essential difference. The total defoliation is influenced by the weather in that in the experimental area where early frost occurred first, the total defoliation occurred accordingly in the given year.

3. Determination of wood stock and growth

The determination of individual trees and the entire stand, tree volume, yield, and annual growth is of fundamental importance, since the entire cultivation technology can be analyzed, economic studies can be carried out, and evaluated based on these data.



Since there are no tree weight tables available for these clones, we determined the breast height figures of these clones for the 1-5 year age group through continuous sampling and wood disc tests, which we used to develop a software that is suitable for calculating the wood volume and yield of all plantations established with these clones in the future using the measured breast height diameter and height depending on.

We have filed a patent for this both domestically and internationally.

At the end of each vegetation period, in each experimental area, for each clone within it and for each network within it, 3 average individuals were cut out, their height was measured, and then for each individual a sample disc was cut at the stem part, or 1; 1.3; 2; 3; 4...etc. m height to the top. A unique annual ring analysis was performed on the sample discs, and this data was processed to calculate the chest height figure characteristic of the clone. We evaluated nearly 1,800 samples.

We also applied the LiDAR technology for large-scale inventory and tree mass estimation and collected data for its reliability calculation.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

4. Determination of volumetric weight

The bulk density of wood is a key property that determines the usability of wood in various applications. This physical characteristic affects the mechanical properties of the wood, as well as its possibilities of processing and use. By understanding the concept, definition and influencing factors of bulk density, wood users and processors can optimize the quality and performance of their products.

In the course of the research, we used volumetric mass measurement based on the principle of water displacement for absolutely dry wood.

The measurements were carried out over 5 years. At the end of each vegetation period, 3 average individuals were cut out in each experimental area, for each clone within it, and for each network within it, and then for each individual, a sample disk was cut at the stem part, or 1.3; 2 m high. The density of 3 individual samples was determined. To determine the density, the fresh, wet weight and volume of the given sample were measured (using the water displacement method), then the absolute dry weight was measured after drying in an oven for 24 hours at 103-105 °C until the mass was constant. From the measured data, we calculated the volumetric weight based on absolute dry wood.

The average measured values are shown below:

T Volumetric mass aTo/m³				
	A4A	**AF2**	**AF16**	**AF18**
1x3	0,367	0,370	0,390	0,360
2x3	0,357	0,367	0,393	0,351
4x3	0,360	0,376	0,401	0,377

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

5. Technical examination of wood

The physical and mechanical properties of wood, its load capacity, and therefore its usability are the result of the combined effect of several factors. The annual ring structure, the resulting inhomogeneous structure, the orthogonal anisotropy, the porous property, the different cell structure characteristic of the given tree species, the moisture content of the wood material, the possible wood defects all have a great importance and an influencing role, which should not be ignored.

In order to produce the samples needed for the measurements, 3-3 trunks were cut for each clone, and the samples were taken from the part between 1-2 m in height. The sample bodies were designed according to ISO13061-6, their dimensions are 20x20x300mm. The tests were carried out in a wood testing laboratory.

The parameters measured during the test showed no significant differences between the individual clones, the average values of the measurements are as follows:

- Tensile strength: 5 N/mm^2
- Flexural strength: 57 N/mm^2
- Compressive strength: 27,5 N/mm^2
- Brinell-Mörath hardness: butt: 28,3 N/mm^2; side 9,7 N/mm^2

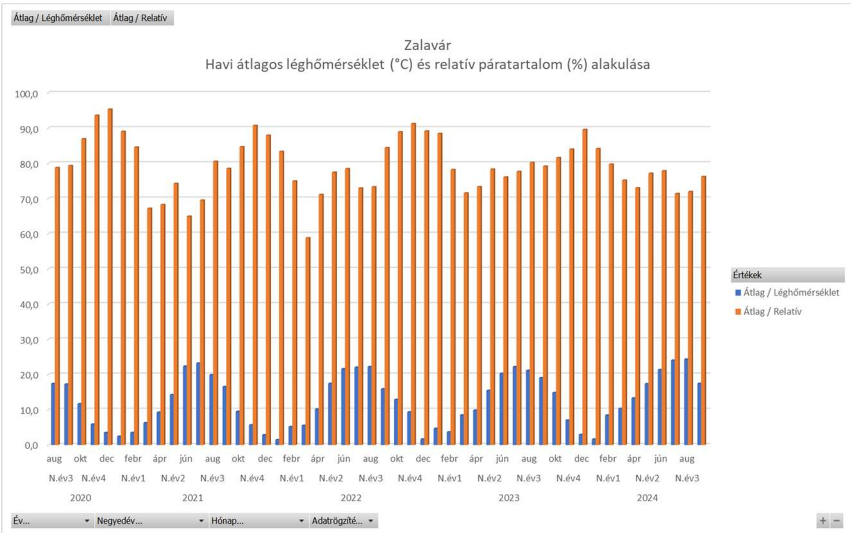
(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

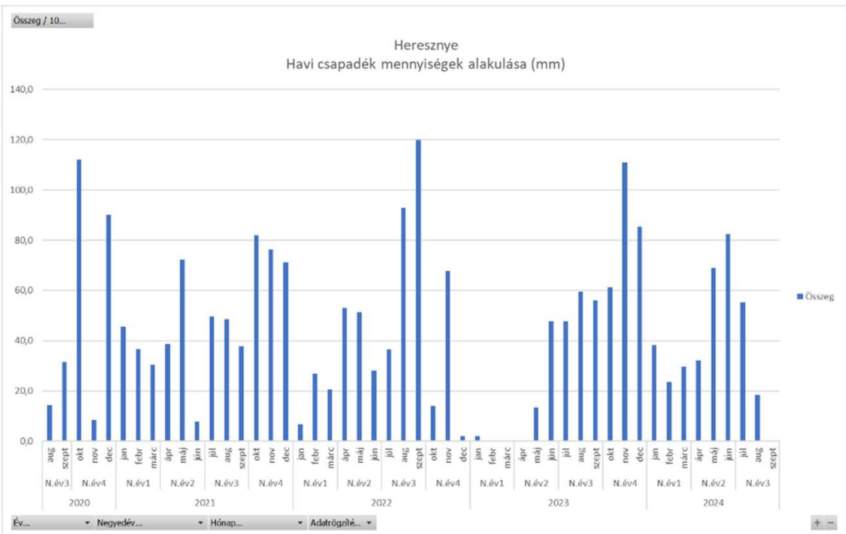
6. Evaluation of meteorological data

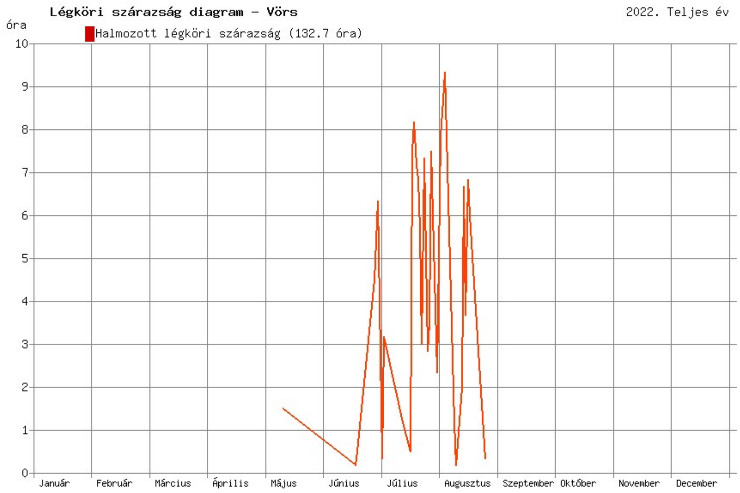
In addition to the soil, meteorological factors have the greatest influence on the growth and development of plants. During plant cultivation, it is absolutely necessary to know which meteorological factor and how it affects the growth and development of a given type of plant, as this is fundamentally necessary for the development of cultivation technology.

In order to measure and record the meteorological data necessary during the research, a mobile meteorological measuring station was installed separately in each experimental area.

During the 5 years, more than 100 million data were recorded, which were evaluated annually.







The meteorological data, as well as the analyzes obtained from the plant physiology point of view, were used in the evaluation of other research points, examining the correlation of environmental effects in each research area.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

7. Determination of LAI index

The Leaf Area Index (LAI) is an important ecological indicator that characterizes the extent of plant foliage and the size of the photosynthesizing surface. This parameter is of great importance in many fields, be it crop cultivation, forestry applications or the use of remote sensing technologies.

The Leaf Area Index (LAI) is the quotient of the leaf area of the vegetation and the soil area unit. In other words, LAI shows the total leaf area of a plant in a given soil area. This is an important indicator because the size of the leaf surface basically determines the rate of photosynthesis, transpiration, radiation absorption and other ecological processes. LAI values thus provide key information about plant development, health and responses to environmental factors.

During the research, we performed the traditional, mechanical LAI index determination. Every year in the experimental areas, during the month of August, we collected the entire foliage of 3-3 individuals from each plot (1-1 per network), i.e. 9 individuals per clone.

We weighed the weight of freshly picked leaves, thus obtaining the total leaf weight of an individual. Afterwards, we placed leaves on a 1x1 m white board, which we photographed. For each individual, 5 such samples were placed on the 1x1 m surface and photographed.

We also weighed the mass of the sample placed on a 1x1 m surface and photographed.

We have created a software that can process the photo in .jpg format of the digitally cut 1x1 m surface and, based on the analysis of pixels, determine the percentage value of the surface of the leaves in relation to 1 m2. Based on the software processing, we obtained the surface area of each sample in m2. Based on these, we were able to determine the value of all leaf surfaces for the entire tree.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

8. Nutrient supply test and nutrient supply experiment

Ensuring adequate nutrient supply is crucial for healthy plant development and optimal yield. With the help of nutrient supply tests, we can assess the current nutritional status of the plants, and based on this, we can develop a more precise nutrient supply strategy. This makes it possible to maximize crop yield, while reducing the environmental burden of unnecessary fertilization.

Basic site exploration

Dimensions of the soil profile:

- 70-100 cm wide
- 200 cm long
- 150-200 cm deep

After opening the soil profile, we evaluate the individual site factors. This is recorded on the production site registration sheet (in forestry practice: T-sheet). The site recording sheet prepared for industrial tree plantations contains the following: the name of the person taking the recording, the date of the recording (year, month, day), forestry landscape, the name of the village, the hours of the given area, the identification number of the soil profile.

When inspecting the production site, the following factors must also be examined:

- Altitude, location, topography, slope, climate, hydrological conditions, bedrock, genetic soil type, thickness of the productive layer, physical soil type, structure, soil defects, water management, variety of site type.

To select the tree species/clone, it is worth examining a soil profile every 3-5 hectares (min. 1 per 5 hectares, or 1 per patch of soil larger than 0.5 hectares / of which the sampling is 1 per genetic level, but at least 1 per 50 cm/). It is recommended to carry out a general laboratory test of the samples (pH, CaCO3, physical soil type, total salt %, humus content %. Al-phosphorus, potassium, total nitrogen). In addition to opening a soil profile, 1 soil drilling per hectare is also recommended: 1 drilling in the nodes of a 100*100 m grid in the entire area. These data can be used to create thematic maps: genetic soil type, hydrology, physical soil type, thickness of the productive layer, thickness of the humus layer.

2. Annual soil analysis

For the nutrient replenishment plan and the yield guarantee, it is recommended to take an average sample of at least 1 per 5 hectares from the 0-30 and 30-60 cm soil layers (the penetration depth of the plant roots is important). It is worth performing an expanded soil test from the average sample (pH, humus content, KA, all water-soluble salts, CaCO3, NO2+NO3, P2O5, K2O, Na, Mg, SO4, Mn, Zn, Cu). By carrying out these tests every year, it is possible to monitor how the individual parameters change in the soil, what nutrients are needed to be replenished, and how the yield data of the industrial plantation develop with the given values. Years later, yield calibrations can be made from these data.

3. Annual plant analyses

In addition to the soil sample tests, plant analyzes should also be carried out, from these we can shed light on the question of what and how much nutrients each plant part contains specifically for industrial plantations. The leaf and plant analysis is based on the fact that the nutrient content of the plant varies within certain limits in proportion to the easily soluble nutrient content of the soil. However, nutrient uptake by plants also depends on other properties. Plant tests are also important because not only the amount of elements, but also their ratio in relation to each other plays an important role in optimal nutrient supply of plants, the growth of plants is always determined by the minimum growth factor. Regarding the quantity of the most important nutrients, the following order can generally be established: N > K > Ca > P > Mg. Different concentrations can be found in certain organs of the trees: leaves > bark > bark > trunk.

During the research, we determined the nutrient supply of the experimental areas. Based on literature data, we calculated the expected nutrient intake of the plantation. The amount of nutrients to be applied was calculated based on the difference between the laboratory measurements and calculations, and it was applied every year to the designated experimental subplots in the experimental areas.

With the help of leaf analysis, we determined the amount of nutrients actually taken up, and based on this, we corrected the amounts to be applied.

Examining the yield difference between the control plot and the nutrient-supplemented plot, it can be established that there are differences between 15-45%. Depending on the water retention capacity of the soil, nutrients were washed out of the root zone to a different extent, so it was better utilized on loamy soils than on sandy soils. In the experimental areas, the yield of the "T+Ö", i.e., nutrient-supplemented and irrigated subplots, exceeded the yield of the control plots by 35-55%, however, the yield of the nutrient-supplemented "T" plots that were less favorable in terms of water balance (higher ground level, hilltop , etc.) this difference decreased to 10-20%.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

9. Irrigation experiment

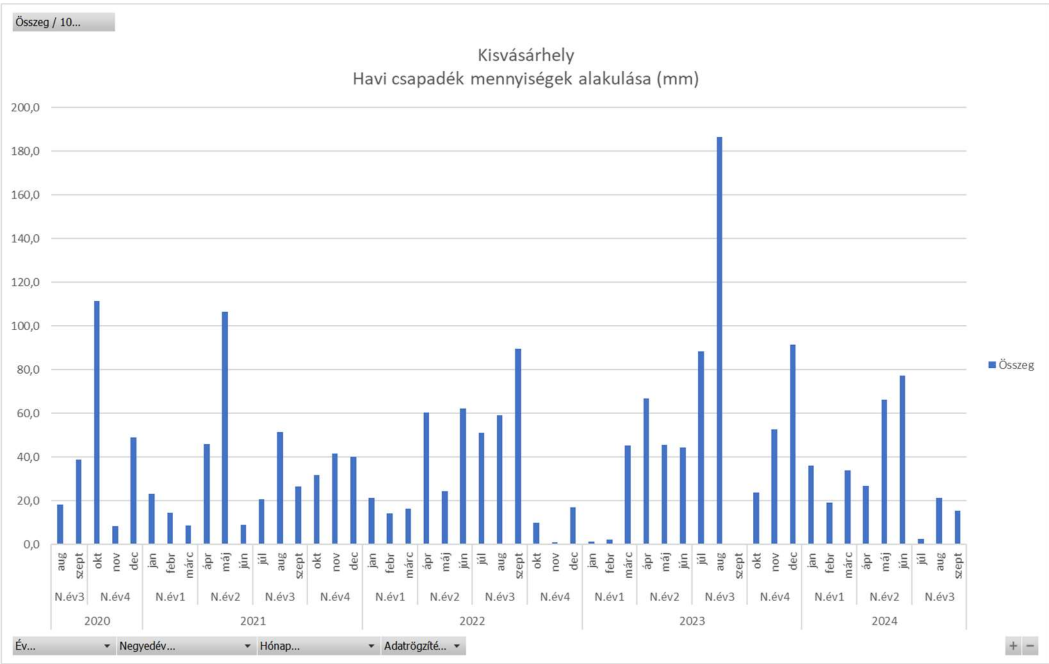
Photosynthesis, the process by which plants convert sunlight into chemical energy, is closely related to water. Water acts as an electron donor during photosynthesis, helping to convert sunlight energy into chemical energy. In addition, water also plays a key role in the absorption of nutrients such as nitrogen, phosphorus and potassium. Water dissolves nutrients in the soil and helps the roots transport them to all parts of the plant.

Our goal with the irrigation experiment was to examine the differences in yield and possibly in health between irrigated plants and non-irrigated plants.

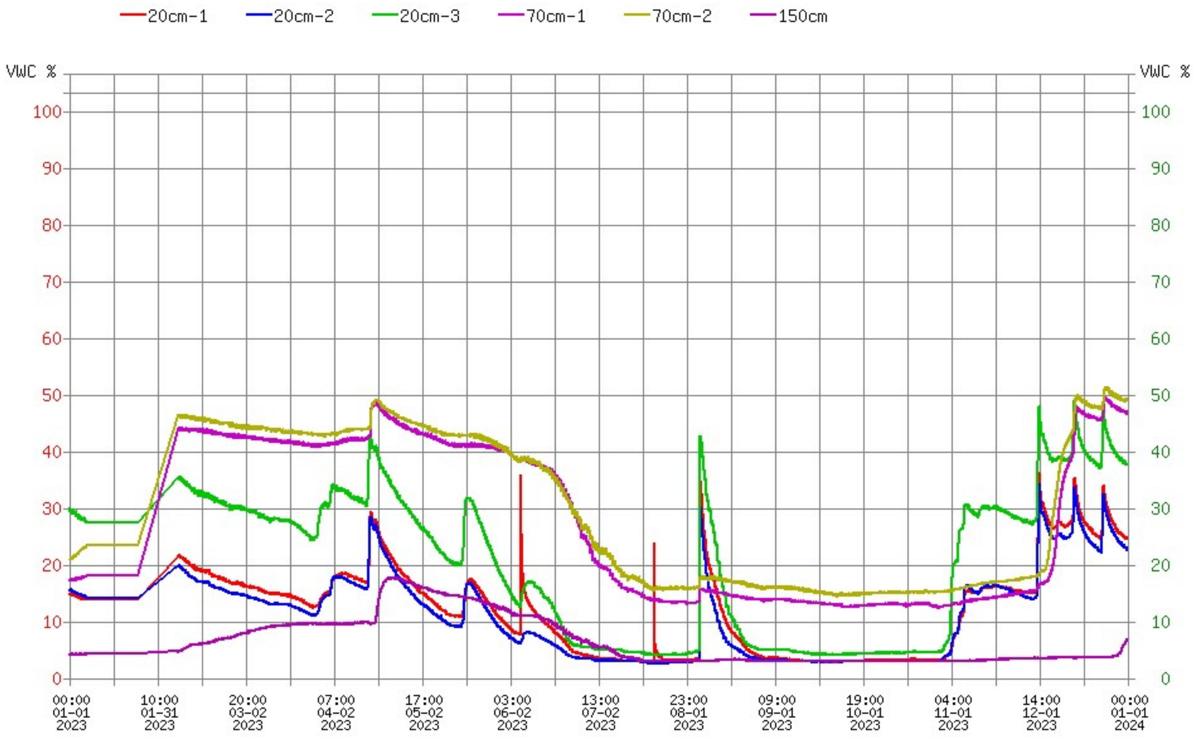
The experiment was carried out on a permanent subplot. In each area included in the experiment, an irrigated subplot was fixed on the field for each clone within blocks a, b, c. We marked this with the letter "Ö" on the map. However, in each case, a control plot marked "K" was also designated, which only received natural precipitation. During the irrigation experiment, we eliminated artificially, by irrigation, those periods in which natural precipitation did not occur. The goal was for the plant to receive ~30 mm of precipitation every 2 weeks during the growing season. In the event that the amount of precipitation fell short or did not even reach 20 mm, we gave extra water to the plants in the experimental subplots so that the ~30 mm of precipitation was met.

Soil moisture was recorded at meteorological stations. For the measurement of soil moisture and soil temperature, 6 measuring sensors were placed for each mobile meteorological measuring station, 3 sensors each at a depth of 20 cm; 2-2 sensors at a depth of 70 cm, and 1-1 sensor at a depth of 150 cm, thus in the critical soil layers from the point of view of the plant's root system and the greater part from the point of view of changing parameters, ensuring the measurements with 3x and 2x repetitions, so that the measurements are as accurate as possible , we get a more realistic picture of the measured values.

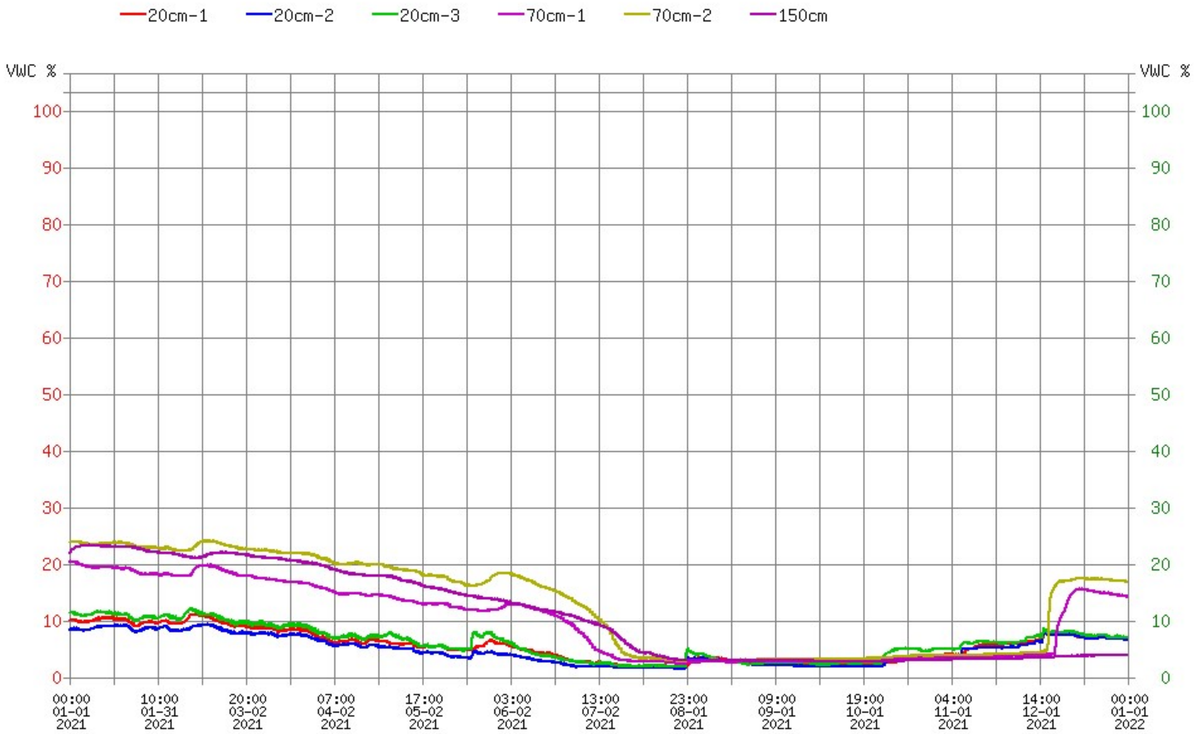
Analyzing the amount of precipitation and soil moisture, it can be established that the value of soil moisture in the production sites with physical characteristics of sand contains minor fluctuations, and is naturally lower overall, but the incoming precipitation can saturate it to a lesser extent, due to its good drainage capacity. This is, for example: in the Heresznyei experimental area, the nearby groundwater modifies it in such a way that in the lower layers, fed by the groundwater due to the capillaries, and due to the groundwater raising effect of the precipitation, a greater fluctuation develops than in the upper layers, where the groundwater no longer has direct effect.



Talajnedvesség (VWC) diagram – Kisvásárhely 2023-01-01 - 2023-12-31



Talajnedvesség (VWC) diagram – Vörs 2021-01-01 - 2021-12-31



For each clone (A4A, AF2, AF16, AF18), it could be established that a soil moisture condition of around 50% (VWC%) provides individuals with ~30% higher yield than a soil moisture condition of ~25% during the vegetation period. The effect of irrigation on the growth of individual clones was greater in the soil with physical characteristics of sand than in the case of loam.

The most extreme values were measured in the Vörs experimental area, where there was a ~50% difference in yield between the individuals in the control plot "K" on the hilltop and the individuals in the irrigated plot "Ö" in the valley. Here, of course, due to the topographical conditions, there was already an additional water effect in addition to the irrigation.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

10. Monitoring of pests and pathogens

In industrial plantations, not only quantitative damage and yield reduction are real damage, but also changes in the quality of the wood that reduce the possibility of industrial use. In the case of industrial poplar plantations, industrial use primarily means use as veneer logs (peeling logs) or as raw material for other packaging materials. The development of damage to an extent that also affects the economics of industrial plantations can be prevented if the pathogens and pests that may appear are continuously monitored, and their major damage can be prevented by appropriate measures taken in time.

During the regular inspection of the experimental areas, we always monitored the potentially appearing pests and pathogens, as well as their damage. In the case of detected damage, or a harmful or pathogenic agent, it has been determined and quantitatively assessed at the level of estimation. We have prepared a summary of pests and pathogens that occur in the tree, thus giving a comprehensive picture of possible pests and pathogens.

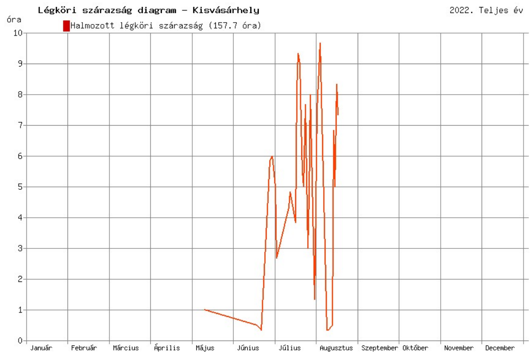
The abiotic damage was negligible, the plants outgrew the possible late frost in the year of planting, later the tilting and breaking due to strong wind pressure only occurred in a small number of individuals. The pest occurring in the largest number of cases was the large poplar (Chrysomela populi). In the experimental areas, immediately after planting, after the formation of the shoots, it was found sporadically in the plantations. In the second year, we recorded an infection rate of 20-25% in the experimental area in Kisvásárhely. Its mass reproduction did not occur.

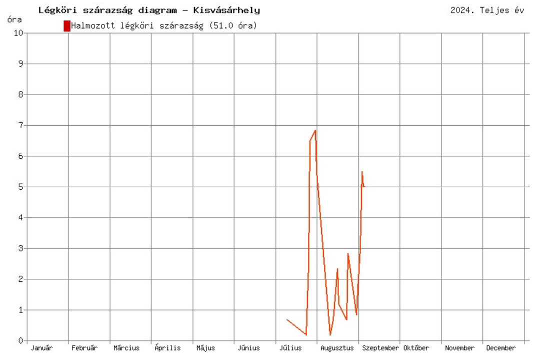
Examining the 5-10 km distance of the experimental areas, poplar stands were present in greater numbers only in the 10 km radius of the Kisvásárhely area, and as a result, the 3 ha plantation, which can be said to be a small area, was therefore more successful for this species there, but the number of individuals it was not significant from the third year on.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

11. Examination of resistance to drought and frost

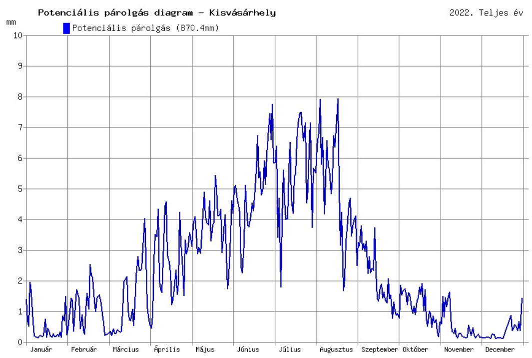
Among the abiotic damages, freezing occurred after planting, however, the plants sprouted again from dormant buds and outgrew these freezes. The ground frost that appeared in small areas at the end of April caused the buds that started late due to the planting to freeze. It certainly caused a small yield loss, but it was not of a measurable magnitude. In later years, freezing no longer occurred, at which time the tree close to the soil surface did not become woody, or leaf buds no longer occurred.

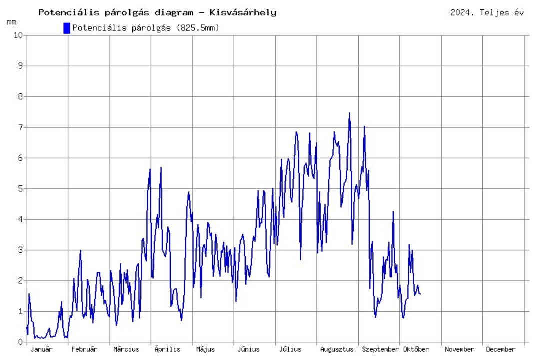




During the 2024 vegetation period in the experimental area of Kisvásárhely, a significant loss of foliage was observed in the case of A4A clones due to the accumulated atmospheric dryness of more than 51 hours in July-September.

Examining the precipitation conditions, it can be concluded that even much greater atmospheric dryness, over 127-157 hours, did not cause problems when a sufficient amount of precipitation fell in the same period, since the potential evaporation was the same.





The plant tried to protect itself against desiccation with leaf loss, but the fact that this level of leaf loss occurred only in the case of the A4A clone shows that it has a lower drought tolerance compared to the other clones. In the other experimental areas, a lower value of accumulated atmospheric dryness was measured, in these areas no similar loss of foliage was observed in the case of the A4A clone either.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))

12. Modelling, economic analysis

When planning industrial tree plantations, economic calculations are always necessary, so that we can select the technology and financial solution with which maximum profit can be achieved for the existing conditions. During the development of industrial tree plantations, many variable factors have to be taken into account, so there are many alternative solutions. Their complexity, as well as the search for suitable financial solutions, requires serious economic calculations, which can be performed with a decision support program, which was specially prepared for the planning and management of the cultivation of industrial tree plantations and woody plantations.

Industrial tree plantations represent a new timber production solution, which does not have the same long-term experience as traditional forestry. If we take the variable factors that influence timber production in the case of an industrial plantation, we can see that they form a multidimensional system, in which a change in one variable affects all other factors and thereby affects the natural values. For all economic activities and investments, it is necessary to have accurate data on the investment, maintenance and operation costs and the expected income, payback period, etc. In a given, available area, in an industrial tree plantation designed to meet a given need, different tree species and varieties can be used due to the diversity of the growing area, and different yields can be forecast even within a species or variety within the growing area of the area designated for a species or variety (on a smaller scale) due to the change. Within this, the yield also changes between successive harvests. Installation takes several years, depending on the technology, due to ensuring annual needs. This is also helped by the fact that during the management of the industrial plantation, different yields can be predicted even as the years progress, and the cultivation technology also depends on several factors, which can also ensure different results. It can therefore be seen that even the calculation of natural data is a very complicated and difficult task.

About information provided by software for economic analysis in general

The decision preparation program gives you the opportunity to examine any solution or technology. Let's examine together with him a system consisting of different solutions appearing in a specific area. We analyze the options that arise in the case of implementation in any combination, so that we can choose the most favorable combination of solutions from the point of view of management, in order to maximize profit.

With the program you can calculate:

- yield formations and natural values depending on given solution combinations and territorial features,
- for all technologies, the arising works in full detail, including taking into account their annual changes,

- different economic events related to investment and operation and their effects and results during the entire period of operation, broken down by year,
- different fixed and variable costs depending on the form of implementation and their effects and results during the entire operating period, broken down by year.

Program provides for the entire system, among other things,:

- the current value of the margin contribution available during the entire lifetime of the investment,
- the future value of the margin contribution available during the entire lifetime of the investment,
- minimum required annual profit amount,
- dynamic rate of return and the internal interest rate,
- maximum investment amount,
- energetic ratio, which means the ratio of the energy that can be produced by the dedromass to be used for energetic purposes and the energy used for the production of this dedromass. Here, the energy value of each operation and material used is calculated, thereby giving the possibility of the extent to which the individual activities do not tilt the value of the quotient in a negative range from an energetic point of view, where we no longer produce excess energy from an energetic point of view,
- specific sales revenue per product per year and for the entire operating period
- the total cost per year and for the entire operating period
- the variable cost per year and for the entire operating period
- the constant cost per year and for the entire operating period
- profitability proportional to production value annually and for the entire operating period
- cost-proportional profitability annually and for the entire operating period
- profitability in proportion to capital (profit rate) annually and for the entire operating period

The program can be used to optimize the value of individual variable factors so that a desired variable, e.g. total cost or profit, is a given value.

The program therefore has two functions. One is decision support during planning, the other is the processing and evaluation of data from an existing industrial tree plantation under management for the planning of further work, the screening of errors, and the determination of appropriate changes. During operation, it is necessary to check whether the actual realized returns meet the pre-planned return, or whether it needs to be modified in the future to reach the planned value. The costs actually incurred during the treatment (mechanical weeding, plant protection, nutrient supply, etc.) are recorded, and thus the development of the economic indicators can be continuously observed, and the necessary interventions can be carried out based on these. To perform these tasks, the decision support program creates a connection with the digital map database, i.e. it uses the data recorded there to perform calculations.

The program is therefore suitable for a fully detailed economic analysis of any industrial tree plantation system, and for selecting the optimal combination and decision support.

(The methodology and detailed results of the study can be found on the project's website (www.eip-fny.hu))