PERFORMANCE OF 'RUBIN' APPLE TREES ON NINETEEN ROOTSTOCKS AFTER FOUR YEARS
ĀBEĻU ŠĶIRNES 'RUBIN' IZVĒRTĒJUMS UZ 19 POTCELMIEM ČETRUS GADUS PĒC STĀDĪŠANAS

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Kopsavilkums

Izmēģinājums tika ierīkots auglīgās aluviālās augsnēs Varšavā, 2001. gadā. Pēc četriem gadiem izvērtējot koku izmēru, kurš izteikts stumbra šķērsgriezuma laukumā, mazākais bija uz Nr. 629 un J-TE-G, tad secīgi pieaugošā kārtībā No 280, PB-4, M. 27, P 59, P 22, No. 387, P 64, P 63, P 65, Unima, P 16 un B 146. Lieli koki bija uz P 66 un B 491, bet vislielākie - uz Arm 18, P 62 un M.9 EMLA. Augstākā kumulatīvā raža 2002. – 2004. gados bija uz P 63, P 65, P 16, P 66, B 491, Arm 18, M.9 EMLA un P 22; kokiem uz P 62, P 59, Unima, No. 387, B 146 un P 64 bija zemas ražas; bet uz PB-4, No. 280, M.27, J-TE-G and No. 629 bija viszemākās ražas. Augstākais ražošanas efektivitātes koeficients (kumulatīvā raža / stumbra šķērsgriezuma laukums) pēc 4. gada bija uz P 63, P 65, P 59, P 22 un P 16, zemākais uz Arm 18, M.9 EMLA and P 62.

Abstract

The trial was established on a fertile alluvial soil at Warsaw-Wilanów, Central Poland, in spring 2001. After four years, tree size, expressed as TCSA, was the smallest on No. 629 and J-TE-G, and then, in increasing order, on No. 280, PB-4, M.27, P 59, P 22, No. 387, P 64, P 63, P 65, Unima, P 16 and B 146; still larger were trees on P 66 and B 491, whereas those on Arm 18, P 62 and M.9 EMLA were the largest. Cumulative yield per tree for the 2002-2004 period was highest on P 63, P 65, P 16, P 66, B 491, Arm 18, M.9 EMLA and P 22; trees on P 62, P 59, Unima, No. 387, B 146 and P 64 gave lower yields, while yields of those on PB-4, No. 280, M.27, J-TE-G and No. 629 were the lowest. The cropping efficiency coefficient, calculated as a ratio of cumulative yield to the TCSA after the 4th year, was highest on P 63, P 65, P 59, P 22 and P 16, and lowest on Arm 18, M.9 EMLA and P 62. The highest yield per ha was obtained from trees on p 63, P 65, P 22 and P 16.

Keywords: apple, rootstock, tree vigour, yield, cropping efficiency, fruit size

Introduction

The Czech apple cultivar Rubin has gained some interest in Poland due to the exceptionally high dessert quality of its fruit (Kruczyńska, 2002). It is considered as one of the tastiest apples in Central Europe. Unfortunately its precocity, as well as its yielding potential, were estimated as rather low (Ugolik *et al*., 2001). Selecting appropriate rootstocks may solve these problems.

Apple growing in Europe is dominated by the old but superb rootstock M.9 (Wertheim, 1998). However, , when grown on very rich soils, trees of vigorous cultivars on M.9 develop too large canopies. Searching for rootstocks inducing weaker vigour is thus necessary (Sadowski, 1999). Testing new rootstocks, bred in different countries, gives an opportunity to select more valuable clones for specific cultivars and specific site conditions. In general, a good rootstock should ensure small tree stature, thus allowing an efficient transformation of solar energy into fruit (Cummins and Aldwinckle, 1983). Other essential features of rootstocks are an ability to induce early, high and regular cropping and create a positive influence on fruit quality (Zagaja *et al*., 1989; Jakubowski, 2004). High winter hardiness is also a desirable characteristic in Poland. Before a rootstock is officially recommended, it should be carefully evaluated, in comparison to the standard rootstocks, under orchard conditions (Jadczuk and Wlosek-Stangret 1999, Czynczyk *et al*. 2001; Jakubowski, 2004).

For Polish climate and soils, native rootstocks or those obtained in countries with similar natural conditions may be the most suitable. Of special interest are rootstocks coming from the breeding programme carried out at the Research Institute of Pomology and Floriculture at

Skierniewice (Zagaja *et al*., 1988). Some interesting rootstocks have been also selected in other countries of Central and Eastern Europe (Samuś, 1996). They apparently need a more careful evaluation.

The objective of this study is to test the suitability of different rootstocks for the vigorous apple cultivar Rubin, grown on a fertile soil, with special reference to the new rootstocks bred in Poland. Preliminary results have been presented in the paper of Piestrzeniewicz and Sadowski (2005).

Materials and Methods

The trial was set up on a silty loam alluvial soil in the Experimental Orchard of the Warsaw Agricultural University at Warsaw-Wilanów, Central Poland, in spring 2001. Nineteen rootstocks were compared: the Armenian rootstock Arm 18, the Belorussian PB-4, the Czech J-TE-G and Unima, Polish rootstocks P 16, P 22, P 59, P 62, P 63, P 64, P 65, P 66, No. 280, No. 387, and No. 629, the Russian B 146 and B 491 as well as the standard English rootstocks M.9 EMLA and M.27.

Maiden trees of Rubin cultivar were planted in rows spaced 3 m apart. The in-row spacing depended on expected tree vigour on a particular rootstock. It was 1 m for trees classified as very dwarf (on J-TE-G, M.27, P 22, P 59, P 63, P 64, P 65 and PB-4), 1.2 m for those assumed as intermediate between very dwarf and dwarf (on B 491, No. 280, No. 387 and No. 629, P 16 and Unima), and 1.5 m for those considered as dwarf (on Arm 18, B 146, M.9 EMLA, P 62 and P 66).

The experiment was established in a randomised block design with four replications and 5 trees per plot, with the exception of the No. 629, which was represented by 3 trees per plot. Trees were planted with the bud union at 5 cm above ground level and trained as standard spindle, with trunks ca 70 cm high. Every year, from mid-May to the beginning of June, all newly developing shoots were successively cut back to about half of their length, when they reached ca 25 cm, to stimulate branching. In 2001 all trees were deblossomed. In 2002, 2003 and 2004 fruitlets were hand thinned after June drop. In 2004 chemical thinning with Pomonit R10 (NAA) was also applied.

In autumn 2004 trunk diameter at 30 cm was measured and trunk cross-sectional area (TCSA) calculated. Yield data were recorded in successive years (2002- 2004) and number of root suckers per tree was counted in May 2005. Data were elaborated by analysis of variance, with mean separation by Newman-Keuls test, at α=0.05.

Results

The TCSA in autumn 2004 served as a measure of tree size after 4 years in the orchard and reflected tree vigour induced by a rootstock. The least vigorous appeared trees on No. 629, followed by those on J-TE-G (Table 1). Trees on the Belorussian PB-4 and on Polish rootstocks No. 280, No. 387, P 59 presented vigour roughly comparable to those on the standard very dwarfing M.27. The rootstock P 22 and the newest Polish clones, No. 387, P 64, P 63 and P 65, induced some more vigour. The size of trees on Unima, P 16, B 146 and P 66 was quite similar, being somewhat smaller than that of the standard dwarfing M.9 EMLA. Growth of trees on B 491, Arm 18, P 62 and M.9 EMLA was the most vigorous, as showen by the TCSA 4-5 times larger than that of trees on No. 629.

In-row spacing, assigned for trees on a particular rootstock was not always right, as the real size of trees sometimes appeared different from the expected. Trees on No. 629 and No. 280 were planted at 1.2 m in row (2778 trees per ha), but it was wrong, as they showed extremely low vigour and have not filled the assigned space after four years. In contrast, trees on new rootstocks P 63 and P 65 were planted too densely (at 1 m in row, 3333 trees per ha). They grew more vigorously than it was expected and after four years got overcrowded. The same was true for trees on B 491, which were spaced at 1.2 m, but should rather have the 1.5-m spacing. Overcrowding was also observed in trees on M.9 EMLA and P 62, though they were planted at maximum planned spacing (1.5 m).

The highest yield in the fourth year after planting (2004) was obtained from trees on Arm 18 and M.9 EMLA – ca. 20-21 kg tree^{-1}, and the lowest on No. 629, J-TE-G and PB-4 – less than 10 kg per tree. The highest cumulative yield per tree for three bearing years (2002-2004), exceeding 25 kg per tree, was on P 63, P 65, P 16 and P 66. Trees on B 491, Arm 18, M.9 EMLA, P 22 and P 62 produced also rather high yields, ranging from 23.6 to 20.2 kg tree^{-1}. The lowest were cumulative yields were from trees on No. 280, M.27, J-TE-G and No. 629 (12.8 to 8.6 kg tree^{-1}).

The yield calculated per ha was a function of yield per tree and of the number of trees per ha; the latter depended, of course, on the in-row spacing. In 2004 most of the tested rootstocks induced

yields higher than 40 t ha^{-1}. The most productive were trees on P 65, P 63 and B 491, with yields over 50 t ha^{-1}. Cumulative yield per hectare was the highest for trees on P 63 and P 65. A high cumulative production (over 60 t ha^{-1}) was also obtained from trees on P 22, P 16, B 491 and P 59. The lowest yields for the three-year period of bearing were obtained from small trees, grown on the rootstocks No. 629 and J-TE-G, but also from trees on B 146.

Table 1. Indices of vigour and cropping of 'Rubin' trees on different rootstocks (listed from the top to the bottom in order of increasing TCSA in autumn 2004)

Rootstock	TCSA autumn 2004, cm^2	Yield, kg tree^{-1}		Number of trees per ha	Yield, t ha^{-1}		CEC [1] kg cm^{-2}	Mean fruit mass 2004, g	No. of suckers per tree
		2004	2002-2004		2004	2002-2004			
No. 629	4.8 f	5.5 h	8.6 i	2778	15.3 f	23.8 f	1.80 a-d	217	0.0 d
J-TE-G	6.2 ef	7.8 gh	11.0 hi	3333	26.0 e	36.8 e	1.77 a-d	239	0.1 d
No. 280	8.4 def	11.6 d-g	14.7 f-h	2778	32.1 c-e	40.9 e	1.76 a-d	265	2.8 b
PB-4	8.5 def	9.2 f-h	15.3 e-h	3333	30.5 de	51.2 c-e	1.82 a-d	238	0.2 d
M.27	8.6 def	10.3 e-h	12.8 g-i	3333	34.4 c-e	42.8 e	1.46 b-f	264	0.0 d
P 59	9.2 cde	10.7 e-h	18.9 c-g	3333	35.7 b-e	63.1 b-e	2.06 ab	255	0.7 cd
P 22	11.0 cde	12.5 c-g	22.0 a-e	3333	41.7 a-e	73.2 b	2.00 a-c	235	1.2 b-d
No. 387	11.3 cde	13.9 b-f	17.8 d-g	2778	38.7 a-e	49.6 c-e	1.61 b-e	251	0.2 d
P 64	11.4 cd	14.3 b-f	17.1 d-g	3333	47.7 a-d	57.1 b-f	1.50 b-f	277	0.1 d
P 63	12.2 bcd	16.7 a-e	27.5 a	3333	55.5 a	91.7 a	2.26 a	252	0.0 d
P 65	12.7 bcd	16.6 a-e	26.0 ab	3333	55.5 a	86.5 a	2.08 ab	243	0.1 d
Unima	13.6 bcd	15.1 a-f	18.7 c-g	2778	41.8 a-e	51.9 c-e	1.41 b-f	271	0.5 d
P 16	13.8 bcd	17.6 a-d	25.7 ab	2778	49.0 a-c	71.4 b	2.00 a-c	260	1.5 b-d
B 146	14.1 bc	14.1 b-f	17.3 d-g	2778	31.3 c-e	38.5 e	1.23 d-f	240	1.6 b-d
P 66	15.8 b	19.2 ab	25.3 abc	2222	42.7 a-e	56.3 b-f	1.60 b-e	268	0.1 d
B 491	17.8 a	18.9 abc	23.6 a-d	2778	52.4 ab	65.6 bc	1.34 c-f	256	2.2 bc
Arm 18	22.4 a	21.2 a	22.8 a-d	2222	47.2 a-d	51.2 c-e	1.04 e-f	274	8.4 a
P 62	23.7 a	18.7 abc	20.2 b-f	2222	41.6 a-e	44.9 de	0.91 f	271	0.4 d
M.9 EMLA	24.0 a	19.8 ab	22.6 a-d	2222	44.0 a-d	50.3 c-e	0.93 f	254	0.0 d

[1] CEC expressed as a ratio of the yield of three years (2002+2003+2004) to the TCSA in autumn 2004
[2] Mean separation (within columns) by Newman-Keuls test, at $\alpha = 0.05$

Cropping efficiency coefficient (CEC), calculated as a ratio of total yield for the three-year period (2002-2004) to the TCSA in autumn 2004, illustrates productivity of trees in relation to their final size. The highest CEC, over 2 kg cm^{-2}, was noted for trees on P 63, P 65, P 59, P 16, and P 22. The lowest relative productivity was demonstrated by trees grown on the most vigorous rootstocks, M.9 EMLA, P 62 and Arm 18; their CEC reached only about 1 kg cm^{-2}.

Fruits of the 2004 crop were large, in general, and were not markedly influenced by rootstock. The smallest fruits were from trees on No. 629, albeit their mean mass was also over 200 g.

Rootstocks No. 629, P 63, M.9 EMLA and M.27 did not produce any suckers. Few suckers were recorded in most of other rootstocks. The rootstock Arm 18 suckered intensely, producing over 8 root sprouts per tree. A considerable suckering was also noted from P 16, B 146 and B 491.

Discussion

Most of the rootstocks tested with Rubin scion exhibited a lower vigour than that of the standard M.9 EMLA. Some of them, like No. 629, showed an extremely low vigour, and might be classified as “ultra dwarf” (more dwarf than M.27), according to the terminology suggested by Zagaja *et al*. (1989) and Jakubowski (2004).

Previous results of the same experiment (Piestrzeniewicz and Sadowski 2004) have shown that ’Rubin’ was the most precocious in bearing when grown on the rootstocks P 63, P 22, P 65, P 59 or P 16. The recent results have confirmed that these rootstocks induced high productivity. When considering cropping efficiency coefficient (CEC) for a period of three years of bearing, the most productive were trees on rootstocks intermediate in vigour between very dwarfing and on typical dwarfing, namely on P 63, P 65 and P 16, but also on P 59 and P 22, classified as very dwarfing.

The best indicator of rootstock suitability is “commercial productivity” induced by it, i.e. yield per unit area, expressed in tons per ha (Jadczuk and Wlosek-Stangret, 1999). However, it is not easy to assign o proper area for a tree, as tree vigour is not easy to predict. Spacing applied for trees on some rootstocks in this study was overestimated or underestimated. Too dense planting of trees on certain rootstocks may cause a necessity of severe pruning and then of decline of productivity in the future.

A tendency of some rootstocks to reduce fruit size was reported by Zagaja *et al.* (1989). In our study, ultra dwarfing No. 629 reduced mean fruit mass, but in the case of the large-fruited 'Rubin' it may have little importance, as in the case of 'Jonagold' (Jakubowski, 2004).

The ability of a rootstock to produce root suckers may influence its acceptability by nurserymen and growers, and, to some extent, is associated with low vigour (Cummins and Aldwinckle, 1983 and Wertheim, 1998). In this experiment some tendency to suckering of P 16 as well as of B 146 and B 491 was noted. This was in line with the reports of Wertheim (1998) and of Sadowski *et al*. (1999). Also an intense suckering of Arm 18 may be considered as a serious disadvantage of this rootstock.

Conclusions

The standard dwarfing rootstock M.9 is too vigorous for vigorous cultivars grown on fertile soils.

The apple cultivar Rubin may be precocious in bearing and highly productive when grown on adequate rootstock of a relatively low vigour P 16, P 63, P 65, P 22 and P 59 may be promising rootstocks for 'Rubin' grown in a fertile soil.

References

1. Cummins J.N. and Aldwinckle H.S. (1983) Breeding apple rootstocks. Plant Breeding Rev., 1, 294-394.
2. Czynczyk A., Bielicki P. and Bartosiewicz B. (2001) Testing new dwarfing apple rootstocks from Polish and foreign breeding programmes. Acta Hort., 557, 83-89.
3. Jadczuk E. and Wlosek-Stangret C.R. (1999) Cropping and fruit quality of Jonagold apple trees depending on rootstock. In: A. Sadowski (ed.) Apple Rootstocks For Intensive Orchards. Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 45- 46.
4. Jakubowski T. (2004) The influence of rootstock clones on yield, fruit size and colouring of apples of the cultivar 'Jonagold'. Acta Hort., 658, 349-351.
5. Jakubowski T. and Zagaja S.W. (2000) 45 years of apple rootstocks breeding in Poland. Acta Hort., 538, 723-727.
6. Kruczyńska D. (2002). Jabłonie – nowe odmiany, Hortpress, Warszawa, Poland, 150.
7. Piestrzeniewicz C. and Sadowski A. (2005) Early orchard performance of 'Rubin' apple on nineteen rootstocks. Acta Hort. [in press].
8. Sadowski A., Pająk T. and Półtorak W. (1999) Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. In: A. Sadowski (ed.) Apple Rootstocks For Intensive Orchards. Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 91- 92.
9. Samuś W.A. (1996) Obiecujące podkładki wegetatywne dla jabłoni. Szkółkarstwo, 3, 6-7.
10. Ugolik M., Zydlik Z. and Kantorowicz-Bąk M. (2001) Wzrost, plonowanie i jakość owoców jabłoni z grupy ‘Golden Delicious’. Zesz. Nauk. Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach, 9, 117-122.
11. Wertheim S.J. (1998) Rootstock guide: apple, pear, cherry, European plum. Fruit Research Station Wilhelminadorp Bulletin, Netherlands.
12. Zagaja S.W., Czynczyk A., Jakubowski T. and Omiecińska B. (1988) Breeding and evaluating apple rootstocks for Northern Europe. HortScience, 23, 109-112.

13. Zagaja S.W., Jakubowski T., Piekło A. and Przybyła A. (1989) Preliminary evaluation of new clones of apple rootstocks. Fruit Sci. Rep., 16, 205-213.