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GROWTH AND BEARING OF APPLE CULTIVAR 'ELISE' ON EIGHTEEN VEGETATIVE ROOTSTOCKS IN "V" PLANTING SYSTEM

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Abstract. For the intensive planting system production of apple fruit orchard, the ideal tree is one that does not grow too vigorously, presents early and constant bearing, and is able to produce high quality fruits. Our experiment was to assess eighteen rootstocks of different origin and vigour for 'Elise' planted in the "V" system. The field experiment was established in 2000, in the experimental orchard of the Department of Pomology, Warsaw University of Life Sciences, Wilanów. The influence of eighteen rootstocks on orchard performance of 'Elise' apple trees was investigated in the years 2000–2009. Different rootstocks were classified into three groups depending on expected tree vigour: superdwarfing (M.27, P 16, PB 4), dwarfing (B 9, B 146, P 2, P 59 and seven subclones of M.9: EMLA, Burgmer 984, Burgmer 751, T 339, Pajam 1, Pajam 2, RN 29), and semi-dwarfing (P 14, M.26, P 60, B 396). Trees on rootstocks assumed as superdwarfing were spaced at a distance of 3.2 × 0.5 m, on dwarfing at 3.5 × 0.7 m and on semi-dwarfing at 3.8 × 1.0 m. The smallest trunk cross-sectional area (TCSA) after 10 years, as well as the increase of TCSA for 2000–2009 among superdwarfing rootstocks was on PB 4, whereas among dwarfing rootstocks was on P 59. Among trees on semi-dwarfing rootstocks the highest TCSA as well as the increase of TCSA was on P 14. The highest cumulative yield per tree among superdwarfing rootstocks (2001–2009) was obtained on P 16, whereas the lowest on PB 4. On rootstocks considered as dwarfing, the lowest cumulative yield was observed on P 59, and the highest on M.9 751. The highest cropping efficiency coefficient (CEC) on super-dwarfing rootstocks was observed on P 16, on dwarfing rootstock on P 59 and on semi-dwarfing rootstock on P 60 and B 396.

Key words: rootstock, tree vigour, cumulative yield, cropping efficiency coefficient, fruit size

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INTRODUCTION

Apple tree is one of the main kind of plant cultivated in orchards, not only in Poland but throughout the world. Favorable weather and climate, as well as soil conditions, and at the same time increase of number of available cultivars and rootstocks increase the popularity of apple trees. Growing number of commercial orchards intensifies competition, as well as contributes to constant changes in apple's production aiming at its intensification. That leads to the increase of number of trees planted per surface area unit, what contributes to vigour, high precocity of bearing, productivity of trees grown, as well as high quality of fruits [Wertheim 1989, Webster 1992]. For the intensive planting, V-Güttingen system (Switzerland) is used in order to assure appropriate amount of day light reaching trees' crowns. Despite the fact, it assures early and regular bearing, high quality fruits, as well as significant yield, it is not much popular due to the high costs of building and running. As rootstock is a major factor in intensive orchard design, the choice of it affects the apple tree in many ways. That is the reason for releasing numerous rootstocks best adapted to local soil and climatic conditions [Christensen 1979, Ferree and Clarson 1987, Riesen and Monney 1996, Czynczyk et al. 2001, Sadowski et al. 2004, Czynczyk and Jakubowski 2007, Hrotkó 2007].

The aim of the experiment conducted was to determine the usefulness of some vegetative rootstocks for the growing of apple tree cultivar 'Elise' in "V" planting system. The preliminary results of the study have already been published [Wrona and Sadowski 2006, Wrona et al. 2007].

MATERIAL AND METHODS

The experiment was conducted on a fertile salty loam alluvial soil, at the Warsaw-Wilanów Experimental Station, Central Poland, in spring of 2000. The influence of eighteen rootstocks on orchard performance of 'Elise' apple was investigated in the years 2000–2009. The trees were planted and trained in 'V' planting system. Different rootstocks were classified into three groups depending on expected tree vigour: superdwarfing (M.27, P 16, PB 4), dwarfing (B 9, B 146, P 2, P 59 and seven subclones of M.9: EMLA, Burgmer 984, Burgmer 751, T 339, Pajam 1, Pajam 2, RN 29), and semi-dwarfing (P 14, M.26, P 60, B 396). Trees on rootstocks assumed as superdwarfing were spaced at a distance of 3.2 × 0.5 m., on dwarfing – at a distance of 3.5 × 0.7 m. and on semi-dwarfing – at a distance of 3.8 × 1.0 m. Each rootstock was represented by 10 trees per plot, in four replications. Alleyways were under sward and herbicide stripes were maintained along tree rows. Vigour of trees was assessed on the base of trunk cross-sectional area (TCSA) after ten years, as well as its increase within ten years (spring 2000 – spring 2010). TCSA was derived from diameter measurement at 30 cm above the ground. The yield was assessed each year on the basis of yield per tree. Cumulative yield was elaborated for the entire period of harvesting (2001–2009). The cropping efficiency coefficient (CEC) was calculated as a cumulative yield from 2001–2009 to the final TCSA (spring 2010). Additionally mean mass of the fruits was assessed. The results were elaborated by analysis of variance, separately for each group of rootstocks. For evaluation of significance of differences between treatment means the Newman-Keuls test was used, at α = 0.05.

RESULTS

For rootstocks considered as semi-dwarfing, after ten years (spring 2010) the trunk cross- sectional area (TCSA) was largest for trees growing on P 14. There were no significant differences in vigour, as far as other rootstocks are concerned (tab. 1). The same applies to the increase of trunk cross-sectional area – spring 2000–2010 (tab. 2). There were no significant differences as far as cumulative yield per tree (2001–2009) was concerned (tab. 6), nevertheless differences were noticed as for single years. In 2001, 2003 and 2007 the yield per tree was the lowest on P 14, whereas in 2006 it was the highest. As for 2002, 2004, 2005, 2008 and 2009 no differences in yield were noticed among trees growing on different semi-dwarfing rootstocks (tab. 3). Fruit size did not depend on the rootstock (tab. 7). The cumulative cropping efficiency (CEC) was the highest for trees on B 396 and P 60, and the lowest on P 14 (tab. 8).

Table 1. Trunk cross-sectional area (TCSA) of apple tree cv. 'Elise' ten years after planting (spring 2010)
Tabela 1. Pole przekroju poprzecznego pnia (PPPP) drzew odmiany 'Elise' po 10 latach badań w sadzie (wiosna 2010)

Semi-dwarfing rootstocks Podkładki półkarłowe	TCSA PPPP cm^2	Dwarfing rootstocks Podkładki karłowe	TCSA PPPP cm^2	Superdwarfing rootstocks Podkładki superkarłowe	TCSA PPPP cm^2
P 14	59.4 b	M.9 EMLA	30.7 d	M.27	13.2 b
P 60	32.3 a	M.9 984	28.7 cd	P 16	13.4 b
B 396	30.7 a	M.9 751	29.6 cd	PB 4	8.7 a
M.26	35.9 a	M.9 T339	24.7 c		
		M.9 Pajam 1	25.2 c		
		M.9 Pajam 2	31.2 d		
		M.9 RN29	24.3 c		
		B.9	24.3 c		
		B.146	18.6 b		
		P 2	25.1 c		
		P 59	9.6 a		

* means followed by the same letter in columns are not significantly different at α = 0.05
* średnie oznaczone tą samą literą w kolumnach nie różnią się istotnie przy α = 0,05

After 10 years, the smallest TCSA on dwarfing rootstocks was observed on P 59, whereas the highest on M.9 EMLA and M.9 Pajam 2 (tab. 1). The same applies to the increase of trunk cross-sectional area – spring 2000–2010 (tab. 2). Significant differences in vigour between the different subclones of M.9 were noted. The TCSA after ten years was the smallest on T 339, Pajam 1 and RN 29 and the largest on EMLA and

Table 2. Increments of trunk cross-sectional area of apple trees cv. 'Elise' within ten years of the study (spring 2000–2010)
Tabela 2. Przyrost pola przekroju poprzecznego pnia (PPPPP) drzew odmiany 'Elise' w ciągu dziesięciu lat badań w sadzie (wiosna 2000–2010)

Semi-dwarfing rootstocks Podkładki półkarłowe	Increments of TCSA PPPPP cm^2	Dwarfing rootstocks Podkładki karłowe	Increments of TCSA PPPPP cm^2	Superdwarfing rootstocks Podkładki superkarłowe	Increments of TCSA PPPPP cm^2
P 14	57.3 b	M.9 EMLA	29.1 de	M.27	12.2 b
P 60	31.0 a	M.9 984	27.2 cde	P 16	12.2 b
B 396	29.2 a	M.9 751	28.2 cde	PB 4	7.6 a
M.26	34.4 a	M.9 T339	23.3 cd		
		M.9 Pajam 1	23.7 cd		
		M.9 Pajam 2	29.7 e		
		M.9 RN29	22.9 c		
		B.9	22.9 c		
		B.146	17.4 b		
		P 2	23.7 cd		
		P 59	8.2 a		

* means followed by the same letter in columns are not significantly different at α = 0.05
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Table 3. Yield of apple tree cv. 'Elise' on semi-dwarfing rootstocks
Tabela 3. Plonowanie drzew odmiany 'Elise' na podkładkach półkarłowych

Rootstock Podkładka	Yield, $kg \cdot tree^{-1}$ Plon, $kg \cdot drzewo^{-1}$								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
P 14	0.6 a	8.7 a	6.0 a	29.8 a	4.8 a	27.8 b	8.8 a	34.9 a	31.2 a
P 60	0.9 a	10.1 a	9.2 ab	22.7 a	7.5 a	17.6 a	15.0 b	26.8 a	29.2 a
B 396	1.8 c	10.2 a	11.5 b	22.6 a	10.8 a	17.7 a	14.7 b	27.1 a	30.8 a
M.26	1.4 b	8.7 a	5.7 a	19.9 a	6.4 a	18.9 a	14.5 b	26.9 a	29.0 a

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Pajam 2 (tab 1). The lowest cumulative yield per tree was obtained on P 59 and the highest on M.9 751. No significant differences in cumulative yield per tree between different subclones of M.9 were noted (tab. 6). Among different dwarfing rootstocks no regularity in yield was noted in successive year. At the period of 2001–2009, yield per tree depended on rootstocks, except for 2005 and 2007, where there were no significant differences (tab. 4). It must be pointed out that at these years ground frost appeared. In 2005, slight frost appeared between 20–25 April (-5.0°C), as well as between 13–14 May (-1.0°C). In 2007, the first slight frost appeared between 21–22 April (-3.5°C) and between 1–2 May (-5.0°C). Nevertheless, the frost did not influence significantly the yield of trees growing on superdwarfing rootstocks (tab. 5). Fruit size did not depend on rootstock (tab. 7). Among dwarfing rootstocks the CEC was the highest on P 59 (tab. 8). The reasons for differences in yield per tree and growth of trees at the period of 2001–2009 were the weather conditions, especially temperature and rainfalls (tab. 9).

Table 4. Yield of apple tree cv. 'Elise' on dwarfing rootstocks.
Tabela 4. Plonowanie drzew odmiany 'Elise' na podkładkach karłowych

Rootstock Podkładka	Yield, $kg \cdot tree^{-1}$ Plon, $kg \cdot drzewo^{-1}$								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
M.9 EMLA	2.7 bc	8.0 c	18.0 ab	19.2 c	8.3 a	16.0 c	7.5 a	19.0 c	25.2 cde
M.9 984	2.9 bc	7.6 bc	19.2 ab	16.3 bc	9.3 a	15.1 c	7.8 a	15.4 bc	23.8 cde
M.9 751	2.5 bc	7.0 abc	20.4 b	15.6 b	13.5 a	14.9 c	12.4 a	17.0 c	26.4 e
M.9 T339	2.5 bc	6.3 abc	18.9 ab	14.7 b	9.3 a	14.4 c	7.4 a	20.9 c	20.6 bcde
M.9 Pajam 1	2.4 bc	6.3 abc	19.2 ab	16.2 bc	10.8 a	13.9 bc	11.2 a	17.6 c	22.4 cde
M.9 Pajam 2	3.3 c	6.6 abc	18.2 ab	14.3 b	10.6 a	14.2 bc	10.4 a	16.4 c	26.0 de
M.9 RN29	2.7 bc	6.0 abc	16.2 a	13.9 b	7.9 a	13.1 bc	7.0 a	17.3 c	19.7 bcd
B.9	2.2 ab	6.7 abc	17.8 ab	15.1 b	8.5 a	13.1 bc	8.8 a	14.5 bc	19.1 bc
B.146	1.9 ab	5.5 ab	18.0 ab	11.1 a	10.7 a	10.3 b	9.5 a	10.1 ab	15.0 b
P 2	1.4 a	6.9 abc	16.1 a	14.9 b	6.4 a	13.1 bc	9.4 a	16.9 c	24.3 cde
P 59	2.3 bc	4.8 a	16.0 a	9.3 a	6.8 a	7.5 a	6.1 a	6.9 a	8.8 a

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Table 5. Yield of apple tree cv. 'Elise' on superdwarfing rootstocks
Tabela 5. Plonowanie drzew odmiany 'Elise' na podkładkach superkarłowych

Rootstock Podkładka	Yield, $kg \cdot tree^{-1}$ Plon, $kg \cdot drzewo^{-1}$								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
M.27	1.9 a	2.3 a	6.0 ab	5.9 a	5.8 a	6.4 a	4.9 b	7.1 a	11.1 b
P 16	1.9 a	3.6 b	7.4 b	8.7 b	8.0 b	9.3b	7.6 c	10.6 b	15.7 c
PB 4	1.6 a	1.7 a	5.0 a	4.1 a	4.1 a	4.7 a	2.2 a	4.6 a	6.2 a

* means followed by the same letter in columns are not significantly different at α = 0.05
* średnie oznaczone tą samą literą w kolumnach nie różnią się istotnie przy α = 0,05

On superdwarfing rootstocks the lowest TCSA and the increase of TCSA had trees on PB 4. Between remaining trees on M.27 and P 16 no significant differences were observed (tab. 1, 2). The lowest cumulative yield per tree was given by the trees on PB 4, whereas on P 16 – the highest (tab. 6). In 2001 there were no significant differences in yield noticed, but a kind of regularity was observed in accordance to P 16. As in majority of years trees on that rootstock presented the greatest yield (tab. 5). Fruit size did not depend on the type of superdwarfing rootstock (tab. 7). The CEC was highest on P 16 (tab. 8).

Table 6. The cumulative yield (2001–2009) of apple tree cv. 'Elise'
Tabela 6. Sumaryczny plon z drzew odmiany 'Elise' (2001–2009)

Semi-dwarfing rootstock Podkładki półkarłowe	Cumulative yield kg·tree^{-1} Skumulowany plon kg·drzewo^{-1}	Dwarfing rootstock Podkładki karłowe	Cumulative yield kg·tree^{-1} Skumulowany plon kg·drzewo^{-1}	Superdwarfing rootstock Podkładki superkarłowe	Cumulative yield kg·tree^{-1} Skumulowany plon kg·drzewo^{-1}
P 14	152.7 a	M.9 EMLA	124.1 bc	M.27	51.5 b
P 60	139.0 a	M.9 984	117.5 bc	P 16	72.9 c
B 396	147.2 a	M.9 751	129.8 c	PB 4	34.3 a
M.26	131.6 a	M.9 T339	115.2 bc		
		M.9 Pajam 1	120.1 bc		
		M.9 Pajam 2	120.2 bc		
		M.9 RN29	103.9 bc		
		B.9	105.8 bc		
		B.146	92.3 b		
		P 2	109.4 bc		
		P 59	68.5 a		

* means followed by the same letter in columns are not significantly different at α = 0.05
* średnie oznaczone tą samą literą w kolumnach nie różnią się istotnie przy α = 0,05

Table 7. Mean fruit mass of apple tree cv. 'Elise'; average for the years 2001–2009
Tabela 7. Średnia masa owocu z drzew odmiany 'Elise'; średnia z lat 2001–2009

Semi-dwarfing rootstock Podkładki półkarłowe	Mean fruit mass Średnia masa owocu g	Dwarfing rootstock Podkładki karłowe	Mean fruit mass Średnia masa owocu g	Superdwarfing rootstock Podkładki superkarłowe	Mean fruit mass Średnia masa owocu g
P 14	217 a	M.9 EMLA	218 a	M.27	179 a
P 60	214 a	M.9 984	216 a	P 16	183 a
B 396	221a	M.9 751	225 a	PB 4	171 a
M.26	215 a	M.9 T339	214 a		
		M.9 Pajam 1	219 a		
		M.9 Pajam 2	225 a		
		M.9 RN29	216 a		
		B.9	214 a		
		B.146	216 a		
		P 2	219 a		
		P 59	203 a		

* means followed by the same letter in columns are not significantly different at α = 0.05
* średnie oznaczone tą samą literą w kolumnach nie różnią się istotnie przy α = 0,05

Table 8. Cropping efficiency coefficient (CEC) of apple tree cv. 'Elise'
Tabela 8. Współczynnik intensywności owocowania (WIO) dla drzew odmiany 'Elise'

Semi-dwarfing rootstock Podkładki półkarłowe	CEC WIO kg·cm^{-2}	Dwarfing rootstock Podkładki karłowe	CEC WIO kg·cm^{-2}	Superdwarfing rootstock Podkładki s uperkarłowe	CEC WIO kg·cm^{-2}
P 14	2.57 a	M.9 EMLA	4.03 a	M.27	3.94 a
P 60	4.32 c	M.9 984	4.10 a	P 16	5.48 b
B 396	4.80 c	M.9 751	4.38 a	PB 4	3.96 a
M.26	3.69 b	M.9 T339	4.74 a		
		M.9 Pajam 1	4.75 a		
		M.9 Pajam 2	3.87 a		
		M.9 RN29	4.26 a		
		B.9	4.37 a		
		B.146	4.93 a		
		P 2	4.39 a		
		P 59	7.17 b		

* means followed by the same letter in columns are not significantly different at α = 0.05
* średnie oznaczone tą samą literą w kolumnach nie różnią się istotnie przy α = 0,05

DISCUSSION

The strongest growth estimated by trunk cross-sectional area, as well as its increase was presented by the trees growing on P 14. On fertile soil in "V" planting system trees on P 14 grew too vigorously and caused problems with machines ride. Opinion presented is confirmed in the research of Wlosek and Jadczuk [1998], Czynczyk et al. [2004] and Skrzyński [2007]. Czynczyk et al. [2009] pointed that trees on P 14 demanded strong and time-consuming cutting, as well as produced too much wood compared to amount and mass of apples. As for vigour of the trees on superdwarfing rootstocks, according to Porębski et al. [2005], trees on PB 4 had similar vigour to M.9. Our research did not confirm that opinion, as trees on PB 4 were dwarfing, as well as showed weaker vigour than M.27 and P 16. It has also been confirmed in the observation of Hirst [2001], Privé [2004], Jadczuk et al. [2007], Piestrzeniewicz and Sadowski [2007] and Piestrzeniewicz et al. [2009], who described that vigour as the weakest.

In our experiment, the highest cumulative yield per tree among superdwarfing rootstocks was obtained on P 16, whereas the lowest on PB 4. High yield of trees growing on P 16 is also confirmed by Hirst [2001], Privé [2004] and Piestrzeniewicz et al. [2009]. Positive impact of P 16 rootstock on yield of the trees is proven by experiments' results of Callesen [1997], Barritt et al. [1997] and Sadowski et al. [1999]. Results obtained within the experiment prove that trees growing on subclones of M.9 did not show differences in yield, as well as mean fruit mass. That has also been confirmed by Loreti et al. [2001], Vercammen et al. [2007] and Czynczyk et al. [2009].

Table 9. Mean temperatures and precipitation sums in 2001–2009 (Meteorological Station, Warsaw-Ursynów)
Tabela 9. Średnie temperatury i sumy opadów w latach 2001–2009 (Stacja Meteorologiczna, Warszawa-Ursynów)

Year Rok	January Styczeń	February Luty	March Marzec	April Kwiecień	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	October Październik	November Listopad	December Grudzień	Annual mean value Średnia roczna
	mean temperatures, °C – średnie tempetarury, °C												
2001	0.0	-0.8	2.2	8.0	14.7	15.5	20.8	19.7	12.5	11.5	2.9	-3.9	8.6
2002	-0.3	3.6	4.6	9.0	17.6	17.9	21.5	21.3	14.4	7.9	4.7	-6.2	9.7
2003	-2.8	-4.9	1.9	7.3	15.7	17.9	20.4	19.3	14.5	5.9	5.6	1.4	8.5
2004	-4.9	0.1	3.2	8.5	11.8	15.9	18.0	19.6	14.2	10.5	4.8	2.2	8.7
2005	1.1	-3.1	0.0	8.9	13.5	15.9	20.8	18.0	16.4	10.2	3.7	0.3	8.8
2006	-8.3	-3.1	-1.1	8.6	13.7	18.0	22.6	17.8	15.1	9.9	5.4	3.6	8.5
2007	3.8	-1.0	7.4	10.1	16.0	19.4	19.3	19.4	8.6	13.8	2.1	0.5	9.9
2008	1.4	3.5	4.0	9.6	14.1	19.3	19.7	19.0	13.0	10.7	5.7	1.7	10.1
2009	-2.4	-0.4	2.9	11.3	13.9	16.3	20.2	18.5	15.5	6.9	5.7	-1.0	8.9
	sum of precipitations, mm – sumy opadów, mm												Annual sum Suma roczna
2001	18.3	14.8	28.3	62.1	37.8	35.8	137.0	37.6	72.8	37.0	33.7	18.3	533.5
2002	33.4	71.0	35.8	17.3	44.0	54.8	23.0	140.8	30.8	58.8	29.0	1.9	540.6
2003	29.5	3.1	11.1	16.2	45.4	42.6	133.3	33.7	52.2	45.4	23.2	45.4	481.1
2004	20.6	49.2	26.7	57.8	58.0	46.8	71.0	46.8	17.4	36.6	51.5	15.4	497.8
2005	33.5	34.4	38.5	22.4	60.2	48.2	83.6	22.4	32.8	5.4	30.1	80.0	492.5
2006	27.8	33.4	13.2	41.0	61.0	22.6	80.9	179.0	14.4	22.0	10.4	124.0	630.6
2007	100.9	39.2	34.3	20.1	74.1	86.8	91.4	44.8	79.1	30.8	42.9	12.6	656.4
2008	74.2	23.8	42.4	31.0	36.8	24.5	97.8	89.0	53.7	19.9	30.9	45.8	570.0
2009	20.6	41.3	52.5	8.0	82.4	123.1	123.3	82.7	13.9	100.3	62.5	55.4	766.0

According to the research conducted, rootstock did have influence on cropping efficiency coefficient (CEC). The highest CEC was observed on P 59 and P 16, and the smallest on P 14, what has been confirmed within the research done by Bielecki et al.[1999], Zagaja [1980], and Słowiński [2004].

CONCLUSIONS

1. Trees growing on semi-dwarfing rootstock P 14 presented too vigorous growth and were not appropriate for high-density planting in "V" system.

2. Trees planted on M.9 EMLA and other subclones on M.9 presented highest productivity, and no significant differences between them were noted as far as yielding in concerned. These rootstocks are considered as universal for intensive orchard on fertile soil.

3. Research conducted proved, that rootstock P 59 had a greater limiting impact on 'Elise' trees growth, than any other dwarfing rootstock. Trees on this rootstock were the smallest and gave the lowest yield.

4. Trees growing on P 16 had relatively low vigour and high cropping efficiency coefficient, what makes that rootstock a promising alternative for M.9 for intensive orchard on fertile soil.

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WZROST I OWOCOWANIE JABŁONI 'ELISE' NA OSIEMNASTU PODKŁADKACH WEGETATYWNYCH, PROWADZONEJ W SYSTEMIE „V"

Streszczenie. Intensyfikacja produkcji sadowniczej jest możliwa dzięki użyciu odpowiedniej podkładki dla danej odmiany. W latach 2000–2009 prowadzono obserwacje i pomiary drzew jabłoni odmiany 'Elise' rosnącej na osiemnastu podkładkach wegetatywnych podzielonych na trzy grupy w zależności od siły wzrostu drzew: superkarłowe

(M.27, P 16, PB 4), karłowe (B 9, B 146, P 2, P 59, siedem podklonów podkładki M.9: EMLA, Burgmer 984, Burgmer 751, T 339, Pajam 1, Pajam 2, RN 29) oraz półkarłowe (P 14, M.26, P 60, B 396). Drzewa na podkładkach superkarłowych rosły w rozstawie 3,2 × 0,5 m, na podkładkach karłowych 3,5 × 0,7 m, natomiast na podkładkach półkarłowych w rozstawie 3,8 × 1,0 m. Spośród wszystkich badanych podkładek najsilniejszy wzrost wykazywały drzewa rosnące na podkładce P 14, najsłabszym wzrostem charakteryzowały się drzewa rosnące na podkładce PB 4. Zarówno najmniejsze pole przekroju poprzecznego pnia (PPPP) po dziesięciu latach wzrostu w sadzie, jak i przyrost pola przekroju poprzecznego pnia (PPPPP) za lata 2000–2009 w grupie podkładek superkarłowych uzyskały drzewa rosnące na podkładce PB 4, natomiast wśród podkładek karłowych na podkładce P 59. W grupie podkładek półkarłowych największe PPPP oraz PPPPP uzyskały drzewa na P 14. Najwyższy sumaryczny plon za lata 2001–2009 w grupie podkładek superkarłowych otrzymano z drzew na podkładce P 16, najniższy zaś z drzew na podkładce PB 4. Spośród podkładek karłowych najsłabiej plonowały drzewa na podkładce P 59, najsilniej na podkładce M.9 751. Podkładka miała istotny wpływ na wskaźnik intensywności owocowania drzew (WIO). W grupie podkładek superkarłowych najwyższy WIO uzyskano z drzew na podkładce P 16, w grupie podkładek karłowych na podkładce P 59, natomiast w grupie podkładek półkarłowych na podkładce P 60 i B 396.

Słowa kluczowe: podkładka, siła wzrostu, sumaryczny plon, współczynnik intensywności owocowania, wielkość owoców

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