ORIGINAL RESEARCH ARTICLE

DOI: 10.2478/frp-2013-0015

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

Sławomir Mioduszewski, Adolf F. Korczyk⊠

Bialystok University of Technology, Forest Faculty in Hajnówka, ul. Piłsudskiego 8, 17-200 Hajnówka, Poland.

☑ Tel. +48 85 6829500, fax +48 85 6829509, e-mail: a.korczyk@pb.edu.pl

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 Goldap (-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 mainforming 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 m³/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).

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	2141	Lśw	9446z	2003	120	32,8	93,3
8	Gołdap	2141	Lśw	9448z	2003	120	29,3	47,6
9	Gołdap	2141	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

1	E	^
- 1	.)	1
-	_	_

15 16 17 18 9652z 9661z	9664z 9629	9542z 9453z		29996 26296		9659z 9446z 9532z 9677z 9674z	9446z 9532z 9677z 9674z 9651z	9446z 9532z 9677z 9674z 9651z 9674z 9656z 9676z	96502 96772 96742 96512 96762 96513 96762 96492 9334 96772 96342	96592 996772 96742 96512 96742 96514 96762 96492 9334 96772 96542 96562 96652	96462 9532 96772 96742 96572 96772 96742 96742 96742 96752 96752 96522 96522 96522 96622 96622 96622 96622 96622 96622 96622 96622 96622	94462 95322 96772 96742 96752 96742 96762 96492 96762 96762 96622 96622 96622 94682 9682 96522 94682	96462 9532 9672 96592 96592 96572 96572 96572 96742 96742 96742 96582 96672 96652 96652 96552 96	94462 95322 96772 96742 96572 96742 96762 96492 96824 96772 96342 96827 9482 96837 9482 96837 9482 96837 9482	94462 95322 96772 96742 96572 96742 96762 96492 96824 96772 96342 96827 94682 96837 9482 96837 9482 96837 9482 96837 9482 96837 9482	94462 95322 96772 96542 96572 96742 96762 96492 96824 96772 96822 96827 9482 96827 9482 96827 9482 96827 9482 96827 9482 96827 9482 96827 9482 96827 9482 96827 9482	94462 95322 96772 96742 96512 96762 9634 96772 96622 96622 94682 96622 94682 96772 96622 96772 96622 96772 96622 96772 96622 96772 96622	94462 95322 96772 96742 96512 96742 9634 96772 96632 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622 96622 94622	94462 95322 96772 96742 96512 96742 96782 96742 96822 96722 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622 96822 94622	96462 95322 96772 96742 96572 96652 96742 96652 96752 96652 96752 96652 96752 96652 96752 96652 96752 96652 96752 96652 97722 96652 97722 96652 97722 96652 97722 96652	96462 95322 96742 96742 96742 96742 96742 96742 96742 96742 96742 96762 96622 96762 96622 96762	96595 96462 95322 96572 96742 9634 96762 96492 96352 96652 96652 96652 96652 94682 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762 96772 96652 94762	96462 95322 96742 96742 96742 96742 96742 96742 96742 96742 96742 96742 96622 96752 96622 96752 96622 96752 96652 96752 96652 96752 96652 96752 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96752 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96652 96742 96752	96462 95322 96742 96742 96742 96742 96742 96742 96742 96742 96742 96742 96622 96752	94462 95322 96742 96742 96742 96742 96742 96742 96742 96742 96742 96742 96762	96462 95322 96742 96742 96742 96742 96742 96742 96742 96742 96742 96762 96762 96762 96762 96752
11 12 13 14 9643z 9644z 9	9676z 9651z	96622 96742 9	9669z		9659z 9661z 9476z	9661z 9476z 9671 9541	9661z 9476z 9671 9541	96612 94762 9671 9541 95332 97722 96642	96612 94762 9671 9541 95332 97722 96642 96312 96652	96612 94762 9671 9541 96332 96312 96842 96312 96652	96612 94762 9671 9541 96332 9772 96642 9631 96652	96612 94762 96332 9772 96642 9772 96642 96312 96652 9639	96672 94762 9533 9772 96642 96312 96642 9632 96422	96812 94762 96332 97722 96642 96392 96542 96892 95422 96642	96672 96642 9672 9672 9672 96642 96642 96642 96642 96642	96672 96672 96772 96772 96772 9679 9669 966	96612 94762 96332 96332 96332 96312 96642 96312 96642 96642 96642 96642 96642 96672 96672 96672	96612 94762 96332 96332 96312 96642 96312 96652 96642 96642 96672 96672 96672 96672 96672	96612 94762 96332 96332 96312 966532 96392 96542 96642 96642 96642 96672 96672 96672 9672 9672 9672 9672	96612 94762 96332 96332 96312 96642 9629 96642 96642 96642 96642 96642 96762 96672 96762 96672 96762 96672	96612 94762 96332 96332 96312 96642 9629 96642 96642 96642 96642 96762 9692 96762 9692 96762 969312	96612 94762 96332 96332 96312 96642 96642 96642 96642 96642 96642 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662	96612 94762 96732 96732 96772 96642 96722 96642 96642 96422 96642 96772 96642 96772 96652 96772 96652 96772 96652 96772	96612 94762 96732 96732 96772 96642 96722 96642 96642 96422 96642 96672 96642 96772 96652 96772 96652 96772 96652 96772 96652 96772 96652 96772 96652 96772	96612 94762 96732 96732 96772 96642 96722 96642 96642 96672 96642 96772 96642 96772 96642 96772 96652 96772 96652 96772 96652 96772 96652 96772 96652 96772 96652 96772 96652 96772	96612 94762 96332 96332 96312 96642 96312 96652 96642 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 96662 966662 96662 96662 96662 96662 96662 96662 96662 96662 966662 96662 96662 96662 96662 96662 96662 96662 96662 966662 96
8 9 10 9532z	9542z	6 6796	96537 0		97722	97722	97722 96652 96322	96652 96852 9629 96322 96592 94532	9772z 9655z 9659z 9659z 9659z 9676z	97722 9652 9652 96532 96592 96762 96692	26296 26966 26966 2696 26966 26966 26966 26966 26966 26966 26966 26966 26966 26966 2	91722 96632 96632 96632 9663 9665 96652 96652	9655 9655 9655 9655 9655 9655 9655 9655	91722 96652 96592 96592 96592 9655 9655 965	91722 96632 96632 96652 96652 96652 96652 96652 96652 96652 96652	91722 96632 96632 96632 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642	94552 9532 96552 9	91772 96632 96652 96552 96552 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652 96652	91722 96652	91772 96652	91772 96632 96632 96632 96632 96642 96732 96632	91772 96632 96632 96632 96632 96642 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632 96632	91772 96652	90652 90	90622 90632 90642 90642 90642 90642	91772 96692 96
5 6 7 9446z 9478z	9671 9669z	9645z	0100	3629S	9659z 9637z 9664z 9667z	9637z 9664z 9677z 9542z	9637z 9664z 9677z 9542z 9669z	96372 96642 96772 95422 9692 96692	96372 96642 96772 95422 9692 9629 96662	96372 96642 96772 95422 9629 96662 95322	9637z 9664z 9677z 9542z 9689z 9629 9666z 9532z	96372 96642 96772 95422 9629 96692 95322 95332	96372 96642 96772 95422 9629 96662 9532 9532 96332	96372 96642 96772 95422 96829 96662 9632 96622 96332 9671	96372 96642 96772 95422 9629 96652 95322 95332 96852	96372 96642 96672 96772 95622 9671 96682 96862 96862 96862 96862 96862 96862 96862 96832 96832 96832 96832 96832 96834 9671 96832	96372 96642 96672 9677 96692 96872 9670 96682 96862 96862 96862 96862 96862 96862 96892 96892 96892 96892 96892 96992 9734 9671 96882 9732 9732 9732 9732 9732 9732 9732 973	96372 96642 96672 96772 95629 96662 96872	96372 96642 96672 9677 9629 96672 9677 9629 96662 9632 9671 9629 9671 96282 9671 96682 9671 96682 9671 96682 9772 94482 9671 96652	96372 96642 96672 96772 96292 9641 9662 9652 9641 9662 9652 9641 96682 96532 96682 9	96372 96642 96672 9677 9629 96672 9677 9629 9677 9629 9677 9629 9677 9629 9677 96682 96782 96782 96782 96682	96372 96642 96672 9677 9629 96672 9677 96682 9671 96882 9671 96882 96882 96882 96882 96882 96882 96882 96882 96682 96882	96372 96642 96672 9677 96242 96672 9677 9624 96652 9541 96582 9674 96582 9674 96582 9674 96582 9674 96582 96672 96	96372 96642 96672 9677 96242 96672 9677 9624 96672 9677 9624 9625 9677 9624 9625 9677 9624 9625 96672	96372 96642 96672 96772 96742 96672 96772 96742 96752 96742 96752 96742 96742 96752 96742 96752	96977 96642 96677 96878 9677 96879 9677 96879 9677 9682 9671 9682 9671 9682 9677 9682 9677 9682 9682 9682 9682 9682 9682 9682 9682
2 3 4 9666z 9661z 9	5	6		9542z 9532z	9532z 9671	9532z 9671 9661z	9532z 9671 9661z	9532z 9671 9661z	9532z 9671 9661z	9532z 9671 9661z	95422 95322 9671 96492 96892 96632 95302	95422 95322 96492 96692 96692 96692 96692 96692	9642z 9532z 9671 96942 9689z 9683z 9663z 9665z 9530z 9668z 9654	9649z 9649z 9649z 9669z 9669z 9669z 9669z 9669z 9658z 9658z 9659z	96422 96322 96492 96492 96692 96693 96693 96532 96592 96541	96422 96322 96492 96492 96692 96693 96532 96302 96541 96642	96422 96322 96492 96812 96892 96892 96832 95302 96842 96542 96642 96612	9642z 9632z 9649z 9649z 9689z 9689z 9685z 9530z 9684z 9644z 9629	96422 96322 96432 96612 96612 96612 96623 96642 96623 96642 96623 96642 96623 96642 96623 96642 96622 96602 96622 966020	96422 96322 96492 96612 96632 96632 96632 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642	96422 96322 96492 96612 96632 96532 96532 96542 96522 96542 96522 96612 96612 96612 96612 96612	96422 96322 96492 96612 96632 96632 96632 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642 96642	96422 96322 96422 96612 96612 96612 96612 96622 96522 96522 96522 96502 96412 96542 96502	96422 96322 96422 96422 96532 96422 96502	96422 96322 96432	96422 96322 96422 96532 96602 96612 96602
18 1 2 1 8 1 9677z	z6996	9664z		9666z 9661z						9661z 9453z 9671	9661z 9453z 9671 9773z	9661z 9453z 9671 9773z 9639z 9639z	96612 94532 9671 97732 96392 96422 96312	9661z 9463z 9671 9773z 9639z 9639z 9631z	9661z 9453z 9671 9773z 9639z 9639z 9639z 9631z	9661z 9453z 9671 9773z 9639z 9639z 9639z 9633z	96612 94532 967132 97732 96392 96422 96312 96332	96612 94532 96732 96392 96392 96392 96392 96392 96372	96612 94532 9671 97732 96392 96312 96312 96312	96662 94532 96732 96732 96382 96382 96372 96372 964762	96662 94532 96732 96332 96312 96312 96322 9642 96322 96322 96332	96662 94532 96732 96332 96332 96332 96322 96662 97732 96332 96332 96662	96662 96732 97732 97732 96332 96332 96332 96332 96332 96332 96332 96332 96332 96332 96332 96332 96532	96662 94532 96732 9632 96	96662 94532 96732 96332 96322 96322 96662 96662 96662 96662 966632 966632 966632 966632	96662 96732 96732 96732 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9632 9633 9632 9633 9632 96
15 16 17 9667z 9674z	9629 9676z	46836		9677z	9677z 967 1 9649z 9661z	9677z 9671 9649z 9661z 9658z	9677z 9677z 9677 9649z 9651z 9658z 9658z 9638z	96772 96672 96692 96692 96692 96382 96632 96692	9649z 9661z 9649z 9661z 9669z 9638z 9663z 9671	96772 96642 966492 96642 96652 9673 96652 9671 96692 96642	96492 96642 96492 96652 96532 9671 96692 96642 96602 96642 96682 96422 96643	96492 96652 96692 96682 96532 9671 96592 96682 96522 96642 96682 96642 96682 96682 96642	96772 96492 96612 96582 96582 96582 96582 96582 96582 96582 96582 96582 96582 96582 96592	96492 96642 96492 96652 96532 9671 96592 96642 96682 96642 96682 96642 96422 96682 96422 96682	96772 96492 96612 96652 96652 96652 96652 96682	96492 96642 96492 96652 96532 9671 96532 96642 96682 96422 96682 96422 96642 96686 96422 96686 96422 96686 96422 96686 96422 96686	96492 96612 96492 96652 96532 96732 96532 96732 96422 96682 96422 966342 9672 9672 96772 96772	96492 96612 96492 96652 9653 9671 9653 9671 96632 96642 96642 96642 96642 96642 96762 96762 96772 96772 96772 96772 96772	96492 96642 96492 96652 96532 9671 96632 9671 96632 9672 9672 9642 9672 9672 9672 9672 96732 9672 96752 96732 96752 96732	96492 96612 96492 96582 9653 9671 9653 9672 96542 96542 96542 96542 96762 96762 96752 96752 96762 96752 96762 96752 96762 96752	96492 96602 96602 96602 96702 96602 96603 96702	96492 96602 96612 96492 96602 96702 96702 96882 96892 96892 96892 96892 96702	96492 96692 96692 96692 96692 966932 96772	96492 96592 96582 96582 96582 96582 96582 96582 96582 96582 96732 96742 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96572 96582	96492 96602 96602 96702 96602 96702 96702 96802 96802 96903 96702	96492 96592 96582 96592 96582 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96592 96692 96592 96692
12 13 14 9664z 9634z		9674z 9530z	_	9661z 9671 9660z 9	9661z 9671 9660z 9664z	9661z 9671 9660z 9664z 9542z	96612 9671 96602 96642 95422 96772	96612 9671 96602 96642 95422 96772 96692	96612 9671 96602 96642 96942 95422 96772 96692 96592	96612 9671 96602 96642 95422 96692 96722 96692 97722	96612 9671 96602 96642 95422 96692 96592 96662 97722	96642 9642 9642 9662 9662 9662 9662 9665 9665 9665 966	96612 9671 96602 96642 96642 96692 96692 96692 96532 96662 96552	96612 96712 96542 96542 96772 96682 97722 96682 95332 96652	96612 96642 96642 96642 96772 96802 96772 96602 97722 96602 96602 96602 96602	96612 9672 96642 96742 96772 96682 97722 96682 9532 96652 96541 9665 96382 96442 96522 96742	96612 9672 96642 96742 96772 96682 97722 96682 96532 96682 96542 96682 96642 96682 96642 96682	96612 96642 96442 96772 96682 97722 96682 96682 96682 96682 96642 96692 96642 96692 96692 96692 96692 966742 96692 966742	96612 96712 96642 96712 96682 97722 96682 97722 96682 96682 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692 96692	96612 96712 96442 96472 96672 96682 97722 96682 96682 96682 96682 96692 96692 96692 96692 96672 966742 96672 966742 96672 966742 96672 966742	96612 96712 96642 96772 96682 97722 96682 97722 96682 96682 96674 9662 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674	96612 96712 96642 96772 96682 97722 96682 97722 96682 96682 96682 96682 96682 96672 96672 96674 96672 96674 96672 96672 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674 96672 96674	96642 96642 96642 96642 96672 96682 96682 96682 96682 96682 96682 96682 96682 96672 96672 96672 96672 96672 96672 96672 96672 96672 96672 96672 96672 96672 96672	96612 96712 96642 96642 96642 96672 96682 96772 96682 96772 96682 96682 96672	96642 96642 96642 96642 96642 96672 96682 96682 96602	96642 96642 96642 96642 96642 96662 96662 96662 96602
9 10 11 9541 9478z	9532z 9677z	9658z 9542z 9645z	1	9629	9629	9629	9629	9629	9629	9629 2 2 2 3 6592 2 3 6592 2 3 8 8	9629	9629 2 96762 2 96762	96292 2 96532 2 96552 2 96762 2 96762 2 96692 2 96692 2 96592 2 96762 3 96592	9659 9659 9659 9650	963/4 9632 963/4 9632 963/4 97732 96772 96652 9677 9662 9677 96632 9671 96632 96372	9631 9632 9637 96532 96622 96622 96622 96622 96622 96622 96622 96622 96622 96622 96622 96622 96622 966	96234 96374 96374 96377 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772 96772	96234 96374 96374 96775 96877 96772 96772 96772 96782 96782 96882 96882 96712 96882 96882 96882 96882 96882 96882 96882 96882 96882 96882 96882 96882 96882	9629.2 9637.2 9687.7 9688.3 9687.7 9688.3 9677.2 9688.2	96274 96374 96374 96777 96883 96777 96883 96777 96882 96882 96872 96882 9682 9682 96837 9682 96832 96832 96832 96832 96832 96832 96832 96832 96832	9629.2 9637.2 9687.7 9688.3 9677.7 9688.3 9677.7 9688.2	96372 96372 96372 96372 96873 96772 96872 96772 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872 96872	96372 96372 96372 96372 96372 96677 96772 96672 96772 96672 96672 96772 96682 96772 96822	96374 96374 96374 96374 96677 96677 96772 96672 96772 96682 96772 96882 96772 96882 96772 96882 96773 96862 96773 96862 96773 96862 96773 96877 96872 96872 96873	9639.6 9637.7 9637.7 9637.7 9637.7 9663.7	9639/2 9637/2 9637/2 9665/2 9677/2 977/2 9
6 7 8 9643z	26296		9665z 9676z	9665z 9676z	9665z 9676z	9665z 9676z 9666z 9542z 9669z	9665z 9676z 9666z 9542z 9669z 9661z	96652 96762 96652 96662 95422 96692 94532 96812	96652 96762 96652 96662 96422 96692 96453 96532	96652 96762 96422 96692 96422 96612 96532 96239 94782	96652 96762 96422 96692 96423 96612 96532 96239 96392	96652 96762 96622 96622 96422 96632 9629 94782 96392	96652 95762 96422 96692 96422 96692 96532 96592 96592 96595	96652 96762 96642 96692 96612 96612 96732 94782 96392 96392	96652 99.762 95.422 96692 96612 96612 96232 96392 96392 96392 96392	96652 96762 95422 96692 96422 96692 96532 96536 96536 96536 96536 96536 96536 96536 96536	96652 96762 96422 96692 96422 96692 96532 96536 96536 96536 96536 965372 96692 965432 96672 96602	96652 96762 96422 96692 96422 96692 96532 96536 96536 96536 96536 96542 96692 96542 96602 96602 96602	96652 96762 96422 96692 96422 96692 96593 96594 96594 96595 96595 96595 96595 96595 96595 96595 96595 96595 96595 96595	96662 96762 96422 96692 96612 96612 96612 96623 96634 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636 96636	96652 96762 95422 96692 96612 96612 96633 96532 96532 96542 96692 96642 96612 96772 96642 96612 96772 96642 96652 96623 96632 96632 96632 96632 96632 96632 96632	96652 96762 95422 96692 96612 96612 96639 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692	96652 96762 95422 96692 96612 96612 96632 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96602 96772 96602 96772 96602 96772 96602 96772 96602 96772 96602	96652 96762 96422 96692 96612 96612 96632 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692	96652 96742 96422 96682 96672 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96662 96772 96662 96772 96662 96772 96692 96772 96772 96692 96772	96652 96762 96422 96682 96523 9672 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692 96772 96692
3 4 5 9533z	9541		9334 9532z 9668z 9	9334 95322 9668z 9669z 9677z 9629	9334 95322 96682 96692 96772 9692 9448z 9664z	9334 9532z 9668z 9669z 9677z 9629 9448z 9664z 9542z 9772z	9334 95322 96682 96692 96772 9629 94482 96642 95422 97722 96372 96522	9334 95322 96882 96692 96772 9629 94482 96642 95422 97722 96372 96522	9334 9532 9682 96692 96772 9629 94482 96642 96372 96522 96372 96532 96582 96582	9334 9532 9682 9662 9677 9629 94482 96742 9642 97722 96372 96522 96682 9672	9334 9532 9682 9662 9677 9629 94482 96642 96422 97722 96372 96522 96682 9671 96422 96592	9334 9532 96682 9662 9677 9629 94482 9652 96372 9652 9662 9672 9662 9672 97732 96682 97732 96692	9334 9532 96652 9662 9677 9629 9442 9652 9637 9652 9662 9671 9541 9662 9662 9662 9662 96652	9662 9672 96682 9662 9677 9629 94482 96624 96422 9772 96872 9682 9682 9674 9541 9682 9672 96682 9682 9664 96682	9682 9672 9682 9682 9677 9629 94482 9662 9642 9682 9682 9677 9841 9682 9672 96682 97732 96682 9682 96672 96682	9334 95322 9682 96772 96482 96372 96372 96372 9673 9673 96682 9673 96682 96682 96682 96682 96682 96683	9334 95322 9682 96772 96482 96372 96372 96372 97732 9673 9673 9674 94482 9673 9674 94482	9334 95322 9682 96772 9682 96772 96832 96832 97732 97732 96773 9682 96832 96832 96833	9334 95322 9682 96772 9682 96772 96832 96773 97732 9682 9673 9682 9674 94462 9674 94462 9673 96432 9674 94462	9632 9632 96482 9652 96432 966	9633 9632 96622 9673 96832 9673 96832 96732 96842 96732 96842 96842 96842 96842 96842 96842 96842 96842 96842 9685	98332 96622 96622 96732 96832 96732 96832 96733 96832 96642 96842 98842	98334 96332 96482 96772 96892 96772 96892 96713 97732 9682 97732 9682 9682 96812 9674 94462 9673 96442 9674 94462 9673 96742 9674 96442 9675 9662 9672 9662 9672 9662 9672 96642	98334 96332 96432 96432 96432 96732 96732 96732 96732 9673 9674 9674 9674 9675 9675 9675 9675 9675 9675 9675 9675	96322 96822 96822 96832 96832 96832 96832 96832 96832 96842 96842 96842 96842 96842 96842 96842 98843 98882	9834 96322 96482 96482 96572 96892 96732 97732
1 2 9476z 9665z	9664z		9631z	29996	3665z	9665z	9665z 9532z	9665z 9532z 9666z	96652	9665z 9532z 9666z	9665z 9632z 9666z 9677z	9665z 9632z 9666z 9677z	9665z 9632z 9666z 9677z	9665z 9532z 9666z 9677z	9665z 9632z 9666z 9677z	9665z 9632z 9632z 9639z 9638z	96652 96322 96382 96382 96382	96652 96322 96322 96332 96312 96312 96312	96652 96622 96682 96682 96682 96382 96312 96512	96652 96862 96862 96772 96392 96392 96312 96462	96652 96392 96392 96392 96312 96462 9629	96652 96322 96392 96392 96392 96392 96392 96393 96393	96652 96322 96332 96392 96312 96512 96593 96392 96392 96392	96652 96322 96322 96382 96382 96382 96382 96382 96382 96392 96392 96392	96652 96322 96382 96382 96382 96382 96382 96382 96382 96582	96652 96322 96652 96382 96382 96382 96382 96382 96382 96382 96382 96382 96592

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: no graft graft fall out

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	Missing grafts						
	No.	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

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.

⁹⁴⁴⁶z – conservative tree clone

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

Demonstra	Bet	ween gi	roups	W	ithin gro	F			
Parameter	SS	df	MS	SS	df	MS	F	p	
		Signific	cance of differe	ences between	the clone	es			
Height (m)	116579	44	2649,53	582405,9	490	1188,583	2,229151	0,00002	
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	0,1813	
urvival	9,102386	44	0,206872	48,05955	554	0,08675	2,384694	0,00000	
	S	Significa	nce of differen	ces between t	he seedbe	eds			
Height (m)	21297,33	3	7099,109	677688,0	531	1276,249	5,562481	0,00091	
Rott collar diameter	549,1411	3	183,0470	4426,603	531	8,336352	21,95769	0,00000	
shape of the crown	5,872701	3	1,957567	332,9871	531	0,627094	3,121647	0,02565	
urvival	1,532236	3	0,510745	55,62970	595	0,093495	5,462791	0,00104	
Significance of diff	ferences betw	een the	provenance (C	zerwony Dwó	or Forest	District or Goł	dap Forest Dis	trict)	
leight (m)	323,77	1	323,769	698661,5	533	1310,810	0,246999	0,61940	
Rott collar diameter	34,86296	1	34,86296	4940,881	533	9,269945	3,760859	0,05299	
shape of the crown	0,506871	1	0,506871	338,3529	533	0,634809	0,798463	0,37195	
Survival	1,023598	1	1,023598	56,13834	597	0,094034	10,88540	0,00102	
Breeding value	0,398345	1	0,398345	2,791455	43	0,064918	6,136164	0,01725	
Signifi	icance of diff	erences	between the pl	us trees clones	s and con	servative trees	clones		
leight (m)	392,7937	1	392,7937	698592,5	533	1310,680	0,299687	0,58430	
Lott collar diameter	13,67272	1	13,67272	4962,071	533	9,309702	1,468652	0,22609	
hape of the crown	0,595607	1	0,595607	338,2642	533	0,634642	0,938493	0,33310	
urvival	0,371177	1	0,371177	56,79076	597	0,095127	3,901917	0,04869	
reeding value	0,026523	1	0,026523	3,163278	43	0,073565	0,360533	0,55136	

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

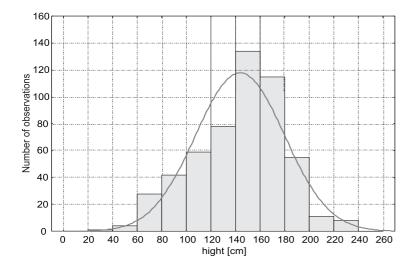


Figure 2. Histograms of height distribution of the *Ulmus glabra* (Huds.) grafts

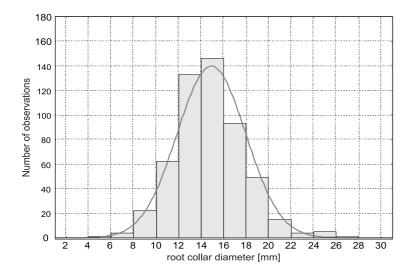


Figure 3. Histograms of root collar diameter distribution of the *Ulmus glabra* (Huds.) grafts

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 guarter - 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 Goldap, 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

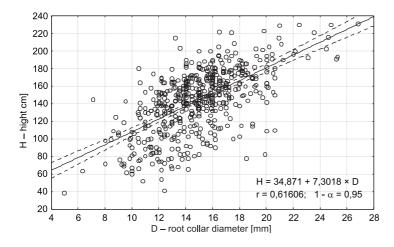


Figure 4. Regression of the tree height and root collar diameter of the *Ulmus glabra* (Huds.) grafts with 95% confidence interval

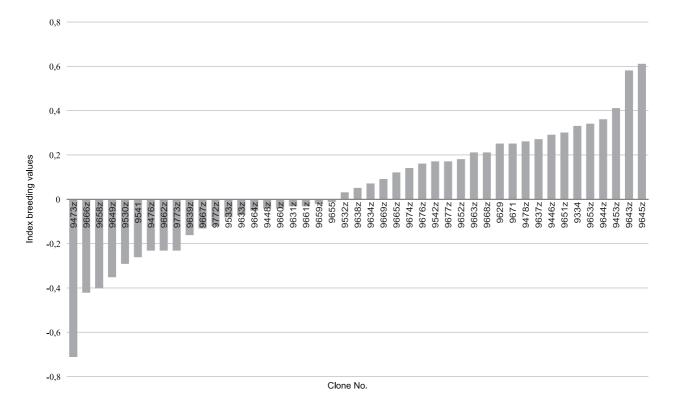


Figure 5. Breeding values of the *Ulmus glabra* (Huds.) clones in the clone archive in the Bielsk Forest District

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

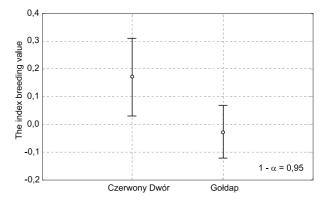


Figure 6. Significance of differences of the breeding values between Forest District, of which provenance the plus trees and conservative trees.

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

References

- Dostal J., Novotny P., Cvrckova H. 2010. Rust a vyvoj vypestku in vitro jilmu habrolisteho (Ulmus minor) na demonstracni plose "Polna" ve srovnani se sazenicemi generativniho puvodu. Zpravy Lesnickeho Vyzkumu, 2: 115-120.
- Franke A. 1998. ULMEN Generhaltung in Europa. AFZ Wald, 5: 232-233.
- Głaza J. 1986. Wiąz w Lasach Państwowych. Sylwan, 1: 23-33. Górniak A. 2000. Klimat województwa podlaskiego. Białystok, IMGW.
- Hynek V., Mala J., Burianek V. 1996. Moznosti slechteni rodu Ulmus v Ceske Republice. Lesnicka Prace, 75 (4): 119-121.
- Ilmurzyński E., Włoczewski T. 2003. Hodowla lasu. Warszawa, PWRiL.
- Jaworski A. 1995. Charakterystyka hodowlana drzew leśnych. Kraków, Gutenberg. ISBN 8386310030.
- Karczmarczuk R. 2002. Nasze wiązy. Wszechświat, 103, 4/6: 151-152.
- Korczyk A.F., Matras J. 2006. Program zakładania i prowadzenia Archiwum klonów drzew leśnych Polski północno-wschodniej. Warszawa, Dokumentacja Instytutu Badawczego Leśnictwa. Manuscript.
- Mańka K. 1954. Dalsze badania nad przebiegiem holenderskiej choroby wiązów na terenie m. Poznania w latach 1946-1953. Acta Societatis Botanicorum Poloniae, 23: 783-805.
- Mańka K. 2005. Fitopatologia leśna. Warszawa, PWRiL. ISBN 83-09-01793-6.
- Mayer H. 1977. Waldbau auf soziologisch-ökologischer Grundlage. Stuttgart-New York, Gustav Fischer Verlag.
- Pacyniak C. 2003. Wiek i wymiary sędziwych wiązów (Ulmus L.) w Polsce. Prace z zakresu nauk leśnych, 94: 83-91.
- Przybył K., Renn K. 2001. Holenderska choroba wiązów. Las Polski, 7: 20-21.
- Siemaszko W. 1935. Naczyniowa choroba wiązów w Polsce. Roczniki Nauk Ogrodniczych, 2: 163-173.
- Trampler T., Dmyterko E., Girżda A. 1986. Przyrodniczoleśna regionalizacja Polski. Prace Instytutu Badawczego Leśnictwa, Seria B, 5: 51-62.

Source Materials

DGLP 2007. Decree no. 50 of Directorate General of State Forests. Leśne archiwum klonów drzew i innej roślinności leśnej dla Polski północno-wschodniej ZG-7130-1/25/07. Warszawa, Dyrekcja Generalna Lasów Państwowych.