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VARIABILITY OF PEDUNCULATE OAK (*QUERCUS ROBUR L.)* PROVENANCES IN CENTRAL UKRAINE

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Abstract: *A total of 65 pedunculate oak (Quercus robur L.) provenances from the southern, central, northern, and eastern parts of the oak distribution range in Vinnytsia region (Central Ukraine) were assessed in a common garden experiment. Analysis of the population's survival dynamics indicates an increase with age in the adaptive capacity of the provenances to the environmental conditions. In the initial stage, up to 10 years, the survival rate of the local populations was about 75%, by 40 years the survival decreased to 15%. At the same time, the number of trees of other provenances, which were characterised by higher survival rate, increased. The best adaptive capacity was obtained for the Rivne (Ostrozke), Kirovohrad (Svitlovodske), Chuvash (Kanaske), and Ulyanovsk (Melekske) provenances. The indicators of average height of the trees and geographic longitude (r=-0.513) and latitude of the natural growth of the populations (r=-0.474) are characterised by a significant and moderately close relationship. Oak populations differ by average diameter and remoteness from the natural location ratio (r=-0.431), and by the geographic latitude of their growing place (r=-0.478) in a moderate correlation. According to the comprehensive assessment of the non-local populations, which included survival rate, mean diameter and height, and tree breeding category, we can conclude that in general, the central populations have optimal values. Populations of Bryansk, Khmelnytskyi, Zaporizhzhya, and Cherkassy origin, as well as the local ones, have the highest values. The lowest indicators were observed manly for the northern oak populations.*

Key words: *provenance trials, pedunculate oak, growth traits.*

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1. Introduction

In the past, a significant amount of forest regeneration work was carried out without taking into account the geographic origin of seeds. As a result, low-quality forest stands were formed. In order to study the influence of the origin of forest seeds on the productivity and qualitative structure of forests, provenance tests were established. The first provenance trials in Ukraine were installed on the basis of mass collection of seeds headed by Tursky M.K.. The same series of provenance tests was used by Ogievsky V.D. in 1911-1916 in the conditions of Chernihiv region. Provenance tests were also established under the coordination of Kobranov, Kolesnikov, Mazhula, Ogiiyevsky, Rostovtsev, and Tkach et al. [11, 12, 18, 25, 28, 34]. With these trials, the period of studying the geographic variability of the main forest tree species began [19].

Owing to the established provenance tests, it was determined that the origin of seeds has significant influence on the growth and quality of stands of Scotch pine, English oak, Norway spruce, and other tree species both within their natural habitat and during their introduction [2, 4, 6, 7, 14, 15, 22, 30]. Ecological and geographic direction as well as population breeding, based on mass selection, have become the key trends of modern genetic-selection research [20, 34]. Today, provenance tests of forest species are the basis for forest-seed zoning, population and form diversity increase, and climate change impact assessment [4, 7, 22, 30].

The assessment of the impact of global environmental changes on forest ecosystems is a topical area of scientific research [1, 10, 13, 21, 27, 29, 32, 33]. Currently, provenance tests are not only the objects of productivity and stability of aboriginal and non-local populations assessment, but also models of climate change influence [6, 7, 16, 17, 22, 23, 30]. According to the results of studies which conducted provenance tests, a number of regularities were established, which are related to the impact of climate change on the growth and productivity of populations [2, 6, 8, 9, 14-16, 26].

Today, the state of forests is deteriorating due to climate change. This also applies to oak forests. More research is necessary on the selection of the best and most adapted populations. The purpose of the study is to assess the state, growth, and adaptability of English oak (*Quercus robur* L.) populations under the conditions of environmental change. The main objective is to identify the most adapted oak populations in the conditions of Vinnytsia region (Central part of Ukraine).

2. Materials and Methods

The study of provenance trials was carried out on the site located in Vinnytsia region (central part of Ukraine). We recorded all the oak trees on the sample plot. We surveyed 65 populations. Height (*H*), diameter (*DBH*), tree breeding category (*TBC*), category of condition (*CC*), and phenologycal phorm (*PhPh*) were determined for each tree. *DBH* was determined at a height of 1.3 meters in two mutually perpendicular directions. *TBC* was established according to the methodology developed by Ukrainian Research Institute of Forestry and Forest

Melioration (URIFFM). The methodology includes a 4-point scale [19].

The condition of the trees was determined according to the URIFFM methodology. All trees were estimated according to a 6-point scale [22]. The condition of the trees was determined according to the following categories: 1 – excellent condition, i.e. the crown is dense, complete shelter is formed with well-developed shoots and leaves or needles of healthy dark green color, without signs of disease and damage, newly-dried branches are absent. The trunk and root collar do not have external signs of damage. The rate of defoliation and dechromation is 0-20%; 2 – good condition: the crown is dense or slightly sparse, well covered with normally developed shoots and needles of green color, weak damage by pathogens or pests. Availability of small newly-dried branches in the crown (up to 10%) is possible. The trunk and root collar have minor external signs of damage. Stem pests or wood-rotting fungi are absent. The rate of defoliation and dechromation is 25-55%; 3 – satisfactory (weakened) state: the crown is sparse, transparent, or shortened and thickened due to the large number of small secondary branches on the basis of the primary branches and trunk. Needles or leaves are coloured green or light green, it is mostly damaged. The crown contains dry branches of medium survival of trees (up to 40%). The trunk and root collar can have several signs of damage. There are minor manifestations of damage by stem pests or wood-rotting fungi. The rate of defoliation and dechromation is 60-80%; 4 – unsatisfactory (much weakened) state: the crown is very sparse, its general form is lost. The living part of the crown is formed by single secondary branches on the basis of the primary branches and trunk; branching and intensity of shooting are very low. The crown has many dry skeletal branches of different age and preservation status, and many newly-dried branches (more than 40%). The needles are green or light green, mostly damaged, yellowed needles may be found. The trunk is covered with numerous drying branches and shoots. The trunk and root collar have numerous signs of damage or disease (fruit bodies or other signs of wood-rotting fungi, cancer, etc.). Much of the trunk is populated with pests. The rate of defoliation and dechromation is 85-95%; 5 – the tree has died during the current year (fresh dry); 6 – the tree died in the past years (old dead wood).

The survival of each population was estimated according to the number of trees of 1-4 CC. The grouping of heights by ranks was carried out on the basis of the 10% scale provenances classification. We determined the correlation coefficients between the average height of the populations and the distance from their natural range. The local population of Vinnytsia region was used as a comparison (control) population. We determined the difference between the average H and *DBH* of the local population and of other populations. The reliability of the difference in mean values was determined using the Student's test. We grouped the populations according to their geographical distribution into six groups: Northeastern, Northwestern, Central, Central-western, Southeastern, Sothern. Based on the results of the research, the populations were divided into classes, which were assigned a corresponding score for the main indicators: survival of trees, *DBH*, average *H*, *TBC*. The ranking was based on the interval assessment of each indicator according to the 10-point scale. We used the p-value in statistical hypothesis testing, specifically in null hypothesis significance testing (the null hypothesis was rejected when $p < 0.05$ and not rejected when $p > 0.05$).

3. Results and Discussion

In 1964, with the purpose of studying the productivity of geographically remote populations, provenance tests of English oak in the conditions of Vinnytsia region were created [2, 14, 15].

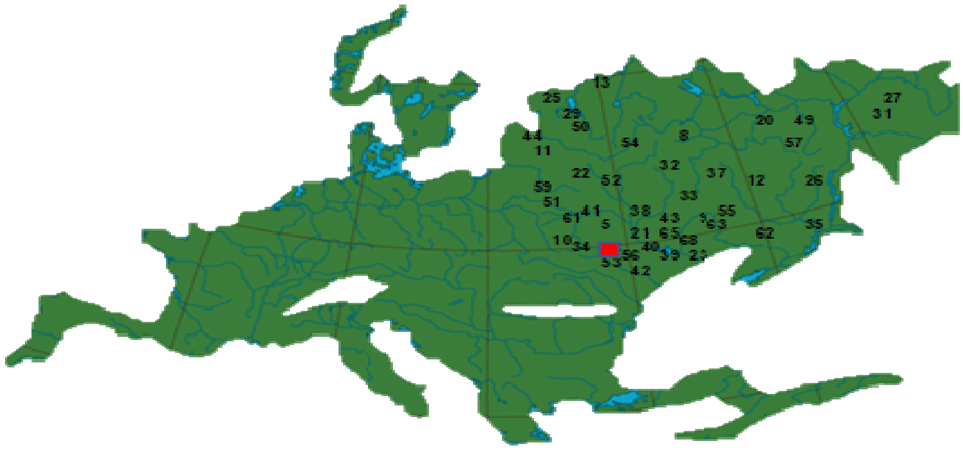

Fig. 1. *Geographic origin of oak provenances: 8 – number of provenance, ■ – location of provenance tests*

The object included 65 provenances from the southern, central, northern, and eastern parts of the oak distribution range. Currently, they are represented by the Ukrainian (30), Russian (20), Belarusian (6), Moldovian (2), Latvian (2), Lithuanian (2), and Estonian (2) progenies. The control variants (5) include local populations. Most of the presented populations are of the north-eastern area of distribution of English oak (Figure 1).

The oak provenance tests were established according to the geographic principle by planting acorns in the corresponding blocks in the Vinnitsia area (Figure 2).

In the northern part, the provenances of the northern and northeastern populations are located, in the centre are the provenances of the central-eastern, central, and eastern populations, and in the south are the provenances of the southern population. Within each group of provenances there is a control one, which is represented by the local population (Figure 3).

Analysis of the population survival dynamics indicates an increase with age growth in the adaptive capacity of the provenances to environmental changes. If at the initial stage, up to 10 years, the local populations' survival was about 75%, then by 40 years of age, their number of trees decreased to 15%. At the same time, the number of trees of other provenances, which were characterised by higher survival of trees, increased. In particular, at the age up to 10 years, six populations were identified, whose indicators of survival (number of trees) were higher than the control. Then, the number of such populations increased to 19 at the age of 25, to 24 at the age of 30, to 28 at the age of 40, and to 32 at the age of 50. It should be noted that the adaptive capacity of the populations to environmental conditions has been increasing over recent decades.

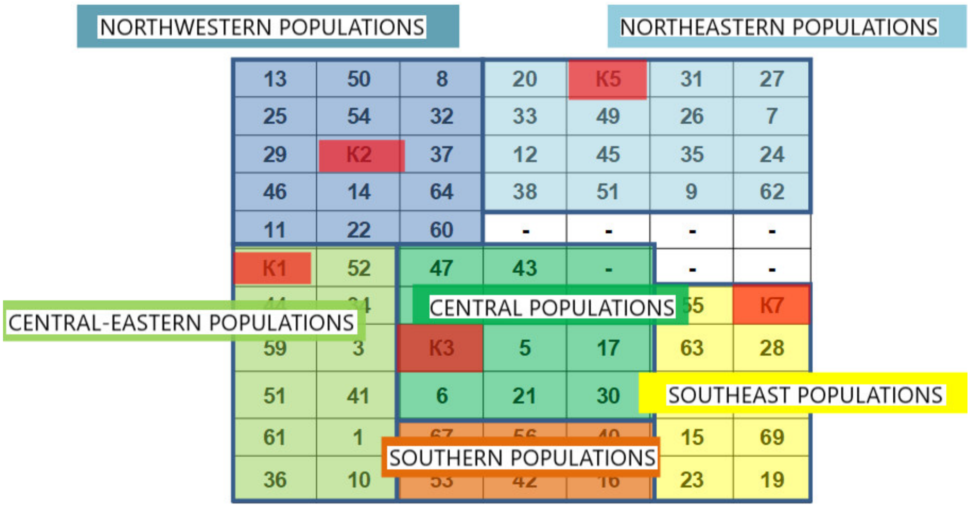

Fig. 2. *Location of oak populations in provenance tests*

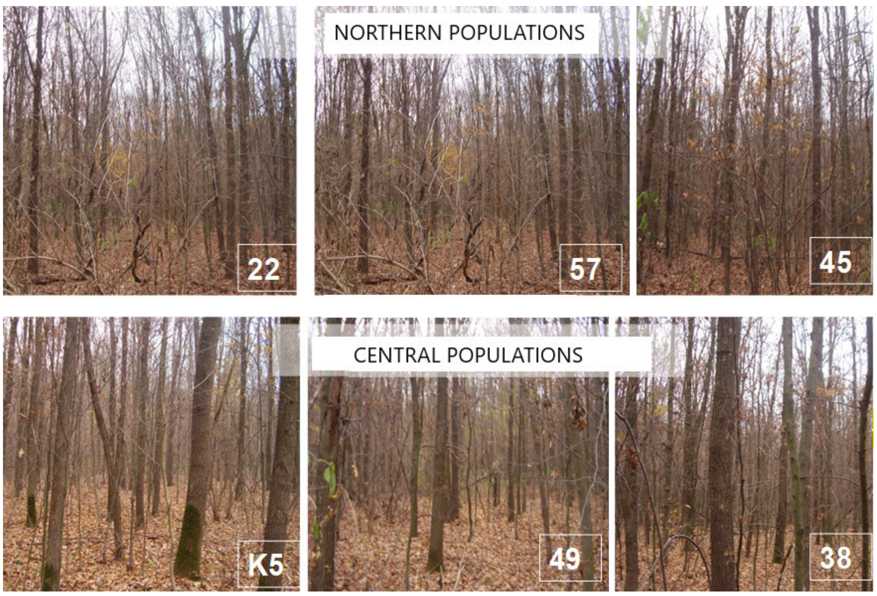

Fig. 3. *Northern and central oak populations in the provenance trial*

An important step in assessing the growth of the adaptive capacity is to determine which populations are most rapidly adapting to environmental change. According to the survival indicator (number of stands), it was found that at the age of up to 10 years, the best adaptive capacity was characteristic of the

Rivne (Ostrozke), Kirovohrad (Svitlovodske), Chuvash (Kanaske), and Ulyanovsk (Melekske) provenances. The predominance of the control over the provenances was retained up to 20 years for the Poltava population (Zinkivske), up to 30 years – for the Voronezh one (Vorontsovske).

The population of Rivne (Ostrozke) origin was characterised by stable trends in survival. At the age of 20, the populations of Khmelnytskyi (Starokonstantynivske), Brest (Gantsevychske), Belgorod (Valuiske) and Lithuanian (Panevezheske), Kirovohrad (Chornoliske), Zaporizhzhya (Melitopolske), Minsk (Vileyske), Saratov (Balashovske), Mogilyov (Osypovetske), Lithuanian (Shylutske), Minsk (Chervenske), and Bryansk (Berzhytske) origin exceeded the control in terms of survival index. Those populations were further characterised by high survival of trees.

At the age of 30-40, most of the populations of Ukrainian (Kharkiv, Kirovohrad, Lviv, Ivano-Frankivsk) origin were characterised by the survival indicator excess compared to the control variant. Up to 20 years, the worst trends in terms of survival were noted in populations of Moscow (Podolske), Estonian (Sadretatske), and Latvian (Ogrske) origins. The origins of Kirovohrad (Holovanivske), Volgograd (Kalachaevske), and Voronezh (Vorontsovske) had the worst survival indicators.

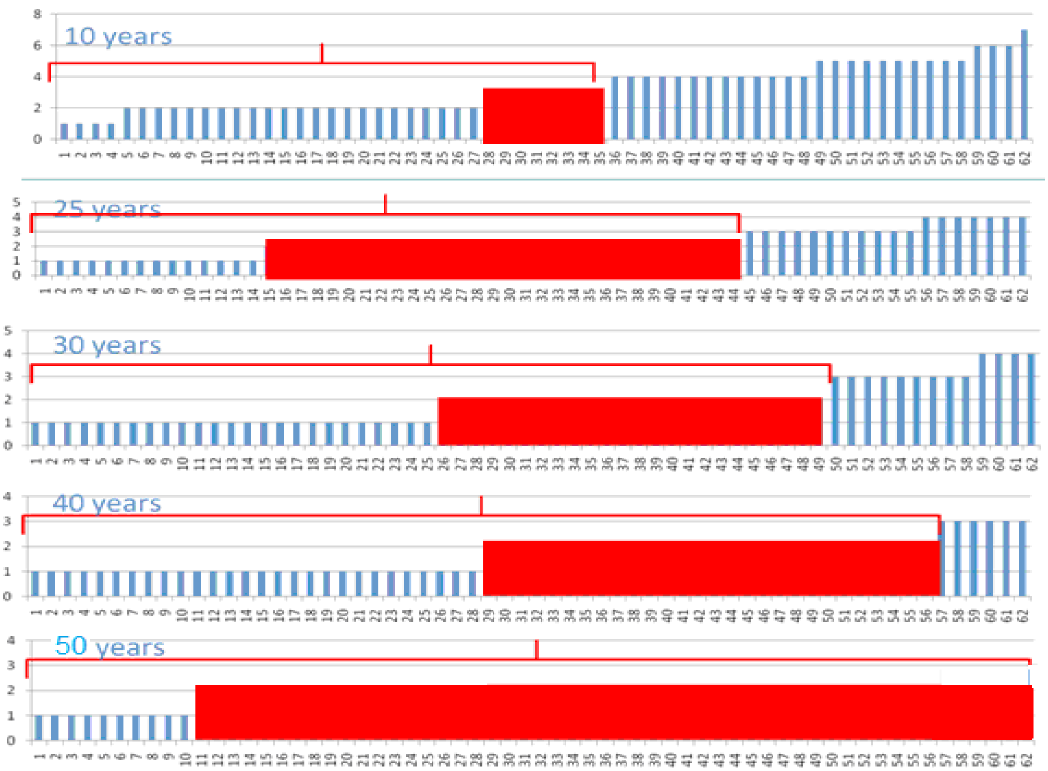

Fig. 4. *Change in the oak population's height ranks*

The height of the populations is one of the main indicators of stands productivity under changing environmental conditions. The grouping of heights by ranks was carried out on the basis of the 10% scale provenances classification (Figure 4).

If at the age of 10, eight height ranks are distinguished, then at the age of 50 – only two. The decrease in the number of ranks with age indicates the decrease in population height differentiation. The diagram also shows the rise in the number of provenances of the 1st and 2nd height ranks, as well as the growth in the number of provenances that are referred to in the same rank as local populations.

Analysis of the correlation dependence indicates a high degree of connection between the average height indicator and the remoteness of the populations from their location. With age, the closeness of the relationship between those indicators increases (at the age of 1 r=-0.459, at the age of 50 r=-0.765) (Table 1).

Table1

Correlation-regression dependences between the average height of the oak populations and their remoteness from the location in the provenance tests

Age of populations [years]	Correlation coefficient	Coefficient of determination	Closeness of connection
1	-0.459	0.227	moderate
4	-0.477	0.274	moderate
10	-0.579	0.335	significant
15	-0.585	0.343	significant
25	-0.604	0.365	significant
30	-0.631	0.398	significant
50	-0.765	0.585	high

Graphical analysis of the average height of the populations and the remoteness of their localisation indicates an increase with age in the dependence between those characteristics. This is confirmed by the increase in the values of the functions arguments and the linear functions coefficient of determination (Figure 5).

The indicators of average height and geographic longitude (r=-0.513) and latitude of the natural growth of the populations (r=-0.474) are characterised by a significant and moderately close relationship. Populations differ by average diameter and the remoteness from the natural location ratio (r=-0.431) and the geographic latitude of their growing place (r=-0.478) in a moderate correlation.

The characteristics of the English oak populations in Vinnytsia region according to the parameters of number of trees, *DBH*, average height, classes of Kraft, and tree breeding category are presented in Table 2.

The table shows a significant difference in the average values from the average control (C_4) according to the Student's criterion. At 50 years of age, most of the provenances do not demonstrate significant excess by diameter over the local climate type. Only one origin (Minsk, Vileyske) is significantly lower, the lag is about 16%. The slowest-growing in height are the remote northern and northeastern populations. Thirty-two provenances grow significantly worse than the control. Of them, nine lag behind by more than 10% (10-15%): Leningrad, Lomonosovske; Saratov, Balashovske; Estonian, Rakverske; Chuvash, Kanashske; Tatar, Zainske; Ulyanovsk, Novo-Cheremshanske; Bashkir, Tuymazinske; Bashkir, Iglinske; Dnipropetrovsk, Dnipropetrovske. There are no populations that simultaneously differ significantly by diameter and height from the local controls.

The growth of the populations was also compared with the growth of the local population of the corresponding block (Table 3).

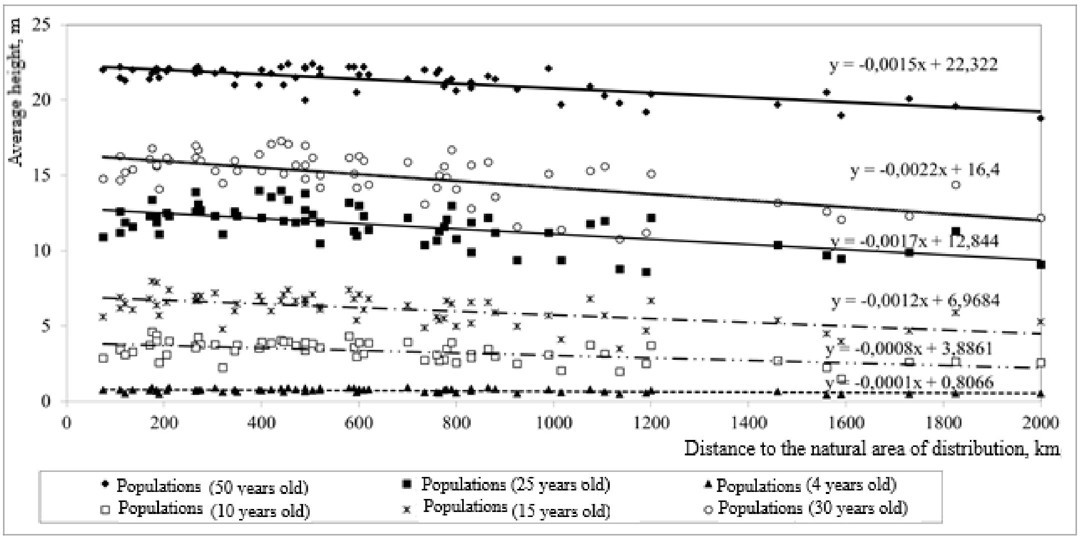

Fig. 5. *Graphical dependence of the population's height and distance to their natural areas of distribution*

Only one population grew better than the local one (Minsk Region, Chervenske Forestry). The excess over the control was 5.9% by height and 1.9% by diameter. There were many more provenances that significantly lagged behind the control in growth: 73% of the total number of populations came from the southeastern region, 71% – from the northwestern and 33% – from the southeastern one. Other offspring were significantly inferior to the local population in terms of productivity, in particular, diameter, and height. According to the results, all populations are ranked in (Table 4).

The highest-ranking classes (21-22 points), together with the local population, have the provenances from Bryansk (Bezhynske), Khmelnytsky (Starokostyantynivske), Zaporizhzhya (Melitopolske), and Cherkasy (Zvenigorodske). Populations from Leningrad (Lomonosovske), Chuvash (Kanashske), Bashkir (Iglinske, Tuimazinske), Estonian (Rakverske), Dnipropetrovsk (Dnipropetrovske), Ulyanovsk (Novo-Cheremshanske), Volgograd (Kalachaevske) are characterised by the lowest rank index (8-10 points).

Characteristics of English oak populations in Vinnytsia region Table 2

Population	Number of trees	DBH, D [cm]	Deviation D from Control, ±m [%]	Students criterionc t_D	Height, H) [m]	Devia-tion H from Control,±m [%]	Student's criterion, t_H	Kraft class	Tree breeding category (TBC)
13	29	22,8	-14,3	-1,340	19,2	**-14,3**	**-7,273**	2,3	2,9
25	39	22,0	-17,3	-1,580	19,7	**-12,1**	**-7,317**	2,4	2,7
29	24	23,9	-10,2	-0,748	19,8	**-11,6**	**-5,804**	2,1	2,7
46	43	24,2	-9,0	-1,124	21,4	**-4,5**	**-3,125**	2,0	2,6
11	35	22,1	-16,9	-1,465	20,9	**-6,7**	**-3,968**	2,4	3,0
C_1	35	25,4	-	-	21,7	-	-	1,8	2,4
44	37	22,6	-15,0	-1,510	21,2	**-5,4**	**-3,125**	2,2	2,7
59	37	25,7	-3,4	-0,266	21,5	**-4,0**	**-3,147**	2,0	2,6
51	27	24,7	-7,1	-0,622	21,0	**-6,2**	**-2,692**	2,3	2,9
61	33	25,1	-5,6	-0,485	21,8	-2,7	-1,719	2,2	2,8
36	31	26,9	1,1	0,104	21,9	-2,2	-1,370	2,0	2,7
50	19	28,9	8,6	0,464	20,8	-7,1	-1,418	1,9	2,3
54	29	25,4	-4,5	-0,391	21,8	-2,7	-1,770	2,1	2,7
C_2	31	27,5	-	-	22,6	-	-	1,9	2,5
14	27	24,5	-7,9	-0,915	22,0	-1,8	-1,176	2,2	2,6
22	42	22,4	**-15,8**	**-2,211**	22,2	-0,9	-0,643	2,4	2,8
52	28	25,9	-2,6	-0,207	22,4	0,0	0,000	2,1	2,5
34	27	24,8	-6,8	-0,496	22,4	0,0	0,000	2,3	2,7
3	42	23,9	-10,2	-1,563	21,8	**-2,7**	**-2,055**	2,4	2,6
41	21	25,1	-5,6	-0,527	21,5	**-4,0**	**-2,083**	2,3	2,9
1	38	25,3	-4,9	-0,524	22,2	-0,9	-0,654	2,2	2,7
10	29	26,9	1,1	0,135	22,1	-1,3	-0,935	2,0	2,8
8	20	26,2	-1,5	-0,102	20,7	**-7,6**	**-3,696**	2,0	2,7
32	23	24,6	-7,5	-0,566	20,6	**-8,0**	**-4,580**	1,9	2,3
37	34	25	-6,0	-0,765	22,0	-1,8	-1,356	2,1	2,7
64	37	25,2	-5,3	-0,497	22,2	-0,9	-0,667	2,0	2,4
60	29	24,1	-9,4	-0,979	22,1	-1,3	-0,860	2,2	2,3
47	25	25,7	-3,4	-0,565	22,0	-1,8	-1,379	2,0	2,4
4	28	24,6	-7,5	-0,911	21,5	**-4,0**	**-2,113**	2,2	2,4
C_3	29	25	-	-	21,8	-	-	2,2	2,6
6	31	25,4	-4,5	-0,469	22,1	-1,3	-0,943	2,2	2,4

67	21	24,7	-7,1	-0,637	21,3	**-4,9**	**-2,576**	2,1	2,6
53	26	27,6	3,8	0,283	21,9	-2,2	-1,401	1,9	2,6
20	27	23,4	-12,0	-0,744	19,7	**-12,1**	**-6,490**	2,3	2,6
33	30	25,4	-4,5	-0,276	20,5	**-8,5**	**-4,910**	2,1	2,5
12	32	23,3	-12,4	-0,990	22,1	-1,3	-0,845	2,3	2,6
38	23	27,8	4,5	0,261	22,0	-1,8	-1,084	1,7	2,5
C_4	**25**	**26,6**	**-**	**-**	**22,4**	**-**	-	**2,0**	**2,5**
43	30	26,4	-0,8	-0,057	22,2	-0,9	-0,551	2,2	2,5
65	30	26,7	0,4	0,022	22,0	-1,8	-1,028	2,3	2,7
5	24	25	-6,0	-0,542	22,0	-1,8	-1,000	2,2	2,4
21	35	25,5	-4,1	-0,389	22,1	-1,3	-0,962	2,1	2,5
56	26	24,6	-7,5	-0,562	21,4	**-4,5**	**-2,288**	2,2	2,5
42	30	24,5	-7,9	-0,848	21,9	-2,2	-0,992	2,2	2,4
C_5	35	26,6	-	-	22,1	-	-	2,1	2,5
49	22	24,4	-8,3	-0,489	20,1	**-10,3**	**-5,610**	2,0	2,5
45	23	24,7	-7,1	-0,410	20,5	**-8,5**	**-4,738**	2,0	2,3
57	11	24,2	-9,0	-0,587	19,0	**-15,2**	**-6,576**	1,9	2,4
58	22	23,6	-11,3	-0,715	21,6	**-3,6**	**-2,020**	2,2	2,4
17	32	26,8	0,8	0,048	22,1	-1,3	-0,870	2,2	2,5
30	19	26,8	0,8	0,039	22,2	-0,9	-0,491	2,1	2,4
40	28	26,7	0,4	0,021	22,2	-0,9	-0,542	2,3	2,6
16	41	24,9	-6,4	-0,518	21,8	**-2,7**	**-2,143**	2,4	2,7
31	23	22,4	-15,8	-1,068	19,6	**-12,5**	**-6,497**	2,2	2,5
26	28	25,8	-3,0	-0,171	20,9	**-6,7**	**-3,741**	2,1	2,7
35	20	24,4	-8,3	-0,461	20,3	**-9,4**	**-4,677**	2,2	3,0
9	36	25,7	-3,4	-0,243	21,4	**-4,5**	**-2,695**	2,2	2,6
55	30	25,5	-4,1	-0,291	21,7	-3,1	-2,077	2,2	2,6
63	28	25,7	-3,4	-0,189	21,7	-3,1	-2,065	2,3	2,6
68	20	27,0	1,5	0,074	21,0	**-6,2**	**-3,448**	1,8	2,2
15	23	26,8	0,8	0,041	21,7	-3,1	-1,928	2,4	2,6
23	34	26,4	-0,8	-0,050	21,8	-2,7	-1,899	2,2	2,8
27	26	23,3	-12,4	-0,805	18,8	**-16,1**	**-9,449**	2,3	2,9
7	19	26,5	-0,4	-0,021	20,4	-8,9	-4,545	2,0	2,9
24	27	27,6	3,8	0,203	21,7	-3,1	-1,737	1,9	2,7
62	20	26,2	-1,5	-	21,4	**-4,5**	**-2,358**	2,2	2,8
C_7	30	26,2	0,0	-	21,9	-	-	1,8	2,7
28	25	24,1	-9,4	-0,658	21,2	**-5,4**	**-3,191**	2,4	3,0
39	24	24,1	-9,4	-0,599	20,0	**-10,7**	**-6,107**	2,3	2,8
69	24	28,4	6,8	0,367	21,0	**-6,2**	**-3,774**	2,0	2,8
19	39	25,2	-5,3	-0,343	22,2	-0,9	-0,568	2,2	2,7
C_{avg}	31	26,2	-14,3	-	22,1	-	-	2,0	2,5

Table3

Distribution of provenances according to growth on provenance tests of English oak

Region of population's origin	Number of populations / number of trees	Number of populations that have significantly better indicators than the local population			Number of populations that have significantly worse indicators than the local population		
		Height [m]	DBH [cm]	H and H together	Height [m]	DBH [cm]	H and H together
Northeastern	15/367	0	0	0	13	11	11
Northwestern	14/430	0	1	0	10	14	10
Central	10/276	0	6	0	0	2	0
Central-western	11/350	1	3	1	0	4	0
Southeastern	9/247	0	3	0	4	5	3
Southern	6/172	0	2	0	0	1	0

Distribution of oak populations by ranking classes Table 4

Population	Origin, forestry	Ranking classes [points]				
		Number of trees, NT [points]	DBH [cm]	Height, H [m]	Tree breeding category (TBC)	Total (NT, DBH, TBC)
64	Bryansk, Bezhynske	7	4	7	4	22
1	Khmelnytskyi, Starokonst.	7	4	7	3	21
19	Zaporizhia, Melitopolske	7	4	7	3	21
21	Cherkassy, Zvenyho-rodske	6	4	7	4	21
C_5	Vinnytsia, Vinnytske	6	5	7	4	22
17	Sumy, Trostianetske	5	5	7	4	21
C_2	Vinnytsia, Vinnytske	5	6	7	4	22
C_{avg}	Vinnytsia, average	5	5	7	4	21
3	Brest, Hantsevytske	8	2	6	3	19
16	Kirovohradska, Holovaniv.	8	3	6	3	20
46	Latvian, Ogreske	8	3	5	3	19
59	Brest, Brestske	7	4	6	3	20
C_1	Vinnytsia, Vinnytske	6	4	6	4	20
37	Tula, Chekalinske	6	4	6	3	19
23	Kirovohradska, Chornol.	6	5	6	2	19
6	Chernivtsi, Chernivetske	5	4	7	4	20
36	Ivano-Frankivsk, Iv-Fran.	5	5	6	3	19
60	Mohyliv, Kostiukovych.	4	3	7	5	19
43	Sumy, Sumske	4	5	7	4	20
52	Minsk, Chervenske	4	4	7	4	19
40	Cherkasy, Kamenske	4	5	7	3	19
C_4	Vinnytsia, Vinnytske	3	5	7	4	19
22	Minsk, Vileyske	8	1	7	2	18
9	Belgorod, Valuyske	6	4	5	3	18
65	Sumy, Romenske	4	5	6	3	18
C_7	Vinnytsia, Vinnytske	4	5	6	3	18

10	Ivano-Frankivsk, Kolom.	4	5	7	2	18
24	Kharkiv, Chuguyevo-B.	3	6	6	3	18
53	Molodova, Orhiivske	3	6	6	3	18
38	Chernihiv, Nizhynske	2	6	6	4	18
44	Lithuanian, Shilutske	7	1	5	3	16
12	Tambov, Tambovske	5	2	7	3	17
61	Lviv, Zolochivske	5	4	6	2	17
4	Zhytomyr, Popelnianske	4	3	6	4	17
42	Odesa, Kotovske	4	3	6	4	17
33	Orel, Dmitrivske	4	4	4	4	16
54	Pskov, Novelske	4	4	6	3	17
55	Kharkiv, Vovchanske	4	4	6	3	17
63	Kharkiv, Bogoduhivske	4	4	6	3	17
C_3	Vinnytsia, Vinnytske	4	4	6	3	17
26	Saratov, Balashivske	4	4	5	3	16
47	Zhytomyr, Berdychivske	3	4	6	4	17
34	Mohyliv, Osypovychske	3	3	7	3	16
5	Kyiv, Bilotserkivske	2	4	6	4	16
15	Kirovohradska, Novo-Heorgiivske	2	5	6	3	16
69	Dnipropetrovska, Pyatikhat.	2	7	5	2	16
68	Poltava, Poltavske	1	6	5	5	17
50	Latvian, Varaklyanske	1	7	4	5	17
30	Poltava, Zinkivske	1	5	7	4	17
56	Odesa, Baltske	3	3	5	4	15
14	Smolensk, Velizhske	3	3	6	3	15
32	Kaluga, Kaluzhske	2	3	4	5	14
25	Estonian, Saderatske	7	1	2	3	13
11	Lithuanian, Panevezyske	6	1	5	1	13
51	Volyn, Volodymyr-Vol.	3	3	5	2	13
45	Ulyanovsk, Melekske	2	3	4	5	14
58	Voronezh, Vorontsovske	2	2	6	4	14
8	Moskow, Podolske	1	5	4	3	13
41	Rivne, Ostrozke	1	4	6	2	13
62	Luhansk, Luhanske	1	5	5	2	13
28	Luhansk, Ivanivske	3	3	5	1	12
49	Tatarstan, Zainske	2	3	3	4	12
67	Moldova, Sorokske	1	3	5	3	12
7	Volgograd, Sredne-Aktub.	1	5	4	2	12
13	Leningrad, Lomonosovske	4	1	2	2	9
20	Chuvash, Kanashskyi	3	2	2	3	10
27	Bashkir, Iglynske	3	2	1	2	8
31	Bashkir, Tuimazynske	2	1	2	4	9
29	Estonian, Rakverskyi	2	2	3	3	10
39	Dnipropetrovska, Dnipro	2	3	3	2	10
57	Ulyanovsk, Novocheremsh.	1	3	1	4	9
35	Volgograd, Kalachayevske	1	3	4	1	9

4. Conclusions

Geographically remote populations of pedunculated oak are distinguished by a high level of ecological plasticity relative to the change in environmental conditions. The analysis of the correlation dependence indicates a high degree of connection between the average height indicator and the remoteness of the populations from their location. With age, the dependence between those indicators increases (at the age of 1 year r=-0.459, at the age of 50 years r=-0.765). The indicators of average height of trees and geographic longitude (r=-0.513) and latitude of the populations' location are characterised by a significant and moderately close relationship (r=-0.474).The populations have a moderate correlation in the ratio of average diameter and remoteness from the localisation of the plantations (r=-0.431) and geographic latitude of their growing place (r=-0.478).

According to the comprehensive assessment of the non-local populations, which included tree survival, mean diameter and height, and tree breeding category, it was found that central populations have optimal values. The populations of Bryansk, Khmelnytskyi, Zaporizhzhya and Cherkassy origin, as well as the local ones, have the highest rank. These populations are the most resistant to environmental change. These populations will probably be less affected by global climate change within their natural area of distribution. The lowest indicators were mainly found for the northern populations. Those populations will be more affected by environmental changes (including global climate change) in the future.

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