TECHNOLOGICAL ASPECTS OF GROWING SALVIA *POPULUS* × *CANADENSIS* FOR THE CREATION OF FOREST PLANTATIONS IN THE NORTHEASTERN FOREST-STEPPE OF UKRAINE

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The scientists have performed research and proved that in seven to ten years, the explored oil reserves will be used by approximately 60%, which will lead to a 40% reduction in production. According to world experts, energy consumption will reach more than double by 2050 in the world. In addition, scientists estimate that the world's proven natural gas reserves will last only 60 years, oil - 30 years, and coal - 600 years. Therefore, a great need exists to use unconventional energy sources as an alternative to fossil fuels.

Nowadays, approximately 40% of energy requirements will be met from alternative energy reserves personally about 30% - by bioenergy, which, in turn, should be based the usage of plant mass of a number of highly productive bioenergy crops.

Today, more than 20 types of plants that give energy were researched in Ukraine that could be grown to produce plant biomass. These crops include, for example, fast-growing trees of various types of willow and poplar sorghum, as well as annual and perennial herbaceous plants: sugar cane, miscanthus, amaranth, sharp-edged bitterroot, Sakhalin bitterroot, Pennsylvania mallow, rumex, rod millet, hybrid tobacco, etc.

Ukraine has approximately territory of unproductive land 4.5 million hectares and eroded land that could be used for plantations.

The forest covers almost15%, in Ukraine while in Poland it is 27% and in Finland it is 70%. To significantly increase this indexes, it is essential to make plantations on an area of at least 1.5 million hectares, including energy plantations, which will be occupied by willow and poplar.

Thus, if energy plants are grown on 1 million hectares and their average yield is 11.5 million tons per year, up to 5.5 billion m^3 of gas can be replaced. Thus, Ukraine can potentially replace about 20 billion m3 of gas with energy crops.

In Western Europe, plants that give energy are cultivated at 117.4 thousand hectares. Such as, this indicator is 18.3 thousand hectares are in Poland or 17.8 thousand hectares are in Germany. According to various estimates, in Ukraine, only 3.5 thousand hectares of fields were given under energy plants.

Among the famous crops for bioenergy purposes is poplar. Poplar is receiving special attention around the world, including in Ukraine.

In general, there are 31.4 million hectares of artificially created plantations of various poplar species all round the world, andthe largest number of them are in Canada (69%) and China (27%) [3].

Research in the field of bioenergy and plantation agriculture in Ukraine is conducted by Y. Fuchylo, Y. Debryniuk, G. Geletukha, T. Zhelezna, V. Litvin, M. Roik, L. Khudoleieva and others.

In the climatic conditions of our country, among other trees, poplar grows the fastest, it is resistant to diseases and cultivation good on non-fertile soil (but 1% of humus is required). In addition, the opportunity of cultivation it on contaminated land has been created.

Nowadays, we have got comparatively quick growing or biomass production, poplar plantations are increasingly using as a regenerative energy source to biofuel manufacture. Timber is easy quite to be extensively exploited for technological target.

Ten tons of poplar wood chips replace 2500 m^3 of natural gas. That’s way biofuel will be worth the country practically five times cheaper than gas. Cottonwood absorbs a big number of carbon dioxide, making it perfect sustainably gasoline. Malicious evaporation will drop by 90% relatively to diesel gasoline [16]. At the commercial farm, the harvest of cottonwood dry mass is up to 12 t/ha, and on fertile soils - 20 t/ha [10, 18].

Cottonwood inculcation stay efficient for up to 20 years and anymore, and biomass be able to be collect every three to six years during this period.

The deepening of energy problems in Ukraine requires the search for new energy sources, including wood raw materials from plantations. The real renewable alternative energy source is the wood biomass production. It is gaining particular popularity in Ukraine. Today, the real way out of the critical situation is to intensively use the forestry industry with a focus on growing phytomass in plantation plantations, instead of traditional timber harvesting in artificially created or natural forests.

The need to introduce new approaches in the energy sector makes it important to create plantations that will be used for the production of alternative fuels.

At the same time, the creation of plantations of energy crops will allow to solve a number of problematic issues in the environmental, social and economic spheres.

Object of research - agrotechnics of growing plantation *Populus x canadensis* planting material in the conditions of the Landscape Design training laboratory.

The subject of the research is the biological characteristics of *Populus x canadensis.*

The aim of the study is to research agrotechnical measures for the production of *P. x canadensis* planting material for the creation of forest plantations and protective plantations in the northeastern forest-steppe.

To get the result, the next main tasks were identified:

- to analyze the experience of creating *Populus* plantations using the special literature and practical sources;
- to assess the natural and climatic terms of the northeastern part of the Forest-Steppe regarding their suitability for the creation of *Populus* energy plantations;
- to consider the impact of growing conditions and micropod thickness of the research of the standard of landing material.

City, methodology and research design. The study of the peculiarities of growing annual cuttings of *Populus x canadensis* was done in 2024 in the training laboratory of "Landscape Design" of Sumy National Agrarian University. Lignified cuttings of different thicknesses were used. The cuttings were cut with secateurs from annual shoots immediately before planting. Slices were made perpendicular to the shoot axis. The cuttings have been planted in the middle of April in containers. Throughout the vegetation period, the crops have been regularly watered and weedage were deleted

The cuttings were harvested before the bud swelling phase. The length of plant cuttings reached 90-120 mm. After harvesting micropropagules, they were placed in water for 3 hours. Rooting of the cuttings was plant in a mixture of earth and substrate which consists of mixture of peat and sand in equal proportions. The experimental design combined variants where the factors were the cultivation technology and the thickness of the cuttings. Micropropagules were planted vertically in 1,0 liter pots. The planting depth of the cuttings was 6-7 cm.

Studies were performed according to the following scheme:

Factor A - natural light conditions: 1) control (4,5 mm); 2) 6 mm; 3) 9 mm; 4) 12 mm. Factor B - shading conditions: 1) control (4,5 mm); 2) 6 mm; 3) 9 mm; 4) 12 mm.

In autumn, in the second decade of September, rooting of cuttings and other qualitative indicators were calculated in accordance to the techniques generally accepted in plant growing and forestry [13].

Research results. Asexual reproduction of plants is relatively common in nature, but people use it even more often to propagate plants and their ornamental forms.

For example, *Populus* is unpretentious and easily propagated both by seeds and vegetatively, in particular by cuttings.

In 2024, in the conditions of the cultivation facility of the Department of Gardening and Forestry, experimental work was carried out on the peculiarities of root propagation of *P. x canadensis*.

According to N. Y. Vysotska [18], the processes of callus and corrosion in *P. x canadensis* planting material are quite rapid due to the presence of a hormonal compound in the plant organism that causes the reproduction of the root system.

Table 1. Influence of *P. x canadensis* planting material thickness on root formation ability

No	Variant	Rooting, %	± to control
1.	4,5	98	- 2
2.	6	99	- 1
3.	9	100	0
4.	Control (12 mm)	100	-

The results of the research (Table 1) show that harvesting of the experimental species cuttings before the phase of bud swelling is necessary, and the thickness of the planting material does not affect the value of the regenerative capacity. According to the author's observations, in the conditions of the cultivation facility, the root system of the cuttings is restored within 14-16 days, and the beginning of callus formation begins on day 5-7.

Fig. 1. *Cultivated planting material of P. x canadensis*

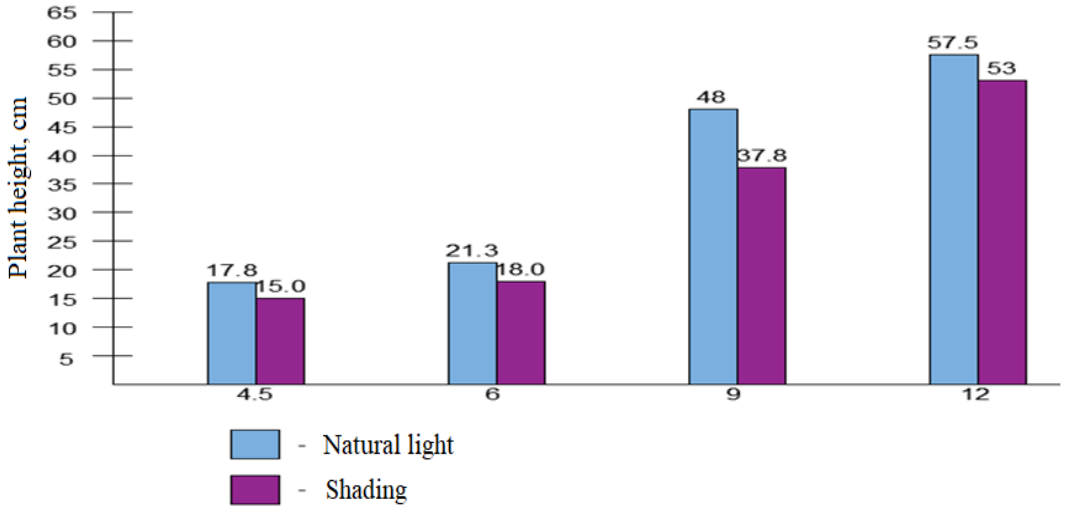

Fig. 2. *Height of P. x canadensis plants*

Table 2. Influence of some factors on biometric parameters of plants

Growing conditions	Variant	Indicators				
		Length, cm	Weight, g			
			of root system	± to control	of the aerial part	± to control
Natural light	Control (4,5)	17,8	7,1		10,1	
Shading		15,0	6,0		4,0	
Natural light	6	21,3	7,7	+ 0,6	13,26	+ 3,16
Shading		18,0	7,0	+ 1,0	7,0	+ 3,0
Natural light	9	48,0	14	+ 6,9	23,66	+ 13,56
Shading		37,8	10,2	+ 4,2	15,0	+ 11,0
Natural light	12	57,5	19,8	+ 12,7	42,2	+ 32,1
Shading		53,0	16,0	+ 10,0	18,0	+ 14,0

Thus, according to the results of the experimental work, a clear correlation was established that an increase in the thickness of the cutting allows you to get a positive effect on the growing material height (Fig. 1-2, Table 2). Given this, the optimal thickness of micropropagules is 9-12 mm.

It should be emphasized that the degree of illumination affected the size of the plants. When using cuttings with a diameter of 12 mm, the height of the plants was in the range of 53.0-57.5 cm, while in the control variant (4.5 mm) it was 15-17 cm, which is 38-39.7 cm less. There was a significant difference between the control and search variants.

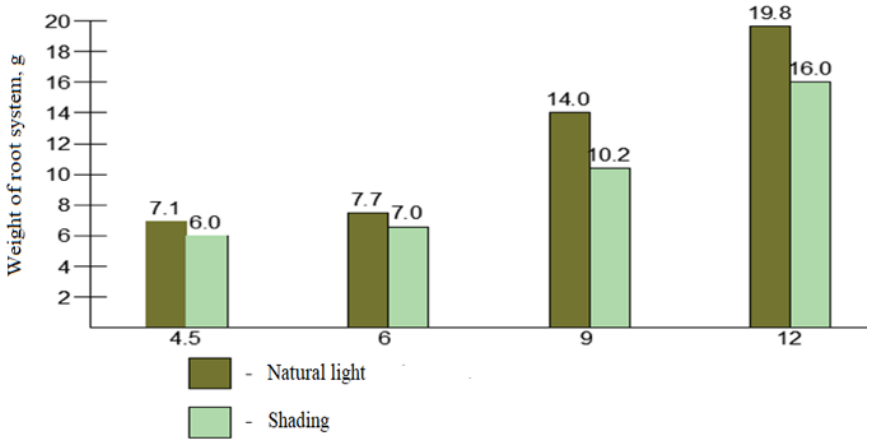

Fig. 3. *Root system weight of P. x canadensis planting material*

Fig. 4. *Root system of P. x canadensis*

In addition, the relationship between the diameter of the cuttings and_ weight of the root system was analyzed in the research work (Fig. 3-4). When micropropagules with a thickness of 4.5 mm using, the root system weight was in range of 6.0-7.1 g, which is 10 and 12.7 g less than in the variant where cuttings with a diameter of 12 mm were used. The difference in root formation capacity by variant was significant.

According to the table, it should be stated that the weight of the root system of the planting material depends on the growing conditions and the diameter of the cuttings.

Considering the root system at different thicknesses of the planting material, we state that the size of the cutting affects its development. Thus, the root system was compared with the control variants of cuttings with a diameter of 12 mm form a branched that_ is of particular importance for the growth of P. *x canadensis* plants and the absorption of nutrients.

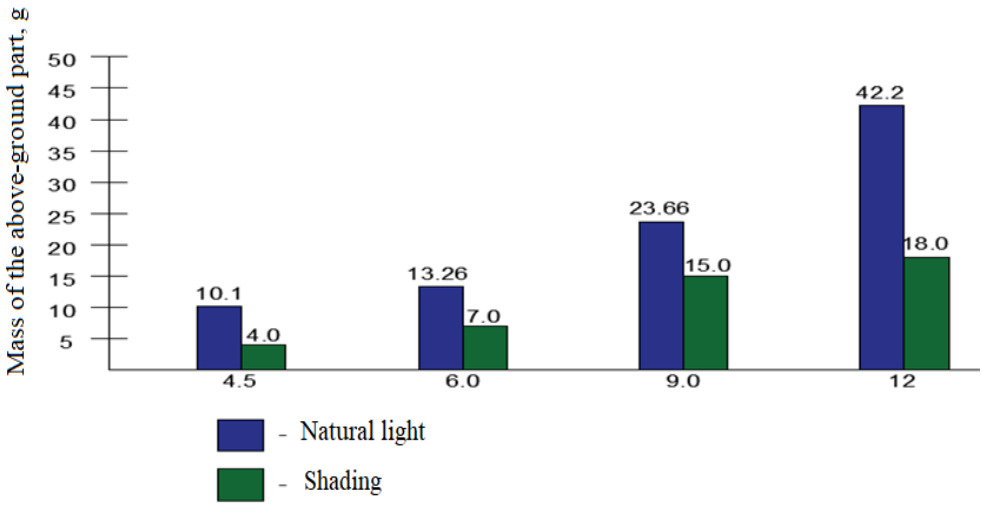

Fig. 5. *Weight of the aboveground part of plants*

When considering the influence of growing conditions and the diameter of the cuttings on the weight of the aerial part of *P. x canadensis* seedlings (Fig. 5) researchers have found important differences between the variants of cuttings. The aerial part plant mass in the planting material ranged from 4.0 to 42.2 g. This figure in the experimental variants was 3.0-32.1 g higher compared to the control.

This figure in the experimental variants was 3.0-32.1 g higher compared to the main indicator.

Concurrently was found that the plants in the control variant had a worse indicator than research samples. It was proved with good lighting and using of larger size of the cuttings, a raise in the weight of the aerial part was observed, which played an important role in physiological processes such as organic matter metabolism and photosynthesis, and also influenced the further development of the plant organism.

According to scientific results, can be said that the growing conditions and the size of the cuttings have a direct impact not only on the height of *P. x canadensis* plants, but also on the weight of the root systems and the aerial parts. It was proved during the experiment, the greatest sizes of *P. x canadensis* plants were obtainedin variant where the experiment was made and where the size of micropropagules was 12 mm.

Scientists have come to a conclusion that for growing seedlings with an uninjured root system, it is worth using cuttings with a diameter of 12 mm.

Scientists from other universities also agreed with the obtained results and they also approved the necessity of applaying micropropagules of the experimental taxon with a thickness of 12 mm.

Photosynthesis is the most important physiological and biochemical action. His role in the existence of organisms is very important, including humans. This process takes place in the leaves. Photosynthesis provides the development of up to 90% of organic compounds. The leaf surface mostly uses ultraviolet and visible solar energy with line length from 300 to 650 nm. On the open territory, just 1-1.5% the amount of sunshine obtained by plants is exploited for the saving of organic substance. The rest of it is used on transpiration_ and heating of the leaf surface.

In our researches the influence of micropod size was proved on the development of the photosynthetic surface (Table 3 and Fig. 6).

Table 3. Effect of growing conditions on photosynthetic surface parameters

Growing conditions	Variant	Leaf weight, g	% to control	Leaf area, cm^2	± to control
Natural light	Control (4,5)	4,5	-	290,7	-
Shading		2,8	-	224,0	-
Natural light	6	7,03	156,2	340,8	117,2/
Shading		5,3	125	258,0	115,2
Natural light	9	10,8	240,0	523,6	180,1/
Shading		8,3	175	448,0	200,0
Natural light	12	18,7	415,6	906,7	311,9/
Shading		15,8	314,3	800	357,1

During the research on the impact of conditions of growing and cutting diameter on the weight of the leaf seed covering material, a difference was found between the variants. The weight of the leaves on the control variants ranged from 2.8 to 4.5 g, which is 314.3 and 415.6 % less compared to the variante in which 12 mm thick cuttings were using. In the experimental version, the authors claim that, the seedlings had better biometric parameters than others. With the conditions of better light conditions and increased diameter of cuttings, there was a raise in the weight of photosynthetic surface, which significantly affects growth of plant processes and development of plant organism.

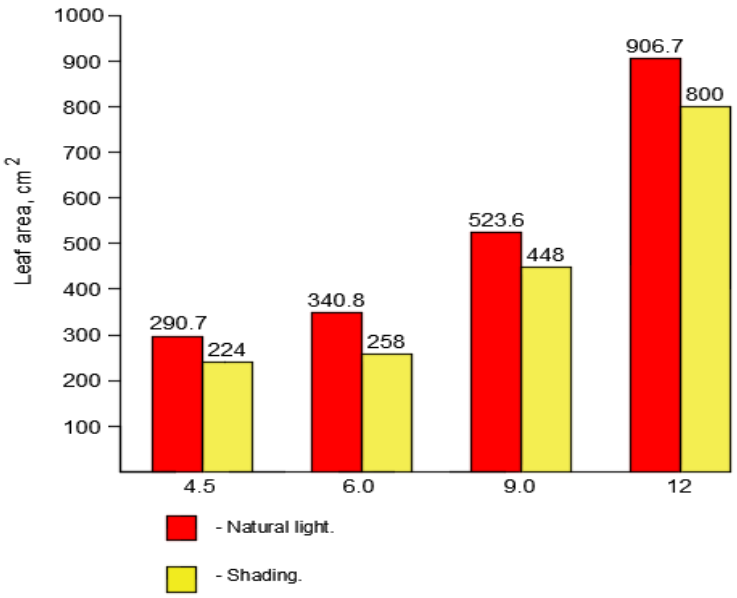

Fig. 6. *Features of photosynthetic apparatus formation in P. x canadensis plants*

During the search work, the light influence supply and the growth of seedlings on the characteristics of leaf surface increase was also analyzed.

The leaf surface of the main group plants was in the range of 224.0-290.7 cm^2, which was 311.0 and 357.1% less than in a experimental version, where 12 mm thick cuttings were used (Fig. 6).

The results of the researches on the influence of micropropagules thickness on the photosynthesizing surface area demonstrated that the highest result was obtained when using cuttings with a diameter of 12 mm. As well, a good impact of lighting conditions on the shaping of the leaf surface was found.

Conclusions and Suggestions For Production

1. *Populus* × *canadensis* is a fast-growing forest species that is grown for the wood production but recently it was using to create plantations.

2. The soil and climatic conditions of Sumy region are suitable for growing *Populus* × *canadensis* planting material with an uninjured root system.

3. It has been found that the quality of planting material of the studied cultivar is influenced by the growing conditions and the diameter of the cuttings:

- the hight of growing plants formed by cuttings with a thickness of 12 mm was 53.0-57.5 cm, which is 33.4 and 63 % more comparing to the main one;
- biometric options of cuttings were affected by the intensity of plant illumination;
- photosynthetic surface area on the control variants was in the range of 224.0-290.7_cm^2, which is 3.5-3.8 times less comparing to the samples where 12 mm thick cuttings were used.

To create forest plantations of *P. x canadensis*, we propose to use planting material with a closed root system. It is capable of forming a significant amount of natural substance. It is more easier to cultivate planting material and is unpretentious to the environment.

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