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PEDUNCULATE OAK (*QUERCUS ROBUR* L.) GROWING IN CONDITIONS OF CLEAR, SHELTERWOOD AND GROUP CUTTINGS FOLLOWING HORNBEAM-OAK OLD-FOREST CLEANING CUTTINGS

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Abstract. The paper presents the structure analysis of breast height diameters, heights and of the biosocial structure of the 39-year old pedunculate oak introduced artificially and growing until 1991 in different conditions created by three different cuttings carried out in the hornbeam-oak old-forest growing on the fresh mixed broad-leaved forest site. Following the removal of the old-forest in winter 1986/87 (group clear cutting) and in winter 1991/92 (shelterwood cutting), in all three variants the oak is growing in open space. The inventory carried out in 2007 showed that in each case the best experimental results were recorded in the stand with clear cutting (1-Rz). Stands from the 2-Rcz and 3-Rg achieved worse, albeit statistically non-significantly different, results. However, formally, from the point of view of mean breast height diameter and height, a slightly better situation was recorded on the 3-Rg plot, while from the point of view of the mean biosocial class – on the 2-Rcz plot.

Key words: pedunculate oak, clear cutting, shelterwood cutting, group clear cutting, breast height diameter structure, height structure, biosocial structure, tree number, productivity

INTRODUCTION

The paper presents results of the stage investigations on the number, thickness, height and biological structure of the pedunculate oak on experimental plots of the Department of Forest Management of Poznań University of Life Sciences. The history of these investigations goes back to 1967 when, in a hornbeam-oak stand which was growing on a mixed fresh broad-leaved forest site, three types of fellings were performed (clear, shelterwood and group clear cutting) and three tree species (including pedunculate oak) were introduced artificially. The aim of the performed experiments was to determine stage changes of growth parameters of this tree species in order to assess which of the applied types of felling creates the best conditions for the growth of this

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species. So far, results of inventories carried out in years 1967, 1968, 1969, 1973, 1986, 1991 and 1996 have been published [Magnuski 1972, 1976, Magnuski and Małys 1988, 1994, Magnuski et al. 1999]. After twenty years of the experiment, the old-forest was removed from the plot with the clear cutting and group clear cutting and after twenty five years – from the surface with shelterwood cutting. In other words, in the case of the plot with the group clear cutting, oak has now been growing without any shelter of the old-forest for twenty years and, in the case of the shelterwood cutting plots – for fifteen years. In 1995, in the case of all experimental variants, thinnings were carried out for the first time removing from 29.2% (group clear cutting) to 52.9% (clear cutting) of trees [Magnuski et al. 1999].

METHODOLOGY

Field works were conducted in the autumn of 2007 during which on three 10-are plots randomly selected within each of the examined types of fellings, the following measurements were made: breast height diameters of all trees with 1 mm accuracy and biosocial position of each tree according to Kraft classification, the height of every fourth randomly selected tree rounded to 0.5 m.

Measurement results were collated according to degrees employing 1 cm ranges for tree thicknesses and 1 m ranges for tree height. Mean values were calculated for: breast height diameters, height and biosocial classes as well as their standard deviations and coefficients of variation. Comparisons of differences of means of the above-mentioned three traits were carried out with the assistance of the standard error of the difference of two means. The numbers of trees within the consecutive Kraft classes as well as in the layer of the main and secondary stands were determined for each of the experimental plots. On the basis of the breast height diameter cross sections, oak productivity in each of the experimental treatments was determined.

The following designations were employed for individual experimental plots: 1-Rz – the plot after clear cutting; 2-Rcz – the plot after shelterwood cutting and 3-Rg – the plot after group clear cutting.

RESULTS

Data concerning tree losses in individual experimental treatments during the period of 11 years are presented in Table 1. It is evident from this table that in the case of two experimental variants (1-Rz and 3-Rg), respectively: 17 (11.3%) and 28 (17.6%) trees were lost. On the other hand, in the case of plot 2-Rcz, no change in the number of trees was recorded in the discussed period.

Table 2 collates major oak characteristics associated with its examined structures. It is apparent from the presented data that the highest mean breast height diameter and height were determined in the 1-Rz treatment (16.20 cm and 16.94 m, respectively), while the lowest ones (12.80 cm and 12.44 m, respectively) – in variant 2-Rcz. The calculated values of the coefficient of variation show that the variability of these traits was the lowest in treatment 1-Rz and the highest in variant 3-Rg. In the case of the tree

Table 1. Number of trees and their losses during the period of 11 years in individual experimental treatments
Tabela 1. Liczba drzew i ich ubytek w okresie 11 lat w poszczególnych wariantach doświadczenia

Item Wyszczególnienie	Experimental variant Wariant doświadczenia		
	1-Rz	2-Rcz	3-Rg
Number of trees in 1996, pieces Liczba drzew w 1996 roku, sztuki	177	151	216
Number of trees in 2007, pieces Liczba drzew w 2007 roku, sztuki	157	151	178
Number of dead trees during the period of 11 years, pieces Liczba drzew wydzielonych w okresie 11 lat, sztuki	17	0	38
Index of tree loss, % Wskaźnik ubytku drzew, %	11.3	0.0	17.6

Table 2. Stand taxation traits in individual experimental treatments
Tabela 2. Cechy taksacyjne drzewostanów w poszczególnych wariantach doświadczenia

Item Wyszczególnienie	Experimental variant Wariant doświadczenia		
	1-Rz	2-Rcz	3-Rg
2007 year Rok 2007			
Mean breast height diameter, cm Przeciętna pierśnica, cm	16.20	12.80	13.87
Standard deviation, cm Odchylenie standardowe, cm	3.97	4.24	5.51
Coefficient of variation, % Współczynnik zmienności, %	24.51	33.13	39.76
Mean height, m Przeciętna wysokość, m	16.94	12.44	12.78
Standard deviation, m Odchylenie standardowe, m	2.57	2.31	2.34
Coefficient of variation, % Współczynnik zmienności, %	15.17	18.61	26.13
Mean Kraft class Przeciętna klasa Krafta	2.68	2.90	3.01
Standard deviation Odchylenie standardowe	1.35	1.38	1.40
Coefficient of variation, % Współczynnik zmienności, %	50.32	47.39	46.72

biosocial position, the best mean Kraft class was determined in the trees from variant 1-Rz (2.68), while the worst – in treatment 3-Rg (3.01). The variability of this trait was the highest in treatment 1-Rz (coefficient of variation – 50.32%) and the lowest – in variant 3-Rg (coefficient of variation – 46.72%).

Table 3 presents the structure of the oak breast height diameter in individual experimental treatments. It is evident from this table that in the case of 1-Rz and 3-Rg variants the degree intervals of the breast height diameter were identical – from 5 to 27 cm, although in the 1-Rz variant no trees in the degree equalling 7 cm were found. In the case of the 1-Rz treatment, it is the distribution with the majority of trees in average degrees (from 11 to 21 cm – their total proportion amounts to 75.8%) which indicates the distribution close to normal, whereas in the 1-Rg variant – 79.7% of trees were assigned to the breast height diameter degree from 7 to 19 cm, which indicates a left-sided asymmetry, i.e. a positively oblique distribution. On the other hand, the breast height diameter structure in the 1-Rcz variant is characterised by the smallest range of the distribution (from 5 to 25 cm) with the highest number of trees found in the interval from 5 to 15 cm. Their total proportion amounted to 78.1%, which indicates a left-sided asymmetry, i.e. a positively oblique distribution.

Table 3. Number of trees in breast height diameter degrees
Tabela 3. Liczba drzew w stopniach grubości pierśnicowej

Breast height diameter degree Stopień grubości pierśnicowej cm	Experimental variant Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pieces sztuki	%	pieces sztuki	%	pieces sztuki	%
5	1	0.6	3	2.0	10	5.6
7			16	10.6	16	9.0
9	7	4.5	24	15.9	30	16.8
11	17	10.8	28	18.5	18	10.1
13	25	15.9	30	19.9	27	15.2
15	27	17.2	20	13.2	16	9.0
17	30	19.1	10	6.6	17	9.5
19	19	12.1	8	5.3	18	10.1
21	18	11.5	7	4.6	8	4.5
23	8	5.1	3	2.0	6	3.4
25	4	2.6	2	1.4	9	5.1
27	1	0.6			3	1.7
Total Razem	157	100.0	156	100.0	178	100.0

The comparison of differences of mean breast height diameters using the standard error of the difference of two means (P = 0.95) indicates that between treatments:

1-Rz and 2-Rcz = $|16.20-12.80| = 3.40 > 0.92$ – the difference is **significant**,

1-Rz and 3-Rg = $|16.20-13.87| = 2.33 > 1.40$ – the difference is **significant**,

2-Rcz and 3-Rg = $|12.80-13.87| = 1.07 < 1.76$ – the difference is **non-significant**.

Therefore, it is evident that, in the case of the mean breast height diameter, there is no statistically significant difference between the experimental variant with the shelterwood cutting (1-Rcz) and group clear cutting (3-Rg). On the other hand, such comparison between the clear cutting (1-Rz) and the remaining two types of fellings (2-Rcz and 3-Rg) demonstrated a statistical significance of differences of mean breast height diameters.

Table 4 presents the oak height structure in individual experimental treatments. It is evident from the presented data that the highest range of height was observed in the stand from plot 1-Rz – from 7 to 22 m, while the smallest range – in variant 2-Rcz – from 7 to 17 m. No dominant degrees of height can be distinguished in the 3-Rg variant. On the other hand, in the case of the 1-Rz treatment, majority of trees occur in the intervals from 15 to 19 m (total proportion – 74.2%), while in the 2-Rcz variant – in the intervals from 9 to 15 m (total proportion – 79.5%). Therefore, it is evident that the

Table 4. Number of trees in height degrees
Tabela 4. Liczba drzew w stopniach wysokości

Height degree Stopień wysokości m	Experimental variant Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pieces sztuki	%	pieces sztuki	%	pieces sztuki	%
4-5					1	2.3
5-6						
6-7					2	4.5
7-8	1	2.6	2	5.1	2	4.5
8-9			1	2.6	3	6.8
9-10			5	12.8	1	2.3
10-11			3	7.7	5	11.4
11-12	1	2.6	5	12.8	2	4.5
12-13	1	2.6	7	18.0	4	9.1
13-14	2	5.1	6	15.4	8	18.2
14-15	1	2.6	5	12.8	3	6.8
15-16	4	10.2	2	5.1	6	13.7
16-17	6	15.3	3	7.7	4	9.1
17-18	11	28.2			3	6.8
18-19	8	20.5				
19-20	2	5.1				
20-21	1	2.6				
21-22	1	2.6				
Total Razem	39	100.0	39	100.0	44	100.0

2-Rcz variant is the closest to the normal distribution, while the 1-Rz variant indicates a right-sided asymmetry, i.e. a negatively oblique distribution.

The comparison of differences of mean breast height diameters using the standard error of the difference of two means (P = 0.95) indicates that between treatments:

1-Rz and 2-Rcz = |16.94-12.44| = 4.50 > 1.10 – the difference is **significant**,

1-Rz and 3-Rg = |16.94-12.78| = 4.16 > 1.30 – the difference is **significant**,

2-Rcz and 3-Rg = |12.44-12.78| = 0.34 < 1.26 – the difference is **non-significant**.

Hence, it is clear that in the case of the mean height there was no statistically significant difference between the experimental treatment with the shelterwood cutting (2--Rcz) and group cutting (3-Rg). On the other hand, this type of comparison between clear cutting (1-Rz) and the remaining two types of cutting (2-Rcz and 3-Rg) revealed a statistical significance of differences of mean heights.

The proportion of different oak biosocial classes in individual experimental treatments is presented in Table 5. It is clear from this Table that the stand in the treatment with group clear cutting (1-Rg) exhibited the least advantageous biological structure – only 65.1% of trees were assigned to the main stand, while 34.9% were classified as dying or dead trees. On the other hand, the treatment with the clear cutting (1-Rz) was characterised by the most advantageous biosocial structure as 73.9% of trees were assigned to the main stand and 26.1% to the secondary stand. In the case of all the three variant of the experiment, most oak trees were assigned to dominant trees (2nd Kraft class) – from 39.7% (2-Rcz) to 43.3% (1-Rz) of trees.

The comparison of differences of mean Kraft classes using the standard error of the difference of two means (P = 0.95) indicates that between treatments:

Table 5. Number of trees in biological classes
Tabela 5. Liczba drzew w klasach biologicznych

Biological class Klasa biologiczna	Experimental variant Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pieces sztuki	%	pieces sztuki	%	pieces sztuki	%
1	26	16.6	19	12.7	17	9.5
2	68	43.3	60	39.7	75	42.1
3	22	14.0	26	17.2	24	13.5
Total 1-3 Razem 1-3	116	73.9	105	69.6	116	65.1
4	12	7.6	13	8.6	14	7.9
5	29	18.5	33	21.8	48	27.0
Total 4-5 Razem 4-5	41	26.1	46	30.4	62	34.9
Total 1-5 Razem 1-5	157	100.0	151	100.0	178	100.0

1-Rz and 2-Rcz= ׀2.6815-2.9038׀ = 0.2223 > 0.2204 – the difference is **significant**,
1-Rz and 3-Rg = ׀2.68-3.01׀ = 0.33 > 0.30 – the difference is **significant**,
2-Rcz and 3-Rg = ׀2.90-3.01׀ = 0.11 > 0.30 – the difference is **non-significant**.

Therefore, it is clear that in the case of the mean Kraft class, there was no statistically significant difference between the experimental treatment with the shelterwood cutting (2-Rcz) and group cutting (3-Rg). On the other hand, this type of comparison between clear cutting (1-Rz) and the remaining two types of cutting (2-Rcz and 3-Rg) revealed a statistical significance of differences of mean biosocial classes.

RECAPITULATION

Following removal cutting during the discussed period, the young oak generation, in all experimental treatments, grew in the shelterwood cutting (2-Rcz) and group cutting (3-Rg) without any shelter. The structure analysis of the selected traits – breast height diameters, heights and Kraft classes – revealed that, in each case, the best experimental results were obtained, as in year 1995 [Magnuski et al. 1999], by the stand on surface 1--Rz. The stands from the 2-Rcz and 3-Rg surfaces showed worse but, simultaneously, statistically non-significantly different from each other, results. However, formally, from the point of view of mean breast height diameter and height, a slightly better situation occurred on the 3-Rs plot and of the mean biosocial position – on the 2-Rcz plot. In comparison with 1996, it can be said that at the present time, growth and development of oak in both variants (2-Rcz and 3-Rg) are at a similar level.

REFERENCES

Magnuski K., 1972. Wpływ rodzaju rębni na wzrost dębu szypułkowego (*Quercus robur* L.) w pierwszych latach po założeniu upraw [The influence of the cutting on oak (*Quercus robur* L.) growth during the first years of plantation]. Rocz. WSR Pozn. 57, 81-103 [in Polish].

Magnuski K., 1976. Wzrost młodego pokolenia dębu szypułkowego (*Quercus robur* L.) w warunkach rębni zupełnej, częściowej i gniazdowej [Growth of the young generation of the English oak (*Quercus robur* L.) under conditions of clearcut, partial cutting and gaps]. Sylwan 7, 49-56 [in Polish].

Magnuski K., Małys L., 1988. Dalsze wyniki badań nad wpływem rodzaju rębni na wzrost młodników dębowych (*Quercus robur* L.) [Further results of studies on the influence of cutting form on the growth of oak thickets (*Quercus robur* L.)]. Sylwan 11-12, 21-27 [in Polish].

Magnuski K., Małys L., 1994. Struktura młodego pokolenia dębu szypułkowego (*Quercus robur* L.) wyrastającego w warunkach rębni zupełnej, częściowej i zupełnej gniazdowej [Structure of a Pedunculate oak stands (*Quercus robur* L.) grown after using clear cutting, strip and group cutting and shelter-wood cutting]. Pr. Kom. Nauk Roln. Kom. Nauk Leśn. PTPN 78, 105-112 [in Polish].

Magnuski K., Małys L., Gałecki I., 1999. Charakterystyka niektórych cech wzrostu dębu szypułkowego (*Quercus robur* L.) rosnącego w kępach po rębni zupełnej, częściowej i zupełnej gniazdowej [Characterisation of some growth traits of common oak (*Quercus robur* L.) clustered on clear-cutting, shelter-wood felling and clear strip and group cutting]. Rocz. AR Pozn. 311, Leśn. 37, 117-125 [in Polish].

DĄB SZYPUŁKOWY (*QUERCUS ROBUR* L.) ROSNĄCY W WARUNKACH RĘBNI ZUPEŁNEJ, CZĘŚCIOWEJ I GNIAZDOWEJ PO CIĘCIACH UPRZĄTAJĄCYCH STARODRZEW GRABOWO-DĘBOWY

Streszczenie. Praca przedstawia analizę struktury pierśnic, wysokości i biosocjalnej 39--letniego dębu szypułkowego, wprowadzonego sztucznie i wzrastającego do 1991 roku w odmiennych warunkach stworzonych przez trzy różne rębnie wykonane w starodrzewiu grabowo-dębowym, rosnącym na siedlisku lasu mieszanego świeżego. Po usunięciu starodrzewu zimą 1986/87 roku (rębnia gniazdowa zupełna) i zimą 1991/92 roku (rębnia częściowa) dąb wzrasta we wszystkich trzech wariantach na otwartej przestrzeni. Inwentaryzacja z 2007 roku wykazała, że w każdym wypadku najlepsze wyniki doświadczenia uzyskał drzewostan na powierzchni z rębnią zupełną (1-Rz). Drzewostany z powierzchni 2-Rcz oraz 3-Rg mają wyniki gorsze, a jednocześnie statystycznie nieistotnie różne między sobą – formalnie jednak z punktu widzenia przeciętnej pierśnicy i wysokości nieco lepsza sytuacja jest na powierzchni 3-Rg, a średniej klasy biosocjalnej na powierzchni 2-Rcz.

Słowa kluczowe: dąb szypułkowy, rębnia zupełna, rębnia częściowa, rębnia gniazdowa zupełna, struktura pierśnic, struktura wysokości, struktura biosocjalna, liczba drzew, produkcyjność

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