Regularities of the Growth of Pedunculate Oak (QUERCUS ROBUR L., 1753) in the Protective Plantings of the Steppe and Forest-steppe of the Volga Upland

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Research

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Abstract

The purpose of the study is to establish the regularities of the growth of pedunculate Oak in protective forest stands on erosion-prone slopes in the conditions of the steppe and forest-steppe of the Volga Upland. Studies have established a regular decrease in the height of the petiolate oak on the southern chernozem and gray forest soil by 6.9-11.3% with an increase in the slope of the slope by 2 times, which is associated with a drop in soil fertility as a result of increased erosion. The index of oak growth intensity with an increase in the slope slope increases on both types of soils by 21.4-38.5%, and the productivity of cambium decreases by 14.1-23.6%. The same trends in the dynamics of taxation indicators are characteristic of the accompanying species of petiolate oak-holly maple and small-leaved linden. The coefficients of determination of the relationship of growth in the height of the pedunculate oak from the indicator of growth intensity and productivity of cambium are 0.95-0.98, which indicates a close interdependence.

1. Introduction

Petiolate oak (Quercus robur L.,1753) is the most common main breed used in protective afforestation in the conditions of the steppe and forest-steppe of the Volga Upland of Russia. The high productivity of oak on chernozems and gray forest soils, durability and drought resistance, allow us to grow protective forest stands with high taxation indicators [1,2,3]. In many respects, the productivity and condition of the petiolate oak depends on the mixing scheme used, the choice of the accompanying breed and timely agrotechnical and forestry care in protective plantings [4,5,6].

2. Materials And Methods

The purpose of the study is to establish the regularities of the growth of the petiolate oak in the steppe and forest-steppe of the Volga Upland.

The experiments were carried out on the southern chernozem of the steppe of the Volga Upland in the "Forest" farm of the Tatishchevsky district of the Saratov Region and on the gray forest soil of the forest-steppe of the Volga Upland in the "New Chemeevo" farm of the Morgaushsky district of the Republic of Chuvashia[3,7].

Research and production anti-erosion experimental sites include:

- in the southern black soil, two 36-year-old flow-regulating forest strips of a dense structure with a width of 57 m with a number of rows of 19 are composed of 5 petiolate Oak (Quercus robur), 3 holly Maple (Acer platanoides), 2 lanceolate Ash (Frahinus lanceolata). Along the edges of the forest strip there are shrubs of narrow-leaved loch (Elaeagnus angustifolia) and golden currant (Ribes aureum). Tree species grow according to the third class of bonitet. The protective height of the forest strip is 8.5 m;

- on gray forest soil, protective forest stands aged 45 years have a composition of six petiolate Oak and four small-leaved Linden (Tilia cordata), growing in the second –third class of bonit with a protective height of 15.4 m.

The methodology and methods of the research are based on the Forest Code of the Russian Federation using the principles of organizing the theory and practice of classical forestry, forest taxation, agroforestry, standard and private methods of planning and conducting experiments. The plantings were studied by forest taxation methods with the taking of model trees (OST 56-69-83) and using the methodology of the Research Institute of Agroforestry for protective forest stands [8].

The dependence of the height of the oak on the age was established according to the regression equation of A. Mitcherlich:

$$h = a_1 \cdot \left[1 + \xi \cdot \exp(-a_2 \cdot \{t - a_3\})\right]^{-1/\xi}$$

where **h-** is the height of the oak, m; a_1 a_2 a_3 -are the parameters of the S-shaped curve; t- is the age of the oak, years;

[illegible] -the degree of curvature of the curve.

To study the relationship between tree species in protective forest stands and the viability of plantings, the K method was used. By Vysotsky [1], with the help of which the following quantitative indicators were determined: a) the growth intensity indicator (IGI)- the ratio of the height of the tree to the cross-sectional area at chest height; b) the coefficient of competitive relations (CCR)- the ratio of the growth intensity of the breed with the best growth (the smallest IGI) to the growth intensity of each other breed in the same plantation; c) the degree of stability of the planting (DSP) – the ratio of the actual amount of CCR and the maximum possible.

The productivity of cambium – the ratio of wood growth by volume for a year or a period of years to the surface area of the cambial tissue was calculated using the complex dependence of S. S. Pyatnitsky, according to the formula we transformed [9],

PC=1.68 x + 3.65 z – 0.05, (2)

where PC is the productivity of cambium, dm3/m2;

x is the average increase in height, m;

z is the average increase in diameter, see

The processing of the research materials was carried out according to the methodology of B. A. Dospekhov [10] - using professional versions of the package of standard computer programs Statistica, SciLab and the" Table processor analysis Package " MS Excel.

3 Results

A comprehensive account of natural and anthropogenic factors affecting the growth and productivity of tree species in protective forest stands, in particular, pedunculate oak, due to their diversity, is a very difficult task. From a fundamental point of view, the totality of natural and anthropogenic factors is a multidimensional hypersurface, the detailed study of which is complicated by the complexity of its structure. We used mathematical models and methods that allowed us to take into account the impact on the growth of the petiolate oak of the most significant factors that allow for a mathematical description available for use: diameter, growth intensity index, cambium productivity.

$H = b_0 + b_1D + b_2P + b_3K + b_4DP + b_5DK + b_6PK + b_7DPK,$ (3)

where, h is the height of the pedunculate oak, m; D is the diameter of the oak at chest height, cm; P is the indicator of growth intensity, cm/cm2; K is the productivity of cambium, dm^3/m^2; b_0-b_7 are the coefficients of multiple regression

The study of forestry and taxation parameters of tree species in protective forest stands on various parts of the slope showed a regular growth dynamics. With an increase in the steepness of the slope, the taxation indicators of tree species, primarily the oak bonitet, naturally decrease, which is associated with a drop-in soil fertility as a result of erosion [2,3]. The height of an oak tree with an increase in steepness by 1.9-2.3 times on southern chernozem and gray forest soil decreases by 6.9-11.3%, and the diameter-by 13.9-24.2 %. The index of oak growth intensity with an increase in the slope of the slope increases by 21.4-38.5%, and the productivity of the cambial tissue decreases by 14.1-23.6%. The same trends in the dynamics of forestry and taxation indicators are characteristic of related breeds. There is a high more than 71% vital state of tree species in protective plantings (Tables 1, 2).

The dynamics of growth in the height of the pedunculate oak, depending on the age, shows that in the first 4-6 years, the breed develops mainly the root system, and then the crown. The dependence of the growth rate in the height of the oak on the age is described by the equation of A. Mitcherlich (1) (Fig. 1,2).

For the three regression curves in Fig. 1, the parameters a2 = 0.2, a3 = 10, and the values of parameter a1 for the upper, middle and lower parts of the slope are 8.1, 7.7 and 7.3, respectively. For the three regression curves, Fig. 2 parameters a2 = 0.2, a3 = 40, and the values of parameter a1 for the upper, middle and lower parts of the slope are 17.1, 16.6 and 16.0, respectively.

Regression and correlation analysis showed that of the many natural and anthropogenic factors that affect the growth in height of the petiolate oak, an indicator of the growth intensity associated with the diameter of the rock and the productivity of the cambium, depending on the increments in diameter and height, have an effect. The coefficients of determination are 0.95-0.98, which indicates a close relationship of the studied features (Fig. 3,4).

Studies of the growth of pedunculate oak, conducted in the conditions of the Central Chernozem Region of Russia, have shown that the use of wide row spacing (2.5 m) in forest strips and the use of accompanying species in mixing with oak - holly maple and small-leaved linden, provides an increase in the taxation indicators of oak by 20% compared with the indicators of oak in forest strips with narrow row spacing (1.5 m) and without accompanying species (Mikhin V. I., Mikhina E. A., Tanyukevich V. V.). In our studies of the growth of pedunculate oak in the forest strips of the Volga Upland, the following indicators were used: the growth intensity index (IGI), the coefficient of competitive relations (CCR), the degree of plant stability (SUN) and the productivity of cambium, (PC) allowing for a deeper assessment of the growth and condition of the pedunculate oak in various growing conditions.

The results of the study were implemented in the farms " Lesnoye "of the Tatishchevsky district of the Saratov region (the steppe of the Volga Upland) and" Novoe Chemeevo " of the Morgaushsky district of the Chuvash Republic (the forest-steppe of the Volga Upland).

The area of protective forest stands on the slopes with the main oak species is 14.5 hectares, which protect 227 hectares of pasture land with a forest cover of 6.4% and an increase in the productivity of pasture grasses by 15-45%.

5 Conclusions

The analysis of the growth of pedunculate oak notes a close relationship between the height of the main tree species with age and taxation parameters with determination coefficients of 0.89-0.98. Long-term studies of forestry and taxation indicators of pedunculate oak and its accompanying species of holly maple and small-leaved linden allowed us to recommend them on erosion-prone slopes in protective forest stands.

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Tables

Table 1. Indicators of the relationship of tree species and the resilience of forest strips on the southern chernozem of the steppe of the Volga Upland

Location of forest strips on the slope	Breed	Medium				IGI, cm/cm^2	CCR	DSP	PC, dm^3/m^2	Vital condition, %
		D, см	Z cm/year	H, m	X m/ year					
Upper part, steepness 3º	Qr	11,8	0,33	7,9	0,22	7,23	1,00		1,52	82
	Az.p	11,0	0,30	7,1	0,20	7,47	0,96	1,96	1,38	82
Middle part, steepness 5º	Qr	10,9	0,30	7,5	0,21	8,04	1,00		1,40	77
	Az.p	9,9	0,28	6,4	0,18	8,32	0,97	1,97	1,27	78
Lower part, steepness 7º	Qr	9,5	0,26	7,1	0,20	10,02	1,00		1,23	74
	Az.p	8,7	0,24	6,1	0,17	10,27	0,98	1,98	1,11	71
Qr - Oak petiolate; Az.p-holly maple; D-diameter, cm; Z - increase in diameter, cm / year; H-height, m; X - increase in height, m / year; IGI-indicator of growth intensity, cm/cm2; CCR-coefficient of competitive relations; DSP-degree of stability of planting; PC-productivity of cambium, dm3/m2										

A source: (Compiled by the authors).

Table 2. Indicators of the relationship of tree species and the resilience of protective forest stands on gray forest soil in the forest-steppe of the Volga Upland

Location of forest strips on the slope	Breed	Medium				IGI, cm/cm^2	CCR	DSP	PC, dm^3/m^2	Vital condition, %
		D, см	Z cm/year	H, m	X m/ year					
Upper part, steepness 15°	Qr	19,7	0,44	17,1	0,38	5,61	1,00		2,19	87
	T.c	17,1	0,39	16,2	0,36	7,06	0,79	1,79	1,98	83
Middle part, steepness 22°	Qr	18,1	0,40	16,6	0,36	6,45	1,00		2,01	84
	T.c	15,9	0,35	15,8	0,35	7,96	0,81	1,81	1,82	80
Lower part, steepness 29°	Qr	17,3	0,38	16,0	0,35	6,81	1,00		1,92	81
	T.c	15,1	0,33	15,1	0,33	8,44	0,81	1,81	1,71	77
T. c – Tília cordáta. The remaining designations are shown in Table 1										

A source: (Compiled by the authors).

Figures

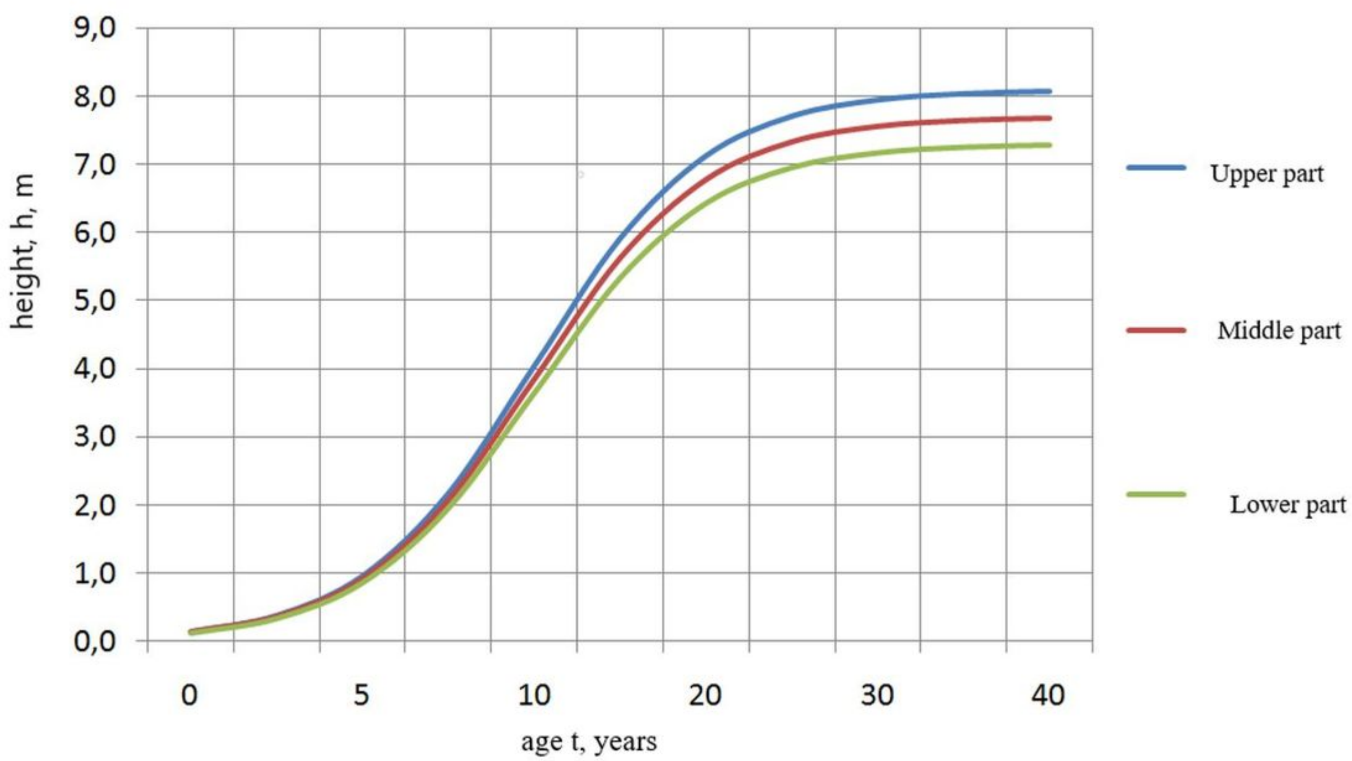

Figure 1

Approximation of the growth course of the oak petiolate oak in height in protective forest stands on southern chernozem in the steppe of the Volga UplandA source: (Compiled by the authors).

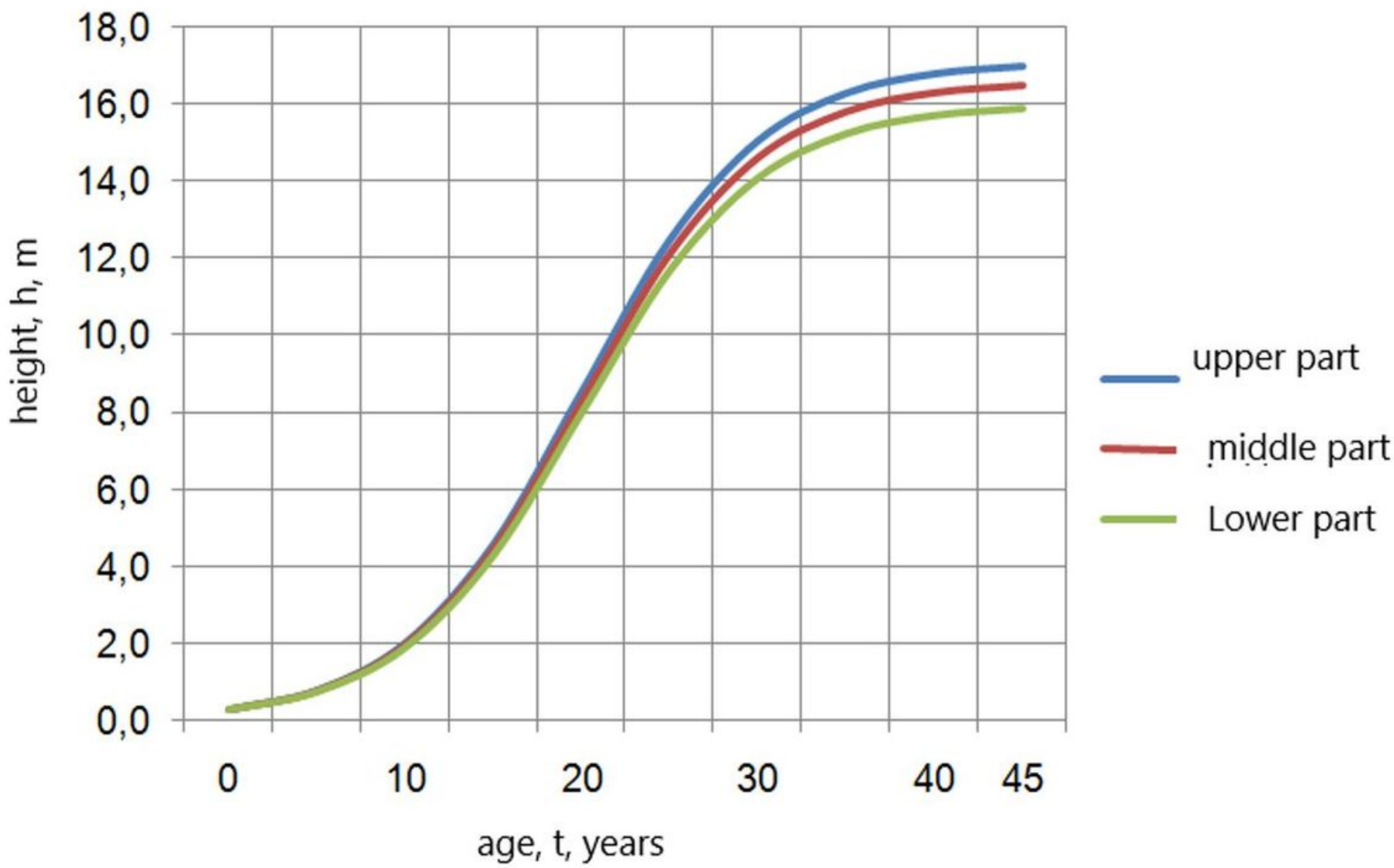

Figure 2

Approximation of the course of growth in height of the petiolate oak in protective forest stands on gray forest soil in the forest-steppe of the Volga UplandA source: (Compiled by the authors).

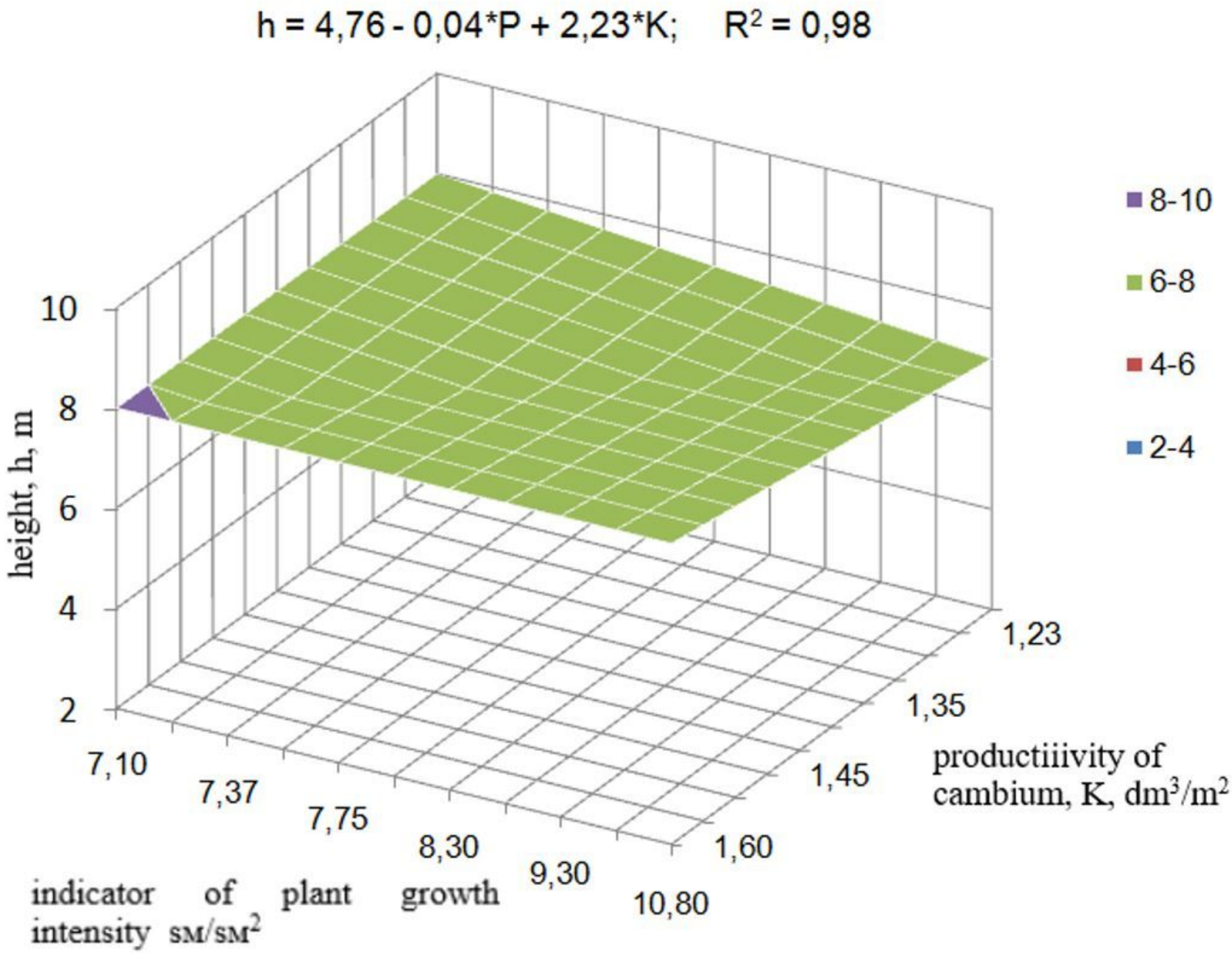

Figure 3

The height of a 36-year-old petiolate oak depending on the indicator of the intensity of growth and productivity of cambium in the steppe of the Volga uplandA source: (Compiled by the authors).

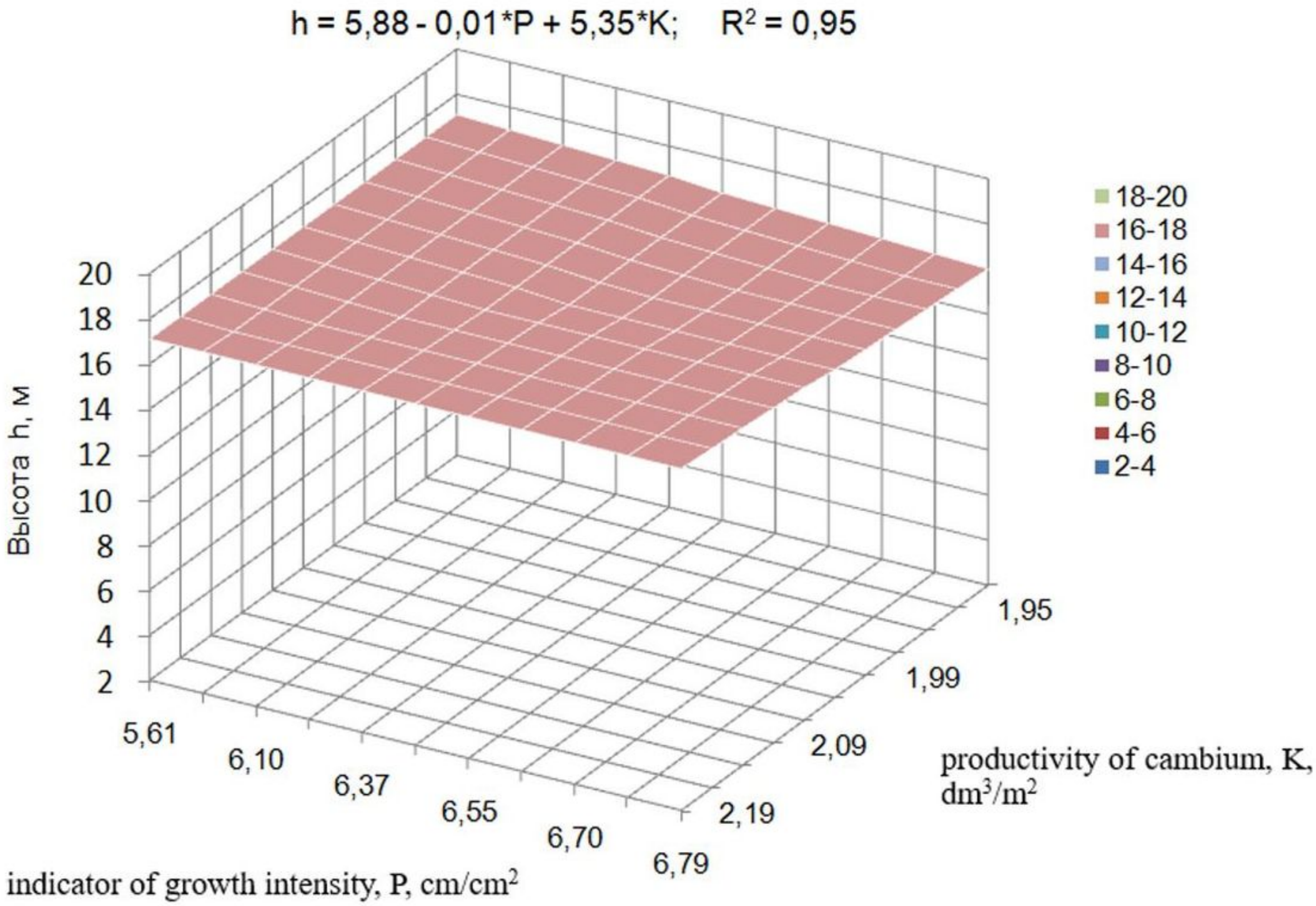

Figure 4

The height of a 45-year-old petiolate oak depending on the indicator of the intensity of growth and productivity of cambium in the forest-steppe of the Volga uplandA source: (Compiled by the authors).