DOI: 10.2478/frp-2013-0019

Leśne Prace Badawcze (*Forest Research Papers*),
September 2013, Vol. 74 (3): 197–203.

ORIGINAL RESEARCH ARTICLE

The results of an 18–year old beech trees (*Fagus sylvatica* L.) provenance trial in the Łobez Forest District

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Abstract. The experimental area is located in the Węgorzyno Forest Sub-District, Łobez Forest District. 29 Polish provenances of beech from their natural range were growth in a completely randomised block design with four replications. In 2010, after the end of the growing season, measurements were carried out on the experimental plot, including: determination of the survival rate and the diameter at breast height, and height of trees. Moreover, the total basal area and the total volume were calculated. Using ANOVA, statistically significant differences between provenances were apparent for four of the five traits measured; all except diameter at breast height. Provenances characterised by high values for the analysed traits were considered the best adapted to the habitat conditions in the experimental plot, while provenances reaching low values were considered unsuitable for use under the conditions similar to those at the trial site location.

Key words: *Fagus sylvatica* L., provenance variability, valuation features

1. Introduction

The European beech, the main forest tree species, has in recent years continued to raise the interest of European researchers. This is reflected, *inter alia*, in the establishment of new provenance trials covering populations from the entire natural range of species. Europe lacks long-term experimental sites with the species, which is so important for such studies. In Poland, there are many such plots covering several decades (Rzeźnik, 1990; Tarasiuk *et al*. 2003; Tarasiuk, Jednoralski 2005), and the obtained results allow broadening the knowledge of the silvicultural value of the tested provenances in local habitat conditions. However, often only a few provenances or those from not fully recognised populations are tested there.

In the spring of 1996, one of the six provenance plots embraced by the research program on the variability of European beech in Poland was established in the Łobez Forest District, in north-western Poland. The paper presents the results of the first phase of the research on the European beech provenances of national origin completed in 2010. The results have demonstrated the usefulness of different provenances for breeding under the conditions of north-western Poland.

2. Methods

The experimental site was established in the post-agricultural land surrounded by a forest in the Węgorzyno Forest Sub-District, Comp, 329 h, i, (length – λ=15°33'E, width – φ=53°32'N), situated at an altitude of 100 m above sea level. The location layout and the description of 29 provenances used in the experiment are included in Kowalkowski's study (2002). The plot was established by the complete randomization method and divided into five blocks as replications. Blocks I, III and V, each containing 29 sites, block II contained 28, and block IV had 27

Received 3 January 2013, accepted after revision 1 March 2013

sites in total. The total area consisted of 142 plots on which 100 non-transplanted 3-year-old beech seedlings were planted in the 1,3×1,5 m spacing (with the exception of the seedlings from Kartuzy and Kańczuga provenances, which were planted with 50 plants per plot).

In 2010, after the end of the growing season, measurements were carried out on the experimental site, including: the number of trees, diameter at breast height of all trees and height of 16–20 trees from each population. These data enabled determining the parameters of height curves using the Näslund parabola.

The following was calculated from the distribution of diameters at breast height of trees on each plot: the total basal area and volume using the smooth height curve for the diameter class, the number of trees in diameter classes and a single tree volume table (Czuraj 1991). The survival rate was calculated from the specified number of trees. The results (Table 1) were subjected to two-way analysis of variance.

The results of the analysis were expressed in units of standard deviation from the mean values of the studied traits. When the results of the analysis of variance allowed rejecting the hypothesis of the lack of differences between the objects (Table 2, 3, 4, 5), a new Duncan's multiple range test was used for further comparisons.

Table 1. Valuation characteristics of the stand determined for individual populations

Provenances	Survival rate	Height	DBH	Total basal area	Volume
	%	m	mm	m^2/ha	m^3/ha
1 Gryfino	77,3	6,7	65,9	16,49	94,60
2 Gryfino	78,0	6,6	66,4	17,52	116,77
3 Bierzwnik	63,0	6,2	60,0	11,78	77,18
4 Drawa National Park	72,0	6,3	59,0	13,77	90,27
5 Karnieszewice	74,5	5,6	52,8	12,36	60,09
6 Wejherowo	66,3	4,9	48,3	9,23	31,76
8 Szczecinek	66,0	6,6	62,6	12,46	62,15
9 Szczecinek	77,0	7,1	69,0	17,48	83,01
10 Lipusz	84,0	6,8	66,9	16,88	107,22
11 Gdańsk	74,0	6,1	56,3	12,32	64,64
14 Kartuzy	85,0	6,6	72,3	11,39	73,23
17 Kwidzyn	76,8	6,3	66,2	15,48	78,44
18 Młynary	65,5	5,9	59,2	12,47	47,39
19 Wipsowo	87,5	6,7	66,7	18,80	81,00
20 Czersk	65,8	7,2	68,3	15,38	94,60
23 Krucz	78,5	5,1	52,2	11,18	62,01
26 Grodzisk	46,3	4,9	49,8	7,53	31,19
27 Pniewy	80,8	6,1	61,4	15,09	62,74
30 Lipinki	65,5	5,6	55,6	11,79	41,59
31 Prudnik	69,3	6,3	62,2	14,72	89,75
33 Suchedniów	79,3	5,6	59,0	15,11	62,12
34 Łagów	67,0	5,2	54,0	11,36	49,44
38 Zdroje	85,5	6,2	65,2	17,66	115,57
39 Ustroń	81,3	6,5	67,1	18,22	77,99
40 Kańczuga	80,7	6,3	75,8	11,90	82,94
42 Bieszczady National Park	81,5	5,6	57,8	14,86	50,78
43 Bieszczady National Park	70,0	5,5	57,7	12,62	67,01
44 Bieszczady National Park	63,8	5,9	56,9	12,08	58,44
45 Łosie	69,8	5,3	58,0	12,50	65,02
Average	73,5	6,1	61,1	13,81	71,69
Standard deviation	8,82	0,6	6,60	2,79	22,23
Coefficient of variation (%)	12,0	9,8	10,8	20,2	31,0

3. Results

Based on the analysis of variance, statistically significant differences were found between provenances in four of the five analysed traits (survival, height, diameter at breast height, total basal area & volume) except for the survival for which no such variability was proven.

Average survival on the experimental site was 73,5% (Table 1). For individual provenances, it ranged from 46,3 (Grodzisk 26) to 87,5% (Wipsowo 19). High rate of survival was found in the Zdroje 38 provenance (85,5%), followed by Kartuzy 14 (85%) and finally Lipusz 10 (84%). The populations of Bierzwnik 3 (63%) and of the Bieszczadzki Park Narodowy

Table 2. Analysis of variance for diameter at breast height

Source of variance	SS	df	MS	F	P value	*F* test
Provenances	7213,71	28	257,6	2,06	0,004	1,576
Blocks	2143,16	4	535,8	4,284	0,002	2,452
Error	14008,1	112	125,1			
Total	23365	144				

SS – sum of squares
df – degree of freedom
MS – Mean Square
F – Fisher-Snedecor's F Statistic value
P Value – level of significance corresponding to critical value
F Test – critical value taken from the Tables

Table 3. Analysis of variance for height

Source of variance	SS	df	MS	F	P Value	*F* test
Provenances	84,12	28	3,004	3,661	0,000	1,556
Blocks	12,56	5	2,512	3,061	0,011	2,278
Error	114,9	140	0,821			
Total	211,6	173				

Symbol description as in Table 2

Table 4. Analysis of variance for sums of total basal area

Source of variance	SS	df	MS	F	P Value	*F* test
Provenances	1372,688	28	49,02459	2,40239	0,000	1,576
Blocks	524,0012	4	131,0003	6,41951	0,000	2,452
Error	2285,538	112	20,40659			
Total	4182,228	144				

Symbol description as in Table 2

Table 5. Analysis of variance for volume

Source of variance	SS	df	MS	F	P Value	*F* test
Provenances	72213,35	28	2579,048	4,258716	0,000	1,576
Blocks	14442,79	4	3610,698	5,962252	0,000	2,452
Error	67826,41	112	605,5929			
Total	154482,5	144				

Symbol description as in Table 2

(Bieszczady National Park 44) 63,8% also showed a low survival rate.

The measurement results expressed in units of standard deviation (Fig. 1) indicate that the Wipsowo 18, Zdroje 38 and Suchedniów 33 provenances were best-adjusted to the habitat conditions of the experimental site in terms of the discussed traits.

The analysis of height data (Fig. 2) identified provenances reaching the maximum values of this trait, including in this group the populations of Czersk 20 and Szczecinek 8, as well as of Wipsowo 19 and Lipusz 10, and those which revealed the worst growth below the experiment average *i.e.* Grodzisk 26, Wejherowo 6 and Krucz 23.

As regards the average diameter at breast height (Fig. 3), the Kańczuga 40 provenance achieved the best results, followed by Kartuzy 14 and Szczecinek 9. The provenances achieving the results below the experiment average include Wejcherowo 6, Grodzisk 26 and Krucz 23.

The total basal area was another significant trait differentiating the populations: Wipsowo 18, Ustroń 39, Zdroje 38 and Szczecinek 9 were in the group of populations with the highest value of this trait, while

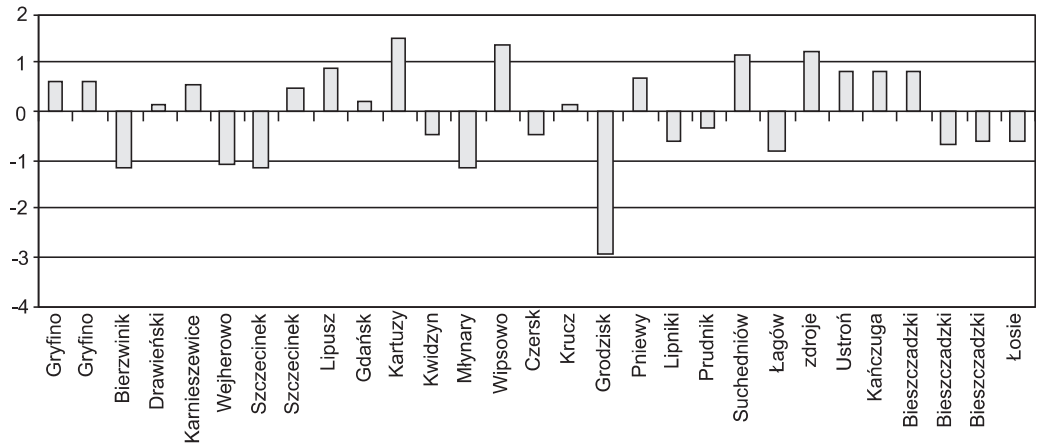

Figure 1. Survival of beech provenances in units of standard deviation

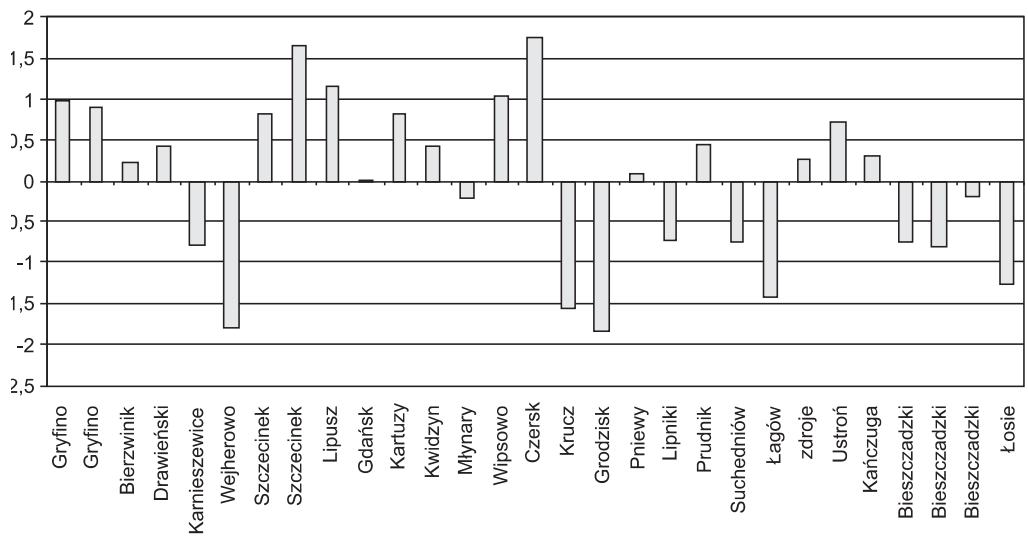

Figure 2. Height of beech provenances in units of standard deviation

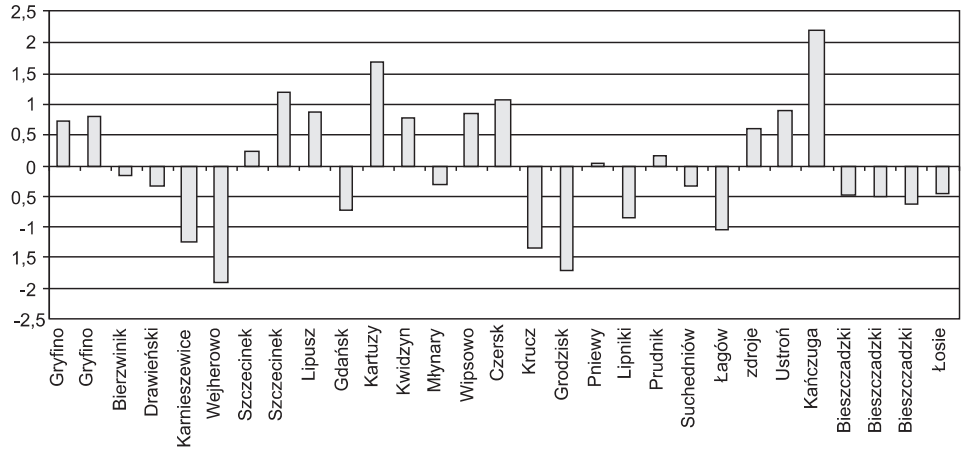

Figure 3. Diameter at breast height of beech provenances in units of standard deviation

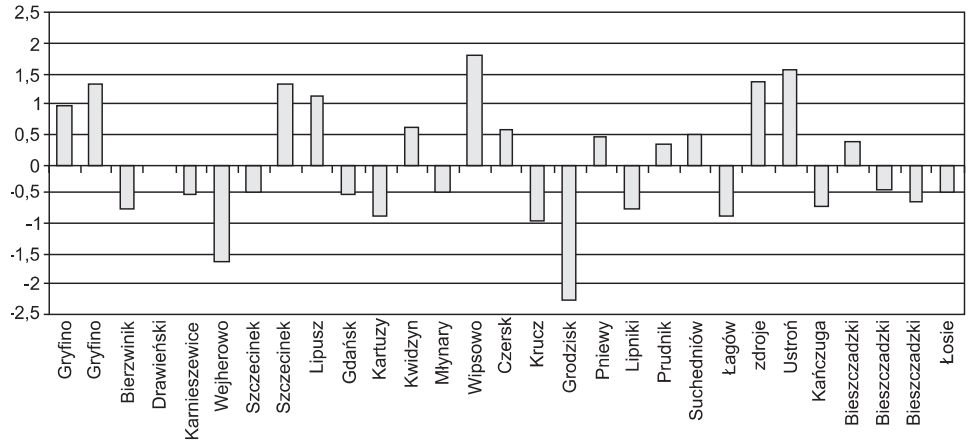

Figure 4. Total basal area of beech provenances in units of standard deviation

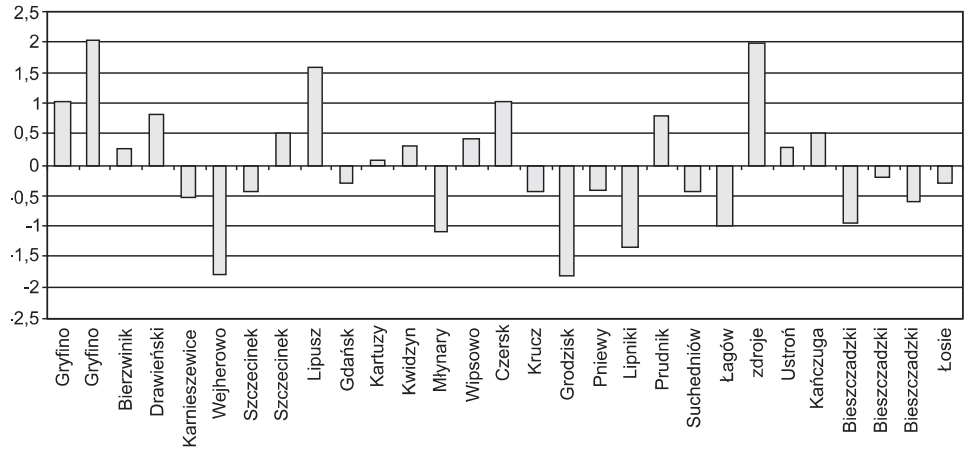

Figure 5. Volume of beech provenances in units of standard deviation

the worst performing populations were: Grodzisk 26, Wejherowo 6 and Krucz 23 (Fig. 4).

The volume was most interesting from a practical point of view and the most differentiating trait of the provenances was analysed. The values of this trait range from 31, 76 to 116,77 m^3/ha. The populations reaching high values (Fig. 5) include Gryfino 2, Zdroje 38 and Lipusz 10, while those reaching low values are Wejcherowo 6, Grodzisk 26 and Lipinka 30.

4. Discussion

The discussed experiment is part of a larger research program consisting of five separate study areas (Barzdajn, Rzeźnik, Kowalkowski 2002). Each of them is under the scientific guidance and supervision of another research unit. Therefore, there are various publications on individual study areas (Chmura, Rożkowski 2002; Kowalkowski 2002; Matras 2002; Rożkowski, Giertych 2002; Sabor, Żuchowska 2002; Tarasiuk at al. 2002; Kowalkowski 2010), as well as collective studies covering all study areas (Barzdajn 2002; Matras 2010). Despite certain objections to the overall reliability of the results obtained from the early test material (Giertych 1990), not yet knowing the final results of the experiment, in each case one can distinguish provenances reaching better and worse results in terms of the features analysed. The occurrence of the same dozen provenances on each study area makes it possible to identify plastic population which, in the case of beech, puts to doubt the belief that this species has developed local races (Giertych 1990). In his synthesis covering the whole experiment, Barzdajn (2002) points to a few plastic provenances showing outstanding growth in all locations. The results presented depict the adjustment, at the current stage, of the tested provenances to the habitat conditions of the study area.

The high average survival of trees in the study area under the Łobez Forest District not only bodes well for the possibilities of measurements and observations in the future, but also shows good adaptability of most of the analysed populations to the habitat conditions of the study area. Compared with the previous results (Kowalkowski 2010), no significant changes in the ordering of provenances were observed as regards this characteristic; also the ranking of the populations in terms of tree height is similar. It is only the populations of Bierzwnik 3, the Drawieński Park Narodowy (Drawa National Park) 4, and Szczecinek 8, which scored above the average, improving their position in the ranking for this characteristic. As concerns the diameter at breast height, the same populations which occupied high positions in the assessment carried out in 2005 still dominate.

Thus, at this stage of research, it may be concluded that both Gryfino 1, Kartuzy 14 and Wipsowo 19 from northern Poland and Zdroje 38, Ustroń 39 and Kańczuga 40 from southern Poland are provenances suitable for growing under the conditions of the analysed study area.

Earlier results from both the present and other study areas (Kowalkowski 2001, 2002, 2010) indicate changes in the ranking of provenances in subsequent measurement periods. For each of the analysed features, there are visible differences in the ranking positions achieved by the tested populations. However, the populations from the north and west of Poland are generally among the best. Yet the results obtained after several years of research do not permit any ultimate indication for the transfer and use of the seeds and seedlings of the European beech.

5. Conclusions

The experiment proved significant variation in four analysed traits of the studied populations.

Provenances showing high values of the analysed traits at the age of 18 years are best adapted to the habitat conditions of the study area.

Provenances characterised by such low values should not, at this stage of the research, be indicated for use under the habitat conditions of the study area.

Acknowledgements

The research was funded by Forest Research Institute under the theme "The population variability of common beech (*Fagus sylvatica* L.) in Poland (population growth and development the coppice interval)".

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Translated by: Katarzyna Mikułowska