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CONTENT

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FOREST ECOLOGY

INFLUENCE OF SOIL CONDITIONS ON THE PECULIARITIES OF GROWING OAK SEEDLINGS IN BOTANICAL GARDEN OF VINNYTSIA NATIONAL AGRARIAN UNIVERSITY

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Abstract

The article presents the main studies and their results on the influence of soil nutrition on the growth and development of seedlings of the pedunculated oak in the botanical garden of VNAU. The study of the soil fertility effect and the influence of nutrient content on the seedlings condition is the main component of the successful cultivation of forest plantations of pedunculated oak in Vinnytsia region.

As a result of the conducted researches it was revealed that the average increase in height of oak seedlings on control made 4.1 cm for 2 months (+55% of the initial). Feeding oak seedlings with the investigated preparations contributed to the increase of the average growth of seedlings from 0.8 cm (+11% compared to the control) to 2.1 cm (+22.4% compared to the control).

Analysis of the dynamics of the oak seedlings root neck average diameter during the 1st year of life was characterized by lower relative growth rates due to 2-months fertilization. Thus, under control (without fertilizers) the diameter of the root neck for the same period increased by 0.065 cm (+29.5%) whereas on plots where fertilizers were applied, the diameter increased by 0.087-0.147 cm (+38.5% - + 64.5%).

Keywords: common oak, seed material, soil nutrient regime, growth, soil extract.

Introduction. The main task of forest economy in Ukraine is to grow highly productive durable and biologically stable forests, field protective and other types of artificial plantations, which would include economically valuable wood species. In the forests of Ukraine oak is one of the most common and valuable species in many respects. It occupies 27% of the area of the state forest fund of Ukraine. Analysis of the forest fund of the Forest-Steppe natural zone of Ukraine shows that the region has substantial reserves for growing highly productive and sustainable oak forests and significant prerequisites for expanding the range of this valuable species [1].

For this purpose it is necessary to study the opportunities for its full-fledged reproduction in the Forest-Steppe zone of Vinnytsia region. The solution to the problem of obtaining quality planting material of pedunculated oak seedlings lies in optimizing the conditions for their cultivation and selection of quality seed material of plus trees [3]. To do this, forestries need highly adaptive planting material, grown in open soil and in nurseries, with both open and closed root system [5]. The development of seedlings largely depends on the creation of optimal growing conditions for them. Nutrient regime of the soil as a vital factor in the development of seedlings of oak is of particular importance.

The range of the oak seedlings development is a direct response to the influence of such factors as seed quality, growing conditions, water-air, heat, redox and nutrient regime of the soil [7].

In the experimental study in the botanical garden, all those conditions were the same, except for the nutrient regime of the soil.

Goals and objectives of the research. Study of the influence of various ecological factors of the environment, first of all the nutrient regime of the soil, on the development of oak seedlings in conditions of the botanical garden of VNAU.

Based on the goal, the following **research objectives** were set: to determine the morphometric parameters of seedlings of the pedunculated oak trees; to evaluate the development of the oak seedlings in conditions of different soil nutrients supply.

Object of the research – processes of development of the oak seedlings in different environmental conditions.

Materials and methods of the research. The seedlings development was determined before and after the experiment by measuring morphometric parameters followed by statistical data processing. The indicators obtained were evaluated by comparing data on samples. A total of 200 plants of oak seedlings were examined. The research began in the fall with the study of morphometric parameters of the seedlings themselves in terms of trunk height and root neck diameter. The height of the plants was measured with a measuring tape, the diameter was determined with the use of a caliper [8].

The variability of seedling was studied by the Pravdina L.F. method (1964). Processing of the records was carried out by variational statistical methods. Mineral fertilization and organic preparations dresiising included 5 options:

1. Control (without fertilizer).
2. Nitroammophoska (NPK).
3. Chelated microelement fertilizer Master + (ME).
4. Organic preparation Humiplant.
5. 0-20 cm layer loamy soil water extract (layer of 0-20 cm).
6. Ground water extract from the 20-40 cm loamy soil layer (layer of 20-40 cm)

Results and discussion. The results of the pedunculated oak seedlings development experimental studies during the 1st year of life (Fig. 1) showed that the average height increase in 2 months of control studies was 4.1 cm (+55% of the initial). Feeding of oak seedlings with the specified above preparations contributed to the increase of the average growth of seedlings from 0.8 cm (+11%) to 2.1 cm (+22.4% compared to the control). The best effect demonstrated application of Master + fertilizer, while the application of GWE (0-20 cm layer), on the contrary, inhibited development of the oak seedlings, causing a lag in height gain by 0.5 cm due to the high concentration of colins in the upper layer of the soil that have a negative allelopathic effect on the oak seedlings, which in turn is associated with accumulation of the oak leaf shedding and its transformation products.

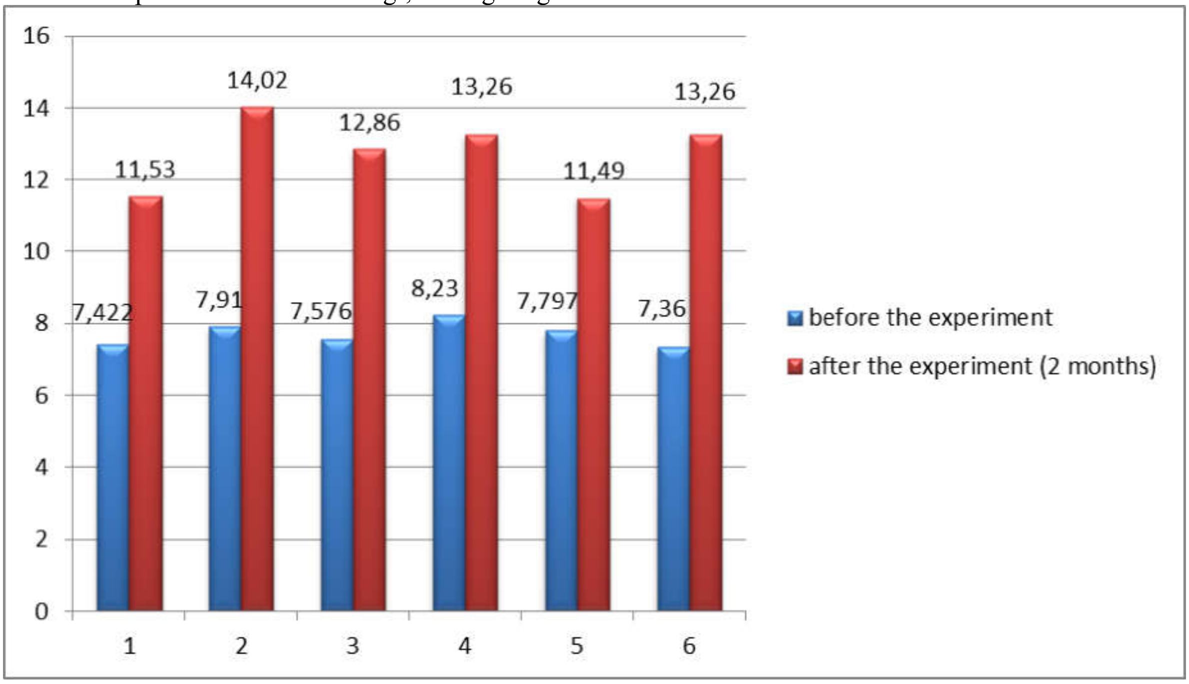

Fig. 1. Dynamics of the height of the oak seedlings under the influence of fertilization during the 1st year of life

Dynamics of the average diameter of the root neck of the oak seedlings during the 1st year of life was characterized by lower relative growth rates due to 2-month fertilization (Fig. 2). So, on control (without fertilizers) the diameter of the root neck for the same period increased by 0.065 cm (+29.5%) whereas on the plots where fertilizers have been applied the diameter increased by 0.087-0.147 cm (+38.5% - + 64.5 %). The most considerable effect during the 1st year of the research showed feeding the seedlings with nitroammophoska (+ 64.5% diameter increase in 2 months of the research), 20-40 cm layer loamy soil water extract ranked second, it provided a corresponding increase in the diameter of the root neck by 49%. The least effective was fertilization with 0-20 cm layer loamy soil water extract, which provided an increase in the diameter of the root neck after 2 months of the research by only 37.5%.

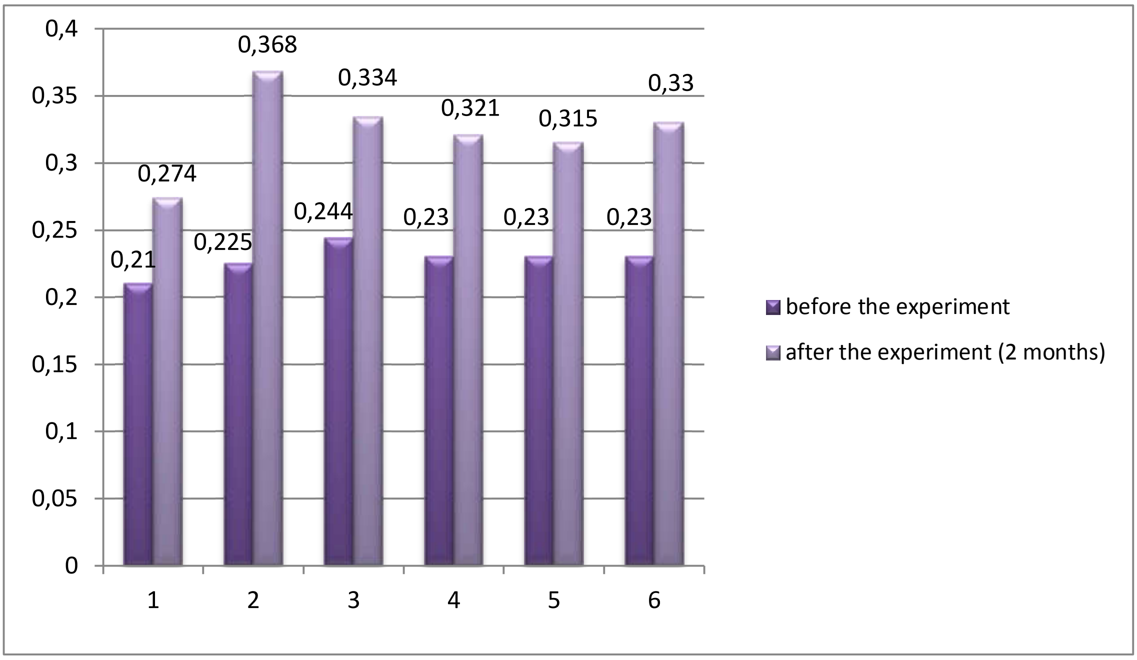

Fig. 2.
Dynamics of the diameter of the root neck of oak seedlings under the influence of fertilization during the 1st year of life

Dynamics of the height amplitude of the oak seedlings under the influence of fertilization during the 1st year of life as a whole indicates the uneven development of the pedunculated oak seedlings (Fig. 3), what could be caused both by different quality of the seed material and spatial heterogeneity of soil nutrient formation due to fertilization.

The high amplitude of fluctuations in development indicators, superimposed on the high average indicators generally demonstrates the positive impact of the studied factor and the need to improve the technology of its application in order to equalize the positive spatial impact. Thus, the maximum values of the hight amplitude dynamics of the oak seedlings are characteristic of the plants fertilized with the 20-40 cm layer loamy soil water extract and indicate high potential of the preparation. This fact stresses the need to improve exactly this means in order to select the groups of mycorrhizal fungi and beneficial bacteria without colins, which could be present in the soil water extract.

The results of the long-term studies (at the end of the 2nd year of the oak seedlings life) showed that the increase in the average height of oak seedlings after 2 years of control studies was +8.4 cm (+ 113% compared to the beginning of the study), while on the fertilized plots it fluctuated within + 11.8… + 15.1 cm (+151% ... + 206%) – see Fig. 4.

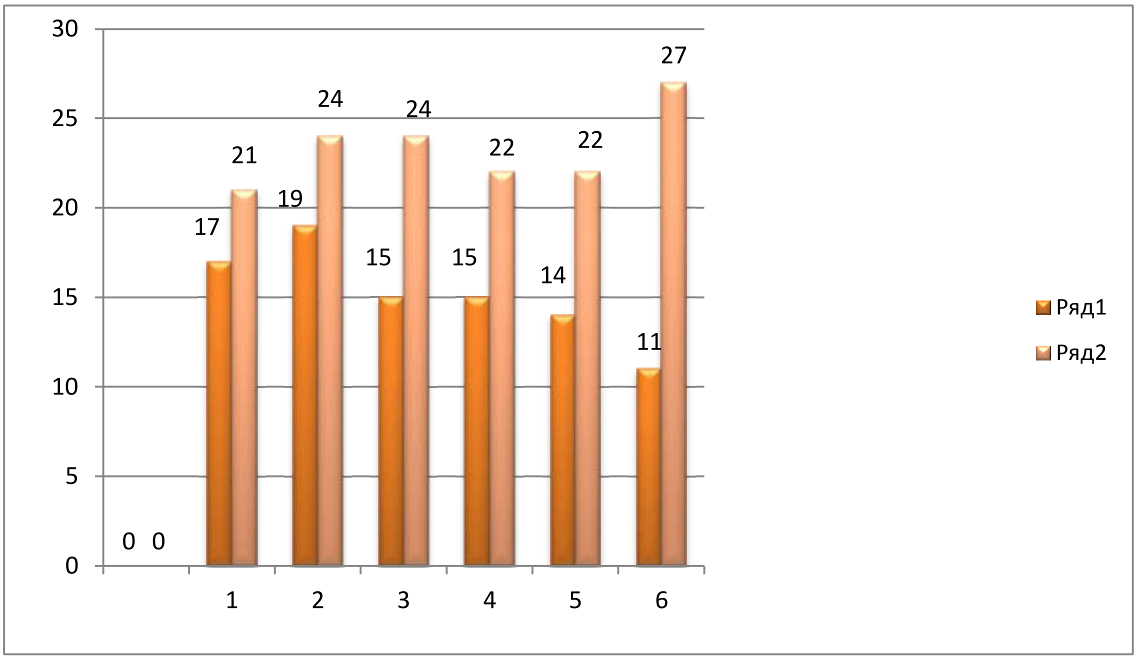

Fig. 3. The amplitude of the seedlings height of the pedunculated oak under the influence of fertilization during the 1st year of life, cm

The best effect on increasing the height of seedlings showed fertilization with 20-40 cm layer loamy soil water extract, while the worst – feeding with soil water extract from the layer of 0-20 cm, what confirms the negative impact of colins on the development of oak seedlings and inexpediency of extracting the useful microflora from the upper 0-20 cm soil layer. Among mineral fertilizers, the Master + microfertilizer showed better effect, which was 9.5% more effective than nitroammophoska. The increase in the average diameter of the root neck of seedlings after 2 years of control studies was +0.13 cm (+59.1% compared to the start of the study), while on the fertilized variants it ranged from + 0.13… + 0.26 cm (+ 59.3% ... + 118.2%).

In general, the results of measurements of biometric indicators of the pedunculated oak development clearly showed the most positive effect of fertilizing oak seedlings with 20-40 cm layer loamy soil water extract, which could be conditioned by mycorrhization of the seedlings root system and a significant increase in surface of its water-mineral nutrition.

In order to confirm the hypothesis of the dependence of biometric indicators of the oak seedlings development on the nutrient regime of the soil, the correlations between the studied indicators were evaluated. Evaluation of correlations between the nutrient regime of the 10-30 cm soil layer (Table 1) testifies a high correlation between the seedlings diameter and phosphorus content of mobile compounds ($r^2 = 0.876$) and medium correlation between the seedling height and mobile phosphorus compounds content ($r^2 = 0.503$). As to the nutrient regime of the 30-50 cm soil layer (Table 2), the existence of a high correlation between the exchangeable potassium rate and the height of seedlings ($r^2 = 0.644$) and the diameter of the root collar ($r^2 = 0.879$) is established.

By the end of the 2nd year of the research, the correlations between the nutrient regime of the 0-50 cm soil layer (Table 2) has increased: the medium correlation between the height of the oak seedlings and the phosphorus content of mobile compounds in the soil ($r^2 = 0.471$), the content of exchangeable potassium ($r^2 = 0.552$) and the content of nitrate nitrogen ($r^2 = 0.462$) has been established. Between the diameter of the root neck of the seedlings and the content of exchangeable potassium medium correlation ($r^2 = 0.488$) has been also observed. For the nutrient regime of the 0-10 cm soil layer (Table 3) correlations between the seedling height and phosphorus content of mobile compounds and with the content of exchangeable potassium were evaluated as high – $r^2 = 0.644$ and r2 = 0.618 correspondently. Between the diameter of the root neck of the seedlings and the content of exchangeable potassium high correlation relationship ($r^2 = 0.879$) was also noted, and nutrient regime of the 10-30 cm soil layer was characterized by the presence of a medium correlation between the nitrate nitrogen content and the height of the seedlings (Table 4).

Table 1

Matrix of correlations between biometric indicators of the oak seedlings development at the end of the 1st year of life and soil nutrient regime (for the 0-10 cm layer)

Indicator		1st year of research			Seedling height				Diameter, cm			
		N	P	K	серед	max	min	amplitude	average	max	min	amplitude
Content in soil, mg / kg	N	1,000										
	P	-0,590	1,000									
	K	-0,360	0,149	1,000								
Seedling height, cm	average	0,544	0,302	-0,016	1,000							
	max	0,185	-0,151	0,306	0,343	1,000						
	min	0,075	0,200	0,493	0,277	-0,442	1,000					
	amplitude	0,108	-0,195	0,028	0,144	0,931	-0,740	1,000				
Seedling diameter, mm	average	0,952	-0,387	-0,225	0,692	0,080	0,341	-0,079	1,000			
	max	0,443	-0,748	0,115	-0,038	0,764	-0,468	0,764	0,229	1,000		
	min	0,302	0,344	0,372	0,893	0,612	0,250	0,357	0,446	0,134	1,000	
	amplitude	0,264	-0,872	-0,078	-0,482	0,408	-0,563	0,536	-0,009	0,869	-0,375	1,000

Table 2

Matrix of correlations between biometric indicators of the oak seedling development at the end of the 1st year of life and soil nutrient regime (for the 10-30 cm layer)

Indicator		1st year of research			Seedling height				Diameter, cm			
		N	P	K	average	max	min	amplitude	average	max	min	amplitude
Content in soil, mg / kg	N	1,000										
	P	0,348	1,000									
	K	0,164	0,410	1,000								
Seedling height, cm	average	0,116	0,503	0,395	1,000							
	max	0,968	0,392	0,290	0,343	1,000						
	min	-0,593	-0,085	0,665	0,277	-0,442	1,000					
	amplitude	0,968	0,329	-0,054	0,144	0,931	-0,740	1,000				
Seedling diameter, mm	average	-0,048	0,876	0,535	0,692	0,080	0,341	-0,079	1,000			
	max	0,845	0,634	0,323	-0,038	0,764	-0,468	0,764	0,229	1,000		
	min	0,395	0,339	0,549	0,893	0,612	0,250	0,357	0,446	0,134	1,000	
	amplitude	0,593	0,424	0,028	-0,482	0,408	-0,563	0,536	-0,009	0,869	-0,375	1,000

Table 3

Matrix of correlations between biometric indicators of the oak seedling development at the end of the 1st year of life and soil nutrient regime (for the 30-50 cm layer)

Indicator		1st year of research			Seedling height				Diameter, cm			
		N	P	K	average	max	min	amplitude	average	max	min	amplitude
Content in soil, mg / kg	N	1,000										
	P	0,732	1,000									
	K	-0,412	0,100	1,000								
Seedling height, cm	average	0,145	0,644	0,618	1,000							
	max	-0,197	-0,298	0,131	0,343	1,000						
	min	0,223	0,427	0,631	0,277	-0,442	1,000					
	amplitude	-0,239	-0,398	-0,159	0,144	0,931	-0,740	1,000				
Seedling diameter, mm	average	-0,520	0,167	0,879	0,692	0,080	0,341	-0,079	1,000			
	max	-0,756	-0,775	0,238	-0,038	0,764	-0,468	0,764	0,229	1,000		
	min	0,236	0,473	0,544	0,893	0,612	0,250	0,357	0,446	0,134	1,000	
	amplitude	-0,826	-0,962	-0,049	-0,482	0,408	-0,563	0,536	-0,009	0,869	-0,375	1,000

Table 4

Matrix of correlations between biometric indicators of the oak seedling development at the end of the 2nd year of life and soil nutrient regime (for the 0-50 cm layer)

Indicator		2nd year of research			Seedling height, cm				The diameter of the seedling, cm			
		N	P	K	average	max	min	amplitude	average	max	min	amplitude
Content in soil, mg / kg	N	1,000										
	P	0,686	1,000									
	K	0,091	0,132	1,000								
Seedling height, cm	average	0,462	0,471	0,552	1,000							
	max	0,368	0,346	0,492	0,945	1,000						
	min	0,266	0,250	0,628	0,796	0,822	1,000					
	amplitude	0,373	0,350	0,454	0,938	0,996	0,766	1,000				
Seedling diameter, mm	average	0,252	0,257	0,488	0,825	0,906	0,942	0,871	1,000			
	max	0,444	0,421	0,575	0,985	0,943	0,728	0,947	0,771	1,000		
	min	0,468	0,526	0,440	0,883	0,810	0,855	0,776	0,790	0,807	1,000	
	amplitude	0,424	0,387	0,577	0,966	0,931	0,680	0,940	0,739	0,995	0,744	1,000

Thus, the correlation analysis of the relationship between the nutrient regime of light gray podzolic soil and biometric indicators of the oak seedlings development for 2 years showed that during the 1st year most attention should be paid to increasing the nitrate nitrogen content in the 0-10 cm layer of soil and potassium exchange in the 30-50 cm layer of soil, what can be provided by the basic fertilization of the soil with potassium fertilizers and application of nitrogen fertilizers.

During the 2nd year of life of the pedunculated oak seedlings it is important to increase the content of the exchangeable potassium in the 0-10 cm layer of soil by fertilizing it with potassium fertilizers and increase the content of the nitrate nitrogen in the layer of 10-30 cm by fertilizing the seedlings with nitrogen or organic fertilizers at the beginning of the 2nd year of life, applying them into the rows before the inter-row cultivation.

Previous studies have shown the existence of correlations between the parameters of the nutrient regime of light gray podzolic soil and biometric indicators of the oak seedlings development. To ensure the production of seedlings with specified biometric parameters, it is necessary to optimize the nutrient regime of the soil. The basis of such optimization should be clear limits of the parameters of the nutrient regime, which allow obtaining seedlings of the pedunculated oak with specified height and diameter of the root neck. For this purpose, regression analyzes were performed and the corresponding regression dependences were established (Fig. 4-5).

Regression dependences of the 2nd year of life seedlings height on the content of nutrients available to plants in the 0-10 cm layer of soil, which is considered to be the most biologically active and plays a major role in ensuring intensive mobilization of nutrients through the activity of the microorganisms were established. These dependencies allow to predict the limits of the optimal content of available nutrients in order to obtain seedlings of a given height.

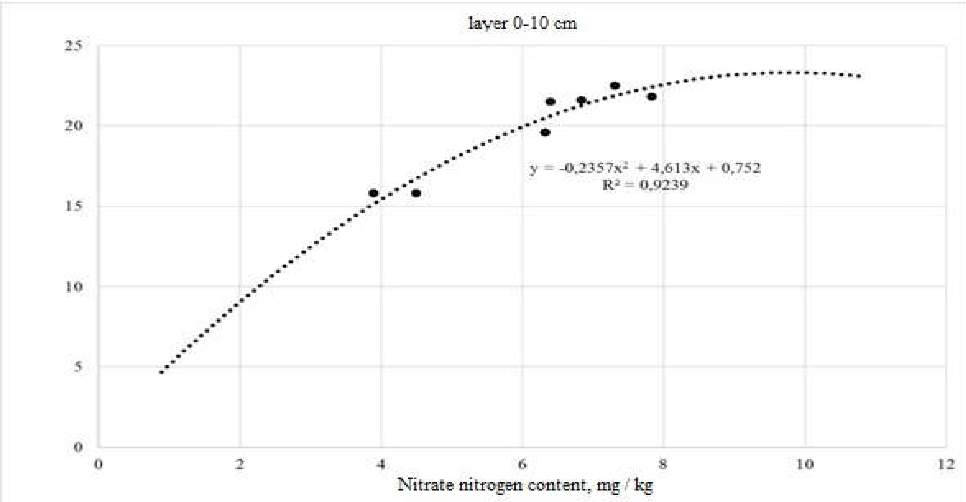

Fig. 4. Regression dependence of the 2nd year of life seedlings height on the content of nitrate nitrogen in the 0-10 cm soil layer

Based on the parabolic regression dependence of the height of the 2nd year of life seedlings on the content of nitrate nitrogen in the soil layer of 0-10 cm, it is established that in order to achieve seedlings of the average height of 21-23 cm it is necessary to ensure the content of nitrogen nitrate in the 0-10 cm soil layer in the amount of 7-9 mg/kg (Fig. 4).

The regression dependence of the height of seedlings of the 2nd year of life on the phosphorus content of mobile compounds in the 0-10 cm soil layer allowed to establish that in order to achieve the average seedling height of 21-23 cm it is necessary to ensure the mobile phosphorus compounds content in the 0-10 cm soil layer in the amount of 2.8-3.7 mg/kg (Fig. 5).

The regression dependence of the height of the 2nd year of life seedlings on the content of potassium exchange in the 0-10 cm soil layer shows that it is necessary to ensure the content of the potassium exchangeable in the soil layer of 0-10 cm at the level of 0.5-0.9 mg/kg in order to achieve the average height of seedlings at 21-23 cm.

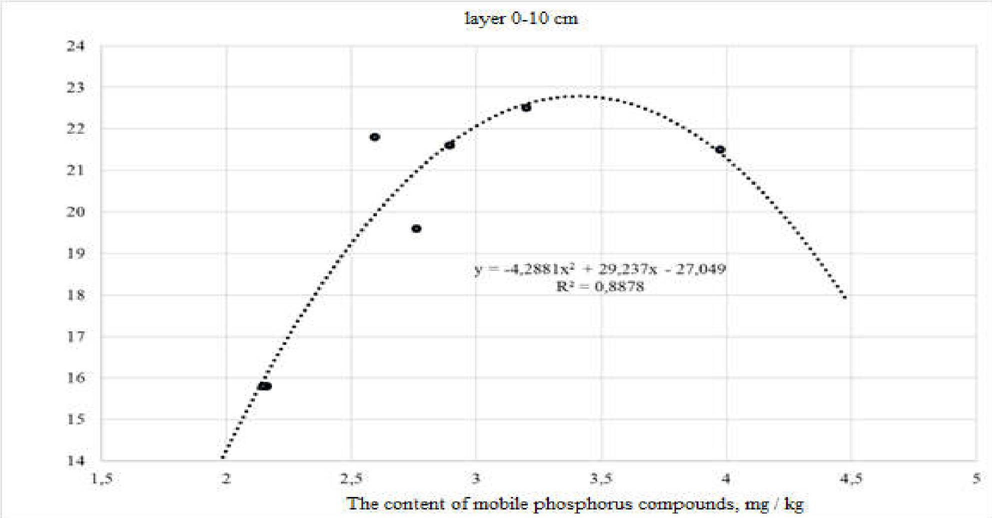

Fig. 5. Regression dependence of the height of seedlings of the 2nd year of life on the mobile phosphorus compounds content in the 0-10 cm soil layer

Regression dependence of the diameter of the root neck of the pedunculated oak seedlings on the content of nitrate nitrogen in the 0-10 cm soil layer (Fig. 4) allows to predict the level of the optimal range of nitrate nitrogen content in this layer to obtain 2-year seedlings of oak with a root neck diameter of at least 0.46 cm, which is not less than 7.5 mg/kg of nitrate nitrogen.

The regression dependence of the diameter of the seedlings root neck of the 2nd year of life on the phosphorus mobile compounds content in the 0-10 cm soil layer (Fig. 5) shows that in order to obtain 2-year seedlings of oak with the root neck diameter of 0.44-0.45 cm it is necessary to maintain the mobile phosphorus compounds content in the soil layer of the 0-10 cm at the level of 2.8-3.7 mg/kg.

Regression dependence of the 2nd year of life seedlings root neck diameter on the content of the exchangeable potassium in the soil layer of 0-10 cm shows that in order to obtain 2-year seedlings of oak with the root neck diameter of of at least 0.44 cm it is necessary to maintain exchangeable potassium content in the layer of soil at the level exceeding 0.8 mg/kg.

Summary of the forecast data based on the regression dependences of biometric indicators on the parameters of the nutrient regime of the 0-10 cm soil layer are presented in table 5.

Table 5

Summary table of the results of the 2-years-old oak seedlings biometric indicators forecasting in dependence of the parameters of the nutrient regime of light gray podzolic loam soil (layer 0-10 cm)

Biometric parameter of the seedlings (2 years old)	Biometric parameter value	Soil nutrient parameter (layer 0-10 cm)		
		$N\text{-}NO_3$, mg/kg	P_2O_{5movb}, mg/kg	K_2O_{exch}, mg/kg
Seedling height, H, cm	21…23	7,0…9,0	2,8…3,7	0,50…0,90
Diameter of the root neck, D, cm	≥ 0,46	≥ 7,5		
	0,44…0,45		2,8…3,7	
	≥ 0,44			≥ 0,80

Conclusions. Thus, the regression equations between the biometric parameters of oak seedlings of the 2nd year of life and the nutrient regime of light gray podzolic soil indicate that to obtain 2-year-old oak seedlings with the 21-23 cm height and the root neck diameter of 0.44-0.45 cm it is necessary to provide soil nutrition in such a way as to achieve the following indicators of the content of available forms of nutrients: nitrate nitrogen – in the range of 7.0-9.0 mg/kg, phosphorus mobile compounds – 2.8-3.7 mg/kg, exchangeable potassium – in the amount 0.80-0.90 mg/kg. The forecast data are valid for the similar weather conditions.

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