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GROWTH, QUALITY AND PRODUCTIVITY IN STOOL BEDS OF ROOTSTOCKS M.9 AND M.26

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ABSTRACT

The study was conducted in the years 1998-2002, at two private nursery farms in the Lublin region, and comprised the estimation of the productivity of the stool bed, and of the quality and the growth dynamics of two apple-tree rootstocks with the greatest economic importance – M.9 and M.26.

Comparing the growth of rootstocks in M.9 and M.26 nurseries on the basis of their length and diameter, and estimating the weight of a single leaf, it was found that all of those traits achieved higher values in the mother plantation of the M.26 rootstock. The growth dynamics of both rootstocks under estimation was similar – the greatest growth increments were recorded during the initial three months. In each of the experiment the nursery of M.26 rootstocks was more productive than that of M.9 rootstocks. The number of rootstocks taken out depended on the age of the mother plantations and increased in the successive years. On average, in the final year of the experiment nearly 80% rootstocks more were obtained than in the first year of the experiment. The highest percentage share, for both M.9 and M.26 rootstocks, was noted for offshoots with diameters above 8 mm – 43.9% and 68.2%, respectively. In the M.9 nursery twice as many non-rooted offshoots were obtained (15.6%) than in the case of the M.26 rootstock.

It was demonstrated that there are correlations among the growth parameters studied, the correlations being stronger between the offshoots diameters and their length than between the length of rootstock offshoots and the weight of a single leaf.

Key words: stool bed, offshoot diameter and length, productivity.

INTRODUCTION

The quality of nursery material used to establish an orchard is highly important. Mistakes made in the process of rootstock production and then trees will have an effect on the productivity of the orchard, and losses resulting from the use of unsuitable material will increase year by year. Therefore it is important to get to know the optimum conditions for the production of the initial material, i.e. rootstocks.

A very important aspect in the nursery practice is the ease of rootstock multiplication, permitting the obtainment of a large number of well grown and rooted rootstocks in a short period of time [3, 14, 18].

The necessary condition for the production of strong and branched trees is that they must be produced on healthy and virus-free rootstocks of high quality [1], which emphasises the importance of stool beds. Rootstocks acquired from a mother plantation are highly varied in terms of quality. The shares of offshoots with various thickness depends on the conditions of rootstock growth [11]. The type of rootstock and its thickness have a bearing on its taking root after planting in a nursery. Bielicki and Czynczyk [1] obtained the highest rates of taking root (90–92%) for rootstocks with diameters of 7–9.9 mm and with numbers of roots higher than 5. The percentage of rootstocks that have taken root was increased by soil fertility, greater number of roots, and irrigation. However, in a study by Kiczorowski [8] there were no differences in the rate of taking root in the nursery with relation to the clone and the rootstock thickness.

In numerous experiments the rootstock and its thickness had an effect on the quality of the scions obtained. The height and the diameter of the trees increased with increase in the rootstock thickness [1, 4, 5, 7, 8].

The objective of the study presented here was the estimation of the productivity of stool beds, and of the quality and growth dynamics of two apple tree rootstocks of the greatest economic importance.

MATERIAL AND METHODS

The study was conducted in the years 1998–2002, at two private nursery farms in the Lublin Province. The experiment comprised model-maintained stool beds of apple tree rootstocks M.9 and M.26, free of viruses, originating from Holland. In both stool beds the rootstocks were multiplied through vertical offshoots.

The mother plants had been planted in 1995, on similar soils. The particle size distribution of the soils classifies them among silty clay formations. The formations are characterised by a low content of sand (2–9%), a considerable share of the silt fraction (46-64%) and of the fine fraction (30–48%).

The following measurements and observations were performed:

- shoot length on four dates: 20th June, 20th July, 20th August, 30th September,
- shoot diameters at the height of 30 cm above the base,
- fresh mass of a single leaf,
- productivity of 1 hectare of stool bed,
- percentage shares of shoots with different diameters,
- percentage share of shoots with no roots,
- correlation between the growth indices studied.

The measurements were taken from the one running meter of stool bed plants in 10 replications.

The mean monthly air temperatures and precipitation during vegetative seasons in the individual years of study in the Table 1 and 2 are presented.

Table 1. Average monthly temperatures (°C) during vegetative season in 1998–2002

Year/Month	April	May	June	July	August	September	October
1998	9.5	13.8	17.5	17.5	15.9	12.3	6.4
1999	8.8	11.1	18.5	20.0	17.3	14.7	7.2
2000	11.1	14.4	17.0	17.0	18.2	11.1	10.6
2001	8.5	13.9	15.3	21.6	19.7	11.9	10.2
2002	8.6	12.4	17.8	21.8	25.0	12.9	8.3

Table 2. Monthly sums (mm) of precipitation during vegetative season in 1998–2002

Year/Month	April	May	June	July	August	September	October
1998	63.9	49.6	61.5	84.0	100.8	59.7	62.6
1999	81.6	45.9	160.9	102.1	33.5	37.6	34.9
2000	68.0	50.7	36.4	138.1	28.3	66.7	2.2
2001	64.9	19.9	47.6	260.9	67.5	125.8	19.3
2002	18.3	28.6	116.8	126.2	18.7	42.5	92.9

The results were subjected to analysis of variance. The significance of differences was assessed on the basis of the Tukey test, at confidence level of α = 0.05%

RESULTS

In all the years of the experiment shoots of rootstock M.26 were longer than those of M.9. in the mother bed of rootstock M.26 a tendency was observed for the length of the shoots to increase in the successive years (except for 2001, when they were shorter than in 2000). A similar tendency occurred in the case of rootstock M.9, where the exception was the September measurement date (Tab. 3).

Table 3. Rootstock shoot length (cm) on four measurement dates and in the years of experiment

Year	Rootstock	Date of measurement			
		20th June	20th July	20th August	30th September
1998	M.9	–	–	–	65.7
	M.26	–	–	–	81.9
1999	M.9	36.3	58.1	62.5	69.9
	M.26	45.1	77.7	82.9	96.1
2000	M.9	36.4	53.8	72.1	83.4
	M.26	46.2	67.0	93.9	106.7
2001	M.9	20.4	51.8	73.3	83.1
	M.26	25.0	69.4	91.1	101.2
2002	M.9	35.1	55.2	77.2	84.1
	M.26	40.7	71.2	103.5	109.8
Mean for the years	M.9	32.1 a*	54.7 bc	71.3 cd	77.2 de
	M.26	39.3 ab	71.3 cd	92.9 ef	99.1 f

* Mean values followed by the same letter are not statistical different at α = 0.05

The most intensive growth of shoots was observed during the period from the beginning of vegetation till mid June, then the rate of growth decreased (Fig. 5). The shortest shoots were observed in August 1999 (for M.9 the shoot length increase was 4.4 cm, and for M.26 – 5.2 cm) (Fig. 1), whereas the longest were noted in June 2000 for both rootstock types (M.9 – 36.4 cm; M.26 – 46.2 cm) (Fig. 2). In 2001 the rootstocks under study achieved the greatest length increase during the period from 20th June till 20th July (Fig. 3). The year 2002 was characterised by similar shoot length increments in July (Phot. 1) and August (Fig. 4).

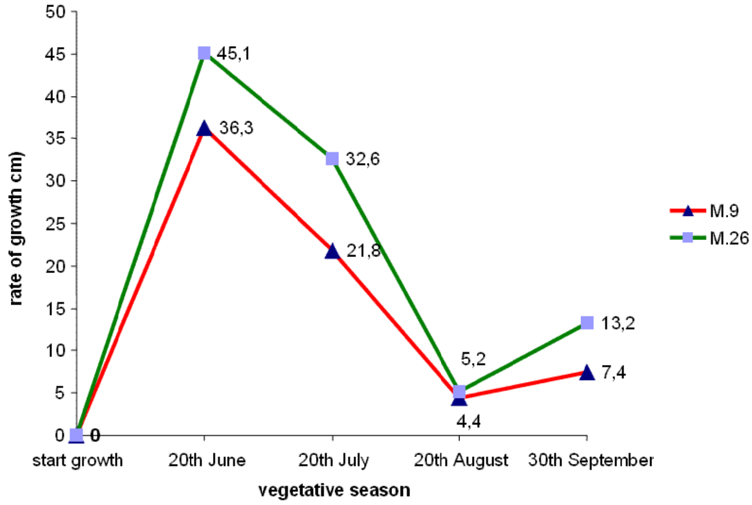

Fig. 1. Dynamics of growth of shoots of rootstocks M.9 and M.26 in 1999

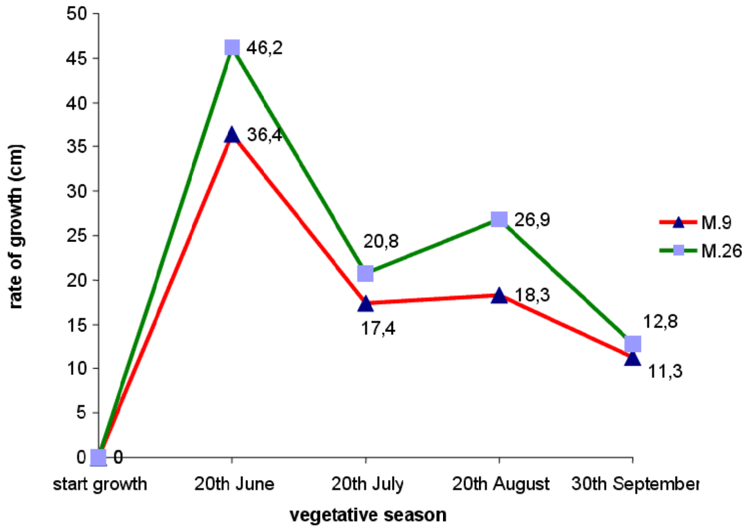

Fig. 2. Dynamics of growth of shoots of rootstocks M.9 and M.26 in 2000

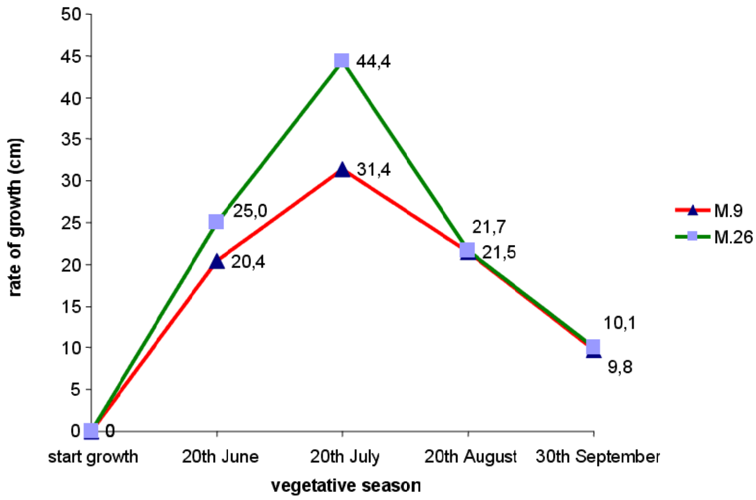

Fig. 3. Dynamics of growth of shoots of rootstocks M.9 and M.26 in 2001

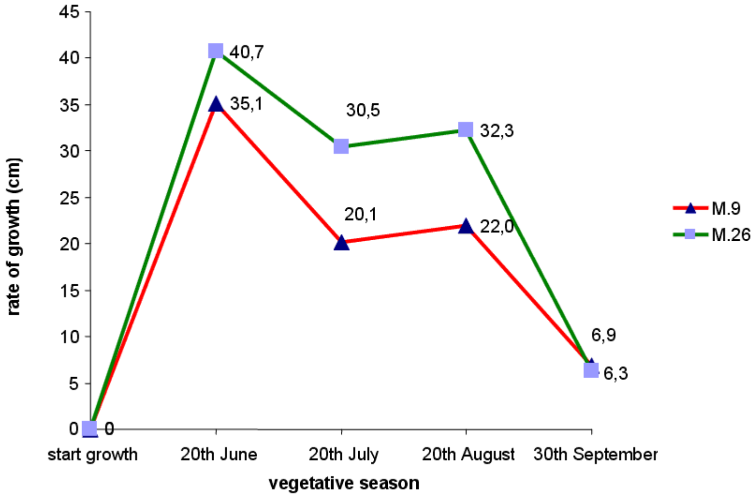

Fig. 4. Dynamics of growth of shoots of rootstocks M.9 and M.26 in 2002

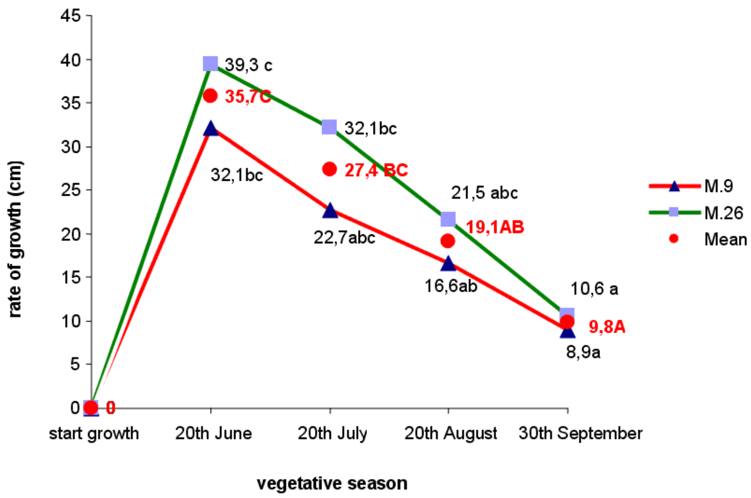

Fig. 5. Dynamics of growth of shoots of rootstocks M.9 and M.26 (mean for four years and the two rootstock types)

Photo 1. Stool bed of M.9 rootstock in July

The thickest shoots were obtained in both stool beds in 2002. On average, rootstock M.26 had shoots 13.2% thicker than M.9; significant differences in shoot thickness were also recorded in the particular years of the experiment, except 2001. Shoot thickness of rootstock M.9 increased with the age of the mother plantation. A similar relationship was observed in the stool bed of rootstock M.26, with the exception of 2001, and also in the case of the mean value for both clones (Tab. 4).

Table 4. Shoot diameter (mm) measured at the height of 30 cm

Year	Rootstock		Mean for the years
	M.9	M.26	
1998	5.8 a*	7.6 bc	6.7 A*
1999	7.4 b	7.9 cd	7.6 B
2000	8.2 de	9.3 g	8.7 C
2001	8.3 def	8.7 f	8.5 C
2002	8.5 ef	9.7 g	9.1 D
Mean for the rootstocks	7.6 A	8.6 B	

* Mean with the same kind of letter (small or big) are not significantly different at α = 0.05.

In the particular years and on the particular dates of measurement leaves of rootstock M.26 were characterised by greater weight than those of M.9. The greatest weight of one leaf of rootstock M.9 was recorded in 2000 (0.723 g), and for rootstock M.26 in 2000 and 2002 that trait reached the same value – 0.744 g. The weight of leaves of both rootstocks increased on the successive dates of measurement during the vegetation period (Tab. 5).

Table 5. Weight of a single leaf (g)

Year	Rootstock	Date of measurement				Mean for rootstock	Mean for year
		20th June	20th July	20th August	30th September		
1999	M.9	0.564	0.611	0.602	0.711	0.622	0.642 a*
	M.26	0.623	0.665	0.633	0.723	0.661	
2000	M.9	0.527	0.755	0.737	0.873	0.723	0.733 b
	M.26	0.495	0.758	0.865	0.857	0.744	
2001	M.9	0.538	0.720	0,591	0.716	0.641	0.658 a
	M.26	0.594	0.813	0.632	0.657	0.674	
2002	M.9	0.660	0.651	0.779	0.691	0.695	0.719 b
	M.26	0.685	0.662	0.839	0.788	0.744	
Mean for the rootstocks	M.9	0,572	0.684	0.677	0.747		
	M.9	0.599	0.725	0.742	0.756		
Means		0.586 a	0.704 b	0.710 b	0.752 b		

* For explanations, see Table 3.

The relationships between the shoot growth indices calculated for the two rootstock types were highly significant. The closest correlation was obtained between the length and the diameter of the shoots (Tab. 6).

Table 6. Values of correlation coefficients

Traits compared	Correlation coefficient
Shoot length × shoot diameter	0.71 **
Shoot length × weight of 1 leaf	0.63 **
Shoot diameter × weight of 1 leaf	0.45 n.i.

** correlation significant at α = 0.01%

In every year of the experiment the stool bed of rootstock M.26 was more productive than that of rootstock M.9, on average by 69.6% for all the years. The highest productivity of both mother plantations was recorded in 2002, when the yield per 1 ha reached 122,000 shoots of rootstock M.9 and 201,000 shoots of M.26. The number of rootstocks produced depended on the age of the mother plantations and increased in the consecutive years. In 1998 the yield per hectare was 70,100 shoots of rootstock M.9, while in 2002 as many as 122,000 shoots. Likewise in the mother plantation of rootstock M.26: in 1998 – 109400, and in 2002 – 201,000 shoots. On average, in the final year of the experiment the yield of rootstocks was almost 80% higher than in the first year of the experiment (Tab. 7).

Table 7. Productivity of 1 ha of stool bed (pcs.)

Year	Rootstock		Mean for the years
	M.9	M.26	
1998	70,100 a	109,400 d	89,750 A
1999	89,890 b	149,200 f	119,545 AB
2000	91,200 b	153,330 f	122,265 B
2001	100,700 c	191,000 g	145,850 BC
2002	122,000 e	201,000 h	161,500 C
Mean for the rootstocks	94,778 A	160,786 B	

* Mean with the same kind of letter (small or big) are not significantly different at α = 0.05.

Table 8. Percentage share of shoots with different diameters

Year	Rootstock							
	M.9				M.26			
	> 8 mm	5–8 mm	< 5 mm	no roots	> 8 mm	5–8 mm	< 5 mm	no roots
1998	35.9	25.3	21.5	17.3	72.1	14.4	5.6	7.9
1999	46.6	16.5	20.7	16.2	73.3	16.4	5.1	5.2
2000	53.2	12.8	17.0	17.0	66.7	23.1	4.6	5.6
2001	43.9	31.2	11.7	13.2	64.1	25.3	5.2	5.4
2002	39.7	33.2	12.6	14.5	65.0	22.5	6.3	6.2
Mean for years	43.9 d	23.8 c	16.7 c	15.6 bc	68.2 e	20.3 c	5.4 a	6.1 ab

* For explanations, see Table 3.

In all the years of the study the share of shoots of rootstock M.26 with diameters >8 mm was higher than in the case of rootstock M.9. The greatest number of rootstocks with diameters >8 mm was obtained in the M.26 mother plantation in 1999 (73.3%), while in the M.9 mother plantation – in 2000 (53.2%). In both mother plantations a similar percentage share of rootstocks with diameters of 5–8 mm was obtained. The difference between M.9 and M.26 was 3.5%. The number of rootstocks with diameters < 5 mm was almost three-fold greater in the case of M.9 compared to M.26. In the stool bed of rootstock M.9 a rather high proportion of shoots with no roots was observed – an average of 15.6%, compared to 6.1% for the M.26 mother plantation (Tab. 8).

DISCUSSION

The quality of rootstocks produced on mother plantations depends both on the rootstock type and on a number of agricultural practice measures. Comparing the growth of shoots in the stool beds of rootstocks M.9 and M.26 on the basis of their length and diameter and by estimating their weight of a single leaf it was observed that all the traits under study achieved higher values in the stool bed of rootstock M.26. That advantage of M.26 over M.9 may result from genetic differences [15], or from more favourable soil conditions in the mother bed of rootstock M.26. Similar results were obtained by Stachowiak and Świerczyński [17] in a study where rootstock M.26 had taller and larger-diameter shoots than rootstocks M.9 and MM106. In turn, in a study by Kopytowski [9], rootstock M.9 in the mother plantation had shoots longer than those of M.26. The same author reports that shoots of rootstock M.26 had larger diameters than shoots of rootstock M.9, which is in agreement with the present results. Whereas, in a study by Bulgarian researchers [19] the thickest rootstock among the five types studied (M.9, M.26, J-TE-H, J-OH-A, J-TE-F) was M.9 with a mean diameter of 10.1 mm.

The study showed the existence of correlations between the growth parameters studied, stronger correlations occurring between rootstock diameters and their length than between the shoot length and the weight of a single leaf. Masseron (cited after Ugolik) [21], studying subclones of rootstock M.9, demonstrated a variation in morphological traits and in the capacity for taking root in the mother bed. Subclones M.9 EMLA, T337 and SP1, with large leaves (101×63 mm), had shorter shoots (50–70 cm) and greater diameters (8.7 mm). Shoots of subclones with small leaves (76×54 mm), e.g. Cepiland, were longer (100–120 cm) and thinner (6.5 mm). In the experiment under discussion the shoots of rootstock M.9 T337 had a mean length of 77.2 cm and diameter of 7.6 mm.

The mean weight of a single leaf of M.26 was 0.705 g, and of M.9 – 0.670 g, whereas in a French study [22] leaves of rootstock M.9 (0.45 g) were heavier than those of M.26 (0.35 g).

According to Czynczyk [2, 3], the productivity of a mother plantation depends primarily on the rootstock clone, and also on soil fertility, fertilisation applied, plant care, and age of the mother plant. Rootstock M.26 is classified among medium-productive rootstocks, while the productivity of rootstock M.9 depends primarily on its subclone. Generally, juvenile forms more shoots with roots in mother plantations than senile forms do [15, 21]. However, Tamai et al. [20], comparing four Japanese senile forms of rootstock M.9 with European clones, obtained very good rootage of all objects studied. In this study the productivity of rootstock M.26 was higher than that of M.9, and in both cases increased with the age of the plantation. An identical relation was observed by Rusnak [16] in a mother plantation of rootstock MM 106.

The number of shoots obtained from the mother stool bed of rootstock M.26 was nearly 70% higher than that of M.9. The mean number for the five years was 160,786 in the case of M.26, and for M.9 – 94,778 rooted shoots. Poorer results were obtained by Czynczyk [3]: for M.26 – 50–80 thousand shoots, for M.9 T337 – 60–80 thousand shoots. Better rooting of shoots of rootstock M.26 as compared to M.9 was shown in a study by Quamme and Brownlee [12], whereas Kopytowski [9] obtained more shoots rooted on sawdust in the case of rootstock M.9 (174 thousand) than of M.26 (134 thousand). The productivity of a mother plantation depends also on the manner in which it is maintained. The productivity of stool beds with horizontal shoots is higher. Rejman and Makosz [14] report after Krzewiński that 6 to 10 rootstocks per plant can be obtained from four years old mother plants of rootstock M.9. Tamai et al. [19] obtained 10 rooted shoots from one plant of M.9 Nagano, the same number was obtained by Przybyła [13] from a mother plant of M.26, Quamme et al. [12] obtained 21.1 rooted shots from 1 running meter of a mother bed, and Kozłowski [10] – 30 rooted shoots of rootstock M.26. Stachowiak and Świerczyński [17] obtained from one mother plant 11.5 rootstocks M.9 and 13.6 rootstocks M.26. In the present experiment – mean for the five years –1 running metre of plantation yielded 23 rootstocks for M.26, and for M.9 – 13 rooted shoots.

Rootstocks produced on mother plantations are highly differentiated in terms of quality. The shares of shoots with various diameters depend on the growth conditions and on the rootstock type. In this experiment the highest percentage share was recorded for shoots with diameters above 8 mm, for both M.9 and M.26, at 43.9% and 68.2%, respectively. Likewise, in the study by Tabakov and Yordanov [19], the diameter of most shoots from the stool beds of M.9 and M.26 was greater than 8 mm, while Stachowiak and Świerczyński [17], in a mother plantation of rootstocks M.9 and M.26, obtained over 70% of shoots meeting the requirements of the Polish Standard PN-R-67010. Whereas, Kiczorowski [6] reports that rootstock M.9 had only 6% of shoots with diameters of 9–11 mm, and as much as 63% of shoots with diameters of 5–7 mm.

REFERENCES

1. Bielicki P., Czynczyk A., 1992. Wstępne wyniki z doświadczenia nad wpływem jakości podkładek słabo rosnących na liczbę i jakość otrzymanych drzewek w szkółce (The preliminary data from research on the influence of dwarf rootstocks quality on the number and quality of young trees in nursery). Prace ISiK, seria C, nr 3–4 (115–116), 164–167 (in Polish).

2. Czynczyk A., 1997. Nowoczesna technologia zakładania i prowadzenia plantacji matecznych podkładek wegetatywnych (The new technology of establishment and management on mother nursery of vegetative rootstocks). ISiK Skierniewice (in Polish).
3. Czynczyk A., 1998. Szkółkarstwo sadownicze (Fruit nursery production). PWRiL Warszawa (in Polish).
4. Gudarowska E., 1996. Zależność pomiędzy grubością sadzonych podkładek do szkółki a jakością uzyskanych drzewek jabłoni (The relationship between the thickness of rootstocks planted in nursery and quality of achieved young apple trees). XXXIV Ogólnopol. Kon. Nauk., Skierniewice: 198–201 (in Polish).
5. Gudarowska E., 2000. Wpływ jakości czterech podkładek wegetatywnych na wzrost i owocowanie dwóch odmian jabłoni w pierwszych pięciu latach po posadzeniu drzew (The influence of four vegetative rootstocks on the growth and yielding of two apple cultivars during five years after planting). Praca dokt.. AR w Wrocławiu, 178 (in Polish).
6. Kiczorowski P., 1994. Wpływ różnej średnicy pnia pięciu typów podkładek na ich wzrost w pierwszym roku prowadzenia szkółki (The influence the differenced trunk diameter of five types of rootstocks on their growth in the first year of nursery establishment). III Międzynarodowe Sem. Szkółkarskie Lublin, Szkółkarstwo, nr spec., 49–50 (in Polish).
7. Kiczorowski P., 1998. Wzrost okulantów jabłoni odmiany ‘Jonagold’, ‘Jonica’ na czterech typach podkładek wegetatywnych (The growth of apple one-year-old maidens cv. ‘Jonagold’ and ‘Jonica’ on four types of vegetative rootstocks). XXXVII Ogólnopol. Nauk. Konf. Sadownicza, Sesja poster., Skierniewice, 508–509 (in Polish).
8. Kiczorowski P., 2003. Badania wybranych czynników wpływających na wzrost podkładek i jakość okulantów jabłoni odmiany ‘Jonica’ (The study of chosen factors influenced on growth of rootstocks and quality of apple one-year-old maidens cv. ‘Jonica’). Praca doktorska AR w Lublinie (in Polish).
9. Kopytowski J., 2001. Effect of different substrates on rootage of shoots in mother plantation of selected apple clones. Sodininkyste ir daržininkyste, Mokslo darbai 20 (3) – 2, 155–159.
10. Kozłowski W.M., Kawecki Z., Kropisz A., 1991. Dwuletnie obserwacje wpływu substancji organicznych na ukorzenianie się podkładek jabłoni. Intensyfikacja sadownictwa w Polsce. Racjonalne nawożenie roślin sadowniczych (The two years observations of the influence of organic substances on apple rootstocks rooting. Intensification fruit crop in Poland. Rational nutrition of fruit plant). ART. Olsztyn, 27–28 maja 1991, 85–89 (in Polish).
11. Lipa T., 2010. Właściwości fizyczne gleby a system korzeniowy roślin matecznych podkładek wegetatywnych jabłoni (Mechanical properties of soil and root system of apple rootstocks in the stoolbed). Acta Agrophysica 2010, 15 (1), 135–143 (in Polish).
12. Quamme H.A., Brownlee R.T., 1990. Stool layering ability of thirty-one apple rootstock cultivars. Fruit Var. J., 44(3), 165–169.
13. Przybyła A.A., 2003. Polskie podkładki dla jabłoni uzyskane w wyniku hodowli mutacyjnej (The Polish rootstocks for apple trees obtained in mutation breeding). OWK, 23, 24 (in Polish).
14. Rejman A., Makosz E., 1994. Szkółkarstwo roślin sadowniczych (Fruit plant nursery production). Plantpress, Kraków (in Polish).
15. Rejman A., Ścibisz K., Czarnecki B., 2002. Szkółkarstwo roślin sadowniczych (Fruit plant nursery production). PWRiL, Warszawa 2002 (in Polish).
16. Rusnak J., 1976. Wstępne wyniki z zastosowania trocin do obsypywania matecznika podkładek wegetatywnych jabłoni typu MM 106 (The preliminary data from using sawdust to mulching of apple vegetative mother rootstocks MM 106). Prace ISK, seria C, nr 1–2 (53–54), 49–52 (in Polish).
17. Stachowiak A., Świerczyński S., 2006. Application of double root system in a mother field of rootstocks for apple trees. Roczniki AR w Poznaniu – 379 (2006) 40, 53–57.
18. Ślaski J., 1974. Szkółkarstwo (Nursery production). PWRiL (in Polish).
19. Tabakov S., Yordanov A., 2006. Performance of some vegetatively propagated apple rootstocks in the nursery. Scientific works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture. Sodininkyste ir daržininkyste 25 (3), 85–89.
20. Tamai H., Ono T., Koikke H., Shigehara L., Jijima A., 2003. Morphological characteristics of 4 clones of M.9 apple rootstock and propagation of M.9 Nagano in the stool bed. Hort. Abstr. 2003, 73, 4, 241–244.
21. Ugolik M., 1986. Jabłoń rajska Żółta z Metz i jej podklony (Crab apple the Jaune de Metz and their subclones). Ogrodnictwo 10, 9–10 (in Polish).
22. Villeneuve F., Boulay H., 1998. Analyse de l’incidence du porte-greffe sur l’absorption et le transfer elements mineraux chez la variete de pommier ‘Golden Delicious’. 8 e Colloque sur les recherches fruitieres – Bordeaux, 7–8 December 1988, 39–57.

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