ACTA SCIENTIARUM POLONORUM
Acta Sci. Pol.
Silv. Colendar. Rat. Ind. Lignar. 7(3) 2008, 15-22

EUROPEAN SILVER FIR (*ABIES ALBA* MILL.) GROWING IN CONDITIONS OF CLEAR CUTTING AS WELL AS SHELTER WOOD AND GROUP CUTTING AFTER CLEANING CUTTING OF HORNBEAM-OAK OLD FOREST

Roman Jaszczak, Konrad Magnuski, Lechosław Małys
Poznań University of Life Sciences

Abstract. The paper presents the analysis of the breast height diameter, height and biosocial structure of 39-year old European silver fir introduced artificially and growing, until winter 1991/92, in different conditions created by three different fellings carried out in hornbeam-oak old forest growing on a fresh mixed forest site type. Following the removal of the old forest in winter 1986/87 on the plot with the group clear cutting and in winter 1991/92 on the plot with the shelter wood cutting, the fir is growing in all three variants in open area. The inventory carried out in 2005 revealed that, in each case, the best experimental results were obtained by the stand on the surface with the group clear cutting (3-Rg). The stands from surfaces with the clear cutting (1-Rz) and shelter wood cutting (2-Rcz) show worse results which also differ from each other. From the point of view of mean breast height diameter and height, a better situation was observed on the 1-Rz, while from the point of view of the number of trees, mean Kraft class and productivity – on surface 2-Rcz.

Key words: European silver fir, clear cutting, shelter wood cutting, group clear cutting, breast height diameter structure, height structure, biosocial structure, number of trees, productivity

INTRODUCTION

In winter 1966, three experimental surfaces were established simultaneously in a hornbeam-oak stand (six oak – 110 years old, four hornbeam – 81 years old) employing three different types of cuttings (clear, shelterbelt and group cuttings) and artificial introduction of different tree species. One of them was European silver fir (*Abies alba* Mill.). The described experiment was one of many conducted from early 1950s within

Corresponding author – Adres do korespondencji: Dr hab. Roman Jaszczak, Department of Forest Management of Poznań University of Life Sciences, Wojska Polskiego 71 C, 60-625 Poznań, Poland, e-mail: romanj@up.poznan.pl

the framework of scientific research of the Department of Forest Management initiated by Professor Magnuski dealing with stand reconstruction in the Laski Experimental Forest District (at present – Siemianice) [Jaszczak and Magnuski 2005, Jaszczak et al. 2008]. In the discussed case, the aim of the investigations was to obtain information about which of the applied methods of cutting created the most favourable conditions for the growth and development of fir introduced artificially in specific site and stand conditions on the basis of consecutive periodical inventories so far carried out in years: 1967, 1973, 1991 and 2005. The first three inventories had already been the subject of separate publications [Magnuski 1975, Magnuski et al. 1993] which also described the way of establishment of the experiment. The presented paper discusses the results of measurements and observations of the last inventory.

METHODOLOGY

The field works were carried out in the autumn of 2005. On randomly selected 10 are plots from each experimental cutting, breast height diameters of all trees were measured with 1 mm accuracy and for each of them its biosocial position was determined in accordance with Kraft's classification. In addition, for every fourth tree selected randomly, its height with 0.5 m accuracy was measured.

The results of measurements were collated in degrees employing 1 cm range for the thickness and 1 m – for the height. Mean values of the breast height diameter, height and biosocial class as well as standard deviations and variability coefficients were calculated. Differences of means of the above-mentioned three traits were compared with the assistance of the standard error of the difference of two means. The number of trees within consecutive Kraft classes as well as in the layer of the main and secondary stands was determined for each of the experimental surfaces. Fir productivity was determined for each experimental treatment on the basis of cross sections of breast height diameter.

Individual experimental surfaces were designated as follows: 1-Rz – area after clear cutting, 2-Rcz – area after shelter wood cutting and 3-Rg – area after group clear cutting.

RESULTS

Table 1 presents data concerning tree wastage in individual experimental treatments during the period of 14 years. It is evident from this Table that the greatest number of trees (619) disappeared from surface 2-Rcz and the smallest (513) – from surface 1-Rz. Nevertheless, percentagewise, the highest tree loss occurred in surface 1-Rz (62.3%), while the smallest (54.2%) – in variant 1-Rcz which indicates clearly in which treatment fir had the least favourable conditions for life.

The basic characteristics of the fir associated with the examined structures can be found in Table 2. It shows that the fir in variant 1-Rg was characterised by the highest mean breast height diameter and height (11.5 cm and 12.55 m, respectively), while in treatment 1-Rcz – these parameters were the lowest (8.9 cm and 9.35 m). Calculated values of the standard deviation and variability coefficient show that the variability

Table 1. Number of trees and their loss during the period of 14 years in individual experimental treatments
Tabela 1. Liczba drzew i ich ubytek w okresie 14 lat w poszczególnych wariantach doświadczenia

Item Wyszczególnienie	Experimental variant Wariant doświadczenia		
	1-Rz	2-Rcz	3-Rg
Number of trees in 1991, pcs. Liczba drzew w 1991 roku, sztuki	823	1 142	996
Number of trees in 2005, pcs. Liczba drzew w 2005 roku, sztuki	310	523	396
Number of trees that dropped out during the period of 14 years, pcs. Liczba drzew wydzielonych w okresie 14 lat, sztuki	513	619	600
Index of tree loss, % Wskaźnik ubytku drzew, %	62.3	54.2	60.2

Table 2. Taxation characteristics of stands in individual experimental treatments in 2005
Tabela 2. Cechy taksacyjne drzewostanów w poszczególnych wariantach doświadczenia w 2005 roku

Item Wyszczególnienie	Experimental variant – Wariant doświadczenia		
	1-Rz	2-Rcz	3-Rg
Mean breast height diameter, cm Przeciętna pierśnica, cm	9.4	8.9	11.5
Standard deviation, cm Odchylenie standardowe, cm	5.33	3.16	4.62
Variability coefficient, % Współczynnik zmienności,%	56.9	35.4	40.0
Mean height, m Przeciętna wysokość, m	10.23	9.35	12.55
Standard deviation, m Odchylenie standardowe, m	5.28	2.56	3.74
Variability coefficient, % Współczynnik zmienności, %	51.6	27.4	29.8
Mean Kraft class Przeciętna klasa Krafta	3.73	2.98	2.78
Standard deviation Odchylenie standardowe	1.39	1.26	1.35
Variability coefficient, % Współczynnik zmienności, %	37.3	42.3	48.6

of these traits was smallest in variant 2-Rcz and the highest – in variant 1-Rz. In the case of the tree biosocial position, the best mean Kraft class was exhibited by trees in variant 3-Rg (2.78) and the worst – in variant 1-Rz (3.73). The variability of this trait was the lowest in variant 1-Rz (variability coefficient – 37.3%) and the highest – in variant 3-Rg (variability coefficient – 48.6%).

Table 3 presents fir thickness structure in individual experimental variants. It is evident from this Table that in the case of variants: 1-Rz and 1-Rg, thickness degree intervals were identical – from 1 to 27 cm but in the case of variant 1-Rz, it is the distribution with the majority of trees in the thinnest degrees (from 3 to 13 cm – their total proportion is 80.8%) which indicates left-sided asymmetry, i.e. positively skewed, whereas in the 1-Rg variant, the tree thickness distribution approaches normal one because trees in central degrees of thickness are dominant here (from 7 to 17 cm – their total proportion is 83.4%). On the other hand, in variant 1-Rcz, the stand thickness structure is characterized by the smallest interval span (from 1 to 21 cm) with the greatest number of trees being in the interval from 5 to 13 cm (their total proportion is 89.2%) which makes also this distribution similar to normal.

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

Thickness degree Stopień grubości cm	Experimental variant – Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pcs. – sztuki	%	pcs. – sztuki	%	pcs. – sztuki	%
1	3	1.0	1	0.2	1	0.2
3	37	11.9	17	3.3	11	2.8
5	58	18.7	77	14.7	21	5.3
7	51	16.4	124	23.7	63	15.9
9	51	16.4	126	24.1	74	18.7
11	28	9.0	88	16.8	59	14.9
13	26	8.4	52	9.9	55	13.9
15	19	6.1	27	5.2	43	10.9
17	14	4.5	7	1.3	36	9.1
19	8	2.6	2	0.4	15	3.8
21	7	2.3	2	0.4	11	2.8
23	2	0.7			2	0.5
25	3	1.0			2	0.5
27	3	1.0			3	0.7
Total Razem	310	100.0	523	100.0	396	100.0

The comparison of differences of mean breast height diameters with the assistance of the standard error of the difference of two means (P = 0.95) reveals that in the case of variants:

1-Rz and 2-Rcz = |9.36-8.91| = 0.45 < 0.66 – the difference is **non-significant**,
1-Rz and 3-Rg = |9.36-11.54| = 2.18 > 0.76 – the difference is **significant**,
2-Rcz and 3-Rg = |8.91-11.54| = 2.63 > 0.54 – the difference is **significant**.

Consequently, it follows that in the case of the mean breast height diameter, there is no statistically significant differences between the experimental variant with clear cutting (1-Rz) and shelter wood cutting (2-Rcz). On the other hand, such comparison between group clear cutting (3-Rg) and the remaining two kinds of cutting (1-Rz and 2-Rcz) showed statistical significance of differences of mean breast height diameters.

Fir height structure in individual experimental treatments is presented in Table 4. It is evident from it that the stand from the experimental surface 1-Rz is characterized

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

Height degree Stopień wysokości m	Experimental variant – Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pcs. – sztuki	%	pcs. – sztuki	%	pcs. – sztuki	%
do 1	2	2.5				
1-2	6	7.8				
2-3	6	7.8	1	0.8	4	4.0
3-4	4	5.2	1	0.8	1	1.0
4-5	3	3.9	8	6.2		
5-6	3	3.9	5	3.8	2	2.0
6-7	5	6.5	10	7.7	2	2.0
7-8	6	7.8	13	10.0	2	2.0
8-9	2	2.6	21	16.2	7	7.1
9-10	5	6.5	21	16.2	5	5.0
10-11	4	5.2	20	15.4	4	4.0
11-12	6	7.8	8	6.1	6	6.1
12-13	6	7.8	12	9.2	17	17.2
13-14	1	1.3	7	5.3	16	16.2
14-15	5	6.5	3	2.3	9	9.1
15-16	5	6.5			6	6.1
16-17	3	3.9			9	9.1
17-18	3	3.9			8	8.1
18-19	1	1.3			1	1.0
19-20	1	1.3				
Total Razem	77	100.0	130	100.0	99	100.0

by the highest height range – from 1 to 20 m, while that from variant 2-Rcz is characterized by the smallest range – from 2 to 15 m. No dominant degrees of height could be distinguished in variant 1-Rz. On the other hand, in the case of variant 2-Rcz, the highest amount of trees occurs in the interval from 6 to 13 m (total proportion – 80.8%), while in the case of variant 3-Rg – in the interval from 11 to 18 m (total proportion – 71.9%). Therefore, it can be said that variant 2-Rcz is closest to the normal distribution, while variant 3-Rg shows right-handed asymmetry, i.e. negatively skewed distribution.

The comparison of differences of mean heights with the assistance of the standard error of the difference of two means (P = 0.95) reveals that in the case of variants:

1-Rz and 2-Rcz = |10.23-9.35| = 0.88 < 1.28 – the difference is **non-significant**,
1-Rz and 3-Rg = |10.23-12.55| = 2.32 > 1.42 – the difference is **significant**,
2-Rcz and 3-Rg = |9.35-12.55| = 3.20 > 0.88 – the difference is **significant**.

Consequently, it follows that in the case of the mean height, there is no statistically significant differences between the experimental variant with clear cutting (1-Rz) and shelter wood cutting (2-Rcz). On the other hand, such comparison between group clear cutting (3-Rg) and the remaining two kinds of cutting (1-Rz and 2-Rcz) revealed statistical significance of differences of mean heights.

The proportion of different biosocial classes in individual experimental variants is shown in Table 5. It is evident from it that the stand from the variant with the clear cutting (1-Rz) shows the least favourable biological structure – only 40.6% of trees were allocated to the main stand, while 46.8% were classified as dying or dead trees. On the other hand, the discussed structure in the remaining two experimental treatments is similar, although it is slightly better in variant 1-Rg in which the proportion of the main stand (69.7%) is by 3.0% higher than in variant 2-Rcz (66.7%).

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

Biological class Klasa biologiczna	Experimental variant variant – Wariant doświadczenia					
	1-Rz		2-Rcz		3-Rg	
	pcs. – sztuki	%	pcs. – sztuki	%	pcs. – sztuki	%
1	21	6.8	50	9.6	71	17.9
2	60	19.3	177	33.8	134	33.9
3	45	14.5	122	23.3	71	17.9
Total 1-3 Razem 1-3	126	40.6	349	66.7	276	69.7
4	39	12.6	82	15.7	52	13.1
5	145	46.8	92	17.6	68	17.2
Total 4-5 Razem 4-5	184	59.4	174	33.3	120	30.3
Total Razem	310	100.0	523	100.0	396	100.0

Table 6. Fir productivity in individual experimental treatments
Tabela 6. Produkcyjność jodły w poszczególnych wariantach doświadczenia

Item Wyszczególnienie	Experimental variant – Wariant doświadczenia		
	1-Rz	2-Rcz	3-Rg
Productivity in 1991, m^2 Produkcyjność w 1991 roku, m^2	15.54	10.88	21.83
Productivity in 2005, m^2 Produkcyjność w 2005 roku, m^2	28.19	36.70	47.99
Change in productivity in years 1991-2005, m^2 Zmiana produkcyjności w latach 1991-2005, m^2	+12.65	+25.88	+26.16
Productivity increment index, % Wskaźnik wzrostu produkcyjności, %	81.4	237.3	119.8

The comparison of differences of mean Kraft classes with the assistance of the standard error of the difference of two means (P = 0.95) reveals that in the case of variants:

1-Rz and 2-Rcz = |3.73-2.98| = 0.75 > 0.20 – the difference is **significant**,
1-Rz and 3-Rg = |3.73-2.78| = 0.95 > 0.20 – the difference is **significant**,
2-Rcz and 3-Rg = |2.98-2.78| = 0.20 > 0.18 – the difference is **significant**.

Consequently it follows that in all cases the significance of differences between mean Kraft classes was confirmed statistically.

Data concerning fir productivity in individual experimental treatments are shown in Table 6. It is clear from it that the variant with the group clear cutting (1-Rg) is characterized with the highest productivity (47.99 m^2), while the variant with the clear cutting (1-Rg) – with the lowest productivity (28.19 m^2). The productivity of the stand from the 3-Rg surface is by over 25% higher in comparison with surface 2-Rcz and by over 41% higher in comparison with the stand from surface 1-Rz. However, during the period of 14 years, the greatest change of productivity took place in the case of variant 2-Rcz – the breast height diameter cross section changed by 237.3%, while the smallest – in variant 1-Rz – by 81.4%.

RECAPITULATION

During the discussed period of time, in all experimental treatments, the young fir generation was growing after cleaning cuttings in the shelter wood cutting (2-Rcz) and group clear cutting (3-Rg) without any shelter whatsoever. The structure analysis of selected traits (breast height diameters, heights and Kraft classes) revealed that in each case, the best experimental results were obtained, similarly as in the year 1991, by the stand on the 3-Rg surface. Stands from 1-Rz and 2-Rz surfaces obtained worse and simultaneously differing results. From the point of view of mean breast height diameter and height, it can be said that the situation is better on surface 1-Rz, while from the point of view of the number of trees, mean Kraft class and productivity – on surface 2-Rcz. The observed facts are in keeping with the results of the previous inventory from 1991 [Magnuski et al. 1993]. However, the demonstrated lack of statistically significant differences of the breast height diameter and height for 1-Rz and 2-Rcz variants is the result of a 14-year long period of the lack of old-forest shelter for the young fir generation for variant 2-Rcz which proves that growth and development conditions of fir in both variants are identical at present.

REFERENCES

Jaszczak R., Magnuski K., 2005. Wyniki przebudowy drzewostanów w Nadleśnictwie Doświadczalnym Siemianice [Results of reconstruction of stands in the Siemianice Experimental Forest Division]. Sylwan 10, 20-27 [in Polish].

Jaszczak R., Magnuski K., Kasprzyk J., 2008. Die Ziele und die Methoden der Umwandlung der Bestände in der Versuchs-Oberförsterei Siemianice – die Zusammenfassung der Untersuchungen aus den Jahren 1953-2006. Nauka Przyr. Technol. 2, 2 [http://www.npt.arpoznan.net/tom2/zeszyt2/art_9.pdf].

Magnuski K., 1975. Wzrost upraw jodłowych w warunkach rębni zupełnej, częściowej i gniazdowej [Growth of fir plantations under conditions of clear-cut, partial and patch cutting]. Sylwan 10, 16-26 [in Polish].

Magnuski K., Małys L., Świtoń M., 1993. Struktura młodego pokolenia jodły pospolitej (*Abies alba* Mill.) wzrastającej w warunkach rębni zupełnej, częściowej i gniazdowej [The structure of young Silver fir (*Abies alba* Mill.) growing in conditions of clear felling, shelter-wood felling and nest felling]. Sylwan 9, 69-75 [in Polish].

JODŁA POSPOLITA (*ABIES ALBA* MILL.) ROSNĄCA W WARUNKACH RĘBNI ZUPEŁNEJ ORAZ CZĘŚCIOWEJ I GNIAZDOWEJ PO CIĘCIACH UPRZĄTAJĄCYCH STARODRZEW GRABOWO-DĘBOWY

Streszczenie. Praca przedstawia analizę struktury pierśnic, wysokości i biosocjalnej 39-letniej jodły pospolitej, wprowadzonej sztucznie i wzrastającej do zimy 1991/92 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 na działce z rębnią zupełną gniazdową i zimą 1991/92 roku na działce z rębnią częściową, jodła wzrasta we wszystkich trzech wariantach na otwartej przestrzeni. Inwentaryzacja z 2005 roku wykazała, że w każdym przypadku najlepsze wyniki doświadczenia uzyskał drzewostan na powierzchni z rębnią gniazdową zupełną (3-Rg). Drzewostany z powierzchni z rębnią zupełną (1-Rz) oraz częściową (2-Rcz) mają wyniki gorsze, a jednocześnie różne między sobą. Z punktu widzenia przeciętnej pierśnicy i wysokości lepsza jest sytuacja na powierzchni 1-Rz, a ze względu na liczbę drzew, przeciętną klasę Krafta i produkcyjność – na powierzchni 2-Rcz.

Słowa kluczowe: jodła pospolita, rębnia zupełna, rębnia częściowa, rębnia gniazdowa zupełna, struktura pierśnic, struktura wysokości, struktura biosocjalna, liczba drzew, produkcyjność

Accepted for print – Zaakceptowano do druku: 29.07.2008

For citation – Do cytowania: Jaszczak R., Magnuski K., Małys L., 2008. European silver fir (Abies alba Mill.) growing in conditions of clear cutting as well as shelter wood and group cutting after cleaning cutting of hornbeam-oak old forest. Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lignar. 7(3), 15-22.