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ORIGINAL RESEARCH ARTICLE

Growth of *Ulmus glabra* Huds. grafts in the clone archive in Bielsk Forest District

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Abstract. Vegetative progeny were obtained from 46 elms (*Ulmus glabra* Huds.) by grafting. These grafted trees were planted in 2009 in a clone archive in forest plot 264j in the Bielsk Forest District.

After one year of growth, elm clone survival ranged from 38% to 100% (89% on average). Although all clones were of similar age and were grown under similar conditions, their average height was highly variable and ranged from 99.0 cm (clone no. 9473z) to 186.6 cm (clone no. 9645z), while average root collar diameter ranged from 8.4 mm (clone no. 9473z) to 18.0 mm (clone no. 9645z).

There were large differences crown architectural among the different clones, and variation in average shape of the crown was high (from 2.6 in clone no. 9655 to 3.8 in clone no. 9446z).

Index breeding values determined on the standardized data for height, root collar diameter, crown shape and survival, ranged from -0.71 (clone no. 9473z) to 0.61 (clone no. 9645z). Clones from Czerwony Dwór reached a better breeding value (0.17) than clones from Gołdap (-0.0266), and variation in their average breeding values was high (0.197).

Key words: vegetative progeny, clone archive, *Ulmus glabra* Huds., Wych elm

1. Introduction

Currently in Poland, Wych elm grows in forests as admixed tree species, where it improves the main-forming species. It is scattered throughout the country and occurs more often in the western and northern Poland Nizina Szczecińska (Szczecin Lowland) and Pojezierze Mazurskie (Masurian Lake District)).

In the mid-twentieth century, due to the spread of Dutch elm disease, also known as *ophipstoma ulmi*, there was a significant reduction in the occurrence of this species. In Poland, the first diagnosed case of Dutch elm disease was recorded in 1927 (Siemaszko, 1935). The second major cause of imbalance of the species was the reduction of the water table caused by large-scale drainage works. In the 1980s, elm stands covered the area of 544 ha, with the average stocking of 0,66 and average plantings of 166 m^3/ha, which accounted for only 0,01% of the national forests (Głaza, 1986). This area is now largely reduced and the elm is considered a "dying" species.

As a "dying" species, elm comes under programmes of genetic resources conservation. The north-eastern Poland has been included in the "Programme of Setting up and Running the Forest Clone Trees Archive of North-Eastern Poland (Korczyk, Matras, 2006), which since 2007 under the name of "Forest Clone Trees and Other Forest Vegetation Archive for North-Eastern Poland" is being implemented by the Regional Directorate of the State Forests in Białystok (DGLP, 2007).

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2. Literature Review

The Wych elm up to the age of 10 is one of the fast-growing species and grows to an average height of 3–4 m (Jaworski, 1995). At the age of 60, an increment in height is complete and is 40 m, while the breast height diameter is 150 cm (Mayer, 1977). This species is characterised by a straight trunk with distinctly cracked reddish bark. It has the largest leaves (up to 16 cm) from among all Polish elm species. At the open space, it breeds at the age of 30 and 40, while in stands, only at the age of 50 (Karczmarczuk, 2002).

The elms are outgoing species in the Polish forests. Distribution of the prevailing elm stands is uneven. Stands with a significant participation of elms are more numerous in the northern and western parts of the country, while elsewhere they can be met occasionally. All three species of elms are mostly found in the lowland areas (98,7%), in large parts of fresh broadleaved forest and most broadleaved forest sites (35,9% and 30% respectively) (Głaza, 1986), with the exception of a Wych elm, which can be found in lower subalpine area (Ilmurzyński, Włoczewski, 2003).

Loss of elms is caused by the spread of Dutch elm disease, to which a smooth-leaved elm (*Ulmus minor* Mill.) and Wych elm (*Ulmus glabra* Huds.) are mostly susceptible (Mańka, 1954; Przybył, Renn, 2001). The root cause of Dutch elm disease is fungus *Ophiostoma Ulmi* (Buisman) carried by elm bark-beetles. Lesions show up early dieback of leaves and discoloration of brush woods and branches (Mańka, 2005).

Very old elms can be met in Poland only occasionally. In majority, these trees grow in park, household or roadside stockings. The oldest and the thickest elm in Poland is a 438-year old spreading elm with the perimeter of 957 cm (data from 1994), which grows in Komorów near Gubin in Lubuskie Voivodeship (Pacyniak, 2003).

Among the oldest Wych elm trees, there is a 327-year old (data from 1993) plant with the perimeter of 670 cm. It grows in Poręba near Limanowa (Pacyniak, 2003).

In Europe, especially in the Czech Republic and Germany, conservation programmes of genus *Ulmus* are carried out. Czech projects include the development of seed orchards and Wych elm clone archive of the local selected, individual trees. Elm grafting is difficult but it allows for selecting the appropriate individuals partially resistant to Dutch elm disease. Such facilities can be met in the Czech Republic: LS Nové Hrady (2,7 ha), LS Janov (1,5 ha) and LS Litovel (2,53 ha) (Hynek et al., 2006). The German programme of elm genetic resource conservation in Europe was established after the United Nations Conference on Environment and Development held in 1992 in Rio de Janeiro. The programme was founded to create a European database of elm clone archives which would include 9 countries and to select clones resistant to Dutch elm disease. The programme allows for the introduction of uniform rules for the classification of elm trees and contributes to the preservation and dissemination of genus *Ulmus* in Europe (Franke, 1998).

3. Aim

The aim of this study is to determine the survival and growth of Wych elm in the clone archive in Bielsk Forest District.

4. Materials and Methods

Wych Elm Clone Archive

According to the natural-forest regionalisation, Bielsk Forest District is located almost entirely in the IV Mazowsze-Podlasie Land, while the only northernmost areas located in Zabłudów Community (area of Pawły Forest Range) belong to the II Mazury-Podlasie Land. Most of the area of the Forest District situated in IV Land was included in the 5th quarter of Podlasie Lowland and Siedlce Upland, mesoregion "c" of Bielsko Upland (Trampler et al., 1986). An average annual temperature there is 6,8°C, ranging from -35,4°C to 35,5°C, with average annual rainfall of 593 mm (Górniak, 2000).

The archive is located in the Hołody Forest Range, at a 264j compartment within Bielsk precinct. It covers post-agrarian soils, which according to the forest management plan are of fresh broadleaved forest site types (Lśw), on brown soil appropriate, made of the poorly-clay sands and silt loam. The area with the adjacent aspen clone archive is fenced with 2-metre high metal wire mesh.

Map of the clones and grafts was developed in 2009 by the Department of Genetics and Physiology of Forest Trees at the Forest Research Institute in Sękocin Stary. The clone archive covers the area of 3,98 ha and is divided into four forest quarters, in which 234 grafts were located, representing 46 clones. The grafts were planted in the square spacing of 6×6 m.

Table 1. Characterization of the *Ulmus glabra* (Huds.) trees from the Borecka Primeval Forest and Romincka Primeval Forest used in 2009 to establish the clone archive in the compartment 264j of the Bielsk Forest District

No.	Forest District	Compartment	Habitat type*	Tree No. Acc. IBL	Date of the selection	Age on DBH	Height (m)	DBH (cm)
1	Czerwony Dwór	205d	Lśw	9334	2002	80	27,7	71,1
2	Gołdap	90f	Lśw	9363	2002	40	22	51
3	Gołdap	162i	Lw	9541	2003	67	25	45
4	Czerwony Dwór	197t	Lśw	9629	2004	125	28,5	64,4
5	Czerwony Dwór	272d	Lśw	9655	2004	92	27	48,4
6	Gołdap	99b	Lśw	9671	2004	74	26	57
7	Gołdap	214l	Lśw	9446z	2003	120	32,8	93,3
8	Gołdap	214l	Lśw	9448z	2003	120	29,3	47,6
9	Gołdap	214l	Lśw	9453z	2003	120	32	81,9
10	Gołdap	150a	Lśw	9473z	2003	100	25,8	43,8
11	Gołdap	207c	Lśw	9476z	2003	100	31,7	52,3
12	Gołdap	207c	Lśw	9478z	2003	100	28,5	52
13	Gołdap	392h	Lśw	9530z	2003	25	24	44
14	Gołdap	378a	Lśw	9532z	2003	58	29	49
15	Gołdap	378a	Lśw	9533z	2003	58	30	66
16	Gołdap	102a	Lśw	9542z	2003	47	26	71
17	Czerwony Dwór	211b	Lśw	9631z	2004	110	29	60,1
18	Czerwony Dwór	211b	Lśw	9633z	2004	110	31	59,1
19	Czerwony Dwór	211b	Lśw	9634z	2004	110	28	54
20	Czerwony Dwór	204g	Lśw	9637z	2004	92	27	86
21	Czerwony Dwór	205d	Lśw	9638z	2004	72	23	48,8
22	Czerwony Dwór	205d	Lśw	9639z	2004	72	28,5	56,7
23	Czerwony Dwór	217g	LMb	9643z	2004	96	27,5	71
24	Czerwony Dwór	195g	Lśw	9644z	2004	47	24,5	60
25	Czerwony Dwór	196dx	Lśw	9645z	2004	57	26,5	73,1
26	Czerwony Dwór	274i	LMśw	9649z	2004	81	25,5	47
27	Czerwony Dwór	272d	Lśw	9651z	2004	92	27,5	50,9
28	Czerwony Dwór	272d	Lśw	9652z	2004	92	27,5	48,6
29	Czerwony Dwór	272d	Lśw	9653z	2004	92	26	45,9
30	Gołdap	272f	Lśw	9658z	2004	51	23,5	41,7
31	Gołdap	78b	Lśw	9659z	2004	63	25,5	47,2
32	Gołdap	27b	Lśw	9660z	2004	54	26	47,3
33	Gołdap	27b	Lśw	9661z	2004	179	27,5	47,4
34	Gołdap	27b	Lśw	9662z	2004	54	31	67,2
35	Gołdap	27b	Lśw	9663z	2004	54	25,5	42
36	Gołdap	27b	Lśw	9664z	2004	186	31	65,9
37	Gołdap	27b	Lśw	9665z	2004	54	25	46,2
38	Gołdap	83b	Lśw	9666z	2004	51	26	46,9
39	Gołdap	83b	Lśw	9667z	2004	51	26,5	41
40	Gołdap	44h	Lśw	9668z	2004	77	25,5	44,4
41	Gołdap	45a	Lśw	9669z	2004	64	25	43,6
42	Gołdap	282g	Lw	9674z	2004	67	24	48,5
43	Gołdap	282g	Lw	9676z	2004	67	23,5	42,8
44	Gołdap	282h	Lśw	9677z	2004	82	27	68,1
45	Gołdap	390f	Lśw	9772z	2005	84	28	43,2
46	Gołdap	390f	Lśw	9773z	2005	84	25,2	42

* Habitat type: Lśw – fresh broadleaved forest, LMśw – fresh mixed broadleaved forest, LMb – boggy mixed broadleaved forest, Lw – moist broadleaved forest

9334 – plus tree, 9446z – conservative tree

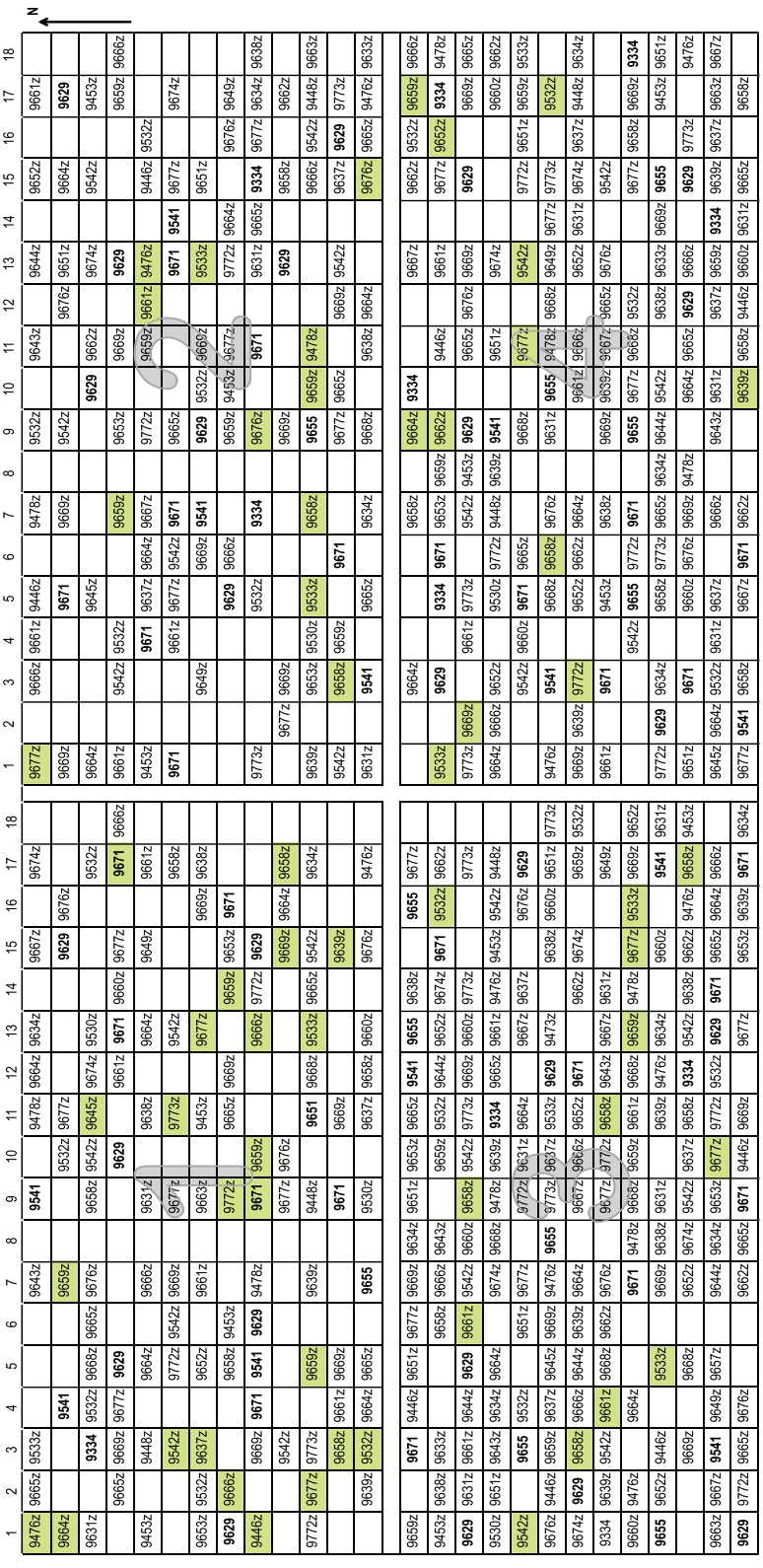

Figure 1. Distribution of the *Ulmus glabra* (Huds.) clones in the clone archive in compartment 264j of the Bielsk Forest District on 10 October 2010: 9541 – plus tree clone, 9476z – conservative tree clone:
graft fall out no graft

Table 2. Missing of the *Ulmus glabra* (Huds.) grafts in the clone archive in compartment 264j of the Bielsk Forest District, autumn 2010

No.	Clone No.	Missing grafts		
		graft fall aut	no planted	sum
1	9334	0	9	9
2	9363	0	20	20
3	9541	0	0	0
4	9629	1	1	2
5	9655	0	7	7
6	9671	2	0	2
7	9446z	1	11	12
8	9448z	0	14	14
9	9453z	0	0	0
10	9473z	0	19	19
11	9476z	3	9	12
12	9478z	1	10	11
13	9530z	0	16	16
14	9532z	2	0	2
15	9533z	5	4	9
16	9542z	4	0	4
17	9631z	0	6	6
18	9633z	0	17	17
19	9634z	0	8	8
20	9637z	1	7	8
21	9638z	1	9	10
22	9639z	2	6	8
23	9643z	0	14	14
24	9644z	0	13	13
25	9645z	1	16	17
26	9649z	0	14	14
27	9651z	0	8	8
28	9652z	1	9	10
29	9653z	0	12	12
30	9658z	9	6	15
31	9659z	8	1	9
32	9660z	0	10	10
33	9661z	3	0	3
34	9662z	1	8	9
35	9663z	0	16	16
36	9664z	2	0	2
37	9665z	0	0	0
38	9666z	3	0	3
39	9667z	0	10	10
40	9668z	0	8	8
41	9669z	2	0	2
42	9674z	0	8	8
43	9676z	2	0	2
44	9677z	5	0	5
45	9772z	3	5	8
46	9773z	1	6	7
	Total	64	337	401

9334 – plus tree clone
9446z – conservative tree clone

Shoots used for grafting were obtained from 46 elms, including 6 mother trees and 40 conservative trees, growing at Czerwony Dwór and Gołdap Forest Districts.

Data on mother and conservative trees was taken from the "Registry of Seed Base in Poland" (Table 1).

Graftings were carried out in spring of 2006 and 2008 at the nursery-selective facility of the Forest Range in Kołaki Wietrzychowo, Łomża Forest District.

The clone archive (lat. 52.48 N, long. 23.33 E) was established in May 2009 under the "Forest Archive Clones of Trees and Other Forest Vegetation of North-Eastern Poland" programme, which was implemented in 2007 as per the ordinance of the State Forests' General Director (DGLP, 2007).

Out of the scheduled 936 grafts, 599 were planted, whereas until October 2010 as many as 535 survived (Fig. 1). Currently, 401 grafts are missing in the archive and they should be promptly supplemented (Table 2).

Measurement Methods

For the measurement and description of grafts the following features were taken into account:

– total height in cm, with an accuracy of 1 cm,

– root collar diameter (mm) above the place of grafting, with an accuracy of 1 mm,

– shape of the crown according to the following scale:

4 – cylindrical crown; with short epicormic shoot; arranged symmetrically around the axis of the arrow,

3 – spherical crown; epicormic shoots forming a spherical outline,

2 – clevis crown,

1 – multi-shoots, without a clear guide

– survival – rate estimated according to the following scale:

1 – fully healthy tree not showing any damage,

0 – dead tree (withered)

Statistical Analyses

For all parameters (survival, height, root collar diameter, shape of a crown, breeding value) versus clones, forest quarters, origin (Czerwony Dwór, Gołdap) as well as origin of grafts used for grafting (mother tree, conservative tree), a one-factor variance analysis was performed.

Normal distribution and linear regression curve for the graft heights and their root collar diameter were also determined.

Calculations were made with use of "STATISTICA 8-StatSoft" software.

5. Study Results

Survival of Clones

Field works in the clone archive were carried out in October 2010.

Wych elm was grafted twice. In 2006, 8 trees were selected for grafting, including one mother tree (9671) and 7 conservative trees (9532z, 9533z, 9542z, 9658z, 9659z, 9667z, 9669z,), out of which as for 30 November 2008, 226 grafts took. The second grafting was performed in 2008, with 45 trees, including 5 mother trees (9629, 9541, 9671, 9334, 9363) and 41 conservative trees (9446z, 9448z, 9453z, 9473z, 9476z, 9478z, 9530z, 9532z, 9542z, 9631z, 9634z, 9637z, 9638z, 9639z, 9643z, 9644z, 9645z, 9649z, 9651z, 9652z, 9653z, 9655, 9658z, 9659z, 9660z, 9661z, 9662z, 9663z, 9664z, 9665z, 9666z, 9667z, 9668z, 9669z, 9674z, 9676z, 9677z, 9772z, 9773z), out of which as for 24 December 2009 476 grafts took with 27% success of grafting. Grafts survival at the first year of planting (2010) at the clone archive was 89% on average, and 38% to 100% respectively for individual

Table 3. An analysis of variance of the height, root collar diameter, shape of the crown, surviving and breeding values of the *Ulmus glabra* (Huds.) clones in the clone archive in compartment 264j the Bielsk Forest District

Parameter	Between groups			Within groups			*F*	*p*
	SS	*df*	*MS*	*SS*	*df*	*MS*		
Significance of differences between the clones								
Height (m)	116579	44	2649,53	582405,9	490	1188,583	2,229151	0,000022
Rott collar diameter (mm)	636,849	44	14,4738	4338,895	490	8,854888	1,634559	0,0077
Shape of the crown	33,0218	44	0,7505	305,838	490	0,624159	1,202409	0,18135
Survival	9,102386	44	0,206872	48,05955	554	0,08675	2,384694	0,000003
Significance of differences between the seedbeds								
Height (m)	21297,33	3	7099,109	677688,0	531	1276,249	5,562481	0,000919
Rott collar diameter	549,1411	3	183,0470	4426,603	531	8,336352	21,95769	0,000000
Shape of the crown	5,872701	3	1,957567	332,9871	531	0,627094	3,121647	0,025650
Survival	1,532236	3	0,510745	55,62970	595	0,093495	5,462791	0,001041
Significance of differences between the provenance (Czerwony Dwór Forest District or Gołdap Forest District)								
Height (m)	323,77	1	323,769	698661,5	533	1310,810	0,246999	0,619401
Rott collar diameter	34,86296	1	34,86296	4940,881	533	9,269945	3,760859	0,052993
Shape of the crown	0,506871	1	0,506871	338,3529	533	0,634809	0,798463	0,371957
Survival	1,023598	1	1,023598	56,13834	597	0,094034	10,88540	0,001027
Breeding value	0,398345	1	0,398345	2,791455	43	0,064918	6,136164	0,017253
Significance of differences between the plus trees clones and conservative trees clones								
Height (m)	392,7937	1	392,7937	698592,5	533	1310,680	0,299687	0,584308
Rott collar diameter	13,67272	1	13,67272	4962,071	533	9,309702	1,468652	0,226095
Shape of the crown	0,595607	1	0,595607	338,2642	533	0,634642	0,938493	0,333105
Survival	0,371177	1	0,371177	56,79076	597	0,095127	3,901917	0,048691
Breeding value	0,026523	1	0,026523	3,163278	43	0,073565	0,360533	0,551362

clones. One-factor variance analysis versus clones, forest quarters, origin (Czerwony Dwór, Gołdap), mother tree or conservative tree showed that the *p* values obtained are in all cases highly significant (Table 3).

Graft Height

The average height of elm clones was 143,7 cm, ranging in particular clones from 99 to 186,6 cm (Table 4).

The height of the particular grafts ranged from 39 to 232 cm. The lowest graft was in IV quarter in clone 9666z, and the highest in II quarter in clone 9532z.

The normal distribution of grafts included them into 11 ranges. Regarding designated Gauss curve, a distinct shift in positive direction was noted (Fig. 2).

One-factor variance analysis of graft height versus clones and quarters revealed that *p* values obtained are statistically highly significant (Table 3). The weakest growth was observed in grafts in I quarter, which was due to the periodic rainwater slacks. The best conditions

Table 4. Characterization of development of the *Ulmus glabra* (Huds.) clones in the clone archive in compartment 264j of the Bielsk Forest District

No.	Clone No.	Height (cm)	Root collar diameter (mm)	Shape of the crown	Surviving %	Breeding values
1	9334	152,2	14,5	3,7	100	0,33
2	9541	118,4	13	2,9	100	-0,26
3	9629	147,8	16	3,3	96	0,25
4	9655	152,5	14,6	2,6	100	-0,01
5	9671	154,9	16,2	3,2	92	0,25
6	9446z	150,5	14,9	3,8	89	0,29
7	9448z	125,5	14,1	3,2	100	-0,04
8	9453z	166,2	15,2	3,5	100	0,41
9	9473z	99	8,4	3	100	-0,71
10	9476z	126,4	14	3,3	73	-0,23
11	9478z	159,1	15,7	3,3	90	0,26
12	9530z	99,1	11,9	3,5	100	-0,29
13	9532z	143,4	15,1	3,1	89	0,03
14	9533z	164	16,6	3,3	38	-0,08
15	9542z	155	15,5	3,2	88	0,17
16	9631z	128,3	15,6	2,8	100	-0,03
17	9633z	129,9	14,1	3	100	-0,07
18	9634z	140,1	15	3	100	0,07
19	9637z	157,4	15,8	3,3	92	0,27
20	9638z	131,8	14	3,6	91	0,05
21	9639z	121,3	14,8	3,1	86	-0,16
22	9643z	181,9	16,8	3,3	100	0,58
23	9644z	154	15,2	3,6	100	0,36
24	9645z	186,6	18	3,7	75	0,61
25	9649z	106,8	12,5	3	100	-0,35
26	9651z	141,7	16,7	3,3	100	0,3
27	9652z	151,5	15,7	3,2	91	0,18
28	9653z	162,5	14,6	3,5	100	0,34
29	9658z	132,5	13,2	3,2	59	-0,4
30	9659z	166,7	14,9	3,2	62	-0,02
31	9660z	130,7	15,7	2,7	100	-0,04
32	9661z	138,7	14,5	3,3	83	-0,03
33	9662z	131	14	2,7	92	-0,23
34	9663z	153,9	16,5	2,8	100	0,21
35	9664z	138,5	14,4	3,1	90	-0,05
36	9665z	147,6	14,7	3,1	100	0,12

No.	Clone No.	Height (cm)	Root collar diameter (mm)	Shape of the crown	Surviving %	Breeding values
37	9666z	120,6	12,7	2,9	82	-0,42
38	9667z	129,8	13,3	3	100	-0,13
39	9668z	150,1	14,9	3,3	100	0,21
40	9669z	142,3	15,8	3	94	0,09
41	9674z	131,3	14,7	3,5	100	0,14
42	9676z	156,4	15,3	3,2	88	0,16
43	9677z	158,9	15,4	3,3	82	0,17
44	9772z	141	13,9	3,2	80	-0,12
45	9773z	128,2	13,4	2,9	93	-0,23
Average		143,7	14,9	3,2	89	0,04
SD		37,7	3,3	0,8	0,3	0,27

9334 – plus tree clone, 9446z – conservative tree clone

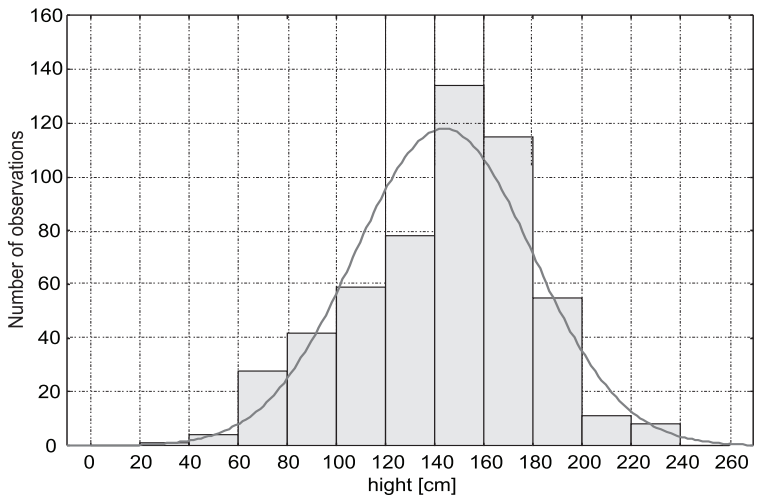

Figure 2. Histograms of height distribution of the *Ulmus glabra* (Huds.) grafts

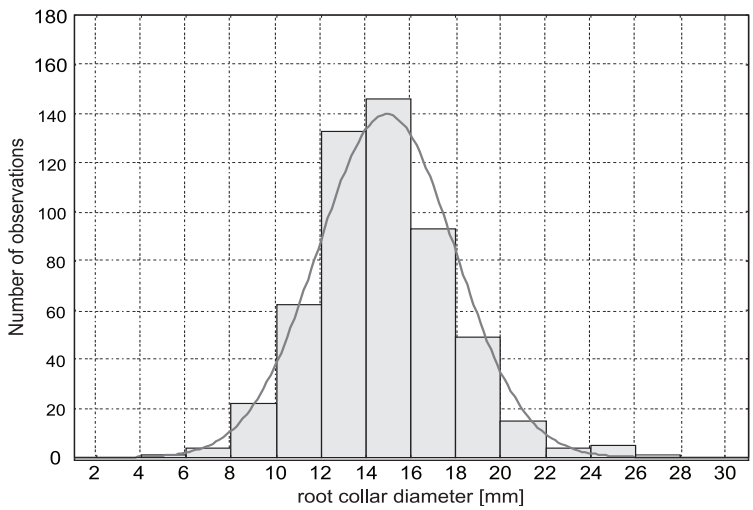

Figure 3. Histograms of root collar diameter distribution of the *Ulmus glabra* (Huds.) grafts

for the graft growth were in III forest quarter with the most fertile soil and regulated water management.

Growth of grafts in the clone archive did not depend on the origin of trees (Czerwony Dwór or Gołdap).

Root Collar Diameter

Root collar diameter was measured with an accuracy of 1 mm. The average diameter across all clones was 14,9 mm, ranging from 8,4 to 18 mm (Table 4). For single grafts, the root collar diameter range was from 5 to 27 mm. The thinnest and the thickest grafts were also the lowest and the highest respectively (II forest quarter – clone 9666z, IV forest quarter – clone 9532z).

Distribution of graft root collar diameter included them into 12 intervals.

With regard to Gauss curve, the excess in the number of observations on the value of the feature in the negative direction was noted (Figure 3).

P values obtained in the variance analysis of graft root collar diameter had similar distribution to that of the height analysis. As far as clones and quarters are concerned, they were statistically highly significant, but the origin had no significance (Table 3). A highly positive correlation occurred between trees' height and their root collar diameter (Table 5). This was confirmed by the linear regression curve (Fig. 4).

Shape of the Crown

The shape of the graft crown relates to the overall shape of the aboveground part of the tree (trunk and crown, branches distribution). It depends on the environmental conditions, in particular the access of light and inherited set of genes.

An average value of the crown shape, according to the adopted 4-point rating scale was 3,2 (Table 4) and it ranged in individual clones from 2,6 to 3,8.

One-factor variance analysis of Wych elm's shape of crowns versus the clones and their origin (Czerwony Dwór or Gołdap, mother tree or conservative tree) revealed that *p* values obtained are statistically insignificant (Table 3). Results of shape crown analysis versus the quarters were different, as the *p* value obtained was of mathematical significance. In both cases, the results revealed that it was not origin but habitat that influenced the shape of grafts.

There was no correlation between the shape of the crown, the height and the root collar diameter. The

Table 5. Correlation between the shape of the crown, height and root collar diameter of the *Ulmus glabra* (Huds.) grafts

Parameter	Root collar diameter (mm)	Height (m)	Shape of the crown
Root collar diameter	1	–	–
Height	0,616063	1	–
Shape of the crown	0,04208	0,231946	1

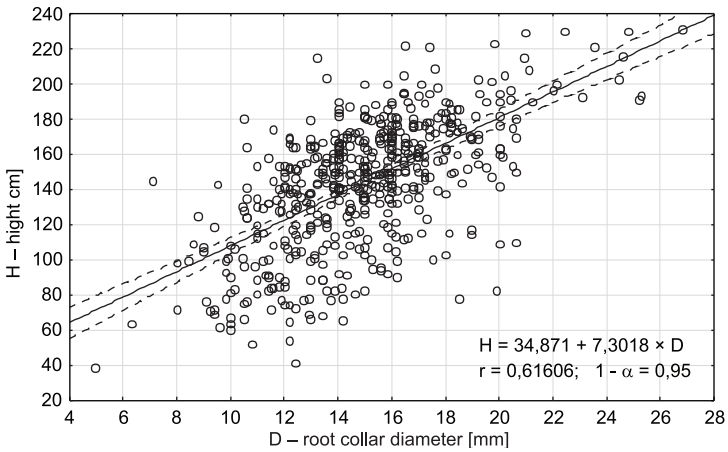

Figure 4. Regression of the tree height and root collar diameter of the *Ulmus glabra* (Huds.) grafts with 95% confidence interval

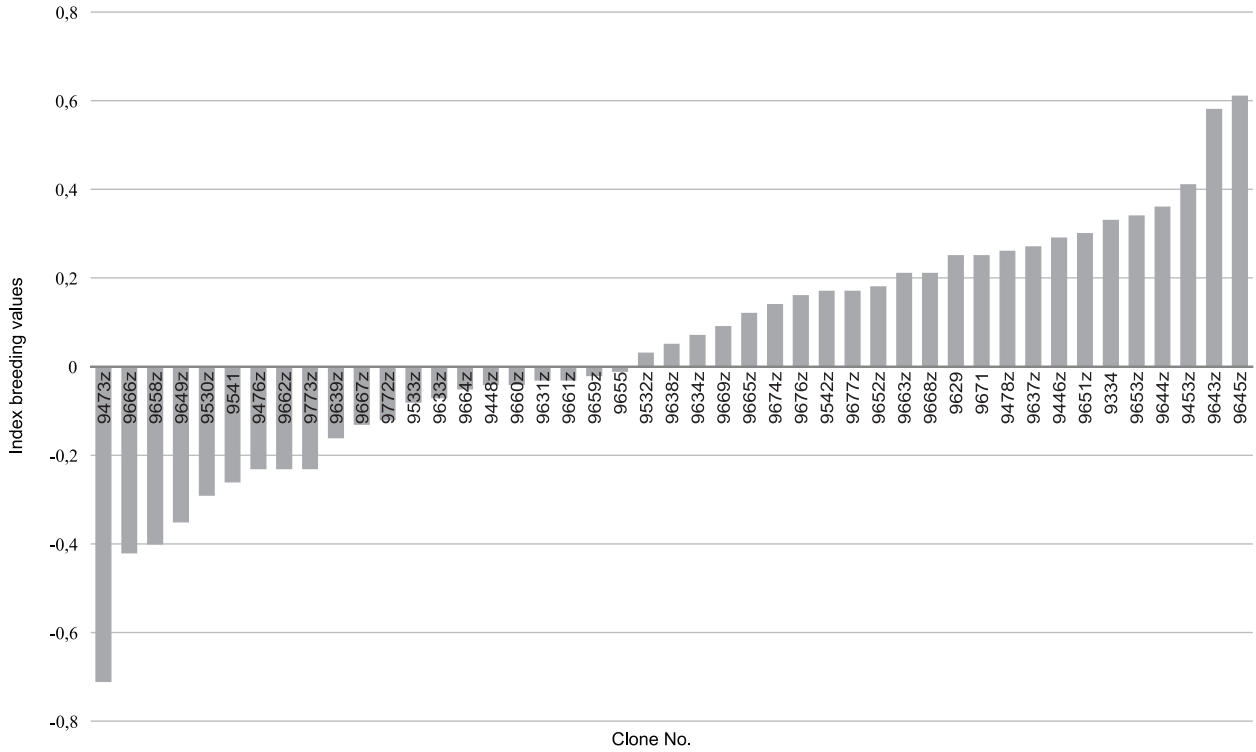

Figure 5. Breeding values of the *Ulmus glabra* (Huds.) clones in the clone archive in the Bielsk Forest District

correlation coefficients obtained were statistically insignificant (Table 5).

Quality of the Breeding Clones

To evaluate the breeding value of the Wych elm, the breeding quality index was used (*Ho*). It was calculated on the basis of the standardised data of four characteristic features: height, root collar diameter, shape of crowns and survival. Arithmetic means and standard deviation for each characteristic feature were calculated on the basis of all graft measurements in the clones tested. Then, the average calculations of all measured characteristic features were standardised. The average breeding value index for each clone was calculated on their basis.

The following clones present the best breeding value index: 9645z (0,61), 9643z (0,58), 9453z (0,41), 9644z (0,36); and the lowest index: 9473z (-0,71), 9666z (-0,42), 9658z (-0,4) (Table 4, Fig. 5).

While analysing the quality of breeding clones versus the forest districts they came from, the *p* value obtained

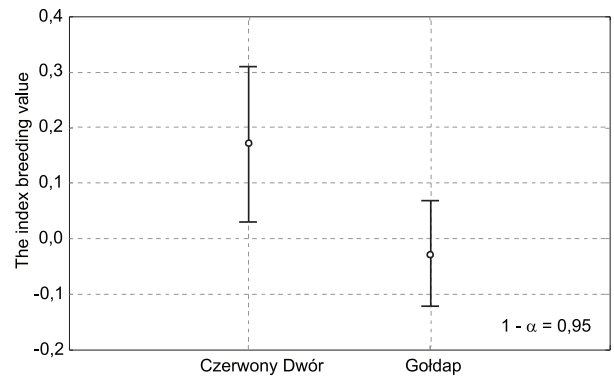

Figure 6. Significance of differences of the breeding values between Forest District, of which provenance the plus trees and conservative trees.

is statistically significant. However, as far as the mother or conservative trees are concerned, the result is not of mathematical importance (Table 3, Fig. 6).

To summarise the obtained results of analysis of clone breeding values, it should be stated that it is influenced by the area of origin of trees used for grafting.

6. Summary and Discussion

The aim of this study was to present the development of Wych elm grafting derived from 45 trees (5 mother trees and 40 conservative trees) in the clone archive in compartment 264j of the Bielsk Forest District.

Height of trees, root collar diameter, shape and survival were taken into account in the study. These features are important for sulviculture. The 2- and 4-year old grafts studied revealed that out of 599 grafts, 535 survived, while 21 of them showed 100% life span. Average height of trees was 143,7 cm, which, at that age, allows us to include Wych elm to fast growing species. Due to the age of grafts and their growth, root collar diameter measurements were used in the study, with the average value of all grafts 14,9 mm.

Comparing the vegetative progeny of mother and conservative trees of Wych elm at the clone archive in Bielsk Forest District with the progeny of in vitro fertilisation of smooth-leaved elm from "Polna" area in the Czech Republic, similar growth was noted. One year after planting, the grafts from Bielsk Forest District reached an average height of 143,7 cm and the root collar diameter of 14,9 mm, while the trees from in vitro fertilisation of smooth-leaved elm reached 135,6 cm and 15 mm respectively (Dostal et al., 2010).

Summing up conservation efforts for forest trees such as Wych elm, we can say that the most important goal of setting the clone archive is to preserve genetic resources of the most magnificent trees. Such activities will help us to permanently preserve the native populations of endangered species that are adapted to the conditions of north-eastern Poland.

7. Conclusions

401 missing grafts should be supplemented promptly in order to fulfil the clone archive. The archive should carry out further research to select clones with superior quality and quantity features, and only then should be left in the archive.

Mother and conservative trees whose progeny are of low genetic and breeding values should be removed from the "Registry of Seed Base in Poland".

Translated by: Katarzyna Kreft

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Source Materials

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